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ISSN: (Print) 2331-1916 (Online) Journal homepage: https://www.tandfonline.com/loi/oaen20

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To cite this article: Carolyn Weeks-Levy, Gautam Sadarangani & Carlo Menon | (2020) Perceptions of senior citizens on the use and desired features of a wristband for maintaining, strengthening, and regaining hand and finger function, Cogent Engineering, 7:1, 1719572

To link to this article: https://doi.org/10.1080/23311916.2020.1719572

Accepted author version posted online: 20 Jan 2020.
Published online: 06 Feb 2020.

Weeks-Levy et al., *Cogent Engineering* (2020), 7: 1719572
https://doi.org/10.1080/23311916.2020.1719572

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BIOMEDICAL ENGINEERING | RESEARCH ARTICLE

Perceptions of senior citizens on the use and desired features of a wristband for maintaining, strengthening, and regaining hand and finger function

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Received: 26 June 2019
Accepted: 16 January 2020

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Reviewing editor:
Zhongmin Jin, Xian Jiao Tong University (China) and Leeds University.(UK), China

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Abstract: The objective of this study was to understand whether seniors would wear a wristband technology to help them improve, retain, regain, or strengthen hand and finger function and to gather information about the desired features of the technology to enhance compliance in use. The strength and functioning of the hand and fingers decrease as people age and can have a detrimental impact on the individual's quality of life. Studies have shown that regular exercise of the hands can help the individual maintain hand strength and improve function. Two self-reported, online questionnaires were designed and administered to seniors. Of the 105 surveyed, 62% indicated they would wear a wristband. The top desired wristband features identified were ease of putting the device on, unobtrusiveness and comfort of the device with a desired price point of $99 or less. The majority of seniors surveyed were interested in wearing the wristband; however, results revealed that the wristband would need to be tailored for this population for use and uptake of the wristband. The results of this study provide insight into the features and functionalities of a wristband that would enhance user compliance in seniors who wished to improve hand and finger function.

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ABOUT THE AUTHOR

Dr. Carlo Menon received a Ph.D. degree from the University of Padua, Italy after completing an internship at Carnegie Mellon University, USA and was a Research Fellow and Technical Officer at the European Space Agency, The Netherlands. He is currently a Professor in the Schools of Mechatronic Systems & Engineering Science at Simon Fraser University (SFU) in Metro Vancouver, British Columbia, Canada and the Director of the WearBioTech University Core Facility. He received several research and career awards including the Career Investigator Award from the Michael Smith Foundation for Health Research (MSFHR), the New Investigator Award from the Canadian Institutes of Health Research (CIHR), and a Tier 1 Canada Research Chair (CRC). Dr. Menon founded the Menrva Research Group (www.sfu.ca/menrva.html) at SFU, which is focused on the research of wearable biomedical technology, biorobotics and smart materials. He has published over 300 articles including both journal and conference papers.

PUBLIC INTEREST STATEMENT

With the increase in the world's senior population, research to study the design of ergonomic assistive devices for this population to support aging in place and a good quality of life is needed. The Menrva Research Group has researched the use of force myography (FMG) to distinguish specific hand and finger movements with a high degree of accuracy. Application of FMG in the design of a wristband to promote hand function provides us an opportunity to develop an assistive device for seniors with the desired features of portability, low expense, ease of use and comfort, which seniors are more likely to use. This paper focuses on understanding the features and ergonomics of designing an assistive wristband device that would be readily used by the senior citizen population to help them regain, maintain, or strengthen hand and finger function.

Subjects: Engineering & Technology; Health and Social Care; Rehabilitation Medicine; Medicine, Dentistry, Nursing & Allied Health

Keywords: assistive device; wristband; independence; quality of life; elderly

1. Introduction

The ability to perform Activities of Daily Life (ADLs) are especially dependent on the proper functioning of the hand and fingers; however, as men and women age, hand function decreases especially after the age of 65 (Carmeli, Patish, & Coleman, 2003; Ljubic, 2012). It is estimated that adults spend 9.5 h of the day performing ADLs with 60–70% of those activities involving the use of the hand (Bureau of Labor Statistics, 2016; Vergara, Sancho-Bru, Gracia-Ibanez, & Perez-Gonzalez, 2014; Zheng, De La Rosa, & Dollar, 2011). Studies have shown that hand function is closely related to the quality of life of seniors largely due to the ability to perform ADLs and remain independent (Ljubic, 2012). A number of factors have been cited that contribute to the decline in functionality of the hands in seniors including genetic and endocrine factors, metabolic disorders, diseases (e.g. arthritis, Parkinson's disease), pathological changes of the soft and hard tissues, environmental factors, physical activities, nutrition and traumatic injuries (Carmeli et al., 2003). Exercise of the hand to improve strength and dexterity has shown to have a positive effect on senior's ability to functionally use their hands, remain independent, and have an improved quality of life (Lefler & Armstrong, 2004; Ljubic, 2012).

By 2036, Statistics Canada estimates that the number of seniors aged 65 and older could reach upwards of 10.9 million, increasing to an upwards estimate of 15.1 million by 2063 (Statistics Canada, 2015). In the United States, the number of seniors aged 65 and older is projected to be 88.5 million by 2050, which is more than double the senior population in 2010 (40.2 million) (Vincent & Velkoff, 2010). Keeping seniors living independently, which reduces healthcare costs, use of caregivers, and promotes aging in place is an important consideration (Helbostad et al., 2017; Hoenig, Taylor, & Sloan, 2003; Mynatt, Essa, & Rogers, 2000). Development of a convenient assistive device to help seniors retain, regain, or improve hand and finger function would help seniors age in place and maintain a good quality of life. Studies have indicated that seniors are interested in assistive devices such as wristbands to help them self-monitor their health and activity levels as a means to maintain their health, independence, and vitality (Helbostad et al., 2017; Holzinger et al., 2010; Rasche et al., 2015; Schlomann, Von Storch, Rasche, & Rietz, 2016; Tedesco, Barton, & O'Flynn, 2017). However, studies exploring acceptance of using assistive devices by the senior population have shown that features of these devices such as wristband fitness trackers will need to be tailored to the specific senior demographic (Helbostad et al., 2017; Holzinger et al., 2010; Rasche et al., 2015; Schlomann et al., 2016). For example, the kind of display and data presented to the user will need to be specifically tailored for the senior population, and the development of apps to support the device will need to be designed for use by seniors who may not be as computer or mobile technology savvy (Helbostad et al., 2017; Rasche et al., 2015).

Current technologies to assist with hand and finger function have not translated into successful commercial product due to limitations such as inaccuracy of tracking hand and finger movements (e.g. ActiGraph accelerometer), high costs (Bioelettronica EMG array system >$50k), inconvenience, and discomfort (e.g. data gloves) or the inability to wear the technology (e.g. Kinect vision system), which eliminates portability and use in all environments. Novel assistive technologies to monitor hand and finger function must be portable, wearable, unobtrusive, cosmetically acceptable and affordable to meet the needs of end-users and their caregivers and reduce healthcare costs.

Force myography (FMG) technology (Castellini et al., 2014; Lukowicz, Hanser, & Schobersberger, 2006; Phillips & Craelius, 2005; Wininger, Kim, & Craelius, 2008) was investigated for use in a wearable and portable technology as an alternative to currently limiting technologies. FMG technology is also referred to as muscle pressure distribution mapping (Phillips & Craelius, 2005) residual kinetic mapping (Castellini et al., 2014) or topographic force mapping (Wininger et al.,

2008). The principle of using FMG to monitor hand and finger movement is that volumetric changes in a limb such as the wrist that occurs with functional movement can be measured by force sensors, and the different signals obtained from the sensors can be used to differentiate between specific movements of the limb. Published studies describe the use of FMG technology embedded in a convenient wristband to measure volumetric changes of muscles and tendons during hand and finger movements to allow for accurate hand and finger gesture recognition (Dementyev & Paradiso, 2014; Eysenback et al., 2017; Sadarangani, Jiang, Simpson, Eng, & Menon, 2017; Wininger et al., 2008; Xiao & Menon, 2014). The aim of the current study was to obtain information directly from seniors about desirable features of a wristband that they would wear to help them regain, retain, or improve their hand and finger function.

2. Materials and methods

2.1. Survey development

A self-reported survey through the use of two online questionnaires was used for this study. A market research company, SmartPoint Research, was used to conduct the questionnaires, and provided access to a large database of vetted Canadian senior citizens profiled by disease state. The research was approved through the ethics board of Simon Fraser University. SmartPoint Research adhered to Canadian market research standards governed by Market Research Intelligence Agency (MRIA) for this study.

Design of the survey, which included two questionnaires was accomplished through a collaboration of scientists from the university and scientists from the company that intends to develop, manufacture, and market the wristband. The main objective of the survey was to gather information from the end users on the features that would need to be incorporated into the wristband to meet their needs and facilitate compliance with the use of the technology. Necessary features were anticipated to include the look of the device, comfort, ease-of-use, social media support, meaningful data presentation, and usefulness of the device. It was decided to survey a group of 100 participants, including healthy seniors and seniors who have different health conditions affecting hand and finger function such as arthritis, Parkinson's Disease (PD), stroke, or injuries. The questionnaires were designed to explore the following: 1. whether seniors would wear such a wristband to help them improve, retain regain or strengthen hand and finger function 2. gather information about the desired features of the wristband to enhance compliance with use; 3. gain insight on the type of information dashboard that would be useful to and desired by seniors; and 4. the types of social media that would best support use of the device. The information obtained from the questionnaires will be used to drive improvements to the wristband to meet the needs of the senior population.

The first part of the survey consisted of a questionnaire that captured characteristics of the respondents such as age, gender, disease state, ability to perform activities of daily living, and leisure activities in which the seniors participate, explore whether the seniors would or would not use a wristband to improve or retain their hand and finger function, and gather basic information on desirable wristband characteristics.

The data gathered from the first questionnaire was used to design a second questionnaire focused on determining the most necessary features that would support the use of the wristband by the seniors. They were first asked the price range they would be willing to pay for the wristband. Participants were then asked to assign points out of a total of 100 points to 14 different features of the wristband giving the most points to the most important features for them. The second questionnaire was sent to the participants who indicated in the first questionnaire that they would be interested in wearing a wristband to help them with hand and finger function. The response rate to this second questionnaire was 73%.

2.2. Participants

The two questionnaires were administered by SmartPoint Research online and they recruited participants for the first questionnaire that met the criteria of age (>50 years old) and met disease states including arthritis, stroke, Parkinson's Disease, injury, other, as well as healthy seniors. The intent was to recruit participants who were healthy or had disease states that affected hand and finger function in equal proportions; in particular, we were looking for 25 healthy seniors, 25 seniors with arthritis, 25 seniors with stroke and 25 seniors with Parkinson's or other maladies that affected hand and finger function. It turned out that it was not possible to equally represent each disease state and non-disease state, as the numbers of stroke, injury, and Parkinson's patients in the database were far lower compared to the seniors with arthritis and the pool of healthy seniors. In total, there were 105 respondents in the first questionnaire and 29 in the follow-up questionnaire.

2.3. Analysis

Quantitative and Qualitative data were inputted into Excel spreadsheets for analysis. The qualitative data were reviewed independently by three scientists from the university and company involved and categorized by consensus. Quantitative data was represented by percentages or point-weighted values (see Table 5).

3. Results

3.1. Questionnaire 1

3.1.1. Characteristics of participants

A total of 105 seniors (40 men and 65 women) responded to the first questionnaire. The age distribution and the health conditions of the participants are shown in Figures 1 and 2, respectively.

Of the 105 participants, 46 were healthy seniors with no reported diseases affecting their hand and finger function followed by the next largest group represented by those seniors with arthritis at 43 participants. Additional conditions reported by the 43 seniors with arthritis included an injury

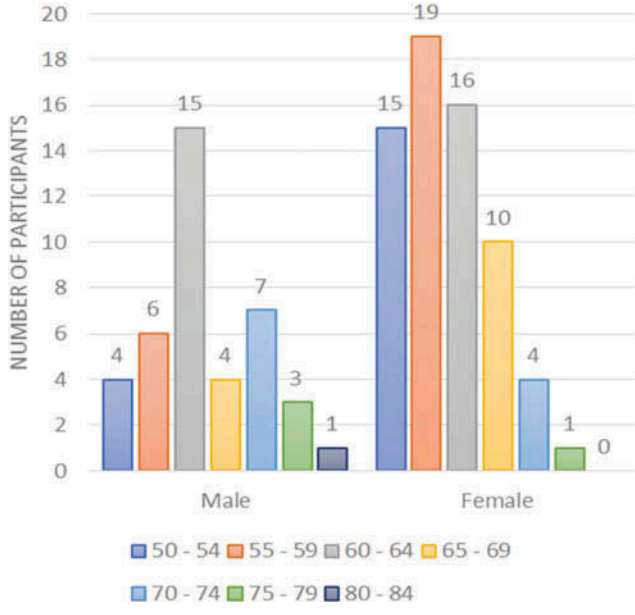

Figure 1. Age and gender of respondents.

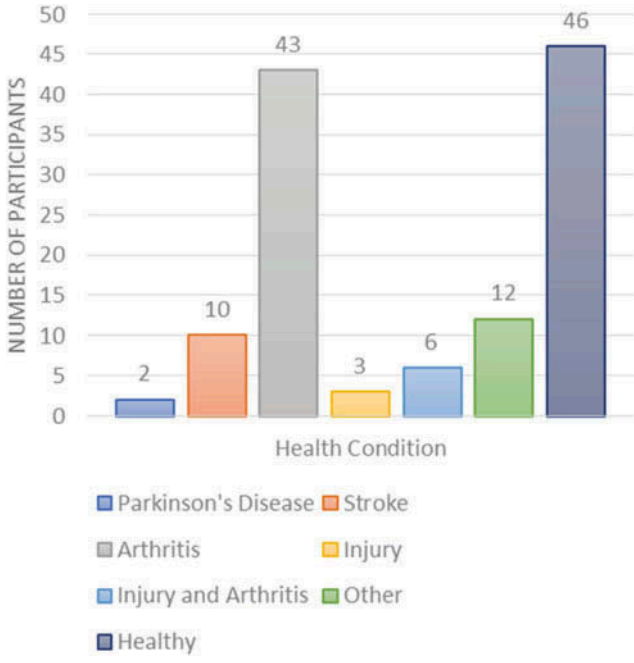

Figure 2. Health conditions of participants. Please note that some participants are represented in multiple health condition categories as described in the text.

to the hand (6), Raynaud's syndrome (2), diabetes (1), stroke (1), and Parkinson's disease plus a stroke (1). The remaining 16 seniors were afflicted with stroke (6), Parkinson's Disease (1), injury (3), multiple sclerosis (1), diabetes (1), neuropathy (1), asthma (1), stroke and diabetes (1) or stroke and cancer (1). Another question was asked about undergoing rehabilitation for loss of motor function in the hand with the majority of the respondents (94%) indicating they were not undergoing any type of hand therapy.

The majority of the 105 respondents lived in their own home (73%), a very small proportion lived in a retirement community or with relatives (4%), and the rest rented apartments or condos (23%).

Information was also collected on the types of activities the respondents were engaged. Choices included exercise, sports, video games, shopping, gardening, cooking house cleaning, working, social games, puzzle games, arts & crafts, volunteer work or other activities. This question was asked to gain insight into activities that could be used with the wristband to encourage seniors to use their hand and fingers. The activity that most were engaged in was shopping followed closely by house cleaning, cooking, and exercising. Figure 3 shows the distribution of activities engaged in by the respondents. Please note that the respondents could choose more than one activity.

3.1.2. Limitations and effect on activities of daily living

Two questions on questionnaire 1 dealt with the participant's mobility limitations and the ability to perform certain activities of daily living. The question on mobility limitations used a scale of 1 to 5 where 1 meant "you do not struggle at all" and 5 meant "you struggle a lot" for the movements of grip, release of grip, shoulder movement, and elbow movement. The majority of participants reported that they had no trouble with the release of grip (64%) and elbow movement (66%). Respondents reported the most difficulty with grip and shoulder movement. Table 1 summarizes the data on the mobility limitations of the participants.

Using the same scale of 1 to 5 where 1 meant "you do not struggle at all" and 5 meant "you struggle a lot", another question explored respondent's limitations on activities of daily living which included dressing, opening jars, using cutlery ad pouring liquids. Participants reported the

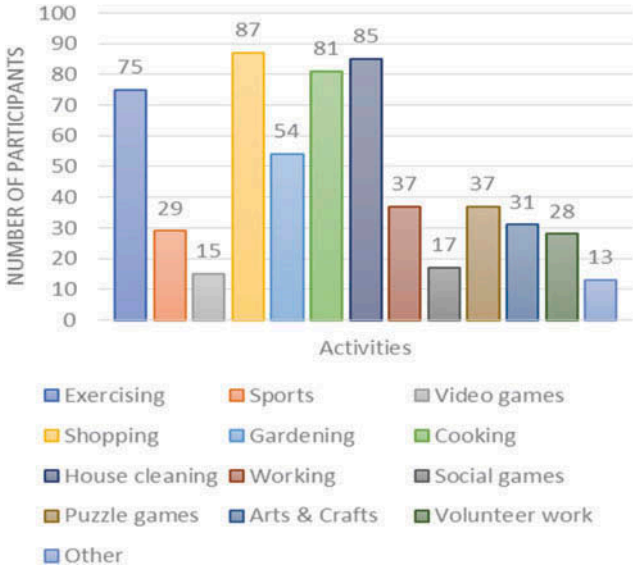

Figure 3. Activities engaged in by participants.

Table 1. Limitations on mobility

Movement	1 (none)*	2	3	4	5 (a lot)*
Grip	43%	21%	23%	10%	3%
Release of grip	64%	15%	13%	6%	2%
Shoulder	47%	24%	14%	10%	5%
Elbow	66%	17%	12%	4%	1%

*scale with 1 = "you do not struggle at all" to 5 = "you struggle a lot"

most difficulty with opening jars followed by dressing. Participants had the least difficulty with using cutlery. Table 2 summarizes the data on limitations on activities of daily living.

3.1.3. Perceived usefulness of technology

Questions were asked to ascertain whether participants already used wristbands or wore jewelry on the wrist. Of the pool of seniors, 62% indicated that they did not currently wear a wristband or wrist jewelry, and 38% responded they did wear something on their wrist. The participants who responded positively to wearing something on their wrist were asked a follow-up question of the type of wristband they wore. Of the participants that indicated they wore something on their wrists, the majority (77%) reported they wore watches on their wrist and 23% reported they wore fitness bands on their wrists. Another question was asked about wearing jewelry on the wrist, with 59% responding they did not wear jewelry on the wrist and 41% responding that they did wear jewelry on their wrist. The types of jewelry worn were reported as bracelets, medic alert bracelets, and watches.

Table 2. Limitations on activities of daily living

Activity	1 (none)*	2	3	4	5 (a lot)*
Dressing	50%	29%	15%	3%	3%
Opening jars	34%	22%	17%	11%	15%
Using cutlery	67%	15%	10%	6%	2%
Pouring liquids	64%	17%	13%	5%	1%

*scale with 1 = "you do not struggle at all" to 5 = "you struggle a lot"

Participants were asked to respond to whether they would be interested in wearing a wristband that could help them track the number of times they used their hand functionally during the day. They were given examples of tasks that would qualify, such as opening doors, turning on lights, and reaching for a glass of water. Thirty eight percent responded they would not wear a wristband for this purpose and 62% responded they would be interested. A follow up question explored why they responded yes or no to this question. The majority of those responding that they would not be interested in wearing this type of wristband cited that it was not necessary. Other responses included that they didn't see benefits to wearing this type of technology, it would be too annoying or inconvenient, they did not need this type of assistance and a few felt the wristband might not be safe to wear. Of the participants that responded they would wear this type of wrist technology, the majority indicated that the wristband would help hand and finger function. Other comments included that data from the wristband would be interesting to know, that they would wear it to support research and they would use the technology if it was comfortable.

Another question explored whether seniors perceived that receiving feedback on the number of times they used their hand and fingers in a day was useful. Forty four percent responded it would not be useful to them and 56% responded it would be useful. Of the no responses, most indicated they did not see a benefit, there was no need, or it was not useful. Some responded that having this information was irrelevant and a waste of time. The yes responders commented that the data would help inform the person and help them understand success and treatment options, the data could help them determine movements that exacerbate symptoms and could show the severity of their hand and finger function loss.

The last question asked about the usefulness of wearing this wristband technology was whether lowering health-care costs would incentivize the seniors to use this type of technology. Responses to this question were primarily positive, with 70% of the seniors responding yes and 30% responding no to this question.

3.1.4. Group comparisons

The two groups of seniors with sufficient numbers for comparison were the healthy and arthritic seniors with 46 and 43 participants, respectively (see Figure 2). The response rates to the yes/no questions for these two groups were compared to get an idea if attitudes about the wristbands and current habits differed greatly between the groups. The healthy seniors responded less favorably to the use of a wristband to help regain, retain, or strengthen help hand and finger function and receiving feedback on the use of their hands and fingers. This group also was less likely to be incentivized to use a wristband, even if it helped lower their healthcare costs. Table 3 summarizes the response rates of the two groups to the yes/no questions in questionnaire 1.

3.1.5. Desired features of technology

The last part of the questionnaire explored features of the technology desired by seniors to encourage its use. The first question used a scale of 1 to 5, where 5 meant the feature was very important and 1 meant the feature was not important at all, to score a list of characteristics of wristbands or jewelry. Participants were asked to choose a value on the scale for each characteristic. Table 4 summarizes the scoring of 11 characteristics.

The top five features that were very important to the seniors in descending order of importance were ease of donning the device, unobtrusiveness, composed of a soft material, thin wristband, and loose-fitting wristband. The top five features that were not important to the seniors included a device that was attention grabbing, bulky wristband, colorful wristband, wristband made of a rigid material, and tight-fitting wristband.

The seniors were also asked to provide their input into all the characteristics they would like to see in a wrist band that they would wear. All 105 participants provided comments, with 14 of the participants responding that they would not wear a wristband and provided no details on features.

Table 3. Comparison of answers to questions from healthy and arthritic seniors

Question (paraphrased)	Healthy (46 seniors)		Arthritic (43 seniors)	
	Yes	No	Yes	No
Use of a wristband that could help track the number of times you use your hand functionally?	50%	50%	74%	26%
Usefulness of receiving feedback on the total number of times you have used your hand and fingers in a day?	35%	65%	67%	33%
Use of a video game to encourage use of your hands and fingers?	54%	46%	70%	30%
Current use of a wristband of any type?	37%	63%	40%	60%
Do you wear jewelry on your wrist?	48%	52%	33%	67%
Do you currently use fitness apps on your smart phone?	22%	78%	12%	88%
Would lowering healthcare costs incentivize you to use a wristband?	54%	46%	79%	21%

Table 4. Importance of characteristics of wristbands and jewelry

Characteristic	1 (not)*	2	3	4	5 (very)*
Thin	25%	4%	22%	18%	31%
Sleek	21%	8%	22%	24%	26%
Bulky	45%	10%	15%	7%	24%
Unobtrusive	22%	6%	15%	10%	47%
Tight fitting	31%	15%	20%	9%	21%
Loose fitting	15%	14%	29%	14%	28%
Attention grabbing	55%	9%	22%	6%	9%
Colorful	45%	12%	23%	11%	9%
Soft material	17%	7%	23%	20%	33%
Rigid material	37%	13%	32%	8%	10%
Easy to put on	6%	3%	11%	15%	65%

*scale with 1 = not important to 5 = very important

The top 10 wristband features listed by the participants in order of descending popularity were: thin band (46), easy to put on (42), feedback (27—most preferred visual), comfortable band (13), soft material for band (12), flexible band (6), light weight band (5), water resistant (5), and stretchy band (2). Three participants indicated they would wear anything as long as it worked. Some participants provided details on specific looks for the band, such as specific colors.

The next three questions were asked to evaluate the importance of feedback and modes to provide the feedback to the seniors. The first question asked about the familiarity of the participants with the use of mobile apps or web-enabled apps. Thirty percent of the participants used apps frequently followed by 19% saying they used apps on a daily basis. Twenty nine percent used apps infrequently followed by 22% who did not use apps at all. A similar question asked whether the participants currently used fitness apps on their phones. The vast majority, 85%, of the seniors responded that they did not use fitness apps and only 15% responded they currently used fitness apps on their phones. When asked about the importance of receiving information that was app and web-enabled, 24% responded it was very important, 46% felt it was somewhat important and 30% responded it was not important at all.

The last feature that was explored was the price that the seniors would be willing to pay for the wristband. Choices for the question were $50–$74, $75–$124, $125–$149, $150+ and not interested. Only 3% of the seniors were willing to pay $150+ for the technology, followed by 10%, 17% and 26% willing to pay $125–$149, $75–$124 and $50–$74, respectively. A large portion of the seniors, 44% indicated that they were not interested in purchasing a wristband.

3.2. Questionnaire 2

3.2.1. Desired features of technology

A second questionnaire was sent to all the participants who indicated that they would be willing to participate in a follow-up survey (40 seniors) to further explore the desired features needed to enhance uptake of the technology in the senior population. Of the 40 seniors that were sent the questionnaire, 29 responded (~73%). There were two parts to the follow-up questionnaire. The first question asked the seniors again to indicate how much they were willing to pay for a wristband; however, the price categories were changed a bit; they were $50–$74, $75–$99, $100–$150, and $151–$199. One person responded that they would be willing to pay $151–$199 for the wristband, followed by four choosing the $100-$150 category. The majority responded they would be willing to pay $75–$99 (15 people) and 9 responded they would be willing to pay $50–$74.

The second part of questionnaire 2 asked the participants to "spend" 100 points on 14 different features to get an idea of the importance of each of the features to this group. Table 5 summarizes the total spent by all the participants for each of the listed features.

Table 5. Total points assigned to 14 wristband features

Feature Number	Feature	Total points*
1	Ability to pair your wristband with your Android mobile phone	146
2	Ability to interchange and use bands of different colors to match your style	118
3	Ability to send your hand activity statistics to your doctor or physiotherapist	287
4	A mobile app that allows you to play virtual sport games as a method to get your hand exercises done	122
5	A water-proof version of the band, so you can keep it on when you bathe or go for a swim	263
6	A mobile app that suggests and guides you through the various hand stretches and exercises	266
7	A water-resistant version of the band, so you can keep it on when you wash your hands	357
8	A screen on the band that tells you the time and gives you key information about your hand activity for the day	346
9	Ability to charge the band wirelessly—with no wires/connections needed	325
10	Ability to compare your hand activity between different days and weeks	163
11	A mobile app that allows you to play virtual puzzle games as a method to get your hand exercises done	198
12	Ability to compare your hand activity with your friends and family	70
13	Ability to sign up for hand activity challenges with your friends and family	96
14	Ability to pair your wristband with your Apple mobile phone (iPhone)	143

*Participants = 29 with each assigning 100 total points to their most important features.

The top five features were: water-resistance of the band, a screen on the band that provides key information, ability to charge the band wirelessly, ability to send hand activity statistics to medical staff, and a mobile app that can suggest and guide the person through various hand stretches and exercises. The two lowest scoring features were activity-based features where the person could engage in hand activity comparisons and challenges with family and friends.

4. Discussion

While research studies have been performed to gain senior citizen's opinions and attitudes toward assistive devices and fitness trackers worn on the wrist (Helbostad et al., 2017; Holzinger et al., 2010; Rasche et al., 2015; Schlomann et al., 2016; Tedesco et al., 2017), no studies have been performed to understand senior's opinions about a wristband that would help them specifically regain, retain, or improve hand and finger function to the authors' knowledge. Important findings from these published studies include the fact that seniors are interested in using technologies that will help them monitor their health; however, design of the technologies needs to be tailored specifically to the senior population (Helbostad et al., 2017; Holzinger et al., 2010; Rasche et al., 2015; Schlomann et al., 2016; Tedesco et al., 2017). For example, ease of use of the assistive technologies was an important consideration for the senior population; many of whom are not proficient with the use of computers and apps (Holzinger et al., 2010; Rasche et al., 2015; Schlomann et al., 2016). These studies point out a clear need to tailor assistive devices to the senior population, and perhaps certain senior subpopulations who have more specific needs due to specific disease states, to enhance uptake and use of these technologies (Helbostad et al., 2017; Holzinger et al., 2010; Rasche et al., 2015; Schlomann et al., 2016; Tedesco et al., 2017). The current study provided additional insight to help inform the design of the wristband for hand and finger function with respect to desired features that would enhance the use of this specific wristband by seniors.

The use of force myography technology allows for the creation of unique wristbands that can track hand and finger gestures, when compared to traditional accelerometer-based devices. This provides an opportunity to develop a wristband that can more accurately map hand and finger gestures to provide a means to accurately monitor hand exercises and provide suggestions for exercises that would help seniors retain, regain, or strengthen hand and finger function. With the increase in the world's senior population, research to study the design of ergonomic assistive devices for this population to support aging in place and a good quality of life is needed. Our questionnaires aimed to understand the features of a wristband that would enhance compliance in use of such a wristband and inform future research on assistive devices to meet the needs of the senior population.

In answer to the first line of inquiry of whether seniors would wear a wrist band to help them retain, regain, or strengthen hand and finger function, more seniors indicated they would wear a wristband to help retain, regain, or improve hand and finger function (62%) than not (38%), based on the responses from the 105 seniors responding to questionnaire 1. This result is reflected in other published studies performed to ascertain senior's interest in using assistive devices including wristbands to support their health and a better quality of life as they aged where there was a clear interest and acceptance of this type of technology by the seniors (Holzinger et al., 2010; Rasche et al., 2015; Schlomann et al., 2016; Tedesco et al., 2017). The current study showed that more of the seniors with arthritis were interested in use of the wristband and features of the wristband to encourage use of the hand and fingers compared to the pool of healthy seniors, implying that the proposed wristband may be of more interest to those living with some impairment, as opposed to those who are otherwise healthy.

The responses obtained during the line of inquiry on device features showed that ease of donning the wristband, unobtrusiveness (thin wristband) and comfort (soft material, loose fitting) were top wristband features desired by seniors who responded to questionnaire 1, and, conversely, a wristband that was attention-grabbing, obtrusive (bulky), and uncomfortable (tight fitting, rigid material) were features least desired by the seniors. Hence, the ultimate design of a wristband that

is not attention-grabbing, comfortable, and easy to don will be necessary to promote the use of the device in the senior population based on questionnaire responses.

When asked about the desired cost for purchasing a wristband, a large portion of the responders from questionnaire 1 indicated they would not be willing to purchase a wristband (44%) at any of the proposed price ranges. Of those willing to purchase a wristband, most seniors chose the lowest price range of $50—$74 (26%), and only 3% responded they would be willing to spend $150+ for the technology. In the follow-up questionnaire 2 sent to those who responded positively to wearing a wristband in questionnaire 1, the largest group of seniors indicated that the desired price point for purchasing the wristband was in the $75—$99 category (52%); an increase over the most desired price point chosen during questionnaire 1. Seventeen percent of those responding to questionnaire 2 indicated that they would be willing to spend over $100 for the device. These results suggest that seniors who were interested in wearing an assistive device appeared more willing to spend more on the technology.

Questionnaire 2 went on to explore the final two areas of inquiry concerning display dashboard information, social media support, as well as other desired features that would be attractive to seniors to promote the use of the wristband. Additional most desired features for the wristband included water-resistance, a screen to display key information, wireless charging capability, and a mobile app that will suggest and guide the person through hand and finger exercises. The ability to share data with medical professionals was also a desirable feature. Interestingly, the two lowest scored features in this questionnaire were social media features that would allow challenging friends and family to hand activities and comparing exercise results with those of friends and family.

While the survey clearly showed interest by the senior population in an assistive device for hand and finger function and provided important information on features to include in the design of the device, further studies asking seniors to test prototype devices and provide feedback on the devices would provide additional insight into the optimal design of the wristband to enhance uptake and use in the senior population. In particular, it will be critical to understand the best formats to present critical information to inform users of exercises useful for hand and finger function and present data on progress. In summary, there is definitely a portion of the senior population that is interested in wearing a wristband that could assist them in retaining, regaining, or improving hand and finger function. The wristband should be comfortable to wear and put on, easy to charge, waterproof, provide exercise regimens, provide useful information of progress with exercising, cost under $99 and have the capability to share exercise information with medical professionals to enhance the use of the device by the senior population.

Funding
This work was supported by the AGE-WELL NCE [AWSIP-Jan17-022].

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Citation information
Cite this article as: Perceptions of senior citizens on the use and desired features of a wristband for maintaining, strengthening, and regaining hand and finger function, Carolyn Weeks-Levy, Gautam Sadarangani & Carlo Menon, *Cogent Engineering* (2020), 7: 1719572.

Data Availability
The data are readily available upon request.

Declaration of Interest
Carlo Menon and Gautam Sadarangani have a vested interest in commercializing the technology tested in this study, if it is proven to be successful and may benefit financially from its potential commercialization.

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