# Physical Activity and Health Outcomes: A Systematic and Methodological Review

by

**Monita R. Sundar**

B.A. (Sociology), Simon Fraser University, 2008

Capstone Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Arts

in the
Department or Gerontology
Faculty of Arts and Social Sciences



**SIMON FRASER UNIVERSITY**

**Spring 2014**

## Approval

**Name:** **Monita R. Sundar**

**Degree:** **Master of Arts (Gerontology)**

**Title of Thesis:** ***Physical Activity and Health Outcomes: A Systematic and Methodological Review***

**Examining Committee:** **Chair:** Dr. Sharon Koehn
Clinical Research Professor

**Dr. Andrew V. Wister**
Senior Supervisor
Professor

**Dr. Andrew Sixsmith**
Supervisor
Professor

**Dr. Megan Winters**
External Examiner
Assistant Professor
Faculty of Health Sciences

**Date Defended/Approved:** April 22, 2014

# Abstract

It is understood that regular physical activity (PA) plays a critical role in improving and maintaining a person's health and well-being, especially as one grows older. Such benefits include preventing or controlling obesity, arthritis, hypertension, diabetes, cardiovascular disease including stroke, depression, cognitive disorders, certain cancers, and improving strength, flexibility and function. Regular PA can also stave off premature mortality. Despite these benefits of PA, older adults are becoming less active as they age. This capstone addresses two objectives: 1) to systematically and methodologically review and analyze cross-sectional and longitudinal associations between PA and health outcomes from the older adult general population living in the community or in institutional care aged 50 years and older and 2) to compare the results cross-sectionally and longitudinally. Results indicated that both cross-sectionally and longitudinally there were weak to moderate associations between PA and health outcomes such as emotional well-being, cognitive function, physical function, mortality, depression, chronic disease, quality of life and successful aging. Demonstrating a positive association between PA and health outcomes among older adults could have considerable public health implications in designing interventions to promote participation in PA.

**Keywords**: Physical activity; leisure-time physical activity; exercise; older adults

*To my daughter Brianna and*

*my parents Guy and Prem,*

*thank you*

*for your continuous love and support.*

## Acknowledgements

I would like to express my sincere gratitude to Dr. Krishnan Ramanathan. Thank you for encouraging me to go back to school. You believed in me at a time when I didn't believe in myself. I have never forgotten your kindness and the opportunities that you have given me over the years.

To my senior supervisor Dr. Andrew Wister and co-supervisor Dr. Andrew Sixsmith, thank you for your support and guidance with my capstone paper. Also, I truly enjoyed all the courses you both taught in the gerontology graduate program.

A special thanks goes to Joanie Wolfe for her expertise in library and formatting support. Also, thank you to the Student Learning Commons for their editing services.

Finally, I would like to thank my dear friends Naomi Uchida, Rusty McColl, Sherry Mark, Donna Demyen and Dr. Jacqueline Saw for all your love and support throughout my graduate studies. Thank you for ensuring I was constantly progressing on my papers and most of all thank you for helping me overcome my fear of giving presentations.

## Table of Contents

## List of Tables



## List of Figures

## List of Acronyms

| | |
|---|---|
| AD | Alzheimer's Disease |
| ADL | Activities of Daily Living |
| AOR | Adjusted Odds Ratio |
| BDI | Beck Depression Inventory |
| BMI | Body Mass Index |
| CI | Confidence Interval |
| CVD | Cardiovascular Disease |
| ES | Effect Size |
| HR | Hazards Ratio |
| HRQOL | Health-Related Quality of Life |
| IADL | Instrumental of Activities of Daily Living |
| LTPA | Leisure Time Physical Activity |
| MCI | Mild Cognitive Impairment |
| METS | Metabolic-Equivalent Tasks |
| NLTPA | Non-Leisure Physical Activity |
| OR | Odd Ratio |
| PA | Physical Activity |
| PASE | Physical Activity Scale for the Elderly |
| QOL | Quality of Life |
| RR | Relative Risk |

## Glossary

| | |
|---|---|
| Leisure Time Physical Activity | Defined as "physical activity performed during exercise, recreation or any time other than those associated with one's regular occupation, housework, or transportation" (Kandula & Lauderdale, 2005, p. 258). |
| Non-Leisure Time Physical Activity | Defined as those activities "associated with transportation, occupations, and housework" (Lin, Huang, Lu, Wu, Chang, & Yang, 2011, p. 1). |
| Physical Activity | Defined as "any bodily movement produced by skeletal muscle and resulting in energy expenditure" (Caspersen, Powell, & Christenson, 1985, p. 126). |
| Exercise | Defined as "a form of physical activity that is structured and repetitive over an extended period of time, with the intention of improving fitness, performance or health" (Theou et al., 2011, p. 2). |

# Chapter 1.

# Introduction

It is understood that regular physical activity (PA) plays a critical role in improving and maintaining a person's health and well-being, especially as one grows older (Costello, Kafchinski, Vrazel, & Sullivan, 2011). Such benefits include preventing or controlling obesity, arthritis, hypertension, diabetes, cardiovascular disease (CVD) including stroke, depression, cognitive disorders, and certain cancers (Balboa-Castillo, Leon-Munoz, Graciani, Rodriguez-Artalejo, & Guallar-Castillon, 2011; Costello et al., 2011; Dye & Wilcox, 2006; Lin et al., 2011). Similarly, PA has been demonstrated to lower all-cause mortality (Samitz, Egger, & Zwahlen, 2011).

The American Heart Association and the American College of Sport Medicine guidelines (AHA-ACSM) recommend that both young and old adults should engage in 30 minutes or more of moderate intensity PA 5 days per week (Ashe, Miller, Eng, & Noreau, 2009). PA is mostly defined as all leisure and non-leisure body movement produced by the skeletal muscles and resulting in an increase in energy expenditure whereas exercise is defined as a type of activity that is planned, "structured, and repetitive over an extended period of time, with the intention of improving fitness, performance or health (Theou et al., 2011, p. 2).

In older adults, the benefits of PA are considerable in that regular PA can help maintain independent living by improving strength, flexibility and functioning while reducing the risk for falls (Costello et al., 2011). Furthermore, older adults who continue to be physically active incur lower total health costs compared to inactive older adults (Plow, Allen, & Resnik, 2010). Yet despite these benefits of PA, older adults are becoming less active as they age. In Canada, 55% of men and 67% of women over the age of 50 years old are not active enough to achieve reduction in disease risk (Chad et al., 2005). This finding is particularly worrisome considering that older adults are greatly affected by non-communicable diseases such as CVD or cancer that could lead to hospitalization, institutionalization or even death (Ferreira, Matsudo, Ribeiro, & Ramos, 2010).

This capstone is intended to address some of the gaps in the literature that there are health benefits for older adults who engage in regular PA. In light of the rapid increase of the aging population worldwide, and the growing amount of physically inactive older adults, it is critical that we understand the relationship between PA and health outcomes so we can enhance our knowledge and efforts in increasing and maintaining PA participation among the older adult population.

A significant body of literature appears to support the idea that exercise and PA are associated with positive health outcomes among the general population. More importantly, an increasing amount of research is being conducted on the association between PA and health outcomes among older adults. The purpose of this capstone is twofold: 1) to systematically and methodologically review and analyze cross-sectional and longitudinal associations between PA and health outcomes from the older adult general population living in the community or in institutional care aged 50 years and older and 2) to compare the results cross-sectionally and longitudinally. Demonstrating a positive association between PA and health outcomes among older adults could have considerable public health implications in designing interventions to promote participation in PA.

# Chapter 2.

# Rationale for Research

Prior to conducting a review of the existing literature related to PA and health outcomes among older adults, three methodological approaches were considered- a narrative review, a meta-analysis or a systematic review. The central focus of this capstone paper was to choose a methodology that would be most appropriate for conducting a rigorous investigation of the available literature. With that said, a narrative review did not adequately meet this criterion. While narrative reviews are widespread and influential, they can result in limitations such as being be mostly descriptive; and because they do not involve a systematic search of the literature, they often focus on a subset of studies based on accessibility or author selection. Additionally, narrative reviews can often include an element of selection bias and they can be confusing at times, especially if similar studies have conflicting results and conclusions (Usman, 2011).

Meta-analysis has been described as “the statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings” (Glass, 1976, p. 3). Two limitations to utilizing a meta-analysis approach for this capstone paper include the high heterogeneity of measurements and study design which can make it difficult to provide a meaningful summary, and the controversy to the use of non-randomized controlled studies (Berman & Parker, 2002).

Therefore, given the nature of this topic, a systematic review was selected as the most appropriate methodological approach for this capstone paper. A systematic review employs a process to meticulously identify all studies for a specific focused question (drawn from research and other sources), evaluates the methods of the studies, presents key findings, summarizes the results, identifies reasons for diverse results across studies, and cites limitations of current knowledge (Garg, Hackam, & Tonelli, 2008). In addition, the systematic review methodology ensures a high degree of thoroughness and inclusivity of the existing literature, while the transparency of the methodology allows for accurate replication (Poth, 2009).

## 2.1. Cross-sectional studies

There are several procedural approaches to examining the association of PA with health outcomes. Those include conducting studies that are cross-sectional, longitudinal (or prospective), retrospective, case-controlled, and randomized controlled in nature. For the purpose of this capstone paper, only cross-sectional and longitudinal studies were examined.

Cross-sectional studies are commonly referred to as observational studies because the researcher merely observes. No interventions are conducted by the researcher (Mann, 2003). Cross-sectional studies are the most frequently used and straightforward design in gerontological research because they are conducted at a single point in time or over a short period of time (Ingram, 1999). These studies are descriptive, and usually in the form of a survey or interview. Cross-sectional studies are ordinarily conducted to estimate the prevalence of the outcome of interest for a specific population, with data collected on individual characteristics (e.g., age, gender and education), including exposure to risk factors, along with information about the outcome. Cross-sectional studies offer a 'snapshot' of the outcome and the characteristics associated with it, at a definite point in time (Levin, 2006). Because cross-sectional studies assess subjects at a specific point in time to determine if they were exposed to the relevant cause and have the outcome of interest, they are also used to infer causation.

A cross-sectional design can be appealing to a researcher for several reasons: 1) they represent a quick and efficient method of accumulating data about a parameter of interest; 2) they are relatively inexpensive and take up little time to conduct; 3) data is collected only once from subjects so there is no attrition; 4) many outcomes and risk factors can be assessed simultaneously; 6) researchers can estimate prevalence of the outcome of interest because the sample is usually taken from the whole population and

7) subjects are neither purposely exposed, treated, or not treated and therefore ethical difficulties are minimal (HealthKnowledge, n.d.; Ingram, 1999; Levin, 2006; Mann, 2003).

The main disadvantage of cross-sectional studies is distinguishing cause and effect from simple associations (Mann, 2003). For example, a study finding association between low PA and depression among older adults does not demonstrate whether low PA causes depression or if depression causes low PA, or both. Since cross-sectional studies are only conducted at one point in time and provide no evidence of the sequence of events of whether exposure occurred before, after or during the onset of disease, it is not possible to infer causality (Levin, 2006).

## 2.2. Longitudinal Studies

Longitudinal studies are also called observational studies and interventions are also not conducted by the researcher. In contrast to cross-sectional studies which look at different subjects, longitudinal studies observe the same subjects repeatedly over a long period of time, sometimes even decades. There are a number of different types of longitudinal studies including: 1) individual studies- when individuals are tracked and studied; 2) household panel surveys- when individuals are followed and observed within their household and information is collected; and 3) cohort studies- when people from certain age groups are studied to investigate their different trajectories as they age.

A major advantage to observing the same subjects over a long period of time is that it provides stronger evidence for determining the sequence of an association. For example, studies examining PA and depression among older adults over a long period of time are able to establish a true causal relationship. Another advantage to longitudinal studies is the "ability to compare the same person at different times, and hence permit within-individual analyzes of individual change" (Farrington, 1991, p. 370). Therefore, while cross-sectional studies examine variation between individuals, longitudinal studies are able to examine variation within and between individuals.

While tracking subjects has some key advantages, it is not without its challenges. Limitations and disadvantages associated with using longitudinal studies include: 1) increased cost of a longitudinal study due to the length of time of the study; 2) the significant resources needed for the researcher to maintain contact with the subjects, collect and analyze data, and maintain records; 2) administrative or institutional stability; 3) progressive error (i.e., respondents becoming more test sophisticated by repeated examination and testing); 4) time-of-measurement effects (i.e., sociocultural events that can interfere data collection) and 6) problems of attrition of subjects due to refusal, tracing difficulties, death etc. (Ingram, 1999).

Choosing a research methodology is the most important decision a researcher can make. As the two primary objectives of this capstone paper are to systematically and methodologically review and analyze cross-sectional and longitudinal associations between PA and health outcome variables such as emotional well-being, mortality, depression, disability, cognitive function, chronic diseases, QOL, and successful aging in the older adult general population living in the community or in institutional care aged 50 years and older, the use of observational studies that permit analyses of prevalence incidence, associations, causes, and outcomes is the most appropriate methodology (Mann, 2003).

# Chapter 3.

# Methodology

## 3.1. Methods

### *3.1.1. Search Strategy and Selection of Studies*

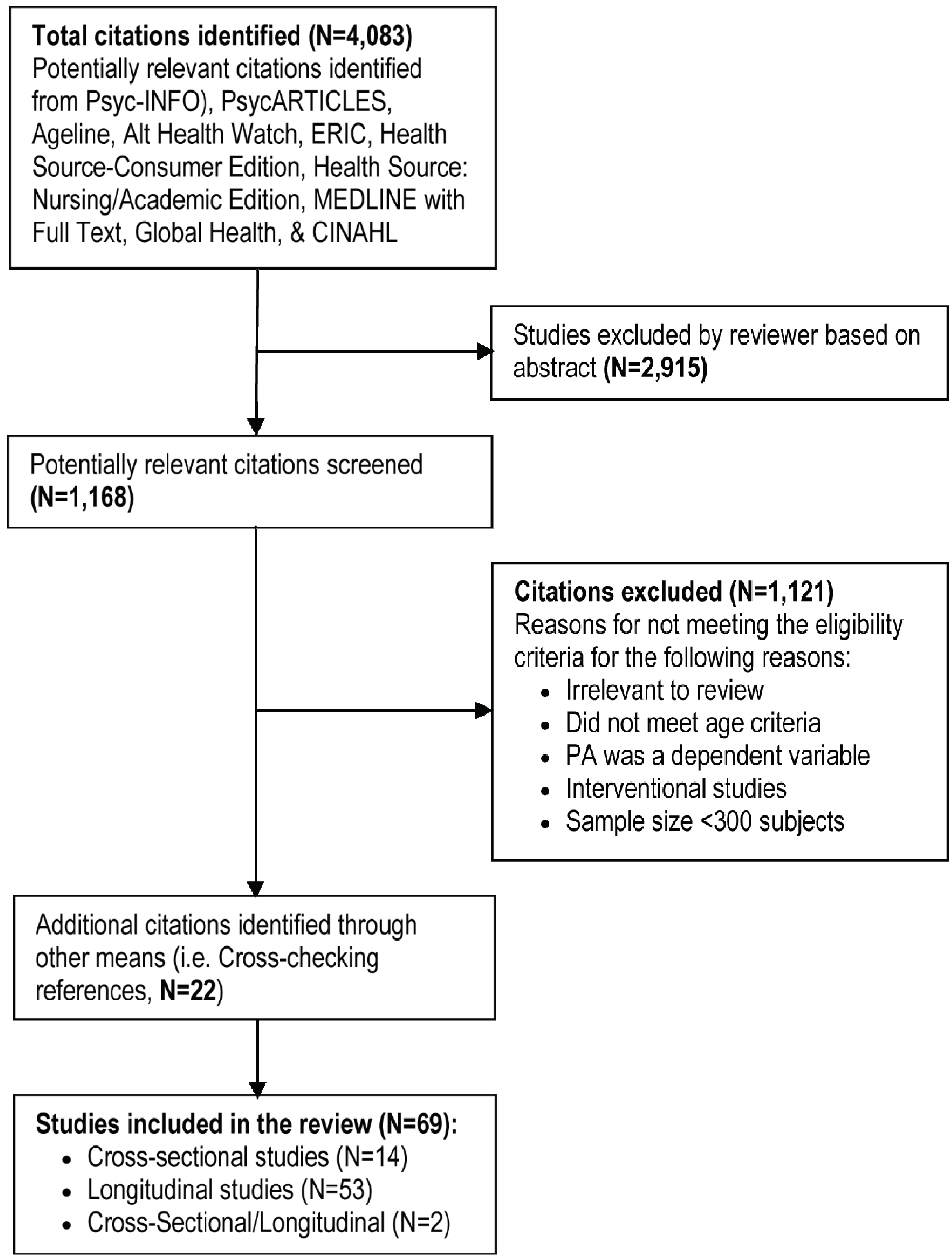
The following ten electronic databases were systematically searched from January 1998 to July 2013: Psyc-INFO, PsycARTICLES, Ageline, Alt HealthWatch, ERIC, Global Health, Health Source-Consumer Edition, Health Source: Nursing/Academic Edition, MEDLINE with Full Text, and CINAHL with Full Text using the keywords in titles, abstracts, or indexing fields: physical activity, exercise and older adults. These terms were combined with mortality, CVD, diabetes, cognitive impairment, disability, successful aging, and quality of life. Studies searched were limited to English language publications. A further technique used to identify articles was “snowballing” (also known as “cross-referencing” citations). This technique involves obtaining additional relevant works identified in the references of articles already reviewed.

Selected studies were peer reviewed journal articles examining PA and health outcomes such as emotional well-being, cognitive function, physical function, successful aging, QOL, mortality, depression, disability, and chronic diseases in older adults aged 50 years or older.

### *3.1.2. Screening*

Identified studies were initially screened based on the study title and abstract. Duplicates, articles that were not published in English, and irrelevant studies were manually removed. Potential studies were briefly scanned to see if they met eligibility criteria. Manual cross-referencing of bibliographies of the selected articles was also completed (see **Figure 3.1**).

***Figure 3.1. Screening Procedures***



### 3.1.3. *Inclusion Criteria*

Eligible participants consisted of male and female older adults' aged 50 years and older, and included both frail and healthy older people drawn from the general population living in the community or in institutional care who had participated in studies related to PA.

In order to ensure that the studies examined truly identified a difference between PA and the specific health outcome, (i.e., mortality, disability, cognitive impairment, etc.), it was important to identify the power of a statistical test. Power refers to the probability that the test will find a statistically significant difference when such a difference truly exists- in other words, power is the probability that a researcher will reject the null hypothesis when they should and as a result avoid a Type II error (Pallant, 2002). Inspection revealed a wide-range of statistical tests (e.g., parametric tests or non-parametric tests) that varied in terms of their statistical power. Three variables, namely sample size, significance criterion (α), and population effect size can all influence the power of a test in a given situation. According to Cohen (1992), "for any statistical model, these relationships are such that each is a function of the other three" (p. 156). Therefore, all four variables were considered when reviewing potential studies for this capstone.

It is widely recognized that power should be 0.80 or greater; that is, the researcher should have an 80% or greater chance of finding a statistically significant difference when there is one. Along with a 0.80 power, the alpha level set by the researcher is traditionally 0.05. As it was anticipated that this systematic literature review would primarily identify small (or weak) and moderate effect sizes, only cross-sectional and longitudinal studies with a sample size of at least 300 eligible participants were selected. According to Lipsey (1990), using a minimum sample of 300 will provide a statistical power of 0.80.

In July 1946, the constitution of the World Health Organization (WHO) defined health as "the state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (Grad, 2002, p. 984). Taking the WHO's health definition into consideration, eligible studies in this review included those examining positive health outcomes such as longevity, functioning well both mentally and physically, and having a sense of well-being.  Also, eligible studies included in this review were those examining negative health outcomes such as mortality, loss of function, disability, cognitive impairment and lack of well-being.  While diseases such as CVD, heart failure, diabetes, cancer, dementia, Alzheimer disease (AD) are considered to be intermediary factors that influence the likelihood of achieving a state of health, these outcomes were also included when examining eligible studies in relation to PA among older adults (Parrish, 2010).  Finally, QOL and successful aging were also included in the review as part of health outcomes.

### *3.1.4. Exclusion Criteria*

Non-English studies and studies specifically targeting persons under the age of 49 years and younger were excluded.  Studies that were interventional in nature such as randomized control studies were not included, nor were samples with less than 300 participants.  Studies that had PA as a dependent variable were also excluded.

### *3.1.5. Measurements*

#### Demographic Variables

Age, gender, marital status, socio-economic status (SES) and education were included in most if not all analyses.  These variables were treated as independent variables.  However, for the purpose of stratified adjustment and regression models, the above variables also operated as potential confounding variables.

#### Physical Activity

Eligible indicators of PA practice included self-report of light, moderate or intense (or vigorous)  PA, leisure time physical activity (LTPA), or non-leisure time physical activity (NLTPA), objective measures of PA measured through electronic devices (accelerators, pedometers, heart rate monitors), and objective measures of physical fitness (e.g., treadmill test, doubly labeled water).  PA operated as an independent variable.

### Health Outcomes

Eligible assessments of health outcomes included all measurements capturing general (self-rated) health or its multidimensional components (physical, emotional, functional and psycho-social). These included but were not limited to well-being, mortality, depression, disability, physical function, cognitive function, quality of life, successful aging and chronic diseases such as CVD, cancer, heart failure, dementia and diabetes. The aforementioned variables operated as dependent variables. These dependent variables were grouped into seven areas.

1. *Mortality* data were obtained from an annual review of death certificates with the national death registry file.
2. *Emotional well-being* included depression, anxiety, general health, positive well-being, self-control, vitality, social functioning, role-emotional (i.e., problems with work or other daily activities as a result of emotional problems) and mental health.
3. *Functional ability* included mobility, balance, disability, frailty and functional performance test batteries.
4. *Cognitive Function* included orientation, concentration, praxis, measures of episodic, semantic and working memory, verbal fluency, perceptual speed, visuospatial abilities, dementia and AD.
5. *Chronic diseases* included CVD, breast cancer, heart failure and diabetes.
6. *Successful Aging* included components such as presence of chronic conditions, cognitive and physical functional capacity, active engagement with life, life satisfaction, happiness and mortality,
7. *Quality of life* included physical and mental health domains such as physical function, role-physical (i.e., problems with work or other daily activities as a result of physical health), bodily pain, general health perceptions, vitality, social functioning, role-emotional and mental health.

## *3.1.6. Data Extraction and Synthesis*

Each study was reviewed and information about the study design, sample characteristics, sample size, objective and subjective measurement of PA, and description of health outcome instruments and context of use, correlations, mean differences, odds ratio (OR), relative risk (RR), and hazards ratio (HR) between PA level and health outcome were extracted.

### 3.1.7. *Calculating Effect Size*

In order to fully understand the significance of the research findings, it was necessary to include some index of effect size (ES) estimate in this review. ES "estimates provide a common metric to compare the direction and strength of the relationship between variables across studies" (Berben, Sereika, & Engberg, 2012, p. 1039). The reporting of ES estimates to describe strength is common, and is often used in a variety of studies to determine the appropriate sample sizes for intervention studies and surveys. Since there were many different types of ES's included in this review, for example, mean differences in scores between groups, odds ratio, relative risk or absolute risk differences for an outcome of interest, or correlation coefficients between variables, it was essential to convert different ES indices to a common index where applicable so that one could easily compare effects. The following is a brief description on how ES was calculated and interpreted according to group design utilized in this review.

Pearson's correlation is commonly referred to as *r* and is extensively used as an ES when paired quantitative data are available or when the data are binary. Its purpose "is to examine the strength and direction of a linear relationship between two continuous variables (independent and dependent)" (Abu-Bader, 2011, p. 4). Pearson's *r* can vary in magnitude from -1 to 1. If *r* is -1, this indicates a perfect negative linear relation, if *r* is 1, this indicates a perfect positive linear relation, and if *r* is 0, this indicates no linear relation between two variables. The positive or negative sign indicates the direction of the relationship between two variables. To convert Pearson *r* correlations into ES, the following arbitrary correlation indices based on Cohen (1992) were used to determine the following ES's: weak (0-.10), weak-moderate (.11-.29), moderate (.30-.40), moderate-strong (.31-.49) and strong ($\geq .50$).

Standardized regression coefficient (beta, β) otherwise known as partial correlation coefficient, is comparable to the Pearson correlation coefficient, but controls for the possible effects of other confounding variables in an analysis (Abu-Bader, 2011). To convert β correlation coefficients into ES, the same arbitrary correlation indices for Pearson's r were used: weak (0-.10), weak-moderate (.11-.29), moderate (.30-.40), moderate-strong (.31-.49) and strong ($\geq .50$).

Using Digby's (1983) transformation of converting odds ratio (OR) into a correlation, ES was calculated using the following formula: r= [OR-1] / [OR+1], where OR is the odds ratio. This same formula was used to convert relative risk (RR) and hazard's ratio (HR) into a correlation. Subsequently the following arbitrary correlation indices based on Cohen (1992) were used to determine the following ES's: weak (0-.10), weak to moderate (.11-.29), moderate (.30-.40), moderate-strong (.31-.49), and strong (≥ .50).

Analysis of variance (ANOVA) and analysis of covariance (ANOVA) are both statistical models used to analyze the difference between group means (Abu-Bader, 2011). In order to determine the ES for ANOVA and ANCOVA, a web-based ES calculator was used (Wilson, n.d.). Subsequently, the following arbitrary correlation indices based on Cohen (1992) ES equivalent was used to determine the following ES's: small (.10), small-moderate (.11-.29), moderate (.30-.40), moderate-strong (.41-.49) and strong (>.50).

# Chapter 4.

# Results

## 4.1. Description of Studies

**Figure 3.1** describes the progress through the stages of study selection. The preliminary search yielded 4,083 citations. After an initial screening of all the titles and abstracts, 1,168 articles remained from which full text were obtained. Of these articles, 47 met the inclusion/exclusion criteria. A manual search from other journal articles provided an additional 22 linkages. A total of 69 studies were included in the review (see **Tables 4.1-4.16** and **Appendices A, B, and C**). Fourteen studies were cross-sectional (see **Appendix A**), 53 studies were longitudinal ranging from 2 years to 46 years of follow-up (see **Appendix B**), and two studies were a combination of cross-sectional and longitudinal studies (see **Appendix C**), respectively.

## 4.2. Physical Activity Measurements

Only five studies (Buchman, Boyle, Yu, Shah, Wilson, & Bennett, 2012; Kokkinos et al., 2010; Manini et al. 2006; Santos, Silva, Baptista, Santos, Vale, Mota, & Sardinha, 2012; Shah, Buchman, Leurgans, Boyle, & Bennett, 2012) used objective measures of PA levels. One (Manini et al., 2006) of which used the 'gold standard' method, that is the doubly labeled water method. The remaining 64 studies (see **Appendix D1**) relied on the self-reported assessment of PA level.

Forty-one studies provided some information about the validity of their PA instrument (see **Appendix D2**). While 28 studies did not provide any information about the validity of their PA instruments (see **Appendix D3**).

It is widely known in the literature that measurement of PA is fraught with challenges, especially with respect to older adults. In addition to using subjective measurements of PA and non-validated PA instruments, other methodological concerns include: an absence of comprehensive parameters of PA (i.e., frequency, duration and intensity) included in the PA instrument; a lack of exhaustive types of PA ( i.e., aerobic, muscle strengthening, bone-strengthening, or stretching) assessed in each study; overestimated or underestimated PA levels due to recall bias or towards social desirability response; misconstrued questions regarding PA; variables in the PA instrument may not have accurately measured what they should have measured; crude measures of PA and finally, a limited selection of types of PA to choose from. Therefore, caution is warranted when interpreting results for this review.

## 4.3. Summary of the Evidence

Cross-sectional data showed a consistently inverse association between PA and psychological distress, depression, cognitive impairment, and chronic diseases. In contrast, there was a positive association between PA and emotional well-being, cognitive function, physical function, QOL and successful aging.

Longitudinal data showed a consistently inverse association between PA and mortality, depression, dementia, AD, disability, cognitive impairment, frailty, and chronic diseases. In contrast, there were positive associations between PA and functional status, cognitive function, and successful aging.

Due to the immense heterogeneity of PA measurements, health outcome instruments, and study designs, it was not possible to pool data quantitatively in some areas. Subsequently, a narrative description of findings is presented.

## 4.4. Cross-sectional Studies

### *4.4.1. Physical Activity and Emotional Well-being*

Three studies (George, Jorm, Kolt, Bambrick, & Lujic, 2012; Lee & Hung, 2011; Mummery, Schofield, & Caperchione, 2004) examined the association between PA and emotional well-being (see **Table 4.1**). Emotional well-being is a complex and multidimensional concept that is not easy to define (Lampinen, Heikkinen, Kauppinen, & Heikkinen, 2006). Previous studies on the relationship between PA and emotional well-being have applied a range of different definitions and have used either one-item measures, multi-item scales or different dimensions of emotional well-being separately or together such as depression, anxiety, positive well-being, vitality, and social-functioning. Consequently, it is impossible to make meaningful comparisons between the results of separate studies. However, the following cross-sectional studies attempt to shed some light on the association between PA and a number of emotional well-being outcomes.

***Table 4.1. Cross-sectional Physical Activity and Emotional Well-being***

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Emotional Well-being |
|---|---|---|---|
| George et al. (2012). Journal of Aging and *Physical Activity, 20,* 300-316. | Physical Activity and Psychological Distress in Older Men: Findings From the New South Wales 45 and Up Study | • Utilized elements of The Active Australian Survey.<br>• Valid instrument | • Psychological distress was evaluated using the Kessler-10 scale (K-10).<br>• Valid Instrument |
| Lee et al. (2011). *Aging and Mental Health, 15*(7), 873-881. | The Relationship Between Exercise Participation and Well-being of the Retired Elderly. | • Measured exercise intensity, frequency and participation level<br>• Valid instrument | • The General Well-Being (GWB) scale<br>• Valid instrument |
| Mummery et al. (2004). *Australian & New Zealand Journal of Public Health, 28*(2), 188-192. | Physical Activity Dose-response Effects on Mental Health Status in Older Adults. | • Active Australian questionnaire<br>• Valid instrument | • The SF-12 questionnaire.<br>• Valid instrument |

George et al. (2012) found there was a weak-moderate inverse association between PA and psychological distress. Specifically, George et al. found that compared with men who engaged in no sessions of PA, those who engaged in at least one to six sessions of PA per week were 34% less likely to report high or very high levels of psychological distress (OR = 0.66, 95% CI = .51–.85, $p = .008$) and decreased to 43% (OR .57, 95% CI = .43–.79) for men who reported 16 or more weekly sessions. ES ranged from -0.21 to -0.27. Moreover, when functional limitation was excluded from the model, George et al. found that there was a stronger inverse relationship between increasing levels of PA and a reduced likelihood of reporting psychological distress. ORs ranged from 0.42 (95% CI = .33–.54, $p < 0.001$) for 1–6 sessions to 0.30 (95% CI = .22–.40, $p < 0.001$) for ≥ 16 sessions of physical activity in the past week, while ES ranged from -0.41 to -0.54.

Lee and Hung (2011) study found there was a weak-moderate positive association between PA and emotional well-being. For example, utilizing a distinct emotional well-being scale called the General Well-being Scale (GWB), Lee and Hung discovered that there was a weak-moderate positive association between exercise frequency and well-being ($\beta=0.13$, $p < 0.01$), and on three dimensions of the GWB scale; depression ($\beta=0.12$, $p < 0.05$), positive well-being ($\beta=0.18$, $p < 0.01$), and vitality ($\beta=0.18$, $p < 0.001$). ES ranged from 0.12 to 0.18. In contrast, they found there was a weak-moderate inverse association between exercise intensity and well-being ($\beta= -0.22$, $p < 0.001$), and on all six dimensions of the GWB scale including anxiety, depression, general health, positive well-being, self-control and vitality.

A study by Mummery et al. (2004) found no association between PA level and emotional well-being while controlling for physical health. Employing the SF-12 questionnaire that assesses the physical (PCS) and mental (MCS) health status of participants, Mummery et al. were not able to discover reliable dose-response effects when considering mental health and the two activity classifications of “moderately active” or “highly active” participants. However, it is worth mentioning that the PA instrument that Mummery et al. used in their study, the test retest reliability in an older population was previously established at 0.54. Hence, their instrument did not meet the required 0.70 or higher correlation standard for the instrument to have good test-retest reliability.

Overall, two studies (George et al., 2012; Lee & Hung, 2011) found statistically significant results with weak-moderate ES. One study (Mummery et al., 2004) found no association.

### 4.4.2. *Physical Activity and Cognitive Function*

Three studies (Benedict et al., 2012; Buchman, Wilson, & Bennett, 2008; Middleton, Barnes, Lui, & Yaffe, 2010) reported on PA and cognitive function (see **Table 4.2**). All three studies found an association between PA and cognitive function but direction and strength of association varied depending on the study. Discrepancies for each study included the use of distinct cognitive assessments and different subjective and objective measurements of PA. For example, using a self-report PA questionnaire and the modified Mini-Mental State Examination (mMMSE) to assess cognitive function, Middleton et al. found there was a weak-moderate inverse association between PA and cognitive impairment in late life. For instance, teenage: 8.5% vs. 16.7% , adjusted odds ratio (AOR) =0.65, 95% CI = 0.53–0.80, $p < 0.001$; age 30: 8.9% vs. 12.0% , AOR = 0.80, 95% CI = 0.67–0.96, $p < 0.05$; age 50: 8.5% vs. 13.1% , AOR = 0.71, 95% CI = 0.59–0.85, $p < 0.001$; and late life: 8.2% vs. 15.9% , AOR = 0.74, 95% CI = 0.61–0.91, $p < 0.001$. ES ranged from -0.11 to -0.22.

***Table 4.2. Cross-sectional Physical Activity and Cognitive Function***

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Cognitive Function |
|---|---|---|---|
| Middleton et al. (2010). *Journal of the American Geriatrics Society, 58,* 1322-1326. | Physical Activity Over the Life Course and Its Association with Cognitive Performance and Impairment in Old Age. | • A modified Paffenbarger questionnaire.<br>• Valid instrument | • Modified Mini-Mental State Examination (mMMSE).<br>• Valid instrument |
| Benedict et al. (2012). *Neurobiology of Aging, 34,* 83-90. | Association Between Physical Activity and Brain Health in Older Adults. | • PA was divided into light and hard exercise and classified as the number of activities with a duration of at least 30 minutes per week.<br>• Valid instrument | • MMSE<br>• Valid instrument |
| Buchman et al. (2008). *American Journal of Geriatric Psychiatry, 16*(8), 607-701. | Total Daily Activity is Associated With Cognition in Older Persons. | • Actical<br>• Valid instrument | • Trained technicians administered 19 cognitive tests from which a composite measure of global cognition and subscale measures of episodic memory, semantic memory, working memory, perceptual speed, and visuospatial abilities were constructed.<br>• Non-valid instrument |

Benedict et al. (2012) utilized a self-report PA instrument and the MMSE to assess overall cognitive function and found a weak-moderate positive association between PA and categorical verbal fluency ($\beta = 0.147$, $p = 0.007$) and a weak-moderate inverse association between PA and shorter time to complete Trail Making test ($\beta = -0.181$, $p < 0.001$), indicating better performance. ES was .15 and -.18, respectively. In contrast, Buchman et al. (2008) utilized an actigraphy, an objective measure of daily PA and a non-validated cognitive instrument, and found there was a weak positive association between total daily activity and global cognition (Estimate, 0.071, SE= 0.015, $p < 0.001$). ES was .07. Additionally, Buchman et al. (2008) found there was a weak inverse association with perceptual speed and a strong inverse association with visuospatial abilities, (estimate, -0.045, SE=0.013, $p = 0.001$; estimate, -6.394, SE=3.129, $p < 0.042$, respectively). ES was -.05 and -6.40, respectively.

Overall, all three studies (Benedict et al., 2012; Buchman et al., 2008; Middleton et al., 2010) found statistically significant results with weak-moderate ES.

### *4.4.3. Physical Activity and Physical Function*

Three studies (Martin, Syddall, Dennison, Cooper, & Sayer, 2008; Santos et al., 2012; Yorston, Kolt, & Rosenkranz, 2012) reported on PA and physical function (see **Table 4.3**). Findings from two of the three studies reported an association between PA and physical function. Although, the third study (Santos et al., 2012) found an extremely weak association between PA and physical function, this review considered the association to be non-significant.

For example, Martin et al. (2008) found that higher levels of customary PA were associated with significantly higher muscle strength and better physical performance; however this was only true for women. In women the following results were obtained: grip strength (kg) in the "keep fit" group: 27.8 (4.9), vs. "indoors" group 25.2 (5.7), $p = 0.0003$ ; 3-m walk(s) "keep fit" group 3.22 (0.50), vs. "indoors" group 3.55 (0.70), $p = 0.0001$; chair rises (SDS) "keep fit" group -0.36 (0.76), vs. "indoor" group 0.17 (1.05), $p = 0.0001$; Balance lost in < 5s "keep fit" group 14 (16.5), vs. "indoor" group 51 (28), $p = 0.05$. Effect size ranged from -1.48 to 0.48. Of interest, Martin et al. found there was an inverse weak-moderate association between increased gardening and lower poor balance for women only (OR = 0.74, 95% , 0.57, 0.95; p = 0.02), ES was -0.17.

Results by Yorston et al. (2012) demonstrated that there was a weak-moderate positive association between PA and physical function (correlation coefficient = 0.166, p < .001). Additionally, they found that there was a moderate to moderate-strong inverse association between higher levels of PA and functional limitation (middle tertile; AOR = 0.48, 95% CI = 0.46-0.50, p < 0.001; highest tertile; AOR = 0.36, 95% CI = 0.34-0.37, p < 0.001), ES ranged from -.35 to -0.47, respectively.

***Table 4.3. Cross-sectional Physical Activity and Physical Function***

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Physical Function |
|---|---|---|---|
| Martin et al. (2008). doi:10.1093/ ageing/afn148 | Relationship Between Customary Physical Activity, Muscle Strength and Physical Performance in Older Men and Women: Findings from the Hertfordshire Cohort Study. | • Hertfordshire Physical Activity Questionnaire (HPAQ)<br>• Valid instrument | • Hand Grip Strength: using the Jamar hand-grip dynamometer.<br>• Valid instrument<br>• Short Physical Performance test: battery of tests comprising of 3 meter customary walking pace, 5 sit-stand chair rises time and timed one-legged balance.<br>• Valid instrument |
| Yorston et al. (2012). *Journal of the American Geriatrics Society, 60,* 719-725. | Physical Activity and Physical Function in Older Adults: The 45 and Up Study. | • The Active Australia survey.<br>• Valid instrument | • Medical Outcomes Study Physical Functioning (MOS-PF) scale.<br>• Valid instrument |
| Santos et al. (2012). *Experimental Gerontology, 47,* 908-912. | Sedentary behaviour and physical activity are independently related to functional fitness in older adults. | • Accelerometry (ActiGraph, GT1M model)<br>• Valid instrument | • The Senior Fitness Test (Rikli and Jones, 1999).<br>• Valid instrument |

A study by Santos et al. (2012) indicated an extremely weak (almost non-significant) positive association between moderate-to-vigorous physical activity (MVPA) and functional fitness as expressed by better scores observed in a composite Z-score ($\beta$=0.004, 95% CI = 0.001, 0.008, p < 0.05 ) even after adjusting for sedentary time, gender, age, and accelerometer register time. Thus, older adults who spent less time in sedentary behaviors or more time in MVPA, independently of each other, had better overall functional fitness. However, as mentioned previously, in light of the extremely weak association between PA and functional fitness, the result of this study was considered non-significant for this review.

Overall, two studies (Martin et al., 2008; Yorston et al., 2012) found statistically significant results with mixed ES's, while the third study (Santos et al., 2012), found no association.

### *4.4.4. Physical Activity and Successful Aging*

Only one cross-sectional study (Baker, Meisner, Logan, Kungl, & Weir, 2009) was indentified that examined the relationship between PA and successful ageing (see **Table 4.4**). Baker et al. study explored the association between PA involvement and successful aging in older adults at least 60 years of age in all provinces and territories of the Canadian population. Results indicated there was a moderate positive association between physically active older adults and aging successfully (OR = 2.26, estimate = 0.817, CI = = 0.703–0.931, $p < 0.001$), ES was 0.39.

***Table 4.4. Cross-sectional Physical Activity and Successful Aging***

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Successful Aging |
|---|---|---|---|
| Baker et al. (2009). *Journal of Aging and Physical Activity, 17,* 223-235. | Physical Activity and Successful Aging in Canadian Older Adults. | • Canadian Community Health Survey (CCHS) Physical Activity Index.<br>• Valid instrument | • Rowe and Kahn's definition of successful aging: presence of chronic conditions, high cognitive and physical functional capacity, active engagement with life.<br>• Non-valid instrument |

### *4.4.5. Physical Activity and Quality of Life (QOL)*

Three studies (Guedes, Hatmann, Martini, Borges, & Bernardelli, 2012; Salguero, Martínez-García, Molinero, & Márquez, 2011; Sampaio & Ito, 2012) examined the relationship between PA and QOL (see **Table 4.5**). All three studies found an association between PA and QOL. Specifically, Salguero et al. (2011) examined whether measures of PA are related to health-related quality of life (HRQoL) and symptoms of depression in a sample of Spanish community dwelling and institutionalized older adults. Results demonstrated there was a weak-moderate positive association between PA and different domains of both the physical and mental components of HrQOL. ES ranged from 0.10 to 0.19. For example, all SF-36 domains, with the exception of role-emotional, were significantly correlated with the Yale Physical Activity Survey (YPAS) activity dimension summary index. Physical function (0.192, $p < 0.001$), role-physical (0.139, $p < 0.01$), general health (0.109, $p < 0.05$) and vitality (0.118, $p < 0.05$) correlated with total time activity. Also, correlations were observed between weekly energy expenditure and physical function (0.176, $p < 0.01$), role physical (0.104, $p < 0.05$), vitality (0.138, $p < 0.01$), and mental health (0.119, $p < 0.05$). This study also found a weak-moderate positive association between both community dwelling and institutionalized active older adults and symptoms of depression. For example, depressive symptoms scores correlated significantly with the activity dimension summary index (0.155, $p < 0.001$) and the estimated weekly energy expenditure (0.120, $p < 0.05$), as well as with the vigorous activity index (0.173, $p < 0.01$) and the standing index (0.171, $p < 0.001$). ES ranged from .12 to .17.

***Table 4.5. Cross-sectional Physical Activity and Quality of Life***

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Quality of Life |
|---|---|---|---|
| Salguero et al. (2011). *Archives of Gerontology and Geriatrics, 53,* 152-157. | Physical activity, quality of life and symptoms of depression in community-dwelling and institutionalized older adults. | • Yale Physical Activity Survey (YPAS).<br>• Valid instrument | • The Spanish version of the SF-36.<br>• Valid instrument |
| Sampaio et al. (2012). *Occupational Therapy International, 20,* 1–10. | Activities with Higher Influence on Quality of Life in Older Adults in Japan. | • The level of activity and participation was measured through an original questionnaire with 10 questions concerning the frequency of engagement in several activities.<br>• Valid instrument | • World Health Organization Quality of Life Assessment (WHOQOL)-BREF Japanese version (Tazaki and Nakane, 1997) and WHOQOL-OLD Japanese preliminary version (Kato et al., 2005).<br>• Japanese version of QOL was not validated at the time. |
| Guedes et al. (2012). *Journal of Aging and Health, 24*(2) 212–226. | Quality of Life and Physical Activity in a Sample of Brazilian Older Adults | • Short version of the International Physical Activity Questionnaire (IPAQ) translated to Portuguese.<br>• Valid instrument | • The WHOQoL, translated and adapted to Portuguese.<br>• Valid instrument |

A study by Sampaio et al. (2012) provides further support for a weak-moderate positive association between PA and QOL. This study investigated the influence of 10 activities on QOL in a sample of Japanese community-dwelling older adults aged 60 years or older and established which activities had higher influence on QOL level. They found that the activity with the highest influence on the World Health Organization Quality of Life Assessment (WHOQOL-BREF) was physical activity ($\beta = 0.209$, $p < 0.01$), followed by art activity ($\beta = 0.169$, $p < 0.01$) and reading and writing ($\beta = 0.141$, $p < 0.01$). ES ranged from 0.14 to 0.21.

Finally, Guedes et al. (2012) examined the association between PA and QOL in a sample of Brazilian older adults aged 60 years and older. Results demonstrated a small-moderate positive association for female older adults (ES ranged between 0.19 to 0.25) and a small to moderate positive association for male older adults (ES ranged between 0.28 to 0.34) who reported being more physically active attributed higher scores to sensory ability (women: $F = 3.796$, $p = .028$; men: $F = 9.486$, $p < .001$, respectively), autonomy (women: $F = 4.227$, $p = .017$; men: $F = 8.237$, $p < .001$, respectively), and intimacy domains (women: $F = 3.549$, $p = .020$; men: $F = 10.114$, $p < .001$, respectively), in addition to presenting significantly higher overall quality of life scores (women: $F = 4.153$, $p = .016$; men: $F = 8.69$, $p = .001$, respectively).

Overall all three studies (Guedes et al., 2012; Salguero et al., 2011; Sampaio & Ito, 2012) found statistically significant associations with ES ranging from weak (or small) to moderate.

### *4.4.6. Physical Activity and Chronic Diseases*

There was only one cross-sectional study (Benedetti, Gonçalves, Petroski, Nassar, Schwingel, & Chodzko-Zajko, 2008) that examined the relationship between PA and chronic disease (see **Table 4.6**). Benedetti et al. explored the association between PA and disease among older persons aged 60 years and older living in Florianópolis, Brazil. Results indicated there was a moderate inverse association between PA and chronic disease. After adjusting for gender and age, less physically active older adults were twice as likely to report the presence of at least one type of disease than were those older adults who were more active (OR = 2.06, 95% CI = 1.49-2.85, $p < 0.001$).

ES was 0.35. In addition, Benedetti et al. assessed the relationship between socioeconomic status (SES) and PA participation and found a moderate positive association between SES and PA participation (OR = 1.941, 95% CI = 1.36-2.77, p <.001), with higher income older adults more likely to be physically active. This finding is consistent with previously published literature.

***Table 4.6. Cross-sectional Physical Activity and Chronic Disease***

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Chronic Disease |
|---|---|---|---|
| Benedetti et al. (2008). *Journal of Applied Gerontology, 27*(5), 631-640. | Physical Activity, Socioeconomic Conditions, and Diseases Among Older Adults in Southern Brazil. | • The International Physical Activity Questionnaire (IPAQ)<br>• Valid instrument | • The World Health Organization's 2004 International Classification of Diseases and Health-Related Problems (Version 10) was used for disease identification and prevalence assessment by the Brazilian Ministry of Health in 2006.<br>• Valid instrument |

## 4.5. Longitudinal Studies

### *4.5.1. Physical Activity and Mortality*

Twenty-one studies (Balboa-Castillo, Guallar-Castillon, Leon-Munoz, Graciani, Lopez-Garcia, & Rodriguez-Artalejo, 2011; Bath & Morgan, 1998; Byberg et al., 2009; Chen, Fox, Ku, Sun, & Chou, 2012; Gillum & Obisesan, 2010; Gregg et al., 2003; Hakim et al., 1998; Kokkinos et al., 2010; Lan, Chang, & Tai, 2006; Lee, Lan, & Lee, 2012; Lee & Paffenbarger, 2000; LicSc & Parkatti, 2011; Lin et al., 2011; Manini et al., 2006; Mullee, Coleman, Briggs, Stevenson, & Turnbull, 2010; Ottenbacher et al., 2012; Paganini-Hill, Kawas, & Corrada, 2010; Stessman, Hammerman-Rozenberg, Cohen, Ein-Mor, & Jacobs, 2009; Sundquist, Qvist, Sundquist, & Johansson, 2004; Ueshima et al., 2010; Woo, Ho, & Yu, 2002) examined the association between PA and mortality (see **Table 4.7**). In general, all studies found an association between PA and mortality. ES ranged from -0.53 to 0.47.

### *Table 4.7. Longitudinal Physical Activity and Mortality*

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Mortality |
|---|---|---|---|
| Manini et al. (2006). *Journal of the American Medical Association, 296,* 171-179. | Daily Activity Energy Expenditure and Mortality Among Older Adults. | • Total energy expenditure was measured using doubly labeled water.<br>• Valid instrument<br>• Self Report PA Level: over the past 7 days PA assessed by an interviewer-administered questionnaire at the time of the doubly labeled water dosing.<br>• Non-valid instrument | • Death certificates<br>• Valid instrument |
| Stressman et al. (2009). *Arch Intern Medicine, 169(16),* 1476-1483. | Physical Activity, Function and Longevity Among the Very Old. | • Participants were asked: "How often are you physically active?"<br>• Non-valid instrument | • Annual review of death certificates issued by the Ministry of the Interior from 1990 through 2008.<br>• Valid instrument |
| Lin et al. (2011). *BMC Public Health, 11*: 428. | Non-Leisure time Physical Activity is an Independent Predictor of Longevity for a Taiwanese Elderly Population: An Eight Year Follow-up Study. | • Subjects asked about the frequency and duration of performing twelve common LTPA in the previous two weeks.<br>• Non-valid instrument<br>• NLTPA assessed the level of activity with housework and transportation. Based on the PASE, the questionnaire was adapted to a modified scale suitable for elderly Taiwanese subjects.<br>• Valid instrument | • Vital status was verified by matching the subjects' personal identity numbers with the national death registry file obtained from the Department of Health, Taiwan where all death certificates issued by doctors are sent.<br>• Valid instrument |
| Gillum et al. (2010). *Annual Epidemiology Journal, 20*(4), 251-257. | Physical Activity, Cognitive Function, and Mortality in a US National Cohort. | • 1985 National Health Interview Survey<br>• Valid instrument | • National Death Index. Information regarding date of death and age of death collected from matched death certificates<br>• Valid instrument |
| Balboa-Castillo, Guallar-Castillon et al. (2011). *Health and Quality of Life Outcomes, 9*(47), 1-10. doi:10.1186/1477-7525-9-47. | Physical Activity and Mortality Related to Obesity and Functional Status in Older Adults in Spain. | • Question: "Tell me which of these choices best describes most of your leisure-time activity".<br>• Non-valid instrument | • Computerized search of the National Death Index, which contains information on the vital status of all residents in Spain<br>• Valid instrument |

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Mortality |
|---|---|---|---|
| Kokkinos et al. (2010). *Circulation, 122,* 790-797. | Exercise Capacity and Mortality in Older Men: A 20 Year Follow-up Study. | • Exercise capacity assessed by the standard Bruce protocol<br>• Valid instrument | • The Social Security Death Index was used to match all subjects to their record according to Social Security number and death dates from the Veterans Affairs Beneficiary Identification and Record Locator System File.<br>• Valid instrument |
| Bath et al. (1998). *Age and Ageing, 27*-S3, 29-34. | Customary Physical Activity and Physical Health Outcomes in Later Life. | • Activities divided into 6 mutually exclusive functional categories: outdoor productive activities, indoor productive activities, total walking, leisure activities, strength activities and joint flexibility activities<br>• Non-valid instrument | • National Health Service Central Register. Causes of death were coded using ICD-9 classifications<br>• Valid instrument |
| LicSc et al. (2011). *Journal of Aging and Health, 23*(1) 70–85. | Independent and Combined Association of Physical Activity and Cardiac Disease on Mortality Risk in the Very Old. | • Modified version of the scale developed by Grimby (1986), including leisure-time activities, work-related activities, and domestic activities.<br>• Valid instrument | • Central Finland provincial government and from the archives of hospitals and old people's homes.<br>• Valid instrument |
| Ottenbacher et al. (2012). J*ournal of American Geriatrics Society, 60,* 1085–1091. | Routine Physical Activity and Mortality in Mexican Americans Aged 75 and Older. | • Physical Activity Scale for the Elderly (PASE)<br>• Valid instrument | • The National Death Index and by relatives at 3-year follow-up.<br>• Valid instrument |
| Woo et al. (2002). *Gerontology, 48,* 234–240. | Lifestyle Factors and Health Outcomes in Elderly Hong Kong Chinese Aged 70 Years and Over. | • PA divided into three categories: no exercise, less than 20 min/day, and 20 min or longer each day.<br>• Non-valid instrument | • Information from relatives or caregivers and also by a search at the Death Registry.<br>• Valid instrument |
| Mullee et al. (2010). *International Journal of Aging and Human Development, 67*(2), 171-186. | Self-rated Activity Levels and Longevity: Evidence from a 20 year Longitudinal Study. | • PA assessed by housework activities, leisure activities and walking.<br>• Non-valid instrument | • Office for National Statistics, UK, to supply the dates of death.<br>• Valid instrument |
| Chen et al. (2012). *Asia-Pacific Journal of Public Health, 24*(5), 795-805. | Prospective Associations between Household-, Work-, and Leisure-Based Physical Activity and All-Cause Mortality among Older Taiwanese Adults. | • Chinese version of the Physical Activity Scale for the Elderly (PASE).<br>• Valid instrument | • Taiwan Hunei Township Household Registration Office with the unique national personal identification number assigned to Taiwanese individuals.<br>• Valid instrument |

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Mortality |
|---|---|---|---|
| Lan et al. (2006). *Journal of American Geriatric Society, 55,* 1836-1841. | Relationship between components of leisure physical activity and mortality in Taiwanese older adults. | • Question "Did you engage in any kind of leisure activity during the last two weeks was asked?" to classify subjects as exerciser (answering "yes") or sedentary individuals (answering "no").<br>• Valid instrument | • Matching personal ID with the latest available national death registry file obtained from the Department of Health, Taiwan.<br>• Valid instrument |
| Sundquist et al. (2004). *American Journal of Preventative Medicine, 7*(1), 22-27. | Frequent and Occasional Physical Activity in the Elderly A 12-Year Follow-up Study of Mortality. | • Individual's response to the following LTPA items: (1) I get practically no exercise at all; (2) I exercise occasionally; (3) I exercise about once a week; (4) I exercise about twice a week; (5) I exercise vigorously at least twice a week.<br>• Non-valid instrument | • Linking SALLS to the Cause-of-Death Register.<br>• Valid instrument |
| Byberg et al. (2009). *British Medical Journal, 388*:b688. | Total Mortality after Changes in Leisure Time Physical Activity in 50 year Old Men: 35 year Follow-up of Population Based Cohort. | • Questions: 1) Do you spend most of your time reading, watching TV, going to the cinema, or engaging in other, mostly sedentary activities?; 2) Do you often go walking or cycling for pleasure?; 3) Do you engage in any active recreational sports or heavy gardening at least 3 hours every week?; 4) Do you regularly engage in hard physical training or competitive sport?<br>• Non-valid instrument | • Individual 10 digit personal identification number given to all Swedish citizens, researchers traced the entire cohort in the continuously updated Swedish National Population Register until the date of death<br>• Valid instrument |
| Gregg et al. (2003). *Journal of American Medical Association, 289*(18), 2379-2386. | Relationship of Changes in Physical Activity and Mortality Among Older Women. | • Modified version of the Harvard Alumni Questionnaire.<br>• Valid instrument | • Death certificates, and, when available, hospital discharge summaries were obtained. The underlying cause of death was coded by a clinical epidemiologist using the International Classification of Diseases, Ninth Revision, Clinical Modification<br>• Valid instrument |
| Lee et al. (2000). *American Journal of Epidemiology, 151*(3), 293-299. | Associations of Light, Moderate, and Vigorous Intensity Physical Activity with Longevity: The Harvard Alumni Health Study. | • Reported as the daily number of blocks walked and flights of stairs climbed. Subjects also reported their sports or recreational activities during the past year, the time spent per week, and the weeks per year of participation for each.<br>• Valid instrument | • Death certificates<br>• Valid instrument |

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Mortality |
|---|---|---|---|
| Hakim et al. (1998). *New England Journal of Medicine, 338,* 94-99. | Effects of Walking on Mortality among Non-smoking Retired Men. | • Men asked about the average distance they walked per day. Overall measures of activity at a variety of intensities were also assessed by recording the number of hours per day spent at each of five levels of activity.<br>• Non-valid instrument | • Death certificates, hospital admissions, and obituary notices.<br>• Valid instrument |
| Paganini-Hill et al. (2010). *Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 66A*(5), 559-567. | Activities and Mortality in the Elderly: The Leisure World Cohort Study. | • Question: "On the average weekday, how much time do you spend in the following activities? Active outdoor activities; Active indoor activities; Other outdoor activities; attending sporting events; Other indoor activities; and Watching TV."<br>• Non-valid instrument | • Hospital discharge data, determination of vital status by search of governmental and commercial death indexes, and ascertainment of death certificates.<br>• Valid instrument |
| Ueshima et al. (2010). *American Journal of Preventative Medicine, 38*(4), 410-418. | Physical Activity and Mortality Risk in the Japanese Elderly A Cohort Study. | • Question: "How many days a week the subject spent 30 or more minutes on LTPA; on walking for transportation; and non-exercise PA".<br>• Non-Valid instrument | • The National Vital Statistics Database from the Ministry of Health, Labour, and Welfare of Japan, by matching the date of birth, gender, and residential area.<br>• Valid instrument |
| Lee et al. (2012). *Educational Gerontology, 38,* 678-690. | Physical Activity Related to Depression and Predicted Mortality Risk: Results from the Americans' Changing Lives Study. | • The instrument of Physical Activity Level (PAL) was designed to measure elders' frequencies of engagement in three common types of PA including gardening, walking, and sport= exercise.<br>• Non-valid instrument | • Short form (11-item) of the Center for Epidemiological Studies-Depression Scale (CES-D).<br>• Valid instrument<br>• The National Death Index, the Social Security Death Index, newspaper obituaries, and informants.<br>• Valid instrument |

Only one study (Manini et al., 2006) found there was a strong inverse association between PA and mortality. Results by Manini et al. indicated that there was a strong inverse association between free-living activity energy expenditure and a lower risk for mortality (HR = 0.31; 95% CI = 0.14-0.69, $p \leq 0.004$), ES was -0.53. This study was unique in that it used the 'gold standard' method that is, it used the doubly labeled water method, an objective measure of physical fitness in measuring activity energy expenditure.

Four studies (Kokkinos et al., 2010; Ottenbacher et al., 2012; Stressman et al., 2009; Ueshima et al., 2010) found there was a weak-moderate to strong inverse association between PA and mortality with strength of association ranging from -0.24 to -0.63. In contrast to Ottenbacher et al. (2010), Stressman et al. (2009), and Ueshima et al. (2010), studies that each used a subjective PA questionnaire, Kokkinos et al. (2010) assessed exercise capacity using the standard Bruce protocol, an objective method of fitness based on metabolic equivalent tasks (MET) levels. Kokkinos et al. (2010) found there was an inverse graded association between exercise capacity and all-cause mortality. In other words, mortality risk declined as participants increased their exercise capacity > 5 METs. In fact, for every 1-MET increase in exercise capacity, the mortality risk was 12% lower (hazard ratio=0.88; CI = 0.86 to 0.90) for the entire cohort and for the two age categories (65 to 70 years old and ≥ 70 years old). In contrast, the study by Stressman et al. (2009) did not demonstrate a dose-dependent association with mortality. However, their study found that the maximum survival benefit was observed in the oldest old group (≥ 85 years old) while participation in higher levels of PA compared to being sedentary, a finding that has not been reported in previous studies.

Seven studies (Balboa-Castillo, Guallar-Castillon et al., 2011; Byberg et al., 2009; Gillum et al., 2010; Gregg et al., 2003; Lan et al., 2006; Mullee et al., 2010; Woo et al., 2002) found there was a weak-moderate to moderate inverse association between PA and mortality with ES ranging from -0.21 to -0.38. Remarkably, Lan et al. (2006) found mortality risks declined with exercisers reporting a dose-response association of total amount of expended energy of 1000kcal or more per week. Additionally, they found a moderate-strong inverse association (HR = 0.35, 95% CI = 0.15-0.82, p = 0.014) and a weak inverse association (HR = 0.81, 95% CI = 0.68-0.96, p = 0.018) for both number of activities (2 or more activities) and for intensity of activity, respectively. These findings suggest that perhaps recommendations of leisure activity should be based on total amount of energy expended by exercise, number of type of exercise and intensity of activity rather than frequency and duration of exercise (Lan et al., 2006). Byberg et al. (2009) found there was a graded reduction in mortality with increasing PA in men but this reduction was not seen until 10 years after follow-up, after which the risk was no different between men who continuously reported high levels of PA. Gregg et al. (2003) found there was a moderate inverse association between women who were initially sedentary but became physically active and a lower risk of all-cause mortality after approximately 6 years (HR = 0.52; 95% CI = 0.40-0.69, p < 0.001).

Three studies (Lee et al., 2000; Paganini-Hill et al., 2010; Sundquist et al., 2004) found there was a weak to weak-moderate inverse association between PA and mortality. ES ranged from -0.07 to -0.25. Interestingly, Sundquist et al. (2004) found that the risk of mortality for those who were moderately or vigorously active at least twice a week (HR = 0.59, CI = 0.45-0.77) was about the same for those for those were physically active only once a week (HR = 0.58, CI = 0.64-0.81). Surprisingly, Paganini-Hill et al. (2010) found older adults who spent just 15 minutes per day in active activities compared with no time in activities significantly lowered their risk for mortality by 15-35% (RR= 0.86, CI = 0.73-1.02; RR=0.65, CI = 0.56-0.76). While Lee et al. (2000) found some support that moderate activity like brisk walking (RR=0.83, 95% CI = 0.75-0.94, p = 0.004) lowered mortality, their findings were more noticeable when it came to vigorous activity (RR=0.77, 95% CI = 0.67-0.89, $p < 0.001$) and longevity.

Two studies (Lin et al., 2011; Lee et al., 2012) found there was a weak-moderate positive association between PA and mortality. ES ranged from 0.12 to 0.26. For example, Lin et al. (2011) found that subjects who were 'inactive' in either leisure-time physical activity (LTPA) or non-leisure time physical activity (NLTPA) had a higher risk for mortality. After adjusting for covariates, when both NLTPA and LTPA were put into the model simultaneously (model 3), NLTPA (HR = 1.40; 95% CI = 1.03-1.91, C statistic 0.48) could significantly predict mortality. In other words, subjects who engaged in less NLTPA had a higher risk for mortality. Similarly, Lee et al. (2012) found that for low levels of gardening (OR = 1.48, CI = 1.13, 1.92, p = .00) and low levels of walking (OR = 1.72, CI = 1.31, 2.24, p = .00) increased the risk for mortality. Interestingly, sport was not found to predict mortality.

Three studies found there was a weak-moderate to moderate positive association between PA and mortality (Bath et al., 1998, Chen et al., 2012; Hakim et al., 1998). ES ranged from 0.21 to 0.35. For example, compared to the high activity group, Bath et al. (1998) found a weak-moderate positive association for higher 12-year mortality for the intermediate (HR = 1.53; 95% CI = 1.10-2.14; $p < 0.05$) and low activity groups (HR = 1.75; 95% CI = 1.24-2.48; $p < 0.005$) for men and higher 12-year mortality for the low activity group for women (HR = 1.73; 95% CI = 1.28-2.33; $p < 0.001$). Correspondingly, Hakim et al. (1998) found that those men who walked less than one miler per day had an increased risk for mortality (RR=1.8, 95% CI = 1.2-2.7, p = 0.01).

Chen et al. (2012) found that there was a weak-moderate to moderate positive association between a lower level of leisure activity in both men and women and an increased risk of all-cause mortality (HR = 2.09, 95% CI = 1.61-2.70, $p < 0.001$ and HR = 1.75, 95% CI = 1.26-2.44, $p = 0.001$ respectively).

One study (LicSc et al., 2011) found there was a weak-moderate and moderate-strong positive association between PA and mortality. ES ranged from 0.26 to 0.47. Specifically, LicSc et al. (2011) found that compared to active people without cardiac disease, there was a weak-moderate positive association between a greater risk of dying and active older people with cardiac disease (HR = 1.69 95% CI = 1.02-2.81, $p = 0.04$); there was a weak-moderate positive association between a greater risk of dying and sedentary older adults without cardiac disease (HR = 1.76 95% CI = 1.14-2.73, $p \leq 0.000$), and there was a moderate-strong positive association between a greater risk of dying and sedentary older adults with cardiac disease (HR = 2.77 95% CI = 1.80-4.26, $p \leq 0.001$ ). Remarkably, the mortality risk was lower among active old people with cardiac diseases than among sedentary people without cardiac diseases. Thus, these results provide evidence that very old people with cardiac disease can benefit from PA.

Overall, all 21 studies found statistically significant results between PA and mortality. However, studies found mixed ES's.

### *4.5.2. Physical Activity and Depression*

Seven studies (Ku et al., 2009; Lampinen et al., 2006; Lindwall et al. 2011; Morgan et al., 1998; Pasco et al. 2011; Smith et al., 2010; Strawbridge et al., 2002) examined the association between PA and depression (see **Table 4.8**). Direction varied among studies but strength of association was generally between weak to moderate. For instance, Morgan and Bath (1998) assessed longitudinal relationships between habitual levels of PA and two indices of psychological well-being- morale and depression- in a representative sample of community dwelling people originally aged 65 and over in Nottingham, United Kingdom. They found there was a weak inverse association between outdoor/leisure activities at time 1 (T1) and risk of depression 4 years later (OR = 0.92 per hour of activity; 95% CI = 0.85-0.99. $p < 0.05$). ES was -0.04. Additionally, there was a weak and weak-moderate positive association between both walking and total indoor activity and morale (β=0.125, $p < 0.001$ and β=0.09, $p < 0.01$ respectively).

***Table 4.8. Longitudinal Physical Activity and Depression***

| **Authors** | **Title of Study** | **Independent Variable: Physical Activity** | **Dependent Variable: Depression** |
|---|---|---|---|
| Morgan et al. (1998). *Age and Ageing, 27*(3), 29-34. | Customary Physical Activity and psychological well-being: A longitudinal Study. | • PA assessed by three mutually exclusive categories of activity: walking; indoor activities; and outdoor/leisure activities.<br>• Non-valid instrument | • 14-item Symptoms of Anxiety and Depression (SAD) scale.<br>• Valid instrument |
| Pasco et al. (2011). *International Psychogeriatrics, 23*(2), 292-298. | Habitual Physical Activity and the Risk for Depressive and Anxiety Disorders among Older Men and Women. | • Question asking how much participation in habitual physical activity throughout the prior year, including household activities, sporting activities and other physically active leisure-time activities.<br>• Valid instrument | • The Structured Clinical Interview for DSM-IVTR Research Version, Non-patient edition (SCIDI/ NP)<br>• Valid instrument |
| Ku et al. (2009). *Preventative Medicine, 48,* 250-255. | Physical activity and Depressive Symptoms in Taiwanese Older Adults: A Seven-Year Follow-up Study. | • Question: "Did you usually engage in any kind of leisure-time physical activity?"<br>• Non-valid instrument | • 10-item Chinese version of the original 20-item CES-D (Radloff, 1977).<br>• Valid instrument |
| Lindwall et al. (2011). *Health Psychology, 30*(4), 453-462. | The Reciprocal Relationship Between Physical Activity and Depression in Older European Adults: A Prospective Cross-Lagged Panel Design Using SHARE Data. | • Frequency of moderate physical activity and frequency of vigorous physical activity.<br>• Non-valid instrument | • Depression measured by the EURO-D scale(Prince et al., 1999b).<br>• Valid instrument |
| Strawbridge et al. (2002). *American Journal of Epidemiology, 156*(4), 328-334. | Physical Activity Reduces the Risk of Subsequent Depression for Older Adults. | • PA scale constructed based on four questions: usual frequency of physical exercise, taking part in active sports, taking long walks, and swimming.<br>• Valid instrument | • Depression measured by a set of 12 items that operationalized the diagnostic criteria for a major depressive episode outlined in Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM–12D).<br>• Valid instrument |
| Smith et al. (2010). *Journal of American Geriatric Society, 58,* 1447-1452. | Effects of Walking Distance on 8 Year Depressive Symptoms in Elderly Men with and without Chronic Disease: The Honolulu-Asia Aging Study. | • Question "How many city blocks subjects walked each day"?<br>• Valid instrument | • An 11-question version of the Centers for Epidemiologic Studies Depression Scale (CES-D 11)<br>• Valid instrument |

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Depression |
|---|---|---|---|
| Lampinen et al. (2006). *Aging & Mental Health, 10*(5), 454-466. | Activity as a Predictor of Mental-Well-being Among Older Adults. | • PA level and intensity assessed on a seven point scale. Leisure Activity: measured with an index based on the sum of score of involvement in 9 different interests ranging from 0=never to 2=regularly.<br>• Non-valid instrument | • Five dimensions of mental well-being: Depressive symptoms: modified version of Beck's depression scale- (RBDI).<br>• Valid instrument<br>• Level of anxiety assessed on a five-point scale.<br>• Valid instrument<br>• Loneliness: standard question: 'Do you think you are lonely?<br>• Valid instrument<br>• Self-rated mental vigor posed by the question: 'How would you describe your self-rated mental vigor at the moment?<br>• Valid instrument<br>• Meaning in life: Question: 'Right now, how meaningful do you consider your life?<br>• Valid instrument |

Pasco et al. (2011) examined habitual PA as a risk factor for incident depressive and anxiety disorders in men and women aged 60 years or more. Results indicated that overall there was a weak-moderate inverse association between PA and likelihood of depressive and anxiety disorders (OR = 0.55; 95% CI = 0.32–0.94, p = 0.03). ES was -0.29. Specifically, LTPA contributed significantly to the overall PA score (OR = 0.59; 95% CI = 0.36–0.96, p = 0.04). However, the likelihood of incident depressive and anxiety disorders was not associated with the household activity or sport activity scores. Smith et al. (2010) found similar results. They found that older Japanese men who participated in high (≥ 1.5 miles/day) and intermediate (0.25-1.5 miles/day) walking groups had lower odds of developing incident depression 8 years later (OR = 0.61, 95% CI = 0.38,-0.97, p = 0.04, OR = 0.52, 95% CI = 0.32-0.84, p = .007, respectively). In addition, their analyses found a moderate-strong inverse association for men only in the intermediate walking group without chronic disease (coronary heart disease, cerebrovascular accident, cancer, Parkinson's disease, dementia, or cognitive impairment) at baseline (OR = 0.39, 95% CI = 0.21-0.71), p = .002), ES was -0.44.

Strawbridge et al. (2002) examined the relation between PA and depression by utilizing community-dwelling adults aged 50 to 94 years (both with and without exclusion of physical disabilities) from the Alameda County Study. Results illustrated that there was a weak inverse association between PA and risk of becoming depressed. In the fully adjusted model, the relative risk was 0.83 (95% CI = 0.73, 0.96), meaning that each one-point increase in the 1994 PA scale was associated with nearly a 20% reduction in the likelihood of becoming depressed in 1999; ES was -0.09. Remarkably, exclusion of disabled participants did not attenuate the incidence results (adjusted OR = 0.79, 95% CI = 0.67, 0.92).

Ku et al. (2009) assessed the association between LTPA and incidence of depressive symptoms over a 7-year follow-up period in a sample of Taiwanese older adults aged 50 years and older. They found that compared with those who were more physically active in LTPA in 1996, there was a weak-moderate positive association between participants engaging in activity less than three sessions per week in 1996 and the likelihood of depressive symptoms in 2003 (AOR = 1.48, 95% CI = 1.19–1.84, $p < 0.001$ in the gender and age adjusted model; AOR = 1.34, 95% CI = 1.05–1.71, $p = 0.02$ in the fully adjusted model). ES ranged from .15 to .19. Moreover, there was a weak-moderate positive association between participants who were low in leisure-time activity in 1996 and in 1999 were at a greater risk of developing depressive symptoms in 2003 (AOR = 1.43, 95% CI = 1.04–1.95, $p = 0.05$ in the fully adjusted model).

Lindwall et al. (2011) explored the reciprocal nature of the PA-depressive relationship in a sample of non-institutionalized older adults aged 50 years and older, from 11 European countries across a 2-year follow-up. Results demonstrated there was a weak-moderate inverse association between PA at time 1 (T1) and depression at time 2 (T2) for affective suffering ($\beta = 0.13$, $p < .001$) and motivation ($\beta = 0.20$, $p < .001$). As a side note, it is worth mentioning that higher values in PA represents lower activity, therefore, higher levels of activity and lower levels of depression are positive. In contrast, affective suffering and motivation at T1 were not significantly related to PA at T2.

Finally, Lampinen et al. (2006) examined the roles of physical and leisure activity as predictors of mental well-being based on five dimensions of mental well-being:

depressive symptoms, anxiety, loneliness, self-rated mental vigour, and meaning in life among older adults aged 64 to 84 years old from the city of Jyvaskyla, central Finland. Results demonstrated there was a weak positive association between PA (0.10, SE=0.02) and leisure activity (0.08, SE=0.02) and mental well-being in follow-up in 1998.

Overall, all seven studies (Ku et al., 2009; Lampinen et al., 2006; Lindwall et al. 2011; Morgan et al., 1998; Pasco et al. 2011; Smith et al., 2010; Strawbridge et al., 2002) found statistically significant results and ES's ranged between weak to moderate.

### *4.5.3. Physical Activity and Dementia/Alzheimer's Disease*

Six studies (Bowen, 2012; Buchman et al., 2012; De Bruijn et al., 2013; Larson et al., 2006; Laurin et al., 2001; Taffee et al., 2008) examined the association between PA and dementia/Alzheimer's disease (see **Table 4.9**). All six studies demonstrated an inverse association but strength of association varied between weak to moderate. For instance, three studies, Bowen (2012), Larson et al. (2006) and De Bruijn et al. (2013) found there was a weak-moderate inverse association between older adults' PA levels and risk of dementia or Alzheimer disease (AD). ES ranged from -.04 to -.19 Specifically, Bowen (2012) found that older adults who engaged in vigorous PA three or more times per week had a lower likelihood of dementia (OR = 0.79, 95% CI = 0.64-0.97,

$p \leq 0.05$) while, Larson found that engaging in regular PA three times per week yielded similar results for a lower risk of dementia (OR = 0.68, 95% CI = 0.48 to 0.96; $p = 0.03$) or AD (OR = 0.69, CI = 0.45 to 1.05; $p = 0.081$). Strikingly, De Bruijn et al. (2013) found there was a weak inverse association but the association for PA and risk of dementia (HR 0.84; 95% CI = 0.73-0.97) or risk of Alzheimer's disease (HR 0.89; 95% CI = 0.76-1.03) was only with a follow-up period up to 4 years but not after a longer follow-up after the 4 years.

***Table 4.9. Longitudinal Physical Activity and Dementia/Alzheimer's Disease***

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Dementia/Alzheimer's Disease |
|---|---|---|---|
| Bowen. (2012). *American Journal of Health Promotion, 26*(6), 333-340. | A Prospective Examination of the Relationship Between Physical Activity and Dementia Risk in Later Life. | • Question: "On average, over the past 12 months, have you participated in activities such as aerobics, sports, running, swimming, bicycling, heavy housework, or a job involving physical labour three or more times/week?"<br>• Valid instrument | • A battery of neuropsychological measures and a standardized neurological examination. The neuropsychological battery included measures of orientation, verbal and visual immediate and delayed memory, language, attention, executive function, reading ability, and general intellect.<br>• Valid instrument |
| Larson et al. (2006). *Annals of Internal Medicine, 144,* 73-81. | Exercise Is Associated with Reduced Risk for Incident Dementia Among Persons 65 Years of Age and Older. | • The number of days per week subjects did each of the following activities for at least 15 minutes at a time during the past year: walking, hiking, bicycling, aerobics or calisthenics, swimming, water aerobics, weight training or stretching, or other exercise.<br>• Non-valid instrument | • Persons who met the Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV), criteria for dementia were considered to have incident dementia. Dementia type determined by the National Institute of Neurological and Communicative Diseases and Stroke–Alzheimer's Disease and Related Disorders Association criteria for Alzheimer disease and by the DSM-IV criteria for other types of dementia.<br>• Valid instrument |
| De Bruijn et al. (2013). *European Journal of Epidemiology, 28,* 277-283. | The Association Between Physical Activity and Dementia in an Elderly Population: the Rotterdam Study. | • Adapted version of the Zutphen Physical Activity Questionnaire (ZPAQ)<br>• Valid instrument | • Mini-Mental State Examination (MMSE) and the Geriatric Mental Schedule (GMS) organic level. The final diagnosis in accordance with standard criteria using the DSM-III-R criteria for dementia and the NINCDS-ADRDA for Alzheimer disease.<br>• Both valid instruments |
| Laurin et al. (2001). *Archives of Neurology, 58,* 498-505. | Physical Activity and Risk of Cognitive Impairment and Dementia in Elderly Persons. | • Level of PA assessed by combining 2 questions from the risk factor questionnaire regarding frequency and intensity of exercise for subjects who reported regular PA.<br>• Valid instrument | • Modified Mini-Mental State (3MS) Examination.<br>• Valid instrument |
| Taaffe et al. (2008). *Journal of Gerontology, 63A*(5), 529-535. | Physical Activity, Physical Function, and Incident Dementia in Elderly Men: The Honolulu-Asia Aging Study. | • The average number of hours per day spent in five levels of activities.<br>• Non-valid instrument | • 100-point Cognitive Abilities Screening Instrument (CASI).<br>• Valid instrument |

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Dementia/Alzheimer's Disease |
|---|---|---|---|
| Buchman et al. (2012). *Neurology, 78,* 1324-1329. | Total Daily Physical Activity and the Risk of AD and Cognitive Decline in Older Adults. | • Actigraphy (Actical®; Mini Mitter, Bend, OR).<br>• Valid instrument | • Cognitive and clinical data to diagnose AD using National Institute of Neurological and Communicative Disorders and Stroke–Alzheimer's Disease and Related Disorders Association criteria.<br>• Valid instrument |

Results from a study by Laurin et al. (2001) demonstrated a protective effect of regular PA on the risk of AD and dementia but only for women. Moreover, these weak-moderate to moderate-strong inverse associations revealed a significant dose-response relationship demonstrating decreasing risk with higher levels of PA. ES ranged from -.20 to -.45. For example, moderate and high levels of PA were associated with significantly lower risks for Alzheimer disease for women only (OR = 0.67, 95% CI = 0.42-1.06, $p = 0.03$; OR = 0.38, 95% CI = 0.16-0.91, $p = 0.03$, respectively) and for dementia of any type (OR = 0.64, 95% CI = 0.43-0.95, $p = 0.02$; OR = 0.48, 95% CI = 0.25-0.94, $p = 0.02$ respectively). A study by Taaffe et al. (2008) focused on elderly Japanese American men and found there was a weak-moderate to moderate inverse association between moderate (HR = 0.57, 95% CI = 0.32-0.99, $p < 0.05$) and high (HR = 0.50; 95% CI = 0.28-0.89, $p < 0.05$) levels of PA and risk of dementia for men with poor physical function. ES ranged from -.27 to -.33. A study by Buchman et al. (2012) was rather unique in that it utilized an objective measure of total daily PA (an actigraph) that predicted incident AD and cognitive decline among older adults without dementia. Results indicated that after a mean follow-up of 4 years, there was a moderate inverse association between total daily PA and a risk of developing AD (HR = 0.477; 95% CI = 0.273-0.832) after adjusting for age, sex, and education.

Overall, all six studies (Bowen, 2012; Buchman et al., 2012; Larson et al., 2006; Laurin et al., 2001; Taffee et al., 2008) found statistically significant results and ES varied between weak to moderate.

### *4.5.4. Physical Activity and Disability*

Four studies (Boyle et al., 2007; Bruce et al., 2008; Hunt et al., 2010; Shah et al., 2012) examined the association between PA and disability (see **Table 4.10**). Three studies (Boyle et al., 2007; Bruce et al., 2008; Shah et al., 2012) found there was an association between PA and disability, while the fourth study (Hunt et al., 2010) found there no association between PA and disability. For example, Boyle et al. (2007) examined the association between PA and the risk of incident activities of daily living (ADL) and instrumental activities of daily living (IADL) disability in community-based older adults dementia-free in the Chicago metropolitan area. Results suggested there was a weak to moderate inverse association between PA and risk of incident disability in ADL's and IADLs. For instance, the relative risk of disability on the Katz index (measuring ADL's) was approximately 16% less (HR = 0.84) for a person who reported 2.33 hours and 41% less (HR = 0.59) for someone who reported 7 hours of PA per week than for a person reporting no PA. As for the relative risk of disability on the measure of IADLs, it was approximately 21% less (HR = 0.79) in a person who reported 2.8 hours and 47% less (HR = 0.53) for someone who reported 7.5 hours of PA per week than for a person who reported no PA.

Shah et al. (2012) tested the hypothesis that total daily PA was associated with lower disability. Their findings indicated that total daily PA was protective against disability, after adjusting for age, education, and sex. The odds ratio for each additional 10 ^5 counts/day of total daily PA was 0.55 (95% CI = 0.47, 0.65, p = 0.01) with ES - 0.29. The study by Bruce et al. (2008) examined the relationship of body weight (normal weight and overweight) and PA to disability in a cohort of healthy, older adults aged 50 to 72 years old over 13 years of follow-up. Overall, the results indicated there was a weak-moderate positive association between physically inactive participants in both weight groups (normal weight and overweight) and the highest levels of disability (0.22, $p < 0.001$ vs. 0.19, $p = 0.001$). ES was -0.27. In contrast, Hunt et al. (2010) found no association between older adults who met the recommended targets for PA (i.e., achieving either 5 moderate or 3 strenuous episodes of activity across all domains) in early old age with decreased locomotor disability (i.e., physical performance).

***Table 4.10. Longitudinal Physical Activity and Disability***

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Disability |
|---|---|---|---|
| Boyle et al. (2007). *Journal of the American* Geriatric Society, 55, 195-207. | Physical Activity Is Associated with Incident Disability in Community-Based Older Persons. | • Questions adapted from the 1985 National Health Interview Survey.<br>• Valid instrument | • Modified version of the Katz Index for ADL's,<br>• Items adapted from the Duke Older Americans Resources and Services project for IADL's<br>• Valid instrument |
| Bruce et al. (2008). *American Journal of Public Health, 98*(7), 1294-1299. | Regular Vigorous Physical Activity and Disability Development in Healthy Overweight and Normal-Weight Seniors: A 13-Year Study. | • The number of minutes spent weekly doing vigorous exercise.<br>• Non-Valid instrument | • Stanford HAQ Disability Index (HAQ-DI).<br>• Valid instrument |
| Hunt et al. (2010). *Journal of Aging and Health, 22*(6), 734-747. | Exercise and the Onset of Disability in Later life. | • Exercise and sport assessed by asking questions about PA in work, home and leisure settings<br>• Non-valid instrument | • Modified version of the UK Office of Population Censuses and Surveys (OPCS) disability questionnaire.<br>• Valid instrument |
| Shah et al. (2012). *Geriatrics, 12*:63. | Association of total daily physical activity with disability in community-dwelling older persons: A Prospective Cohort study | • An Actial (Mini Mitter, Bend, OR).<br>• Valid instrument<br>• Self-report PA assessed using questions adapted from the 1985 National Health Interview Survey<br>• Valid instrument | • Modified version of the Katz Index.<br>• Valid instrument |

Overall, three studies (Boyle et al., 2007; Bruce et al., 2008; Shah et al., 2012) found statistically significant results between PA and disability, with ES ranging from weak to moderate. While one study (Hunt et al., 2010), found no association between PA and disability.

### *4.5.5. Physical Activity and Functional Status*

Two studies (Feinglass et al., 2005; Lang et al., 2007) examined the association between PA and functional status (see **Table 4.11**). Both Feinglass et al. (2005) and Lang et al. (2007) found there was a weak-moderate inverse association between PA and functional impairment. Feinglass et al. (2005) study examined the effect of LTPA and work-related PA on changes in physical functioning among older adults with arthritis and joint symptoms. Their results demonstrated that older adults with arthritis who engaged in recommended or insufficient LTPA had a lower likelihood of functional difficulties (OR = .59, CI = 0.44-0.78, $p < 0.0001$ and OR = 0.62, CI = 0.48-0.79, $p < 0.0001$, respectively) compared to inactive older adults. ES ranged from -0.23 to -0.26. However, work-related PA was not a predictor of decline or improvement.

***Table 4.11. Longitudinal Physical Activity and Functional Status***

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Functional Status |
|---|---|---|---|
| Feinglass et al. (2005). *Arthritis and Rheumatism, 53*(6), 879-885. | Effect of Physical Activity on Functional Status Among Older Middle-Age with Arthritis. | • 2 original series of HRS 'light' and 'vigorous' exercise questions, fielded in 1992 and 1994<br>• Valid instrument | • A 0-9 scale derived from 9 questions asking about difficulties in climbing stairs (1 flight or several), walking (across a room, 1 block, or several blocks), getting in and out of bed, bathing or showering, and eating or dressing without help.<br>• Valid instrument |
| Lang et al. (2007). *Journal of American Geriatric Society, 55,*1836-1841 | Physical Activity in Middle-Aged Adults Reduces Risks of Functional Impairment Independent of Its Effect on Weight. | • PA-HRS Question: "On average, over the last 12 months, have you participated in vigorous PA or exercise three times a week or more?<br>• Valid Instrument<br>• PA- ELSA Question: "In the last week have you done any housework or gardening that involved pulling or pushing, like hoovering, cleaning a car, mowing grass, or sweeping up leaves for at least 15 minutes at a time?"<br>• Non-valid instrument | • Self-Reported Mobility Impairment (HRS) Question: If any difficulty walking several blocks, climbing several flights of stairs, and climbing one flight of stairs.<br>• Non-Valid instrument<br>• Measured Physical Performance Impairment (ELSA): Physical performance score was calculated based on performance on three tests: balance, chair stands, and grip strength. This test is a modified form of the Short Physical Performance Battery to assess lower extremity function with gait speed replaced by grip strength.<br>• Valid instrument |

Research by Lang et al. (2007) involved examining data from two previous studies: The Health and Retirement Study and The English Longitudinal Study of Ageing, to determine whether body mass index (BMI) and level of PA were independently associated with incident impaired physical functioning in persons aged 50 to 69 years old who were free of impairment at baseline. They reported that in all weight categories and for both countries, there was a weak-moderate inverse association where levels of PA were associated with lower risks of mobility impairment. For example, U.S.A. respondents of recommended weight (BMI 20–25) who were active on 3 or more days per week, had a relative risk (RR) of incident mobility difficulties, compared with those who were less active, of 0.56 (95% CI; 50.40–0.78). For those who were obese (BMI ≥ 30) the corresponding RR was 0.59 (95% CI = 50.45–0.76). ES ranged from -0.26 to – 0.28.

Overall both studies (Feinglass et al., 2005; Lang et al., 2007) found statistically significant results between PA and functional status, and both studies found a weak-moderate ES.

### 4.5.6. Physical Activity and Frailty

One study (Peterson et al., 2009) examined the association between PA and frailty (see **Table 4.12**). Peterson et al. examined different doses and types of PA and their association with the onset and severity of frailty among well-functioning older adults aged 70 to 79 years old. Results indicated there was a weak-moderate positive association between sedentary individuals and a likelihood for developing frailty (AOR = 1.45; 95% CI = 1.04 – 2.01, p = 0.03), with ES 0.18. They also found support for up to a four-fold increased likelihood of a transition from moderate to severe frailty in the sedentary (unadjusted OR = 4.26; 95% CI = 1.82–9.98, p = 0.0003) and lifestyle active (unadjusted OR = 2.66; 95% CI = 1.15 – 6.13, p = 0.003), groups compared with the exercise active group.

***Table 4.12. Longitudinal Physical Activity and Frailty***

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Frailty |
|---|---|---|---|
| Peterson et al. (2009). *Journal of Gerontology, 64A*(1),61-68. | Physical Activity as a Preventative Factor for Frailty: The Health, Aging, and Body Composition Study. | • A self-report instrument developed specifically for the Health ABC study. The standardized questionnaire was modeled the well-validated Minnesota Leisure- Time PA questionnaire.<br>• Unsure if valid instrument | • Frailty defined as having a gait speed of less than 0.60 m/s or being unable to rise from a chair once with arms folded.<br>• Valid instrument |

### 4.5.7. Physical Activity and Cognitive Function/Cognitive Impairment

Five studies (Chang et al., 2010; Geda et al., 2010; Ku et al., 2012; Weuve et al., 2004; Yaffe et al., 2001) examined the association between PA and cognitive function/cognitive impairment (see **Table 4.13**). All five studies found an association between PA and cognitive function/cognitive impairment. Direction of association varied depending on which variable (i.e., cognitive function or cognitive impairment) was utilized. In other words, if studies were measuring cognitive function as a dependent variable, and found that PA led to better cognitive performance, then the direction of association was positive. However, if studies were measuring cognitive impairment as a dependent variable, and found that PA led to lower cognitive impairment, then the direction of association was inverse. Strength of association was weak-moderate to moderate.

With that said, one study found that increasing PA levels led to better cognitive performance. Results from a study by Ku et al. (2012) indicated there was a weak-moderate positive association between higher initial levels of PA and better cognitive performance (standardized coefficient $\beta = 0.17$, $p < 0.05$). Additionally, there was evidence that a higher level of PA at baseline (1996) was significantly related to slower decline in cognitive performance, as compared with a lower level of activity ($\beta = 0.22$, $p < 0.05$). Likewise, results by Chang et al. (2010) indicated that compared with those who never exercised at midlife, the two groups that were physically active at midlife had a weak-moderate and moderate positive association for faster speed of processing (SP) (≤ 5hours, $\beta$=.22; > 5 hours, $\beta$= .32 $p <.0001$), and a weak-moderate positive association for better memory (MEM) (≤ 5hours, $\beta$= .15; > 5 hours $\beta$=.18 $p < .0001$), and a weak and weak-moderate positive association for executive function (EF) (≤ 5 hours, $\beta$= .09; > 5 hours, $\beta$=.18 $p < .0001$); after controlling for demographic and cardiovascular risk factors. Moreover, there was support to suggest that compared with the group that never exercised at midlife, those who reported ≤5 hours per week were less likely to have dementia in late life (OR: 0.59, 95% CI = 0.40–0.88), with ES -0.26.

***Table 4.13. Longitudinal Physical Activity and Cognitive Function/Cognitive Impairment***

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Cognitive Function/Impairment |
|---|---|---|---|
| Ku et al. (2012). *Journal of Epidemiology, 22*(3), 230-237. | Prospective Associations Between Leisure-Time Physical Activity and Cognitive Performance among Older Adults across an 11-Year Period. | • Question: "Did you usually engage in any kind of leisure-time PA?"<br>• Valid instrument | • 10-item Short Portable Mental Status Questionnaire (SPMSQ).<br>• Valid instrument |
| Chang et al. (2010). *Journal of Gerontology, 65A*(12), 1369-1374. | The Effect of Midlife Physical Activity on Cognitive Function Among Older Adults: AGES—Reykjavik Study. | • Questions: 1) Whether subjects had ever regularly participated in sports or exercised at any time during their adult life and 2) how many hours per week they exercised during winter and summer time?<br>• Non-valid instrument | • Speed of processing (SP) composite includes digit symbol substitution test, Figure Comparison, and a modified Stroop Test part I (Word Reading) and part II (Color Naming).<br>• The memory (MEM) composite includes a modified version of the California Verbal Learning Test, immediate and delayed recall.<br>• The executive function (EF) composite includes Digits Backward, a shortened version of the CANTAB Spatial Working Memory test and the Stroop Test part III (Word–Color Interference).<br>• All valid instruments |
| Yaffe et al. (2001). *Archives Internal Medicine, 161,* 1703-1708. | A Prospective Study of Physical Activity and Cognitive Decline in Elderly Women. | • Question: how many city blocks the women walked each day for exercise or as part of their normal routine and how many flights of stairs they climbed up each day and using a modified Paffenbarger Scale.<br>• Valid instrument | • mMMSE, which does not include some questions assessing orientation.<br>• Valid instrument |
| Geda et al. (2010). *Archives Neurology, 67*(1), 80-86. | Physical Exercise, Aging, and Mild Cognitive Impairment A Population-Based Study. | • Frequency and intensity of exercise using a self-reported questionnaire with ordinal responses.<br>• Valid instrument | • Neuropsychologic testing using 9 cognitive tests to assess the following 4 cognitive domains: (1) memory from the Wechsler Memory Scale–Revised and delayed recall from the Auditory Verbal Learning Test); (2) executive function (Trail Making Test B28 and digit symbol substitution from the Wechsler Adult Intelligence Scale–Revised); (3) language (Boston Naming Test29 and category fluency); and (4) visuospatial skills (picture completion and block design from the Wechsler Adult Intelligence Scale–Revised).<br>• Valid instrument |

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Cognitive Function/Impairment |
|---|---|---|---|
| Weuve et al. (2004). *Journal of the American Medical Association, 292,* 1452-1461. | Physical Activity, Including Walking, and Cognitive Function in Older Women. | • Question: to estimate average amount of time per week during the past year spent on the following activities: running; jogging; walking or hiking outdoors; racquet sports; lap swimming; bicycling; aerobic dance or use of exercise machines; other vigorous activities; and low-intensity exercise and indicate usual outdoor walking pace.<br>• Non-valid instrument | • Interviews conducted by trained nurses. Administered only the Telephone Interview for Cognitive Status (TICS) and gradually added 5 more tests as participants for cognitive testing became clear.<br>• Valid instrument |

Three studies, Weuve et al. (2004), Yaffe et al. (2001) and Geda et al. (2010) found there was a weak-moderate inverse association between PA levels and cognitive decline. ES ranged from -.11 to -.24. For example, Weuve et al. (2004) found there was a weak-moderate inverse association between women who engaged in the highest PA level and a lower risk of cognitive impairment (OR = 0.80, 95% CI = 0.67-0.95, $p < 0.05$). In examining walking, Weuve et al. also found considerably higher cognitive scores for women in the third and fourth quartiles of walking on all cognitive measures. Yaffe et al. (2001) examined predominately white community dwelling women and measured PA by self-reported blocks walked per week and by total kilocalories (energy) expended per week in recreation, blocks walked and stairs climbed. After adjusting for baseline age, educational level, health status, functional limitation, depression score, stroke, diabetes, hypertension, myocardial infarction, smoking, and estrogen use, they reported there was a weak-moderate inverse association between women in the highest quartile of PA (OR = 0.66; 95% CI = 0.54-0.82, $p < 0.05$) and a lower likelihood to develop cognitive decline. Moreover, they found there was a weak-moderate inverse association between women in the highest quartile of total kilocalories expended (OR = 0.74; 95% CI = 0.60-0.90, $p < 0.05$) and a lower likelihood to develop cognitive decline.

Likewise, results by Geda et al. (2010) indicated there was a weak-moderate inverse association between midlife moderate exercise and a lower likelihood of mild cognitive impairment (MCI) (OR = 0.61; 95% CI = 0.43-0.88; $p = 0.008$), ES was -.24. Additionally, there was a consistent weak-moderate inverse association between late-life moderate exercise and a lower likelihood of MCI = (OR = 0.68; 95% CI = 0.49-0.93; p = 0.02) for both men and women. ES was -.19. In contrast, light and vigorous exercise was not significantly associated with decreased risk of MCI.

All five studies found statistically significant results between PA and cognitive function/cognitive impairment. ES varied between weak to moderate.

### *4.5.8. Physical Activity and Successful Aging*

Two studies (Menec, 2003; Sun et al., 2010) examined the association between PA and successful aging (see **Table 4.14**). Both studies found a positive association between PA and successful aging although strength of association varied between studies. For example, Menec (2003) examined the relation between everyday activities and several indicators of successful aging, specifically well-being, function, and mortality in a sample of older adults aged 67 to 95 years old living in Manitoba, Canada. While results demonstrated there was no association between activity and the life satisfaction scale, there was a weak positive association between activity level and feelings of happiness ($\beta = 0.10$, $p < .001$). Additionally, there was a weak inverse association between both greater activity level in 1990 and reduced functional decline 6 years later (AOR = 0.93, $p < .05$); and between greater activity level and lower mortality in 6 years (AOR = 0.95, $p < .05$). ES varied from -0.04 to -0.02.

Similarly, Sun et al. (2010) found a weak-moderate to moderate positive association between midlife leisure-time PA and the likelihood of successful survival in later life starting at the third quintile activity: OR in the lowest to highest quintiles were 1 [reference], 0.98, 1.37, 1.34, and 1.99 for total METs ($p < .001$ for trend). ES varied from 0.16 to 0.33. Additionally, Sun et al. (2010) demonstrated a moderate to moderate-strong positive association between increasing walking pace and the increase likelihood of successful aging (OR = 1.90, 95% CI = 1.52-2.38, $p < 0.001$ for moderate walking pace and brisk or very brisk walking pace OR = 2.68, 95% CI = 2.13-3.37, $p < 0.001$, respectively). ES varied from 0.31 to .46.

*Table 4.14. Longitudinal Physical Activity and Successful Aging*

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Successful Aging |
|---|---|---|---|
| Menec. (2003). *Journal of Gerontology, 58B*(2), S74-S82. | The Relation Between Everyday Activities and Successful Aging: A 6 Year Longitudinal Study. | • 18 activities grouped into 3 categories based on their likely social component or purpose: social activities (e.g. visiting family or relatives), more solitary activities (e.g. collecting hobbies) and productive activities (e.g. volunteer work, doing light housework/gardening).<br>• Non-valid instrument | • Indicators of Successful aging:<br>• Life Satisfaction: Measured with 20-item Life Satisfaction Index (LSIA).<br>• Valid instrument<br>• Happiness: A single item measure assessed feelings of happiness: "Would you describe yourself as being usually.<br>• Non-valid instrument<br>• Function: A composite measure of function created based on ADL's, IADL's, MSQ (cognitive impairment), and interviewer observed physical difficulties.<br>• Non-valid instrument<br>• Mortality: determined from data from the Office of Vital Statistics.<br>• Valid instrument |
| Sun et al. (2010). *Archives Internal Medicine, 170*(2), 194-201. | Physical Activity at Midlife in Relation to Successful Survival in Women at Age 70 Years or Older. | • Question: average time per week in the past year participants spent on leisure-time physical activities, including walking or hiking outdoors; jogging (10 min/mile); running ( 10 min/mile); bicycling; lap swimming; playing tennis; doing calisthenics, aerobics, aerobic dance, and/or rowing machine exercise; and playing squash or racquet ball.<br>• Valid instrument | • Successful Aging: Addressed 4 domains: (1) no history of cancer, diabetes, myocardial infarction, coronary artery bypass graft surgery, congestive heart failure, stroke, kidney failure, chronic obstructive pulmonary disease, Parkinson disease, multiple sclerosis, or amyotrophic lateral sclerosis; (2) no impairment in cognitive function (TICS score 31); (3) no physical disabilities; and (4) no mental health limitations.<br>• Valid instrument |

Overall both studies (Menec, 2003; Sun et al., 2010) found statistically significant results between PA and successful aging, ES's were mixed.

### *4.5.9. Physical Activity and Chronic Diseases*

Five studies (DeFilippi et al., 2012; Demakakos et al., 2010; Franco et al., 2005; Manson et al., 2002; McTierman et al., 2003) examined the association between PA and a variety of chronic diseases (see **Table 4.15**). Specifically, one study (McTierman et al., 2003) examined the association between PA and breast cancer, two studies (Franco et al., 2005; Manson et al., 2002) examined the association between PA and cardiovascular disease, one study (DeFilippi et al., 2012) examined the association between PA and heart failure and one study (Demakakos et al., 2010) examined the association between PA and diabetes. Overall results demonstrated an inverse association between PA and risk of chronic disease. Strength of association varied depending on the type of chronic disease.

***Table 4.15. Longitudinal Physical Activity and Chronic Disease***

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Chronic Disease |
|---|---|---|---|
| McTierman et al. (2003). *Journal of the American Medical Association, 290,* 1331-1336. | Recreational Physical Activity and the Risk of Breast Cancer in Postmenopausal Women: The Women's Health Initiative Cohort Study. | • Question: if women (yes/no) usually did strenuous or very hard exercises (long enough to work up a sweat and make their hearts beat fast) at least 3 times per week at ages 18, 35, and 50 years.<br>• Non-valid instrument | • Breast cancer assessed by study physicians and cancer coders, blinded to exposure status, reviewed pathology reports, discharge summary, operative reports, and radiology reports for all biopsies and surgeries and coded cases according to National Cancer Institute Surveillance, Epidemiology, and End Results guidelines.<br>• Valid instrument |
| Manson et al. (2002). *New England Journal of Medicine, 347*(10), 716-725. | Walking Compared with Vigorous Exercise for the Prevention of Cardiovascular Events in Women. | • Question: on the frequency and duration of walking and of several other types of activity (strenuous, moderate, and mild).<br>• Non-valid instrument | • Diagnosis of nonfatal myocardial infarction confirmed if data in the hospital record met standardized criteria of diagnostic electrocardiographic changes, elevated cardiac-enzyme levels, or both. Treatment with coronary or carotid revascularization confirmed by documentation of the procedure in the medical record. The presence of angina confirmed by hospitalization and confirmatory evidence on angiography, diagnostic stress test, or diagnosis by a physician and medical treatment. The occurrence of stroke confirmed by documentation in the medical record of the rapid onset of a neurologic deficit consistent with stroke and lasting at least 24 hours or until death. The presence of congestive heart failure confirmed by hospitalization and diagnostic confirmatory tests. Fatal coronary disease confirmed if documentation in the hospital or autopsy records or if coronary disease was listed as cause of death on death certificate and evidence of previous coronary disease was available. For deaths from other cardiovascular causes, a review of confirmatory evidence by physician-adjudicators was required.<br>• Valid instruments |
| Franco et al. (2005). *Archives Internal Medicine, 165,* 2355-2360. | Effects of Physical Activity on Life Expectancy with Cardiovascular Disease. | • Question: to estimate how long subjects spent in a typical day at various levels of activity: sleeping, resting, or engaging in light, moderate, or heavy PA.<br>• Non-valid instrument | • Cardiovascular disease assessed by a panel of 3 physicians and evaluated all events; agreement of all 3 was required.<br>• Valid instrument |

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Chronic Disease |
|---|---|---|---|
| DeFilippi et al. (2012). *Journal of American College of Cardiology, 60,* 2539-2547. | Physical Activity, Change in Biomarkers of Myocardial Stress and Injury, and Subsequent Heart Failure Risk in Older Adults. | • Modified Minnesota Leisure-Time Activity Questionnaire<br>• Valid instrument | • The CHS Events Committee adjudicated incident heart failure by reviewing all pertinent data, including history, physical examination, chest radiography report, and medication use.<br>• Valid instrument |
| Demakakos et al. (2010). *Diabetologia, 53,* 1877-1885. | Low-Intensity Physical Activity is Associated with Reduced Risk of Incident Type 2 Diabetes in Older Adults: Evidence from the English Longitudinal Study of Aging. | • Question: how often subjects took part in three different types of PA: vigorous, moderate and low intensity. The response options were: more than once a week, once a week, one to three times a month and hardly ever/never.<br>• Non-valid instrument | • Diabetes measured by doctor-diagnosed diabetes.<br>• Valid instrument |

For example, McTierman et al. (2003) examined the association between current and past recreational PA and incidence of breast cancer in postmenopausal women aged 50 to 79 years in the USA. They found that there was a weak inverse association between women who engaged in strenuous PA at least 3 times per week at age 35 and a 14% reduced risk of breast cancer (RR, 0.86; 95% CI = 0.78-0.95, p = 0.003) compared with women who did not engage in this level of activity. Likewise, there was a weak to weak-moderate inverse association between women who exercised on average 5.1 to 10.0 MET-h/wk with a 18% reduced risk of developing breast cancer compared to sedentary women (RR=0.82, 95% CI = 0.68-0.97, p = 0.03). Women who exercised more than 40 MET-h/wk had a 22% reduction in risk of developing breast cancer compared to sedentary women (RR=0.78, 95% CI = 0.62-1.0, p = 0.03). ES ranged from -.10 to -0.12.

Manson et al. (2002) compared the roles of walking and vigorous exercise in the prevention of coronary and cardiovascular events in a large, ethnically diverse cohort of postmenopausal women in the Women’s Health Initiative Observational Study. They found that an increasing PA score had a strong, graded, inverse association with the risk of both coronary events and total cardiovascular events. For instance, in the age-adjusted analyses, there was a weak-moderate to moderate inverse association between women in increasing quintiles of energy expenditure and a lower risk of coronary events (total MET score relative risk [RR]: 1.00, 0.73, 0.69, 0.68, and 0.47, respectively; p for trend <0.001). ES ranged from -.16 to -.36. In the multivariate analyses, there was also a weak to weak-moderate inverse association between increasing quintiles of total MET score and a lower risk of cardiovascular events (RR: 1.00, 0.89, 0.81, 0.78, and 0.72, respectively; p for trend <0.001). ES ranged between -.06 to-.16. Likewise, there was a weak to weak-moderate inverse association between both increasing categories of walking (RR: 1.00, 0.91, 0.82, 0.75, 0.68) and vigorous exercise (RR: 1.00, 0.91, 0.81, 0.85, 0.76) and a lower risk of cardiovascular events. ES ranged from -.05 to -.19. In contrast, there was a weak-moderate positive association between women who spent more time sitting and an increased risk of cardiovascular events RR: 1.68 (95% CI = 1.07 to 2.64), ES was 0.25.

Franco et al. (2005) evaluated the effects of different levels of PA on life expectancy and years lived with and without CVD among men and women 50 years or older. Results indicated there was a dose-response protective association between PA level and incident CVD or death among participants with no CVD and for mortality among participants with CVD. For example, after adjustment for age, sex and selected confounders, results demonstrated there was a weak-moderate inverse association between high PA and incident CVD HR = 0.77, 0.68-0.89; no CVD to death HR = 0.72, 0.58-0.89; and CVD to death HR = 0.77, 0.65-0.89. ES ranged between -.13 to -.16. However, for the group with a moderate level of PA, the protective effect of PA was only significant for no CVD to death (HR = 0.72, 0.58-0.89), strength of association was -.11. Overall, moderate and high PA levels led to 1.3 and 3.7 years more lived in total life expectancy and 1.1 and 3.2 more years lived without CVD, respectively for men. For women, the differences were 1.5 and 3.5 in total life expectancy and 1.3 and 3.3 more years lived free of CVD, respectively.

DeFilippi et al. (2012) evaluated the association between PA and changes in levels of highly sensitive troponin T (cTnT) and N-terminal pro–B-type natriuretic peptide (NT-proBNP), and the subsequent risk of development of heart failure (HF) in community-dwelling older adults 65 years and older who participated in the Cardiovascular Heart Study (CHS). Results showed there was a moderate to strong inverse association between individuals with the highest PA score and lower likelihood of an increase in NT-proBNP (OR = 0.50; 95% CI = 0.33 to 0.76, $p = 0.001$) and an increase in cTNT (OR = 0.30; 95% CI = 0.16 to 0.55, $p < 0.001$), ES ranged from -0.33 to -0.54. Thus, a higher activity score was associated with a lower long-term incidence of heart failure.

Demakakos et al. (2010) examined whether small amounts of low-intensity PA was associated with a lower risk of developing Type II diabetes in a national sample of men and women aged 50 years and over. Results demonstrated that for older adults who engaged in vigorous/moderate intensity PA at least once a week, there was a weak-moderate inverse association in the fully adjusted model (HR = 0.64, 95% CI = 0.43-0.95, $p = 0.02$) with a lower risk of type 2 diabetes. ES was -.22. But there was no association for low-intensity PA performed at least once a week. Interestingly, in the oldest category (≥ 70 years) there was a moderate inverse association in the age adjusted low intensity PA categories (HR = 0.53, 95% CI = 0.28-1.02, $p = 0.059$) but not for ages 50 to 69 years old.

Overall, all five studies (DeFilippi et al., 2012; Demakakos et al., 2010; Franco et al., 2005; Manson et al., 2002; McTierman et al., 2003) found statistically significant results between PA and a variety of chronic diseases. ES's were mixed depending on the type of chronic disease examined.

## 4.6. Cross-sectional and Longitudinal/Prospective Studies

### *4.6.1. Physical Activity and Emotional Well-being*

Two studies (Lee et al., 2003; Kritz-Silverstein et al., 2000) examined the association between PA and emotional well-being both cross-sectionally and longitudinally/prospectively (see **Table 4.16**). Results cross-sectionally were similar; however, results longitudinally/prospectively differed.

Lee et al. (2003) found there was a positive association in both their cross-sectional and prospective analyses of PA and emotional well-being. While only examining Australian older women in their study, Lee et al. found that on every SF-36 variable, group means increased with increasing levels of exercise, and for every level of

PA, the group mean was significantly higher than that of the "None or very low" PA group: Vitality F=50.22, p < 0.001; Social functioning F=28.24, p < 0.001; Emotional role F=61.91, p < 0.001; and Mental Health F=62.68, p < 0.001, ES size ranged between small-moderate to moderate (0.20-0.33). As for their longitudinal data, associations were found between PA and emotional well-being, but they were not as strong or consistent (ES was small to small-moderate, 0.05-0.20). Overall, the pattern of results suggested women who had made a transition from some PA to none generally showed more adverse changes in emotional well-being than those who had always been sedentary, while those who maintained or adopted PA tended to have better outcomes (Vitality: F=43.52, p < 0.001; Social functioning: F=66.50, p < 0.001; Emotional Role: F=10.39, p < 0.001; & Mental Health: F=4.87, p < 0.02, respectively).

***Table 4.16. Cross-sectional and Longitudinal Physical Activity and Emotional Well-being***

| Authors | Title of Study | Independent Variable: Physical Activity | Dependent Variable: Emotional Well-being |
|---|---|---|---|
| Lee et al. (2003). *Journal of Psychosomatic Research, 54,*155-160. | Effects of physical activity on emotional well-being among older Australian women: cross-sectional and longitudinal analyses. | • Question: frequency of engaging in "vigorous activity" and "less vigorous activity" at survey 1 and PA assessed from self-reported time spent engaging in "vigorous activity", "moderate activity", and "walking" in the previous week at survey 2.<br>• Non-valid instrument | • Four mental health subscales and the mental health component scores (MHC) of the Medical Outcomes Study Short Form (SF-36).<br>• Valid instrument |
| Kritz-Silverstein et al. (2000). *American Journal of Epidemiology, 153*(6), 596-603. | Cross-sectional and Prospective Study of Exercise and Depressed Mood in the Elderly: The Rancho Bernardo Study. | • Questions: Do you regularly engage in strenuous exercise or hard physical labour? (no/yes), and Do you exercise or labour at least three times a week? (no/yes).<br>• Valid instrument | • Beck Depression Inventory (BDI).<br>• Valid instrument |

In their cross-sectional analysis, Kritz-Silverstein et al. (2000) found a small-moderate inverse association between men who engaged in both regular strenuous exercise or exercise three or more times per week and lower depression scores (F =9.85, p < 0.01, F=5.51, p < 0.05, respectively) compared to men who did not exercise. Effect size for men ranged between -0.17 to -0.18. Additionally, there was a small-moderate inverse association between women who engaged in both regular strenuous exercise or exercise three or more times per week and lower depression scores ($F=8.16$, $p < 0.01$, $F=5.44$, $p < 0.05$, respectively) compared to women who did not exercise. Effect size for women ranged between -0.12 to -0.17. However, in their prospective analyses there was no association between baseline exercise and either follow-up BDI score ($p>0.10$) or change in BDI score between baseline and follow-up ($p>0.10$). Therefore, while exercisers have less depressed mood, exercise does not necessarily protect against future depressed mood for those not clinically depressed at baseline.

Overall both studies (Lee et al., 2003; Kritz-Silverstein et al., 2000) found statistically significant results in their cross-sectional analyses between PA and emotional well-being. In fact, both Lee et al. (2003) and Kritz-Silverstein et al. (2000) found a small-moderate to moderate ES in their cross-sectional study. In contrast, only Lee et al. (2003) found statistically significant results in their prospective analysis, ES was small-moderate.

# Chapter 5.

# Discussion: Comparing Cross-sectional and Longitudinal Studies

## 5.1. Physical Activity and Emotional Well-being/Depression

Support for the association between PA and emotional well-being/depression was mixed between cross-sectional and longitudinal/prospective studies. Although 11 studies found an association between PA and emotional well-being/depression, 2 studies found no association. In addition, as mentioned previously, the cross-sectional study by Mummery et al. (2004) had serious validity concerns with regards to their PA instrument. As for Kritz-Silverstein et al. (2000) prospective study, the authors excluded categorically depressed and physically limited participants at baseline which may have contributed to selection bias. Some have argued that physical disability acts as a possible influential confounding variable because it is associated with both a higher risk of depression and lower levels of PA. It is therefore perhaps not surprising there was no association between PA and depression. However, the Strawbridge et al. (2002) longitudinal study did provide support for an association between PA and depression even when including individuals with disability at baseline.

Future research should focus on PA interventions with stronger reliable and valid PA instruments, include more participants with baseline disability, and conduct assessments of mood before, during and at the end of the study to determine direction of the association of PA and emotional well-being/depression.

## 5.2. Physical Activity and Cognitive Function/Cognitive Impairment

Support for the association between PA and cognitive function/cognitive impairment was seen in both cross-sectional and longitudinal studies. However, due to the disparities of distinct cognitive assessments and different subjective and objective measurements of PA employed in each study, caution is necessary when interpreting these results. With the exception of one study (Buchman et al., 2008) all five studies utilized self-report PA instruments. Therefore, there is some possibility of bias due to social desirability response or recall bias. Moreover, three studies (Chang et al., 2010; Middleton et al., 2008; Weuve et al., 2004) employed non-validated PA instruments which lead to concerns about the reliability and validity of the PA instrument. Additionally, LTPA was extensively assessed among the studies. Given that the literature acknowledges older adults engage in very little PA, assessing mostly LTPA could inaccurately reflect older adults PA levels. Perhaps future studies should not only include objective measurements of PA but also, measure other types of PA such as household PA which many older adults engage in. Finally, future research should assess intensity and duration of PA.

## 5.3. Physical Activity and Physical Function/Functional Status

Support for the association between PA and physical function/functional status was seen in both cross-sectional and longitudinal studies. Of interest, the study by Martin et al. (2008) found that higher levels of customary PA were associated with significantly higher muscle strength and better physical performance only among women. The authors provided several suggestions for the gender difference such as women having a higher fat-to-muscle ratio which may have resulted in women gaining more benefit from PA with respect to strength and physical performance. The authors also suggest that there may have been a ceiling effect with men having greater muscle bulk than women and therefore in order to demonstrate differences in PA relative to physical performance among men, a broad range and greater intensity of PA may been required to see any effect. Another reason the authors provided was that their physical performance assessments involved low intensity PA. Thus, future research should employ higher intensity PA measurements to validate differences between men and women.

## 5.4. Physical Activity and Successful Aging

Support for the association between PA and successful aging was seen in both cross-sectional and longitudinal studies. However, there is argument whether older adults can be realistically classified as either successful or unsuccessful aging. Of concern is Rowe and Kahn's (1987) model of successful aging which was used in both Baker et al. (2006) study and Sun et al. (2010) study. Specifically, many researchers contend that the 'low probability of disease or disease-related disability' criterion of successful aging is imbalanced because it results in very few older adults being classified as successful agers. Hence, future research should look for a more viable and inclusive approach to the study of successful aging and PA.

## 5.5. Physical Activity and Chronic Diseases

Support for the association between PA and chronic disease was seen in both cross-sectional and longitudinal studies. While Benedetti et al. (2008) cross-sectional Brazilian study found a moderate positive association between less physically active older adults and the likelihood of reporting the presence of at least one chronic disease, it can be argued that these results are not surprising given that older adults do have at least one chronic disease as they age (Benedetti et al., 2008; participants' average age was 71.6 ± 7.9 years). Future research should examine the association between lower PA and the presence of at least 2 to 3 chronic diseases.

# Chapter 6. Critical Summary of Evidence

To my knowledge, this systematic and methodological review is the first synthesis on the cross-sectional and longitudinal associations between PA and health outcomes in the older adult population. The cross-sectional evidence revealed a weak to moderate association between higher levels of PA and better health outcomes. In contrast, lower levels of PA were associated with poorer health outcomes. The direction of the association is consistent with previous literature. Similarly, longitudinal evidence revealed a weak to moderate association between higher levels of PA and better health outcomes. In contrast, lower levels of PA were associated with poorer health outcomes. The direction of the associations is again consistent with previous literature.

It is argued that evidence from a cross-sectional design is problematic because it makes assumptions of causality. While cross-sectional studies do measure two distinct variables at the same point in time, it cannot differentiate between cause and effect. Rather the results are merely correlations between variables. Also, the generalizability of cross-sectional results is always an issue because they do not consider historical or cultural differences between groups.

One would assume that evidence from a longitudinal design would provide stronger causality because they allow us to focus on intraindividual change, developmental sequences and co-occurring social and environmental change (McCall, 1977). However, there are still issues of causality when it comes to a longitudinal design. Firstly, caution is warranted when examining study results with short follow-ups. While a key strength of a longitudinal study is the ability to measure change in outcomes and/or exposure at the individual level, is it reasonable to accept a correlation based on a study that has, say for example, a 2-year follow-up? Lindwall et al. (2011) study examined the reciprocal relationship between PA and depression in older adults across a 2-year follow-up and found that PA at time 1 was related to lower depression at time 2. However, can one really assume causality given such a short follow-up? Several criticisms of their study include their use of a non-validated, self-report PA instrument (which can lead to social desirability responses), crude measures of PA, and a short follow-up?

Secondly, longitudinal designs suffer from measurement error (or measurement variation) over time. In other words, if you measure the same object two different times, the measurements may not be exactly the same. The difference between two measurements is called an 'error' (or variation) in the measurements. In order to reduce the likelihood of measurement error, it is crucial for researchers to ensure that the measurement instruments (i.e., surveys, tests, questionnaires) employed in their study are valid and reliable. That is, the instruments measure what they are supposed to measure and the instrument consistently measures what it is suppose to measure. Thirdly, it is difficult to account for intra-individual variability such as disease status, changes in activity levels due to changes in health or demands on time among older adults in a longitudinal design. Finally, there are concerns that repeated measures in longitudinal studies are not well-defined in the literature and there is no consensus to the appropriate length of time between repeated measures.

Notwithstanding the above limitations to establish causation in cross-sectional and longitudinal studies, this review found unequivocally that there was strong evidence on the association between PA and across all health outcomes. Not only was the strength of association consistent among most of the studies, but also, this association held true across both observational designs, different PA measures and when controlled for many covariates such as age, gender, education, and SES. These indicators of causation are further supported by the Bradford Hill criteria (1965), that helps determine if association is due to causation.

This review cannot assess whether the ES is consistent with previous literature. None of the studies reviewed for this capstone paper provided ES's with their results. This is due, in part, to the absence of a requirement to report ES. It is argued that there is very little guidance on the application and interpretability of ES in most statistical texts and consequently many researchers are not skilled in incorporating ES's into their work (Durlak, 2009). Another explanation for the reluctance to report ES is fear that the study may not be published because the ES is not considered meaningful because the results found a weak ES. However, according to Durlak (2009):

> an effect size by itself can mean almost anything. A 'small' effect size can be important and have practical value whereas a 'large' one might be relatively less important or persuasive. It is up to each author to use effect sizes to explain the meaning and practical value of their findings. (p. 926)

This is particularly evident in this review. Overall the findings from this systematic and methodological review found a weak to moderate ES between PA and health outcomes both cross-sectionally and longitudinally. However, attention should be drawn to the fact that a weak/small ES does not mean that the study does not have important practical or clinical significance; rather, weak/small to moderate ES suggests substantively important results. Moreover, this review demonstrated compelling evidence that all of the studies found consistent associations between PA and all of the eleven health outcomes examined. Hence, a small ES in this population of older adults is a strong association and a substantially important finding. Thus, this review contributes new knowledge to the literature on the association between PA and health outcome.

Furthermore, the present study demonstrated that PA measurement varied widely among the reviewed researcher. Subjective PA using self-report instruments were the most commonly used instruments in both cross-sectional and longitudinal studies. While self-report PA instruments are easy to administer, low cost, provide anonymity, and reduce interviewer bias, self-report PA instruments may over or under estimate overall PA due to social desirability response or recall bias. Notwithstanding the increased cost, utilizing objective PA measurement is recommended in future studies. Additionally, this review found that LTPA was the most frequent type of PA assessed among studies. Consequently, there may be an over estimate of overall PA. Choosing the appropriate instrument to measure PA in older adults is complex. Researchers need to be aware of which measure is the most appropriate for older adults and what combination of instruments is the most appropriate as PA cannot adequately capture all of its dimensions with a single measure (Kolwalski, Rhodes, Naylor, Tuokko, & MacDonald, 2012). Given that previous studies acknowledge that older adults do not engage in sufficient PA for health benefits, future research should explore other types of

PA such as NLTPA among older adults (Costello et al., 2011; Hamdorf, Starr, & Williams, 2002).

The current review provides some support for a dose-response relationship between PA level and mortality and PA level and AD/dementia. For example, Lan et al. (2006) found mortality risks declined with exercisers reporting a dose-response association of total amount of expended energy of 1000kcal or more per week and Laurin et al. (2001) found a protective effect of regular PA on the risk of AD and dementia but only for women. However, further research is needed to confirm this association.

Finally, this review revealed that several studies utilized non-validated health outcome instruments. For example, Sampaio et al. (2012) assessed QOL in older adults using the World Health Organization Quality of Life Assessment (WHOQOL)-OLD Japanese version. However, the internal consistency for the final version of the Japanese WHOQOL-OLD instrument was not yet published at the time and therefore there were reliability and validity concerns. The study by Balboa-Castillo, Guallar-Castillon et al. (2011) reported they used crude and non-validated measures of limited mobility and limited agility. Likewise, Lampinen et al. (2006) study demonstrated they employed non-validated one-item measurement scales of mental well-being and several independent variables such as anxiety, mobility and chronic illness. Therefore, it is imperative that future research develop and utilize valid and reliable health outcome instruments.

## 6.1. Limitations

Several limitations to this systematic and methodological review should be considered. First, in compiling relevant information for this review, often there are two reviewers abstracting key information from each primary study, including study and patient characteristics, setting, and details about the exposure or diagnostic test as is appropriate. This was not possible as this capstone is meant to be undertaken solely by a graduate student to satisfy the requirements in Simon Fraser Graduate General

Regulations. Therefore, it is possible that there is some bias for including studies and for study quality and data extracted for this review.

Second, this review revealed many methodological challenges to data analysis across the selected studies. Of concern, many studies did not account for the reliability and validity of their PA scales. While both of these factors can influence the quality of the data obtained in their respective studies, those studies that utilized non-validated PA scales, the overall results were not affected because the ES's were still weak to moderate regardless if a study utilized a non-validated or validated PA scale.

Third, few studies pilot-tested their instruments/scales with their intended sample; therefore, there may be concerns of clarity and/or if questions in the survey measured what they were supposed to measure.

Fourth, a problem that has plagued the literature on PA is the lack of consistency in activity measures. While conducting this review, it became increasingly clear that not all studies assessed frequency, intensity and type of PA equally. Rather, studies included some variation of frequency, intensity and type of PA or just one of the variables. Therefore, due to the lack of consistency in activity measures, it is difficult to determine with certainty the 'best' type, frequency and intensity of PA older adults need to engage in PA in order to gain health benefits.

Fifth, some studies utilized crude assessments of PA. For example, Lang et al. (2007) asked their respondents to answer, ''On average, over the last 12 months, have you participated in vigorous PA or exercise three times a week or more? By vigorous PA, the authors meant things like sports, heavy housework, or a job that involves physical labor.'' By not providing respondents an exhaustive list of vigorous PA or exercises to choose from, this type of question allows respondents to openly interpret what they consider to be vigorous PA or exercise. Thus, it is not clear if respondents interpreted the question in the way the researchers anticipated.

Sixth, some areas of this review such as "PA and Frailty" and "PA and Successful Aging" only included one or two studies for this review. Therefore, it is not possible to generalize if the association between PA and those health outcomes are consistent and meaningful.

Seventh, this review did not include case-controlled or retrospective studies. Due to time constraints and resources required to thoroughly review and analyze all the cross-sectional and longitudinal studies for this review, it was not possible to include case-controlled or retrospective studies. Perhaps future studies could conduct a comprehensive review of all observational studies (i.e., cross-sectional, longitudinal, case-controlled, panel and retrospective study) as well as RCTs on PA and health outcomes.

Eighth, because this review utilized varying statistical methods (i.e., Pearson correlation, odds ratio, hazards ratio, etc.) on how to measure PA, the ES estimates are crude. Therefore, caution is warranted.

Finally, this review was limited to English language literature. It may be possible that non-English studies may have found different results when examining PA and health outcomes.

## 6.2. Future Directions in Research

This systematic and methodological review demonstrates that there are health benefits for older adults to engage in PA. What is less clear are the type, frequency and intensity of PA to gain health benefits for older adults. Future studies should focus on utilizing standardized, valid and reliable PA instruments whether that involves employing subjective or objective instruments. Also, future research should explore our limited understanding of why older adults' do not engage in PA. Improved understanding of this issue among health care professionals is fundamental to research and practice in health promotion and should be a research priority. Since randomized controlled trials are the most rigorous of determining whether a cause-effect relation exists between treatment and outcome and for assessing the cost effectiveness of a treatment, future research should include more randomized controlled trials involving older adults and PA. Moreover, this review validates the necessity for intervention methods that are theory-driven to promote and further increase older adults' involvement in PA. It is widely believed that theories commonly posit factors that mediate or motivate behavior change. While a handful of studies focused on ethnic populations, further research is needed to determine if PA is beneficial for ethnically diverse populations. Finally, future research should make it a priority to include effect sizes with their results. Then and only then, are we able to establish with certainty the practical or clinical significance of their results.

## 6.3. Conclusion

To conclude, there is an increasing amount of literature that indicates regular PA is beneficial in improving and maintaining a person's health and well-being, especially as one grows older. Despite the many benefits from PA, there is a paucity of older adults regularly engaging in PA. This systematic and methodological review was undertaken against the backdrop of the increasing number of physically inactive older adults. To my knowledge, this review is the first of its kind. This review illustrates that there is a consistent association between PA and health outcomes among older adults in both cross-sectional and longitudinal studies. More importantly, the ES's were weak (or small) to moderate. Thus, a physically active lifestyle, whether it be light, moderate or vigorous PA is advantageous for older adults overall.

Due to the unprecedented growth of the aging population worldwide, now more than ever, it is important that older adults maintain better physical and emotional health, and independent living, specifically delaying or preventing disability or frailty. PA should become a priority area in general health promotion and as a specific objective for an individuals' health. Moreover, it is imperative that public health policies design intervention methods to promote and further increase older adults' involvement in PA. It is hoped that effective strategies could result in considerable benefits through improved quality of life, and reduced economic cost and social burden.

## References


Abu-Bader, S. H. (2011). *Advanced and multivariate statistical methods for social science research.* Chicago, IL: Lyceum.

Ashe, M. C., Miller, W. C., Eng, J. J., & Noreau, L. (2009). Older adults, chronic disease and leisure-time physical activity. *Gerontology, 55*(1), 64-72. doi:10.1159/000141518

Baker, J., Meisner, B. A., Logan, A. J., Kungl, A., & Weir, P. (2009). Physical activity and successful aging in canadian older adults. *Journal of Aging and Physical Activity, 17,* 223-235.

Balboa-Castillo, T., Guallar-Castillon, P., Leon-Munoz, L., Graciani, A., Lopez-Garcia, E., & Rodriguez-Artalejo, F. (2011). Physical activity and mortality related to obesity and functional status in older adults in Spain. *American Journal of Preventative Medicine, 20*(1), 39-46.

Balboa-Castillo, T., Leon-Munoz, L. M., Graciani, A., Rodriguez-Artalejo, F., & Guallar-Castillon, P. (2011). Longitudinal associations of physical activity and sedentary behavior during leisure time with health-related quality of life in community-dwelling older adults. *Health and Quality of Life Outcomes, 9*(47), 1-10. doi:10.1186/1477-7525-9-47

Bath, P. A., & Morgan, K. (1998). Customary physical activity and physical health outcomes in later life. *Age and Ageing, 27*(S3), 29-34.

Benedetti, T. R. B., Gonçalves, L. H. T., Petroski, E. L., Nassar, S. M., Schwingel, A., & Chodzko-Zajko, W. (2008). Physical activity, socioeconomic conditions, and diseases among older adults in southern Brazil. *Journal of Applied Gerontology, 27*(5), 631-640.

Benedict, C., Brooks, S. J., Kullberg, J., Nordenskjöld, R., Burgos, J., Le Grevès, M., … Schiöth, H. B. (2012). Association between physical activity and brain health in older adults. *Neurobiology of Aging, 34,* 83-90.

Berben, L., Sereika, S. M., & Engberg, S. (2012). Effect size estimation: Methods and examples. *International Journal of Nursing Studies, 49,* 1039-1047.

Berman, N. G., & Parker, R. A. (2002). Meta-analysis: Neither quick nor easy. *BMC Medical Research Methodology, 2*(10). doi:10.1186/1471-2288-2-10

Bowen, M. E. (2012). A prospective examination of the relationship between physical activity and dementia risk in later life. *American Journal of Health Promotion, 26*(6), 333-340.

Boyle, P. A., Buchman, A. S., Wilson, R. S., Bienias, J. L., & Bennett D. A. (2007). Physical activity is associated with incident disability in community-based older persons. *Journal of the American Geriatrics Society, 55,* 195-207.

Bruce, B., Fries, J. F., & Hubert, H., (2008). Regular vigorous physical activity and disability development in healthy overweight and normal-weight seniors: A 13-year study. *American Journal of Public Health, 98*(7), 1294-1299.

Buchman, A. S., Boyle, P. A., Yu, L., Shah, R. C., Wilson, R. S., & Bennett, D. A. (2012). Total daily physical activity and the risk of AD and cognitive decline in older adults. *Neurology, 78*, 1324-1329.

Buchman, A. S., Wilson, R. S., & Bennett, D. A. (2008). Total daily activity is associated with cognition in older persons. *American Journal of Geriatric Psychiatry, 16*(8), 697-701.

Bushman, B. J., & Anderson, C. A. (2007). Measuring the strength of the effect of violent media on aggression. *American Psychologist, 62*(3), 253-254.

Byberg, L., Melhus, H., Gedeborg, R., Sundström, J., Ahlbom, A., Björn, Z., … Michaëlsson, K. (2009). Total mortality after changes in leisure time physical activity in 50 year old men: 35 year follow-up of population based cohort. *British Medical Journal, 338,* b688.

Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: Definitions and distinctions for health-related research. *Public Health Reports, 100,*126-131.

Chad, K. E., Reeder, B. A., Harrison, E. L., Ashworth, N. L., Sheppard, S. M., Schultz, S.L., … Lawson, J. A. (2005). Profile of physical activity levels in community-dwelling older adults. *Medicine & Science in Sports & Exercise, 13,* 1774-1784. doi: 10.1249/01.mss0000181303.51937.9

Chang, M., Jonsson, P. V., Snaedal, J., Bjornsson, S., Saczynski, J. S., Aspelund, T., … Launer, L. J. (2010). The effect of midlife physical activity on cognitive function among older adults: AGES—Reykjavik Study. *Journal of Gerontology, 65A*(12), 1369-1374.

Chen, L., Fox, K. R., Ku, P., Sun, W., & Chou, P. (2012). Prospective associations between household-, work-, and leisure-based physical activity and all-cause mortality among older Taiwanese adults. *Asia-Pacific Journal of Public Health,* 24(5) 795–805.

Cohen, J. (1992). "A power primer". *Psychological Bulletin, 112*(1), 155-159. doi:10.1037/0033-2909.112.1.155.

Cohen's *d*. (n.d.). CEP932: Effect size: II. Calculating effect size. *Wikispaces.com.* Retrieved from http://cep932.wikispaces.com/Effect+Size

Costello, E., Kafchinski, M., Vrazel, J., & Sullivan, P. (2011). Motivators, barriers, and beliefs regarding physical activity in an older adult population. *Journal of Geriatric Physical Therapy, 34*(3), 138-147.

De Bruijn, R. F. A. G., Schrijvers, E. M. C., De Groot, K. A., Witteman, J. C. M., Hofman, A., Franco, O. H., … Ikram, M. A. (2013). The association between physical activity and dementia in an elderly population: The Rotterdam study. *European Journal of Epidemiology, 28,* 277-283.

DeFilippi, C. R., De Lemos, J. A., Tkaczuk, A. T., Christenson, R. H., Carnethon, M. R., Siscovick, D. S., … Seliger, S. L. (2012). Physical activity, change in biomarkers of myocardial stress and injury, and subsequent heart failure risk in older adults. *Journal of American College of Cardiology, 60,* 2539-2547.

Demakakos, P., Hamer, M., Stamatakis, E., & Steptoe, A. (2010). Low-intensity physical activity is associated with reduced risk of incident Type 2 Diabetes in older adults: Evidence from the English Longitudinal Study of Ageing. *Diabetologia, 53,* 1877-1885.

Digby, P. G. N. (1983). Approximating the tetrachoric correlation coefficient, *Biometrics, 39,* 753-757.

Dye, C. J., & Wilcox, S. (2006). Beliefs of low-income and rural older women regarding physical activity: You have to want to make your life better. *Women & Health, 43*(1), 115-134.

Farrington, D. P. (1991). Longitudinal research strategies: Advantages, problems and prospects. *Journal of the American Academy of Child and Adolescent Psychiatry, 30*(3), 369-374.

Feinglass, J., Thompson, J. A., He, X. Z., Witt, W., Chang, R. W., & Baker, D. W. (2005). Effect of physical activity on functional status among older middle-age adults with arthritis. *Arthritis & Rheumatism, 53*(6), 879-885.

Ferreira, M. T., Matsudo, S. M. M., Ribeiro, M. C. S. A., & Ramos, L. R. (2010). Health-related factors correlate with behavior trends in physical activity level in old age: Longitudinal results from a population in São Paulo, Brazil. *BMC Public Health, 10,* 690. Available at http://www.biomedcentral.com/1471-2458/10/690

Franco, O. H., De Laet, C., Peeters, A., Jonker, J., Mackenbach, J., & Nusselder, W. (2005). Effects of physical activity on life expectancy with cardiovascular disease. *Archives Internal Medicine, 165,* 2355-2360.

Garg, A. X., Hackam, D., & Tonelli, M. (2008). Systematic review and meta-analysis: When one study is just not enough. *Clinical Journal of the American Society of Nephrology, 3,* 253-260.

Geda, Y. E., Rosebud, O. R., Knopman, D. S., Christianson, T. J. H., Pankratz, V. S., Ivnik, R. J., … Rocca., W. A. (2010). Physical exercise, aging, and mild cognitive impairment a population-based study. *Archives Neurology, 67*(1), 80-86.

George, E. S., Jorm, L., Kolt, G. S., Bambrick, H., & Lujic, S. (2012). Physical activity and psychological distress in older men: Findings from the New South Wales 45 and up study. *Journal of Aging and Physical Activity, 20,* 300-316.

Gillum, R. F., & Obisesan, T. O. (2010). Physical activity, cognitive function, and mortality in a US National Cohort. *Annual Epidemiology Journal, 20*(4), 251-257.

Glass, G. V. (1976). Primary, secondary, and meta-analysis. *Educational Researcher, 5,* 3-8.

Grad, F. P. (2002). Public health classics: The preamble of the constitution of the World Health Organization. *Bulletin of the World Health Organization, 80*(12), 981-984. Retrieved from http://www.who.int/bulletin/archives/80% 2812% 29981.pdf

Gregg, E. W., Cauley, J. A., Stone, K., Thompson, T. J., Bauer, D. C., Cummings, S. R., Ensrud, K. E. (2003). Relationship of changes in physical activity and mortality among older women. *Journal of American Medical Association, 289*(18), 2379-2386.

Guedes, D. P., Hatmann, A. C., Martini, F. A. N., Borges, M. B., & Bernardelli, R., Jr. (2012). Quality of life and physical activity in a sample of Brazilian older adults. *Journal of Aging and Health, 24*(2) 212–226.

Hakim, A. A., Petrovitch, H., Burchfiel, C. M., Ross, W., Rodriguez, B. L., White, L. R., … Abbott, R. D. (1998). Effects of walking on mortality among non-smoking retired men. *The New England Journal of Medicine, 338,* 94-99.

Hamdorf, P., Starr, G., & Williams, G. (2002). A survey of physical-activity levels and functional capacity in South Australia. *Journal of Aging and Physical Activity, 10*, 281-289.

HealthKnowledge. (n.d.). *Introduction to study designs: Cross-sectional studies.* Retrieved from http://www.healthknowledge.org.uk/e-learning/epidemiology/practitioners/introduction-study-design-css

Hemingway, P., & Brereton, N. (2009). *What is a systematic review?* (2nd ed.). Retrieved from http://www.medicine.ox.ac.uk/bandolier/painres/download/whatis/syst-review.pdf

Hill, B. A. (1965). The environment and disease: Association or causation? *Proceedings of the Royal Society of Medicine, 58,* 295-300.

Ingram, D. K. (1999). Design of cross-sectional, longitudinal, and sequential studies in gerontology. In B.P. Yu (Ed.), *Methods in aging research* (pp. 25-42). New York, NY: CRC Press.

Kandula, N. R., & Lauderdale, D. S. (2005). Leisure time, non-leisure time, and occupational physical activity in Asian Americans. *Annals of Epidemiology, 15,* 257-265.

Kokkinos, P., Myers, J., Faselis, C., Panagiotakos, D. B., Doumas, M., Pittaras, A., … Fletcher, R. (2010). Exercise capacity and mortality in older men: A 20-year follow-up study. *Circulation, 122,* 790-797.

Kowalski, K., Rhodes, R., Naylor, P., Tuokko, H., & Macdonald, S. (2012). Direct and indirect measurement of physical activity in older adults: A systematic review of the literature. *International Journal of Behavioral Nutrition and Physical Activity, 9,* 148.

Kritz-Silverstein, D., Barrett-Connor, E., & Corbeau, C. (2000). Cross-sectional and prospective study of exercise and depressed mood in the elderly: The Rancho Bernardo Study. *American Journal of Epidemiology, 153*(6), 596-603.

Ku, P., Fox, K. R., & Chen, L. (2009). Physical activity and depressive symptoms in Taiwanese older adults: A Seven-Year Follow-up Study. *Preventative Medicine, 48,* 250-255.

Ku, P., Stevinson, C., & Chen, L. (2012). Prospective associations between leisure-time physical activity and cognitive performance among older adults across an 11-year period. *Journal of Epidemiology, 22*(3), 230-237.

Lampinen, P., Heikkinen, R. L., Kauppinen, M., & Heikkinen, E. (2006). Activity as a predictor of mental-well-being among older adults. *Aging & Mental Health, 10*(5), 454-466.

Lan, T., Chang, H., & Tai, T. (2006). Relationship between components of leisure physical activity and mortality in Taiwanese older adults. *Preventive Medicine,* 43, 36–41. *Journal of American Geriatric Society, 55,* 1836-1841.

Lang, I. A., Guralnik, J. M., & Melzer, D. (2007). Physical activity in middle-aged adults reduces risks of functional impairment independent of its effect on weight. *Journal of American Geriatric Society, 55,* 1836-1841.

Larson, E. B., Wang, L., Bowen, J. D., McCormick, W., Teri, L., Crane, P., & Kukull, W. (2006). Exercise is associated with reduced risk for incident dementia among persons 65 years of age and older. *Annals of Internal Medicine, 144,* 73-81.

Laurin, D., Verreault, R., Lindsay, J., MacPherson, K., & Rockwood, K. (2001). Physical activity and risk of cognitive impairment and dementia in elderly persons. *Archives of Neurology, 58,* 498-504.

Lee, Y., & Hung, W. (2011). The relationship between exercise participation and well-being of the retired elderly. *Aging and Mental Health, 15*(7), 873-881.

Lee, P., Lan, W., & Lee, C. L. (2012). Physical activity related to depression and predicted mortality risk: Results from the Americans' Changing Lives Study. *Educational Gerontology, 38,* 678–690.

Lee, I., & Paffenbarger, R. S., Jr. (2000). Associations of light, moderate, and vigorous intensity physical activity with longevity: The Harvard Alumni Health Study. *American Journal of Epidemiology, 151*(3), 293-299.

Lee, C., & Russell, A. (2003). Effects of physical activity on emotional well-being among older Australian women cross-sectional and longitudinal analyses. *Journal of Psychosomatic Research, 54,* 155-160.

Levin, K. A. (2006). Study design III: Cross-sectional studies. *Evidence-Based Dentistry, 7,* 24-25. doi:10.1038/sj.ebd.6400375

LicSc, M. A., & Parkatti, T. (2011). Independent and combined association of physical activity and cardiac disease on mortality risk in the very old. *Journal of Aging and Health, 23*(1) 70–85.

Lin, Y., Huang, Y., Lu, F., Wu, J., Chang, C., & Yang, Y. (2011). Non-leisure time physical activity is an independent predictor of longevity for a Taiwanese elderly population: An eight year follow-up study. *BMC Public Health, 11,* 428.

Lindwall, M., Larsman, P., & Hagger, M. S. (2011). The reciprocal relationship between physical activity and depression in older European adults: A prospective cross-lagged panel design using SHARE data. *Health Psychology, 30*(4), 453-462.

Lipsey, M. W. (1990). *Design sensitivity: Statistical power for experimental research.* Newbury Park, CA: Sage Publications.

Manini, T. M., Everhart, J. E., Patel, K. V., Schoeller, D. A., Colbert, L. H., Visser, M., … Harris, T. B. (2006). Daily activity energy expenditure and mortality among older adults. *Journal of the American Medical Association, 296,* 171-179.

Mann, C. J. (2003). Observational research methods. Research Design II: Cohort, cross-sectional, and case-control. *Emergency Medicine, 20*, 54-60.

Manson, J. E., Greenland, P., LaCroix, A. Z., Stefanik, M. L., Mouton, C. P., Oberman, A., … Siscovick, D. S. (2002). Walking compared with vigorous exercise for the prevention of cardiovascular events in women. *New England Journal of Medicine, 347*(10), 716-725.

Martin, H. J., Syddall, H. E., Dennison, E. M., Cooper, C., & Sayer, A. A. (2008). *Relationship between customary physical activity, muscle strength and physical performance in older men and women: Findings from the Hertfordshire Cohort Study.* doi:10.1093/ageing/afn148

McCall, R. B. (1977). Challenges to a science of developmental psychology. *Child Development*, *48*, 333-344.

McTierman, A., Kooperberg, C., White, E., Wilcox, S., Coates, R., Adams-Campbell, L. … Ockene, J. (2003). Recreational physical activity and the risk of breast cancer in postmenopausal women: The Women's Health Initiative Cohort Study. *Journal of the American Medical Association, 290,* 1331-1336.

Menec, V. H. (2003). The relation between everyday activities and successful aging: A 6-year longitudinal study. *Journal of Gerontology, 58B*(2), S74-S82.

Middleton, L. E., Barnes, D. E., Lui, L., & Yaffe, K. (2010). Physical activity over the life course and its association with cognitive performance and impairment in old age. *Journal of the American Geriatrics Society, 58,* 1322-1326.

Morgan, K., & Bath, P. A. (1998). Customary physical activity and psychological wellbeing: A longitudinal Study. *Age and Ageing, 27*(3), 29-34.

Mullee, M. A., Coleman, P. G., Briggs, R. S. J., Stevenson, J. E., & Turnbull, J. C. (2010). Self-rated activity levels and longevity: Evidence from a 20 year longitudinal study. *International Journal of Aging and Human Development, 67*(2), 171-186.

Mummery, K., Schofield, G., & Caperchione, C. (2004). Physical activity and dose-response effects on mental health status in older adults. *Australian and New Zealand Journal of Public Health, 28*(2), 188-192.

Ottenbacher, A. J., Snih, S. A., Karmarkar, A., Lee, J., Samper-Ternent, R., Kumar, A., … Ottenbacher, K.J. (2012). Routine physical activity and mortality in Mexican Americans aged 75 and older. *Journal of American Geriatrics Society, 60,* 1085–1091.

Paganini-Hill, A., Kawas, C. H., & Corrada, M. M. (2010). Activities and mortality in the elderly: The Leisure World Cohort Study. *Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 66A*(5), 559–567.

Pallant, J. (2005). *SPSS survival manual: A step by step guide to data analysis using SPSS for Windows* (version 12; 2nd ed.). Crows Nest, New South Wales, Australia: Allen & Unwin.

Parrish, R.G. (2010). Measuring population health outcomes. *Preventing Chronic Disease, 7*(4), A71.

Pasco, J. A., Williams, L. J., Jacka, F. N., Henry, M. J., Coulson, C. E., Brennan, S. L., … Berk, M. (2011). Habitual physical activity and the risk for depressive and anxiety disorders among older men and women. *International Psychogeriatrics, 23*(2), 292-298.

Peterson, M. J., Giuliani, C., Morey, M. C., Pieper, C. F., Evenson, K. R., Mercer, V., Cohen, H. J., … Simonsick, E. M. (2009). Physical activity as a preventative factor for frailty: The Health, Aging, and Body Composition Study. *Journal of Gerontology, 64A*(1), 61-68.

Plow, M. A., Allen, S. M., & Resnik, L. (2010). Correlates of physical activity among low-income older adults. *Journal of Applied Gerontology, 30*(5), 629-642.

Poth, C. (2009). *Meta-analysis, systematic review, or scoping review? Comparing methodologies in educational research.* Paper presentation to the XXXVIIth Annual Confere of the Canadian Society for the Student of Education at Carleton University, Ottawa, Ontario, Canada.

Salguero, A., Martínez-García, R., Molinero, O., & Márquez, S. (2011). Physical activity, quality of life and symptoms of depression in community-dwelling and institutionalized older adults. *Archives of Gerontology and Geriatrics, 53,* 152-157.

Samitz, G., Egger, M., & Zwahlen, M. (2011). Domains of physical activity and all-cause mortality: Systematic review and dose-response, meta-analysis of cohort studies. *International Journal of Epidemiology, 40,* 1382-1400.

Sampaio, P. Y. S., & Ito, E. (2012). Activities with higher influence on quality of life in older adults in Japan. *Occupational Therapy International, 20,* 1-10.

Santos, D. A., Silva, A. M., Baptista, F., Santos, R., Vale, S., Mota, J., & Sardinha, L. B., (2012). Sedentary behavior and physical activity are independently related to functional fitness in older adults. *Experimental Gerontology, 47,* 908-912.

Shah, R. C., Buchman, A. S., Leurgans, S., Boyle, P. A., & Bennett, D. A. (2012). Association of total daily physical activity with disability in community-dwelling older persons: A prospective cohort study. *Geriatrics, 12,* 63.

Smith, T. L., Masaki, K. H., Fong, K., Abbott, R. D., Ross, G. W., Petrovitch, H., Blanchette, P. L., & White, L. R. (2010). Effects of walking distance on 8 year depressive symptoms in elderly men with and without chronic disease: The Honolulu-Asia Aging Study. *Journal of American Geriatric Society, 58,* 1447-1452.

Stessman, J., Hammerman-Rozenberg, R., Cohen, A., Ein-Mor, E., & Jacobs, J. M. (2009). Physical activity, function, and longevity among the very old. *Archives of Internal Medicine, 169*(16), 1476-1483. Retrieved from http://www.nutrociencia.com.br/upload_files/artigos_download/atividade% 20fisica% 20terceira% 20idade.pdf

Strawbridge, W. J., Deleger, S., Roberts, R. E., & Kaplan, G. (2002). Physical activity reduces the risk of subsequent depression for older adults. *American Journal of Epidemiology, 156*(4), 328-334.

Sun, Q., Townsend, M. K., Okereke, O. I., Franco, O. H., Hu, F. B., & Grodstein, F. (2010). Physical activity at midlife in relation to successful survival in women at age 70 years or older. *Archives of Internal Medicine, 170*(2), 194-201.

Sundquist, K., Qvist, J., Sundquist, J., & Johansson, S. (2004). Frequent and occasional physical activity in the elderly: A 12-year follow-up study of mortality. *American Journal of Preventive Medicine, 7*(1), 22–27.

Taaffe, D. R., Masaki, K. H., Abbott, D., Petrovitch, H., Ross, G. W., & White, L. R. (2008). Physical activity, physical function, and incident dementia in elderly men: The Honolulu-Asia Aging Study. *Journal of Gerontology, 63A*(5), 529-535.

Theou, O., Stathokostas, L., Roland, K. P., Jakobi, J. M., Patterson, C., Vandervoort, A. A., & Jones, G. R. (2011). The effectiveness of exercise interventions for the management of frailty: A systematic review. *Journal of Aging Research,* 1-19. doi:10.4061/2011/569194

Ueshima, K., Ishikawa-Takata, K., Yorifuji, T., Suzuki, E., Kashima, S., Takoa, S., … Doi, H. (2010). Physical activity and mortality risk in the Japanese elderly: A cohort study. *American Journal of Preventative Medicine, 38*(4), 410-418.

Usman, L. S. (2011). Systematic reviews and meta-analyses. *Journal of Canadian Academy of Child and Adolescent Psychiatry, 20*(1), 57-59.

Weuve, J., Kang, J. H, Manson, J. E., Breteler, M. M. B., Ware, J. H., & Grodstein, F. (2004). Physical activity, including walking, and cognitive function in older women. *Journal of the American Medical Association, 292, 1*452-1461.

Wilson, D. B. (n.d.). *Practical meta-analysis effect size calculator.* Retrieved from http://www.campbellcollaboration.org/escalc/html/EffectSizeCalculator-SMD5.php

Woo, J., Ho, S. C., & Yu, A. L. M. (2002). Lifestyle factors and health outcomes in elderly Hong Kong Chinese aged 70 years and over. *Gerontology, 48,* 234–240.

Yaffe, K., Barnes, D., Nevitt, M., Lui, L., & Covinsky, K. (2001). A prospective study of physical activity and cognitive decline in elderly women. *Archives of Internal Medicine, 161,* 1703-1708.

Yorston, L. C., Kolt, G. S., & Rosenkranz, R. R. (2012). Physical activity and physical function in older adults: The 45 and up study. *Journal of the American Geriatrics Society, 60,* 719-725.

# Appendix A. Cross-Sectional Data Table

| Publica-tion | Focus of Study | Target population | Sample Size | PA Instrument | Health Outcomes | Measures | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| George et al. (2012) | To investigate the association between levels of PA and psychological distress in older men. | Random sample of men age ≥65 yr old drawn from a large-scale Australian cohort study of people age 45 years and over. | N= 17,689 | **PA:** Questions in this survey related to an individual's participation in different types of PA, with a reference period of the previous week. A session of PA was defined as walking continuously for at least 10 min (for recreation or exercise or to get to or from places), vigorous PA (that made you breathe harder or puff and pant, such as jogging, cycling, aerobics, and competitive tennis but not household chores or gardening), and moderate PA (like gentle swimming, social tennis, vigorous gardening, or work around the house). Participants indicated the number of times, as well as the total time (in minutes) they participated in each of these different types of activity. A weighted weekly average number of PA sessions was calculated by summing total number of sessions, with vigorous-activity sessions given a weighting factor of 2, compared with walking and moderate sessions. PA sessions were divided into zero and quartiles of 1–6, 7–10, 11–15, and 16 or more sessions per week. The Active Australia Survey has been found to have a acceptable test-retest reliability and has been used in a number of Australian population surveys. PA was categorized into sessions, as opposed to total time spent (minutes/hours) for each activity to ensure consistency across different versions of the 45 and Up Study baseline questionnaire. | **EMOTIONAL WELL-BEING:** Psychological distress was evaluated using the Kessler-10 scale (K-10). The K-10 consists of 10 items designed to assess the occurrence of negative emotional states, including depressive symptoms and anxiety, in the previous 4 weeks. Participants were asked about the frequency (over the past 4 weeks) of feeling tired out for no good reason, nervous, so nervous that nothing could calm them down, hopeless, restless or fidgety, so restless that they could not sit still, depressed that everything was an effort, so sad that nothing could cheer them up, and worthless. The total score was categorized into one of four groups: Low psychological distress was indicated by a K-10 score of 10–15, while moderate psychological distress was indicated by a score of 16–21. A K-10 score of 22–29 indicated high psychological distress, and very high psychological distress was indicated by a score of 30 or higher. | • Age<br>• Housing location<br>• Income<br>• Educational levels<br>• Relationship status<br>• Function-al limitation<br>• BMI<br>• Current employment status<br>• Possession of health care card<br>• Alcohol consumption<br>• Smoking status<br>• Country of birth + language<br>• Physical activity | • Multi-variable logistic regression | • Compared with men who engaged in no sessions of PA in the previous week, those who engaged in one to six sessions were 34% less likely to report high or very high levels of psychological distress (OR=0.66, 95% CI .51–.85). Men engaging in 7–10 sessions were 39% less likely to report high or very high psychological distress (OR .61, 95% CI .47–.80), while those engaging in 11–15 and 16 or more sessions of PA were 37% (OR .63, 95% CI .48–.84) and 43% (OR .57, 95% CI .43–.79) less likely to report these high levels, respectively (trend-test p = .008).<br>• Excluding functional limitation from the multivariable model produced ORs ranging from 0.42 (95% CI .33–.54, P<0.001) for 1–6 sessions to 0.30 (95% CI .22–.40, P<0.001) for ≥16 sessions of PA in the past week, in comparison with the reference category. | • The 45 and Up Study baseline questionnaire was only available in English. The data are likely to underestimate this effect, given the exclusion of people who were unable to complete the questionnaire in English.<br>• The self-report measures of PA may bias the results due to social desirability response, recall bias or lack of understanding questions<br>• The reference period for the questions used in the 45 and Up baseline questionnaire was 1 week, and while this may not necessarily be indicative of usual participation in PA.<br>• The use of sessions per week of PA, rather than time spent in various types of activity, was a potential limitation of the study.<br>• Due to the nature of cross-sectional analyses of the current study, the authors were not able to establish potential cause-and-effect relationships with these data.<br>• Participants were randomly sampled from the national universal health insurance (Medicare Australia) database. Therefore, participants who did not have insurance were not considered into the study.<br>• Results are not generalizable to women or ethnic groups. | • There was a weak-moderate inverse association between increasing levels of PA and less likelihood of reporting high or very high psychological distress after adjusting for demographic and health-related factors.<br>• There was an inverse strong association between increasing levels of PA and less likelihood of reporting high or very high psychological distress when functional limitation was removed from the multi-variable model. |

| Publica-tion | Focus of Study | Target population | Sample Size | PA Instrument | Health Outcomes | Measures | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Lee & Hung (2011) | To examine the relationships between exercise intensity, exercise frequency, and feelings of well-being of the elderly. | Proportional quota sampling of male and female adults ≥ 60 years old living in Taipei. | N=352 | **Exercise intensity:** Light PA defined as requiring less than three Metabolic equivalents (METs). Moderate-intensity required three to six METs, while vigorous activities required more than six METs. The study adopted self-reporting to describe the exercise intensity. Respondents were asked to report the exercise they engaged as being easy, little hard (some sweating, heart rate increased slightly), and hard (sweating, out of breath, heart rate increased). The levels of self-reported intensity were then coded into three categories: low (scored 1), moderate (scored 2), and high (scored 3).<br>**Exercise frequency:** The respondents were asked to give information on exercise types, duration of exercise in minutes each time, exercise days per week, and exercise months per year. Average hours of exercise per week were calculated for each respective exercise, and then summed up for all the exercises the respondents engaged in.<br>**Exercise participation level:** was calculated from a combination of exercise intensity and frequency. The average hours of exercise per week were weighted by being multiplied the exercise intensity scores. The PA instrument was pre-tested with a sample of 100 elderly people. Based on the results of the pilot study, certain items were revised and changes were made to the questionnaire format. | **EMOTIONAL WELL-BEING:** The General Well-Being (GWB) schedule developed by Dupuy (1977) was used to measure the well-being of the respondents. The GWB scale has been used and examined by a number of researchers and both the reliability and the validity of the scale were found to be good (McDowell & Newell, 1996). The scale consists of 18 items including six dimensions of anxiety, depression, general health, positive well-being, self-control, and vitality. The first 14 items use a six-point scale, and the final four items use a 0–10 rating scale defined by differential adjectives at each end. A total score is calculated by summing up the individual score on each item, with lower scores indicating more severe distress. There are three levels of distress according to the total score: 0–60 reflect 'severe distress'; 61–72 'moderate distress'; and 73–110 'positive well-being'. The well-being scale was examined by five scholars to check face validity and content validity of the questionnaires. All the items were translated into Chinese and then back-translated to English again by two bilingual researchers. | • Age<br>• Gender<br>• Monthly disposable income<br>• Marital status<br>• Living arrangement<br>• Educational level<br>• Exercise participation level | • Regres-sion analyses | • The regression analysis showed that exercise frequency had a significantly positive effect on well-being (β=0.13, p<0.01), and on three dimensions 'depression (β=0.12, p<0.05)', 'positive well-being (β=0.18, p<0.01)', and 'vitality (β=0.18, p<0.001)'.<br>• In contrast, it was found that exercise intensity had a significantly negative effect on well-being (β= -0.22, p<0.001), and on all the six dimensions. | • The sample of this study was limited to the elderly in public parks, excluding those who did not go to parks.<br>• Small sample size<br>• Popular exercise engaged in by the Taiwanese elderly such as Tai-chi or Yuanji were not included in the ACSM list to choose from. Therefore, PA results may be underreported.<br>• Crude choices for respondents to report exercise intensity.<br>• Because PA was self-reported, analysis indicates that there were significant differences between the profiles of respondents and their perceptions of exercise intensity. Therefore, respondents under estimated their intensity of exercise.<br>• Difficulty recalling type and number of times (frequency) exercise per days/week and per month/year.<br>• Results may not be generalizable to other ethnic groups.<br>• Elderly Taiwan OA are more active than younger people. Therefore, results may be biased and not generalizable to other groups of people.<br>• PA instrument was self-reported therefore possibility of social desirability response.<br>• Due to the nature of cross-sectional analyses of the current study, the authors were not able to establish potential cause-and-effect relationships with these data. | • There was a weak-moderate positive association between exercise frequency and on well-being.<br>• There was a weak-moderate inverse association between exercise intensity and well-being |

| Publication | Focus of Study | Target population | Sample Size | PA Instrument | Health Outcomes | Measures | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Mummery et al. (2004) | To examine the dose-response relationship between PA and mental health, comparing two recommended levels of PA involvement (150 minutes/ week vs. 420 minutes/ week) | Independent living OA ranging from 55 to 89 years of age. | N=312 | **PA:** measured by the Active Australian questionnaire. It comprises 12 questions that assesses the number of sessions and total time spent doing activities during the previous week. The activity compendium in the survey includes walking for recreation, exercise or transport; moderate intense PA such as swimming, and social tennis; vigorous-intensity PA such as jogging, cycling, aerobics, competitive tennis, and vigorous intensity gardening or heavy yard work. All resultant data were coded using established procedures with data being truncated using the criteria specified by Armstrong et al in order to avoid measurement error due to over-reporting. The max time spent in any type of PA was truncated to 14 hours per week and the max allowable total hours per week in all activities was 28 hours per week. Test retest reliability of the instrument in an older population has been previously established at 0.54. Additionally, the measure has been shown to have accepted convergent validity with established health surveys utilized in Australia and has been recommended for use in population-based, health related PA research in Australia. Individuals were categorized as being (a) inactive, (b) moderately active, or (c) highly active based on the total minutes of moderate to vigorous PA collected by means of the Active Australia Questionnaire. Inactive participants were those who reported < 150 min of moderate and/or vigorous intensity PA per week. Participants were classified as moderate active if they reported between 150 to 420 min per week. According to the Australian National Physical Activity Guidelines, people accumulating more than 150 min per week are thought to be gaining sufficient activity for health benefit. To investigate the effects of increased dose recommended by the Institute of Medicine, participants accumulating more than 420 minutes per week were classified as highly active. | **EMOTIONAL WELL-BEING:** The SF-12 questionnaire was used to assess health status of the participants. The SF-12 is a multi-purpose, generic measure of health status that has become one of the widely used instruments in the world for the study of health status in general and specific populations. The SF-12 allows for the construction of summary measures that assess the physical (PCS) and mental (MCS) health status of the participant. The physical health measure is the summary of six separate questions assessing physical functioning, role-function, bodily pain and general health. The mental health summary scale is the summary measure of the combination of six questions which assess vitality, social functioning, role-emotional and mental health. Scores were transformed into standardized T scores (M=50, SD=10) where higher scores indicate better functioning. Test retest reliability within two week time interval has been established as 0.89 for the PCS summary scale and 0.76 for MCS summary scale. Relative validity coefficients, measured with a known groups procedure, have been reported ranging from 0.43 to 0.78 for the PCS summary scale and 0.93 to 0.98 MCS summary scale | • Age<br>• Gender<br>• Marital status<br>• Education<br>• Retired or pensioner<br>• Residential location<br>• Median minutes of PA/week | • Two-way ANOVA<br>• ANCOVA | Results of the ANOVA examining differences in mental health status (MCS) between activity classifications (moderately active and highly active) revealed no significant main effects for activity classification or gender or significant activity by gender interaction. | • Selection bias may have occurred when choosing sample. Did not include OA who did not have a phone, who lived in a nursing home, or lived in collective dwellings.<br>• Small sample size<br>• Most of the sample was married (58%) therefore result may be biased as married people have better mental health and are found to exercise more than single or widowed people.<br>• Cross-sectional survey that cannot yield a definitive causal relationship between PA and mental health status in OA.<br>• Low validity of PA instrument. Test retest reliability of the instrument in an older population has been previously established at 0.54. | • There was no reliable dose-response effect observed when considering mental health (MCS). |

| Publication | Focus of Study | Target population | Sample Size | PA Instrument | Health Outcomes | Measures | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Middleton et al. (2010) | To examine how PA at several points over the life course is related to cognitive impairment in old age. | Women aged 65 and older recruited from four metropolitan areas in the United States: Baltimore, Maryland; Minneapolis, Minnesota; Portland, Oregon; and Monongahela Valley, Pennsylvania who self-reported teenage, age 30, age 50, and late-life PA. | N=9344 | **PA:** Participants were asked about teenage, age 30, age 50, and current (late life) yearly frequencies of low- (e.g., walking or gardening), moderate- (e.g., dancing or tennis), or high-intensity (jogging or skiing) physical activities using a modified Paffenbarger questionnaire. In preliminary analyses, there was no evidence of a dose response between PA at any age (according to frequency or intensity) and cognition or odds of cognitive impairment. As a result, the participants were dichotomized at each age into women who were physically active and inactive (those who reported no regular participation in any PA or sport at the relevant age) for the final analyses. | **Cognition:** Clinic staff administered a 26-point modified Mini-Mental State Examination (mMMSE) to assess cognitive function. The mMMSE is a brief test of global cognitive function that evaluates orientation, concentration, praxis, and memory and is based on the Mini-Mental State Examination (MMSE) but omits questions regarding language. Significant cognitive impairment was defined as an mMMSE score at least 1.5 standard deviations (SDs) below the mean (mMMSE score ≤ 22). | • Age<br>• Race<br>• Years of education<br>• Smoked cigarettes<br>• Marital status<br>• Living arrangements<br>• BMI<br>• Medical history<br>• Blood pressure<br>• Depressive symptoms | • Multiple linear regressions<br>• Multiple logistic regressions | • Women who were physically active at each age were less likely to have cognitive impairment in late life than those who were inactive in adjusted analyses (teenage: 8.5% vs. 16.7%, odds ratio (OR) =0.65, 95% CI=0.53–0.80. P<0.001; age 30: 8.9% vs. 12.0%, OR=0.80, 95% CI=0.67–0.96, P<0.05; age 50: 8.5% vs. 13.1%, OR=0.71, 95% CI= 0.59–0.85, P<0.001; late life: 8.2% vs. 15.9%, OR=0.74, 95% CI=0.61–0.91, P<0.001).<br>• When PA status for all four ages were entered into a single model, teenage PA status was most strongly associated with lower odds of cognitive impairment (OR=0.73, 95% CI=0.58– 0.92); the association between PA status at other ages and the odds of cognitive impairment were not statistically significant.<br>• Women who were physically inactive at teenage but became physically active at 30 and 50 had significantly lower odds of cognitive impairment than those who remained physically inactive. In contrast, being physically active at 30 and 50 was not significantly associated with rates of cognitive impairment in women who were already physically active at teenage. | • Self-reports of PA, which may not be highly accurate, were relied on. In particular, non-exercise PA, such as daily chores and child rearing, may not have been adequately captured, underestimating PA levels.<br>• People who were cognitively impaired may also have been more likely to misreport PA levels, which may bias results.<br>• There was no clinical assessment for cognitive impairment, so some women may have been misclassified, and the etiology of the cognitive impairment is not certain.<br>• The mMMSE is a simple test of cognitive function that may not be sensitive enough to distinguish subtle changes in cognition, especially at higher levels of cognitive functioning. This may account for the lack of dose response between PA and cognition in these analyses.<br>• Most of the subjects in the sample were white women, so it is unknown whether the findings are generalizable to men or people from other ethnic groups.<br>• Due to the nature of cross-sectional analyses of the current study, the authors were not able to establish potential cause-and-effect relationships with these data. | • There was a weak-moderate inverse association between women who were physically active at each age and the less likelihood to have cognitive impairment in late life. |

| Publication | Focus of Study | Target population | Sample Size | PA Instrument | Health Outcomes | Measures | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Benedict et al. (2012) | To examine the association between self-reported PA and both cognitive performance and brian morpho-metry. | OA aged 75 years or older. | N=331 | **PA:** was divided into light and hard exercise and classified as the number of activities with duration of at least 30 minutes per week. The participants were asked how many times per week they performed light (e.g., walking, gardening) or hard exercise (e.g., running, swimming) for at least 30 minutes. Based on the responses to these questions, 4 PA categories were constructed: very low, low, medium, and high. The questions used here to assess PA have been validated elsewhere. | **COGNITION:** included the MMSE to ascertain the overall cognitive status, a categorical verbal fluency task during which the subject named as many different animals as possible in 1 minute, and the Trail-Making (TMT) A and B subtests to assess executive functions. **MRI Acquisition and Processing:** At the age of 75 years, a high resolution 3-D T1- weighted "Turbo Field Echo" (TFE) scan was acquired using a Philips 1.5 Tesla scanner (Gyroscan NT, Philips Medical Systems, Best, The Netherlands). A sagittal 3-D gradient echo sequence with TR (time of repetition) 8.6 ms, TE (echo time) 4.0 ms, flip angle 8°, field of view of 240mm, slice thickness 1.2 mm, and in-slice resolution 0.94mm2 was used. Images were processed using voxel-based morphometry (VBM), a technique that used statistical parametric mapping (SPM) to determine local concentrations of gray matter volumes on a voxel-by-voxel basis. Gray matter was calculated by segmenting it from white matter and cerebrospinal fluid using the unified segmentation approach. Following this segmentation procedure, probability maps of gray matter were "modulated" to account for the effect of spatial normalization, by multiplying the probability value of each voxel by its relative volume in native space before and after warping.Gray matter images based on probability maps at each voxel were normalized into Montreal Neurological Institute (MNI) standard space with a voxel size of 2 x 2 x 2 mm. Modulated images were smoothed with an 8-mm full width half maximum (FWHM) Gaussian kernel, in line with other recent VBM studies. This smoothing kernel was applied prior to statistical analysis, to reduce signal noise and to compensate for image variability. VBM analyses were carried out using SPM8. | • Sex<br>• Education<br>• BMI<br>• Diabetic<br>• Fasting plasma glucose levels<br>• Serum low-density lipoprotein cholesterol<br>• Mean arterial blood pressure<br>• Abdominal visceral fat volume<br>• Physical activity | • Multi-variate linear regression | • A linear regression analyses revealed a positive association between the greater PA and the categorical verbal fluency task (β= 0.147, p=0.007). Moreover, the completion time for the TMT-B (β= -0.181, P, 0.001) was inversely associated with higher PA (i.e., OA who reported more frequent PA per week needed less time to complete this memory task, indicating a better memory performance).<br>• The level of self-reported PA was positively correlated with brain volume (β=0.169, p=0.002), white matter (β= 0.143, p=0.009, and parietal lobe grey matter volume (β=0.120, p=0.028) situated bilaterally at the precunes. | • Self-reported PA may bias results.<br>• PA, in contrast to physical fitness, was used in this study. Thus, the design does not inform the reader about the influence of fitness on cognitive ability and brain structure in elderly, as fitness and physical activity can be uncorrelated (e.g., someone can be active but not have high aerobic fitness).<br>• The cross-sectional nature of the data do not allow resolution of the interrelationships among PA, education, and body mass index in the context of a prospective cohort study.<br>• A methodological limitation that warrants attention when interpreting these results is that lesions in white matter have an intensity similar to gray matter, and thus would not have been included in the final white matter maps.<br>• Small sample size<br>• Moderate exercise was not considered for PA only light and hard exercise thus may over or underestimate intensity of PA. | • There was a weak-moderate positive association between greater PA and the higher levels of categorical verbal fluency and a weak-moderate inverse association between shorter time to complete Trail Making test (indicating better performance) and higher PA.<br>• There was a positive weak association between the level of PA and the regional brain volume, white matter, and parietal lobe gray matter volume situated bilaterally in the precuneus. |

| Publica-tion | Focus of Study | Target population | Sample Size | PA Instrument | Health Outcomes | Measures | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Buchman et al. (2008). | To test the hypothesis that total daily PA is related to the level of cognition in OA. | Subjects aged 65 years and older participating in the Rush Memory and Aging project study. | N= 521 | **PA:** was quantified using Actical, similar in size to a wristwatch and placed on the non-dominant wrist for 10 days. Actical contains a piezoelectric accelerometer to measure movement. These measures do not directly correspond to observed movements but are proportional to the degree and intensity of movements as reflected in recorded activity curves. The activity curve for each 1-second sample is integrated and the area stored as "activity counts". Activity counts are summed for each epoch (15 second) and valued at zero if there is no activity. Total daily activity was the sum of all activity counts during a 24-hour period. Activity was summed from all nonzero epochs during 24 hours, divided by the number of hours with activity, to yield activity/ active hours. This provides an index of the intensity of activity. Mean activity was also calculated for count per epoch as counts/epoch. | **COGNITION:** Trained technicians administered 19 cognitive tests from which a composite measure of global cognition and subscale measures of episodic memory, semantic memory, working memory, perceptual speed, and visuospatial abilities were constructed. DEMENTIA: was diagnosed in a three-step process. Cognitive testing was scored by computer and reviewed by a neuropsychologist to diagnose cognitive impairment. Participants were then evaluated by a physician who used all cognitive and clinical data to diagnose dementia. | • Age<br>• Gender<br>• Education<br>• BMI<br>• Physical activity<br>• Parkinson's disease<br>• Physical frailty<br>• Lower extremity performance<br>• Depression<br>• Number of vascular risk factors<br>• Number of vascular diseases | • Linear regression model<br>• Spear-man's correlation analysis | • Controlling for age, sex, and education, total daily activity showed a linear association with global cognition (Estimate, 0.071, SE= 0.015, p<0.001).<br>• The association of PA varied with five subscales including: episodic memory, semantic memory, working memory, perceptual speed, and visuospatial abilities. Total daily activity had a linear association with all five subscales, and an additional nonlinear association with perceptual speed and visuospatial abilities, respectively (Estimate, -0.045, SE=0.013, P=0.001; Estimate, -6.394, SE=3.129, P<0.042). | • Study used a volunteer cohort whose level of activity may not be representative of the general population, so the results need to be repeated in a more diverse cohort.<br>• Actical has a number of limitations: it cannot identify the types of activity being performed; level of activity varies with where the device is placed on the body; any acceleration causes increased activity; and removal of the device during the recording period cannot be differentiated from "no activity" during sleep.<br>• The present study is cross-sectional therefore limits the ability to infer casual directions.<br>• Using actical as an indicator of PA, may encourage participants to exercise more that usual, given the participants know their activity is being recorded for 10 days.<br>• Fairly small sample size<br>• Non-validated cognitive instrument | • There was a weak positive association between total daily activity and global cognition.<br>• There was a weak inverse association with perceptual speed and a strong inverse association with visuospatial abilities. |

| Publica-tion | Focus of Study | Target population | Sample Size | PA Instrument | Health Outcomes | Measures | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Martin et al. (2008). | To investigate the relationship between customary PA, muscle strength and physical performance in older men and women. | Older women and men residents born from 1931 and 1939 in West Hertfordshire. | N= 504 | **PA:** A 69-item validated self-administered questionnaire [Hertfordshire Physical Activity Questionnaire (HPAQ)] based on the Minnesota instrument which assessed activity over the previous 12 months. Respondents indicated whether they participated in each activity (yes/no), and if yes, ticked the months during which they did it and gave the typical duration of time spent doing it (in hours and minutes). | **PHYSICAL FUNCTION:** Hand Grip Strength: using the Jamar hand-grip dynamometer.<br>Short Physical Performance test: battery of tests comprising of 3 meter customary walking pace, 5 sit-stand chair rises time and timed one-legged balance. | • Age<br>• Gender<br>• Height<br>• Weight<br>• Physical activity | • ANOVA<br>• Linear regression<br>• Logistic regression | • Higher levels of customary PA were associated with significantly higher muscle strength and better physical performance among women but not men.<br>• In women, increasing gardening activity was associated with stronger grip strength, quicker 3-m walk, and chair rises test times and better balance [Average change (95% CI) in grip per increased band of gardening activity: 1.02 kg (0.43, 1.61) P = 0.001 for women; average change (95% CI) in 3 m walk time per increased band of gardening activity: −0.10 (−0.17, −0.03) P = 0.006 for women; average change (95% CI) in chair rises time per increased band of gardening activity: −0.11 SD units (−0.22, 0.00) P = 0.05 for women.<br>• Odds ratio (95% CI) for poor balance per increased band of gardening activity: 0.74 (0.57, 0.95) P = 0.02 for women).<br>• Grip strength (kg) for women "keep fit": 27.8 (4.9) vs. "indoors" 25.2 (5.7), P=0.0003; 3-m walk (s) "keep fit" 3.22 (0.50) vs. "indoors" 3.55 (0.70), P=0.0001 ; Chair rises (SDS) "keep fit" -0.36 (0.76) vs. "indoor" 0.17 (1.05), P=0.0001; Balance lost in < 5s "keep fit" 14 (16.5) vs. "indoor" 51 (28), P=0.05. | • Response bias may have occurred as men and women who progressed from home interview to clinic tended to smoke less, and had better self-reported function and general health than those participating only in the home interview.<br>• Recall bias may have occurred when indicating whether participants participated in each activity in each month and the duration of time spent doing the activity in hours and minutes.<br>• Small sample size for each gender group.<br>• Bias may have occurred from the questionnaire as it quantified overall energy expenditure rather than quantifying levels of specific category of activities.<br>• PA assessment involved low intensity exercise. | • There was a strong positive association between PA and grip strength.<br>• There was a strong inverse association between PA and 3M walk.<br>• There was a strong inverse association between PA and chair rises.<br>• There was a strong inverse association between PA and balance lost in <5 sec.<br>• There was a weak-moderate inverse association between increased gardening and lower poor balance for women only. |

| Publication | Focus of Study | Target population | Sample Size | PA Instrument | Health Outcomes | Measures | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Santos et al. (2012). | To examine the independent impact of objectively measured moderate-to-vigorous physical activity (MVPA) and sedentary time on functional fitness in OA. | Non-institutionalized independent physical functioning Portuguese OA aged 65 years or older | N= 312 | **PA:** assessed by accelerometry (ActiGraph, GT1M model, Fort Walton Beach, Florida). The accelerometer measures the acceleration of normal human movements ignoring high frequency vibrations associated with mechanical equipment. All participants were asked to use an accelerometer on the right hip, near the iliac crest during four consecutive days, including two weekdays and two weekend days. The devices were activated on the first day at 6.00 a.m., and data were recorded in 15-s epochs. The device activation and data download were performed using the software ActiLife Lifestyle (v.3.2; Fort Walton Beach, FL). Processing was done with the program MAHUffe v.1.9.0.3 from the original downloaded files. For the analyses, a valid day was defined as having 600 min (10 h) or more of monitor wear, corresponding to the minimum daily use of the accelerometer (Matthews et al., 2012). (Ward et al., 2005). Apart from accelerometer nonwear time (i.e., when it was removed for sleeping or water activities), periods of at least 60 consecutive minutes of zero activity intensity counts were also considered nonwear time. The study included the results from participants with at least three valid days (including one weekend day), with at least 10 h of wear time per day. Data processing resulted in the following variables: mean time (min/day) of sedentary, light PA, moderate PA, vigorous PA, MVPA and total PA intensity (counts/min/day). The cutoff values used to define the intensity of PA and therefore to quantify the mean time in each intensity (sedentary, light, moderate, or vigorous) were the following: sedentary =100 counts per minute, light=100–2019 counts per minute, moderate= 2020–5998 counts per minute (corresponding to 3–5.9 METs), and vigorous≥ 5999 counts per minute (corresponding to ≥ 6METs). To analyze the adherence to PA recommendations for public health we assessed the accumulation of at least 30 min/day of MVPA (Nelson et al., 2007). | **PHYSICAL FUNCTION:** Functional fitness was assessed according to the Senior Fitness Test (Rikli and Jones, 1999), which has been validated for the evaluation of functional fitness in community-dwelling OA. Physical fitness parameters selected were lower and upper body strength, lower and upper body flexibility, agility/dynamic balance and aerobic endurance. The items were evaluated, respectively, by the following tests: 30 s chair stand (repetitions), arm curl (repetitions), chair sit-and-reach (cm), back scratch (cm), 8-foot up-and-go (s), 6minute walk test (m) (6MWT). The result of each test was converted into a Z-score by gender. The Z-score is the number of standard deviations (SD) a specific value differs from the sample mean [Z-score= (observed-sample mean)/sample SD)]. The mean of the six Z-scores was used to compute an overall continuous measure of functional fitness. | • Age<br>• BMI<br>• Weight<br>• Height<br>• Sedentary time<br>• Physical activity (MVPA) | • Multiple regression analyses | • Sedentary time was inversely associated with the functional fitness composite Z-score (β=-0.002, 95% CI -0.002, -0.001, p<0.05,), even when adjusting for MVPA, gender, age, and accelerometer register time.<br>• MVPA was positively related to composite Z-score (β=0.004, 95% CI 0.001, 0.008, p<0.05) even after adjusting for the sedentary time, gender, age, and accelerometer register time. | • The cross sectional design of the study does not allow for conclusions about changes in PA or sedentary behavior and improved functional fitness.<br>• The use of accelerometers, although widely used for research proposes, are limited in assessing water activities, and other activities, namely, cycling, rowing, and some free weight exercises<br>• Strength and flexibility were part of the components evaluated as they may be determinant in the independence of the older adults<br>• Small sample size<br>• Only included non-institutionalized Portuguese OA.<br>• Sample recruitment was only carried out in senior universities, parish councils, city halls, day care centers and health promotion fairs. Therefore, limits individuals who don't attend these places.<br>• Wearing an accelerometer may encourage participants to be more active than usual.<br>• Although, all participants were asked to use an accelerometer during four consecutive days, including two weekdays and two weekend days, some participants may have forgotten to wear the accelerometer consecutively or at all. Therefore limiting results.<br>• Results may not be generalizable to other ethnic groups. | • There was a very weak inverse association between sedentary time and functional fitness.<br>• There was a very weak positive association between MVPA and functional fitness.<br>• Both results considered NS for this review. |

| Publication | Focus of Study | Target population | Sample Size | PA Instrument | Health Outcomes | Measures | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Yorston et al. (2012). | To determine the strength of the relationship between PA and physical function in OA. | OA aged ≥ 65 years living in New South Wales, Australia. | N=91,375 | **PA:** The Active Australia survey elicited information regarding participants' frequency, intensity, duration, and type of PA engagement. Participants indicated the number of times they engaged in different types of PA (leisurely, walking continuously for at least 10 minutes; vigorous, that makes one breathe harder or puff and pant; and moderate, e.g., gentle swimming, social tennis, vigorous gardening, or work around the house) and the hours and minutes spent doing each in the 7 days before questionnaire completion. Because current PA guidelines recommend 150 minutes of PA per week, participants were classified as sedentary (0 minutes), not meeting guidelines (1–149 minutes), or meeting guidelines (150 minutes). The Active Australia Survey exhibits good face and criterion validity and has been demonstrated to have acceptable test–retest reliability as a self-reported measure of PA. | **PHYSICAL FUNCTION:** measured using the Medical Outcomes Study Physical Functioning (MOS-PF) scale, which indicates how participants' health limits them in their daily functional activities. Based on their score, participants were classified as having severe functional limitation, significant functional limitation (21–40), moderate functional limitation (41–60), slight functional limitation (61–80), or no functional limitation (≥ 81). The MOS-PF is a valid and reliable measure of physical functioning. | • Age<br>• Sex<br>• Educational attainment<br>• Smoking history<br>• BMI<br>• Psychological distress<br>• Physical activity | • Bivariate Pearson product moment correlations and partial correlations<br>• Multivariate logistic regression | • A positive relationship was found between PA and physical function in this sample of OA (correlation coefficient = 0.166, P < .001).<br>• OA engaging in higher levels of PA had progressively lower likelihood of having a functional limitation than in the lowest tertile of PA engagement. The relationship between PA and functional limitation remained significant (middle tertile; AOR=0.48, 95% CI 0.46-0.50,p<0.01; highest tertile: AOR = 0.36, 95% CI = 0.34–0.37, p<0.001), albeit slightly weaker, when all other variables were accounted for (age, sex, educational attainment, smoking history, BMI, and psychological distress). | • The cross-sectional design of the study may partially limit the findings, in that cause-and-effect relationships could not be determined.<br>• The questionnaire was only available in English and hence excluded participants who didn't English.<br>• The 45 and Up Study questionnaire was based on self-report of participants, which is open to biased reporting.<br>• The authors accept that other variables, such as disease and disability, may also affect PA engagement and physical function of participants, as well as the relationship between the two, but it was not possible to compile an accurate variable of individual conditions based on the data available. | • There was a positive weak association between PA and physical function.<br>• There was an inverse moderate to strong association between OA engaging in higher levels of PA and lower likelihood of having functional limitation. |

| Publication | Focus of Study | Target population | Sample Size | PA Instrument | Health Outcomes | Measures | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Baker et al. (2009). | To examine the relationship between PA involvement and successful aging. | OA at least 60 years of age in all provinces and territories of the Canadian population | N = 12,042 | **PA:** examined using the CCHS's Physical Activity Index, a derived composite score categorizing respondents as inactive, moderately active, and active based on average daily energy expenditure values derived from participation in all forms of active leisure ranging from gardening and yard work to jogging and running. Energy expenditure was calculated using the frequency and duration of each session of PA, as well as the MET value of the activity. The MET is a value of the metabolic energy cost expressed as a multiple of the resting metabolic rate (e.g. an activity of 3 METS requires 3 times the energy as when the body is at rest). MET values are usually expressed in three intensity levels (i.e., low, medium, and high); however, the CCHS did not require respondents to specify the intensity level of their activities. As a result, the MET values adopted correspond to the low intensity value of each activity. Physically active respondents had an average daily energy expenditure greater than 3 METs, and moderately active and inactive respondents had daily energy expenditure values of 1.5–3.0 and <1.5, respectively. This variable provides a reasonable proxy for a respondent's habitual involvement in PA. | **Successful Aging:** requires measurement of three distinct components:<br>1) Presence of chronic conditions- respondents asked about current long-term conditions expected to last (or already lasted) 6 months or more and diagnosed by a health professional. Conditions included asthma, fibromyalgia, arthritis, or rheumatism (excluding fibromyalgia), high blood pressure, chronic bronchitis, emphysema or COPD, heart disease (angina, CHF), cancer, urinary incontinence, stroke, cataracts, glaucoma, back problems. Respondents stating presence of any of these classified as having a chronic condition.<br>2) High cognitive and physical functional capacity summed up with "restriction of activities" scale. This scale examined respondents' ability to perform ADL's such as preparing meals, shopping for groceries/other necessities, everyday housework, heavy household chores, personal care, moving about inside house, paying bills. Respondents who reported requiring assistance (as a result of poor health) with tasks classified having a functional limitation.<br>3) Active engagement with life- determined using two criteria both relating to activity involvement: 1) the total number of hours in a typical week spent in sedentary activities. Measure computed total time spent in leisure-time sedentary activities only. 2) Sense of belonging to local community and involvement in voluntary organization. The scale for sense of belonging asked respondents to describe their sense of belonging to their local community. Responses identified very strong or somewhat strong combined and recoded as 1, and somewhat weak and very weak were recoded as 2. Respondents' involvement in voluntary organizations measured directly by asking if they were members of any voluntary organizations or associations. Membership in an organization or association scored as 1, non-membership identified as a 2. Using multi-level criteria (hrs of sedentary behavior, sense of belonging to the local community, and membership in voluntary organizations), an individual's engagement with life classified as unengaged if (a) respondent spent ≥35 sedentary hrs/week and identified a somewhat weak or very weak sense of belonging to the local community or (b) the respondent spent ≥35 sedentary hrs/week and was not a member of a voluntary organization or association. Respondents had to meet all three of these criteria for successful aging. If respondents did not meet any of the criteria classified as unsuccessful. Respondents met some of the criteria classified as moderately successful. | • Age<br>• Sex<br>• SES<br>• Physical activity | • Ordinal regression | • Adjusting for age, sex, and income, the results between PA and successful aging remained, those who were physically active were 2.26 times more likely to age successfully (estimate = 0.817, CI = 0.703–0.931, $p<0.001$) than the physically inactive group.<br>• Those who were moderately active were 1.60 times more likely to be successful agers (estimate = 0.473, CI = 0.365–0.580, $p<0.001$) than the physically inactive referent. Even after accounting for the covariates, as PA status increased, the odds of being rated as successful increased. | • Engagement with life was difficult to determine using the CCHS variables, and it is possible that the multi-criterion measure devised is not a good proxy for this variable.<br>• The current study analyses were limited to only four provinces because of the measures used in this study, which might limit the generalizability of these results to the population level.<br>• Some significant age-associated chronic conditions such as Alzheimer's and dementia were not available in the CCHS data.<br>• CCHS is a telephone-based survey. Therefore, individuals who don't have a phone were excluded from the study.<br>• The term "successful aging" is debatable. No consensus as to what is really considered "successful aging".<br>• Non-validated PA instrument was used.<br>• MET valued assigned was rather low: physically active > 3 METs, moderately active and inactive respondents had daily energy expenditure values of 1.5–3.0 and <1.5, respectively. | • There was a positive moderate association between physically active OA and aging successfully. |

| Publication | Focus of Study | Target population | Sample Size | PA Instrument | Health Outcomes | Measures | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Salguero et al. (2011). | To examine whether measures of PA are related to HRQoL and symptoms of depression in a sample of Spanish community dwelling and institutionalized OA. | Community-dwellers from activity programs and senior residences aged 60– 98 years from the north of Spain. | N=436 | **PA:** assessed using the Yale Physical Activity Survey (YPAS). The YPAS is divided into 2 sections: First section, there is a comprehensive physical work, exercise, and recreational activities checklist to assess time spent in these types of activities during a typical week in the past month. Recreational activities ranged from low-intensity activities to high-intensity activities. Time spent in each activity is multiplied by an intensity code (kcal min-1) and then summed across all activities to create an index of weekly energy expenditure (kcal week-1). In addition, time spent in each activity is summed to provide a total time index (hweek-1). The second section contains questions to quickly assess an individual's participation in five activity dimensions: vigorous activity, leisurely walking, moving on feet, standing, and sitting. Weights are assigned to each category (vigorous activity: 5; leisurely walking: 4; moving: 3; standing: 2; sitting: 1). The frequency score and the duration score are multiplied together and then multiplied again by each dimension's weighting factor to calculate an index for each dimension. A summary index is the sum of the five individual indices. Responses on the YPAS allow eight summary indices to be calculated: total time spent per week in all physical activities, estimated weekly energy expenditure in kcal per week, five individual indices for the activity dimensions, and an activity dimension summary index. The Spanish version of the questionnaire here used, seems to meet the requirements for a valid age- specific questionnaire, having been found that total time and energy expenditure correlate positively with Caltrac activity units and negatively with body weight. Thus, the YPAS could be considered a reliable measure of regular PA on a group basis. According to the YPAS summary index distribution, participants were classified into more active and less active groups. | **HrQoL:** assessed using the SF-36 questionnaire (Ware et al., 1993). The Spanish version of the SF-36 is a validated instrument (Alonso et al., 1995), comprised of 36 questions assessing 8 physical and mental health domains: physical function, role-physical, bodily pain, general health perceptions, vitality, social functioning, role emotional, and mental health. Domains scores range from 0 to 100, with higher scores indicating better HRQoL. Domains are also weighted and summed to calculate physical and mental component summary scores, standardized to a mean of 50.<br>**DEPRESSION:** Symptoms of depression were measured by the GDS (Brink et al., 1982; Yesavage et al., 1982–1983). The validated Spanish version of the GDS scale (Fernandez-San Martın et al., 2002) is comprised of 30 questions with a dichotomous yes/no response which is evaluated as either 1 or 0. A response with a value of 1 indicates the presence of a depressive symptom. There are 10 inverted questions in which a negative response is scored as 1. | • Age<br>• Gender<br>• Height<br>• Weight<br>• BMI<br>• Marital status<br>• Place of living<br>• Depression<br>• Physical activity | • Pearson correlation analysis<br>• ANCOVA<br>• MANCOVA | • Results indicate that all SF-36 domains, except role-emotional, were significantly correlated with the YPAS activity dimension summary index. Physical function (0.192, p<0.001), role-physical (0.139, p<0.01), general health (0.109, p<0.05) and vitality (0.118, p<0.05) correlated with total time activity.<br>• A significant correlation was observed between estimated weekly energy expenditure and physical function (0.176, p<0.01), role-physical (0.104, p<0.05), vitality (0.138, p<0.01) and mental health (0.119, p<0.05).<br>• The SF-36 physical component correlated with all YPAS indices except the sitting index. There was no significant correlation among the SF-36 mental component and the YPAS indices.<br>• Depressive symptoms scores correlated significantly with the activity dimension summary index (0.155, p<0.001) and the estimated weekly energy expenditure (0.120, p< 0.05), as well as with the vigorous activity index (0.173, p<0.01) and the standing index (0.171, p<0.001). | • The cross-sectional method of this study leaves the question of direction of causality open.<br>• Community-dwellers and elderly living in senior residential housing was not randomly selected, and this convenience sample of healthy adults with few co-morbid conditions makes difficult the generalization of the findings.<br>• Different variables that act as mediators between physical activity and HRQoL, such as self-efficacy, may confound the associations detected.<br>• Relatively small sample size<br>• Self-report of personal and medical history could bias results.<br>• YPAS was interviewer administered leading participants to answer with a desirability response.<br>• Results may not be generalizable to other ethnic groups. | • There was a weak-moderate positive association between PA and different domains of both the physical and mental components of HrQOL<br>• There was a weak-moderate positive association between both community dwelling and institutionalized higher active older adults and lower values in symptoms of depression. |

| Publica-tion | Focus of Study | Target population | Sample Size | PA Instrument | Health Outcomes | Measures | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Sampaio et al. (2012). | To investigate the influence of 10 activities on quality of life (QOL) in Japanese OA and to verify which activities had higher influence on QOL level. | Japanese community-dwelling OA aged 60 years or older. | N= 465 | **PA:** The level of activity and participation was measured through an original questionnaire with 10 questions concerning the frequency of engagement in several activities. These activities were chosen on the basis of occupational performance areas in the Occupational Therapy Practice Framework, which focuses on occupations and daily living activities (American Occupational Therapy Association, 2002). Other items were taken from Activity and Participation in the International Classification of Functioning, Disability and Health, such as learning and applying knowledge; general tasks and demands; communication; mobility; domestic life; interpersonal interactions and relationships; major life areas; and community, social and civic life (World Health Organization, 2001), and from a previous study that included engagement in activities for Japanese OA (Ito et al., 2003). | **QUALITY OF LIFE:** assessed through two questionnaires: World Health Organization Quality of Life Assessment (WHOQOL)-BREF Japanese version (Tazaki and Nakane, 1997) and WHOQOL-OLD Japanese preliminary version (Kato et al., 2005). Both were developed by the World Health Organization and were used together to assess the QOL in OA. WHOQOL-BREF is an abbreviated version of WHOQOL-100. It consists of 26 items: two items measure overall QOL and general health, and the others items are divided into the physical, psychological, social relationship and environment domains. The scores for each item range from 1 (poor) to 5 (good); a higher score means a higher level of QOL. The internal consistency tested by Cronbach's alpha ranges from 0.66 to 0.82. Discriminate validity is 31.2 for physical health, 12.3 for psychological health, 8.4 for social relationships and 6.6 for environment (World Health Organization – WHO, 1998). WHOQOL-OLD is a complementary assessment to measure the QOL of older adults. It consists of 24 questions divided into six domains: sensory abilities, autonomy, past– present– future activities, social participation, death and dying, and intimacy. The scoring is similar to those for the WHOQOL-BREF. The WHOQOL-OLD Japanese preliminary version showed a high validity score, except for the question of death and dying (Tazaki, 2004). The internal consistency for the final version of the Japanese WHOQOL-OLD instrument has not yet been published. | • Age<br>• Sex<br>• Education<br>• Place (rural or urban)<br>• Family structure<br>• Fre-quency of medical services<br>• Physical activity | • Spearman's correlation analysis<br>• Multiple regression analysis | • The activity with the highest influence on WHOQOL-BREF was PA (β = 0.209, p<0.01), followed by art activity (β= 0.169, p<0.01) and reading and writing (β = 0.141, p<0.01).<br>• The activity with the highest influence on WHOQOL-OLD was social activity (β=0.222, p<0.01), followed by reading and writing activity (β = 0.118, p<0.05). | • The proportion of subjects and the place of recruitment was a limitation. There was a different proportion of subjects in urban and rural areas according to gender, age and educational levels.<br>• Physical and cognitive health status these factors may possibly affect QOL as well.<br>• Relatively small sample size.<br>• Poor response rate (56%). Perhaps providing an incentive to mail back the questionnaires could increase response rate.<br>• Results may not be generalizable to other ethnic groups.<br>• Level of intensity of PA was not taken into consideration 60% of the subjects were between 60-69 years old. Results may be biased towards higher QOL among younger subjects.<br>• Self-report PA may bias results.<br>• The internal consistency for the final version of the Japanese WHOQOL-OLD instrument is not yet available. Therefore, validity concerns. | • There was a weak-moderate positive association between PA and higher QOL on the WHOQOL-BREF.<br>• There was a weak-moderate positive to moderate association found between social activity and reading and writing and higher QOL on the WHOQOL-OLD. |

| Publica-tion | Focus of Study | Target population | Sample Size | PA Instrument | Health Outcomes | Measures | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Guedes et al. (2012). | To investigate the association between PA and QOL in a sample of Brazilian OA. | The reference population for the study included OA registered at the family health center of the town of União da Vitória, southwestern region of the State of Paraná, Brazil. OA who volunteered to participate in the study were: (a) age ≥ 60 years; (b) living with the family in the urban area of the town; (c) independence in activities of daily living; and (d) cognitive ability to respond to the questionnaires | N= 1,204 | **PA:** assessed using the short version of the International Physical Activity Questionnaire (IPAQ) translated to Portuguese, with the last 7 days as reference period. The four questions of the questionnaire aimed at obtaining information about the frequency (days/week) and duration (minutes/days) of walks and daily activities that require physical effort of moderate to vigorous intensity, in addition to the time (minutes/day) spent on activities in the sitting position on week days and on the weekend. PA was defined as "any bodily movement produced by skeletal muscles that results in energy expenditure above a basal level" was classified into three categories according to the IPAQ consensus group: sedentary (< 600 Met-minutes/week), active (≥ 600 Met-minutes/week), and very active ( ≥ 3,000 Met-minutes/week). | **WHOQoL:** translated and adapted to Portuguese, which measures the QOL perception of OA. The questionnaire consisted of 24 items divided into six domains, with a 5-point Likert-type response scale: sensory abilities, autonomy, past/present/future activities, social participation, death/dying, and intimacy. In addition to the six specific domains, the WHOQol-Old also includes an additional domain that results from the responses to the set of 24 items (overall QOL).The final scores obtained for each domain were transformed to a scale ranging from 0 to 100, with zero corresponding to a low perception and 100 to a high perception of the QOL indicator in each domain. | • Gender<br>• Age<br>• Marital status<br>• Education level<br>• Family socio-econo-mic status<br>• Physical activity | • ANCOVA<br>• Chi-square ($\chi$2) test | • OA of both genders who reported to be more physically active attributed higher scores to the sensory ability (women: F = 3.796, p = .028; men: F = 9.486, p < .001), autonomy (women: F = 4.227, p = .017; men: F = 8.237, p < .001), and intimacy domains (women: F = 3.549, p = .020; men: F = 10.114, p < .001), in addition to presenting significantly higher overall QOL scores (women: F = 4.153, p = .016; men: F = 8.69, p = .001).<br>• In women, the scores obtained for the social participation domain were significantly higher in the strata of active and very active subjects when compared to sedentary subjects (F = 4.535, p = .014). | • The IPAQ is a retrospective instrument of self-recall of daily activities performed in the week preceding its application. There is the possibility of seasonal influences that may interfere with the identification of PA.<br>• The reports provided by the OA of the present sample indicate that self-perception of QOL reflects individual responses that exclusively depend on attitudes toward different surrounding situations. Thus, since the sample consisted of OA with a wide diversity of life experiences, the possibility of eventual bias in the interpretation of the questions of the WHOQOL-Old cannot be ruled out.<br>• The selected sample comprising only OA from a specific town in the southwestern region of the State of Paraná, Brazil, which is located in a region with specific social, economic, and cultural characteristics, may weaken the external validity of the study and impair generalization of the results.<br>• The sample did not include individuals who lived in nursing homes.<br>• Cross-sectional study may limit the cause-effect findings. | • There was a small to moderate positive association between female older adults who reported to be more physically active attributing higher scores to overall QOL score (ES 0.19 to 0.25).<br>• There was a small to moderate positive association between male older adults who reported to be more physically active attributing higher scores to overall QOL score (ES 0.28 to 0.34). |

| Publica-tion | Focus of Study | Target population | Sample Size | PA Instrument | Health Outcomes | Measures | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Benedetti et al. (2008) | To examine the association between PA and disease among OA living in a major city in southern Brazil (Florianópolis). Additionally, to assess the relationship between socioeconomic status and PA participation levels. | OA 60 years or older living in Florianópolis. | N= 875 | **PA:** International Physical Activity Questionnaire (IPAQ) measures PA level in four domains (work, transportation, domestic tasks, and leisure). For this report, the middle level proposed in the original IPAQ was suppressed, following the recommendations from previous surveys using IPAQ with OA in Brazil. Therefore, older adults who carried out moderate or vigorous physical activities within the four domains for 150 min per week or more were classified as more active, whereas those who did not reach 150 min per week were classified as less active. | **Chronic Disease:** The World Health Organization's (2004) International Classification of Diseases and Health-Related Problems (Version 10) was used for disease identification and prevalence assessment (Brazilian Ministry of Health, 2006). | • Age<br>• Gender<br>• Marital status<br>• Educa-tion<br>• House-hold income<br>• Source of income<br>• Physical activity | • Logistic regression analyses | • After adjusting for gender and age, less physically active OA were twice as likely to report the presence of at least one type of disease than were those who were more active (OR=2.06, 95% CI 1.49-2.85, p<0.001).<br>• Individuals in the highest income category (more than 6 MMS) group were almost twice as likely (OR= 1.941, 95% CI 1.36-2.77, p <.001) to be physically active than individuals in the lowest income category (less than 2 MMS). | • Results from a particular area in Brazil may have limited generalizability to other regions.<br>• The study being a cross-sectional study limits ability to infer causal direction.<br>• Face-to-face interviews with researcher could cause participants to answer questions with desirability response.<br>• Fairly small sample size.<br>• Family history was not accounted for as baseline characteristics.<br>• Results not surprising given that most older adults are likely to have at least one chronic disease as they age. | • There was a moderate inverse association between less physically active OA and the likelihood to report the presence of at least one chronic disease.<br>• There was a positive moderate association between higher income seniors and the likelihood to be more physically active. |

## Appendix B. Longitudinal Data Table

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Stessman et al. (2009) | To examine the influence of PA levels on survival, function, and health status among the very old. | Randomly selected Jerusalem OA aged 70 years and older. | N= 457 at Phase I<br>N= 894 at Phase II<br>N= 1172 at Phase III | **PA:** Participants were asked: "How often are you physically active?" The answers were as follows: (1) less than 4 hours weekly, (2) about 4 hours weekly, (3) vigorous sports at least twice weekly (e.g., jogging or swimming), and (4) regular PA (e.g., walking at least an hour daily). This 4-item questionnaire, introduced in 1990 at the baseline evaluation, was adapted from the Gothenburg population study of 70-year-olds. The same questions were asked at follow-up to ensure internal consistency of longitudinal data. PA was dichotomized as sedentary (answer to 1) vs. physically active (answers to 2, 3, and 4). This cutoff was justified statistically, accounting for distribution and frequency of responses. Separate analyses examined the 4 levels of PA as discrete variables in their effect on survival and function. Furthermore, at age 78 years, participants were classified according to PA levels at ages 70 and 78 years; at age 85 years, participants were classified according to PA levels at ages 78 and 85 years: consistent (physically active→physically active), decreasers (physically active→sedentary), increasers (sedentary→physically active), and low (sedentary→sedentary). | **Mortality:** The primary outcome was death, and mortality data were obtained from an annual review of death certificates issued by the Ministry of the Interior from 1990 through 2008. | • Sex<br>• Origin<br>• Educational level<br>• Financial status<br>• Loneliness<br>• BMI<br>• Smoking pack/years<br>• Chronic joint or musculoskeletal pain<br>• Medications used<br>• Falls in the last year<br>• Fractures in the last 7 years<br>• Major diseases<br>• ADL's<br>• Depression<br>• Health status<br>• Mini–Mental State Examination score<br>• Functional status<br>• Physical activity | • Cox proportional hazards model<br>• Logistic regression models | • Lower mortality was associated with PA level at ages 70 (hazard ratio, 0.61; 95% confidence interval, 0.38- 0.96), 78 (0.69; 0.48-0.98), and 85 (0.42; 0.25-0.68).<br>• Participation in higher levels of PA, compared with being sedentary, did not show a dose dependent association with mortality. | • The diminishing size of the sample during follow-up.<br>• The self-reported nature of the PA data, a lack of documented validity or reliability of the PA question, or its sensitivity at detecting changes in PA levels is a concern.<br>• Reverse causality is a possibility<br>• Interviews were conducted at participants' home, leading to social desirability response.<br>• This cohort was fairly active, 76.9% were active at age 78, and therefore, generalizability of results to other cultures requires caution. | • There was a weak-moderate to strong association between PA and lower mortality. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Lin et al. (2011) | To determine the relationship between non-leisure type physical activity (NLTPA) and leisure type physical activity (LTPA), on mortality among the elderly in Taiwan. | Elderly Taiwanese non-institutionalized community-dwelling adults aged 65 years or older located in Southern Taiwan-Tainan City. | N=876 | **LTPA:** assessed at the beginning of the follow up period in 1996. Subjects were asked about the frequency and duration of performing twelve common LTPA in the previous two weeks, which were as follows: calisthenics or tai chi, gardening, walking for pleasure, bicycling, jogging, hiking, aerobic dancing, folk dancing, tennis, swimming, golf, and miscellaneous exercise. The intensity levels were estimated using the compendium of physical activities developed by Ainsworth et al. For each individual LTPA energy expenditure in METs per kilogram body weight can be estimated by summing up the energy expenditure of all activities on a weekly basis (METxhrxwk). The subjects were divided into two groups: LTPA non participants (MET-hour/week=0) and LTPA participants (MET-hour/week>0).<br>**NLTPA**-an NLTPA questionnaire used to assess level of activity with regard to housework and transportation. Based on the PASE, the questionnaire adapted to a modified scale suitable for elderly Taiwanese subjects and verified in terms of both experts and content validity. The test-retest reliability after two weeks was 0.99. In this analysis, subjects who engaged in any activities of NLTPA (either housework or transportation) at least five times per week were classified as part of the "NLTPA active" group, and those who failed to meet this level as the among the "NLTPA inactive" group. The cut-off point to define NLTPA is arbitrary. | **MORTALITY:** Vital status was verified by matching the subjects personal identity numbers with the national death registry file obtained from the Department of Health, Taiwan where all death certificates issued by doctors are sent. Mortality follow-up began on 1 January 1996, and ended on 31 December 2004. | • Age<br>• Gender<br>• Marital status<br>• Education level<br>• Occupation<br>• Smoking status<br>• Alcohol habit<br>• LTPA<br>• NLTPA<br>• Living alone<br>• BMI<br>• ADL<br>• Medical history | • Cox proportional hazards regression models | • Adjusting for covariates, those subjects who were inactive in LTPA or NLTPA had higher mortality rates with the HR of 1.27 (95% CI =0.97-1.66, C statistic 0.49) and 1.45 (95% CI = 1.07-1.97, C statistic 0.49), respectively, in models 1 and 2.<br>• Adjusting for covariates, when both NLTPA and LTPA were put into the model simultaneously (model 3), NLTPA but not LTPA could significantly predict mortality (HR of 1.40 (95% CI = 1.03-1.91, C statistic 0.48). That is, subjects who engaged in less NLTPA had a higher mortality rate than their counterparts. | • There is a potential non-response bias, since the non-responders were older and had a higher prevalence of widow/widower status, and also might be expected to have a higher mortality rate and lower participation in NLTPA and LTPA.<br>• Some information bias might be inevitable when communication problems occurred in the interviews, perhaps due to hearing or cognitive impairment, which might lead to a non-differentiated misclassification of our data collection.<br>• The authors only semi-quantify the amount of NLTPA by frequency of activities, and thus results from this might not be very precise.<br>• The information about physical activities was collected for only the two weeks before the interview, and therefore misclassification might occur if the subjects had recently changed their lifestyle or health status.<br>• Since the residual confounders cannot be completely eliminated by multiple risk factors adjustments, the results of this study are not sufficient to infer causal relation between survival and NLTPA/LTPA.<br>• Three Cox models failed to provide a good discriminatory power with a low C statistic-index.<br>• Most of the data was collected face-to-face leading to possible social desirability responses.<br>• Subjects who engaged in activities of NLTPA at least 5times/week were classified as "NLTPA active" group, and those who failed to meet this level were considered classified as "NLTPA inactive" group. There could be bias as the cut-off point to define NLTPA was arbitrary<br>• Crude cut-off of MET's for LTPA<br>• There is no report of validity or reliability of LTPA instrument. | • There was a weak-moderate positive association between subjects [illegible]<br>• There was a weak-moderate positive association between inactive NLTPA and higher mortality. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Gillum et al. (2010) | To test the hypothesis that the relative protective effect of high PA level as related to mortality is greater in persons with impaired cognitive function than in others. | American men and women aged 60 years and older | N=5903 | **PA:** interview questions on LTPA were adapted from the 1985 National Health Interview Survey. Participants were asked, "in the past month did you..?" (Yes/No). If yes, "In the past month, how often did you..?" (Specify number of times), for the following: jogging or running, riding a bicycle or exercise bicycle, swimming, aerobic dancing, other dancing, calisthenics or floor exercises, gardening or yard work and weight lifting. Open-ended questions assessed up to four other activities. Frequency of walking a mile or more also was asked. Person responding "no times" to all the aforementioned questions were classified "no LTPA". For LTPA rated at least moderate for age 60 or older, four groups of frequency of activity were formed (0, 1-4, 5-7, and 8+ times/week) to divide persons into similar sized groups to facilitate analysis. | **MORTALITY:** National Center for Health Statistics conducted a mortality linkage of NHANES III participants with the National Death Index. The current linkage of the NHANES III includes deaths for adult participants occurring from the date of NHANES III interview through December 31, 2000. Information regarding the date of death and age of death was collected from matched death certificates. This process detected 2431 deaths in those in the present analysis. Efforts to link all NHANES III participants who died may have been unsuccessful in some cases. For details about NHANES III Linked Mortality Files. | • Age<br>• Gender<br>• Level of education<br>• Marital status<br>• Health status<br>• LTPA<br>• Cognitive function<br>• Limitation of mobility<br>• Race/ethnicity<br>• Census region<br>• Urbanization<br>• Chronic morbidity<br>• Alcohol use<br>• Regular source of care at baseline<br>• Regular personal physician<br>• BMI<br>• Systolic blood pressure<br>• Smoking<br>• Log C-reactive protein | • Cox proportional hazards regression models | • After adjusting for confounding variables, at ages 60-74, the hazards ratio (95% CI) for LTPA more than 8 times weekly compared to none (0.51; 0.38-0.76, p<.001) and for low SICF score compared with high 1.43 (1.36;1.00-1.84, p<.05) was associated with mortality. | • Possible bias arising from survey non-response and missing values for some variables and from possible changes in LTPA and cognitive function and/or other variables during the follow-up period.<br>• Possible selection bias cannot be excluded. Those excluded for missing data but eligible for follow-up revealed those excluded were more likely to be female, Mexican American, in poor health, and to die during the follow-up.<br>• Duration of LTPA was not recorded, so caloric expenditure per week could not be computed.<br>• Occupational PA was not measured, despite most persons older than 60 years of age were retired.<br>• SICF is an indicator of memory and orientation. Different results may have been obtained had other dimensions of cognitive function been studied.<br>• Temporal sequence cannot be ascertained for the association of LTPA and SICF.<br>• Interviews were conducted at participant's home thus bias due potential for social desirability response.<br>• Health status and limited mobility was self-reported therefore possible bias.<br>• There is no report of validity or reliability of PA instrument | • There was an inverse moderate association between LTPA more than 8 times weekly and lower risk of mortality.<br>• There was a weak-moderate positive association between the persons with low SICF score and higher risk of mortality. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Balboa-Castillo et al. (2011) | To examine the association between change in LTPA and mortality in older adults, and whether this association varied with obesity and functional limitations. | Non-institutionalized Spanish men and women aged ≥ 60 years old. | N= 2732 | **PA:** was evaluated in 2001 and 2003 with the question Tell me which of these choices best describes most of your leisure-time activity: (a) I don't exercise, my leisure time is spent almost completely in sedentary activities (reading, watching TV, going to the movies, etc.); (b) occasional physical or sports activities (walking or riding a bike, gardening, light exercise, light recreational activities, etc.); (c) regular PA several times a month (tennis, gym, running, swimming, biking, team sports, etc.) or physical training several times a week? Those who reported belonging to category (a) were considered sedentary. Because only 3.6% of participants in 2001 and 3.5% in 2003 reported engaging in regular PA, categories (a) and (b) were combined, so that people with occasional or regular LTPA were considered to be active. Four categories of change in LTPA were defined for the period 2001 to 2003: continually sedentary (sedentary in 2001 and 2003); decreased LTPA (active in 2001 and sedentary in 2003); increased LTPA (sedentary in 2001 and active in 2003); and continually active (active in 2001 and 2003). | **MORTALITY:** Mortality in the cohort during the period 2001 to 2009 was obtained by a computerized search of the National Death Index, which contains information on the vital status of all residents in Spain. | • Age<br>• Gender<br>• Educational level<br>• Smoking status<br>• Alcohol consumption<br>• LTPA<br>• Physician-diagnosed diseases<br>• Perceived health status<br>• Physical component summary (PCS)<br>• Cognitive function<br>• BMI<br>• Abdominal obesity<br>• Limitations of mobility<br>• Limitation of agility<br>• Limitations of IADLs | • Cox proportional hazards regression models | • In comparison with continually sedentary people, those who increased their LTPA had 34% lower mortality (HR 0.66, 95% CI 0.52- 0.84), and those who were continually active had 45% lower mortality (HR 0.55, 95% CI 0.43-0.70).<br>• Results did not vary in analyses stratified by obesity and functional limitations, especially in IADL. | • The LTPA was a self-report questionnaire that has not been formally validated.<br>• Collapsing occasional and regular activity into one category may have led to some classification error.<br>• The available sample size precluded that stratified analyses considered several categories rather than only dichotomies of obesity or functional limitations.<br>• The data corresponded to a relatively brief period in the life of older adults (2-year change in LTPA and 6-year mortality).<br>• It is not possible to rule out some selection bias and residual confounding due to unreported variables or imprecise measures.<br>• Results may not be generalizable to other cultures.<br>• Information was collected in the households by personal interview, therefore bias due to potential for social desirability response.<br>• Crude and non-valid measure of mobility limitations and limited agility. | • There was a weak-moderate inverse association between people who increased their LTPA or those who were continually active and lower risk for mortality. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Kokkinos et al. (2010) | To assess the association between exercise capacity and all-cause mortality among older male veterans. | Male veterans aged from 65 to 92 years old) from the Veterans Exercise Testing Study (VETS) | N= 5314 | **PA:** Exercise capacity assessed by the standard Bruce protocol. Peak exercise time was recorded in seconds. Peak workload was estimated in metabolic equivalents (METs). One MET is defined as the energy expended at rest, which is equivalent to an oxygen consumption of 3.5 mL per kilogram of body weight per minute. Exercise capacity (in METs) was estimated on the basis of exercise time via a commonly used equation for the Bruce protocol and based on American College of Sports Medicine equations for the ramp protocol. Subjects were encouraged to exercise until the occurrence of volitional fatigue in the absence of symptoms or other clinical indications for stopping the test. The use of handrails during the exercise test was discouraged. Age-predicted peak exercise heart rate (HR) was determined on the basis of standardized methods. Medications were not changed or stopped before testing. Supine resting HR and BP were assessed after 5 minutes of rest. Exercise BP was recorded at 2 minutes of each exercise stage, at peak exercise, and during recovery. Indirect arm-cuff sphygmomanometry was utilized for all BP assessments. ST-segment depression was measured visually. ST depression 1.0 mm that was horizontal or down sloping was considered to be suggestive of ischemia. The authors established fitness categories on the basis of the MET level achieved. For the formation of fitness categories, they chose the lowest 20th percentile of METs for the entire cohort (4 METs), a cutoff employed in previous studies, to represent the lowest fit category. Thereafter, categories were established per 1-MET incremental increase in exercise capacity (e.g. 4.1 to 5; 5.1 to 6; 6.1 to 7; 7.1 to 8; 8.1 to 9; and 9 METs). Those who achieved 9 METs comprised the highest fitness category. The establishment of fitness on the basis of MET level achieved is a more objective method of fitness than self-reported PA habits. | **MORTALITY:** The Social Security Death Index was used to match all subjects to their record according to Social Security number and death dates from the Veterans Affairs Beneficiary Identification and Record Locator System File. This system is used to determine survivors among veterans and has been shown to be complete and accurate. Vital status was evaluated annually and determined as of June 30, 2009; the outcome of interest was death from any cause. | • Age<br>• BMI<br>• Exercise capacity<br>• Hypertension<br>• Diabetes mellitus<br>• Dyslipidemia<br>• Chronic disease<br>• Current medications<br>• Cigarette smoking habits<br>• Cardiovascular Disease | • Cox proportional hazards models | • The fully adjusted model revealed that mortality risk was 12% lower for each 1-MET increase in exercise capacity (HR= 0.88; CI, 0.86-0.90).<br>• The hazard ratios for mortality were progressively lower as exercise capacity increased from 5.1 to 6.0 METs (HR= 0.62; CI, 0.54 to 0.71; P<0.001); to 6.1 to 7.0 METs (HR= 0.53; CI, 0.46 to 0.62; P< 0.001); to 7.1 to 8.0 METs (HR= 0.53; CI, 0.44 to 0.64; P< 0.001); to 8.1 to 9.0 METs (HR= 0.48; CI, 0.38 to 0.60; P< 0.001); and > 9 METs (HR=0.39; CI, 0.32 to 0.49; P< 0.001). | • The inverse relationship between fitness and mortality may not demonstrate cause because residual confounding may still exist.<br>• The authors only had information on all-cause mortality and did not have data on mortality related to cardiovascular interventions.<br>• The authors did not have information on physical activity patterns in all subjects; the extent to which exercise capacity reflects physical activity patterns in the sample is unknown.<br>• The onset of chronic diseases, their severity, and the duration of therapy were not evaluated because of incomplete records.<br>• Dietary information was also not available in the records.<br>• The fact that 2 different exercise protocols were used to assess fitness is also a potential limitation.<br>• The findings are based on men only and cannot be extrapolated to women.<br>• Results may not be generalizable to all men. | • There was a weak inverse association between 1-MET increase in exercise capacity and lower mortality.<br>• There was a weak-moderate to moderate inverse association between all fitness categories (> 5.0 METS) and lower risk for all cause-mortality. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Bath & Morgan (1998) | To explore associations between customary PA and 3 longitudinal outcomes: 12 year all-cause mortality, 12 year disease specific mortality and 8 year change in general practitioner and personal social service use. | A representative sample of community dwelling people originally aged 65 and over randomly sampled from a general practitioner lists in Nottingham UK. | N=1042 | **PA:** All activities were divided into seven mutually exclusive functional categories: outdoor productive activities (e.g. gardening, house and car maintenance), indoor productive activities (e.g. housework, decorating, indoor maintenance), walking (purposeful walking outside the house or garden), shopping (i.e. continuous ambulatory behavior associated with shopping), leisure activities (e.g. cycling, swimming), strength activities (e.g. climbing high steps, dragging heavy loads) and joint flexibility activities (e.g. reaching for high shelves, bending for low shelves). For the purpose of the current analyses, walking and shopping were combined into a single measure of 'total walking'. | **MORTALITY:** Information on mortality within the baseline sample was provided by the National Health Service Central Register. Causes of death were coded using ICD-9 classifications | • Age<br>• Gender<br>• Smoking status<br>• Weight<br>• General health<br>• Contact with general practitioner<br>• Contact with social services<br>• Anthropometric measurements<br>• PA | • Cox regression survival<br>• Logistic regression analyses | • Relative to the high-activity group, 12-year mortality was significantly increased in both the intermediate [HR =1.53; 95% CI= 1.10-2.14; P < 0.05] and low [HR = 1.75; 95% CI =1.24-2.48; P < 0.005] activity groups for men, and in the low-activity group [HR= 1.73; 95% CI = 1.28-2.33;P < 0.001] for women.<br>• Relative to the high activity groups, the low-activity groups had a significantly increased risk of dying from respiratory disease [AOR = 2.65; 95% CI= 1.23-5.70; P <0.05], but a decreased risk of dying from cardiovascular disease [AOR= 0.43; 95% CI = 0.21-0.88; P < 0.05] versus other primary causes for men. | • Disease categories themselves are not mutually exclusive, and represent only the assumed primary cause of death<br>• Previous analyses of the death certificate date indicated a bias for recording broncho-pneumonia (classified here as respiratory disease) as a primary cause<br>• Logistic regression models used to analyze disease specific mortality did not allow for an independent assessment of risk per cause. For example, low-activity men had an increases risk of dying from respirator disease, they were less likely to die from other causes, including CVD.<br>• Participants were chosen from a randomly sampled general practitioner lists in Nottingham UK. Individuals without general practitioners were not included in the study. Therefore, results could be bias.<br>• Participants were interviewed at their home, leading to social desirability response.<br>• There is no report of validity or reliability of PA instrument. | • There was a weak-moderate positive association between 12-year mortality and in both the intermediate and low activity groups for men and in the low-activity group for women.<br>• There was a large positive association between the low-activity groups and an increased risk of dying from respiratory disease and a large inverse association between low-activity and a decreased risk of dying from cardiovascular disease versus other primary causes for men. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| LicSc & Parkatti (2011) | To investigate PA as a predictor of all-cause mortality among 75- and 80-year-old people with and without chronic cardiac disease over a 10-year follow-up period. | The target population comprised all people aged 75 or 80 years in the city of Jyväskylä. | N = 481 | **PA:** assessed in an interview using a modified version of the scale developed by Grimby (1986), including leisure-time activities, work-related activities, and domestic activities. The responses were divided into two groups for the analyses: sedentary (1 = mainly sitting in one place, reading, or watching TV, 2 = light physical activities such as easy household tasks: heating up food, dusting, and sometimes a walk or easy gardening, 3 = moderate PA about 3 hr per week, such as dusting, ordinary gardening, walking a longer distance and cycling) and active (4 = moderate PA over 4 hr per week or intense PA up to 4 hr per week such as heavier gardening, home maintenance, or heavier domestic activities involving some breathlessness and sweating, 5 = active sports at least 3 hr per week such as tennis, badminton, swimming, jogging, or heavy gardening or heavy leisure time activities, and 6 = competitive sports, strenuous exercise several times a week involving considerable physical exertion, such as swimming or jogging longer distance). | **MORTALITY:** The date of death was recorded for all subjects who had died during the 10-year follow-up period. This information was obtained from the Central Finland provincial government and from the archives of hospitals and old people's homes. For the 75-year-old people, the period continued until 31.1.2000, and for the 80-year-olds until 31.1.2001. | • Age<br>• Gender<br>• Health behavior<br>• Chronic diseases<br>• Symptoms related to the cardiac diseases<br>• Alcohol consumption<br>• Smoking status<br>• PA & Chronic Cardiac Disease | • Chi-squared test<br>• Cox proportional hazard regression analysis | • The relative risk of death adjusted for age, gender, cardiac diseases, other chronic diseases, and health behavior, was 1.7 (HR = 1.69 95% CI = 1.02-2.81, p=0.04) among active with cardiac disease (ACD); 1.8 (HR=1.76 95% CI 1.14-2.73, p≤ 0.000 among sedentary without cardiac disease (SNCD); and 2.8 (HR=2.77 95% CI 1.80-4.26, p≤ 0.001) among sedentary with cardiac disease (SCD) compare to the control group, active people without cardiac disease (ANCD). | • The level of PA is based on one self-reported question.<br>• The authors cannot estimate the intensity of PA and how PA maintains the health and functional ability among older people based on that question.<br>• The mortality was based on the information of all-cause mortality. Therefore, it might include people who died accidently.<br>• Small sample size<br>• Results may not be over reported given non-institutionalized participants were not included in the study.<br>• Data were collected by interview during home visits, therefore bias due to potential for social desirability response.<br>• Question regarding experience of interviewers. Study used female university students. | • There was a weak-moderate to moderate-strong positive association between a greater risk of dying and active older people with cardiac disease and sedentary older adults without cardiac disease. In fact, the mortality risk was lower among active old people with cardiac diseases than sedentary people without cardiac diseases. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Otten-bacher et al. (2012) | To examine the association between routine PA and risk of 3-year mortality in Mexican Americans aged 75 and older. | Mexican Americans aged 75 years and older. | N = 948 | **PA:** Everyday activity was assessed using the Physical Activity Scale for the Elderly (PASE).Differences in the types of PA as reflected in two subscales of the PASE were also explored (leisure activity and household activity). PASE is a well-established, validated instrument used to assess activity levels in older adults. Frequency and duration of activity are measured using three subscales: leisure, household, and occupational activity. Leisure PA includes walking; light, moderate, and strenuous sports; and muscle strength and endurance exercise. Household activities include housework, home repairs, lawn work, gardening, and caring for others. Occupational activity is measured with respect to hours worked and type of job (sedentary vs. active). Each item in the PASE refers to the previous week of activities. Calculations include an empirically derived weighting system used to obtain a score for each subscale (leisure, household, occupational) and a total PA score. For data analyses, the total and subscale PASE scores were converted into quartiles representing four levels of activity: sedentary, low, moderate, and high. For example, a person categorized as sedentary in the household activity subscale (lowest quartile) did not engage in any activity in this category during the previous week, a person in the low activity group participated in one activity, a person in the moderate activity group engaged in a two or three household activities, and a person in the high activity group (highest quartile) engaged in four or more household activities in the previous week. | **MORTALITY:** Confirmed through the National Death Index and by relatives at 3 year follow-up. | • Age<br>• Gender<br>• Education<br>• PA (total, leisure ad household)<br>• Marital status<br>• Financial strain<br>• Smoking status<br>• BMI<br>• Functional disability<br>• Depressive symptoms<br>• Cognition<br>• Co-morbidities | • Cox proportional hazards regression | • The adjusted Cox proportional hazards regression indicated an inverse trend between level of PA and risk of mortality. There was 55% lower risk of mortality in persons in the highest active quartile than in those in the lowest quartile (HR = 0.45, 95% CI = 0.26-0.78). The greatest reduction in risk of mortality after adjusting for covariates was for persons in the moderate activity quartile (HR = 0.36, 95% CI = 0.21–0.62). Persons in the low activity quartile also had significantly lower mortality risk (HR = 0.50, 95% CI = 0.31–0.82) than persons in the sedentary quartile. | • Self-reported PA measure may over- or under report activity levels.<br>• Data not available on the consistency of the activities performed over a long period of time.<br>• The cohort studied consisted of survivors and represented the hardiest of the original 3,050 participants.<br>• The findings apply to older Mexican-American adults and not be representative of the general Hispanic population.<br>• Relatively short a short follow-up<br>• Also, Intensity and type was not measured. | • There was a moderate to strong inverse association between higher levels of PA and a lower risk of mortality. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Woo et al. (2002) | To examine the relationships between PA, dietary habits, smoking and alcohol intake on 3-year mortality and other health outcomes in a cohort of older Hong Kong Chinese. | Hong Kong Chinese men and women aged 70 years and older. | N= 2032 | **PA:** was divided into three categories: no exercise, less than 20 min/day, and 20 min or longer each day. | **MORTALITY:** Documented by information from relatives or caregivers and also by a search at the Death Registry which included subjects lost to follow-up because of death. | • Age<br>• Gender<br>• Self-rated health<br>• Alcohol intake<br>• Smoking status<br>• Dietary habits<br>• Frequency of hospitalizations<br>• Physical activity | • Logistic regression | • After adjustment for age and baseline self-perceived health, PA (OR= 0.46 95% CI=0.36-0.58, p<0.0001) lowered the mortality risk.<br>• Daily fish intake, moderate alcohol consumption and refraining from smoking also reduced the mortality risk. | • Seventeen percent of the subjects were lost to follow-up.<br>• In the assessment of development of new diseases, the authors relied on self-reported diagnoses, thus bias may have occurred.<br>• Self-perceived health was used as a general indicator of the health status at baseline and as a 3-year outcome measure and may be considered too subjective.<br>• No detailed food frequency questionnaire was used in this study.<br>• Since the subjects were elderly, there may be inaccuracies from poor recall.<br>• Health outcomes are likely to be related to dietary habits over a lifetime, and current habits at the time of the interview may not be an accurate indication of lifetime habits.<br>• In assessing the impact of lifestyle factors on health outcomes, it is unclear whether there should be an adjustment for baseline health status in observational studies of the elderly population.<br>• Low response rate 60%<br>• Questionnaire was administered at participant's home. Thus possibility of social desirability response.<br>• Crude and unvalidated measure of PA. Also, Intensity and type was not measured. | • There was a moderate inverse association between increased PA and a lower risk for mortality. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Mullee et al. (2010) | To report on activity and attitude to own activity level predicting the longevity of people over the age of 65 followed over 20 years. | Persons aged 65 years and older | N= 328 | **Housework activities**: included eight items: washing clothes, bed making, cooking, cleaning, repair work in the house, decorating, gardening outdoors and growing indoor plants. These were selected to represent “male” and “female” oriented tasks. The items were re-coded on a 3-point scale: never/no; sometimes/small; all/always/yes. There were marked sex differences in all the items and therefore sum scores were re-coded into quartiles according to sex.<br>**Leisure activities**: included 14 items: reading, listening to TV/radio, sedentary hobbies (e.g., craftwork, table games), physical activities (e.g., sport, dancing), community social activities, pet care, shopping, using public transport, day trips, longer holidays, visiting friends, visiting relatives, visiting clubs and public houses, and viewing events (e.g., concerts, sporting events). Again items were re-coded onto a 3-point scale.<br>**Walking: w**as assessed by the participant’s own rating of the average distance he or she walked in a week. Categories were chairfast/bedbound, housebound, less than 100 yards, 100-400 yards, up to a mile, more than a mile. These three indices were correlated moderately highly together across all three observations (range of Pearson’s correlation coefficient, r, 0.45 to 0.61). It was therefore thought justified to compute a total score from all three indices. | **MORTALITY:** In 1999, the Office for National Statistics, UK, was contacted to supply the dates of death where this was not known to the study. Survival time was calculated as the time from entry into the study in 1977-78 to date of death or censorship (December 31, 1998). Cases that could not be traced were excluded from the analysis, leaving a maximum of 328 available for survival analysis. | • Age<br>• Gender<br>• Health risks<br>• Health threats<br>• Depression score<br>• Cognitive functioning<br>• Health perception<br>• Reported activity<br>• Activity evaluation | • Cox proportional hazards regression | • After controlling for variables, an overall activity score predicted lower mortality. Compared to the “low” group, the "medium" reported activity HR (95% CI)= 0.48, (0.34, 0.67), p < 0.001 and "high" reported activity HR = 0.46, (0.32, 0.65), p < 0.001. | • Relatively small sample size<br>• Limited health threats choices. Questionnaire did not include chronic illnesses such as arthritis or cancer.<br>• Confounding variables such as education or income, marital status, living arrangement etc. were not included in the analyses.<br>• Non-validated measures of activities (Household, LTPA and walking)<br>• High attrition rate (90% died-294) | • There was a moderate inverse association between higher levels of activity score and lower risk of mortality. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Chen et al. (2012) | To assess the associations between leisure, work, and household PA and subsequent all-cause mortality among older adults over an 8 year follow-up period. | Men and women aged 65 years and older in the township of Hunei, located in the south of Taiwan. | N== 2133 | **PA:** evaluated with the Chinese version of the Physical Activity Scale for the Elderly (PASE). The PASE is a brief, easily scored, reliable and valid instrument specifically designed for the elderly and has been widely used, including among Taiwanese older people. It comprises 12 components pertaining to leisure time activity (5 components), work-related activity (1 component), and household activity (6 components) over the past 7 days. LTPA consists of walking outside the home; light, moderate, and strenuous sports; and activities aimed at muscle strength/endurance. Work-related PA includes jobs involving standing or walking. Household physical activity contains light housework, heavy housework, home repairs, lawn work/yard care, outdoor gardening, and caring for another person. The total PASE score represents total PA and is computed by multiplying the amount of time spent (or participation) in each activity by item weights and summed over all activities. The item weights are based on comparison with PA derived by regressing a component score developed from a 3-day motion sensor count, 3-day PA diary, and global activity assessment. Scores of leisure activity, household activity, and total activity were all categorized into 3 levels by tertiles: low, moderate, and high. The work-related activity was grouped into 2 levels (low and high) because 92% of the participants reported no work-related activity. | **MORTALITY:** Data were obtained at the end of December 2007 by linkage to the death register of the Taiwan Hunei Township Household Registration Office with the unique national personal identification number assigned to Taiwanese individuals. | • Age<br>• Gender<br>• Education<br>• Marital status<br>• BMI<br>• PASE<br>• Chronic conditions<br>• Cigarette smoking<br>• Alcohol consumption | • Cox proportional hazard models | • After adjusting for age, BMI, education, marital status, cigarette smoking, alcohol intake, and health status, both men and women in the low leisure activity group experienced an increased all-cause mortality than did those in the high leisure activity group (HR = 2.09, 95%CI = 1.61-2.70, $p<0.001$, and HR = 1.75, 95%CI = 1.26-2.44, $p=0.001$, respectively).<br>• The low household activity group showed an increase in all-cause mortality both for men and women (men: HR = 1.59, 95%CI = 1.23-2.06, $p<0.001$; women: HR = 1.68, 95%CI = 1.19-2.40, $p=0.03$). | • The sample in this study is restricted to 1 district region in Taiwan, and generalization to older people from the remainder of Taiwan or beyond should be undertaken with caution.<br>• PA was only assessed at baseline.<br>• Relied on self-reports of PA.<br>• The selected chronic conditions used in risk assessment might not be sufficiently comprehensive.<br>• 23 trained interviewers were utilized to collect baseline data. Biases may have occurred in the ways data were collected. | • There was a weak-moderate to moderate positive association between a lower level of leisure activity in both men and women and an increased risk of all-cause mortality<br>• There was a weak-moderate positive association between a lower level of household activity in both men and women and an increased risk for all-cause mortality. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Manini et al. (2006) | To determine whether free-living activity energy expenditure is associated with all-cause mortality among older adults. | High-functioning, community-dwelling older adults aged 70-82 years. | N=302 | **Doubly labeled Water Protocol:** Total energy expenditure measured using doubly labeled water. Measurements obtained between 2 visits separated by 2 weeks. On the first visit, participants ingested an estimated 2-g/kg total body water dose of doubly labeled water. This dose was composed of an estimated 1.9- g/kg total body water of 10%H2 18Oand an estimated 0.12-g/kg total body water of 99.9% 2H2O. After dosing, 3 urine samples were obtained at approximately 2, 3, and 4 hours. Two consecutive urine voids were taken during a second visit to the laboratory 15 days after the first visit. Plasma from a 5-mL blood sample was obtained from everyone but only used for those who had evidence of delayed isotopic equilibration likely caused from urine retention in the bladder (n=28). The within subject repeatability of total energy expenditure was based on blinded, repeated, urine isotopic analysis and was excellent and compared well with rates given in a review article.<br>**Self Reported PA:** over the past 7 days PA assessed by interviewer-administered questionnaire at time of doubly labeled water dosing. Questions about walking for exercise, other walking, climbing stairs, working for pay, and volunteering assessed for both duration and intensity. The duration and intensity level of these activities used to estimate energy expenditure with established MET values for each activity. An additional question asked whether participants performed high-intensity exercise but information on duration and intensity were not collected.<br>**Free-Living Activity Energy Expenditure:** was expressed in 2 ways. Activity energy expenditure calculated as (total energy expenditure X 0.90) − resting metabolic rate; removing energy expenditure from the thermic effect of meals and subtracting energy devoted to basal metabolism. Activity energy expenditure defined as amount of kilocalories an individual expends in any activity per day. PA level calculated as total energy expenditure/resting metabolic rate. Activity energy expenditure and PA level are highly correlated (r=0.91) but offer different advantages (eg, simplicity of expression and inherently controlling for differences in body composition, respectively). | **MORTALITY:** Vital status was ascertained by telephone contact every 6 months over an 8-year period (1998-2006). Date of death was verified with death certificates and survival time was defined as the time of the second energy expenditure visit to the date of death or date of last contact. There were too few deaths to assess cause-specific mortality. | • Age<br>• Gender<br>• Ethnicity<br>• Weight<br>• Height<br>• Body fat<br>• BMI<br>• Education<br>• Cigarette smoking<br>• Self-rated health<br>• Sleep duration<br>• Prevalent Health Conditions<br>• Number of Health conditions<br>• Energy Expenditure | • Cox proportional hazard models | • Higher levels of free-living activity energy expenditure and PA were associated with lower mortality risk (every 287 kcal/d for free-living activity energy expenditure: hazard ratio [HR], 0.68 [95% CI, 0.48-0.96, p≤ 0.05]; every 0.24 for PA level: HR, 0.66 [95% CI, 0.47-0.93, p≤ 0.05]). The estimates changed little when factors related to mortality risk were added to model 3.<br>• Compared with the lowest free-living activity energy expenditure tertile, those in the highest tertile had a lower risk of mortality (model 2: HR, 0.31; 95% CI, 0.14-0.69, p≤ 0.05). Similar results were observed with PA level (HR, 0.40; 95% CI, 0.19-0.81, p≤ 0.05). For PA level, risk of mortality was 12.0% in the highest tertile, 17.8% in the middle, and 24.7% in the lowest. The effects changed little after adjusting for smoking status, educational level, self-rated health, and prevalent health conditions. | • The current study specifically recruited high-functioning older adults who did not have mobility disabilities and thus would likely be capable of PA. Therefore, there is bias.<br>• Because the doubly labeled water method directly measures carbon dioxide production over an extended period of normal activity, it is considered the most accurate estimate of free-living activity energy expenditure. It is, however, expensive on an individual basis and requires special expertise limiting investigation to smaller sample sizes.<br>• Small sample size limited the ability to assess cause-specific mortality.<br>• Only included community-dwelling participants. Institutionalized participants were excluded.<br>• Individuals were paid to participate in the study, therefore possibility of bias.<br>• PA assessed over the past 7 days. Results may not accurately reflect the amount of PA.<br>• PA assessed by an interviewer-administered questionnaire; therefore results may have led to social desirability response.<br>• Unsure of validity and reliability of self-reported PA questionnaire.<br>• Household PA not assessed.<br>• Intensity and duration of high PA not assessed. | • There was a strong inverse association between both highest level of free-living activity energy expenditure and highest PA level and lower mortality risk. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Lan et al. (2006) | To examine: 1) the minimum amount of exercise in association with reduced mortality; 2) to examine the association between the number of exercises and mortality and 3) to assess the independent effect of intensity, duration and frequency on mortality. | Persons aged 65 and older participating in the 2001 Taiwan National Health Interview Survey were studied. | N=2113 | **PA:** question "Did you engage in any kind of leisure activity during the last two weeks was asked?" to classify subjects as exerciser (answering "yes") or sedentary individuals (answering "no"). For exercisers, information on names, total times, and durations for each activity (up to three) during the 2-week period was further collected. Thirteen activities were identified: walking leisurely; jogging or race walking; swimming leisurely; Chinese-style exercise; sports with light effort; aerobic dancing; folk dancing; bicycling leisurely; mountain climbing; weight lifting with light effort; walking up stairs; other indoor exercises; miscellaneous exercises. Similar questions were previously used in the sister study—the Elderly Nutrition and Health Survey. In its validity study, 3 repeated measures for selected questions on 72 participants were conducted at 1, 3, and 6 months after the formal interview. Consistency of the main exercise question read 0.88, while Kappa among repeated measures of reported frequency and duration ranged from 0.41 to 0.46, indicating acceptable validity and reproducibility of the questions adopted by the study (Pan et al., 2005). Energy expenditure value for each activity was assigned according to activity intensity codes (including Chinese-style exercise such as Tai-chi) calculated from the ratio of work to resting metabolic rate (Ainsworth et al., 1993, 2000) or Activity Metabolic Index (Taylor et al., 1978), all based on the assumption of an individual with 60 kg of weight. Energy expenditure (kcal) of each activity per week was obtained by: activity intensity code (kcal/min)×frequency (times)×duration for each time (min) / 2. The energy expenditure values were then added up into total weekly amount of energy expenditure. For example, an individual engaged during the past 2 weeks 14 rounds of 30-min walking leisurely and 4 rounds of 1-h bicycling. The total weekly energy expended per week was accordingly: (3.5×14×30/2) + (4×4×60/2) = 1215. | **MORTALITY:** Vital status was verified by matching personal ID with the latest available national death registry file obtained from the Department of Health, Taiwan. Review found death certificates and death codes in the files in fine overall agreement, with rates ranging from 80.9 to 83.9% (Lu et al., 2000). Mortality follow-up began on 1 August 2001 and ended on 31 December 2003. A total of 197 participants died during the follow-up period, yielding a 9.3% of cumulative death rate. The mean follow-up year was 2.2 (standard deviation [SD] = 0.4). Cardiovascular disease (ICD 390–459), cancer (ICD 140–239), respiratory disease (ICD 460–519), and diabetes (ICD 250) accounted, respectively for 28.4%, 23.4%, 13.7%, and 8.6% of the deaths. | • Age<br>• Sex<br>• Education<br>• Chronic diseases<br>• Alcohol use<br>• Cigarette use<br>• BMI<br>• Reported health status<br>• Physical function<br>• Employment<br>• LTPA | • Cox proportional hazards model | • Compared to sedentary individuals, regular exercisers benefited from greater risk reduction in total mortality. This finding persisted after adjustment for covariates, although the magnitude of risk reduction decreased. The risk reduction was 35% (HR=0.65, 95% CI 0.47-0.91, P = 0.011) when all covariates were adjusted.<br>• Mortality risks declined with exercisers reporting larger total amount of expended energy. In the model with all covariates adjusted, significant risk reduction among groups was only observed in those with 1000 kcal and more per week. The HRs in groups of 1000–1999 kcal and 2000 kcal and over were HR= 0.50, 95% CI = 0.27–0.90, P = 0.043 and 0.43, 95% CI = 0.21–0.87, P = 0.043, respectively.<br>• After adjustment, association remained significant in both number of activity > 2 and more (HR= 0.35, 95% CI 0.15-0.82, P = 0.014), and intensity (HR= 0.81, 95% CI 0.68-0.96, P = 0.018) while frequency (overall P = 0.08) and duration (overall P = 0.06) were not significant. | • The study measured only leisure activities; the results are not generalizable to home, occupation, commuting, and other physical activities<br>• The follow-up time relatively short compared with those in previous studies, meaning there is not enough number of deaths to further examine the relations between PA and cause-specific mortality.<br>• The study was limited by including older adults only. It is unknown whether similar findings are also observed among persons in other age groups or older adults having different types of exercise from those in this study.<br>• The relationship of exercise and its energy components with mortality was purposely adjusted with all variables used in other studies. Some of these variables in the model may potentially correlate with others. However, even when the correlated variables were deleted, the relationship between exercise and mortality remained similar to what it was originally observed.<br>• Need to assume that the 2-week exercise-related information is representative of long-term exercise habits.<br>• Results may not be generalizable to other cultures/ethnicities.<br>• Study only included non-institutionalized participants. Therefore, possible bias. | • There was a weak-moderate inverse association between regular exercisers and lower risk in total mortality.<br>• There was a moderate-strong inverse association between exercisers reporting larger total amount of expended energy (1000–1999 kcal and 2000 kcal and over per week) and lower risk in mortality risks.<br>• There was a strong inverse association between number of activity and lower risk for mortality and a weak weak association between intensity and lower risk for mortality. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Sundquist et al. (2004) | To analyze the association between five levels of PA and all-cause mortality for people aged ≥65 using the Swedish population. | A national random sample of non-institutionalized Swedish population of men and women aged 65 years and older. | N= 3,206 | **PA:** based on the individual's response to the following LTPA items: (1) I get practically no exercise at all; (2) I exercise occasionally (e.g., 1-hour walks, skiing a couple of times every year, swimming, picking mushrooms); (3) I exercise about once a week (e.g., fast walks, skiing, swimming, jogging, cycling); (4) I exercise about twice a week (e.g., fast walks, skiing, swimming, jogging, cycling); (5) I exercise vigorously at least twice a week (e.g., skiing, swimming, running, cycling for quite a while, ball games). | **MORTALITY:** All-cause mortality was obtained by linking SALLS to the Cause-of-Death Register. | • Age<br>• Educational status<br>• LTPA<br>• Smoking habits<br>• BMI<br>• Diabetes<br>• Hypertension<br>• Self-rated health | • Cox proportional hazards regression | • Both men and women who were physically active occasionally or more often (levels 2 to 5) had a significantly decreased mortality risk compared to those who were physically inactive. For example, men and women who were physically active occasionally had a lower risk of all-cause mortality (HR=0.72; CI 0.64-0.81) than for those who were physically inactive after adjustment for all explanatory variables.<br>• For those who were physically active once a week, the mortality risk decreased even further. Compared with those who were physically inactive, mortality risk decreased by 40% (HR 0.60; CI 0.50–0.71).<br>• There was no statistically significant difference in mortality risk between PA once a week (HR=0.58, CI, 0.64-0.81) and twice a week (HR=0.50, CI, 0.42-0.60) or vigorously at least twice a week (HR=0.59, CI, 0.45-0.77). | • Questionnaire did not take NLTPA, such as gardening or household-related activities, into consideration might serve to bias results. The total amount of PA would then be underestimated among certain groups.<br>• LTPA questionnaire does not accurately reflect intensity and duration of exercise.<br>• Self-report might also constitute an important bias.<br>• The survival-cohort effect. There is no reason to believe that the survival cohort effect is different among various subgroups.<br>• Non-response (22.1%) may be a limitation.<br>• Participants were interviewed face-to-face. Possibility of social desirability response.<br>• Non-validated measure of LTPA instrument | • There was a weak-moderate inverse association between both men and women who were physically active occasionally or more often (levels 2 to 5) and having a lower mortality risk. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Byberg et al. (2009) | To investigate how change in level of PA after middle-age influences total (all cause) mortality and to compare it with the effect of smoking cessation. | Men aged 50 in 1970-3 and living in the municipality of Uppsala, Sweden who were reexamined at ages 60,70,77, and 82 years. | N= 2205 | **PA:** in the self-administered LTPA questionnaire in survey 1. Identical questions were asked at each survey: 1) Do you spend most of your time reading, watching TV, going to the cinema, or engaging in other, mostly sedentary activities?; 2) Do you often go walking or cycling for pleasure?; 3) Do you engage in any active recreational sports or heavy gardening at least 3 hours every week?; 4) Do you regularly engage in hard physical training or competitive sport? The two highest activity categories were considered, questions 3 and 4, together as only 5% of the participants reported hard physical training. Participants answering yes to question 1 were categorized as low activity; 2 as medium; and 3 and 4 as high. The questionnaire has been used and validated in other studies and has also been shown to have a high reliability over time. Changes in the PA level between the first and second survey were considered in four categories: unchanged low (low or medium activity at both surveys), unchanged high (high activity at both surveys), decreased (high in survey 1, low or medium in current at that time. Based on job titles retrieved from the national censuses from 1970 and 1980, the authors categorized occupational PA as sedentary, light, medium, high, unknown, and none (unemployed). | **MORTALITY:** Using the individual 10 digit personal identification number given to all Swedish citizens, we traced the entire cohort in the continuously updated Swedish National Population Register until the date of death or 31 December 2006. The main outcome was total (all cause) mortality. | • Age<br>• Weight<br>• Height<br>• BMI<br>• Obesity<br>• Systolic and diastolic blood pressure<br>• Antihypertensive medication<br>• Total serum cholesterol<br>• Self-rated good health<br>• Smoking status<br>• Alcohol use<br>• SES<br>• Physical activity | • Cox proportional hazards regression | • Men who reported high levels of PA were expected to live 2.3 (95% CI 1.3 to 3.3) years longer than sedentary men and 1.1 (95% CI 0.6 to 1.6) years longer than men who reported medium levels of PA after adjustment for potential confounding variables.<br>• Men who increased their PA level between the ages of 50 and 60 continued to have a higher mortality rate during the first five years of follow-up (adjusted HR= 2.64; 96% CI 1.32-5.27) compared with unchanged high PA.<br>• After 10 years of follow-up the mortality rate did not diff between men who had increased their PA and men who were at an unchanged high level (HR= 1.10; 95% CI 0.87-1.38).<br>• Men who maintained a low level of PA and men who decreased their level had higher mortality rates than those with unchanged high PA, irrespective of the length of follow-up.<br>• The mortality rate after more than 10 years of follow-up was halved in men who had increased their PA to a high level both from a medium (AHR= 0.58, 0.39 to 0.87) and a low (AHR= 0.51, 0.26 to 0.97) level. | • Restriction to men participants, therefore, results may not be generalizable to women.<br>• Crude assessment of PA by questionnaire, with risk of misclassification possibly leading to underestimation of the results.<br>• Self-report PA questionnaire may have led to social desirability response.<br>• Biases could stem from the adjustment for variables that were regarded not only as confounders but also as intermediates on the causal pathway—such as perceived health, body weight, and diabetes.<br>• A healthy survivor effect cannot be excluded as survival until age 60 was necessary for this analysis.<br>• Non-validated measure of PA instrument | • After ten years of follow up, there is a graded reduction in mortality with increasing PA in men. There is a weak inverse association between men who increased their PA from low to moderate and lower risk of mortality. The risk was no different between men at unchanged high level.<br>• After more than 10 years of follow up, there was a weak-moderate to moderate inverse association for men who increased their PA to a high level from a medium and a low level and lower risk of mortality. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Gregg et al. (2003) | To examine the relationship of changes in PA and mortality among older women. | Community-dwelling women aged at least 65 years who were participating in the Study of Osteoporotic Fractures (SOF). | N= 9518 | **PA:** assessed using a modified version of the Harvard Alumni Questionnaire. Women were asked about the number of city blocks or equivalent (12 blocks = 1 mile [1.6 km]) they walked each day for exercise or as part of their normal routine and about frequency and duration of other leisure activities during the past year. Walking for exercise was attributed an intensity of 8.3 kcal/block (equivalent to 5 kcal/min) and non-exercise walking was attributed 5 kcal/block (equivalent to 3 kcal/min). Other low- and moderate-intensity activities were attributed 5 kcal/min and 7.5 kcal/min, respectively. A summary estimate of PA was calculated and expressed in kilocalories per week. For analyses of changes in PA levels, high-intensity activities were excluded to make computation of PA consistent across visits, because this information was collected only at baseline and high-intensity activities were reported by only 300 women (4.0%). Women were categorized women by quintile of total PA at baseline. Classification of PA: For analyses of changes in PA levels, mortality risks were compared among 4 groups: those sedentary at both baseline and follow-up, defined as being in the lowest 40% (<595 kcal/wk); those physically active at baseline and sedentary at follow-up (ie, moved from highest 60% to lowest 40%); those sedentary at baseline and active at follow-up (ie, moved from lowest 40% to highest 60%); and those physically active at both visits. The amount of absolute kilocalorie change in PA were examined. For these analyses, the quintile with the least PA change was the referent group (referred to as maintainers); women with decreases and increases in PA were divided evenly into categories. | **MORTALITY:** Causes of death were confirmed by death certificates, and, when available, hospital discharge summaries were obtained. The underlying cause of death was coded by a clinical epidemiologist using the International Classification of Diseases, Ninth Revision, Clinical Modification, and categorized as due to all causes, CVD (ICD-9-CM codes 401 to <405, 410 to <415, 425, 428, 429.2, 430 to <439, 440 to <445, and 798), and cancer (ICD-9-CM codes 140 to 239). | • Age<br>• Smoking<br>• Physician-diagnosed medical conditions<br>• Hypertension<br>• BMI<br>• Hip fractures<br>• Self-rated health status<br>• Physical activity | • Cox proportional hazards regression | • Higher levels of total PA and walking at baseline were associated with lower all-cause and CVD mortality rates, controlling for age, BMI, smoking, and co-morbid conditions. The magnitude of risk reduction associated with PA was greatest for CVD mortality; compared with the lowest quintile, hazard rate ratios (HRRs) were lowest for women in the highest quintile (HRR, 0.58; 95% CI, 0.46-0.74, p<0.001 for total PA and HRR, 0.61; 95% CI, 0.49-0.78, p<0.001 for walking).<br>• Compared with women who were sedentary at both visits, sedentary women who became active had significantly reduced rates of mortality due to all causes (HRR, 0.52; 95% CI, 0.40-0.69,p<0.001), CVD (HRR, 0.64; 95% CI, 0.42-0.97,p<0.001), and cancer (HRR, 0.49; 95% CI, 0.29-0.84,p<0.001) after controlling for age, BMI, smoking, co-morbid conditions, and baseline PA.<br>• Mortality rates for women who decreased their activity levels did not differ significantly from those of continually sedentary women, except for cancer mortality, for which they had a lower mortality rate (HRR, 0.61; 95% CI, 0.42-0.90, p<0.001). | • Dependence on self-reported PA and the inability to assess the effects of lower-level non-leisure activities.<br>• There was slight variation in the PA questionnaires used at baseline and follow-up.<br>• Changes in PA levels could indicate a regression to the mean.<br>• Less power for the evaluation of cancer mortality than for all-cause and CVD mortality.<br>• The study excluded African American women and institutionalized women therefore, results are not generalizable to all women.<br>• The study cannot rule out the influence of selection biases, residual confounding, or findings due to chance. | • There was a weak-moderate inverse association between women in the highest quintile of PA and walking and lower risk for all-cause and CVD mortality.<br>• There was a weak-moderate to moderate inverse association for sedentary women who increased their PA levels between baseline and follow-up and having lower mortality from all causes, cardiovascular disease, and cancer. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Lee & Paffenbarger (2000) | To compared the merits of non-vigorous and vigorous activity for longevity. | Men who were undergraduates from The Harvard Alumni Health Study | N=13485 | **PA:** alumni reported the daily number of blocks walked and flights of stairs climbed. They also reported their sports or recreational activities during the past year, the time spent per week, and the weeks per year of participation for each. This activity assessment is reasonably reliable and valid ; for example, for energy expenditure, the test retest correlation over 1 month was 0.72, while the correlation for questionnaire estimates and estimates from activity records was 0.65. Walking one block daily rated 235 kJ/week (4.2 kJ =1 kcal); climbing up and down one flight of stairs daily, 118 kJ/week. The authors assigned a multiple of resting metabolic rate (MET score) to each sport/recreation. Since the resting metabolic rate is approximately 4.2 kJ/kg of body weight/hour, they estimated the yearly energy expended on that activity by multiplying its MET score by 4.2, body weight, and hours per year of participation, dividing by 52 to obtain the average weekly expenditure. The authors summed energy expenditure from walking, stair climbing, and sports/recreation and defined five categories: <4,200, 4,200-<8,400, 8,400-<12,600, 12,600<16,800, and ≥ 16,8O0kJ/week(31.2, 28.5,18.4, 10.0, and 11.9 percent of men, respectively). The authors additionally were interested in the specific activity components. They grouped men into approximate fourths of distance walked (1 block = 0.13 km; <5, 5-<10, 10-<20, and >20 km/week; 31.1, 21.6, 26.4, and 20.8 percent, respectively) and flights climbed (2 flights = 1 storey; <10, 10-<20, 20-<35, and £35 storeys/week; 22.9, 21.0, 20.6, and 35.5 percent, respectively). They divided sports/recreation into vigorous (≥ 6 METs; e.g., running/jogging, swimming laps, shoveling snow), moderate (4—<6 METs; e.g., golfing, dancing, gardening), or light (<4 METs; e.g., bowling, boating, housekeeping) activities (27). They then defined five groups of vigorous energy expenditure using the same cutpoints as previously: <630, 630-< l,680,1,680-<3,150, 3,150-<6,300, and ≥ 6,300 kJ/week (52.3, 11.3, 10.0, 12.2, and 14.3 percent, respectively). They did likewise for moderate (66.7, 8.9, 7.3, 8.4, and 8.7 percent, respectively) and light (90.8, 4.2, 2.5, 1.5, and 1.0 percent, respectively) energy expenditure. | **MORTALITY:** The Harvard Alumni Office maintains records of deceased alumni. Using this information, the authors obtained copies of death certificates for men dying from 1977 through 1992. Previously, they found a <1 percent loss to mortality follow-up. In 1998, they randomly sampled 500 alumni last contacted in 1988 and not known, according to our records, to have died through 1992. The National Death Index identified only two (0.4 percent) of the 500 as definitely deceased. | • Age<br>• Quetelets index (BMI)<br>• Energy<br>• Cigarette Habit<br>• Alcohol habit<br>• Early parental death<br>• Hypertension<br>• Diabetes Mellitus<br>• Physical activity | • Cox Proportional Hazards Model | • The most active group experienced, on average, 1.50 (95% CI: 0.85, 2.15, p<0.001) added years of life compared with the least active.<br>• Declining age-adjusted mortality rates with greater distance walked (RR=0.83, 95% CI 0.75-0.94, p=0.004), more stairs climbed (RR=0.82, 95% CI 0.74-0.91, p< 0.001) and greater energy expended on vigorous activities (RR=0.77, 95% CI 0.67-0.89, p<0.001) was observed.<br>• Four groups classified by PA (<4,200 vs. >4,200 kJ/week) and Quetelefs index (>25 vs. <25 kg/m2) were examined. In multivariate analysis, inactive, overweight men experienced the highest mortality rate, while active, not overweight men (RR=0.67, 95% CI 0.60-0.75, p<0.001) enjoyed the lowest. | • The PA activity assessment appears less valid for light and moderate than vigorous activities. Hence, the weaker relation with moderate activity and the lack of association for light activity might reflect less precise assessment.<br>• Assessed activity only once, in 1977, and did not account for changes over time.<br>• Some participants may have neglected to report activities not perceived as "sports" or "recreation," leading to underestimation of energy expenditure.<br>• The authors did not collect detailed dietary information in 1977.<br>• Results are not generalizable to women.<br>• The sample is very educated and intelligent. Therefore, results may not be generalizable to all men.<br>• Selection bias, study excluded 3706 men reporting physician diagnosed CVD, cancer and COPD on initial PA questionnaire. | • There was a weak to weak-moderate inverse association between greater distanced walked, more stairs climbed, greater energy expended on vigorous activities and a reduced risk of mortality.<br>• There was a weak-moderate inverse association between active, not overweight men and a reduced risk of experiencing higher mortality rate. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Hakim et al. (1998) | To examine the association between walking and mortality in a cohort of retired men who were nonsmokers and physically capable of participating in low-intensity activities on a daily basis. | Nonsmoking retired men, 61 to 81 years of age, who were enrolled in the Honolulu Heart Program. | N=707 | **PA:** the men were asked about the average distance they walked per day. Overall measures of activity at a variety of intensities were also assessed by recording the number of hours per day spent at each of five levels of activity with the use of questionnaires similar to those of the Framingham 4 and Puerto Rico 11 heart studies. The five levels of activity were basal (sleeping or lying down), sedentary (sitting or standing), slight (e.g., casual walking), moderate (e.g., light carpentry or gardening), and heavy (e.g., lifting or shoveling). Only physically capable men were included in this study. Such men were included for follow-up if they reported undertaking at least one hour of slight, moderate, or heavy activity on a daily basis. | **MORTALITY:** 12 years of follow-up were available in which to assess the relation between the distance walked and the risk of death on the basis of comprehensive surveillance of death certificates, hospital admissions, and obituary notices. As of 1990, 62 of the 8006 men in the original cohort had moved off the island of Oahu, resulting in an out-migration rate of about 1 per 1000 men per year. The current survival status of only five men is unknown. | • Age<br>• Total cholesterol<br>• High-density lipoprotein (HDL) cholesterol<br>• Blood pressure<br>• Diabetes<br>• Alcohol intake<br>• 24-hour dietary-recall<br>• Physical activity | • Cox proportional hazards model<br>• ANOVA based on linear and logistic regression | • The 12-year cumulative mortality rate was significantly lower among the men who walked a mile or more per day than among those who walked shorter distances (P <0.001).<br>• For the men who walked less than 1 mile (1.6 km) per day, the unadjusted mortality rate was 43.1 deaths per 100 men. For the men who walked more than 2 miles (3.2 km) per day, the unadjusted mortality was more than halved (21.5 per 100).<br>• After adjustment for risk factors, the risk of death among the men who walked less than one mile per day was 1.8 times (RR=1.8, 95% CI 1.2-2.7, p=0.01) than among the men who walked more than two miles per day (RR= 1.1, 95% CI 0.8–1.7, p=0.01). The risk of death among the men who walked the least (1mile per day) was 50 percent greater (RR=1.5, 95% CI 1.1-2.1, p=0.01) than it was among the men who walked 1 to 2 miles per day (P= 0.008). | • Observational studies often have a limited ability to describe relations between PA and the risk of disease because of difficulties in quantifying highly variable behavioral patterns on the basis of self-reported information and individual recall or social desirability response<br>• Selection bias may also exist among older members of the Honolulu cohort, since morbidity and mortality may have removed men who were perhaps less fit, leaving a group of healthy survivors who were more robust.<br>• Documenting the consistency of behavioral patterns over time is also difficult, particularly in those who die before their behavior can be reassessed.<br>• Information on specific forms of activity other than walking in the Honolulu Heart Program is also limited.<br>• Information about the intensity of walking by the men in this study also was not available.<br>• Small sample size.<br>• Results not generalizable to women.<br>• Results may not be generalizable to other cultures or ethnicities.<br>• PA instrument used was not validated | • There was a weak-moderate positive association between men who walked less than one mile per day and a higher risk of death. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Paganini-Hill et al. (2010) | To explore the association of activity on all-cause mortality in a large cohort of elderly men and women. | Residents of a California retirement community aged 75 years and older who participated in the Leisure World Cohort Study. | N=13,199 | **PA:** The amount of time spent on physical activities was ascertained by asking, "On the average weekday, how much time do you spend in the following activities?—Active outdoor activities (eg, swimming, biking, jogging, tennis, vigorous walking)—Active indoor activities (eg, exercising, dancing)—Other outdoor activities (eg, sightseeing, boating, fishing, golf, gardening, attending sporting events)—Other indoor activities (eg, reading, sewing, crafts, board games, pool, attending theater or concerts, performing household chores) —Watching TV." For each question, the response categories were 0, 15, 30 minutes, 1, 2, 3–4, 5–6, 7–8, 9 hours or more per day. The time spent per day in active activities was calculated by summing the times spent in active outdoor and active indoor activities; in other less physically demanding activities by summing the times spent in other outdoor and other indoor activities. Additional questions included "Have you had to cut down or stop any activity you used to do because of some illness or injury?" and the usual number of hours of sleep each night and whether a nap was taken during the day. Follow-up Questions on Activities: Two follow-up surveys included questions on activities. In 1983 surviving participants were asked, "How many hours a week, on average, do you usually spend in vigorous exercise (vigorous walking, biking, jogging, tennis, swimming, etc.)?" as well the hours per day spent watching TV and sleeping. In a second follow-up in 1985, participants were asked, "When you were 40 years old, did you regularly (at least once a week) engage in vigorous sports or recreational activities (such as swimming, hiking, tennis, basketball, jogging)? | **MORTALITY:** Follow-up of the cohort is maintained by periodic resurvey, review of local hospital discharge data, determination of vital status by search of governmental and commercial death indexes, and ascertainment of death certificates. Participants were followed to death or December 31, 2009, whichever came first. | • Age<br>• PA<br>• Medical history<br>• Naps during the day<br>• Cut down activity due to illness or injury<br>• Cigarette smoking status<br>• Alcohol consumption (confounding variable)<br>• Caffeine intake (confounding variable)<br>• BMI (confounding variable) | • Cox proportional hazard regression analysis | • Time spent in active activities, even ¼ hour/day, resulted in significantly lower (15–35%) mortality risks compared with no time in active activities (RR= 0.86, CI 0.73-1.02; RR=0.65, CI 0.56-0.76). This reduction was evident in all sex–age groups except the youngest men, (RR= 1.03, 0.86, CI 0.79-1.34). | • The indices of physical activities used are crude and self-reported and their reliability and validity were not ascertained.<br>• Changes over time in all potential risk factors may affect outcome.<br>• The participants were mostly white, highly educated, and of middle social–economic class, thus results may not be representative of the general population.<br>• Self-report of PA may be biased due to social desirability response<br>• Question about vigorous activity at age 40 was retrospective and may be subject to recall bias.<br>• PA instrument does not assess household PA<br>• Unrecognized and uncontrolled confounding variables may bias results.<br>• Results may not be generalizable to ethnic groups | • There was a weak to weak-moderate inverse association between time spent in active activities and reduced risk for mortality. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Ueshima et al. (2010) | To examine the association between the frequency of PA and all-cause, CVD, and cancer mortality among a sample of elderly subjects, most of whom were under treatment of a pre-existing disease. | Men and women aged 65 years and older in Shizuoka, Japan. | N=10,385 | **PA:** was obtained by asking how many days a week the subject spent 30 or more minutes on LTPA (such as walking, calisthenics, gateball); on walking for transportation (not include time on walking for exercise; Walk); and non-exercise PA (such as farm work, housework, and gardening; non-exercise PA). For each type of activity, the subjects chose an answer form the following: none, 1-2 days per week, 3-4 days per week, and 5 or more days per week. To examine overall PA and mortality risk, the subjects were classified into mutually exclusive groups according to the most frequency performed of three types of PA. Subjects who did not spend 30 min or more a day on any kinds of PA (LTPA, Walk and Non-exercise PA) were categorized as low. Mid-low was defined as subjects who spent 30 or more min a day on any kind of PA 1-2 days per week. Mid-high was defined as subjects who spent 30 or more min a day on any kind of PA 3-4 days per week. High was defined as subjects who spent 30 or more min a day on any kind of PA 5 or more days per week. | **MORTALITY:** Identification of the causes of death was accomplished by record linkage of the cohort database with the National Vital Statistics Database from the Ministry of Health, Labor, and Welfare of Japan, by matching the date of birth, gender, and residential area. The underlying causes of death were coded according to the ICD-0, and the numbers of death from all causes; CVD (ICD-10 codes 100-199); and cancer (ICD-10 codes: C00-C97) were determined. | • Age<br>• Sex<br>• SES<br>• Smoking Status<br>• Alcohol status<br>• BMI<br>• Mood status<br>• Pre-existing Illness<br>• Spent ≥ 30 min on LTPA<br>• Spent ≥ 30 min on walking for transportation<br>• Spent ≥ 30 min on non-exercise PA | • Cox Proportional Hazards | • Every PA was associated with a reduced risk of all-cause mortality and CVD among the total sample and those with pre-existing disease.<br>• The HR for CVD mortality among participants with 5 or more days of non-exercise PA per week for the total sample and those with pre-existing disease were 0.38 (95% CI=0.22, 0.55) and 0.35 (95% CI= 0.24, 0.52) respectively.<br>• The HR for all-cause mortality among participants with 5 or more days of non-exercise PA per week for the total sample and those with pre-existing disease were HR=0.47, 95% CI=0.39, 0.58) and HR=0.39, 95% CI=0.28, 0.54).<br>• Association for cancer and mortality was not clear. | • Does not measure intensity of PA<br>• Choices of frequency of PA was crude<br>• Short follow up<br>• Self-report questionnaire was utilized to assess frequency of PA. Therefore misclassification may occur as well as social desirability response.<br>• Low response rate (63%) and losses to follow up may result in selection bias.<br>• Residual confounding by categorizing SES and mental status as dichotomous variables may remain.<br>• Results may not be generalizable to other ethnic groups.<br>• Non-validated measure of PA instrument | • There was a moderate inverse association between participants with 5 or more days of non-exercise PA per week and a reduced risk for CVD mortality.<br>• There was a moderate inverse association between participants with 5 or more days of non-exercise PA per week and a reduced risk of all-cause mortality. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Lee et al. (2012) | To examine the association between three types of PA and depression cross-sectionally, and the relationship between PA and later mortality (six years later) longitudinally in a sample of older adults aged 65 years and older. | A representative sample of adults in the United States from the sample of Americans' Changing Lives (ACL) Wave 4 study who were aged 65 years or older and assessed with the CES-D for depression. | N=624 | **PA:** The instrument of Physical Activity Level (PAL) was designed to measure elders' frequencies of engagement in three common types of PA including gardening, walking, and sport= exercise. The instrument includes three statements: ''How often do you typically work in the garden or yard?'' ''How often do you walk?'' and ''In addition to walking, how often are you engaged in other types of sports or exercise?'' Participants were instructed to respond to a four-point Likert scale with the response options of often (1), sometimes (2), rarely (3), and never (4). The PA is coded so that higher scores signal lower frequencies of the activities. Participants' responses to the three questions were averaged so that higher scores indicate lower frequencies of physical activeness in the three activities. | **MORTALITY:** was ascertained through data obtained from the National Death Index, the Social Security Death Index, newspaper obituaries, and informants. Mortality of participants in the Americans' Changing Lives study (ACL) was updated through July 7, 2008. **DEPRESSION:** Assessed by the short form (11-item) of the Center for Epidemiological Studies-Depression Scale (CES-D).The 11-item measurement assesses depressive symptomatology within the past week on a three-point scale, with the answer options of: 1=never or hardly ever, 2=some of the time, and 3=most of the time. Sample items include ''I felt depressed'' or ''I felt everything I did was an effort.'' Participants' responses to the 11 items were summed up for a total score on depression, while items of (you were happy in the past week) and (you enjoyed life in the past week) were reversed coded before data analysis. The scores ≥ 9 were previously set as the cut-point for depression. | • Age<br>• Gender<br>• Race<br>• Education<br>• Income<br>• Marital status<br>• Smoking habit<br>• Chronic conditions<br>• Friend-relative care<br>• Physical activity | • Logistic regression model | • Each 1-standard-unit increase on the physical inactivity scale significantly predicted adjusted<br>• 29%, 30%, and 33% increased risk of depression for gardening, walking, and sport, respectively.<br>• After adjusting covariates for sex, age, race, education, income, and marital status in Model 1; for smoking habit and chronic health conditions in Model 2; and for friend-relative care in Model 3, the results show that the two types of PA, gardening (OR=1.48, CI=1.13, 1.92, p=.00) and walking (OR=1.72, CI=1.31, 2.24, p=.00) are both significantly associated with the risk of later mortality; sport does not significantly (p=.27) predict later mortality. | • The instrument to assess PA may have been interpreted inconsistently by study participants given that the survey item did not indicate a time period (e.g., average week over the past month, over the last seven days, etc.). The definition of ''often'' might vary among elders. What ''sometimes'' is to one person may be quite different to another.<br>• Whether the participants conducted PA in a group setting is unknown. The self-report tool for PA and other covariates in the study might not be precise enough as those studies use objective measurements.<br>• Unsure of validity of PA instrument.<br>• Self-report may have led to social desirability response.<br>• Depressed individuals may evaluate their friend-relative care more negatively than those who are not depressed, so it is possible that controlling for self-reported friend relative care is an over adjustment.<br>• Study did not include institutionalized participants therefore results may be biased.<br>• Small sample size.<br>• Center for Epidemiological Studies-Depression Scale (CES-D) may not accurately reflect depression for participants as the 11-item measurement assessed depressive symptomatology within the past week. | • There was a positive weak association between physical inactivity and increased risk of depression for gardening, walking, and sport.<br>• There was a weak-moderate positive association between older adults who engaged in low levels of PA like gardening and an increased likelihood of mortality.<br>• There was a weak-moderate positive association between older adults who engaged in low levels of PA like walking and an increased likelihood of mortality. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Morgan & Bath (1998) | To assess longitudinal relationships between habitual levels of PA and two indices of psychological well-being: morale and depression in older people. | A representative sample of community dwelling people originally aged 65 and over randomly sampled from a general practitioner lists in Nottingham UK. | N=1042 | **PA:** was assessed by three mutually exclusive categories of activity included: walking (purposeful walking outside or garden); indoor activities (e.g., housework or decorating); and outdoor/leisure activities (e.g., gardening, cycling, swimming). Walking was assessed as min per typical day; all other activities were assessed as min per week. | **DEPRESSSION:** Assessed using the 14-item Symptoms of Anxiety and Depression (SAD) scale. The SAD scale focuses exclusively on recent symptoms and comprises two seven-item subscales relating to anxiety and depression respectively.<br>**MORALE:** Assessments of morale were provided by a modified version of the 13-item Life satisfaction scale Index (LSI). | • Age<br>• Sex<br>• Marital status<br>• Social Class<br>• General health<br>• Levels of social activity<br>• Cognitive Impairment<br>• Total walking<br>• Total indoor activity<br>• Total outdoor and leisure activity | • Logistic regression models<br>• Multiple linear regression models | • Lower levels of outdoor/leisure activities at T1 were also associated with some increased risk of depression 4 years later (OR=0.92 per hour of activity; 95% CI=0.85-0.99. $p<0.05$).<br>• Time spent walking B=0.125, $p<0.001$ increased LSI score at T2<br>• Total indoor activity B=0.09, $p<0.01$ increased LSI score at T2 | • Participants were chosen from a randomly sampled general practitioner lists in Nottingham UK. Individuals without general practitioner's were not included in the study. Therefore, results could be bias.<br>• The evidence for a physical activity-affect relationship independent of social activities should be interpreted with caution for several reasons. First, while statistically significant, the contribution of PA to the predictive power of these models is very small. Second, since the prevailing assumption in the exercise literature is that activity-affect relationships are, in large part, physiologically mediated by training effects, a linear dose-response relationship is further assumed. It may be, however, that in combination with other psycho-social influences (mastery, body image, etc.), some of the impact of PA levels on mood may be threshold-dependent, with little activity-affect co-variation below a particular threshold for a given individual. Thus, the present analyses may underestimate possible non-linear relationships. Third, since many social activities carry an implicit energy cost (e.g. attending meetings), it is possible that the BASE scale used in the present analyses controls only partially for social activity levels<br>• The present findings do not provide strong evidence that increases in physical activity (as exercise) will reliably promote improvements in psychological wellbeing among elderly people living at home.<br>• Unvalidated PA instrument | • There was a weak inverse association between higher levels of outdoor/leisure activities at T1 and decreased risk of depression 4 years later.<br>• There was a weak-moderate positive association between time spent walking and increased morale<br>• There was a weak positive association between total indoor activity and increased morale. |

| Publication | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Pasco et al. (2011) | To investigate habitual PA as a risk factor for incident depressive and anxiety disorders in men and women aged 60 years or more. | Men and women aged at least 60 years old. | N=547 | **PA:** assessed at baseline interview using a validated questionnaire designed for the elderly and for use in epidemiological studies (Voorrips et al., 1991). Subjects reported participation in habitual PA throughout the prior year, including household activities, sporting activities and other physically active leisure-time activities. Items relating to household activities had four to five possible ratings ranging from very active to inactive; those relating to sport and other activities included details on type of activity, intensity, hours per week and period of the year in which the activity occurred. An overall PA score was obtained by combining scores for activities from the household, sporting and leisure domains. | **DEPRESSION:** The Structured Clinical Interview for DSM-IVTR Research Version, Non-patient edition (SCIDI/ NP) was used to identify cases with a lifetime history of depressive and/or anxiety disorders at endpoint, and to determine the age of onset. Individuals with depression or anxiety that predated baseline were excluded; cases were identified as those who met DSM-IV-TR criteria for a depressive or anxiety disorder during the period of follow-up. Controls had no history of depressive and anxiety disorders. Trained personnel conducted psychiatric interviews. The authors decided a priori to pool depression and anxiety disorders to ensure that the study was adequately powered. | • Age<br>• Gender<br>• Weight<br>• Height<br>• BMI<br>• Smoking status<br>• Alcohol consumption<br>• Socioeconomic status (SES)<br>• Employment status<br>• Marital status<br>• Physical Activity | • Logistic regression | • Overall, PA was protective against the likelihood of depressive and anxiety disorders; OR = 0.55 (95% CI 0.32–0.94), p = 0.03; thus, each standard deviation increase in the transformed PA score was associated with an approximate halving in the likelihood of developing depressive or anxiety disorders during the ensuing four-year period.<br>• LTPA score was protective against the likelihood of depressive and anxiety disorders; OR = 0.59 (95% CI 0.36–0.96), p = 0.04.<br>• The likelihood of incident depressive and anxiety disorders was not associated with the household activity or sport activity scores. | • Inconsistencies in the pattern of PA over time may have resulted in misclassification of exposure status, attenuating the association.<br>• The possible confounding by co-morbid disease and cognitive impairment was not addressed, as subjects were not clinically screened for all potential physical and neurological illnesses.<br>• Confounding by genetic factors was not addressed.<br>• It is possible that other components of LTPA such as social engagement may have contributed to the beneficial effects of exercise.<br>• Small sample size | • There was a weak-moderate inverse association between LTPA and the lower likelihood of depressive and anxiety disorders. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Ku et al. (2009) | To assess the association between LTPA and incidence of depressive symptoms over a seven-year follow-up period in a sample of Taiwanese older adults. | Taiwanese adults aged 50 years or older in 1996. | N= 2831 | **PA:** Participants were asked 'Did you usually engage in any kind of leisure-time physical activity?' and four response categories were provided (none, 1–2, 3–5, and 7+ per week). Participants engaging in at least three activity sessions per week of any intensity were classified as being high physically active and the remainder classed as low. Using PA status in 1996 and 1999, four categories of activity status were created (low to low, low to high, high to low and high to high). | **DEPRESSION:** Measured using a 10-item Chinese version of the original 20-item CES-D (Radloff, 1977). The sum of the 10 items has a potential range of 0 to 30. The selection of the 10 items was based on the factorial analyses by Radloff (1977), representing the identified four dimensions, including 'depressed affect', 'somatic symptoms', 'positive affect', and 'interpersonal difficulties'. The 10-item Chinese version of the CES-D is consistent with the modified 11-item version of the CES-D (except one item: I felt that people dislike me.), which is highly correlated with the standard 20-item CES-D (r=0.95) (Kohout et al., 1993). The short Chinese CES-D has been shown to function well in cross-cultural studies including older Chinese populations (Krause and Liang, 1992, Ofstedal et al., 1999). Cronbach's alpha reliability coefficients for the 10-item CES-D in the 1996, 1999, and 2003 surveys range between 0.84 and 0.86 (Seplaki et al., 2006), which is comparable with a 10- item Chinese version developed in Hong Kong older adults (0.78–0.79) (Boey,1999). Incident cases in the present study were defined as those who were not expressing depressive symptoms in 1996 but who were in 2003 (CES-D-10 score ≥10) (Taiwan Bureau of Health Promotion, 2006). | • Gender<br>• Age<br>• Education level<br>• Marital status<br>• Cohabitation status<br>• Satisfaction with income<br>• Satisfaction with social support<br>• Alcohol consumption<br>• Smoking status<br>• Chronic diseases<br>• Activities of daily living<br>• Physical activity | • Multivariate logistic regression models | • Compared with those who were more physically active at leisure in 1996, participants engaging in activity less than three sessions per week had a higher risk of depressive symptoms in 2003 (AOR=1.48, 95% CI: 1.19–1.84 p<0.001 in the gender and age adjusted model; AOR=1.34, 95% CI: 1.05–1.71 p=0.02 in the fully adjusted model).<br>• Participants who were low active at both time points were at greater risk of developing depressive symptoms in 2003 (AOR=1.43, 95% CI: 1.04–1.95, p=0.05 in the fully adjusted model). | • The data are limited to self-reported frequency of LTPA only.<br>• Other components of PA such as duration, intensity and types are warranted in further studies.<br>• A broader range of PA measures that includes activity undertaken as transport, in occupations or household chores, as well as daily walking, and cycling<br>• Results may not generalizable to other groups that are non-Asian groups.<br>• Non-validated PA instrument | • There was a weak-moderate positive association between participants engaging in activity less than three sessions per week in 1996 and having a higher likelihood of depressive symptoms in 2003.<br>• There was a weak-moderate positive association between participants who were low active at both time points and a greater likelihood of developing depressive symptoms in 2003 |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Lindwall et al. (2011) | To investigate the reciprocal nature of the physical activity-depressive relationship in older adults from across a two-year follow-up. | Non-institutionalized older adults aged 50 years and older from 11 European countries. | N=17,593 | **PA:** was measured as "frequency of moderate physical activity" (such as gardening, cleaning the car, doing a walk) and "frequency of vigorous physical activity" (sports, heavy housework, a job involving physical labor). The response alternatives both for moderate and vigorous activity were: 1=more than once a week; 2 = once a week; 3= up to three times a month; 4= hardly ever or never. Higher values thus represent less activity. | **DEPRESSION:** The EURO-D scale was originally developed to be able to compare depressive symptoms across European countries (Prince et al., 1999b). It consists of 12 binary items (no/yes) scored 0 to 1, where higher values indicate depressive symptoms. The affective suffering factor comprises the depression, tearfulness, suicidality, sleep, guilt, irritability, and fatigue items from the scale, and motivation factor includes the interest, enjoyment, concentration, pessimism, and appetite items. The psychometric properties of the EURO-D scale have been thoroughly examined, and it has demonstrated criterion validity in the cross-cultural context as well as internal robustness (Castro-Costa et al., 2007; Prince et al., 1999a). | • Age<br>• Gender<br>• Education<br>• Marital status<br>• Chronic diseases<br>• Physical activity | • A two-wave cross-lagged design<br>• Latent change score model<br>• Structural equation modeling | • Higher levels of PA at T2 were associated with lower levels of affective suffering ( ø= .24, p< .001) and motivation (ø= .39, p <.001) at T2. As lower values in PA represent more activity, the standardized estimates between higher levels of activity and lower levels of depression are positive.<br>• A higher level of PA at T1 was related to lower depression at T2 for affective suffering ( β= 0.13, p < .001) and motivation (β= 0.20, p < .001). | •The use of self-report measures for PA<br>•The rather crude measures of PA used in SHARE, where the highest possible response alternative for the most active group was "more than once a week," may have created a ceiling effect and failed to distinguish between relevant group of more active individuals.<br>• Short follow-up.<br>• Non-validated PA instrument | • There was a weak-moderate positive association between higher levels of PA at T2 and lower levels of affective suffering at T2 and a moderate positive association between higher levels of PA at T2 and lower levels of motivation at T2.<br>• There was a weak-moderate association between higher level of physical activity at T1 and to lower depression at T2 for affective suffering and motivation. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Straw-bridge et al. (2002) | To clarify the relation between PA and depression by utilizing a community sample that included both with and without exclusion of physically disabled men and women at baseline over a wide age range. | Community-dwelling adults from the Alameda County Study aged 50–94 years at baseline in 1994. | N=1,947 | **PA:** A PA scale was constructed based on four questions: usual frequency of physical exercise, taking part in active sports, taking long walks, and swimming. The response set for each item was never, sometimes, or often; scoring was zero, one, or two, respectively. The resulting scale had a range of 0–8 with a mean of 3.4; reliability (standardized Cronbach's alpha) was 0.64. | **DEPRESSION:** The measure of depression was a set of 12 items that operationalized the diagnostic criteria for a major depressive episode outlined in Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition. Designated the DSM–12D, the items or symptom queries were adapted from the PRIME-MD mood disorders section of the Manual. Cases of major depressive episode were subjects who had experienced five or more symptoms of depression almost every day for the previous 2 weeks, including disturbed mood or anhedonia. | • Age<br>• Gender<br>• Ethnicity<br>• Education<br>• Financial strain<br>• Neighborhood problems<br>• Chronic conditions<br>• Cigarette smoking<br>• Alcohol consumption<br>• BMI<br>• Number of close friends<br>• Number of close relatives<br>• Friendship satisfaction<br>• Physical activity<br>• Physical disability | • Logistic regression models | • In the fully adjusted model (model 4), the relative risk was 0.83 (95 percent CI: 0.73, 0.96), meaning that each one-point increase in the 1994 PA scale was associated with nearly a 20 percent reduction in the likelihood of becoming depressed in 1999. Exclusion of disabled participants did not attenuate the incidence results (adjusted OR = 0.79, 95% CI: 0.67, 0.92). | • PA measure was constructed with a low Cronbach's alpha .64, therefore validity concerns<br>• Self-report PA questionnaire could lead to social desirability response.<br>• PA questionnaire is a crude estimate of PA. Does not include intensity of exercise or household PA.<br>• Short follow-up.<br>• Study did not include non-institutionalized participants<br>• Majority of the participants were White (84%), therefore may not be generalizable to ethnic groups.<br>• Cases of major depressive episode were only captured for the previous 2 weeks. Therefore, this may not accurately reflect depressive episodes.<br>• Given physically active older persons may interact more and form relations with those with whom they come into contact as a result of their PA. Perhaps the social relations variable should have acted as an intervening variable between PA and depression rather than a confounder and should not have been included as adjustment variables. | • There was a weak inverse association between higher levels of PA and a reduced risk of becoming depressed. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Smith et al. (2010) | To examine the cross-sectional and longitudinal relationships between walking distance and incident depressive symptoms in elderly Japanese-American men with or without chronic disease. | Japanese-American men from the ages of 71-93 years old at baseline. | N=3,196 | **PA:** was characterized as walking distance. During the fourth examination (1991-1993), the subjects were asked how many city blocks they walked each day. Blocks were then converted to miles using 12 blocks per mile as a conversion factor. The assessment of PA was developed from the Harvard Alumni Survey, and validity and reliability have been determined previously. | **DEPRESSION:** Participants were screened for depressive symptoms using an 11-question version of the Centers for Epidemiologic Studies Depression Scale (CES-D 11). Participants who did not answer three or more of the 11 depression questions were excluded from the analysis. The standard 20 question CES-D uses a cutoff score of 16 points for depressive symptoms. In the CES-D 11, a score of 9 or greater was used as a cut point (determined by extrapolation; 16/20 x 11= 8.8, rounded up to 9). Shorten forms of the CES-D have been found to be comparable with the full-scale version. Prevalent depressive symptoms were defined as valid CES-D 11 score of 9 or greater or taking antidepressive medications at Examination 4 (338/3.196, 10.6%). The CES-D 11 screening test was repeated during the seventh examination 8 years later, and again, subjects who did not answer three or more of the questions were excluded from the analysis. Subjects were defined as having 8 year incident depressive symptoms if they had a CES-D 11 score of 9 or greater or were taking antidepressive medications at Examination 7. Subjects with prevalent depressive symptoms at Examination 4 were excluded from the incidence analysis. | • Age<br>• Education<br>• Marital Status<br>• BMI<br>• Smoking status<br>• Hypertension<br>• Alcohol consumption<br>• Diabetes<br>• Coronary heart disease<br>• Stroke<br>• Cancer<br>• Cognitive Function<br>• Dementia<br>• Parkinson's Disease<br>• Functional Impairment | • Multiple logistic regression models | • After adjusting for age, education, marital status, cardiovascular risk factors, prevalent diseases, and functional impairment, multivariate models found significantly lower odds of development of 8 year incident depressive symptoms in the high OR=0.61 (95% CI=0.38,-0.97, P=0.04) and intermediate walking-distance OR= 0.52, 95% CI=0.32-0.84, P=.007) groups. This association was only significant in participants without chronic disease (coronary heart disease, cerebrovascular accident, cancer, Parkinson’s disease, dementia, or cognitive impairment) at baseline.<br>• Adjusting for age, education, marital status, cardiovascular risk factors and functional impairment, those in the intermediate-walking group who were healthy (without chronic disease at baseline) had a significantly lower odds of developing incident depressive symptoms (OR=0.39, 95% CI=0.21-0.71), P=.002). | • Results may not be generalizable to women or ethnic groups.<br>• Results may be biased as participants who were excluded because of incomplete or invalid answers may had more-severe cognitive impairment or medical burden or higher depressive symptoms.<br>• Self-report of blocks walked each day may be biased due to social desirability response.<br>• There may be recall bias when asked "how many city blocks they walked each day". | • There was a weak-moderate to moderate inverse association between men in both the high walking-distance group and intermediate walking-distance group and a lower odd of developing incident depressive symptoms at year 8.<br>• There was a moderate-strong inverse association between healthy men (without chronic disease at baseline) in the intermediate walking-distance group and lower odds of developing incident depressive symptoms. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Lampinen et al. (2006) | To examine the roles of physical and leisure activity as predictors of mental well-being among older adults born in 1904-1923. | Elderly residents aged 64- 84 years old from the city of Jyvaskyla, central Finland. | N=663 | **PA:** level and intensity assessed on a seven point scale- (1) performance of necessary chores only; (2) walking 1–2 times/week; (3) walking several times/week; (4) exercising 1–2 times/week to the point of perspiring and heavy breathing; (5) exercising several times/week to the point of perspiring and heavy breathing; (6) doing keep-fit exercises; and (7) participation in competitive sports.<br>**Leisure Activity:** measured with an index based on the sum of score of involvement in 9 different interests ranging from 0=never to 2=regularly-nine different interests (e.g., active and passive art interests, involvement in associations and religious activities, handicrafts, reading, studying), A high score indicated a higher frequency of leisure activity. PA was not included in leisure activities. | Five dimensions of mental well-being:<br>**Depressive symptoms:** used modified version of Beck's depression scale-(RBDI). Every item rated from 0-3 with higher scores indicating greater severity of symptoms. The maximum score for the scale is 39 points. Those scoring four or less were considered not to be depressed. 5-39 points were considered to be depressed.<br>**Level of anxiety:** assessed on a five-point scale: (1) I consider myself fairly relaxed and do not get anxious easily; (2) I do not feel anxious or nervous; (3) I get anxious and excited fairly easily; (4) I get especially easily distressed anxious or exited; and (5) I continually feel anxious and distressed as if I were at the end of my tether. Every item is rated from 0–3 with higher scores indicating greater severity of anxiety.<br>**Loneliness:** measured with a standard question: 'Do you think you are lonely? (1) I do not feel lonely; (2) I sometimes feel lonely; (3) I am fairly lonely; or (4) I am very lonely.<br>**Self-rated mental vigor**: was posed by the question: 'How would you describe your self-rated mental vigor at the moment? (1) very good; (2) good; (3) moderate, satisfactory; (4) poor; or (5) very poor'.<br>**Meaning in life:** measured using the question: 'Right now, how meaningful do you consider your life? (1) very meaningful; (2) meaningful; (3) neither meaningful nor meaningless; (4) meaningless; or (5) very meaningless'.<br>**Mental well-being:** factors for path analysis models were constructed from the factor scores of mental well-being indicators (depressive symptoms, anxiety, loneliness, self-rated mental vigor, meaning in life) using factor analysis. | • Age group<br>• Mobility status<br>• Number of chronic illnesses<br>• PA<br>• Leisure activity | • Path analysis model<br>• Multi-variate regression models | • Higher PA (0.10, SE=0.02) and higher leisure activity (0.08, SE=0.02) had an indirect effect on mental well-being in follow-up (in 1996). | • The trust on the accuracy of self-reports.<br>• The validity of one-item scales (e.g. almost all of the mental well-being and independent variables). Although the one-item scales of mental well-being applied in the study have been used in earlier studies, the validity of these scales in the assessment of the phenomenon in question is not well known.<br>• No feasible theory of mental well-being that would have sufficiently addressed the different dimensions of mental well-being and thus provided a sound foundation for the logical construction of the path analysis model.<br>• Some evidence of sample selection.<br>• The interval between the two assessments was eight years and little is known about individuals' life changes over such a long period.<br>• Interviews were performed at participant's homes. Possible social desirability responses may have occurred.<br>• Leisure PA instrument validity concerns.<br>• Relatively small sample size | • There was a weak positive association with both higher PA and higher leisure activity predicting better mental well-being in follow-up. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Bowen (2012) | To examine the relationship between vigorous PA and dementia risk. | Community-based adults age 71 years and over with 3 to 7 years of PA information prior to dementia/no dementia diagnosis. | N=808 | **PA:** was measured at baseline (1998) and subsequently in years 2000 and 2002. Respondents were asked: "On average, over the past 12 months, have you participated in activities such as aerobics, sports, running, swimming, bicycling, heavy housework, or a job involving physical labor three or more times/week?" This vigorous PA measure, which has been validated in previous work, was used in this study because this is the only PA measure asked consistently over the course of the survey. To account for intraindividual variation in vigorous PA over the course of the study and to examine the cumulative effects of vigorous PA on dementia risk over time, vigorous PA was summed into a score (ranging from 0 to 3) where 0 =no vigorous PA over the course of the study and 3= 3 years of vigorous PA over the course of the study. | **DEMENTIA:** Measured in the Aging, Demographics, and Memory Study (ADAMS) from 2001 to 2005 and included all subtypes (e.g., Alzheimer's disease). Dementia was determined by a battery of neuropsychological measures and a standardized neurological examination. The neuropsychological battery included measures of orientation, verbal and visual immediate and delayed memory, language, attention, executive function, reading ability, and general intellect. Assessment and diagnostic procedures in the ADAMS have been validated against neuropathological diagnoses. | • Age<br>• Gender<br>• Education<br>• Race<br>• Genetic risk factors<br>• Health behaviors<br>• Health indicators<br>• Health conditions<br>• Mental Status | • Binary logistic regression | • Older adults who were physically active were 21% (p≤ 0.05) less likely than their counterparts to be diagnosed with dementia (OR=0.79, 95% CI 0.64-0.97, p≤ 0.05).<br>• In addition, each unit increase in vigorous PA was associated with .77 times lower odds of dementia. (OR=0.77, 95% CI 0.64-0.94, p<0.01). | • This study was unable to adjust for cognitively stimulating activities, such as reading books or completing puzzles, which have been shown to delay cognitive impairment.<br>• This study used a self-reported vigorous PA measure and there may be social desirability bias in self-reports.<br>• Although this study used a prospective measure of vigorous PA, it remains that less activity may be a consequence rather than a predictor of dementia.<br>• This study focused on older adults who lived to at least age 71, thus there may be selective survival effects.<br>• The study was unable to adjust for a family history of dementia. | • There was a weak-moderate inverse association between older adults who engaged in vigorous PA three or more times per week for at least 12 months and the less likelihood to be diagnosed with dementia than their counterparts. |
| Larson et al. (2006) | To determine whether regular exercise is associated with a reduced risk for dementia and Alzheimer disease. | Men and women aged 65 years of age and older cognitively intact at baseline. | N= 1740 | **PA:** assessed at baseline by asking participants the number of days per week they did each of the following activities for at least 15 minutes at a time during the past year: walking, hiking, bicycling, aerobics or calisthenics, swimming, water aerobics, weight training or stretching, or other exercise. The frequency of exercise was calculated by the times per week that participants engaged in any of these forms of exercise. In this study, persons who exercised at least 3 times a week, above the lowest quartile, were classified as exercising regularly. | **DEMENTIA:** Biennial examinations were conducted to identify cases of incident dementia, when participants were rescreened with the CASI. Those who scored 86 or higher on the CASI remained in the ACT cohort. Scores on the CASI that were < 86 at follow-up prompted a full standardized clinical examination. The results of rescreening by the CASI and by the clinical and neuropsychological examinations were reviewed at a consensus diagnosis conference that included at least the examining physician, a neuropsychologist, another study physician, and the study nurse. Persons who did not meet the criteria for dementia were considered as not having dementia and were followed in the ACT cohort. Persons who met the Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV), criteria for dementia were considered to have incident dementia. Dementia type was determined by the National Institute of Neurological and Communicative Diseases and Stroke–Alzheimer's Disease and Related Disorders Association criteria for Alzheimer disease and by the DSM-IV criteria for other types of dementia. Level of physical activity was not considered at the consensus conference. | • Age<br>• Gender<br>• Race<br>• Supplement use<br>• Smoking status<br>• Alcohol use<br>• Comorbid conditions<br>• Self-rated health status<br>• Physical functioning<br>• Cognitive function<br>• Depression<br>• Genetic risk factor for Alzheimer disease | • Logistic regression<br>• Cox proportional hazards regression | • The age- and sex-adjusted hazard ratio (HR) of dementia for the regular exercise group was 0.62 (CI, 0.44 to 0.86; P = 0.004). After adjusting for potential confounders, the HR of dementia by exercise was 0.68 (CI, 0.48 to 0.96; P = 0.030).<br>• The age and sex-adjusted HR of Alzheimer disease by exercise was 0.64 (CI, 0.43 to 0.96; P=0.031). After adjusting for potential confounders, the HR of Alzheimer disease by exercise was 0.69 (CI, 0.45 to 1.05; P= 0.081). | • Exercise was measured by self-reported frequency.<br>• Exercise measure did not have a good measure of intensity and duration for calculating the dose of exercise.<br>• The study population had a relatively high proportion of regular exercisers at baseline.<br>• The cohort was largely white and well-educated.<br>• Bias selection as individuals were drawn from Seattle-area members of Group Health Cooperative (GHC), a consumer-governed health maintenance organization<br>• The study did not collect information about the history of exercise before the participants entered the study.<br>• The measure of exercise did not include information about work and non-leisure activities or changes after baseline, and the adjustments in potential confounders are probably incomplete<br>• Non-validated PA instrument was utilized | • There was a weak-moderate inverse association between those who exercised three or more times a week and a lower risk for dementia and Alzheimer disease. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| De Bruijn et al. (2013) | To examine the association of PA with dementia, and separately with Alzheimer disease, during longer follow-up. | Men and women aged 55 years and older, of Ommoord, a suburb of Rotterdam, the Netherlands. | N= 4,406 | **PA:** assessed by means of an adapted version of the Zutphen Physical Activity Questionnaire (ZPAQ). ZPAQ has been validated previously: The test–retest reliability was 0.93 and the correlation with doubly labeled water, the golden standard measurement of PA, was 0.61. The original questionnaire contains questions on walking, cycling, gardening, diverse sports, and hobbies. To obtain a more complete overview of PA, questions on housekeeping activities were added. Participants were asked how many hours they spent per week on these activities during the past 2 weeks. For some activities, like sports and gardening, participants were asked whether this activity was practiced only during summer or winter. When answered positive, the given period of time for that activity was divided by two. To study body movement associated with the activity, the authors used the metabolic equivalent of task (MET). MET is a widely used method to assign intensity units to PA questionnaires. The MET-value is based on the ratio of work metabolic rate to resting metabolic rate and 1 MET is defined as 1 kcal/kg/hour. The number of MET-hour for an individual spent on a specific activity was therefore calculated by multiplying the MET-value by time spent on that specific activity (in hours) per week. | **DEMENTIA:** Participants were screened for dementia at baseline and follow-up examinations using a three-step protocol. Screening was done using the Mini-Mental State Examination (MMSE) and the Geriatric Mental Schedule (GMS) organic level. Screen-positives (MMSE <26 or GMS organic level >0) subsequently underwent an examination and informant interview with the Cambridge Examination for Mental Disorders in the Elderly. Participants who were suspected of having dementia, underwent, further neuropsychological testing. Additionally, the total cohort was continuously monitored for dementia through computerized linkage between the study database and digitized medical records from general practitioners and the Regional Institute for Outpatient Mental Health Care. When information on neuro-imaging was required and available, it was used for decision making on the diagnosis. In the end, a consensus panel, led by a neurologist, decided on the final diagnosis in accordance with standard criteria using the DSM-III-R criteria for dementia and the NINCDS-ADRDA for Alzheimer disease. | • Age<br>• Gender<br>• Educational level<br>• Smoking habits<br>• APOE genotype<br>• Hypertension<br>• BMI<br>• Diabetes mellitus<br>• Serum glucose<br>• Total cholesterol<br>• HDL-cholesterol levels<br>• Physical activity | • Cox proportional hazards | • As association between higher PA and lower risk of dementia was found after adjusting for potential confounders. This association was restricted to follow-up to 4 years (HR 0.84; 95% CI 0.73-0.97), and not to follow up of at least 4 years.<br>• An association between higher PA and lower risk of Alzheimer disease was found after adjusting for potential confounders. This association was restricted to follow-up to 4 years (HR 0.89; 95% CI 0.76-1.03), and not to follow up of at least 4 years. | • Subjective PA measurement may have led to bias or social desirability response.<br>• The PA questionnaire did not contain questions on work related PA.<br>• There might be some survivor effect as PA was assessed at the second follow-up exam of the Rotterdam Study and unhealthy persons may have died during the intermediate time period. | • There was a weak inverse association between higher levels of PA and lower risk of dementia and lower risk of Alzheimer disease. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Laurin et al. (2001) | To explore the association between regular PA and the risk of cognitive impairment and dementia. | A community representative sample of men and women aged 65 years or older, were drawn from a population based listings for 36 urban and surrounding rural areas in all 10 Canadian provinces. | N= 4615 | **PA:** Exercise data were collected as part of CSHA-1 when subjects were not demented and represent a proxy for earlier activity up until the time of baseline. The level of PA was assessed by combining 2 questions from the risk factor questionnaire regarding frequency and intensity of exercise for subjects who reported regular PA. A composite score rating PA as either low, moderate, or high, was obtained by summing answers to the frequency question (≥ 3 times per week, weekly, or less than weekly) and the intensity question (more vigorous, equal to, or less vigorous than walking). A high level of PA corresponded to an exercise engaged 3 or more times per week at an intensity greater than walking, while a moderate level of PA corresponded to exercise also engaged 3 or more times per week, but of an intensity equal to walking. All other combinations of frequency and intensity were considered low level of PA. Subjects who reported no regular exercise constituted the reference category. The measurement properties of this index were assessed with an independent sample of 738 elderly individuals, to whom the risk factor questionnaire was administered by an interviewer. Construct validity was assessed by comparing the combined score with other reported markers of health hypothesized to be related to exercise and self-rated health. the average intraclass coefficient for the combined score was 0.76 (95% CI, 0.72-0.79; P=.002), while the combined score demonstrated satisfactory construct validity, and seemed to be well associated with mortality over 5 years. | **DEMENTIA:** Using the modified Mini-Mental State (3MS) Examination. Subjects who screened positive (3MS Examination score ≤ 77) and a random sample of those who screened negative (3MS Examination score ≥ 78) were asked to attend an extensive standardized 3-stage clinical evaluation. A nurse first screened for hearing and vision problems, and collected information about medication regimen and medical and family histories. Next, a physician carried out standardized physical and neurological examinations. Third, a psychometrist administered a neuropsychological test battery to all individuals deemed testable 93MS Examination score ≥ 50), the results of which were interpreted by a neuropsychologist. Preliminary diagnoses were made independently according to Diagnostic and Statistical Manual of Mental Disorders, Revised Third Edition criteria by the physician and the neuropsychologist who subsequently arrived at a diagnosis in a consensus conference. Consensus diagnoses constituted the following: no cognitive impairment, cognitive-impairment-no dementia [CIND], Alzheimer disease (probable or possible) according to the National Institute of Neurological Disorders and Stroke-Alzheimer's Disease and related Disorders Association criteria, vascular dementia according to World Health Organization International Classification of Diseases, 10th Revision criteria, other specific dementia and unclassifiable dementia. All subjects without dementia were asked to complete and return by mail a self-administered risk factor questionnaire covering specific expositions for which prior hypotheses existed. This questionnaire included questions about demographic characteristics, occupational and environmental exposures, lifestyle, and medial and family histories. Four outcomes were examined: CIND, Alzheimer disease, vascular dementia, and any type of dementia. | • Age<br>• Sex<br>• Education<br>• Smoking status<br>• Alcohol Consumption<br>• Physical activity | • Univariate logistic regression models<br>• Multivariate logistic regression models | • Adjusting for sex, moderate and high levels of PA were associated with significantly lower risks for Alzheimer disease for women only (OR= 0.67, 95% CI 0.42-1.06, p=0.03; OR=0.38, 95% CI 0.16-0.91, p=0.03, respectively) and for dementia of any type (OR=0.64, 95% CI 0.43-0.95 p=0.02; OR= 0.48, 95% CI 0.25-0.94, p=0.02, respectively). | • Possible survival bias as all eligible subjects at baseline for whom a risk factor questionnaire was available, died during the 5 year follow-up period and were excluded from the analyses. These subjects were, at baseline, generally older, less educated, less physically active, and suffered more frequently from chronic diseases than subjects who completed follow-up.<br>• The results might possibly be explained by some preclinical cognitive decline (not yet detectable by screening and clinical evaluations at CSHA-1) among subjects who later developed CIND or dementia by CHSA-2. | • There was a weak-moderate to moderate-strong inverse association between increasing levels of PA (moderate and high) and a lower likelihood for Alzheimer's disease and dementia of any type for women only. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Taaffe et al. (2008) | To examine the association of late life PA and the modifying effect of physical function with future risk of dementia in a cohort of elderly men participating in the Honolulu-Asia Aging Study (HAAS). | Japanese-American men from the ages of 71-93 years old without dementia at baseline. | N=2263 | **PA:** Usual 24hr PA was assessed based on questions regarding the average number of hours per day spent in five levels of activities. The activity levels were basal (sleeping or lying down), sedentary (e.g. sitting or standing, reading, eating), slight (e.g., walking on level ground), moderate (e.g. gardening or carpentry), and heavy (e.g. lifting or shoveling). A weighting factor based on the approximate oxygen consumption required for each level of activity was multiplied by the hours spent in that activity and summed across the five levels to derive an index of PA. The weighting factors were: 1.0 for basal, 1.1 sedentary, 1.5 for slight, 2.4 for moderate, and 5.0 for heavy activity. | **DEMENTIA:** Initial screening considered a participant's age and cognitive performance using the 100-point Cognitive Abilities Screening Instrument (CASI). The CASI includes 9 cognitive domains. Scores <74 were considered a priori as an indicator of possible dementia. Men with such scores were subjected to a second phase of dementia screening that included a repeat CASI and administration of the Informant Questionnaire on Cognitive Decline in the Elderly (IQCODE). Men with a second CASI score <74 or with a IQCODE score of ≥ 3.6 underwent a third phase that included a standardized interview, assessment by the Consortium to Establish a Registry for Alzheimer's Disease neuropsychological battery, a proxy interview, a neurological examination, neuroimaging, and blood tests. For repeat examinations, the CASI was administered once. For the first follow-up examination (1994-1996), men with a CASI score ≤ 77 with < 12 years of education, a CASI score of ≤ 79 with ≥ 12 years of education, or an absolute drop of ≥9 points from the baseline examination were recruited to complete dementia assessment. For the second follow-up examination (1997-1999), a complete assessment was undertaken for all participants with a CASI score of < 70. Final diagnosis was assigned by a consensus panel consisting of a neurologist and at least two additional docs with expertise in geriatrics and dementia. | • Age<br>• Education<br>• BMI<br>• PA<br>• Smoking status<br>• Hypertension<br>• Total cholesterol<br>• Diabetes<br>• Coronary heart disease<br>• Depression<br>• APOE genotype | • Linear regressions models<br>• Logistic regression models<br>• Cox proportional hazards regression models | • High levels of PA were associated with a reduction in the risk for dementia in men with poor physical function only (HR=0.50; 95% CI, 0.28-0.89, p<0.05).<br>• Moderate PA levels also provided a protective effect for the risk of dementia, with the risk of dementia reduced by 43% versus the men who were the least physically active (HR=0.57, 95% CI, 0.32-0.99, p<0.05). | • Results may not be generalizable since the study sample only included men without dementia at the baseline examination of the HAAS and who survived at least to the first follow-up examination.<br>• Results may not be generalizable to other ethnic groups.<br>• Physical function was objectively assessed using standardized physical performance tests that could be easily performed with minimal equipment in the home or clinical setting. However, as performance on these tests required the individual to understand the instructions and be motivated to undertake the tests, bias may have entered as a result of persons with cognitive impairment<br>• Although PA instrument was similar to those used in two other studies, those studies were much older and the articles were not accessible to be reviewed. Therefore, unsure of validation of PA instrument. | • There was a moderate inverse association between high levels of PA and a reduced risk for dementia in men with poor physical function.<br>• There was a weak-moderate inverse association between the moderate PA group and reduced risk of dementia. |
| Buchman et al. (2012) | To examine the hypothesis that an objective measure of total daily PA predicts incident Alzheimer's disease (AD) and cognitive decline. | Participants were older individuals from the Rush Memory and Aging Project without dementia. | N=716 | **PA:** Total daily exercise and non-exercise PA was measured 24 hours/day for up to 10 days with actigraphs worn on the non-dominant wrist. PA was measured with actigraphy (Actical®; Mini Mitter, Bend, OR). Total daily PA was the average sum of all daily activity counts recorded. On average, there were more than 3 x 10 (power of 5) activity counts/day; raw counts were divided by 1 x 10 (power of 5) (about 1 SD) to facilitate presentation and interpretation of the results.<br>**Late Life PA:** Self-report assessment of late-life PA was based on questions adapted from the 1985 National Health Interview Survey. Five activities included walking for exercise, gardening or yard work, calisthenics or general exercise, bicycle riding, and swimming or water exercise. Minutes spent engaged in each of these activities were summed and expressed as hours of activity/week. | **ALZHEIMER DISEASE:** Participants were evaluated by a clinician who used all cognitive and clinical data to diagnose AD using National Institute of Neurological and Communicative Disorders and Stroke–Alzheimer's Disease and Related Disorders Association criteria. | • Age<br>• Sex<br>• Years of education<br>• Motor function<br>• BMI<br>• Depression<br>• Vascular risk factors<br>• Vascular diseases<br>• Physical activity<br>• Social activity<br>• Cognitive activity | Cox proportional hazards model | • Adjusted for age, sex, and education, total daily PA was associated with the risk of developing AD (HR= 0.477; 95% CI 0.273-0.832).<br>• Total daily PA remained associated with AD even after adjusting for self-report PA as well as the frequency of social and cognitive activities in a single model (HR=0.528; 95% CI 0.293-0.951). | • Inferences regarding causality must be drawn with caution from observational studies.<br>• The percentage of female participants was high and this was a volunteer cohort, and thus may not be representative of the general population of older adults.<br>• Actigraphs used in this study do not differentiate the types of activities that were performed, and removal of the device cannot always be distinguished from periods of no activity.<br>• Short follow-up (4 years).<br>• Self-report assessment of late-life PA could lead to social desirability response.<br>• Survival bias.<br>• Relatively small sample size. | • There was a moderate inverse association between total daily PA and a lower risk of developing AD |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Boyle et al. (2007) | To examine the association between PA and the risk of incident ADL and IADL disability in community-based older persons free of dementia. | Residents of approximately 40 senior housing facilities in the Chicago metropolitan area. | N=1020 | **PA:** was assessed using questions adapted from the 1985 National Health Interview Survey. The activities included walking for exercise, gardening or yard work, calisthenics or general exercise, bicycle riding, and swimming or water exercise. Participants were asked if they had engaged in any of those activities within the previous 2 weeks and, if so, the number of occasions per week and the average number of minutes per occasion. Minutes spent engaged in each activity were summed and divided by 120 to yield a composite measure of participation in PA expressed as hours per week, as previously described. | **DISABILITY:** Assessed using two instruments. First, ADLs were assessed using a modified version of the Katz Index, a self-report measure that includes six activities: feeding, bathing, dressing, toileting, transferring, and walking across a small room. Participants were given the following response choices with regard to their ability to perform each of the six activities: no help, help, unable to do. For these analyses, participants who reported needing help on or an inability to perform one or more tasks were classified as being disabled. Although this is only one of several methods of operationalizing disability, it is a commonly used definition, and prior research has shown that, although older persons can transition in and out of disability, those who are disabled at any point in time are likely to remain disabled or show progression of disability over time. IADLs were assessed using items adapted from the Duke Older Americans Resources and Services project. Items assessed include eight activities: telephone use, meal preparation, money management, medication management, light and heavy housekeeping, shopping, and local travel. Participants were given the following response choices with regard to their ability to perform each of the eight IADLs: no help, help, unable to do. As with the Katz scale, those who reported needing help on or an inability to perform one or more tasks were classified as having disability on the measure of IADLs. | • Age<br>• Gender<br>• Race/ethnicity<br>• Education<br>• PA score<br>• Gait<br>• Global cognitive function<br>• Vascular risk factors<br>• Vascular disease burden<br>• Joint pain<br>• Head injury<br>• Cancer<br>• BMI<br>• Depressive symptoms | • Cox proportional hazards models | • The relative risk (RR) of disability on the measure of ADL's was 7% less for every additional hour of PA per week (HR=0.93, 95% CI=0.877–0.982). The RR of disability on the Katz was approximately 16% less (HR=0.84) for a person who reported 2.33 hours and 41% less (HR=0.59) for someone who reported 7 hours of PA per week than for a person reporting no PA.<br>• The RR of disability on the measure of IADLs was 7% less for every hour increase in PA per week (HR=0.93, 95% CI=0.887–0.978). The RR of disability in IADLs was approximately 21% less (HR=0.79) in a person who reported 2.8 hours and 47% less (HR=0.53) for someone who reported 7.5 hours of PA per week than a person who reported no PA. | • The use of a volunteer cohort and the short duration of follow-up is a limitation of the study.<br>• The findings were based on self-report measures of PA and disability, which are subject to recall bias and inaccuracies.<br>• Although these findings suggest that PA is associated with important health outcomes in old age, unmeasured confounders could also affect the results of observational studies such as this.<br>• Although it was not possible to control for musculoskeletal fitness, musculoskeletal fitness is an important determinant of the risk for functional dependence.<br>• Majority of the participants were women and non-Hispanic white. Therefore may limit the generalizability of results.<br>• PA instrument does not reflect intensity of PA | • There was a weak and weak-moderate inverse association between more frequent PA and a lower risk of incident disability in ADL's<br>• There was a weak-moderate to moderate inverse association between more frequent PA and lower risk of incident disability in IADLs. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Bruce et al. (2008) | To examine the relationship of body weight and PA to disability in a cohort of healthy, older adults over 13 years of follow-up. | Men and women aged 50-72 years old, had at least a high school diploma, and spoke English as their primary language. Participants were from a national runners' association Eind from the local Stanford University community. | N=805 | **PA:** assessed as the number of minutes spent weekly doing vigorous exercise. Vigorous exercise was defined on the questionnaire as "vigorous exercise that will cause you to sweat and your pulse, if taken, will be above 120." Activities under this definition included running, swimming, bicycling or using a stationary bike, aerobic dance and exercise, stair steppers, brisk walking, hiking or using a treadmill, racket sports, and also periods of rapid walking at work and in daily activities. For convenience, the authors chose to use the terms "active" and "inactive" to describe PA groups in this study. Participants were categorized as active if they participated in vigorous exercise for more than 60 minutes per week or inactive if they participated in vigorous exercise for 60 minutes or fewer per week. | **DISABILITY:** Assessed with the Stanford HAQ Disability Index (HAQ-DI), which includes items that evaluate fine movements of the upper extremity, locomotor activity of the lower extremity, and activities that involve both upper and lower extremities. The HAQ-DI contains 20 items in 8 categories of functioning—rising, dressing, eating, walking, hygiene, reaching, gripping, and ability to do usual daily activities. Responses are made on a scale from 0 (no difficulty) to 3 (unable to do). The maximum item scores in each of the 8 categories were summed, then averaged, to obtain an overall HAQ-DI from 0 (no disability) to 3 (completely disabled).The HAQ-DI has been extensively studied and is valid and sensitive to change. | • Age<br>• Gender<br>• Years of education<br>• Race/ethnicity<br>• Baseline disability<br>• Exercise<br>• Smoking status<br>• Co-morbid conditions<br>• Global health status<br>• BMI<br>• Physical activity | • Chi-squared and 2-tailed t-tests<br>• Multivariable Analysis of Covariance | • Overweight active participants had significantly less disability than did overweight inactive (0.14 vs 0.19; P=.001) and normal-weight inactive (0.22; P=.03) participants.<br>• Physically inactive participants in both weight groups (normal weight and overweight) had the highest levels of disability (0.22, p< 0.001 vs. 0.19, p=0.001).<br>• In the fully adjusted model, overweight active participants had significantly less disability than their normal-weight inactive counterparts (0.14 vs 0.22; P<.001). | • The study cohort was predominantly well-educated (> 16 years of education) White men. Findings may not be applicable to aging seniors such as women, other ethnic groups, and the less-educated.<br>• The authors based PA levels on the amount of vigorous activity compared with other studies that have used less-vigorous kinds of activity such as walking.<br>• Crude and non-validated PA measure was utilized<br>• Use of BMI to classify individuals also may have influenced the findings because BMI is not entirely accurate measure of body composition and may result in misclassification of certain groups, such as the elderly.<br>• Data was collected by self-report<br>• Participants were from a national runners' association Eind from the local Stanford University community. Therefore, results may limit generalizability.<br>• Runners' association members were younger, had significantly lower BMIs, and the biggest difference was the number of miles run, compared with the community controls. Therefore, findings may not be applicable to the morbidly obese, heavy smokers, seniors who are ill or frail, or to octogenarians or older aged individuals.<br>• Data on moderate or light activities were not collected in earlier years of this study, thus the impact of less-vigorous activity could not be assessed. | • There was a weak-moderate inverse association between overweight active and lower levels of disability. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Hunt et al. (2010) | To examine whether overall activity levels and earlier sporting activities are associated with onset of locomotor disability in earlier old age in a general population. | Men and women aged 58 years old from the West of Scotland Twenty-07 Study. | N=547 | **Exercise and Sport:** the interview schedule included questions about PA in work (hard physical and stair climbing) and home and leisure settings (light and heavy housework, chores and maintenance, gardening, walking, stair climbing, cycling). These questions gathered information on past (defined as since leaving school) PA and current PA based on the Allied Dunbar National Fitness Survey. These data contributed to summary indicators of overall activity level. The total number of weekly occasions of moderate activity lasting 30 min or more and vigorous activity lasting 20 min or more were estimated. Respondents were then dichotomized to reflect whether or not they achieved an "active lifestyle" which was defined as attaining either three occasions of vigorous activity lasting 20 min per week or five occasions of moderate activity lasting 30 min per week. This approach was commensurate with previous recommendations of active living from the US Centers for Disease Control and Prevention and the American College of Sports Medicine. Respondents also answered a detailed section on past and current participation in specified games and sports. These were presented on a series of cards that listed 52 activities, grouped in to cards from team games, individual sport, training and fitness activities, outdoor activities, and other games and sports. Respondents indicated which sports/activities they did regularly (meaning at least once a week for 2 or more months in the year) and provide subsequent detail on intensity(makes a person sweaty or breathless) and frequency (how many days per year). They were also asked to indicate which of the 52 sports/activities they had done regularly earlier in their life (excluding sport/activities that they had only done while still at school) but stopped doing regularly. For each sport done in the past, total number of years done and age at which they gave up were recorded. Summary variables were constructed for key types of sporting activity: dance/keep fit (social dancing, dancing from fitness, exercise/circuit training, keep-fit dancing), walking (walking, rambling, hiking, backpacking), swimming, golf, racket sports (tennis, squash, badminton), and active team sports (football, hockey, rugby, netball, basketball) currently at age 58 and in the past only (during adult life but given up by age 58). | **LOCOMOTOR DISABILITY (LD):** respondents completed a modified version of the UK Office of Population Censuses and Surveys (OPCS) disability questionnaire. LD is derived from questions pertaining to a person's reported physical performance across a number of tasks, including, for example, "what is the furthest you can walk on your own without stopping and without discomfort?" and "Could you walk up and down one step on your own?" Other tasks include bending and straightening, balance, and the number of falls in the past 12 months. The minimum score for each dimension is 0 (i.e. no disability); those responding positively to any question in the locomotor section of this questionnaire were classified as having LD. | • Age<br>• Gender<br>• Occupational Social Class<br>• Physical measurements<br>• Severity and frequency of pain in major joints<br>• Chronic Illnesses<br>• Overall level of Activity | • Multivariable logistic regression models | • Measures of overall activity levels (i.e., achieving either 5 moderate or 3 strenuous episodes of activity across all domains) at age 58 did not show a relationship between locomotor disability 5-6 years later.<br>• Swimming was the only sporting activity to show any strong evidence of a protective association with later locomotor disability (OR=0.32, 95% CI0.14-0.73 adjusted for gender and occupational social class). | • Self-reported PA and sport activities prone to recall bias<br>• Interviewed by nurses may lead to social desirability response.<br>• Small sample size could have resulted in Type 2 errors<br>• Contemporaneous public health messages to promote increased PA, may likely have respondents overestimate their previous PA answers<br>• Five year follow up of locomotor disability may not have been long enough to determine association between PA and locomotor disability.<br>• Non-validated PA instrument. | • No association |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Shah et al. (2012) | To examine whether greater total daily PA was associated with less report of disability in older adults. | Older community-dwelling men and women in the Rush Memory and Aging Project. | N=870 | **Quantitative Total Daily PA:** Participants wore an Actial (Mini Mitter, Bend, OR), a device with a piezo-electric accelerometer. Participants were instructed to wear the actigraphy device continuously without taking it off. The non-dominate wrist was chosen as the application site to facilitate participants ability to wear the device throughout the measurement period. Actical retrieval was scheduled for 10 days later but could vary depending on participant availability. Upon retrieval of the actigraph, raw data were downloaded and viewed using software provided by Respironics, Inc (Bend, OR). Data than partitioned into 24 hour periods from the time of placement to the time of retrieval, and only data from complete 24 hours periods were used to determine average total daily PA. A cyclical measure do no directly correspond to observed movements but are proportional to the degree and intensity of movements as reflected in recorded activity curves. Activity counts represent the are calculated by integrating the activity curve for each 1-second sample, where non-zero values reflected activity. Activity counts are summed for each epoch (15 second). Total daily PA was the mean sum of all 24-hour activity counts.<br>**Self-report PA:** Using questions adapted from the 1985 National Health Interview Survey, self-report PA was assessed. Participants were asked of they had engaged in any five activities (exercise, gardening or yard work, calisthenics or general exercise, bicycle riding, and swimming or water exercise within the previous two weeks. Using the number of occasions, the minutes spent engaged in each activity was summed and divided by 120 to yield a composite measure of participation in PA expressed as hours per week. | **DISABILITY:** A modified version of the Katz Index was used to measure independence with basic ADL's. Participants reported whether they needed (1) no help, (20) help, or (3) were unable to do each of the six activities: bathing, dressing, feeding, toileting, transferring, and walking across a small room. The number of activities participants reported as needing help or unable to perform was calculated for each evaluation. Disability was defined as being dependent in at least one basic ADL. | • Gender<br>• Age<br>• Education<br>• Cognitive function<br>• Dementia diagnosis<br>• Vascular risk factors and vascular disease burden<br>• Joint pain<br>• BMI<br>• Depression<br>• Reported PA<br>• Total Daily PA | • Logistic regression<br>• Cox proportional hazard | • Total daily PA was protective against disability, after adjusting for age, education, and sex the odds ratio for each additional 10 ^5 counts/day of total daily PA was 0.55 (95% CI = 0.47, 0.65, p=0.01).<br>• In a discrete time proportional hazards model adjusted for age, sex, and education, the hazard of developing disability was 25% less for each additional 10^5 counts/day of total daily PA (HR = 0.75, 95% CI = 0.66,0.84, p=0.01). | • Quantitative PA results may be biased as some participants were measured on more than 10 days of activity.<br>• Self-report PA results may be biased due to recall of activities or social desirability response.<br>• Both PA (quantitative or self-report) did not measure intensity.<br>• Crude self-report PA. Did not include household PA.<br>• Actical did not classify types of PA<br>• Study sample was a volunteer cohort.<br>• The high education level of participants may limit the generalizability of the results to persons with less than 12 years of formal schooling. | • There was a weak-moderate inverse association between higher levels of total daily PA and lower likelihood of reporting disability.<br>• There was a weak-moderate inverse association between each additional 10^5 counts/day of total daily PA and lower likelihood of developing disability. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Feinglass et al. (2005) | To examine the effect of leisure time and work-related PA on changes in physical functioning among 53-63 years in 1994, with arthritis and joint symptoms. | Men and women 53-63 years old with arthritis and joint symptoms from the Health and Retirement Study (HRS). | N=3,554 | **LTPA & Work-related PA:** This study used the 2 original series of HRS "light" and "vigorous" exercise questions, fielded in 1992 and 1994, the only HRS waves with detailed, multiple PA questions. These items describe "light PA such as walking, dancing, gardening, golfing, or bowling, etc." and "vigorous activities or sports such as aerobics, running, swimming, or bicycling". In 1992, a separate question was asked about heavy household work, which in 1994 was collapsed into the vigorous activity question. The 3 leisure PA categories (tabulated from 6 duration and intensity questions) were "inactive" (<10 min of daily moderate or vigorous activity, corresponding to a 0-3 HRS score), "insufficient (moderate PA <30 min a day or for <3 days a week, or < 20min of vigorous activity for < 3 days a week, corresponding to a 4-6 HRS score)", and "meets recommended level" (at least 30 min of moderate activity ≥ 5 days a week or at least 20 min of vigorous activity at least 3 days a week corresponding to a 7-12 HRS score). Inactive respondents in the 0-3 range of the HRS leisure time activity scale therefore with never engaged in moderate or vigorous activity, or did so less than once a month or only 1-3 times a month. The HRS work-related PA question was phrased, "My job requires lots of physical effort, such as lifting heavy loads, stooping, kneeling, or crouching". There were 4 response options: "true almost all of the time", "most of time", "some of the time" and " non or almost none of the time". This 0-3 measure was similarly averaged for 1992-1994, based on the assumption that 1992 responses remained the same for those who reported no changes in their job in 1994. | **FUNCTIONAL STATUS:** Functional status was measured on a 0-9 scale derived from 9 questions asking about difficulties in climbing stairs (1 flight or several), walking (across a room, 1 block, or several blocks), getting in and out of bed, bathing or showering, and eating or dressing without help. Because level of difficulty response options varied slightly across the 1994 and 1996 waves, all responses were dichotomized as "some difficulty" or "none". The Cronbach alpha measure of internal consistency for this 9-item scale in 1994 was 0.81. Because their functional outcomes would primarily be related to surgical treatment, 124 respondents undergoing total joint replacement surgery between 1994 and 1996 were excluded from analyses of changes in functioning. Although 1994-1996 changes in physical functioning difficulties ranged from -9 (dramatic improvement) to +9 (dramatic decline), the primary analysis addressed the effect of PA level on the proportion of respondents with arthritis who experienced any functional decline between 1994 and 1996. Decline was defined as the proportion of respondents reporting a greater number of functional difficulties at follow (1996) than at baseline (1994). A secondary aim was to analyze the effect of PA level on improvement in functioning, based on the subpopulation of respondents with at least 1 baseline functional difficulty in 1994 who were this capable of reporting improvement. | • Age<br>• Gender<br>• Race/ethnicity<br>• Education<br>• Household income<br>• Smoking status<br>• Weight<br>• Number of chronic conditions<br>• Health status<br>• Arthritis or joint symptoms | • Linear regression model<br>• Logistic regression model | • Compared with inactive respondents, respondents with arthritis who engaged in either recommended or insufficient LTPA had significantly better 1996 functional outcomes (OR=.59, CI 0.44-0.78, P<0.0001 and OR=0.62, CI 0.48-0.79, P<0.0001, respectively).<br>• Work-related activity was not significant. | • Potential for residual confounding. It is likely that higher levels of PA reflect other, unmeasured health-seeking behaviors, and that individuals who exercise regularly may have other characteristic that contribute to preserve functioning.<br>• The findings for exercise reported in this study are hypothesis generating and await validation in sufficiently rigorous controlled trials.<br>• Survey attrition<br>• Non-specific arthritis prevalence estimates<br>• HRS PA questions provide a crude approximate of PA intensity<br>• Self-reported PA may lead to bias due to social desirability response.<br>• The extent to which arthritis specifically impacted functional declines in unknown.<br>• The level of difficulty or need for assistance were not uniformly collected in the HRS functional mobility and facility items. In particular, the amount of functional improvement frequently reported among older survey respondents probably reflects significant "noise" or measurement error related to panel conditioning and response variability (changes in the meaning of the question).<br>• Exaggeration of self-reported functional improvement may account for the relatively weak predictive performance of models of functional improvement as compared with models of functional decline. | • There was a weak-moderate inverse association between both recommended and insufficient LTPA and fewer functional difficulties among respondents with arthritis. |

| Publication | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Lang et al. (2007) | To assess whether BMI and level of PA were independently associated with incident impaired physical functioning over 6-to7-years period. | Persons aged 50 to 69 years old free of impairment at baseline in the United States (US) and in England. | N=8,702 in the US N=1,507 in England. | **PA-HRS:** Respondents were asked, ''On average, over the last 12 months, have you participated in vigorous PA or exercise three times a week or more? By vigorous PA meant things like sports, heavy housework, or a job that involves physical labor.'' Possible answers were yes and no.<br>**PA- ELSA:** Respondents were asked a range of questions about their activities in the following format. ''In the last week have you done any housework or gardening that involved pulling or pushing, like hoovering, cleaning a car, mowing grass, or sweeping up leaves for at least 15 minutes at a time?'' Those who answered yes were then asked two questions. ''On how many days in the last week have you done any housework or gardening of this type for at least 15 minutes at a time?'' ''On each day that you did any housework or gardening of this type for at least 15 minutes at a time, how long did you spend? Please give an answer from this card.'' Responses on the card were 15 to 30 minutes, 30 minutes to 1 hour, 1 to 1.5 hours, 1.5 to 2 hours, and so on, up to 4 hours or more. Aside from housework, a similar range of questions was asked about doing manual labor, walking at a fast or brisk pace, and doing sports that made the participant feel out of breath or sweaty. Responses to these questions were combined to produce a summary measure of the number of days per week in which respondents did any of these activities for 30 minutes or longer. In line with the HRS questions, ELSA respondents were categorized into whether or not they participated in vigorous activity 3 (or more) days a week. | **Self-Reported Mobility Impairment (HRS):** Respondents were asked at follow-up whether they had difficulty walking several blocks, climbing several flights of stairs, and climbing one flight of stairs. Respondents who reported that they had difficulty with one or more of these activities were classed as having mobility impairment.<br>**Measured Physical Performance Impairment (ELSA):** A physical performance score was calculated based on performance on three tests: balance, chair stands, and grip strength. This test is a modified form of the Short Physical Performance Battery to assess lower extremity function with gait speed replaced by grip strength. The test was scored as follows. The balance component tested the respondent's ability to complete three tasks. Respondents scored 0 if they could not complete any of the tasks; only respondents who successfully completed a given stance attempted the following one. They scored 1 point for completing the first task, holding a side-by-side stance (standing with feet together) for 10 seconds. The second task was a semi-tandemstand (heel of one foot against side of the big toe of the other) and was also worth 1 point if held for 10 seconds. The third task was a full-tandem stance (feet aligned heel to toe); respondents scored no additional points if they could not hold this position for 3 seconds, 1 point if they held it for 3 to 10 seconds, and two points if they held it for more than 20 seconds. The chair stand test involved a pretest and a timed test. The chair used was the respondent's own armless, straightbacked chair; beds, cots, folding chairs, garden chairs, and chairs with wheels or that swiveled were not used. For the pretest, respondents were asked to fold their arms across their chest and try to stand up once from a chair. Those unable to do this scored 0 and did not attempt the rest of this test. Those who were able to do this repeated this movement five times in succession as quickly as possible. Scores were calculated according to quartiles of time taken: the fastest quartile scored 4, the slowest scored 1. Those who had completed the pretest but were unable to complete the timed test within 1 minute were given a score of 0. The grip strength test involved squeezing a handheld grip-strength meter. Grip strength was recorded for the dominant hand, and the mean of two attempts was used. Scoring was according to quartile, with the strongest quartile scoring 4, and the weakest scoring 1. Because of sex differences in grip strength, quartiles were calculated separately according to sex. A trained clinician conducted all three tests. Scores were out of 12, and a score of 7 or less was taken to represent impaired performance. | • Age<br>• Sex<br>• Education<br>• BMI<br>• Physical activity<br>• Smoking status<br>• Alcohol consumption<br>• Socioeconomic status | • Logistic regression modeling | • In all weight categories and both countries, higher levels of PA were associated with lower risks of mobility impairment. For U.S. respondents of recommended weight (BMI 20–25) who were active on 3 or more days per week had a relative risk (RR) of incident mobility difficulties, compared with those who were less active, of 0.56 (95% CI; 50.40–0.78); for those who were obese (BMI ≥ 30) the corresponding RR was 0.59 (95% CI 50.45–0.76). | • Crude assessment of HRS PA level. Additionally, recall bias or social desirability responses may have occurred.<br>• ELSA PA questionnaire only asked PA during the past 7 days. Possible biases may have occurred as the PA level may not accurately reflect usual PA level.<br>• ELSA PA questionnaire used in the study lacks validity.<br>• Self-reported mobility impairment may be biased.<br>• There were differences in the level of PA collected between both studies. Therefore, causation should be interpreted cautiously.<br>• Non-validated self-report mobility impairment questionnaire. | • There was a weak-moderate inverse association between US respondents of recommended weight or obese who were active on 3 or more days per week and had a lower risk of incident mobility difficulties. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Peterson et al. (2009) | To examine different doses and types of PA and their association with the onset and severity of frailty. | Well-functioning black and white men and women aged 70 – 79 years in the surrounding Pittsburgh, PA and Memphis, TN area. | N=2964 | **PA:** Collected from participants at baseline using a self-report instrument developed specifically for the Health ABC study. The standardized questionnaire was modeled after several commonly used activity questionnaires, particularly the well-validated Minnesota Leisure- Time PA questionnaire. Kilocalories per week (kcal/wk) expended in common exercise activities and lifestyle activities were collected. For each activity that participants reported doing at least 10 times in the past 12 months, participants were asked how much time they spent performing the activity for the past 7 days and the level of effort expended, where applicable. From reported volume and effort and estimated metabolic cost, a summary variable of kcal/wk was calculated for each activity performed in the past week. Based on current public health recommendations for aerobic activity the authors developed hierarchical doses within each PA category. Briefly, doses within the volume category were low and recommended. Doses within the intensity category were sedentary, light, moderate, and vigorous. An activity type category was also developed, with the specific types being sedentary, lifestyle active, and exercise active. The activity type category is based on the previous construct developed by Brach and colleagues in the Health ABC cohort. Briefly, the cut points for sedentary, lifestyle active, and exercise active categories were based on a combination of surgeon general's recommendations or PA (approximately at least 1,000 kcal/wk) and the cohort's distribution of weekly caloric expenditure in PAs (25th percentile = 2,719 kcal/wk). | **FRAILITY:** Determined at three time points (baseline, and 3 and 5 years), following the model developed by Gill and colleagues, as the component measures were readily available and key components of other frailty assessments were not. Frailty in the context of this study was described by the presence of functional limitations, or "physical frailty" as described by Gill. Frailty was defined as having a gait speed of less than 0.60 m/s or being unable to rise from a chair once with arms folded. Similar to Gill, the authors considered anyone meeting either frailty criterion as moderately frail, and those meeting both criteria as severely frail. | • Age<br>• Gender<br>• Race<br>• Education<br>• Marital status<br>• Height<br>• Weight<br>• Waist circumference<br>• BMI<br>• Chronic Disease prevalence<br>• Smoking status<br>• Alcohol consumption<br>• Physical activity | • Generalized estimating equation (GEE) logistic regression models | • Compared to those who regularly participated in exercise activities, the sedentary group had significantly increased odds for developing frailty (AOR = 1.45; 95% CI: 1.04 – 2.01, p=0.03).<br>• Of those who became and remained frail for a period of 5 years, sedentary active and lifestyle active (unadjusted OR=4.26;95% CI 1.82 – 9.98, p=0.0003; unadjusted OR= 2.66; 95% CI 1.15 – 6.13, p=0.003), respectively) groups had up to four times the odds of developing frailty compared with the exercise active group. | • The study used a self-report questionnaire to derive levels of PA during the previous 7 days.<br>• The detailed PA questionnaire was administered only at baseline.<br>• Optimally the authors would have been able to assess whether very specific types of PA, particularly strengthening and balance exercises, were associated with frailty.<br>• Because of inadequate sample sizes, the authors were unable to create highly active groups and examine their likelihood of frailty.<br>• The missing follow-up data from those who died during follow-up could have led to estimates not representative of the entire group.<br>• Unsure of validation of PA instrument. | • There was a positive weak association between sedentary individuals and a higher likelihood for developing frailty.<br>• There was a positive strong association between sedentary and lifestyle active groups and a higher likelihood for developing frailty. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Ku et al. (2012) | To examine the prospective associations between changes in PA and cognitive performance in a population-based sample of Taiwanese older adults during an 11-year period of leisure-time PA. | Taiwanese older adults aged 67 years and older at baseline in 1996. | N= 1160 | **PA:** Participants were asked “Did you usually engage in any kind of leisure-time PA?” Four response categories were provided (none, 1–2, 3–5, and 6+ sessions per week), which were coded 0, 1.5, 4, and 7, respectively. The reliability and validity of this measure were assessed in the same sample described above. Test-retest reliability with a 3-day interval was $r = 0.65$ ($P < 0.001$). Concurrent validity was assessed by calculating the Spearman correlation between PA frequencies and triaxial accelerometer measures generated by the ActiGraph GT3X accelerometer (ActiGraph, Pensacola, FL, USA). Based on a 3-day activity record (2 weekdays and 1 weekend day), 1-week energy expenditure (or steps) was calculated as (2.5 × 2 weekdays) + (2 × 1 weekend day) ($\rho = 0.36$, $P < 0.001$; walking steps: $\rho = 0.41$, $P < 0.001$) and was comparable with findings from other studies of self-reported PA among older adults. | **COGNITIVE PERFORMANCE:** Assessed using the 10-item Short Portable Mental Status Questionnaire (SPMSQ). Because the number of items used in each survey varied, only 5 items were used in this analysis, to ensure consistency. Respondents were required to recall their address, current age, the date, and day of the week, and to count backwards from 20 in steps of 3 a total of 4 times. A total score ranging from 0 to 5 was recorded based on the number of correct responses; higher scores indicated better cognitive functioning. The use of these questions as cognitive tests has been analyzed in other studies and has been validated for the Chinese version of the MMSE. The authors conducted a sub study to further examine the reliability and validity of this measure. The sub study included 96 community-dwelling older adults (mean age ± SD = 74.48 ± 6.45 years, male/female ratio = 30/66). Test-retest reliability with a 3-day interval was $r = 0.69$ ($P < 0.001$). Concurrent validity was examined by calculating the Spearman correlation between the 5-item scores and MMSE scores (Spearman $\rho = 0.63$, $P < 0.001$), and the results provided additional evidence of validity. | • Age<br>• Sex<br>• Marital status<br>• Education level<br>• Cohabitation status<br>• Income status<br>• Self-perceived social support<br>• Alcohol consumption<br>• Smoking status<br>• ADL<br>• Number of chronic diseases<br>• Physical activity | • Latent Growth model | • With multivariate adjustment, higher initial levels of PA were significantly associated with better cognitive performance (standardized coefficient $\beta = 0.17$, $p<0.05$).<br>• A higher level of PA at baseline (1996) was significantly related to slower decline in cognitive performance, as compared with a lower level of activity ($\beta = 0.22$, $p<0.05$).<br>• The association between changes in PA and changes in cognitive performance was stronger ($\beta = 0.36$, $p<0.05$) than the previous 2 associations. The effect remained after excluding participants with cognitive decline before baseline. | • The attrition rate of the study sample was relatively high.<br>• The information on PA was restricted to self-reported frequency and only represented leisure-time activity.<br>• PA questionnaire did not report intensity.<br>• The measure of cognitive performance was brief and did not assess all areas of cognitive functioning.<br>• The observational nature of the study prevents definitive conclusions about the direction of causality.<br>• Results may not be generalizable to other cultures/ethnicities.<br>• Cannot rule out the possibility that the intervention effect from the first assessment of PA in 1996 influenced subsequent PA behaviors. | • There was a weak-moderate positive association between higher initial levels of PA and better cognitive performance.<br>• There was a weak-moderate positive association between a higher level of PA at baseline (1996) and slower decline in cognitive performance.<br>• There was a moderate positive association between changes in PA and changes in cognitive performance. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Chang et al. (2010) | To examine the association of midlife PA to late-life cognitive performance and dementia. | Men and women born in 1907–1935 living in Reykjavik. | N= 4945 | **PA:** At the midlife Reykjavik study interview, participants were asked two questions related to PA. First, participants were asked about whether they had ever regularly participated in sports or exercised at any time during their adult life. Participants who answered "yes" to this question were then asked a second question about how many hours per week they exercised during winter and summer time (three categories to answer, [1] none, [2] ≤5 hours, and [3] >5 hours). Hours of PA per week were calculated from the total sum of hours in winter and summer. The midlife PA groups were defined as (a) reported no PA (none), (b) ≤5 hours of PA per week, and (c) >5 hours or more of PA per week. | **COGNITIVE FUNCTION:** All participants were administered a battery of cognitive tests that included multiple tests of three cognitive domains. From these tests, the authors constructed composite scores for speed of processing (SP), memory (MEM), and executive function (EF) based on a theoretical grouping of tests similar to other population-based studies. The SP composite includes digit symbol substitution test, Figure Comparison, and a modified Stroop Test part I (Word Reading) and part II (Color Naming). The MEM composite includes a modified version of the California Verbal Learning Test, immediate and delayed recall. The EF composite includes Digits Backward, a shortened version of the CANTAB Spatial Working Memory test and the Stroop Test part III (Word–Color Interference). All tests were normally distributed in the cohort, and interrater reliability was excellent (Spearman correlations range from .96 to .99 for all the tests).<br>Dementia: A three-step protocol was used to identify dementia cases in the cohort. First, the digit symbol substitution test and the Mini-Mental State Examination were administered to the total sample. Participants who scored 23 or lower on the Mini-Mental State Examination or had a raw score of 17 or lower on the digit symbol substitution test were administered a second diagnostic cognitive test battery. Participants who scored 8 or more on Trails B that was the ratio of time taken for "Trails B/Trails A" (corrected for the number correct: [{time Trails B/number correct Trails B}/{time Trails A/number correct Trails A}]) or had lower than total score of 19 for the four immediate recall trials of the Rey Auditory Verbal Learning went on to a third step. This step included a neurological test and a proxy interview regarding medical history, social, cognitive, and daily functioning changes of the participant. A consensus diagnosis of dementia was made according to international guidelines, Diagnostic and Statistical Manual of Mental Disorder, Fourth Edition (DSM-IV) by a geriatrician, neurologist, neuropsychologist, and neuroradiologist. | • Age<br>• Gender<br>• Education<br>• Blood pressure<br>• BMI<br>• Serum cholesterol<br>• Smoking status<br>• Resting heart rate.<br>• Depressive symptoms<br>• APOE e4 carrier<br>• Mid-life PA | • Chi-squared test<br>• Linear regression<br>• Logistic regression | • In a fully adjusted model compared with those who never exercised at midlife, the two groups that were physically active at midlife had significantly faster SP (≤ 5hours, β=.22; > 5 hours, β= .32 p <.0001), better MEM (≤ 5hours, β= .15; > 5 hours β=.18 p < .0001), and EF (≤ 5hours, β= .09; > 5 hours, β=.18 p < .0001); the associations were strongest for SP.<br>• Compared with the group that never exercised at midlife, those who reported ≤5 hours per week were less likely to have dementia in late life (OR: 0.59, 95% CI: 0.40–0.88) after full adjustment.<br>• The >5 hours group was also less likely to have dementia, but it did not reach statistical significance. | • The authors did not take into account changes in PA during 26 years of interval time.<br>• The population had a higher number of sedentary people (69%) but this could be due to how PA was characterized. PA was defined as a sport or an exercise.<br>• Crude and non-validated assessment of mid-life PA.<br>• Given the type of sample, the study did not include LTPA or household PA. | • Both PA groups had a weak to moderate positive association with SP; a weak association with MEM, and weak association with EF.<br>• There was a weak-moderate inverse association between those who reported ≤5 hours per week were less likely to have dementia in late life |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Yaffe et al. (2001) | To examine the association between baseline PA and cognitive decline during 8 years of follow-up in elderly community-dwelling women. | All community-dwelling women aged 65 years and older who completed cognitive tests at baseline and follow-up were enrolled in the Study of Osteoporotic Fractures study. | N=5925 | **PA:** By asking how many city blocks (1 block=160 m) (or the equivalent) the women walked each day for exercise or as part of their normal routine and how many flights of stairs they climbed up each day. PA was also measured using a modified Paffenbarger Scale, in which trained interviewers asked subjects to report the frequency and duration of their participation per week during the past year in 33 different physical activities. Specifically, the women were asked, "Did you participate in any physical activities, recreation, or sport in the past week?" If the answer was yes, the subjects were asked how often (weeks per year and times per week) and for how long they participated in the activity. The activities were classified according to low, (walking or gardening), medium (dancing or tennis), or high (jogging or skiing) intensity and assigned energy expenditures of 5.0, 7.5, or 10.0 kcal/min, respectively, according to previously reported methods. Total PA, expressed in kilocalories (energy) expended per week, was calculated by adding kilocalories expended in the 33 recreational activities, blocks walked (8kcal per block), and stairs climbed (4kcal per flight). For this analyses, the primary measure of PA were blocks walked per week and total kilocalories expended per week. | **COGNITIVE FUNCTION:** A trained examiner administered the cognitive testing during the baseline clinic visit and at the follow-up visits 6 and 8 years later. The mMMSE, which does not include some questions assessing orientation, was administered. This is a brief global cognitive function test with concentration, language, and memory components designed to screen for cognitive impairment. The mMMSe has a potential range of 0-26, with higher numbers indicating better performance (subjects with baseline scores < 23 were excluded from the analytic cohort). Cognitive decline was defined as a decrease of 3 or more points on the mMMSE from baseline to the 6-or-8 year follow-up (which ever was lower). This definition has been previously used for the full mMMSE to identify the onset of dementia in a group of community-dwelling elderly persons. | • Age<br>• Level of education<br>• Alcohol use<br>• Smoking status<br>• Co-morbidities<br>• Self-rated health<br>• Functional status<br>• Depression<br>• BMI<br>• Current medications<br>• Physical activity | • Logistic regression analysis<br>• Linear regression analysis | • After adjusting for baseline age, educational level, health status, functional limitation, depression score, stroke, diabetes, hypertension, myocardial infarction, smoking, and estrogen use, compared with the lowest quartile, the odds of developing cognitive decline were 34% lower (OR, 0.66; 95% CI, 0.54-0.82, p<0.05) in the highest quartile of blocks walked and 26% lower (OR, 0.745; 95% CI, 0.60-0.90, p<0.05) in the highest quartile of total kilocalories expended. | • The measure of PA is based on a subject's self-report. Therefore, possibility of social desirability response.<br>• While the authors used a conservative criterion of cognitive decline, defined as a 3-point decline or greater on the mMMSE, women did not undergo a clinical assessment of dementia and they could not determine the cause of the cognitive decline.<br>• There was some attrition of study subjects between the first cognitive test and testing that was performed 6 to 8 years later.<br>• While the authors restricted their analyses to those without cognitive or physical impairment at baseline, it is possible that an association between subclinical cognitive impairment and physical activity level partially explains their results.<br>• Most of the study subjects were white and the authors cannot conclude whether the findings would apply to other ethnic groups or to men.<br>• The study only included community-dwelling participants. Non-institutionalized participants were excluded.<br>• Recall difficulties for participants to report frequency and duration of their participation per week during the past year in 33 different physical activities. | • There was a weak-moderate inverse association between women in the highest quartile of PA and highest quartile of total kilocalories expended and a lower likelihood to develop cognitive decline. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Geda et al. (2010) | To investigate whether physical exercise is associated with a decreased risk of mild cognitive impairment in a case-control study derived from the Mayo Clinic Study of Aging. | Men and women in 2 age strata (70-79 and 80-89 years) living in Olmsted County, Minnesota without dementia. | N=1324 | **PA:** studied the frequency and intensity of exercise using a self-reported questionnaire with ordinal responses. Questions from 2 previously validated instruments (the 1985 National Health Interview Survey and the Minnesota Heart Survey intensity codes) were utilized. Subjects were asked to provide information about physical exercise performed within 1 year of the date of cognitive assessment (late-life physical exercise) and performed at age 50 to 65 years (midlife physical exercise). The questionnaire inquired about light, moderate, and vigorous exercise. Light exercise was defined as bowling, leisurely walking, stretching, slow dancing, and golfing using a golf cart. Moderate exercise was defined as brisk walking, hiking, aerobics, strength training, swimming, tennis doubles, yoga, martial arts, weight lifting, golfing without using a golf cart, and moderate use of exercise machines (e.g., an exercise bike). Vigorous exercise was defined as jogging, backpacking, bicycling uphill, tennis singles, racquetball, skiing, and intense or extended use of exercise machines. For each category of intensity, further inquiry was made as to the frequency of exercise (times per month or per week). | **COGNITIVE FUNCTION:** Neuropsychologic testing was performed using 9 cognitive tests to assess the following 4 cognitive domains: (1) memory (logical memory II and visual reproduction II [both delayed recall] from the Wechsler Memory Scale–Revised and delayed recall from the Auditory Verbal Learning Test); (2) executive function (Trail Making Test B28 and digit symbol substitution from the Wechsler Adult Intelligence Scale–Revised); (3) language (Boston Naming Test29 and category fluency); and (4) visuospatial skills (picture completion and block design from the Wechsler Adult Intelligence Scale–Revised). Raw scores were transformed on each test into age-adjusted scores using Mayo's Older American Normative Studies data. These adjusted scores were also scaled to have a mean (SD) of 10. Cognitive domain scores were obtained for every subject by summing the age-adjusted scores within each domain. Because different numbers of tests were used to compute cognitive domain scores (i.e., 2 tests for the executive function, language, and visuospatial skills domains vs. 3 tests for memory), the domain scores were also scaled to allow comparisons across domains. In summary, the performance of a subject in a particular cognitive domain was measured by comparing his or her domain score with the score among persons with normal cognition, available from previous normative work among this same population. However, the final decision about impairment in any cognitive domain was made by consensus agreement among the examining physician, nurse, and neuropsychologist, taking into account years of education, prior occupation, and other information. All subjects who met the following revised Mayo Clinic criteria for mild cognitive impairment (MCI) were considered: (1) cognitive concern expressed by a physician, informant, subject, or nurse; (2) cognitive impairment in 1 or more domains (memory, executive function, language, or visuospatial skills); (3) normal functional activities; and (4) without dementia. Subjects with MCI could have a CDR score of 0 or 0.5; however, the final diagnosis of MCI was not based exclusively on the CDR score but rather on all available data. Controls were considered as all subjects who had normal cognition according to published normative data developed among this population. | • Age<br>• Sex<br>• Years of education<br>• Medical comorbidity<br>• Depression<br>• Physical activity | • Logistic regression model | • Midlife moderate exercise was associated with a 39% reduced OR for MCI (OR=0.61; 95% CI 0.43-0.88; p=0.008).<br>• Late-life moderate exercise was associated with a 32% reduced OR for MCI (OR=0.68; 95% CI 0.49-0.93; p=0.02).<br>• Light and vigorous exercises were not significantly associated with decreased risk of MCI. | • The study design is a limitation. The exposure (physical exercise) and the outcome (MCI) were measured at a cross-sectional point in time. Therefore, it is difficult to study the direction of causality.<br>• The measurement of physical exercise is limited. A self-reported questionnaire was used to collect physical exercise data. Such measurement is prone to recall bias and/or social desirability response).<br>• The PA measurement did not account for duration of exercise.<br>• Few subjects engaged in vigorous exercise in late life; therefore, statistical power was limited for that analysis.<br>• The study did not address mechanisms of action. Based on the literature, the authors can speculate that physical exercise may be directly protective against MCI via increased production of neurotrophic factors, greater cerebral blood flow, improved neurogenesis, enhanced neuronal survival, mobilization of gene expression affecting neuronal plasticity, and decreased risk of cardiovascular and cerebrovascular diseases. A second possibility is that physical exercise may be a marker for a healthy lifestyle. A subject who engages in regular physical exercise may also show the same type of discipline in dietary habits, accident prevention, adherence to preventive intervention, compliance with medical care, and similar health-promoting behaviors | • There was a weak-moderate inverse association between midlife moderate exercise and a lower likelihood of MCI.<br>• There was a weak-moderate inverse association between late-life moderate exercise and a lower likelihood of MCI. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Weuve et al. (2004) | To examine the relation of long-term PA, including walking, to cognitive function. | Women aged 71-80 years old with no history of stroke from the Nurses' Health study | N=18,766 | **PA:** Assessed detailed information on leisure PA. Women were asked to estimate the average amount of time per week during the past year spent on the following activities: running (≤ 10min/mile); jogging (> 10min/mile); walking or hiking outdoors; racquet sports; lap swimming; bicycling; aerobic dance or use of exercise machines; other vigorous activities (e.g. lawn mowing); and low-intensity exercise (e.g. yoga, stretching, toning). Participants also indicated their usual outdoor walking pace: easy (> 30min/mile), normal (21-30 min/mile), brisk (16-20min/mile) or very brisk (≤ 15 min/mile), and the number of flights of stairs climbed daily. We assigned each activity a metabolic equivalent value (MET) according to accepted standards, where 1 MET is proportional to the energy expended while sitting quietly. MET values were 12 for running; 8 for stair climbing; 7 for jogging, racquet sports, lap-swimming and bicycling; 6 for aerobic dance, use of exercise machines, and other vigorous activities; and 4 for yoga, stretching, or toning. MET values for walking varied by reported pace from 2.5 METs for easy pace to 4.5 METs for very brisk pace. For each activity, we estimated the energy expended in MET-hours/wk, by multiplying its MET value by the time spent performing it. | **COGNITIVE FUNCTION:** was assessed by using validated telephone interviews conducted by trained nurses. Initial interview, we administered only the Telephone Interview for Cognitive Status (TICS) and gradually added 5 more tests as participants for cognitive testing became clear. The TICS as modeled on the Mini-Mental State Examination (MMSE). The authors also added the East Boston Memory Test (EBMT) to assess immediate and delayed paragraph recall. They administered a test of category fluency in which participants were asked to name as many animals as they could in one minute. Finally, participants were administered the Digit Span Backwards test, which measures working memory and attention. To summarize the overall association of PA with cognitive performance, for women given all 6 tests, we constructed a global score by averaging the Z sores from all tests. To asses overall verbal memory, the authors combined the intermediate and delayed recalls of the EBMT and the TICS 10 word list, for women given all 4 tests by averaging the z scores from these tests. The authors extensively tested the reliability and validity of the telephone procedure for assessing cognition in high functioning, educated women. They found high reliability of test performance among 35 given the TICS twice, 31 days apart (test-retest correlation, 0.70, P<0.001). | • Age<br>• Marital status<br>• Type of degree<br>• Smoking status<br>• Alcohol intake<br>• Medication intake<br>• Self-reported health history | • Multiple Linear regression<br>• Multiple Logistic regression | • Compared with women in the lowest PA quintile, they found a 20% lower risk of cognitive impairment for women in the highest quintile of activity (OR=0.80, 95% CI 0.67-0.95, p<0.05).<br>• Among women performing the equivalent of walking at an easy pace for at least 1.5h/wk, mean global scores were 0.06 to 0.07 units higher compared with walking less than 40min/wk (P≤ 0.003). | • Results may not be generalizable to women or ethnic groups.<br>• PA did not assess household PA<br>• Results may be cofounded by unmeasured factors.<br>• The findings could reflect reverse causation such that preexisting CI caused a reduction in PA.<br>• Short follow-up period for measuring change in cognitive function is a limitation.<br>• Authors did not assess development of dementia in their cohort.<br>• Non-validated PA instrument | • There was a weak-moderate inverse association between women engaged in the highest PA and lower risk of cognitive impairment. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| McTierman et al. (2003) | To prospectively examine the association between current and past recreational PA and incidence of breast cancer in postmenopausal women. | Ethnically and racially diverse cohort of older women aged 50 to 79 years at study entry in the USA. | N=74,171 | **PA:** Women were asked (yes/no) if they usually did strenuous or very hard exercises (long enough to work up a sweat and make their hearts beat fast) at least 3 times per week at ages 18, 35, and 50 years. Participants then were asked how often they currently (at study entry) walked outside the home for more than 10 minutes without stopping, the usual duration, and the speed. Categories of frequency were rarely/never, 1 to 3 times per week, 4 to 6 times per week, and 7 or more times per week. Duration categories were less than 20 min, 20 to 39 minutes, 40 to 59 minutes, and 1 hour or more. Four speed categories ranged from less than 2 mph (casual walking to more than 4mph (very fast). Women were then asked how often they currently (at study entry) exercised at strenuous levels (that increased heart rate and produced sweating) by checking categories never, 1, 2, 3, 4, or 5 day/week or more, and for how long they exercised at each session by checking categories less than 20 min, 20 to 39 min, 40 to 59 min, or 1 hour or more. Women were asked similar questions about moderate- and low-intensity physical activities. The authors constructed several composite PA variables. They imputed the midpoint value for ranges of frequency and duration of exercise sessions. The authors multiplied minutes x frequency to create a variable "hours exercised per week", separately for strenuous, moderate, light and 3 intensities of walking. Then assigned metabolic equivalent (MET) values for strenuous, moderate, and low intensity activities as 7, 4, and 3 METs, respectively. For mean speed of walking (average [2-3 mph], fast [3-4 mph], and very fast [>4mph], the authors assigned MET values of 3, 4, and 4.5 respectively. Then they computed a current total PA variable (MET-hours/week) by multiplying the MET level for the activity by the hours exercised per week and summing values for all types of activities. | **BREAST CANCER:** Study physicians and cancer coders, blinded to exposure status, reviewed pathology reports, discharge summary, operative reports, and radiology reports for all biopsies and surgeries and coded cases according to National Cancer Institute Surveillance, Epidemiology, and End Results guidelines. | • Age<br>• Race<br>• Geographic region<br>• Income<br>• Education<br>• Medical history<br>• Reproductive history<br>• Menstrual history<br>• Diet<br>• BMI<br>• Alcohol use<br>• Physical activity<br>• Family history<br>• Use of Hormone therapy | • Cox proportional hazards regression | • Women who engaged in strenuous PA at least 3 times per week at age 35 had a statistically significant decreased risk of breast of 14% (RR, 0.86; 95% CI 0.78-0.95, p=0.03) compared with women who did not engage in this level of activity.<br>• Women who exercised on average 5.1 to 10.0 MET-h/wk had a statistically significant reduction in risk of developing breast cancer of 18% compared to sedentary women (RR=0.82, 95% CI 0.68-0.97, p=0.03). Women who exercised more than 40 MET-h/wk had a 22% reduction in risk of developing breast cancer compared to sedentary women (RR=0.78, 95% CI 0.62-1.0, p=0.03). Women who engaged in 7h/wk of moderate/strenuous activity had a 21% reduction risk of breast cancer compared to sedentary women (RR=0.79, 95% CI 0.63-0.99).<br>• Women in (≤ 24.13) BMI group who engaged in 5.1 to 10 MET-h/wk of PA had a 30% reduction in risk for breast cancer (RR=0.70, 95% CI 0.51-0.97). Women who engaged in 20.1 to 40.0 MET-h/wk had a 32% reduction in breast cancer risk (RR=0.68, 95% CI 0.51-0.92). More than 40 MET-h/wk decreased risk even further (RR=0.63, 95% CI 0.43-0.93). | • The study did not collect detailed data on lifetime PA.<br>• Some of the PA questions grouped exercises together into those that are most often low, moderate, or vigorous in intensity. If individual women performed activities at other intensities, there would be misclassification of intensity. The use of imputed midpoint values for ranges of PA data could have introduced error.<br>• Only data on recreational and walking activities were collected.<br>• There may have been recall bias when asked "if they usually did strenuous or very hard exercises (long enough to make their heart beat fat) at least three times a week at ages 18, 35, and 50 years old.<br>• Possibility for social desirability response for PA questions.<br>• The study population is not an entirely representative cross-section of US women.<br>• Although the study was a multiethnic multiracial cohort, there were too few numbers of cases to report race-ethnic specific associations between PA and breast cancer risk.<br>• Non-validated PA instrument | • There was a weak inverse association between women who engaged in strenuous PA at least 3 times per week at age 35 and a reduced risk of breast cancer.<br>• There was a weak to weak-moderate inverse association between increased METs-h/week and a reduced risk of breast cancer.<br>• There was an inverse weak to moderate association between increasing levels of total current PA among women in the lowest tertile of BMI (≤ 24.13) and a reduced risk of breast cancer. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Manson et al. (2002) | To compare the roles of walking and vigorous exercise in the prevention of coronary and cardiovascular events in a large, ethnically diverse cohort of postmenopausal women in the Women's Health Initiative Observational Study. | Postmenopausal women aged 50 to 79 years of age free of diagnosed cardiovascular disease and cancer in the Women's Health Initiative Observational Study. | N=73,743 | **PA:** Recreational PA was assessed by a detailed questionnaire on the frequency and duration of walking and of several other types of activity (strenuous, moderate, and mild). Walking was assessed by a series of questions about the frequency of walks outside the home for more than 10 minutes without stopping, the average duration of each walk, and the usual walking pace. Vigorous exercise was defined as that in which "you work up a sweat and your heart beats fast," and examples included aerobics, aerobic dancing, jogging, tennis, and swimming laps. Moderate exercise was defined as that which was "not exhausting," and examples included biking outdoors, using an exercise machine (such as a stationary bicycle or a treadmill), calisthenics, easy swimming, and popular or folk dancing. Examples of mild exercise were slow dancing, bowling, and golf. Using a standardized classification of the energy expenditure associated with physical activities, we calculated a weekly energy expenditure score in metabolic equivalents (MET score) for walking and for total PA. Finally, participants were asked to estimate the number of hours per day they spent engaged in sedentary behavior, including time spent sitting as well as lying down or sleeping. | **CARDIOVASCULAR DISEASE:** The primary end points for this study were newly diagnosed coronary heart disease (nonfatal myocardial infarction or death from coronary causes) and total cardiovascular events (myocardial infarction, death from coronary causes, coronary revascularization, angina, congestive heart failure, stroke, or carotid revascularization) that occurred after the return of the base-line questionnaire but before August 27, 2000.Newly diagnosed cardiovascular events were identified on the basis of annual mailed follow-up questionnaires (response rates have been above 95 percent), and permission to review medical records was requested. Study physicians with no knowledge of the self-reported risk-factor status reviewed the records. The diagnosis of nonfatal myocardial infarction was confirmed if data in the hospital record met standardized criteria of diagnostic electrocardiographic changes, elevated cardiac-enzyme levels, or both. Treatment with coronary or carotid revascularization was confirmed by documentation of the procedure in the medical record. The presence of angina was confirmed by hospitalization and confirmatory evidence on angiography, diagnostic stress test, or diagnosis by a physician and medical treatment. The occurrence of stroke was confirmed by documentation in the medical record of the rapid onset of a neurologic deficit consistent with stroke and lasting at least 24 hours or until death. The presence of congestive heart failure was confirmed by hospitalization and diagnostic confirmatory tests. Fatal coronary disease was considered confirmed if there was documentation in the hospital or autopsy records or if coronary disease was listed as the cause of death on the death certificate and evidence of previous coronary disease was available. For deaths from other cardiovascular causes, a review of confirmatory evidence by physician-adjudicators was required. | • Age<br>• Racial/Ethnic group<br>• Family medical history<br>• Physical activity<br>• Smoking status<br>• Diet<br>• Height<br>• Weight<br>• BMI<br>• Alcohol Consumption<br>• Age of menopause<br>• Use of hormone-replacement therapy | • Cox proportional -hazards regression | • In age-adjusted analyses, the RR declined for coronary events with increasing quintiles of the total MET score (1.00, 0.73, 0.69, 0.68, and 0.47, respectively; P for trend <0.001). Risk reductions for increasing categories of walking (P for trend=0.004) were similar to those for increasing categories of vigorous exercise (activities with MET scores of 6 or higher; P for trend=0.008).Women who either walked or exercised vigorously at least 2.5 hours per week had a risk reduction of approximately 30 percent.<br>• In multivariate analyses, for increasing quintiles of the total MET score, the relative risks (RR) of cardiovascular events were 1.00, 0.89, 0.81, 0.78, and 0.72, respectively (P for trend <0.001).<br>• Increasing categories of walking associated with similar reductions in risk (RR, 1.00, 0.91, 0.82, 0.75, and 0.68, respectively; P for trend <0.001), which were also similar to the risk reductions with vigorous exercise and remained unchanged after simultaneous inclusion of walking and vigorous exercise in the model.<br>• After accounting for age and recreational energy expenditure (total MET score), the RR of CVD was 1.68 (95% CI, 1.07 to 2.64) among women who spent at least 16 hr/day sitting, as compared with those who spent less than 4 hours per day. | • PA assessed by questionnaire, and some misclassification of exposure was inevitable.<br>• Despite the fact that authors controlled for a large number of potentially confounding variables in their multivariate analyses, residual confounding by lifestyle-related factors cannot be excluded.<br>• The study population of volunteers in the Women's Health Initiative, although of more diverse racial and ethnic background and socioeconomic status than most previously studied cohorts, is not an entirely representative cross-section of women in the United States.<br>• Results are not generalizable to men.<br>• Non-validated PA instrument | • There was a weak-moderate to moderate inverse association between women in increasing quintiles of energy expenditure and lower risk of coronary events.<br>• There was a weak to weak-moderate inverse association between both increasing quintiles of total MET score and increasing categories of walking and vigorous exercise and a lower risk of CV events. .<br>• There was a weak-moderate positive association between women spent at least 16hr/day sitting and a higher risk of CVD. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Franco et al. (2005) | To calculate the effects of different levels of PA on life expectancy and years lived with and without cardiovascular disease after age 50 years or older. | Men and women 50 years or older. | N= 4121 | **PA:** Participants were asked to estimate how long they spent in a typical day at various levels of activity: sleeping, resting, or engaging in light, moderate, or heavy PA. The reported levels of activity were weighted based on the estimated oxygen consumption for each activity to reflect metabolic expenditure corresponding to metabolic equivalents. Weights used were as follows: for sleeping, 1; for being sedentary, 1.1; for light activity, 1.5; for moderate activity, 2.4; and for heavy activity, 5. finally, a daily PA score was calculated by adding the sum of the weighted hours for each level of activity. The minimum possible score was 24 for a participant sleeping 24 hours a day. Based on tertiles of the PA score, the participants were grouped into 3 levels: low (< 30), moderate (30-33), and high (>33) PA level. | **CARDIOVASCULAR DISEASE:** Included coronary heart disease (angina, coronary insufficiency, myocardial infarction, and sudden or not-sudden death as a consequence of coronary disease), congestive heart failure, stroke, transient ischemic attack, and intermittent claudication. A panel of 3 physicians evaluated all events; agreement of all 3 was required. | • Age<br>• Sex<br>• Education<br>• Smoking status<br>• Marital status<br>• Comorbidity<br>• Hypertension<br>• BMI<br>• Physical activity | • Cox proportional hazards ratio | • There was a dose-response protective association between PA level and incident CVD or death among participants with no CVD and for mortality among participants with CVD<br>• After adjustment for age, sex and selected confounders, the effect of PA was significant for a high level of PA with all transitions (incident CVD HR=0.77, 0.68-0.89; no CVD to death HR=0.72, 0.58-0.89; and CVD to death HR=0.77, 0.65-0.89).<br>• For the group with a moderate level of PA, the protective effect of PA was only significant for no CVD to death (HR=0.72, 0.58-0.89),<br>• Overall, moderate and high PA levels led to 1.3 and 3.7 years more lived in total life expectancy and 1.1 and 3.2 more years lived without CVD, respectively for men. For women, the differences were 1.5 and 3.5 in total life expectancy and 1.3 and 3.3 more years lived free of CVD, respectively | • Because this is a prospective observational study in which no intervention was performed; therefore, it has the inherent weaknesses of all cohort studies and lacks the strength of causality that a randomized trial could offer.<br>• PA levels were evaluated by self-report, which may introduce misclassification of exposure and/or social desirability response.<br>• The authors could not evaluate the effect of PA levels completely independently of other risk factors of cardiovascular disease such as diet and alcohol and aspirin intake.<br>• Non-validated PA instrument | • There was a weak inverse association between high PA and incident of CVD or death among participants free of CVD and for mortality among participants with CVD<br>• There was a weak inverse association between moderate PA and no CVD to death. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| DeFilippi et al. (2012) | To evaluate the association between PA and changes in levels of highly sensitive troponin T (cTnT) and N-terminal pro–B-type natriuretic peptide (NT-proBNP), and the subsequent risk of the development of heart failure (HF) in community-dwelling older adults. | Adults 65 years and older free of heart failure participating in the Cardiovascular Heart Study (CHS). | N= 2,933 | **PA:** Leisure-time activity was a self-reported measure of weekly energy expenditure in kilocalories quantified by participant responses to a modified Minnesota Leisure-Time Activity Questionnaire that evaluated frequency and duration of 15 different activities during the previous 2 weeks. Average walking pace, a self-reported measure, was classified in ordinal categories ( <2, 2 to 3, and > 3 mph). Activity and walking pace information were collected at the time of the baseline biomarker measures. Using a composite scoring system previously developed in CHS to predict new-onset diabetes and validated to predict the risk of decline in renal function, leisure time activity was summed in quartiles (range, 1 to 4) and walking pace (range, 1 to 3) to generate a combined physical activity score with a possible range of 2 to 7. To test for trends, individuals were categorized with a score of 2 as low activity, those with a score of 3 to 6 as moderate activity, and those with a score of 7 as high activity. | Significant increase in cTnT or NT-proBNP and INCIDENT HEART FAILURE: The cut points used have been shown to strongly predict the risk of incident HF and cardiovascular death independently of baseline concentrations and cardiovascular risk factors. A significant increase in cTnT was defined as a > 50% increase in cTnT level between measures among individuals with detectable (≥ 3 pg/ml) baseline levels. A sensitivity analysis was performed including those with undetectable baseline cTnT, imputing a baseline concentration of 2.99 pg/ml. A significant increase in NT-proBNP was defined as a >25% increase to a level ≥190 pg/ml. Incident HF was defined as the first adjudicated HF event occurring after the second biomarker measurement over the course of follow-up. The CHS Events Committee adjudicated incident HF by reviewing all pertinent data, including history, physical examination, chest radiography report, and medication use. NT-proBNP and cTnT data were not available to the adjudicators. | • Age<br>• Sex<br>• BMI<br>• CHD<br>• Co-morbidities<br>• Alcohol Consumption<br>• Smoking Status<br>• Health Status<br>• cTnT<br>• NT-proBNP<br>• LTPA | • Logistic regression models.<br>• Cox proportional hazards models | • In fully adjusted models, the odds ratio (OR) of a significant increase in cardiac biomarkers between visits, comparing the lowest with the highest baseline activity score category, was 0.50 (95% CI: 0.33 to 0.76, p=0.001) for NT-proBNP and 0.30 (95% CI: 0.16 to 0.55, p<0.001) for cTnT.<br>• The incidence of HF decreased with progressively higher levels of fitness in both subjects with and without an increase in either biomarkers. | • LTPA and walking pace were measured by self-reported questionnaires. These measures lack the objectivity of direct measurement of activity levels. Therefore, misclassification of PA may be present, which could have biased the association with an increase in cardiac specific biomarkers toward the null.<br>• Despite adjustment for multiple co-morbidities associated with the risk of HF and impeding regular exercise, PA may simply be a marker rather than a mediator of cardiac health in this cohort.<br>• Short follow-up time (2-3 years). | • There was a moderate to strong inverse association between individuals with the highest PA score and lower likelihood of an increase in NT-proBNP and an increase in cTNT. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Demakakos et al. (2010) | To examine whether small amounts of low-intensity PA were associated with reduced risk of developing Type II diabetes in a national sample of people aged 50 years and over. | Men and women aged 50 years and older free from self-reported doctor diagnosed diabetes. | N= 7466 | **PA:** Participants were asked how often they took part in three different types of PA: vigorous, moderate and low intensity. The response options were: more than once a week, once a week, one to three times a month and hardly ever/never. For the purposes of the analysis the authors derived a summary index of PA by summing responses to the three PA questions after they had been dichotomized around the frequency cut-point of once a week or more often. The derived summary index categorized PA as follows: (1) physical inactivity; (2) low-intensity but not vigorous/moderate-intensity PA at least once a week; and (3) vigorous/moderate-intensity PA at least once a week. The reliability and validity of the measure have not been assessed but a similar categorization of PA has previously been shown to demonstrate excellent convergent validity in grading a plethora of biochemical and other risk factors, including BMI, triacylglycerols, fibrinogen and C-reactive protein in the same cohort. | **DIABETES:** The outcome measure was incident self-reported doctor-diagnosed diabetes (i.e. new cases of diabetes that were diagnosed after the baseline interview). All new cases of diabetes were treated as new cases of type 2 rather than type 1 diabetes because of the age of the participants. Because medical records were not available to confirm the diagnosis of diabetes and blood samples and data on use of diabetes medication were not collected at baseline, the authors used data on use of diabetes medication from ELSA wave 0 that were collected before the ELSA baseline (in HSE 1998, 1999 and 2001) to confirm diagnosis of diabetes in their participants. | • Age<br>• Sex<br>• Marital status<br>• Types of PA<br>• Existence of long-standing illness or disability<br>• Smoking status<br>• Alcohol consumption<br>• Socioeconomic status (SES)<br>• Educational attainment<br>• Cardiovascular morbidity<br>• Non-cardiovascular morbidity<br>• Depression<br>• BMI | • Cox proportional hazard regression | • Vigorous/moderate intensity PA performed at least once a week was associated with reduced risk for diabetes after fully adjusted model (HR=0.64, 95% CI 0.43-0.95, p=0.026).<br>• In the oldest category (≥ 70 years) the age adjusted HR's were (HR= 0.53, 95% CI 0.28-1.02, p=0.059). | • The study may have considerably underestimated the strength of associations between PA and diabetes due to the crude non-validated self-reported PA measure.<br>• Cannot completely rule out the possibility of reverse causality due to the use of self-reported diabetes data (undiagnosed diabetes causing physical inactivity at baseline).<br>• The attrition that ELSA has suffered must also be considered. The results may provide a conservative account of the association between PA and the risk of developing diabetes because it was mostly the less-educated participants who dropped out from ELSA. These individuals were probably less active and therefore their risk for incident diabetes may have been higher. | • There was a weak-moderate inverse association between older adults who engaged in vigorous/moderate intensity PA at least once a week and a lower risk of type 2 diabetes.<br>• There was a moderate inverse association for those aged 70 years or older who engaged in low-intensity PA at least one a week and a lower risk for type 2 diabetes. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Menec (2003) | To examine longitudinally the relation between everyday activities and several indicators of successful aging, specifically well-being, function and mortality. | Older adults aged 67-95 years old living in Manitoba, Canada. | N= 1,439 when looking at happiness; N=1,208 for life satisfaction, and N= 1,292 for function. N= 2,291 for mortality analyses | **PA:** 18 activities were grouped into three categories based on their likely social component or purpose: social activities (e.g. visiting family or relatives), more solitary activities (e.g. collecting hobbies) and productive activities (e.g. volunteer work, doing light housework/gardening). | **Indicators of Successful aging:**<br>**Life Satisfaction:** Measured with the 20-item Life Satisfaction Index (LSIA). Cronbach's alpha=.70.<br>**Happiness:** A single item measure was used to assess feelings of happiness: "Would you describe yourself as being usually:"1=happy and interested in life? 2=somewhat happy? 3= somewhat unhappy? 4= unhappy with little interest in life? and 5=so unhappy that life is not worthwhile?" the scale was subsequently recoded so that higher numbers indicate greater happiness and interest in life.<br>**Function:** A composite measure of function was created based on ADL's, IADL's, MSQ (cognitive impairment), and interviewer observed physical difficulties. Participants were classified as functioning well if they required no assistance with any ADL's, required assistance with a maximum of 1 ADL, had an MSQ score greater than equal to 7, and no physical difficulties, as assessed by the interviewers. The cutoffs represent median splits and individuals who were above the median on all four variables were classified as functioning well.<br>**Mortality:** AIM participants were dead or alive in 1996 was determined from data from the Office of Vital Statistics where all deaths in the population are recorded. | • Gender<br>• Age<br>• Education<br>• Social support<br>• Functional status<br>• Cognitive impairment<br>• Physical difficulties<br>• Self-rated health<br>• Morbidity<br>• Activities (social, solitary, productive) | • Ordinary least squares regressions<br>• Logistic regression<br>• Hierarchical regressions | • Activity level was significantly related to feelings of happiness ($\beta$= 0.10, $p < .001$).<br>• Activity level in 1990 predicted reduced functional decline 6 years later (AOR= 0.93, P<.05).<br>• Activity level was also related to lower mortality (AOR=0.95, p< .05). The odds of dying within 6 years of the initial interview were reduced for individuals with greater activity level. | • Older adults in this study were a relatively healthy sample<br>• It is not entirely clear what the LSIA measures given that it is multidimensional in nature.<br>• Concerns of reliability of the happiness measure-only single item measure.<br>• There was no assessment of the frequency of the activity or of the time spent on each activity.<br>• The activity scale occasionally combined several activities into one item, making it impossible to examine the effect of each activity listed.<br>• Interpreting the causal directions of the findings is warranted. It is possible that engaging in certain types of activities is causally linked to well-being, function, and mortality.<br>• Interviews were conducted at participants home. Answers could lead to social desirability responses.<br>• Non-validated activities instrument | • There was a weak positive association between activity level and feelings of happiness.<br>• There was a weak inverse association between greater activity level in 1990 and reduced functional decline 6 years later.<br>• There was a weak inverse association between greater activity level and lower mortality in 6 years. |

| Public-cation | Focus of Study | Target Population | Sample Size | PA Instrument | Health-Related Outcomes | Covariates & Confounding Variables | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Sun et al. (2010) | To explore the relation between midlife PA and successful aging as measured by a full spectrum of health outcomes, including incidence of chronic diseases, cognitive and physical functioning, and mental status. | Female registered nurses who were free of major chronic diseases at baseline in 1986 and had survived to age 70 years or older as of the 1995-2001 period. | N=13,535 | **PA:** In 1986, inquiry about the average time per week in the past year participants spent on leisure-time physical activities, including walking or hiking outdoors; jogging (10 min/mile); running ( 10 min/mile); bicycling; lap swimming; playing tennis; doing calisthenics, aerobics, aerobic dance, and/or rowing machine exercise; and playing squash or racquet ball. For each question, there were 10 possible response categories (range, 0 to 11 h/wk). Furthermore, inquiry about flights of stairs climbed each day, and, for walkers, the usual walking pace: easy or casual (2.0 mph), normal (2.0-2.9 mph), brisk (3.0-3.9 mph), and very brisk (4.0 mph). Based on this information, calculation of energy expenditure in METs was measured in hours per week. Each MET-hour is the caloric need per kilogram of body weight per hour of activity divided by the caloric need per kilogram of weight per hour at rest. According to this standard, the authors assigned a MET value of 12.0 to running; 8.0 to stair-climbing; 7.0 to jogging, bicycling, lap swimming, and playing tennis and other racquet sports; 6.0 to aerobics and calisthenics; and 2.5 to 4.5 to walking, depending on the pace. The same amount of energy expenditure can be achieved by various physical activities. In analyses of activity intensity, the authors defined activity with a MET value larger than 6 as vigorous; walking was defined as a moderate-intensity activity owing to the lower MET value. For the current analysis, 1986 detailed physical activity information was first obtained, as the study baseline. Moreover, in all analyses, the authors only considered physical activity reported in 1986 because they wanted to minimize the possibility of reverse causation with aging. At baseline in 1986, the mean age was 60 years for study participants, and therefore, midlife was defined as age 60 years for the purposes of this report.The physical activity questionnaire has been validated in a similar population (the NHS II). In a representative sample of 147 nurses, the physical activity scores based on this questionnaire administered 2 years apart were reasonably correlated, given some true changes in activity across 2 years; the test-retest correlation coefficient (r) was 0.59. The questionnaire estimate of physical activity levels was highly correlated with those reported in 1-week recalls (r=0.79) and those logged in diaries during the year (r=0.62). | **Successful Aging:** Addressed 4 domains: (1) no history of cancer (except nonmelanoma skin cancer), diabetes, myocardial infarction, coronary artery bypass graft surgery (CABG), congestive heart failure, stroke, kidney failure, chronic obstructive pulmonary disease, Parkinson disease, multiple sclerosis, or amyotrophic lateral sclerosis; (2) no impairment in cognitive function (TICS score 31); (3) no physical disabilities (no limitations on moderate activities and no more than moderate limitations on more demanding physical performance measures); and (4) no mental health limitations (mental health score 84, which is the median score in our study population). Any participant who survived to at least age 70 years and met all these criteria was defined as a successful survivor; the remaining participants who survived to at least aged 70 years but had a chronic disease history, CABG, cognitive impairment, physical or mental health limitations were defined as usual survivors. | • Age<br>• BMI<br>• Waist circumference<br>• Waist to hip ratio<br>• Saturated fat intake<br>• Polyunsaturated fat intake<br>• Polyunsaturated to saturated fat ratio<br>• Trans fat intake<br>• Alcohol intake<br>• Cereal fiber intake<br>• Red meat servings<br>• Fruits and vegetables servings<br>• Smoking status<br>• Education<br>• Husband's education<br>• Marital status<br>• Post menopausal hormone use<br>• Family history<br>• History of hypertension<br>• History of high cholesterol<br>• Physical Activity METs | • Logistic regression | • After adjustment for multiple covariates, the ORs for successful survival across PA quintiles were 1 [reference], 0.98, 1.37, 1.34, and 1.99 for total METs (P< .001 for trend).<br>• After multivariate adjustment of covariates, ORs for successful survival across walking METs quintiles were 1 [reference], 0.99, 1.19, 1.50, and 1.47 (P< .001 for trend).<br>• Compared with women whose walking pace was easy, women with a moderate walking pace had a 90% (OR=1.90, 95% CI 1.52-2.38, p,0.001) increased odds of successful aging; women whose walking pace was brisk or very brisk had 2.68-fold ( OR=2.68, 95% CI 2.13-3.37, p<0.01) increased odds of successful aging. | • The generalizability of the current study may be limited to women who were primarily of European ancestry and largely healthy at midlife.<br>• The authors considered successful survival as of age 70 years. Whether the observed associations can be generalized to populations at much older ages is unknown.<br>• The self-reported PA levels are inevitably subject to measurement error.<br>• Residual confounding is also an alternative explanation of these observations.<br>• The authors did not assess physical and mental health status at baseline. Therefore, long-term physical impairment or mental limitations might have biased their observations.<br>• Approximately 16% of eligible women were excluded from the present analysis because of missing PA data at baseline. These participants had slightly higher BMIs; worse physical, cognitive, and mental status at older ages; and were less likely to be active at baseline than women who provided data on their PA. This combination could lead to bias toward the null.<br>• Detailed PA was first obtained in 1986 and was the study's baseline.1986 was also when midlife was defined as age 60 years. Could bias results given midlife age was considerably older and successful survival age was 70 yrs old. | • There was a weak-moderate to moderate positive association between midlife leisure-time PA and the likelihood of successful survival in later life starting at the third quintile activity.<br>• There was a moderate positive weak association between moderate walking pace and higher likelihood of successful aging.<br>• There was a moderate-strong positive association between brisk or very brisk walking pace and higher likelihood of successful aging. |

## Appendix C. Cross-Sectional & Longitudinal/Prospective Data Table

| Publication | Focus of Study | Target Population | Sample Size | PA Instrument | Health Outcomes | Measures | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Lee & Russell, (2003). | To explore the relationship between PA and mental health cross-sectionally and longitudinally in a large cohort of older Australian women. | Women in their 70's participating in the Australian Longitudinal Study on Women's Health | N= 10,063 cross-sectionally N=6472 longitudinally | **PA at Survey 1**- was determined from self-reported frequency of engaging in "vigorous activity" and "less vigorous activity". Responses of never, once a week, two to three times per week, four., five, or six times per week, once every day, and more than once a day were scored 0, 1, 2.5, 5, 7 and 10 respectively. They were weighted by multiplying the "vigorous" score by 5 and the "less vigorous" by 3 and summed to provide a score with a theoretical range from 0 to 80. Scores were then categorized as <5 (none or very low), from 5 to <15 (low), from 15 to <25 (moderate) and 25 or more (high).<br>**PA at Survey 2**-was determined from self-reported time spent engaging in "vigorous activity", "moderate activity", and "walking" in the previous week. Number of minutes of exercise was weighted by multiplying "vigorous activity" by 7.5, "moderate activity" by 4 and "walking" by 3. Scores were then categorized as <40 (none or very low), from 40 to <600 (low), from 600 to <1200 (moderate), and from 1200 or more (high).<br>Four transition categories were identified for PA: Sedentary (none or very low at both surveys), Exercise adoption (none or very low at Survey 1; low, moderate or high at Survey 2), Exercise Cessation (low, moderate or high at Survey 1; none or very low at Survey 2) and Maintenance (low, moderate, or high at both surveys). | **EMOTIONAL WELL-BEING:** Outcome variables at Survey 1 (cross-sectional) were the four mental health subscales and the mental health component scores (MHC) of the Medical Outcomes Study Short Form (SF-36). The SF36 is a comprehensive measure of health-related quality of life, which produces eight subscales of which the four mental health subscales were used in the analysis. These relate to emotional well-being: vitality, social functioning, role-emotional, and mental health. Additionally, the MCS was calculated. All measures were standardized for this population. Outcome variables for mental health were calculated by subtracting the Survey 1 score from the Survey 2 score for each of these variables. | • Age<br>• Gender<br>• Marital status<br>• Education<br>• BMI<br>• Birth Country | • Linear regression model | • **Cross-Sectionally:** on every SF-36 variable, group means increased with increasing levels of exercise, and for every level of PA, the group mean was significantly higher than that of the "None or very low" PA group: Vitality: F=50.22, P<0.001; Social functioning: F=28.24, P<0.001; Emotional role: F=61.91, P<0.001 & Metal Health: F=62.68, P<0.001.<br>• **Longitudinally:** MCS change showed no difference across the four PA transition categories either with or without adjustment, but there were significant effects for each of the subscales, and pattern of significance showed some consistencies. By comparison of the "Sedentary" group, the "Exercise Cessation" group showed a greater a greater decrease in vitality (adjusted Mean= -7.21) and social functioning (adjusted Mean= -8.51) than the "Sedentary" group (adjusted Mean Vitality= -5.23) and (adjusted Mean= -5.19). The "Exercise Adoption" groups showed more positive (less negative) changes on social functioning on all four subscales: Vitality F= 43.52, social functioning F=66.50, emotional role F=10.39 and mental health F= with adjustment. | • Reliance on self-reported PA<br>• Level of missing data was high<br>• Women who were lost to follow up were in poorer health. Therefore, some bias in results.<br>• Results may not be generalizable to men or ethnic groups.<br>• Temporal pattern of changes in PA and well-being over the 3-year period was not explored.<br>• Results do not indicate a definitive causal link.<br>• Crude description of "vigorous activity" and "less vigorous activity"<br>• Non-validated PA instrument | • Cross-sectionally, there was a small-moderate to moderate positive association between PA and the MCS and four mental health subscales: vitality, social functioning, emotional role, and mental health.<br>• Longitudinally, there was a small to small-moderate positive association between the exercise adoption group and all four mental health subscales: vitality, social functioning, emotional role and mental health. |

| Publica-tion | Focus of Study | Target Population | Sample Size | PA Instrument | Health Outcomes | Measures | Statistical Method | Results | Critique | Strength of Association |
|---|---|---|---|---|---|---|---|---|---|---|
| Kritz-Silverstein et al. (2000). | To examine the cross-sectional and prospective association of exercise with depressed mood in a community-based sample of older men and women who were not clinically depressed or physically limited at baseline. | White, middle-class men and women aged 50–89 years in southern California. | N=944 | **PA:** Regular strenuous exercise and exercise at least three times a week were assessed by asking the following questions: Do you regularly engage in strenuous exercise or hard physical labor? (no/yes), and Do you exercise or labor at least three times a week? (no/yes). Reported PA was validated indirectly by demonstrating a significant inverse correlation with pulse rate and by a positive correlation with high-density lipoprotein cholesterol levels. | **EMOTIONAL WELL-BEING:** At the 1984–1987 visits, depressed mood was assessed by using 18 of the 21 items on the Beck Depression Inventory (BDI). In accord with criteria described by Shrout and Yager, 3 of the original 21 items (guilt, expectation of punishment, and self-hate) were excluded from the questionnaire in an effort to reduce the length of the scale without compromising its reliability in this population. Total scores were adjusted proportionally to correspond to scores and cut points established for the full 21-item scale by multiplying them by 21/18. At the 1992–1995 visit, the full 21-item BDI was administered. For the present analysis, only the 18 items administered at both visits were used to calculate BDI score. Reliability of the BDI, as assessed with Cronbach's alpha, was 0.73 for the 1984–1987 visits and 0.75 for the 1992–1995 visit. Persons who scored below the cutpoint of 13 were considered not categorically depressed. | • Age<br>• Gender<br>• Marital status<br>• Cigarette smoking history<br>• Alcohol consumption<br>• Estrogen replacement therapy (women)<br>• Social support<br>• BMI<br>• Physical Activity | • ANCOVA | • **Cross-sectionally:** after adjustment for age, both men and women who engaged in regular strenuous exercise had significantly lower BDI scores than men and women who did not ($F = 9.85$ and $F= 8.16$, respectively; $p < 0.01$).<br>• **Cross-sectionally:** exercise three or more times per week was also associated with significantly lower age-adjusted BDI scores for men ($F =5.51$, $p < 0.05$) and women ($F= 5.44$, $p < 0.05$.<br>• **Prospectively:** no association for between baseline exercise pattern and predicting BDI 8 years later. | • The Rancho Bernardo study used two questions and dichotomous variables (no/yes) to represent regular exercise and exercising at least three times a week.<br>• Because depression could reduce exercise, the low rates of depressed mood at baseline and follow-up may reflect in part the exclusion of categorically depressed subjects at baseline.<br>• Selection bias was observed, with a lower response rate for depressed subjects.<br>• Response bias, in which persons who participated in both visits were more likely to engage in PA was also observed.<br>• The exercise measures used in this study reflected relative intensity (or strenuousness) of exercise rather than absolute intensity.<br>• Overall, the prevalence of depressed mood in this middle-class cohort was low, probably reflecting their relatively high socioeconomic status.<br>• Age may also been a confounder.<br>• Results may not be generalizable to ethnic groups, given the sample was consisted of all white participants.<br>• Possible social desirable response bias due to interviewer administrated questions.<br>• LTPA or household PA was not assessed.<br>• Persons with categorical depression and physical limitations at baseline were excluded from the study. Therefore, results may be biased. | • There was a small-moderate inverse association between men who engaged in both regular strenuous exercise or exercise three or more times per week and lower BDI scores than men who did not (cross-sectionally).<br>• There was a small-moderate inverse association between women who engaged in both regular strenuous exercise or exercise three or more times per week and lower BDI scores than women who did not (cross-sectionally).<br>• No association prospectively |

# Appendix D.
# Measurement and Validity of Physical Activity Instruments

## 1. Studies Using Self-Report Physical Activity Instruments

Baker et al., 2009; Balboa-Castillo, Guallar-Castillon, Leon-Munoz et al., 2011; Bath & Morgan, 1998; Benedetti et al., 2008; Benedict et al., 2012; Bowen, 2012; Boyle et al., 2007; Bruce et al., 2008; Byberg et al., 2009; Chang et al., 2010; Chen et al., 2012; DeBruijn et al., 2013; DeFilippi et al., 2012; Demakakos et al., 2010; Feinglass et al., 2005; Franco et al., 2005; Geda et al., 2010; George et al., 2012; Gillum et al., 2010; Gregg et al., 2003; Guedes et al., 2012; Hakim et al., 1998; Hunt et al., 2010; Krits-Silverstein et al., 2000; Ku et al., 2009; Ku et al., 2012; Lampinen et al., 2006; Lan et al., 2006; Lang et al., 2007; Larson et al., 2006; Laurin et al., 2001; Lee & Hung, 2011; Lee & Paffenbarger, 2011; Lee & Russell, 2003; Lee et al., 20120;LicSc & Parkatti, 2011; Lin et al., 2011; Lindwall et al., 2011; Manson et al., 2002; McTeirman et al., 2003; Menec, 2003; Middleton et al., 2010; Martin et al., 2008; Morgan & Bath, 1998; Mullee et al., 2010; Mummery et al., 2004; Ottenbacher et al., 2012; Paganini-Hill et al., 2010; Pasco et al., 2011; Peterson et al., 2009; Salguero et al., 2011; Sampaio & Ito, 2012; Smith et al., 2010; Strawbridge et al., 2002; Stressman et al., 2009; Sun et al., 2010; Sundquist et al., 2004; Taaffe et al., 2008; Ueshima et al., 2010; Weuve et al., 2004; Woo et al., 2002; Yaffe et al., 2001; Yorston et al., 2012.

## 2. Studies with Validity of Physical Activity Instruments

Baker et al., 2009; Benedict et al., 2012; Benedetti et al., 2008; Bowen et al., 2012; Boyle et al., 2007; Buchman et al. 2008; Buchman et al., 2012; Byberg et al., 2009; Chen et al., 2012; DeBruijn et al., 2013; DeFillippi et al., 2012; Feinglass et al., 2005; Geda et al., 2010; George et al., 2012; Gregg et al., 2003; Guedes et al., 2012; Kokkinos et al., 2010; Kritz-Silverstein et al., 2000; Lan et al., 2006; Laurin et al., 2001; Lee et al., 2000; Lee et al., 2011; LisSc & Parkatti, 2011; Manini et al., 2006; Manson et al., 2002; Martin et al., 2008; McTeirman et al., 2003; Middleton et al., 2010; Mummery et al., 2004; Ottenbacher et al., 2012; Pasco et al., 2011; Peterson et al., 2009; Santos et al., 2012; Shah et al., 2012; Salguero et al., 2011; Smith et al., 2010; Strawbridge et al., 2002; Yaffe et al., 2001; Sun et al., 2010; Weuve et al., 2004; Yorston et al., 2012.

## 3. Studies with No Validity of Physical Activity Instruments

Balboa-Castillo, Guallar-Castillon, Leon-Munoz et al., 2011; Bath & Morgan, 1998; Bruce et al., 2008; Chang et al., 2010; Demakakos et al., 2010; Franco et al., 2005; Gillum et al., 2010; Hakim et al., 1998; Hunt et al., 2010; Ku et al., 2009; Ku et al., 2012; Lampinen et al., 2006; Lang et al., 2007; Larson et al., 2006; Lee et al., 2003; Lee et al., 2012; Lindwall et al., 2011; Morgan & Bath, 1998; Lin et al., 2011; Menec, 2003; Mullee et al., 2010; Paganini-Hill et al., 2010; Sampaio & Ito, 2012; Stressman et al., 2009; Sundquist et al., 2004; Ueshima et al., 2010; Woo et al., 2002; Taaffe et al., 2008.