PSYCHO-PHYSIOLOGICAL VARIABLES AND HOCKEY PLAYING ABILITY

by

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ABSTRACT

A variety of measures was administered to hockey players in three different categories, differentiated by age and level of play. Combinations of these measures were examined in order to select those batteries which correlated most strongly with coaches' ratings of the hockey ability of the players.

The categories of players included Junior (N=24), Midget (N=48), and nine to 13 year old boys (N=60) attending summer hockey school. The measures employed were concentrated in four domains: anaerobic system measures, specific skill measures, psychological measures, and measures of perceptual-motor ability. Scores were obtained on 17 variables for the Junior sample; these 17 variables, plus another 12 variables, produced a total of 29 scores for each player in the Midget and hockey school samples. Coaches or instructors rated players on paper-and-pencil rating scales.

Samples were analyzed separately and in combination. Univariate statistics were presented as were the correlations between all pairs of variables. Regression analyses, using the BMDP9R program, were conducted and the "best" and selected subsets were described.

Discussion of batteries across subject categories was prohibited because of the finding of substantial differences between categories of subjects. When subject categories were

analyzed separately, significant subsets of predictors emerged in the data for the Midget and hockey school samples. In the former group, a battery or variable subset of 14 variables (derived from nine measures) produced a multiple correlation of 0.91 with hockey ability ratings (i.e., R^2=0.83). In the hockey school sample, a battery of five variables (derived from four measures) produced a multiple correlation of 0.68 with hockey ability ratings (R^2=0.46). Other subsets were discussed.

Discussion of the findings included a concern for sample specificity and the need for replicative studies. Nonetheless, the findings pointed to the plausibility of the use of manageable batteries of tests for the prediction of ice hockey ability.

DEDICATION

To

Mary and Myalisa

for

making it all worthwhile.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF CHARTS

I. Introduction

"Hockey is the Canadian metaphor, the rink a symbol of this country's vast stretches of water and wilderness, its extremes of climate, the player a symbol of our struggle to civilize such a land. Some people call it our national religion" (Kidd and Macfarlane, 1972, p. 4). In times of change, little has remained unquestioned. Recent events have focused greater attention on the health of our "national religion".

In February, 1979, the national hockey team from the U.S.S.R. defeated a select group of players from the National Hockey League in a three game series. Although the National Hockey League included some players from the United States and Europe at that time, the largest proportion of the players were Canadians who had received their training and playing experience in Canada. Although 16 of the 21 N.H.L. teams were based in the United States, the league was generally considered to be the domain of Canada's elite hockey players. Thus, the defeat of the N.H.L. team by the U.S.S.R. was considered to be a defeat of Canada's best.

Debate about the relative skills of players and teams from Canada and from the Soviet Union had continued since the first meeting of superior teams from these two nations in 1972. The victory by the Soviets in 1979 left at least one writer in a national Canadian magazine (Quinn, 1979) with no doubts as to who possessed greater skills:

> "The humiliating defeat at the hands of the Soviets demonstrated ... that the NHL style of play is poverty-stricken, that the highly paid and once hero-worshiped [sic] stars of the league are light years behind the Soviets in physical conditioning and that the fundamental skills of skating, puck handling and passing have eroded in the NHL just as they have been honed to excellence by the Soviets" (p. 39).

If Quinn's perceptions were accurate, and if Soviet hockey supremacy was to be seriously challenged, then those responsible for the development of hockey in Canada should have acted. As Quinn (1979) added,

> "...our entire approach to the game must be reworked. We must take helmet in hand and learn from the Soviets, introduce their training and style to our youngest players and - perhaps a generation from now - we may legitimately challenge for their cup" (p. 41).

Attempts at change have been made, particularly at the amateur level. Recently, the Canadian team entered in the 1980 Winter Olympics employed the "European training system" (Mclaughlin, 1980, p. 3). This team, composed mainly of college players, was exposed to special nutrition and weight training programs. Since they did not win a medal in Olympic competition, the success of the training regime was debated. The United States team also used college players and a training program similar to the Canadians; their winning of a gold medal was a major surprise of the 1980 Winter Olympics. Nonetheless, it seemed unreasonable to attribute superiority to the American or North American hockey development programs over those of the Soviets or Europeans on the basis of victories in the few emotionally-laden games of the Olympics; long-term plans were required.

A former chairman of Hockey Canada, Doug Fisher, agreed that changes must be made in Canadian methods of developing hockey players:

> "The evidence is barefaced in front of anyone who wants to look, that our system, and I'm talking about our minor system, simply does not produce the people with the skills and techniques that the Russians, Czechs, Swedes and Finns are producing" (McLaughlin, 1980, p. 2).

Commenting on the Soviet and Czechoslovakian hockey development programs, Kingston (1980) noted that young players followed specific programs at each age level and used the club system to expose promising players to available resources. At age 16, the programs became even more intense as selected players were further nurtured in club settings with specialized coaching and training regimes. With elite players and teams, the relationship between the sport scientists and coaches and trainers was much closer than in North America. The Czechoslovakian national team, for example, had specialists in sports medicine and sports psychology working closely with it. Players were often tested as part of research projects and appropriate findings were utilized in an attempt to produce better on-ice performance.

Efforts to give direction to the pursuit of lost excellence in North American hockey could have relied more heavily on the examination and application of research findings to the training and performance of players (Kaufman, 1979). In commenting on the developments in the years since Canada's dramatic last-minute victory over a Soviet team in 1972, McLaughlin (1980) stated that the years since that surprisingly narrow victory "should have been time for introspection and change. But the coaching methods and style of play, from the minor leagues up to the professionals, remain relatively the same as they have always been" (p. 3). Research could have investigated, for example, coaching techniques, skill development, conditioning methods and the organization of teams into competitive leagues, all of which might have resulted in the improved performance of hockey players. Research might also have attempted to determine which factors - both psychological and physical - best predicted those individuals likely to have performed well (according to stated criteria) during competition. In the U.S.S.R., for example, boys as young as six years old underwent examination, including the collection of biographical data and the results of physical and psycho-motor tests, to determine their promise as hockey players (Kingston, 1980).

A look at studies of performance in hockey throughout the world showed that research to date has been diverse. Some investigators (Green, 1979; Marcotte, 1973; Rusko, Havu and Karvinen, 1978) have examined the physiological characteristics of players, focusing primarily on the contributions of the different energy systems and substrates to performance. Others (Ferguson, Marcotte and Monpetit, 1969) have attempted to simplify the means of measuring physiological variables.

Studies (Dorion, 1979; Newton, 1978) have also focused on the measurement of physical or anthropometric characteristics of hockey players. Some investigators (Newton, 1978) have compared data on players of different ages and skill levels or from different countries to determine if differences existed in absolute size, relative size and somatotype when players were grouped by team or by playing position.

Some attention has also been directed to players' psychological attributes. Studies have examined, for example, motivation (Carron, Ball and Chelladurai, 1977) and aggression (McCarthy and Kelly, 1978). One investigation (Scaramella and Brown, 1978) found a relationship between aggression in hockey players and the level of a physiological variable, serum testosterone. The importance of teamwork was indicated by studies such as those that have examined team achievement (Iso-Ahola, 1976) and team cohesion (Ball and Carron, 1976).

An attempt to determine skill levels of hockey players has resulted in the development of skating tests (Lariviere, Lavallee and Shephard, 1976) or, in some cases, batteries of hockey skill tests (Enos, 1973; Merrifield and Walford, 1969) which included measures of stickhandling, shooting and passing in addition to skating.

Examinations in the psycho-motor domain have perhaps been less numerous than in the above-mentioned areas. Studies have been conducted on the visual perceptual speed (Thiffault, 1974) and the peripheral vision (Deshaies, Pargman and Thiffault, 1978) of hockey players.

The Selection of Potential Predictors

As the above brief review of research implied, a body of contributing knowledge was available to assist in the analysis of the performance of hockey players. However, such analysis might have been more fruitful if the relative importance of contributors to performance had been established. The utility of a myriad of research findings on such diverse components as anaerobic power, perceptual speed and aggression was limited for a hockey coach or team manager with little training in the sports sciences. Studies that isolated a few variables or a battery of measures which best predicted performance might have offered more assistance to hockey "practitioners" by having made their task more manageable. Attempts could then have been made to devise effective means of optimizing the scores obtained by individual players or teams on the battery of a relatively few predictor variables. Prediction equations have undoubtedly never accounted for 100 percent of the variance in performance in athletic situations. Nonetheless, increasingly accurate predictions should have resulted from continuous modifications to the regression equations as research suggested the addition or deletion of variables or the revision of measurement techniques.

Current knowledge has suggested certain promising predictors of hockey performance. For example, in the physiological domain, studies (Green and Houston, 1975; Seliger, Kostka, Grusova, Kovac, Machovcova, Pauer, Pribylova and Urbankova, 1972) have confirmed the importance of the anaerobic systems to hockey performance. By definition, the typical shift by hockey players was less than two minutes in duration and thus it did not qualify as aerobic work (Mathews and Fox, 1971).

In the psychological domain, a study by McCarthy and Kelly (1978) indicated that aggressive players scored more goals and took more shots on goal than did players rated low in aggression. The findings of Russell (1974) lent support to the potential of aggression as a predictor of ice hockey performance as the number of goals and assists obtained by players correlated with measures of aggression. Other studies focused on related psychological variables and demonstrated, for instance, the importance of motivational factors in performance (Ball and Carron, 1976; Desharnais, 1975).

The prediction of hockey performance or ability from measures of skill seemed axiomatic; however, a consistent finding of one predictor was not forth-coming. Nonetheless, measures of skating speed (Deshaies et al., 1978) and stickhandling ability (Merrifield and Walford, 1969) were found to relate to coaches' ratings of hockey playing ability.

Statement of the Problem

The problem addressed in the present study was that of attempting to predict the ability or performance of ice hockey players or, more specifically, to improve on the prediction attempts of previous investigations.

The Present Study

The present study was designed to examine a variety of measures in an attempt to isolate batteries of predictors of hockey ability or performance. The inclusion of measures of both physiological and psychological factors was supported by statements of Morgan (1973) that much of the inquiry into exercise and sport sciences had suffered from the specialized orientation of the investigators, that the latter had too often focused exclusively either on psychological or biological variables. Morgan argued convincingly for the "psychobiological approach". One study supporting his claim was conducted by Nagle, Morgan, Hellickson, Serfass and Alexander (1975). This investigation involved the measurement of a variety of psychological and physiological factors on 42 candidates for an Olympic wrestling team. Multiple correlations relating the psychological (N=40) and physiological (N=29) data to successful performance were 0.73 and 0.67, respectively. When both selected psychological and physiological variables were employed (N=25), the multiple R increased to 0.92, thus allowing for improved discrimination between successful and unsuccessful athletes. Morgan's (1973) feelings were clear: "Insofar as prediction is a central function of any scientific enterprise, the case for the superiority of psychobiological models is unambiguous and uncontestable" (p. 40).

Another study using a psychobiological model was that of Deshaies et al. (1978). This study examined the relationships between 14 physiological-anthropometric, psychological and motor skill variables and a measure of hockey playing ability (as defined by coaches' ratings of a player's individual and tactical skills). The data - on 116 "major junior" league players whose average age was 214.5 months - were subjected to a stepwise regression analysis with hockey playing ability as the criterion measure. This analysis revealed that the following four variables accounted for 55 percent of the variance in ice hockey performance ($F_{4,111}$ =33.23, $p<.05$): forward skating speed, achievement motivation, visual perceptual speed and anaerobic power. This study also found, in support of Morgan's (1973) contention, that the variance in hockey performance (55 percent) accounted for by the "psychobiological profile was larger than that observed individually for either the biological (17%), physiological (20%), or the specific skill profile (33%)" (p. 36).

The present study was based on Morgan's (1973) claim that psychobiological models were superior to those containing only psychological or physiological variables. The selection of variables or variable-types relied on a review of the literature, but received major directions from the work of Deshaies et al. (1978). The latter authors' finding of a multiple correlation of 0.74 between four variables and hockey performance showed promise. The present study attempted to improve, where possible, on the measures employed by Deshaies et al. and to add other promising measures in an effort to predict more accurately hockey ability or performance. An important consideration was the economy of test administration: the time required and inconvenience to subjects had to be minimized and administration procedures had to be simple. (These restrictions were not overtly stated by the subjects tested or their superiors but were thought by the researcher to be critical to gaining acceptance to conduct the study).

Thus, based on the results of Deshaies et al. (1978), the decision was made to include measures within the following categories of variables: (1) the anaerobic systems, (2) specific skills, (3) psychological measures, and (4) perceptual-motor ability. General support for inclusion of these types of variables came from the spirit of the remarks of the respected Soviet coach Tarasov (1969) who said that hockey was a game of conditioning, intellect and skill. Justification for inclusion of each specific measure included in the present study was contained in the following literature review section which focused on the four categories of variables mentioned above. Readily available descriptive measures, such as age, height and weight, were also included, as was information on the hockey playing experience of the players. Forearm girth, a relatively simple anthropometric measure, was included since it was a probable index of relative muscularity (Ross, 1980).

Hypotheses

The present study was designed to test the following general hypothesis:

> accurate estimations of ratings of hockey playing ability were obtainable from scores on an isolated battery of measures, i.e., the variance in perceived hockey playing ability was explicable by scores on a battery of tests purporting to measure anaerobic power and capacity, specific hockey skills, psychological factors and perceptual-motor behaviour.

While the general hypothesis provided the focus for the present study, acceptance or rejection of the hypothesis would have been highly subjective. Thus, in addition to the general hypothesis, six specific hypotheses, derived from a precedent in the literature, provided operational definitions of the strengths of relationships under investigation. These specific hypotheses were

a. that the employed battery of measures accounted for more than 55 percent of the variance in ice hockey playing ability -- a figure reported by Deshaies et al. (1978) -- where ability was defined by the subjective ratings of experts;

b. that the employed measures of anaerobic power and capacity correlated more strongly with hockey playing ability than the value (r=0.42) reported by Deshaies et al. (1978) between ability and anaerobic power;

c. that the skating speed measure employed, being the same as that used by Deshaies et al. (1978), showed a similar strength of correlation (r=0.55) as that obtained by the latter authors;

d. that one or a combination of the employed psychological measures correlated more strongly with hockey ability than in the relationship (r=0.35) reported by Deshaies et al. (1978) between a measure of achievement motivation and hockey ability;

e. that the employed measure of perceptual-motor ability correlated more strongly with hockey ability than the relationship (r=-0.22) reported by Deshaies et al. (1978); and,

f. that the hypotheses stated above were valid in hockey players of different ages and skill levels.

Delimitations

The major delimiting factors in the present study were associated with time and with the sampling of subjects. As mentioned above, efforts were made to employ measures which were simple and relatively quick to administer. Consideration for the players and teams tested prompted the search for instruments which could be administered quickly and economically. It was also believed that future use of any test battery by hockey practitioners would be enhanced by the battery's convenience. Time considerations also militated against the use of some techniques involving sophisticated equipment or procedures or equipment that was delicate, expensive or not portable. Hence, a major consideration in the selection of instruments was their applicable in the field as relatively simple and economical measures.

Studies which have examined the relationships among variables using a small, select group have limited generalizability from the findings because of sample specificity. This concern was addressed in the present study by testing players at three different levels of play. One group of players formed a team at the top Junior level of play. A second group of intermediate age consisted of an elite group of

"Midget" players who were invited to a one-week camp as part of a newly developed provincial program. The third group were younger players of varying ages and from different teams who were attending a summer hockey school. The ability of the test battery to predict hockey ability in all these groups was examined with respect to the problem of sample specificity.

II. A Survey of Related Literature

In this section, literature was reviewed which was relevant to the categories of variables under investigation, i.e.,

(1) the anaerobic systems,

(2) specific skills,

(3) psychological, and

(4) perceptual-motor ability.

The Anaerobic Systems

A general review of energy systems

Before considering the evidence linking anaerobic systems and performance in ice hockey, it seemed appropriate to present a brief description of anaerobic and aerobic metabolism.

Energy to support man's functioning was derived from the food he eats. The breakdown of the food supplied the necessary energy to support biological processes such as the chemical work of growth and the mechanical work of muscular contraction (Mathews and Fox, 1971). The chemical compound adenosine triphosphate (APT) was considered to be the major energy "currency" and it was this compound, which resulted from food breakdown, that was stored in muscle cells for use in muscle work.

In general, there were two major systems or pathways which lead to the production of ATP, i.e., the anaerobic and aerobic systems. Anaerobic systems, which functioned without the presence of oxygen, were the essential suppliers of energy for intense work of only a few minutes duration since oxygen could not be inspired and utilized quickly enough for muscular work within that short time frame. In fact, there were two anaerobic systems. ATP could be produced from breakdown of phosphocreatine (PC), another compound stored in the muscle cells. The breakdown of PC was often referred to as the alactic phase of anaerobic metabolism or as the source of anaerobic power. The remaining anaerobic system involved the breakdown of glucose (a plentiful form of carbohydrate) to produce ATP and lactic acid. Hence, this system was often referred to as the lactic phase and, also, as the source of anaerobic capacity. Anaerobic capacity referred to the ability to perform in vigorous events of about 10 to 60 seconds in duration (Shephard, 1978) but this lactic acid system might have been the major contributor to maximum effort for up to two or three minutes (Mathews and Fox, 1971). Anaerobic power involved events of only four to six seconds (Margaria, 1968) or perhaps 10 seconds (Shephard, 1978) in length. Anaerobic systems resulted in the limited production of ATP and could, therefore, have sustained vigorous work for a relatively short period of time. The progressive buildup of lactic acid as a product of glucose breakdown or glycolysis was thought to lead to muscular fatigue and thus to a cessation of, or decrease in, exertion.

The aerobic system or aerobic pathway, which functioned in the presence of oxygen, involved the complete breakdown of glucose (or fats or protein) to produce carbon dioxide (CO_2), water (H_2O) and 19 times the number of ATP molecules produced by anaerobic glycolysis alone. Since lactic acid did not accumulate when oxygen was present, a major source of fatigue was thought to be eliminated and submaximal work could be maintained by the aerobic system for some time. It was the aerobic system that supplied energy needs at rest and, also, during recovery from intense exercise. Phosphocreatine stores, which might have been exhausted during anaerobic activity, were replenished primarily from the breakdown of ATP which was produced aerobically. Thus, the systems worked to complement one another in supplying the energy requirements of the body for various types of activity.

Although evidence was reported on the response to training of aerobic (Holloszy, 1973) and, to a lesser extent, anaerobic systems (Gollnick and Hermansen, 1973; Weltman, Moffatt and Stamford, 1978), other factors were important in influencing individual performance. Apparently, skeletal muscle, the contraction of which resulted in work being done, was composed of different fibre types (Essen, 1978). The two major categories of fibres appeared to have different metabolic characteristics.

The red (i.e., "slow twitch") fibres had large blood supplies and seemed particularly adapted to support aerobic activity. The other fibre type, i.e., the white (or "fast twitch") fibres, had more limited blood supplies and appeared suited to anaerobic activity. Red fibres contained high lipid or fat stores whereas white fibres contained relatively large glycogen stores (Essen, 1978). As noted above, glucose or its stored form, glycogen, was the major fuel during anaerobic activity whereas fat, a more plentiful source of fuel in the body, could be utilized during aerobic work.

Gollnick and Hermansen (1973) reported that the distinction between the capabilities of fibre types was not rigid as a "spectrum of oxidative capacities exists in both fibre types" (p. 2). It appeared that most muscle groups in man contained a mixture of fibre types (Essen, 1978). Of interest, too, was that "the relative porportion of the two fibre types does vary from individual to individual" (Gollnick and Hermansen, 1973, p. 3).

In summary, then, it has been shown that work or activity involved the contraction of muscle which was supported by the breakdown of ATP. ATP might have been produced anaerobically (without oxygen) to support brief, intense activity or aerobically to supply energy needs at rest or during submaximal, steady-state activities. It was also mentioned that muscle in man was composed of two different fibre types suited, to differing degrees, for the support of either aerobic or anaerobic activities and that the proportion of these fibre types varied across individuals. This brief review was intended to describe the basic components of the two major energy systems and not to explain, as Essen (1978) stated, the "complex system of regulatory mechanisms (nervous, hormonal and cellular)" involved in "the degradation of lipids and carbohydrates to release energy for muscle work" (p. 7). Essen (1978) also noted that the sources of energy for working muscle depended on factors such as diet and fitness as well as on the "mode, intensity and duration of work" performed.

The nature of the game

Since, as stated above, the nature of the work influenced energy utilization, a brief description of the game of hockey and the type of work or activity involved in by hockey players might have assisted in the discussion of energy utilization in hockey. This section provided such a description.

Seliger, et al. (1972) described the game as follows:

> "Ice hockey is a sports play, performed on an ice surface and characterized by a rapid change of play situations as well as permanent personal duels between the players moving on the skates in a special outfit weighing 8-10 kg, and using the hockey stick and the puck. During the short time interval for which the player is staying on the ice he must prove the maximum performance. The application of endurance is specific in connection with maximal speed. On the whole, the rapid changing from the load on the ice surface to the rest on the seat requires an immediate reaction to these extreme phases of the players activity occuring for the whole time of the play. In the course of the play the muscles of the lower limbs will be loaded which assigurate

[sic]the locomotion in the space at substantial [sic] changes of speed and direction, and more than in most sports plays also the muscles of the trunk and upper limbs. A good deal of static contractions appears" (p. 283-284).

For those ignorant of the game, it could have been added that the ice surface in North America was approximately 200 X 85 feet (wider in Europe). Teams usually were allowed 18 players for a game, including two goaltenders. Six players, including a goaltender, were allowed on the ice at one time for one team. Players specialized as forwards (attackers), defencemen (defenders) and goaltenders. Goals were situated at opposite ends of the ice surface. The object of the game was to advance the puck (a disk made of hard rubber) into the opposing team's area and shoot it past the goaltender into the goal. Hockey sticks, composed of long, wooden shafts with flatter "blades" on the end, were used to pass and shoot the puck. The players all wore skates which were essentially sharpened, steel blades attached to specialized boots. A hockey game consisted of three 20 minute periods. Players were allowed to substitute as play continued or during a stoppage called for a rule violation. Thus, the game involved individual capacities and skills as well as team play and strategies.

A time-motion analysis of eight college hockey players during 10 games (Green, Bishop, Houston, McKillop, Norman and Stothart, 1976) revealed the following characteristics of play. The mean playing time per game was 24.5 minutes per player and a mean distance of 5,553 metres was covered by a player in a game. The mean playing time per shift was 85.4 seconds; however, an average shift "included 39.7-s of the uninterrupted play followed by a 27.1-s play stoppage, repeated 2.3 times" (p. 160). Actual playing time and playing time per shift increased over the three periods as did time for play stoppages. Differences by position were noted as defencemen played 21.2 percent longer than the forwards due to a greater number of shifts, but the defencemen's shifts were shorter in duration.

Styles of play have varied considerably for different teams as well as players. Games sometimes were relatively slow and reflected cautious and close-checking strategies by one or both teams. Some players or teams were particularly noted for physical or aggressive play. Other teams or games have emphasized a very fast style of play with quick skating and little close-checking. Obviously, some players appeared more adept at one particular style of play than another. Thus, even within the sport, different game situations or styles of play might have made different demands on an individual's energy sources and capacities.

Energy sources and performance in hockey

Although apparently straightforward, the issue of the contributions of the anaerobic and aerobic systems to performance in hockey was complex. Whereas Fox and Mathews

(1974) stated that energy requirements for hockey were derived entirely from anaerobic sources, others seemed to disagree. As mentioned above, Green et al. (1976) reported that the mean playing time per shift was 85.4 seconds. Using data presented by Gollnick and Hermansen (1973), relative contributions of anaerobic processes for the mean shift would fall between 60 percent (one minute) and 40 percent (two minutes). Astrand and Rodahl (1977) reported comparable contributions of anaerobic systems of 65 to 70 percent and 50 percent at one and two minutes, respectively. However, as Green et al. (1976) also reported, play stoppages divided shifts into uninterrupted play periods averaging 39.7 seconds in length. Using data mentioned above (Astrand and Rodahl, 1977), this shortening of actual playing time would have meant even greater contributions of anaerobic systems.

The relative importance of the anaerobic energy supplies seemed to be supported from studies conducted on hockey players. Green and Houston (1975) found that, whereas changes in aerobic capacity [measured by gas analysis after running (2.5 m/min., 1% increment/min.) to exhaustion on a treadmill], when expressed in ml/kg/min., did not appear in Junior hockey players (N=16 to 24) when tests were conducted at the beginning and end of the season, statistically significant improvements were noted in measures of anaerobic capacity (measured by run time on a treadmill at 215 m/min. and 20% grade) and anaerobic power (measured by speed in running up a flight of stairs). Seliger et al. (1972) confirmed the importance of both aerobic and anaerobic systems to hockey performance. In the latter authors' examination of 13 members of the Czechoslovakian national hockey team (heart rates were measured telemetrically; bicycle ergometers and gas analysis were used to assess fitness; blood samples were taken to measure lactate levels), they concluded that about 66 percent of the energy demands of hockey players were met by anaerobic sources.

The complexity with regard to the energy sources for hockey players came from the nature of the game, intermittent work that required a blending of endurance, speed and strength. Comparisons of various athletes by Rusko, Havu and Karvinen (1978) showed that hockey players (N=13, Finnish, many of national or international calibre) possessed aerobic capacities as measured by treadmill run (1% increment/2 min., speed selected to produce 8-12 min. run) and gas analysis, by percent of slow-twitch fibres and by SDH activity, that were statistically significantly higher than a group of active but untrained individuals (N=23), but that these capacities were considerably less than those of long distance runners and competitors in some nordic events. On the other hand, data from another study (Komi, Rusko, Vos and Vihko, 1977) revealed that the same hockey players that were tested by Rusko et al. (1978) had high values on some, but not all, of the indicators of the anaerobic systems. For example, hockey players had relatively high values on measures of leg forces (speed up a flight of stairs, isometric contractions of extensor muscles) but not in terms of percentage of fast-twitch fibres (in vastus lateralis) nor blood lactate levels (after maximal treadmill run and maximal arm ergometer test).

The energy requirements for intermittent work of high intensity and concern about performance with increasing lactate levels seemed of relevance here. A recent report by Essen (1978) stated that studies with 54 subjects (both sexes, age range 20 to 41) found that high intensity work (mean load 299W) performed intermittently for up to 60 minutes (15 seconds work - 15 seconds rest) on a bicycle ergometer was more similar metabolically to continuous exercise at half the load (mean load 157W) than continous exercise to exhaustion at an equally intense load (280W). This meant that intermittent work resulted in less glycogen and more lipid utilization than previously thought. It was also noted that both muscle fibre types had a capacity for carbohydrate and lipid metabolism.

Studies (Essen and Haggmark, 1975; Tesch, Sjodin, Thorstensson and Karlsson, 1978) had showed increased muscle lactate after intense exercise and implicated these increases (Tesch et al., 1978) in subsequent impairment of muscle functioning. However, other evidence (Segal and Brooks, 1979; Weltman, Stamford and Fulco, 1979) suggested that high lactate levels did not impair subsequent performance. Although a thorough understanding of the causes of muscle fatigue did not exist (Gollnick and Hermansen, 1973), the high lactate levels reported in performing hockey players (Green et al., 1976) might not have been critical. Evidence was presented, too, that improved aerobic capacity (Weltman and Katch, 1979) delayed the onset of anaerobic processes (and lactate buildup) and that training of specific limbs reduced lactate buildup (Cerretelli, Pendergast, Paganelli and Rennie, 1979).

Green's (1979) excellent analysis of metabolic events with respect to hockey (based on a review of the literature, including many of his own studies with university hockey players) suggested possible explanations of the integration between aerobic and anaerobic energy supplies. He stated that, following maximal anaerobic exertion, full recovery of the muscle may take 60 minutes. This made it seem unlikely, then, that hockey players could have utilized anaerobic energy supplies to their fullest and still have continued to play. He noted, however, that the frequent stoppages in play during a hockey game may have allowed fuller utilization of phosphocreatine than expected, since approximately 90 percent of this substance was resynthesized in the first minute of recovery (Harris, Edwards, Hultman, Nordesjo, Nylind and Sahlin, 1976). He also suggested that the nature of the game and the pace at which the players played may have reduced glycolytic involvement and thus minimized the buildup of lactate. Aerobic mechanisms may, in fact, have been dominant in the resynthesis of ATP over the course of a two hour game. Green (1979) concluded that the tempo of the game would have dictated the relative contributions of aerobic and anaerobic systems but that the development of aerobic capacity had not been emphasized for the North American player. Seliger et al. (1972) concurred that both systems should have been trained by hockey players even though two-thirds of the energy demands in playing the game were supplied anaerobically.

In summary, it appeared evident that energy demands of performing hockey players were dependent on a variety of game and individual factors. Nonetheless, the literature (Astrand and Rodahl, 1977; Green and Houston, 1975; Seliger et al., 1972) seemed to suggest that the nature of the work involved in hockey games reflected relatively greater contributions of anaerobic rather than aerobic energy sources.

Prediction of hockey ability from energy system indicators

Although measures of physiological variables such as aerobic and anaerobic capacities and anaerobic power were taken on hockey players, little investigation was undertaken on the relationship between such variables and hockey performance or ability. Studies were descriptive rather than predictive. The work of Deshaies et al. (1978) was an exception to this trend as the latter authors examined the ability of 14 variables, including anaerobic power and aerobic capacity, to predict hockey performance (as defined by coaches' ratings of individual and tactical skills). Whereas scores on the measure of aerobic capacity [predicted from a submaximal (900 kpm/min. for 6 min. at 50 r.p. m.) bicycle ergometer test] showed virtually no correlation (Pearson r=0.01) with hockey performance, anaerobic power (measured by timed runs up a flight of stairs) was statistically significantly correlated (r=0.42,p<.05) with performance and subsequently entered the regression equation.

Further support for the promise of anaerobic system indicators as predictors of hockey performance lacked the experimental base of the findings of Deshaies et al. However, some support came from the previously mentioned study by Green and Houston (1975) which reported no changes in aerobic capacity over a hockey season while finding statistically significant improvements in both anaerobic power and anaerobic capacity. The latter authors noted that the most impressive changes were in anaerobic capacity, in which total run times on the demanding treadmill test (at 215 m/min. and 20% grade) increased by an average of 16.3 percent over the hockey season. Since the Deshaies et al. (1978) study did not include a measure of anaerobic capacity, a true indication of the total contribution of anaerobic systems - both the alactic and lactic phases - was not forthcoming in the latter study.

There might have been several reasons for the poor predictive power of aerobic capacity in the Deshaies et al. study. As was stated above, Green (1979) commented that the development of aerobic systems has not been emphasized in North American hockey, even though aerobic metabolism was important in ATP resynthesis during the course of a hockey game. Two studies were noted to illustrate this lack of emphasis on aerobic training. Hutchinson, Maas and Murdoch (1979) measured the aerobic capacity (treadmill at 7 m.p. h., 2% grade increment/2 min., expired gas analysis) of 11 college hockey players who were exposed to a six-week dry land training schedule, which included running five miles three times a week. This schedule resulted in a statistically significant ($N=8$, $F=7.96$, $P<.001$) increase in VO_2max. after the six weeks. However, the players then began their competitive hockey season and, when tested at its completion, VO_2max. values had declined to below initial pre-training schedule scores. Although Hutchinson et al. (1979) did not measure anaerobic variables, they concluded that energy expenditure during the season was primarily anaerobic and aerobic training was lacking. Lehtonen and Viikari (1980) studied the concentrations of serum cholesterols in elite Finnish hockey players (N=24, mean age was 25.6) and found that hockey players had considerably lower values than elite soccer players whose training stressed endurance. (They suggested that particular serum cholesterols might have protected against coronary heart disease.) It was concluded that hockey training emphasized anaerobic systems. Lehtonen and Viikari (1980) added that, when hockey players had more aerobic exercise (running at 4.5-5.0 min/km for about an hour a week, total duration not reported), "the ratio of HDL - cholesterol to total cholesterol became normal" (p. 38).

Another mitigating factor with respect to aerobic capacity and hockey was the crucial influence of skill in energy expenditure. As Green (1979) illustrated by comparing the VO_2max and skating speed scores of three players, energy expenditure was least for the individual with the lowest VO_2max, suggesting "that efficiency may be a more statistically significant indicator of fatiguability than a low VO_2max" (p. 33). Thus, considering the style of play in North American hockey and the probability that skating skill reduced the need for a well-developed aerobic systems, the poor predictive power of aerobic capacity in the Deshaies et al. (1978) study became less surprising.

Measures of anaerobic energy

As the above discussion indicated, although the literature relating energy systems and performance or ability in hockey was sparse, anaerobic rather than aerobic system indicators appeared to offer more promise as predictors of hockey performance and ability. This section reviewed some available measures of anaerobic energy supplies and their suitability for application in the field.

In general, less attention appeared to have been given to measures of anaerobic than aerobic functioning and little agreement existed as to the most valid measure of anaerobic activity (Bar-Or, 1978; Katch, Weltman, Martin and Gray, 1977; Weltman, Moffatt and Stamford, 1978). Several criterion measures have been employed, however,

> "including initial or postexercise glycogen levels, initial levels of muscle phosphagen (ATP and PC), peak exercise muscle or blood lactate acid and/or pyruvate concentrations, one or several glycolytic enzyme concentrations, or even the quantity of postexercise oxygen uptake (the oxygen debt)" (Katch, Weltman, Martin and Gray, 1977, p. 319).

Although an exhaustive review of these criterion measures was beyond the scope of the present paper, some illustrative discussion about concerns with respect to some of these measures was provided. For example, Segal and Brooks (1979) took issue with the traditional O_2 debt hypothesis citing a study [N=11 males, bicycle ergometer, moderate (55% VO_2 max) & heavy (95% VO_2 max.) workloads, normal & glycogen depleted states] in which reducing lactate levels did not change postexercise O_2 consumption. If the "lactacid O_2 debt" represented the utilization of O_2 to reconvert lactate to glycogen, then changing lactate levels should have affected O_2 consumption after exercise. Blood lactate levels, as measures of anaerobic metabolism, reflected "only imperfectly the total quantity of lactate produced at the time of exercise" (Freund and Gendry, 1978, p. 123). Astrand and Rodahl (1977) added concern about the "lack of information about the total water in the body available for uptake of lactate and the uneven distribution of lactate in various water compartments in the body. Other hidden information is the rate by which lactate is chemically removed during exercise and recovery" (p. 312). The reliability of evaluating work from glycogen depletion patterns has been questioned. For example, Essen (1978) noted that substrates other than glycogen "are available to the muscle cell and can be utilized for energy production, such as glucose, fatty acids, and triglycerides" (p. 22).

In short, tests of anaerobic functioning that required physiological or biochemical analysis were available but dispute continued about their utility. Tests of this nature had other major drawbacks as well. They were invasive, involved highly skilled personnel, sophisticated and expensive equipment, and usually involved submitting subjects to workloads of an exhaustive nature, thereby requiring considerable subject commitment and motivation. These considerations, along with their undetermined reliability and validity, made such invasive techniques unattractive as on-site tests of hockey performance.

Performance tests have also been devised to measure anaerobic functioning. As stated by Katch et al. (1977), characteristics of such performance tests seemed obvious:

> "the test must be of maximal intensity (for a given individual) and must be performed for as long as possible. More precisely, the rate of work must allow not only for the greatest percentage of energy production for nonaerobic sources but also for the greatest differentiation of individual difference in performance before the test is terminated or before aerobic energy production supercedes" (p. 320).

One frequently employed measure of maximal intensity, albeit for a short duration, was that designed by Margaria, Aghemo and Rovelli (1966). This measure, involving a run at top speed up a flight of stairs, was purported to estimate anaerobic power, i.e., that portion of anaerobic energy supplied from the breakdown of phosphocreatine stores in the muscle. However, Katch and Weltman (1979) reported that this test correlated poorly with other estimates of anaerobic work and that scores were correlated highly with body weight. The latter point received support from a study (Kitagawa, Suzuki and Miyashita, 1980) in which obese men (N=14, 20% fat or more) scored higher in average power output on the (Margaria et al. (1966) test than lean (N=16, less than 10% fat) or ordinary men (N=21, 10 to 19.9% fat; all aged 18 to 22). When eight non-obese subjects added weight belts (i.e., inert mass), their power output scores increased to approximate those of the obese men.

Katch et al. (1977) reported on the development of a test of anaerobic work using a bicycle ergometer. After a number of studies utilizing various workloads and test durations (usually on male college students), these authors concluded that anaerobic output would be optimized by employing a 40 second test with a resistance of 5.0 to 6.0 kp. Furthermore, more work was accomplished by employing an all-out rather than pacing strategy (Katch, Weltman and Traeger, 1976). Anaerobic capacity was measured in a later study (Katch and Weltman, 1979) by the total number of revolutions during a two minute all-out effort; anaerobic power was indicated by revolutions in the first six seconds of the test. (The use of a two minute test apparently reflected the belief that capacity would not be measured by a 40 second test, even though the earlier work had shown a high correlation (r=0.95, N=58) between output at 42 seconds and at two minutes.) Using the six second and two minutes indices of anaerobic power and capacity, respectively, Katch and Weltman (1979) reported correlations of r=-0.57 between VO_2 max, ("continuous" treadmill test, gas analysis), r=0.27 between VO_2 max. and anaerobic capacity and r=0.42 between anaerobic capacity and anaerobic power (N=16 "healthy" males, mean age was 22.5). The authors concluded that these data "are supportive of a specificity hypothesis regarding the three energy systems. That is, individual differences in the three energy systems are essentially unrelated to each other" (p. 330). In short, the authors reported the development of a reliable (r=0.92, test-retest) test of individual differences of anaerobic power and capacity, while admitting that "cross-validity is ... undertermined at the present time" (Katch et al., 1977, p. 426).

Another recently developed test purporting to measure contributions of anaerobic energy sources was the Wingate Anaerobic Test (1977). This test involved a 30 second all-out sprint on a bicycle ergometer after a warm-up and rest of specified duration. Resistance on the ergometer was determined according to body weight. Bar-Or (1978) reported that studies to date had suggested that output was maximized by utilizing resistance settings of 0.075 kp per kilogram of body weight on the Monark ergometer. The number of revolutions was recorded at five second intervals for a total of 30 seconds. Values were converted to overall mechanical power; power output in 30 seconds was thought to represent anaerobic capacity whereas power output during the five second interval of most revolutions represented anaerobic power. Bar-Or (1978) reported test-retest reliabilities of 0.95 to 0.98 (same day) or 0.90 to 0.93 (tests one to two weeks apart). Bar-Or (1978) noted that attempts to validate the test were still proceeding, although "it was somewhat hard to decide which of the existing tests is valid enough as an indicator of anaerobic capability and can serve as a reference for the Wingate Test" (p. 23). He did report, however, that studies to date had shown a high correlation (r=0.86, N=16 "trained male young adults") between anaerobic capacity and O_2 debt (treadmill, "progressive continuous" test) and similar values between anaerobic capacity and a 25 metre swim (r=0.87 to 0.90, N=20 "teen-agers") or a 300 metre run (r=0.86, N=20 "teen-agers"). The anaerobic power index showed a correlation of 0.79 with the Margaria et al. (1966) test. In a recent study, Bar-Or, Dotan, Inbar, Rothstein, Karlsson and Tesch (1980) administered the Wingate test to 19 subjects ("healthy males, 20- to 30-year-old physical education students") who also had biopsies taken from the left vastus lateralis muscle. These authors reported statistically significant correlations between anaerobic capacity and relative fibre size (average FT area/average ST area) ($r=0.63$, $p<.01$) and between anaerobic power and the percent of FT fibres ($r=0.54$, $p<.05$).

Both the Wingate Anaerobic Test (1977) and the Katch et al. (1977) test were attractive as measures to be employed in the field since they were relatively easy to administer, a minimum of skill and time was required, and they purported, albeit cautiously, to measure both anaerobic power and capacity. The Wingate test, at 30 seconds, was somewhat shorter than the optimal 40 seconds proposed by Katch et al. (1977), and considerably shorter than the two minutes which Katch seemed to favour as an anaerobic capacity measure in a later paper (Katch and Weltman, 1979). Another difference between the Wingate and Katch tests was the resistance setting employed. Whereas the latter author favoured a setting of 5.0 to 6.0 kp, the Wingate test presented a wide range of settings based on body weight. This difference probably reflected subject groups involved in the development of the tests; the Katch test appeared to have been devised using college students whereas the Wingate test had been employed with "6 age groups of children, teenagers and adults (males and females)" (Bar-Or, 1978, p. 8). Although Katch and Weltman (1979) claimed that anaerobic power was always reflected in the first six seconds of pedalling, Bar-Or (1978) stated that the highest five second period should be taken. (In a schematic representation of power output, Bar-Or (1978) showed greatest output between five and ten seconds; both Katch and Weltman (1979) and Bar-Or (1977) seemed to agree that inertial factors of heavy resistance might have delayed maximum power output.) Although Katch et al. (1977) mentioned a warm-up, details were not specified: Bar-Or (1978) presented details of possible warm-ups and cited evidence that warm-up improved performance on the Wingate test.

In summary, a few relatively simple performance measures of anaerobic energy sources were available. Although the Deshaies et al. (1978) study employed the Margaria et al. (1966) test in their study and it was a predictor of hockey performance, reservations about this test (as discussed above) made it less attractive than a measure purporting to provide scores of both anaerobic power and capacity. Both the Katch et al. (1977) and Wingate Anaerobic Test (1977) have reported high reliabilities and some indicators of validity; Bar-Or et al. (1980) has reported some recent data from biochemical analysis which was offered as support for the Wingate Test's validity. The Wingate test did include a variety of resistance settings based on work with children and older subjects, whereas the Katch test seemed more applicable to adults. Stated protocol for the Wingate test also included warm-up procedures; this test was also the shorter ergometer test proposed.

Summary

It appeared from a review of relevant literature that measures of anaerobic systems rather than the aerobic system offered more promise as predictors of hockey performance. No agreement existed as to the most valid criterion measure of anaerobic activity. Of the performance measures reviewed, the Wingate Anaerobic Test (1977) might be favoured over the Katch et al. (1977) test because of evidence supporting applicability to a wide age range of subjects, its shorter (30 seconds) duration, and specified warm-up procedures. Both the latter tests purported to include indicators of anaerobic power and capacity, although support for such claims required further validation.

Specific Skills

Introduction

This section provided the reader with a brief introduction to some of the terminology employed in this field; a thorough review of theoretical positions and findings in motor learning and performance was beyond the scope of this paper.

Two commonly used terms which required definitions were "ability" and "skill". The *Dictionary of Behavioral Science* (Wolman, 1973) provided the following definitions:

> "*ability* - The power to perform an act, either physical or mental, whether innate or acquired by education and practice. *Ability*, as distinguished from aptitude, implies that an act can be performed now. *Aptitude* implies that the individual can develop by training the ability to perform a certain act. *Capability* is the maximum effectiveness a person can attain under optimal conditions of training" (p. 2). "*skill* - An acquired aptitude" (p. 348).

Baumgartner and Jackson (1975), in reviewing historical developments in the field of motor ability and performance, mentioned that the notion of a general motor ability had been widely accepted until the 1960's. This view held that "the individual who is skilled in one motor task will be skilled in another motor task" and that "performance of many different motor tasks may be predicted on the basis of a single or limited number of test items" (p. 111). The opposing view was forwarded by Henry (1960) who theorized that motor ability was specific to particular tasks and that there was no generalized motor ability. Not surprisingly, another position was presented (Fleishman, 1964) that performance of a specific skill might be explained in terms of a few basic abilities. In the latter position, psychomotor skill was "defined as one's level of proficiency on a specific task or limited group of tasks", whereas "a psychomotor ability is a more general trait which may be common to many psychomotor tasks" (Baumgartner and Jackson, 1975, p. 127). Basic abilities were viewed as a product of both genetic and environmental influences, reflecting development in childhood and adolescence. Basic abilities limited the rate of learning and level reached on a specific motor skill.

Theories of motor learning were also diverse. In Henry's (1960) specificity position, specific motor programs for each new movement were learned. Adam's (1971) closed-loop theory proposed that the accuracy of movements was determined by comparing the movements to "traces" left by previous movements. Nonetheless, specific programs were required for each movement in Adam's theory. Schmidt (1975), by comparison, proposed a schema theory in which a general set of rules were learned; from this general schema, specific motor programs were generated to perform particular activities. Schmidt (1975) described the processes involved in producing a movement as follows:

> "Learning is possible by feeding back the essential error information to the schemata. The response specifications and initial conditions are stored when

the movement is selected, and the actual proprioceptive and exteroceptive feedback are stored as the movement is progressing and as these sources of information are generated. Finally, the actual outcome is stored, based on KR [knowledge of results] when it is present, but based on subjective reinforcement if KR is not present. These sources of information can then be used to update the schema rules and provide revised estimates of the expected sensory consequences and response specification on the next trial" (p. 240).

Kerr (1977) presented evidence to support the schema theory and suggested that further substantiation of the theory would point to the development of "very different" elementary physical education programs.

In summary, some definitions were provided of "ability", "skill" and related terms. A brief review was presented of the positions regarding the generality or specificity of abilities. An outline of Schmidt's (1975) schema theory was included to describe how specific motor programs might have been generated. The latter author believed his theory was applicable to both open and closed skill situations. Whereas, in closed skills, the environment and the performer's goal remained fairly constant, open skills were defined as "those in which environmental and situational characteristics can change as the subject plans or performs his response, such as the response that would be required of a wrestler attempting a take-down" (Schmidt, 1975, p. 240). Schmidt added that open skills become "closed" after the performer makes "the best estimate of the changing environment"; for a brief moment, the environment and goal" were fixed in that state predicted by the subject when he planned the movement" (p. 241). It was this description that seemed applicable to hockey performers: players interacted in an open skill situation but at isolated moments, attempted to perform specific motor skills with the goals, for example, of beating a defender in face-to-face confrontation, of passing to a moving teammate, or of shooting the puck past a goaltender.

Hockey Skills

Several authors seemed to agree that the essential specific skills required in hockey were skating, stickhandling, shooting and passing (Enos, 1973; Merrifield and Walford, 1969; Percival, 1960); others (Tarasov, 1973; R.C.A.F., 1966) might have added checking to the list.

One introductory book on hockey (R.C.A.F., 1966) described the basic hockey skills as follows:

> "<u>Skating</u> - You need to know how:
> - to start and stop quickly;
> - to turn either way without losing balance or speed;
> - to skate backwards"(p. 10).
>
> "<u>Stickhandling</u> - You need to know how:
> - to carry the puck forward on your stick;
> - to stickhandle around a checker" (p. 11).
>
> "<u>Passing</u> - You need to know how:
> - to make a pass forehand and backhand;
> - to receive a pass forehand and backhand;
> - and when to pass" (p. 12).
>
> "<u>Shooting</u> - You need to know how:
> - to shoot forehand and backhand;
> - to locate the ideal target areas in the net" (p. 12).
>
> "<u>Checking</u> - You need to know how;
> - to poke check and hook check with your stick;

- to bodycheck;
- to cover a man without the puck" (p. 14).

Tarasov (1973), the innovative Soviet coach, approached the topic somewhat differently and described the "Top Ten" list of points or skills that would assist in classifying hockey players. Those points were as follows:

"

1. Skating: easy, unconstrained and powerful.
2. Quick starts: in all situations, in all directions and with good balance.
3. Speed and suddenness: in all directions and without any warning.
4. Technique in skating: turning, stopping, reversing, changing over from forward to backward skating and vice versa, cross-stepping.
5. The ability to do everything just as well from left or right: turn, stop, reverse, cross-step, check, break, shoot and pass on the backhand or forehand.
6. Stickhandling technique: light rapid movements, gentle handling of the puck, using the stick equally well to the left or right.
7. Passing technique: rapid, well-concealed passes that are easy to intercept, also, the ability to intercept and utilize a pass.
8. Shooting technique: the ability to shoot fast, unexpectedly, low and skillfully.
9. Stick checking: fast and unexpected; also the ability to take charge of the puck after stealing it.
10. Checking, going down to block shots: both of these require courage, good co-ordination, speed and determination" (pp. 4-5).

Tarasov (1973) stated that acquiring different hockey skills was a complicated process since an individual had to learn to stickhandle, to pass and to shoot while also learning to skate. It was noted, however, that both excerpts quoted above mentioned skating first. Tarasov (1973) said that there were other things to concentrate on during a game and that skating should be automatic: "By learning to skate effortlessly from the very beginning the player will subsequently find it easier to manage other technical details and discover how to conserve his energy" (p. 7). Howe (1972), a famous North American professional player, left little doubt as to his opinion of the importance of skating: "You will never be a good hockey player until you're a good skater. Skating is the first thing that a scout looks for in a boy" (p. 31).

Therefore, it appeared to be agreed that the basic hockey skills were skating, stickhandling, shooting and passing. Of necessity, it seemed that the primary skill was skating. It might have been added that since specialized positions existed in hockey, specialized skills also existed. A goaltender's role, as well as that of a defenceman, differed from that of a forward. The skills required of a goaltender were most unique but in many ways, were similar to those of the other players, i.e., "supple, fast, strong and possesses an excellent game sense, . . . good co-ordination and skates well" (Tarasov, 1973, p. 80). It was interesting to note that skating skill was again emphasized. The present study attempted to focus on common skills rather than delineate the differnces in the performing of different positions in hockey.

Studies of hockey skills

Studies of hockey skills have been diverse. Some (Enos, 1973; Merrifield and Walford, 1969) have examined batteries of hockey skill tests, whereas other (Hermiston, 1975; Marino, 1979) have focused on particular skills.

Naud and Holt (1979) examined three types of hockey skating starts for their quickness and biomechanical efficiency. They tested six subjects from each of four groups (Professional, Junior "B", College and Bantam) and trained all subjects in the three methods twice a week for eight weeks. When tested for the quickness of each start (10 trials for each start), all but the Professional group demonstrated the superiority (ANOVA: Bantams-$F_{2,177}$ =36.01,P<.05; College-$F_{2,177}$ =7.48,p<.05; Junior "B"-$F_{2,177}$ =26.83; p<.05;Professional-$F_{2,177}$ =2.27,p>.05) of the "thrust-and-glide" method (i.e., the player pushed off from his rear foot which was perpendicular to the direction of movement, rotated the front foot outwardly, and glided on the front foot). Analysis of pictures using a "cinema-computer program" also favoured this method as it reportedly utilized muscular energy effectively in producing the greatest initial acceleration of the centre of gravity. A subsequently reported study (apparently using the same subjects described above) by these authors (Naud and Holt, 1980) found the "thrust-and-glide" method was also superior to other techniques when used in a stop, reverse and start skating sequence (ANOVA: Bantams - $F_{2,177}$ =10.47, p<.05;

College-$F_{2,177}$ =14.90,p<.05; Junior"B"-$F_{2,177}$ =18.76,p<.05; Professionals-$F_{2,177}$ =19.11,p<.05).

Marino (1977) utilized a high-speed (100 frames per second) 16mm camera to analyze skating performance at three different (maximum, medium and slow) skating velocities (N=10 college students , various skill levels). He reported that although stride length remained constant, stride rate increased with increasing velocity. He also noted that times of single and double support both decreased with increased velocity. In another study, Marino (1979) reported data from the kinematic analysis of four college students, ranging from "highly skilled to moderately skilled". He found that the greatest period of acceleration occurred in the 1.25 seconds after movement was initiated and that, during the first few strides from start, 85.3 percent of each stride involved single support.

Other studies examining particular skills included Wilberg's (1979) photographic analysis of over 300 goalkeepers from the 10 year old to the professiional level. He reported that three basic stances were adopted by goalkeepers when preparing to stop a shot but that one stance appeared to become dominant as subjects increased in age. In attempting to improve specific use of the hockey stick (i.e, lifting or depressing an opponent's stick, pushing an opponent's stick to the right, drawing it to the left), Hermiston (1975) examined the use of a specially designed dynamic resistance machine with two groups of nine to 12 year old boys. The group (N=6) which practised these skills (two sets X 25 reps., three times a week for eight weeks) showed statistically significantly greater improvement in applied strength using the device to measure the four skills than did the control group (N=6; t values for the four tests were from 2.55 to 4.68, p's <.05).

Numerous skating tests have been reported (Doroschuk and Marcotte, 1965; MacNab, 1979) that have attempted to include indicators of such elements as speed, agility and puck control. Doroschuk and Marcotte (1965), for example, adapted the Illinois Agility Run for use on ice. They reported a test-retest reliability of 0.93 (N=27,aged 18 to 25, variety of skill levels). MacNab (1979) reported the use of four tests which emphasized one or more of the following skills: skating forward, backward, turning, jumping, stopping and starting - some skills were performed while demonstrating puck control. MacNab (1979) administered these tests each year for five years to players who aged from eight to 12 years and played in highly competitive (N=15) or less competitive (N=11) leagues. Both groups demonstrated skill learning over the five years with the competitive players showing higher skill levels in terms of test scores. Hermiston, Gratto and Teno (1979) reported the use of three hockey skill tests with 90 players on six teams, varying in age from 11 to 18. The tests, ranging in difficulty from the Illinois Agility test mentioned above to a complicated measure of skating/puck control, showed improved skills with increasing age.

Enos (1973) developed a battery of seven skill tests in the four areas of (1) skating (skating agility, starts-stops-turns, forward skating speed), (2) stickhandling, (3) shooting (wrist shot, slap shot), and (4) (forehand) passing. The battery was administered to players at four levels of proficiency: Bantam (N=40), Senior High School (N=40), College (N=40) and Professional (N=6). All but the professional players completed the battery twice. Test-retest correlations were statistically significant (r=0.90 to 0.98). The battery was able to distinguish players according to the four levels of proficiency.

Merrifield and Walford (1969) administered six hockey skill tests to 15 members of a college hockey club who had varying amounts of playing experience. The tests were repeated one week later. Low test-retest correlations were found for the passing (r=0.37) and shooting (r=0.62) tests and these tests were eliminated: test-retest correlations varied from 0.74 to 0.94 for the forward and backward skating speed, skating agility, and puck carry tests. These four measures were considered to have sufficient reliabilities "to warrant additional statistical treatment" (pp. 150-151). Intercorrelations among the four test items were significant between the puck carry test and each of the other measures (r=0.71 to 0.78) and between the backward skating speed and skating agility tests (r=0.91).

In short, numerous tests of hockey skills have been reported in the literature, although most have not included reliability indicators. The test batteries of Enos (1973) and Merrifield and Walford (1969) and the agility test of Doroschuk and Marcotte (1965) were exceptions to this trend: all reported reliable tests of puck control and the battery developers both reported reliable measures of skating.

Measures of skills as predictors of overall hockey ability or performance

As indicated above, there appeared to be agreement that the basic skills required in hockey were skating, stickhandling, shooting and passing (Enos, 1973; Merrifield and Walford, 1969; Percival, 1960). Evidence was less available as to the promise of various measures as predictors of overall hockey ability or performance during games.

Doroschuk and Marcotte (1965) reported that scores on their adapted Illinois Agility Run were compared with the instructor's rankings of the 27 subjects in terms of their "hockey ability". The biserial correlation between rankings and times on the agility test score was 0.83. Since the reliability of this puck carry test was also high (r=0.93, test-retest), the author proposed the test as "a screening devise to objectively and effectively rate hockey players at initial try-outs, and also as a short objective test for hockey ability" (p. 8).

MacNab (1979) used tests of skating speed and agility and puck control in his longitudinal study of eight to 12 year old boys. In comparing scores of players in highly (N=15) and less (N=11) competitive leagues, the author stated that "the more complex the skill the greater the separation between the competitive and less competitive groups" (p. 17). Therefore, he thought that the relatively simple forward skating test was the least discriminative test while a more complex puck control test was most discriminative. MacNab (1979) failed, however, to support these conclusions by reference to any statistical analysis of his findings. Some support for MacNab's conclusions came from the study of Hermiston, Gratto and Teno (1979), in which the most complex of three puck carry tests correlated most highly (Spearman rho=0.83, N=90) with coaches' ratings of "the value of the players to their teams" (p. 95). The strength of the correlation increased from players at ages 11 to 12 (rho=0.70) to those at ages 17 to 18 (rho=.92). It was interesting to note that the scores on the simplest test employed by Hermiston et al. (1979), i.e., Doroschuk and Marcotte's (1965) Illinois Agility measure, exhibited considerably less relationship (rho=0.56) with coaches' ratings than that reported by Doroschuk and Marcotte (r=0.83).

The hockey skill batteries discussed above were also validated by comparisons with hockey ability ratings by hockey coaches. Enos (1973) claimed validity for his battery of skating, stickhandling, shooting and passing tests as the battery was able to distinguish players according to the four levels of proficiency of the players tested; battery scores were also statistically significantly correlated (r=0.82 to 0.92) with ranks assigned to players by a panel of seven coaches. Validity was claimed by Merrifield and Walford (1969) for their four most reliable measures (i.e., forward and backward skating speed, skating agility and puck carry tests) as these measures all correlated statistically significantly (r=0.75 to 0.96) with the coach's rankings of overall hockey ability. Intercorrelations among the four test items were statistically significant for the puck carry test and each of the other measures (r=0.71 to 0.78) and between the backward skating speed and skating agility tests (r=0.91). On the basis of these data, Merrifield and Walford concluded the puck carry test "would be the best single-item test for determining overall ice hockey ability" (p. 151).

Deshaies et al. (1978) employed the skating speed (forward and backward) and puck carry (stickhandling) tests developed by Merrifield and Walford (1969) and also the skating agility test of Doroschuk and Marcotte (1966). Although all these measures were statistically significantly correlated (r=0.23 to 0.55) with hockey ability (coaches' ratings) in the Deshaies et al. study, the highest correlation with ability (r=0.55) was for forward speed, a variable which subsequently entered the prediction equation. It should be noted that statistically significant relationships were found between measures of forward skating speed and stickhandling in both the Deshaies et al. (1978) (r=0.49) and Merrifield and Walford (1969) (r=0.78) studies. This lent some support to the latter authors' contention that the puck carry test was the best single predictor of hockey ability. The use of a larger sample size (N=116 vs. N=15) in the Deshaies et al. (1978) study, however, auqured for the use of forward skating speed as a probable predictor of hockey ability. Undoubtedly, both skating speed and stickhandling were important hockey skills. Evidence of statistically significant correlations between the measures of these two skills suggested that players who possessed a high level of one skill tended to possess a high level of the other (at least in terms of scores on measures of these skills).

Skating speed tests required even less equipment than stickhandling or puck carry tests. The Merrifield and Walford (1969) skating speed test had the advantage of being administratively simpler than others (Lariviere, Lavallee and Shephard, 1976) and was possible to accommodate in most practice sessions. It was a moot point as to whether it was primarily a measure of skill or of fitness. Lariviere et al. (1976) contended that their test, albeit five minutes in duration, was more a fitness measure since skating skill was a less important contributor to test results in older boys. Deshaies et al.

(1978), however, classified the skating test they employed as a measure of skill. Nonetheless, their data indicated statistically significant correlations between skating speed and stickhandling (r=0.49) -- clearly a skill -- and between skating speed and fitness factors such as anaerobic power (r=0.43) and leg strength (r=0.23). It appears that skating speed was a function of both skill and specific fitness factors, even with regard to high level performers. As Hollering and Simpson (1977) concluded, for example, anaerobic alactic power appeared to play a limiting role in skating speed but skating speed might have possibly been improved through training proper skating techniques. When aerobic capacity, as a fitness variable, was related to skating speed, the results were quite different. Skating speed and aerobic capacity showed virtually no relationship (r=0.04) in the Deshaies et al. study and, as mentioned above, Green (1979) noted that low aerobic capacity did not necessarily lead to slow skating speed.

In summary, the evidence for a single skill predictor of hockey performance was not overwhelming. Both skating speed and stickhandling did show some promise as predictors. The simplicity of administration of the skating speed test made it somewhat more attractive than the stickhandling measure.

Merrifield and Walford (1969) reported a test-retest correlation (reliability) of 0.74 for their forward skating speed measure. Validity for the measure was reported as 0.83, which represented correlations between test results and the coach's rankings of the subjects' playing ability. This test was attractive in that it could be accommodated in most on-ice practice sessions; it was also administratively simple and required only a stopwatch as equipment. Players were asked to skate as quickly as possible from one goal line to the second blue line, a distance of approximately 120 feet on a regulation-marked ice rink. Stickhandling or puck carry tests, on the other hand, usually involved the construction of a course on the ice as well as instruction and practice in performing the test before reliable scores could be obtained.

Summary

The basic terminology involved in a discussion of skills was presented. Hockey skills were noted as were a number of studies of hockey skills that were reported in the literature. An examination of available evidence relating measures of hockey skills to perceived overall hockey ability resulted in some support for certain measures, particularly those of skating and stickhandling. The Merrifield and Walford (1969) forward skating speed measure was thought to be attractive for use in the field because of its ease of administration and its reported relationship with coaches' ratings of overall hockey ability.

Psychological Variables

Introduction

Definitions of some of the basic terms relevant to the inclusion of "psychological variables" in the present study were presented in this section.

The explanation of behaviour had long been the challenge of psychologists and others. Behaviour, as defined by Alderman (1974), was "the total aggregate of human responses that the person makes to both internal and external stimuli" (p. 1); to understand behaviour, everything a person "does, thinks, and feels should be examined" (p. 1). In a search for the understanding of behaviour, much attention has been given to the concepts of personality and motivation.

Personality had been defined in various ways. Lawther (1972), for instance, stated that "Personality is a term used to characterize the individual that emerges as the newborn child grows, matures, and reacts to the thousands of environmental stimuli which surround him" (p. 87). Allport (1937) defined personality as "the dynamic organization within the individual of those psychophysical systems that determine his unique adjustments to his environment" (p. 48). Alderman (1974) stated that personality represented the

> "total psychological structure of the individual. The personality of a person is an integration or merging of

> all the parts of one's psychological life - the way one thinks, feels, acts and behaves. It is this combination that characterizes or distinguishes a person from other people and that represents the more permanent or enduring aspects of one's behavioral patterns" (p. 109).

In short, personality referred to the psychological uniqueness of individuals.

In attempting to provide a conceptual framework for the discussion of personality, investigations have varied from Sheldon's (1942) explanation of behaviour as dependent on body type to a more recent emphasis on personality "traits" (Cattell, 1966). Traits were "a generalized and dependable way of thinking, feeling, and otherwise reacting" (Sartain, North, Strange and Chapman, 1967, p. 35). Traits were to have varied; they might have been common to everyone or unique to individuals, or determined primarily through the influences of heredity or environment. Individuals varied in the amount of a trait they possessed (Alderman, 1974). Examples of traits were extraversion, optimism, aggressiveness, submissiveness and forthrightness.

Whereas the study of personality involved attempts at providing <u>descriptions</u> of individuals in terms of traits or other concepts, motivation tended to focus on <u>why</u> people behaved the way they did. Motivation was

> "concerned with the analysis of those factors which initiate individual action and then direct it toward a particular end or goal. Its scope is the explanation and analysis of why certain behavior is initially selected by the person, why it varies in intensity, and why it

persists" (Alderman, 1974, p. 185).

Mussen and Rosenzweig (1973) defined motivation as a "generic term referring to activating states of the individual directing his behaviour toward the fulfillment of specific needs" (p. xviii). Theories of motivation have involved explanations of such activation or initiation of behaviour by the use of, for example, physiological drives (hunger, thirst, sex, maternal drive) or social or learned motives (anxiety, approval, achievement, aggression). In stressing the attention this area has received, Alderman (1974) noted that one-third of psychological literature was related to motivation.

Although this review was necessarily limited, the addition of two further points seemed justified. One involved clarification of what should be included under discussions of personality or motivation. Aggression, for example, was referred to as both a personality trait and as a learned motive. As mentioned above, personality might have involved a description of an individual's uniqueness in terms of the degree to which he/she possessed certain traits. Thus, it might have been said that someone was aggressive or even very aggressive; it should have been noted, however, that this was a description of the individual's behaviour and not an explanation of why the aggressive trait or behaviour was displayed. The use of aggression as a construct in motivation attempted to explain the behaviour. Whereas some investigators (Lorenz, 1966) stated that aggression was an innate urge, others (Levin and Fleischmann, 1968) believed that learning influenced the display of aggression. Thus in the case of aggression, the explanation of a particular personality trait was attempted by evoking the concept of an innate or learned motive; both the trait and motive were called aggression.

The second point concerned Alderman's (1974) caution that

> "we must not make the mistake in physical education and sport of assuming that people participate solely because of some unknown unconscious, instinctual need. Rather, it is important for one to realize that the conscious deliberation, or free will of the person reinforced or initiated by some general, secondary drive is probably closer to the answer. Motivation thus becomes a combination of both conscious and unconscious instincts, needs, and drives .... People choose to do certain things and do them for a multitude of simultaneously conflicting and congruent reasons" (p. 201).

In short, this brief review provided some definitions of terms used in the discussion of personality and motivation. These two terms were involved in the description and explanation of human behaviour, whether within or without the confines of sport and physical activity.

Psychological variables and sports

Athletes were hardly exempt from efforts to study personality and motivation. Furthermore, according to King and Chi (1974), the study of personality in athletics was attractive in that "athletic structure ... is much less ambiguous than that of politics or religion and is not beset with the complexities of numerous confounding variables as in occupational structures". (p. 180). Numerous studies have focused on the personality characteristics of athletes versus non-athletes, elite athletes versus the less elite, and athletes in one sport versus those in another. For example, differences were found between elite and non-elite male golfers (Heinrichs, 1975), between superior and average male martial artists (Duthie, 1976), between different competitive levels in football (Straub and Davis, 1971), between female athletes and non-athletes (Jones, 1974), among female athletes in different sports (O'Connor and Webb, 1977), and between male runners and joggers and the general population (Harting and Farge, 1977). In a review of research of the male athlete's personality, Cooper (1969) suggested that evidence showed male athletes to be more outgoing and socially confident, more socially aggressive, higher in social adjustment, prestige, social status and self-confidence, stronger competitors, less anxious, more emotionally stable, less compulsive, and to have greater tolerance for physical pain than non-athletes.

Some other reviews, however, did not give the impression of "consistency" which Cooper (1969) apparently gained from his literature review. Rushall (1968) "proposed that personality is not a significant factor in sport performance" (p. 164) and Alderman (1974) concluded that "little success ... has been attained in identifying an 'athletic' type of personality" (p.

150). Reasons for the lack of agreement among investigators included the following: sample sizes had tended to be small and, therefore, findings lacked generalizability (Rushall, 1968); identification of personality traits was a function of the tests employed (i.e., a trait was identified only if the test purported to measure it) (Alderman, 1974); traits with similar labels but from different tests might have been measuring dissimilar behaviours (nonstandardization) (Cooper, 1969); definitions of what constituted an athlete have varied (Lawther, 1972); differences between athletes and non-athletes have disappeared when matching for motor ability occurred (Merriman, 1960).

Straub and Davis (1971) were also critical of available instruments for measuring personality factors in athletes. They commented that faulty research design, misinterpretation of results, and a dearth of valid, reliable and objective instruments negatively affected personality research. Showing some optimism, however, they anticipated that these problems in personality assessment, particularly with respect to the assessment of athletes, would be alleviated as research continued in this relatively new field.

Rushall (1978) was specifically critical of the trait theory or the use of rather general traits in explaining behaviour and saw more promise in the development of "environmental specific behavior inventories". He described the task as being one of discovering the "responses of which an individual is or is not capable in certain stimulus situations. This interpretation implies prediction through the definition of specific environmental circumstances that are necessary for a certain behaviour to occur" (Rushall, 1978, p. 99). He reported (Rushall and Fox, 1980) the construction of "An Approach-avoidance Motivations Scale for Sports" and suggested that similar scales could be developed for a variety of sports. Support for the use of instruments specific to particular situations also came from Martens and Simon (1977) and Ostrow (1977), among others.

Morgan (1980) contended that trait theory had undergone periods of general support and of criticism for many years but believed that, despite methodological and conceptual problems in employing "trait theory", the theory should not have been abandoned. Morgan (1980), in his review of the "trait psychology controversy", stated that

> "It is probably time to discontinue the argument about the value of trait theory in predicting behavior. Trait theory is clearly of <u>limited</u> <u>value</u> where one is interested in the description, explanation, and prediction of behavior. If continued progress is to be made in sport psychology, however, it will be necessary to employ other models that may or may not rely on broad traits. Any dependent variable that accounts for 20-45% of the variance should theoretically be useful in predicting behavior if utilized in concert with other dependent measures" (p. 23).

Morgan (1980) reviewed a considerable number of studies and concluded that, in fact, "various personality traits have consistently been observed to account for 20% to 45% of the variance in sport performance" (p. 23). He added that the use of psychological variables in concert with physiological factors would have accounted for more of the variance in behaviour.

The study of motivation in sport has, not surprisingly, included discussions of motivational concepts found in attempted explanations of behaviour in all settings. Alderman (1974), for instance, reviewed motivational theories involving concepts such as instinct, drive, needs and incentive and discussed their relevance to sport. He then specifically focused on achievement, aggression and affiliation as prominent motives in sport or, more specifically, "general motive-incentive systems which, though rooted in traditional or historical instinctual patterns, are both individually and culturally determined" (p. 202). Alderman (1974) reiterated that underlying behaviour was most likely a complex of forces, both innate and learned, conscious and unconscious.

Lawther's (1972) review of motivation in sports included reference to pleasure (play for the joy of living), achievement (excelling at a task), psychological aspects (expressing aggression), and rewards (intrinsic or extrinsic). Epuran and Horghidan (1968) concluded that there were three categories of motivational factors in sport:

1. movement need, similar to Lawther's (1972) statement that man had an innate need to move;
2. need for self-assertion, i.e., the drive towards improvement and "at the same time towards exposing one's self to oneself and to others" (p. 144), and;
3. motor habits, i.e., habits of some strength which, through practice, have become part of someone's way of life.

Butt (1976) proposed a four-levelled model of sports motivation, the levels reflecting biological, psychological and social influences and those from secondary or learned reinforcements. Butt hypothesized that a biological or life force energized sports behaviour which was shaped by various reinforcement contingencies. On a psychological level, the three most important styles of sports motivation were aggression, conflict and competence. Social motivation involved two constructs, competition and cooperation. Butt (1976) suggested that interaction occurred as follows:

> "Aggressive motivation and neurotic conflict are most likely to lead to competitive social motivation and, to a lesser extent, to cooperation. Competence motivation is most likely to lead to cooperative social motivation. Both the competitively and cooperatively motivated will be affected by the reinforcements of sport. The external rewards will usually be most important to the competitor, however, and the internal rewards to the cooperator" (p. 2).

Studies of participants in sport and motivation have included many of the concepts mentioned above. Jones (1974), for example, found that female athletes scored more highly on a measure of aggression than did non-athletes. Cooper (1969) reported that athletes showed a greater motivation to achieve than did non-athletes. Fodero (1976), however, used two measures of achievement motivation with 60 male and 60 female gymnasts but found no significant relationships between scores on these measures and skill in gymnastics. Cohesiveness, perhaps an indicator of man's need to affiliate, was shown to be positively related to a team's performance (Bird, 1977; Nixon, 1977; Widmeyer, 1977).

One concept that received considerable attention, both within and without sports situations, was aggression. Debate on this concept was many-faceted: much interest was shown in the effects on the viewer of watching aggressive behaviour (Puleo, 1978; Wurtzel, 1977); numerous investigators (Foss and Fouts, 1977; Patterson, 1974) have cited evidence that most conveniently placed aggression in either instinctual or social learning theories, and; others have examined the relationship between aggression and other psychological (Edmunds, 1977) or physiological (Ehrenkranz, Bliss and Sheard, 1974) indices.

Interest in viewers' reactions to aggression was probably precipitated by some rather dramatic anecdotes involving televised violence and subsequent aggressive acts committed by viewers. In citing such anecdotes and reviewing literature on the topic, Wurtzel (1977) stated that, although the evidence was inconclusive, there appeared to be a relationship between violence on television and subsequent displays of aggression. Since many sports were seen as involving aggression, spectators have been studied at sporting events. Sysler (1977), for example, reported that, although underlying aggressive tendencies related to overt displays of "aggression" as a spectator, the greatest proportion of such aggression was accounted for by interest in the sport.

Whether a viewer or spectator should have reacted to aggression with displays of increased or decreased aggression was the focus of those interested in the origin of aggression as a motivator. Two basic theories were prominent: one held that the urge to aggress was innate and the other that aggressive behaviour was shaped through learning. Lorenz (1966) was one proponent of aggression as being instinctual energy. He believed that aggressive behaviour was one way of releasing contained feelings or emotions; this release of energy was termed "catharsis". Lorenz thought that competitive sport might have been "conceived of as a ritualized form of instinctive aggression" and "provides an important means of curtailing violence in society" (Zillman, Johnson and Day, 1974, p. 139). The opposing view, i.e., that of social learning theorists (Berkowitz, 1970), was that the tendency toward aggressive behaviour, like all behaviours, would have been strengthened if positively reinforced. Thus, for instance, one might have expected aggressive play to reappear on the playing field if the aggressor were praised for such behaviour. Since these conflicting theories have predicted opposite reactions to initial aggression, many investigations have focused on testing the theories experimentally. Findings have been cited to support both positions: Patterson (1974) and Schneider (1973), for example, found that aggression in football players increased rather than diminshed over the course of a season: others (Canaris, 1973; Foss and Fouts, 1977) have cited evidence supporting catharsis, i.e., that aggression reduced subsequent aggression. Perhaps a blending of the theories was most palatable. Alderman (1974), for example, proposed that

> "Each person is born with a capacity and a need to move against his environment - to be aggressive. This capacity is developed to a lesser or fuller degree during the remainder of his life, depending largely on a continual series of complex learning experiences" (p. 231).

Individual differences might have reflected a combination of biological and environmental determinants. Different reinforcement contingencies would have been reflected in the expression of aggression as a situation-specific response. "For example, a boy who is aggressive in football may be quite timid in the classroom or in a social situation where he feels (or knows) his level of competence is inferior to that of other people" (Alderman, 1974, p. 239).

The relationship between aggression and physiological variables, especially testosterone, has been studied. Reports have stated that increased testosterone levels were noted in more aggressive male prisoners (Ehrenkranz, Bliss and Sheard, 1974) and male patients in a mental health facility (Kedenburg, 1977). Other studies (Monti, Brown and Corriveau, 1977) failed to show any relationship between aggression and testosterone levels in 101 healthy male volunteers. In categorizing previous research, Kedenburg (1977) noted that reports of aggression/testosterone relationships only appeared in studies involving institutionalized subjects. Kedenburg cited the need for further experimentation to clarify the issue.

In summary, the study of personality and motivation has included a focus on athletes. Despite evidence for differences in measures of psychological functioning between elite athletes, athletes and non-athletes, findings were inconclusive; methodological and conceptual problems were also noted. Aggression was arbitrarily chosen as a concept for further discussion. Debate has continued over the conceptual underpinnings of aggression; evidence for each opposing viewpoint was equivocal. Interactions with other concepts might have clouded findings to date: consideration of, for example, self-esteem (Van Gorder, 1975), team versus individual sports (Martin, 1977), or variables such as extroversion or neuroticism (Edmunds, 1977) might have aided in interpreting aggressive behaviour. Despite the obvious problems, Morgan (1980), for one, saw the value of utilizing psychological variables, particularly in concert with physiological indicators, to better predictions of performance in sports.

Psychological variables and hockey

Studies of psychological variables with respect to ice hockey have focused both on teams and on individuals. Data on teams included, for example, a study by Carron et al. (1977) who administered a motivation questionnaire to 183 players from 12 college hockey teams. Players were asked to indicate their degree of satisfaction with their personal and their team's performance over the season. The study found that successful teams (with a winning percentage of at least .690) showed statistically significantly ($F=12.54$, $p < .001$) more satisfaction with team performance than did unsuccessful teams (with a winning percentage of .400 or lower) but that there were no differences between these teams in terms of satisfaction with individual performance. A study by Ball and Carron (1976), which utilized the same sample as described above in Carron et al. (1977), compared responses on questionnaires assessing team cohesiveness and participation motives for successful and unsuccessful teams. Through stepwise multiple regression analysis, Ball and Carron found that 95 percent of the variability in post-season success was accounted for by the cohesion variables of midseason teamwork or closeness, enjoyment and early season self-motivation ($R=0.973$). A study of a minor hockey league by Russell and Drewry (1976) indicated that aggression displayed by a team was statistically significantly related to league standing ($F_{4,149}=2.81$, $p<.05$), that aggression increased during the course of the games ($F_{2,259}=5.97$, $p<.01$), and that the frequency of the aggressive behaviour related to existing game score ($\chi^2=81.0$, df=6, $p<.001$). Aggression was discussed by Russell and Drewry (1976) in terms of its relation to frustration (Dollard, Doob, Miller, Mowrer and Sears, 1939) and competition (Berkowitz, 1962). Russell and Drewry contended that aggression, a likely result of the competitive and frustrating situations found in hockey, might have been manifested in the number of penalties during a game, i.e., those incidences of physical aggression and challenge to the authority of game officials which frequently resulted in the assessment of penalties.

Measures taken on individual hockey players included those by Chien (1978), who collected data on a variety of physiological, psycholcgical and skill variables on 21 college players. Among his findings were psychological test results showing that the players became more outgoing, ambitious, intense and ready to fight as they proceeded through a hockey season. Bird (1979) reported that eight to 11 year old hockey playing girls (N=17) were statistically significantly different from 44 boys of similar ages who played hockey on the "tough-minded" (Hotelling's $T^2=5.68$, $p<.01$) and "enthusiastic"

(Hotelling's $T^2 = 4.03$, $p < .01$) scales of the Children's Personality Questionnaire. Deshaies et al. (1978) found a statistically significant correlation ($N=116$; $r=0.34, p<.05$) between achievement motivation and coaches' ability ratings. McCarthy and Kelly (1978) examined aggression (against other individuals) in college hockey players ($N=40$) and found that those rated high in aggression ($N=9$) scored statistically significantly more goals for the two years studied ($t=4.48, p<.05$; $t=5.85, p<.002$), took more shots on goal ($t=2.22, p<.05$; $t=3.78, p<.05$) and scored on more of their shots (25.4% vs. 15.8%) than players rated low in aggression ($N=9$). Additional support for this finding came from Russell (1974), who also discovered a statistically significant relationship between goal scoring and some measures of aggression ($N=6$ teams; $r=0.19, r=0.20$, p's$<.05$). The latter two studies determined aggression by examining league records as to penalties taken and, in Russell's (1974) study, by games played and average percentage of ice time. Scaramella and Brown (1978) found a relationship between serum testosterone, a possible correlate of aggressive behaviour and coaches' ratings on a seven-item scale of college hockey players' responses to aggressive situations ($N=14$; $r=0.55, p<.05$).

Relating measures of aggression to performance in hockey was not without problems. As Widmeyer and Birch (1979) noted, styles of play in the teams studied might have affected the results on any analysis. For example, aggressive play might have been encouraged more and penalized less in the professional leagues than at the amateur level. Relationships between aggression and successful performance should have also been examined over time as atypical years might have shown less than enduring relationships. Widmeyer and Birch also observed that differences in the definitions of individual aggression and performance were not consistent. Russell (1974), for example, used goals and assists as criteria of performance and found statistically significant relationships between these indicators and his measure of aggression. Widmeyer and Birch (1979) defined a successful performer as an "all-star", claiming that such designation often included the possession of defensive skills and leadership qualities, in addition to goal-scoring prowess. The latter authors found no relationship between being selected an all-star and the average number of penalty minutes per individual. The definition of aggression was also important. Widmeyer and Birch (1979) noted that some aggressive acts in hockey went unpenalized whereas seemingly unaggressive behaviour (such as delay of the game) might have resulted in penalties. McCarthy and Kelly (1978) considered only acts of "physical or verbal actions that were directed against another individual" (p. 97) in their index of aggression whereas, for example, Widmeyer and Birch (1979) considered all penalties. The latter authors suggested that agreement by some panel of "experts" was needed to determine what penalties were, indeed, "aggressive penalties". Thus, although some measures of aggression have been shown to be related to some measures of hockey performance, the findings in the literature were inconsistent and did not clearly suggest one indicator of aggression as the best potential predictor of performance in hockey.

Potential psychological predictors of hockey performance

From the above review, it appeared that evidence relating psychological variables to athletes and, specifically, to hockey players was equivocal. The selection of potential predictors of hockey performance seemed, of necessity, to be somewhat arbitrary. Team cohesiveness appeared to be a useful concept but was limited to employment with teams, preferably of players with considerable familiarity with one another. Aggression showed some promise as a predictor of performance, but the selection of a measure could not be based on any definitive previous study. Many measures of other psychological variables lacked specificity to hockey or, indeed, to sports situations. Measures adapted from the approaches of Rushall (1978) or Butt (1979) did offer some specificity to athletics but did not have impressive statistical support. Hence, it appeared that selection of motivation or aggression measures for use in a study of hockey performance would have involved a subjective appraisal of such factors as the specificity of a measure to hockey or sports situations, its economy in terms of time and inconvenience to the subjects, and the ease of administration. Further use of psychological measures could have been of value in assessing the measures' validity and reliability, particularly with regard to hockey performance.

Butt's (1979) self-report scales were purported to measure aggression, conflict, competence, competition and cooperation. Use of the scales had resulted in findings (intercorrelations between the five components which were in the predicted direction) which supported the model; further utilization of the instruments might have lead to specific interpretations in particular sports or situations. (Test-retest reliabilities varied from 0.50 to 0.80; correlations with numerous subscales of other instruments ranged from 0.18 to 0.67; males (N=67) and females (N=121) of varying ages took part in some initial studies). Butt's 25 item Sports Scale was attractive in that the instrument was simple to administer and could be completed by subjects of various ages in a few minutes.

Deshaies et al. (1978) utilized the Mehrebian Achieving Tendency Scale for Males, a paper-and-pencil measure designed to detect differences in need for achievement (split-half r=0.69, test-retest r=0.78). Although a successful predictor of hockey ability, the resulting scores on this scale indicated that the motivation to avoid failure was greater in the subjects than the desire to succeed. This finding seemed to disagree with the results of a study by Desharnais (1975) that a strong motive to succeed would have been reflected in confidence and determination and, therefore, positively affected performance. Improvements of such general measures might come from the development of scales specific to particular sports or circumstances.

Rushall's (1978) "environment specific" approach would have necessitated the development of a scale specific to hockey, but such development could have been based on the description of scale design provided by Rushall and Fox (1980). The development of such a hockey scale, subject to an examination of validity and reliability, could have added to the available assessment tools of hockey performance.

Although the measures of aggression employed by McCarthy and Kelly (1978) and Russell (1974) showed some promise as potential predictors of hockey performance, these measures were typically based on the players' performance (penalties) in previous or current seasons. Since many of the players on any team played in different leagues or, indeed, leagues of lower calibre in previous seasons, it seemed inappropriate to base a measure of aggression solely on performance in past years. If a season was just beginning when players were tested, then penalty statistics would not have been available for that year. Item 6 of the scale developed by Scaramella and Brown (1978) was attractive as a simple measure of aggression. This instrument relied on the coach's ranking of each player's response in aggressive situations; the coach was perhaps the best person to make such judgments since he had usually followed most of the players for some time, even though they might have played in other leagues in the past. Even at the beginning of a season, he had observed their play in training camp, exhibition games and in numerous practices. The possibility also existed that this simple scale could have been employed as a self-report measure.

Morgan (1979) listed five psychological inventories which he had employed in his own research involving athletes competing for places on Olympic teams. Of these instruments, Morgan favoured selected scales of the Profile of Mood States (POMS) and the Eysenck Personality Inventory (EPI) as the "most consistent predictors" of performance in sports. He noted, for example, a study by Nagle et al. (1975) in which the conformity or lie scale of the EPI accounted for 34 percent of the variance when predicting which wrestlers would be chosen for an Olympic team. The next strongest predictor was the score obtained on the tension subscale of the POMS.

The use of the EPI and POMS, as advocated by Morgan (1979), was thought to be appealing because these measures had been used extensively in the past. Although they had been used with a variety of athletes, Morgan did not report their use with hockey players. (Chien (1978) used the POMS with hockey players but not to predict performance; Maloy (1976) found the EPI useful in selecting elite goaltenders.) Thus, it would be interesting to compare responses of hockey players with those of others as reported in the literature. It would also have been of value to correlate responses on the EPI and POMS with those on the scale adapted from Rushall and Fox (1980) and Butt's (1979) Sports Scale in an attempt to validate the latter instruments.

Summary

It appeared from a review of the literature that psychological variables offered some promise as predictors of hockey performance, especially, as Morgan (1980) contended, if such variables were used in concert with physiological measures. It was also noted, however, that concern was expressed about a variety of methodolcgical and conceptual problems in utilizing psychological measures. This concern, coupled with a plethora of available instruments but few studies in hockey, lead to discussion of a relatively few and sometimes arbitrarily selected potential predictors of hockey performance.

Instruments that were noted included a simple rating of aggression, the recently developed Sports Scale of motivation (Butt, 1979), and the more extensively used Eysenck Personality Inventory (EPI) and Profile of Mood States (POMS). The possibility of developing an "environment specific" motivation scale, adapted from Rushall and Fox (1980), was also discussed. It was noted that some value would have been derived from relating scores on the more recent, specific measures to those on more general trait measures.

Perceptual-Motor Variables

Introduction

Since perceptual-motor was an obvious juxtaposition of two terms, definitions of these terms and other terminology employed in this field were provided.

Perception was defined in the Dictionary of Behavioral Science (Wolman, 1973) as "The process of obtaining information about the world through the senses" (p. 273). Lawther (1972) forwarded the following definition:

> "Perception is the rather prompt organization and interpretation of experience which follows sensory stimuli, providing that the stimuli are not completely novel. Perceptions are usually the result of a prompt organization of patterns of stimuli rather than the interpretation of only one stimulus. The background and context of the situation are also sensed and affect the precise interpretation" (p. 105).

Thus, perception differed from sensation, i.e., the impinging of stimuli on receptors, in that interpretation or cognitive organization of the sensory events was involved in perception.

Cratty (1973) linked the term, motor, to the more general "movement behavior", which he defined as "overt movements of the skeletal muscles" or "observable movement of the body, excluding such functions as visceral changes, conduction of nerve impulses, and circulation of body fluids" (p. 9). Cratty (1973) considered motor performance to be an aspect of movement behaviour that was "goal-centered, purposeful, measurable, observable movement behaviour of relatively short duration" (p. 10). Performance differred from learning in that learning produced rather permanent change in behaviour resulting from practice, whereas performance involved a short-term display of behaviour. Learning might have been studied by analyzing changes in various measures of performance over time.

The terms, ability and skill, mentioned in an earlier section of this chapter, deserved repetition here. Fleishman (1968) defined ability as

> "a more general trait of the individual which has been inferred from certain response consistencies (correlations) on certain kinds of tasks. These are fairly enduring traits, which in the adult are more difficult to change" (p. 545).

Fleishman considered that most abilities were dependent on both genetic factors and learning to some extent. He stated that "skill refers to the level of proficiency on a specific task or limited group of tasks" (p. 456). Cratty (1973) stated that motor skill was a "reasonably complex motor performance" and emphasized that

> "skill denotes that some learning has taken place and that a smoothing or an integration of behavior has resulted. Extraneous movements have been omitted, and the performance is executed with increasing speed and accuracy, a decrease in errors ..." (p. 10).

Salmela (1976) contended that motor learning had spawned sports psychology and "psycho-motor performance" and that these were the "two major academic areas of concern on the North American continent regarding the psychological aspects of human physical activity ... "(p. 23). The use of terms such as psycho-motor, perceptual-motor or sensory motor were, as Cratty (1973) noted, indicative of the attention directed to interactions between input or perceptual processes and output or motor processes.

> "Some of the findings from studies in which the perceptual bases of motor activities have been explored offer obvious guidelines for the improvement of instruction in motor skills, while other information emanating from these investigations contributes to more basic understandings of how humans perceive, move, and develop during the earliest months of life" (Cratty, 1973, p. 71).

Cratty continued by explaining his multi-channelled theory of development in which branching between parallel channels reflecting verbal, motor, perceptual and cognitive functionning resulted in the acquisition and development of various competencies in the maturing child. Welford (1968) employed the term, sensory-motor, and noted the difficulty in distinguishing between sensory-motor and mental skills.

> "All skilled performance is mental in the sense that perception, decision, knowledge and judgment are required. At the same time all skills involve some kind of co-ordinated, overt activity by hands, organs of speech or other effectors" (Welford, 1968, p. 21).

Thus, sensory-motor skills involved both a mental and overt motor component.

The discussion above provided definitions of some of the terminology attending the use of the term, perceptual-motor. The latter term apparently reflected an appreciation of the interaction between perception and motor behaviour. Perhaps, as Singer (1980) commented, "Cognitive processes are much more involved than heretofore realized by many scholars and practitioners in the acquisition of complex motor behaviors" (p. 25). Cratty (1973) seemed to concur as he noted that simple response tasks, while sometimes being termed motor, appeared to require considerable use of perceptual factors. He cautioned that "Many of the so-called motor skill investigations have used tasks that are largely cognitive or perceptual in nature, with the motor component of the task being a relatively simple, unchanging, and minor portion of the behavior measured" (p. 430). Thus, although some agreement on the use of the term perceptual-motor, seemed apparent, the intricacies involving interactions between perceptual and motor processes remained unexplained.

Perceptual-motor variables

Before citing studies of the perceptual-motor behaviours of athletes, it seemed appropriate to provide some delineations of variables found in this field so that the reader might have been assisted in putting subsequent discussions in context.

Lists of perceptual-motor or psycho-motor variables have ranged from general descriptions to complete taxonomies. (Harrow (1972, p. 183) considered perceptual-motor and psycho-motor to be synomymous terms.) A general description was provided by Baumgartner and Jackson (1975), for example, who reported that flexibility, balance, kinesthesis (perception of the body in space), and perceptual-motor development were "accepted components of the psychomotor domain" (p. 163). (The distinction between psychomotor and perceptual-motor was not clarified.) Cratty (1969) proposed a three-level theory of perceptual motor behaviour which included as a base, general behavioural supports (aspiration level, arousal, ability to analyze a task, persistence at a task), as a second level, ability traits (arm-leg speed, finger-wrist speed, ballistic strength, static strength, trunk strength, wrist-arm accuracy), and, at the uppermost level, factors specific to the task and situation (past experience, spatial dimensions, practice conditions, force requirements, amount of visual monitoring, social conditions present).

Examples of psycho-motor taxonomies included those of Fleishman (1968) and Harrow (1972). Fleishman (1968) reported the emergence of the following perceptual-motor abilities from a "series of interlocking studies" (p. 549): control precision, multilimb coordination, response orientation, reaction time, speed of arm movement, rate control, manual dexterity, finger dexterity, arm-hand steadiness, wrist/finger speed, and aiming. To the above abilities, Fleishman added nine skill or physical proficiency factors to complete the taxonomy: the skills included types of flexibility, strength, coordination, balance and stamina. Harrow's (1972) taxonomy of the psycho-motor domain was too extensive to describe fully here as it included six classification levels, 20 subcategories and numerous divisions and subdivisions. The six classification levels were reflex movements (included as prerequisites to following levels), basic-fundamental movements, perceptual abilities, physical abilities, skilled movements, and non-discursive communication (facial expression, interpretive movements).

This brief review was intended to provide the reader with a flavour of the scope of the perceptual-motor or psycho-motor domain (see, for example, Harrow (1972) or Merrill (1972) for more complete reviews). Although the categories Fleishman (1968) provided were derived from research findings, he added that these categories were not all inclusive. Fleishman reported the use of extensive perceptual-motor and cognitive test batteries to identify ability factors relevant to a complex tracking task. Subsequently, a skill training program was developed utilizing research findings.

Examples of research examining many of the variables listed above, usually in relation to other factors, were readily available. For instance, Flowers (1975) reported a relationship between hand preference and skill on a "tapping" test (wrist and finger speed). Williams (1974) found a relationship between leg strength and speed of body movement. Barrell and Trippe (1975) reported a difference in field-dependence (a perceptual ability) and skill in various sports. Dickinson (1969) found no relationship between distance perception and an aiming task. The perceptual-motor variable in most common use, however, was reaction time (Morris, 1977). A selection of some of the research involving reaction time was included below.

Although reaction time was the common term, studies in this area were often concerned with other aspects of responding to a stimulus. Reaction (or decision) time actually referred to the elapsed time between the onset of a stimulus and the initiation of a response by a subject; total response time was the elapsed time between stimulus onset and completion of a response; movement time was the difference between total response time and decision time (Cratty, 1973; Lawther, 1972). Experiments involving these variables might have varied considerably in complexity: situations involving a single stimulus and response were said to involve simple reaction time, whereas those with multiple stimuli and response possibilities were termed complex reaction time situations.

Studies of response speed might have involved, for example, examinations of the apparent effects of age on responding (Fulton and Hubbard, 1975; Nebes, 1978), the relationship between reaction and movement times (Henry, 1961; Magill and Powell, 1975), or relationships between response speeds and psychological "states" such as depression (Byrne, 1975) or retardation (Gosling and Jenness, 1974).

After examining the response speeds of nine to 17 year olds (N=250), Fulton and Hubbard (1975) reported that, while both reaction times and movement times tended to decrease with age, females had faster reaction times and males faster movement times. The authors concluded that strength seemed to contribute to movement time but not reaction time. Surwillo (1977) reported, after studying simple and choice reaction times in boys (N=108) from four to 17, that "5-year-olds took nearly three times longer than 17-year-olds to process one bit of information" (p. 97). Although response speed apparently improved during adolescence, most investigations had cited decline with increasing age beyond that (Baumgartner and Jackson, 1975). Nebes (1978) found, however, in a comparison of response speeds of young (mean age was 18.9; N=32) and elderly (mean age was 67.7; N=32) subjects, that the "usual age decrement in response latency" (P. 884) was evident when subjects responded manually but not when they responded vocally. Thus, Nebes concluded that the decline in response speeds with age might not have been a general phenomenon.

Debate had continued for many years about the relationship between reaction time and movement time. Whereas some writers

(Henry, 1961) reported no relationship between these variables, others (Pierson and Rasch, 1960) found statistically significant reaction time/movement time correlations. In a more recent paper, Magill and Powell (1975) postulated that an "essentially zero" relationship between reaction and movement times, if valid, should not have been affected by the "manipulation of various experimental variables" (p. 720). Their finding of a statistically significant relationship for males (N=18) and not females (N=18; both groups were college students, ages 19 to 24) caused them to question the generality of the "essentially zero" position.

The decision time-movement time relationship was also examined with respect to other variables. Byrne (1975), for instance, found no relationship between these variables in control subjects (N=15; mean age was 36.5 years) but a statistically significant correlation in depressive subjects (N=30; mean age was 40.6 years; 14 males, 16 females). In a subsequent study, Byrne (1976) reported that only decision time (and not movement time) "was further sensitive to clinical variation within the depressive state" (p. 149), in that decision time was statistically significantly longer in the psychotic (N=15; mean age was 46.1 years) than neurotic (N=15; mean age was 35.1 years; 7 males and 8 females in each group) depressive subjects. Other studies focused on differences in response speeds between retarded and nonretarded subjects.

Gosling and Jenness (1974), for example, found that increasing the period between reaction time trials had affected retarded (N=12; mean age was 17.3 years) but not nonretarded (N=12; mean age was 17.1 years) subjects. Not surprisingly, as the findings of Wade, Newell and Wallace (1978) supported, retarded subjects were generally slower than nonretarded subjects on response speed tasks. Although the latter authors reported that increasing task difficulty had greater effect on retarded than nonretarded subjects (in terms of reaction and movement times), retarded subjects did statistically significantly reduce movement time over the five days of practice of the study.

This section provided delineations of some of the variables in the perceptual-motor domain and presented some examples of research findings, particularly with respect to reaction time, movement time or response speed in general.

Perceptual-motor variables and behaviour in sport

A sample of some of the research findings concerning perceptual-motor variables and those involved in sport was presented below: an exhaustive review of relevant literature was beyond the scope of this paper. The studies presented might have reflected different points on Cratty's (1973) "perceptual-motor continuum" (p. 430), i.e., variables might have reflected to a greater or lesser extent the components of perception and motor behaviour.

One variable that generated some interest was spatial orientation (or response orientation, in Fleishman's (1968) taxonomy). Apparently, differences existed in individuals' dependence on environmental cues in estimating the true vertical position in some visual display. Individuals who relied heavily on environmental cues, even distorted ones, to estimate the vertical were called field dependent; those who relied on their own inner (proprioceptive) cues were termed field independent. Although Barrell and Trippe (1975) noted that over two thousand projects had utilized the concept of field dependence/independence, they contended that the concept had had little application with research of performers in sport. Barrell and Trippe examined field dependence/independence in professional ballet dancers (N=12), professional soccer players (N=30), professional cricketers (N=13), high calibre tennis players (N=18), high calibre track and field athletes (N=21), and players of medium ability in soccer (N=16), cricket (N=9), tennis (18), and track and field (N=16); an additional group (N=28) of males served as controls. The results indicated that the high calibre tennis players (mean score=3.42) were statistically significantly more field-dependent than medium level tennis players ($t=2.87, p<.05$) and also statistically significantly (Duncan's multiple range test; $p<.05$) more field dependent than high calibre track and field athletes (mean score=1.63) or the control group (mean score=1.81).

Another study (Meek and Skubic, 1971) compared field dependence/independence of the highest (N=30) and lowest (N=30) skill groups of high school females; skill was determined by the ratings of three experts. The authors reported that the highly skilled performers were statistically significantly (Fisher's $t=3.08, p=.01$) more field independent than the poorly skilled group. Some support for the latter finding came from Guyot, Fairchild and Hill (1980) who examined the relationship between fitness and field dependence/independence in four groups of children in Grades 4 to 6; 43 boys and 92 girls were rated high in fitness (on a fitness-motor ability battery), and 67 boys and 77 girls were placed in low fitness groups. The findings indicated that girls were more field-dependent than boys ($F_{1,325}=21.49, p<.001$) and that girls low in fitness were more field dependent than the other groups ($F_{1,325}=7.31, p<.01$). Guyot et al. also concluded that "girls skilled in physical activities may be as field-independent as boys" (p. 413).

Other studies employing measures of field dependence/independence have reported no differences between groups. Williams (1975), for example, found no differences between highly rated (n=14; mean age was 26.7) and less highly rated (N=11; mean age was 26.9) fencers on a test of field dependence (means=25.00(highly skilled) vs. 21.64; $t=1.55, p>.05$). Pargman, Bender and Deshaies (1975) examined basketball shooting performance of male (N=11; mean age was 20.7) and female (N=9; mean age was 20.5) college basketball players and also tested the players using the measure of field dependence/independence that Williams (1975) employed. Pargman et al. reported that scores on the latter measures did not correlate statistically significantly with percentages of free throws ($r=0.41$ (males); $r=-0.05$ (females)) or field goals ($r=0.16$ (males); $r=-0.21$ (females)) made by the basketball players.

The lack of consistent findings using measures of field dependence/independence might have been due in part to the variety of instruments employed. The two studies above which reported statistical non-significance used the Hidden Figures Test Cf-1 whereas Meek and Skubic (1971) and Barrell and Trippe (1975) reported statistically significant results using rod-and-frame tests. Guyot et al. (1980) reported statistical significance but used a different hidden-figures instrument i.e., the embedded figures test (Witkin, Dyk, Faterson, Goodenough and Karp, 1962). Although this discussion tended to support Deshaies and Pargman's (1976) finding that hidden-figures tests appeared to be poor measures of field dependence/independence, it appeared that measures of spatial orientation, or at least those of field dependence/independence, have not produced consistent findings with regard to behaviour in sports situations. Another point was made by Graydon (1980), who found no differences ($F_{2,36}=.58, p>.05$) in spatial ability among groups of women international squash players (N=13; mean age was 28 years), players of low ability (N=13), and non-players (N=13); groups were equated for age and education. She suggested that perhaps performance at squash "is so exceedingly complex that the contribution of a single factor such as spatial ability is likely to be minimal" (p. 970).

Data involving recognition and visual perceptual speed of athletes came from studies by Allard, Graham and Paarsalv (1979) and Allard (1979). The former study found that when female college basketball players (N=10) and "non-players" (N=10) were presented with slides tachistoscopically that depicted situations that were structured (actual basketball game situations) or unstructured (the ball had just changed hands or was in neither team's possession), the players demonstrated superior ($F_{1,18}$ =7.37, $p<.05$) recall but only for the structured slides. The authors considered the players' superiority in recall to be a function of their encoding information to a deeper level than non-players.

A subsequent study (Allard, 1979), however, found that female college volleyball players (N=10) were faster ($F_{1,18}$ =10.78, $p<.01$) than "non-players" (N=10) in detecting a ball in tachistoscopically presented slides, regardless of whether the slides depicted game or non-game situations. Further evidence was gathered to show that perception time in this task was related to the volleyball skill possessed by the subject and not to simple reaction time capabilities of the subjects.

Another perceptual-motor variable was balance. In 1968, Singer reported that, although it appeared that balance was especially important in athletic performance, research on the relation of balance to athletic success had been limited. In reviewing the literature to date, Singer (1968) noted that different tests of balance were not highly correlated and that studies comparing balance in athletes and non-athletes were "inconclusive". He then reported the results of his own work in which balance of college students in the following groups was measured using a stabilometer apparatus which Singer designed: "Fifteen of the best athletes, according to their coaches" (p. 646) in basketball, baseball, football, gymnastics, and wrestling, 15 experienced water skiers, 15 male non-athletes, and 15 "female students". Singer (1968) concluded that the water skier (mean score=17.41) and gymnastic (mean score=16.58) groups were more effective in the balance task ($F_{8,134}=2.65, p<.05$) than "many of the other athletic groups, non-athletes and girls" (p. 654). He added that there was little correlation between balance and either height or weight; Singer also noted that the similarity between the task employed and abilities demanded in particular sports might have influenced the findings.

As mentioned earlier, reaction time was a popular measure in studies of behaviour. Cratty and Hutton (1969) stated that "For the past seventy-five years, experiments in reaction time and movement time have provided data which offer reasonably precise guide lines for coaches and physical educators" (p. 3). He added (Cratty, 1973) that reaction time tests have been used to evaluate the "quickness" of movements, for example, of football players and that "Complex reaction time tests have been employed with European athletes, and, when experimental conditions are similar to those they encounter in their sport, the results are moderately predictable of athletic success" (p. 25).

In reviewing reaction and movement time literature, MacGillivary (1965) concluded that findings clearly showed the superiority of athletes over non-athletes on measures of simple reaction time and movement time. In an earlier study, Olsen (1956) administered three types of reaction time measures (simple, two choice and three choice) and measures of depth perception and "span of apprehension" to groups of male varsity athletes (Athletic Group), 100 active males (Intermediate Group), and 100 male non-athletes. The findings indicated that the Athletic Group was superior to the Intermediate Group on the reaction time measures (Critical Ratios from 2.51 to 4.75; level of statistical significance from .02 to .001), that the Athletic Group was superior to the non-athletes on all measures (CR's from 4.53 to 10.15; level of statistical significance was .001 for all measures), and that the Intermediate Group was superior to the non-athletes on all measures (CR's from 2.88 to 5.92;

level of statistical significance from .01 to .001).

In a more recent study, Fujita (1976) divided response time into nine phases. Using a sophisticated design, 10 high calibre tennis players, gymnasts and sprinters and (although reporting was unclear, a presumably equal number of) "nonsportsmen" were asked to react to a visual display by an orienting response and the appropriate behaviour. Electrode attachments allowed for the detection of eye movements and muscle contractions of the tibialis anterior and gastrocnemius; since the subjects stood on a force platform, body movement was also detectable. From traces of the various physical and myographical events, response time was analyzed into nine phases. In summarizing his findings, Fujita concluded "that sportsmen tended to react to the stimulus with shorter reaction time depending upon shorter latency of leg flexion [difference t's=5.88,4.57;p<.001] and shorter decision time [difference t's=4.81,3.97;p<.001] than nonsportsmen" (p. 136). Decision time was defined as

> "Conduction time on nervous system which includes the time phases from the moment of reception of stimulus on retinal fovea, the descrimination of it, and decision making on cerebral cortex, to the moment when gastrocnemius muscle begins contraction" (p. 129).

Other studies examined the apparent influence of physical activity on response speed. For instance, Spirduso and Clifford (1978) examined simple and choice reaction times and movement time of young (mean age was 22.2) and old (mean age was 64.2) men who were either regular runners, regular participants in a racketsport or nonactive (N=15 for each of the six groups). The findings indicated that the older active men were not statistically significantly different ($F_{1,84}$=2.55,1.55;p>.05) from the young nonactive men on the simple and choice reaction time tests but were faster ($F_{1,84}$=4.31,5.48;p<.05) than the young nonactives on the movement time measures. In short, the authors concluded that "older men who maintain an active life style react and move statistically significantly faster and more consistently than their sedentary peers. Even more importantly, they react and move at least as quickly as sedentary men 40 years younger" (p. 29). In contrast to the above finding, Boarman (1977) reported that a five week (twice a week) folk dance program did not statistically significantly affect an experimental group (N=20; aged 60 to 94; 18 females and two males) when compared with a similar control group on measures of simple reaction and movement times.

Studies have also examined the influence of increased stress, in the form of physical activity, on response speed. Reynolds (1976) found that when fit or "conditioned" (N=11) and "unconditioned" (N=12) college women (aged 20 to 28) were asked to perform response speed tests while maintaining a heart rate of 160 beats per minute during 12 minute trials, mean reaction time was slower for the unconditioned group ($F_{1,734}$ =4.19,p<.05). The latter group also showed poorer peripheral reaction (left side χ^2=11.44,p<.05; right side χ^2=11.03,p<.05). Reynolds noted, however, that "Reaction time in the peripheral visual field did not increase as a result of augmented levels of stress. Neither did reaction time increase uniformly with augmented levels of stress" (p. 772). Sjoberg (1975) subjected 25 male subjects (mean age was 24.8) to various work loads (from 150 to 750 kpm/min.) on a bicycle ergometer and administered a choice reaction task at each work load. He found an inverted-U shaped relationship between work load and reaction speed (between sessions $F=11.26; df=4; p<.001$), concluding that performance was more efficient at moderate activation levels. Thomas and Reilly (1975) examined reaction time periodically as a male athlete (age was 31) took part in "continuous paced work at moderate intensity for 100 hours" (p. 149). The authors reported that reaction time statistically significantly ($p<.05$; figures unavailable) increased during the 100 hours but no statistically significant cyclical variation was found. Using movement time to examine the biomechanics in overhead badminton stroking, Johnson and Hartung (1974) measured four actions using male (N=29) and female (N=29) college students who were beginning badminton players. They reported that forearm rotational movements resulted in faster (t's from 5.95 to 10.34; $p<.01$) racket-head movement time than wrist actions for both sexes.

This review presented findings of some of the studies that have examined the relation of perceptual-motor variables to behaviour in sport or to various fitness or activity levels.

Although data were provided that apparently indicated the superiority of athletes over non-athletes on perceptual-motor variables, the literature did not present that case unequivocably. Concern was expressed, for example, about the apparent lack of consistency in instruments purporting to measure field dependence/independence and balance. Reaction time and movement time appeared to be popular measures but, as Morris (1976) noted, procedural considerations could have affected reaction time values. The popularity of reaction time might have been due to several influences:

> "For example, it can be precisely assessed in an inexpensive manner and it is perhaps the simplest overt response that requires central processing. Particularly important to those concerned with information processing; reaction time provides one of the few possible indicators of ongoing internal events, which, of course, is their duration" (Morris, 1976, p. 259).

Perceptual-motor variables and hockey ability or performance

Research relating measures of perceptual-motor activity to behaviour in hockey was not extensive. Available literature was reviewed below; discussion of the utility and promise of the perceptual-motor measures as predictors of hockey ability was included.

Salmela and Fiorito (1979) examined the accuracy of predicting the destination of a shot when varying visual cues were given to young goaltenders (N=34; mean age was 15.8). Subjects were asked to respond to filmed presentations of an approaching player by predicting to which corner of the net the impending shot would be aimed. The quantity of pre-shot visual cues was varied. The findings were that prediction was different than chance (χ^2=8.1,p<.05) and that there were about 2.5 times more successful than unsuccessful predictions. The authors also reported that prediction improved with the availability of more pre-shot cues (χ^2=9.1,p<.01) and that prediction was better for wrist shots than for slap shots (χ^2=6.2,p<.05). Sinclair and Moyls (1979) examined reaction and movement times of small numbers (N=2 or 3) of goaltenders from each of five levels of play (PeeWee, Bantam, Midget, Junior and College). Among the findings, which were necessarily cautious because of small samples, were that limbs exhibiting the fastest reaction time usually did not exhibit the fastest movement time; in fact, players usually reacted fastest with one limb and moved fastest with the opposite limb.

Deshaies et al. (1978) used measures of both peripheral vision and specific visual perceptual speed in their study of Junior hockey players (N=116; mean age was 214.5 months); only specific visual perceptual speed correlated statistically significantly (r=0.27,p<.05) with hockey ability (coaches' ratings) and visual perceptual speed subsequently entered the regression equation. The procedure employed by Deshaies et al. to measure visual perceptual speed was developed by Thiffault (1974). Thiffault tested the vusual perceptual performance of 60 young players (ages 11 to 14) by showing slides of hockey situations on a tachistoscope. Thiffault was able to show an improvement, compared to controls (N=30), in the visual perceptual performance of the group (N=30) who received tachistoscopic training for 30 minutes a day for 10 days. Deshaies et al. (1978) presented 20 slides of tactical situations in hockey tachistoscopically and subjects were asked to state whether the appropriate action involved passing, shooting or skating. Scores were based on the average reaction time of verbal responses to the 20 slides.

Although a statistically significant correlation ($r=-0.27, p<.05$) existed between the measures of visual perceptual speed and hockey playing ability in the Deshaies et al. study, the relationship was not as strong as between ability and the other predictors. In some respects, it seemed that the measure could have been criticized for its lack of sophistication. For instance, it seemed unlikely that standard reactions should be expected in response to the slides; position on the ice, score, time remaining, coaching instructions, and confidence of the player could have been some of the factors that influenced the speed of response as well as its appropriateness. However, Deshaies et al. (1978) implied that they did not consider the measure they employed to be discriminatory in that sense, believing that the judgments to be made required only a minimal knowledge of hockey. If the knowledge required was minimal, then it might have been argued that the measure was basically a choice reaction time indicator and that content of the slides was unimportant.

The potential of movement time as a predictor of hockey performance received some support from a study by MacGillivary (1965). He included measures of total body reaction time, movement time, peripheral vision and depth perception in his investigation and had college hockey players (N=28) ranked in ability by experts. The only variable to correlate statistically significantly with hockey ability was simple movement time. Olsen (1956) did not differentiate between movement time and reaction time but found that a measure of the latter ("simple reaction time") correlated statistically significantly ($r=0.40, p<.05$) with a measure of offensive hockey skill (average number of goals and assists per game for 26 college players over the hockey season). What Olsen called reaction time should more properly have been termed total response time: it was unfortunate that the relationship of the response components, decision time and movement time, to hockey ability was not determined.

In short, the above review did not provide support for any particular perceptual-motor measure as a predictor of hockey ability. As discussed above, the visual perceptual speed employed by Deshaies et al. (1978) might have been considered a choice reaction time task. Some concern might have been expressed about the appropriateness or level of sophistication of the slides and situations they depicted, particularly when the subjects were elite players. Although players might have been told that a test using slides of game situations was not intended to tap knowledge, the possibility of that implication could have negatively affected performance. It might have been argued that, if little knowledge was required in the Deshaies et al. (1978) measure, then response speed to any stimulus could have been measured.

The omission of a movement time measure in Olsen's (1956) study prohibited conclusions about its possible contribution to the relationship between response speed and hockey ability. Although MacGillivary (1965) noted a relationship between hockey ability and movement time, the latter variable actually involved a 15 foot skate in response to a stimulus. The involvement of such a distance seemed necessarily to involve a skill component.

Therefore, the literature did not provide substantial guidance in the selection of a promising perceptual-motor measure that might have been related to hockey ability. A response speed measure that included indicators of both reaction or decision time and movement time appeared to offer some promise as a correlate of hockey ability, especially if such measures could have been administered simply in an on-site investigation.

Summary

This portion of the literature review provided defintions of some of the terms employed in a discussion of perceptual-motor variables and an indication of some lists or taxonomies in the perceptual-motor domain. Studies relating perceptual-motor variables to sports behaviour were cited as was available evidence of perceptual-motor performance of hockey players. Although the selection of a promising perceptual-motor indicator of hockey playing ability did not receive strong direction from the literature, measures including reaction and movement time appeared to be most promising.

III. Method

The present study involved the administration of measures to groups of hockey players who were distinguishable by level of play and age. Therefore, the following descriptions of subjects and procedures were divided to accommodate the three different categories of players. Phase 1 was concerned with the oldest group, Phase 2 with an intermediate group and Phase 3 with the youngest players tested. A description of the instruments employed was also included in this section of the report. (See Appendix B for copies of the instruments.)

Phase 1

Subjects. The subjects were members of the New Westminster Bruins Hockey Club, one of 12 teams in the Western Hockey League. Players in this league were amateurs but at the top "Junior" (tier 1) level of play. Many players at this level have proceeded to the professional leagues upon graduation.

The subjects were male and ranged in age from 203 to 238 months at the time of initial testing. Twenty-four players completed some of the items on the test battery; data on all battery measures were available for 16 players. (Two players were injured and could not be tested on all measures; three players were transferred or left the team before all data could be collected; one player refused to take one test, and; ratings of playing ability were not provided for the two goaltenders, presumably because the rating scales were inappropriate.)

<u>Procedure.</u> The subjects were tested near the beginning of their season (early October, 1979) after completing a series of exhibition games. The coach introduced the researcher to the players as they prepared themselves for a routine practice session. The researcher, who was described by the coach as someone who would be conducting "some tests" on the players, then told the players that he wanted to give them four different kinds of tests, both on and off the ice, and explained briefly what the tests entailed. (The tests were described as (1) questionnaires which asked about attitudes toward hockey and sport (HAS, Sports Scale); (2) a "reaction-time test"; (3) a skating speed test on the ice, and (4) a "fitness" test using a stationary bicycle.) The players were told that the first two tests would be given that day and asked that they come to the testing room when called. It was added that the skating speed test would be administered the following day and the "fitness" test the day after that. Questions were encouraged and answered by the researcher at that time. The researcher then expressed his thanks for the players' cooperation and his pleasure for being allowed to work with such a well-known team.

The tests were administered concurrently with the team's regular afternoon practice sessions. No testing was done on the day of a game. The off-ice tests were administered in a spare changing room which the team did not use. Benches were available for the players to sit on and a table with accompanying chairs could also be utilized by the researcher.

On the first testing day subjects completed two paper-and-pencil measures (the Sports Scale and the Hockey Attitude Scale) and the response speed test. Players were called from the practice in groups of two or three, came to the testing room and were given the questionnaires and asked to complete them while sitting on one of the benches. The questionnaires were described as being concerned with their "attitudes and feelings" about playing or preparing for hockey. Questions regarding the instructions or the meaning of words or phrases were answered briefly. Collaboration between subjects was discouraged. When players completed the written measures, they were tested individually on the response speed apparatus. The table and chairs were utilized for the latter test: the subject was asked to sit in the appropriate chair, the researcher sat in the chair opposite to the subject and explained the test. Subjects were given two practice and five test trials. On leaving, appropriate players were asked to send others to the testing room so that the testing process was continuous for the researcher.

On the second testing day, the skating speed test was conducted on the ice surface. When all players were dressed and on the ice, they completed some basic stretching exercises for about 10 minutes. The researcher was then invited to explain the test: players were told that the test was simply a measure of how fast they could skate from one goal line to the second blue line. They lined up behind the goal line at one end of the arena and each, in turn, skated the required distance on viewing the researcher's dropping his raised arm as the starting signal. The researcher stood at one side of the arena at the appropriate blue line and timed the subjects with a stopwatch (sweep hand type). Times were estimated to the nearest 0.1 second. When all subjects were timed, they returned for a second trial. (The inter-trial period was approximately 10 minutes.)

On day three, players completed the Wingate Anaerobic Test on a Monark bicycle ergometer. (Testing was begun earlier than on the previous days so as not to conflict with the practice. Thus, most players were tested in street clothes or the hockey underwear they had put on before dressing in full equipment for practice.) Players came to the testing room in groups of two or three. The researcher explained the test as being of short duration, i.e., only 30 seconds, but difficult. Each player warmed up by riding the bicycle at a moderate setting until a heart rate of 150 beats per minute, palpated at the carotid artery by the researcher, was reached; speed and/or setting were adjusted so that this rate was obtained in approximately five minutes. Subjects then sat on one of the benches and rested for five minutes. After five minutes, subjects were again seated on the bicycle for the 30-second test. Seat height was adjusted and the test protocol was briefly reviewed. The subject began pedalling quickly at no resistance, the researcher then set the ergometer according to the subject's weight and encouraged the subject during the test. Two assistants noted times (five second intervals for 30 seconds) and readings from the revolution counter. Players were cautioned to keep moving after completing the test to avoid venous pooling.

The few available subjects who had not completed the other tests on days one and two were administered those measures on day three. The researcher then thanked all the players for their cooperation and answered any questions.

The coach's ratings on the aggression scale were obtained approximately three weeks after the players were tested. (The delay was due to finding a convenient time for the coach.) Names and addresses of coaches of other teams in the league were obtained: an explanatory letter (see Appendix A) and a copy of the criterion measure were sent later in the season to each coach in the tested team's division asking for his assistance in rating the subjects. No cooperation was obtained. The criterion measure was completed by the subjects' coach after the season had finished. An assistant coach who had joined the team during the season was also asked to complete the criterion measure for players with whom he was familiar. Ratings by either or both the coach and assistant were totalled and compared with the rating points possible for all items checked; the percentage of rating points obtained over total possible points served as a subject's hockey ability rating.

Phase 2

Subjects. The subjects were 48 males who ranged in age from 187 to 200 months. The players were attending (in August, 1980) the British Columbia Junior Olympic Program, an invitational hockey camp organized as part of the Hockey Development Program of the British Columbia Amateur Hockey Association. The invited players were selected from teams at the Midget level from throughout British Columbia. During the camp, the players were exposed to lectures, dicussions and on-ice instruction from a variety of "experts". For most activities, the subjects were divided into two groups of 24, each with its own head coach and three off-ice instructors.

Procedure. The researcher was introduced to the total player group (N=48) at an initial organizational meeting in which all personnel were introduced and the camp program outlined. The researcher briefly explained that he was interested in finding out more about hockey and would be asking for the players' cooperation in completing questionnaires concerned with their attitudes about hockey and other things, and in taking tests that were concerned with reaction time, skating speed and fitness, as measured by a brief test on a "stationary bicycle". The researcher added that he would be meeting with each of the two groups (N=24) to administer most of the questionnaires in one sitting but that, for the remaining measures, players would be tested in small groups when they were not scheduled for another activity. The researcher noted that everyone would receive a summary of their test results.

The following paper-and-pencil measures were administered to one group on the second morning of camp and to the other group on the third morning: the Student Hockey Form, which asked for birth date and an indication of their hockey experience; the Sports Scale; the Hockey Attitude Scale; and, the Junior Eysenck Personality Inventory (Jr. EPI). The researcher preceded the administration of the above measures by reiterating the purpose of his study and stating that perhaps "attitude" as well as, for example, skating speed "has a lot to do with how good a player is". The content of the measures was briefly described, players were told not to spend "too much time on each question", and to raise their hands if problems arose. Queries were answered without trying to direct subjects' responses.

The Wingate Anaerobic Test was administered during free-time sessions in the mornings in a little-used section of the arena complex, near to both on-ice and off-ice instruction sites. The response speed measure was administered before or after dinners in the building where players ate their meals.

(The number of trials was increased from Phase 1 to include five practice and 20 test trials.) Players in each group were numbered from one to 24. Testing on the Wingate Anaerobic Test began with player number one, whereas players with numbers 24, 23, etc. were the first to complete the response speed measure. This arrangement avoided the necessity of two testing sessions per day for most players.

To maximize the usefulness of test sessions involving small groups, the players were asked to complete other measures when not being tested on the bicycle ergometer or response speed apparatus. In each subject's initial small group test session, he was asked to complete the Profile of Mood States (POMS) instrument while waiting to be tested on the ergometer or response speed apparatus. The POMS was described as another test, "like the questionnaires you filled out" previously, which asked about feelings towards a number of things. During the second small group test session, subjects were asked to complete a form on which they were

1. to supply ratings of the other players in their group (from zero to 20, on "how good a hockey player you think he is", where 20 meant "very good"),
2. to indicate (on a five-point scale) how often they, themselves, played hockey "aggressively", and
3. to indicate their height.

The researcher also measured forearm girth during the second small group session.

The skating speed test was conducted near the beginning of regularly scheduled on-ice sessions during the fifth full day of camp. Coaches conducted warm-up sessions (some stretching routines and skating drills) for approximately 10 minutes and then invited the researcher to explain the test protocol to the players. Players were divided into two groups who formed lines on both sides of the ice surface behind the goal line at one end of the rink. The researchers and two assistants with (digital) stopwatches were stationed at the blue line farthest from the players. Players initiated their own skating speed trials; times (to the nearest 0.01 seconds) were reported by the assistants to the researcher, who recorded them. Players returned to the appropriate line-up and place for their second trial. The entire procedure took less than 15 minutes for each group of 24 players.

The criterion measure (i.e., ratings from zero to 20 on hockey ability, with higher ratings signifying better players) was completed by at least two coaches or instructors who worked with each group of players during the week. Additional ratings of some players were provided by one visiting instructor who worked with both groups during the week and by the head coach of one group who rated players from the other group whom he had coached in the final day "tournament" (i.e., players were "drafted" to form three teams which played each other in a series of shortened games that served as the end-of-week finale). All available ratings were averaged to produce a mean rating for each player. (Unfortunately, the head coach of one group had to leave camp early. Although he provided ratings on each of his group's players, he did not employ the criterion measure but instead used a form on which ratings of one to 10 were provided on "skating", "puck control" and "team play". The use of these ratings was discussed later in this paper.)

Phase 3

Subjects. The subjects were two groups (N=31 & 29) of males who had registered for the University of British Columbia's Summer Hockey School. Each group attended the camp for one week (not concurrently) in July of 1980. The boys ranged in age from 112 to 158 months and came from various places in British Columbia and the Western United States. Boys were accepted into the Hockey School on a first-come, first-served basis and not according to previous hockey experience. Two instructors were with each group at all times (on-ice and off-ice); additional instructors were added for on-ice sessions.

Procedure. The researcher met players and their parents when they registered for camp. A letter explaining the study was shown to parents and questions were answered. The players received a brief verbal description of the study. Both parents and players were asked to sign consent forms (see Appendix A for letter and consent forms) to allow participation of the boys. The researcher indicated that the results of the project would be sent to players and their parents.

After dinner on registration days, the researcher met with each group in a classroom to administer the Student Hockey Form (asked for age and hockey experience), the Sports Scale, the Hockey Attitude Scale and the Junior Eysenck Personality Inventory. The rationale and general directions with respect to these paper-and-pencil measures was similar to that noted in Phase 2. (Because of age and reading level, more queries arose with the Phase 3 players in comparison to those in Phase 2. Again, assistance focused on interpretation rather than directing players' responses.)

The Wingate Anaerobic Test was administered before lunches and dinners and the response speed test after these meals to groups of three or four players. Testing took place in a small room in the building where players had their meals. Protocols for the Wingate and response speed tests were identical to those used in Phase 2 (see Instruments section). As in Phase 2, testing was organized so that most players had only one test session in any one day. Also, as in Phase 2, the PCMS measure was completed in a subject's initial small group test session; data on peer ratings, aggression (self-reported), height and forearm girth were collected in each subject's second test session.

The skating speed measure was administered at the beginning of on-ice sessions during the fourth full day of camp for the first group and the fifth full day of camp for the second group. The test protocol was identical to that described in Phase 2: instructors arranged the subjects in proper order and two assistants noted times (to 0.01 seconds) on digital stopwatches and relayed them to the researcher. (The same two assistants timed both groups of players.)

The criterion measure was completed by the two instructors who were with each group full-time during the week. The two ratings on each player were averaged to produce a single rating of overall hockey ability.

Instruments

This section described the various measures employed in the present study. Also noted were the measures that were employed in each of the three phases of the study; any differences in test protocols between the phases were also described. In general, however, most measures were common to Phase 1, 2 and 3 but additional variables were included in Phases 2 and 3.

Anaerobic systems

The present study employed the Wingate Anaerobic Test (1977). In Phase 1, a single Monark bicycle ergometer was employed. Subjects pedalled slowly on the bicycle with little resistance as the researcher monitored heart rate from the carotid pulse. Resistance and/or pedalling speed was increased until a heart rate of approximately 25 beats per 10 second count (150 beats per minute) was noted. Such a heart rate was usually achieved in approximately five minutes. Subjects were then told to sit down and rest for about five minutes. In Phase 2 and 3, a modified protocol (see Bar-Or, 1978) was employed. Subjects pedalled for four to five minutes at moderate workload, interspersed by two or three "sprints" at higher workloads for about five seconds. Again, workload was adjusted during the warm-up to achieve the criterion heart rate in four to five minutes. The test was explained to subjects during the warm-up; subjects were also asked for their weight at that time. In Phases 2 and 3, two Monark bicycle ergometers were employed so that two subjects could warm-up simultaneously. As explained above, subjects in Phases 2 and 3 completed other written measures when not on a bicycle.

After resting for approximately five minutes, subjects were seated on the bicycle (only one ergometer was used for the final test in Phase 2 and 3) and seat height was adjusted until one leg was almost fully extended at the bottom of the stroke for that leg. Subjects pedalled quickly for a few seconds at no resistance to overcome the initial resistance of the flywheel. The resistance was then set according to each subject's weight, the researcher said "start" and a stopwatch was started. The bicycle was equipped with a revolution counter which was activated at the "start" signal. The researcher gave verbal encouragement to each subject to perform to his maximum. Each five second interval was noted and the corresponding number of revolutions recorded. When the test was completed at 30 seconds, subjects were urged to walk or, in Phases 2 and 3, ride the other ergometer for a few minutes to avoid venous pooling. The test bicycle was then freed for testing the next subject.

In Phase 1, one assistant used a stopwatch and noted the passage of five second intervals during the test; another assistant recorded the number of revolutions attained during each five second interval. In Phases 2 and 3, subjects received an explanation of the revolution counter and test procedure during their warm-ups; subjects not being tested served as recorders and noted the number of revolutions obtained when the researcher called out five second points during the tests.

Values were converted to mechanical power (kpm/min/kg) according to the test description (Wingate Anaerobic Test, 1977). The test's designers termed total power output in 30 seconds anaerobic capacity whereas the greatest output during any one five second period was called anaerobic power.

As mentioned in Chapter 2, Bar-Or (1978) reported test-retest reliabilities of 0.95 to 0.98 (same day) and 0.90 to 0.93 (two weeks apart) for "various age, sex and fitness groups" (p. 11). Validity was examined by comparing the test components with other measures. Bar-Or (1978) reported correlations of 0.79 to 0.86 between anaerobic power and the Margaria et al. (1966) test and 40 metre running speed, respectively. Correlations were reported between anaerobic capacity and oxygen debt maximum (r=0.86,N=16), 300 metre run time (r=0.86,N=20), and 25 metre swim time (r=0.87 to 0.90,N=20). Recent data (Bar-Or et al. 1980) showed a significant relationship between anaerobic capacity and the ratio of fast twitch to slow twitch fibres (r=0.63,p<.01) and between anaerobic power and the percent of fast twitch area (r=0.60,p<.01). Bar-Or (1978) noted that validation studies were continuing and that, although some caution was required, "we can still conclude that our test apparently does measure muscular performance capacity of the individuals, as limited by his anaerobic energy turnover" (p. 16). (It should have been emphasized, however, that the present study was not intended to validate the Wingate test. The terms, anaerobic power and capacity, were used in the present study to note the two indices that were derived from the test. Their use was not intended to indicate that the terms were necessarily valid.)

Specific Skills

Merrifield and Walford's (1969) forward skating speed measure was employed in the present study. This test involved asking players to skate as fast as possible from one goal line to the second blue line, a distance of approximately 120 feet on a regulation sized ice surface.

As mentioned above, the test was administered after a warm-up in each phase of the study. The warm-ups varied but were usually about 10 minutes long: those in Phase 2 were perhaps the most vigorous of all the phases. Players wore full equipment and skated the required distance twice. Times (to the nearest 0.1 second) were noted by the researcher in Phase 1 using (a sweep hand type) stopwatch. Two assistants noted times (to the nearest 0.01 second) in Phases 2 and 3 using digital stopwatches and the researcher recorded them. The average time of a subject's two trials served as his score on the skating speed measure. In general, the test took approximately 10 to 15 minutes to administer in all phases.

Although 120 feet was the distance between a goal line and second blue line on regulation sized ice surface, both the test sites in the present study involved smaller than "normal" ice surfaces. The site in Phase 1 was an older arena; the distance of interest was only 105'4". The site in Phases 2 and 3 involved two adjacent smaller ice surfaces which were used mainly for recreational hockey; the distance of interest was 101'8".

Using the 15 players in their study, Merrifield and Walford (1969) reported a test-retest reliability (tests one week apart) correlation of 0.74. Validity was claimed since a correlation of 0.83 was found between forward skating speed and a coach's rankings of playing ability. (Spearman's rho was used to calculate both reliability and validity coefficients.)

Psychological variables

Butt's (1979) 25-item "Sports Scales" was administered to players in Phases 1, 2 and 3. Subjects were asked to indicate "YES" or "NO" in response to items which asked about their feelings "during the last month while participating (training or competing) in hockey". (In Phase 2 and 3, which took place during the summer, the researcher instructed subjects to answer according to the last month they played hockey or, failing that, for their previous year in hockey.) Five items were included in the scale for each of Butt's five motivational components in sport (aggression, conflict, competence, competition and cooperation). Each scale could, therefore, yield a score from zero to five. Again, players were told to ask for help with any confusing or ambiguous terms. Most players completed the measure in a few minutes. Butt (1979) reported test-retest reliabilities (test two weeks apart; N=67 males, N=121 females) of 0.43 to 0.75 for the five subtests. (Subtests were reduced to five from 10 items each to make the "scales more efficient in the use of time" (p. 7).) Correlations of subtests scores, in different populations (N=178, N=36), with a variety of other psychological measures ranged from zero to 0.67. Although the statistical support was not strong, Butt (1979) believed the "results generally support the theoretical descriptions of the constructs" (p. 9).

A 10-item "Hockey Attitude Scale", adapted from the work of Rushall and his associates (Rushall and Fox (1980)), was administered to the players in Phases 1, 2 and 3. Subjects were asked to respond on four-point scales ranging from "Always" (i.e., 3) to "Never" (i.e., 0) to items which asked about their feelings with respect to training, preparing for and playing hockey. Players were asked to complete the measure individually and to ask the researcher for any necessary assistance in interpreting any word or item. Most players completed the measure in five minutes or less. Responses to each item were added to give a total score for each subject. Items 4, 7 and 10 were reversed and thus scored in the opposite direction to the other seven items.

In Phase 1, the present study employed item 6 of the scale developed by Scaramella and Brown (1978). The coach was asked to rate each player according to his perceived reactions of the player to an aggressive situation. The five-point scale varied from a rating of five, i.e., "always able", to one, i.e., "rarely able to respond in an aggressive manner without becoming intimidated". The coach completed the measure for each player in a few minutes. In Phases 2 and 3, no single coach was available since players came from many different teams. Therefore, the Scaramella and Brown (1978) measure was adapted to become a self-report measure. On a scale from five, i.e., "always", to one, i.e., "rarely", players were to indicate "How often do you play hockey aggressively (hustling, fighting hard for the puck, etc.)?". (This item was included on a form which asked for ratings of other players and an indication of the subject's height.)

In addition to the above psychological measures, subjects in Phases 2 and 3 were asked to complete the Junior Eysenck Personality Inventory (i.e., Jr.EPI) (Eysenck, 1963). This measure was adapted from the Eysenck Personality Inventory (Eysenck and Eysenck, 1963) for adults. The Jr.EPI contained 60 items requiring subjects to give a "YES" or "NO" response regarding their tendencies to feel or behave in certain ways. The instrument was scored to result in indices for three subscales, extraversion-introversion (24 items), neuroticism or emotionality (24 items), and a lie subscale (12 items) for the detection of faking. Extraversion-introversion and neuroticism were termed "two major personality variables" (Esysenck, 1963, p. 3). Eysenck reported standardization data on over 2,000 children ranging from ages seven to 16. Test-retest reliabilities (tests one month apart) within this age range varied from 0.41 to 0.92 (N=1056 boys, N=1074 girls); split-half reliabilities (Spearman Brown Prophecy Formula) ranged from 0.41 to 0.89 (N=3372 boys, N=3388 girls). Eysenck (1963) reported that there was some clinical evidence pointing to the validity of the Jr.EPI but it was too soon to make claims about the validity of the scale. Most subjects in the present study completed this measure in a few minutes. Scoring keys were available to arrive at scores for each subscale. (Copies of the Jr.EPI were available from EdITS, P.O. Box 7234, San Diego, California 92107.)

The Profile of Mood States (i.e., POMS) (McNair, Lorr and, Droppleman, 1971) was also completed by subjects in Phases 2 and 3. Subjects were asked to describe how they "have been feeling during the past week including today" by responding to 65 descriptors of feelings, using a five-point semantic differential ranging from zero, i.e., "Not at all", to four, i.e., "Extremely". Scoring keys allowed for the separation of responses into six factors, i.e., tension-anxiety (nine items), depression-dejection (15 items), anger-hostility (12 items), vigor-activity (eight items), fatigue-inertia (seven items), and confusion-bewilderment (seven items). The test's authors reported that the measurement of these six mood or affective states was useful in assessing change in psychiatric outpatients as a result of therapy or affective traits or changes in normal subjects. McNair et al. (1971) reported internal consistency correlations (Kuder-Richardson) of between 0.84 and 0.95 (N=1000) for the six subscales; test-retest reliabilities (four weeks between tests) of from 0.61 to 0.69 (N=150) were also noted. Examinations of validity included the reporting of correlations between PCMS and various other measures; r's ranged from 0.18 (N=523) to 0.80 (N=200), the latter representing the relationship between the Manifest Anxiety Scale and the POMS tension-anxiety subscale. (Whereas most Phase 2 subjects completed the POMS in a few minutes, many more questions were asked by the younger subjects in Phase 3. As mentioned previously, the meanings of words unknown to subjects were given without directing subjects' responses.) (Copies of the PCMS were available from EdITS, P.O. Box 7234, San Diego, California 92107.)

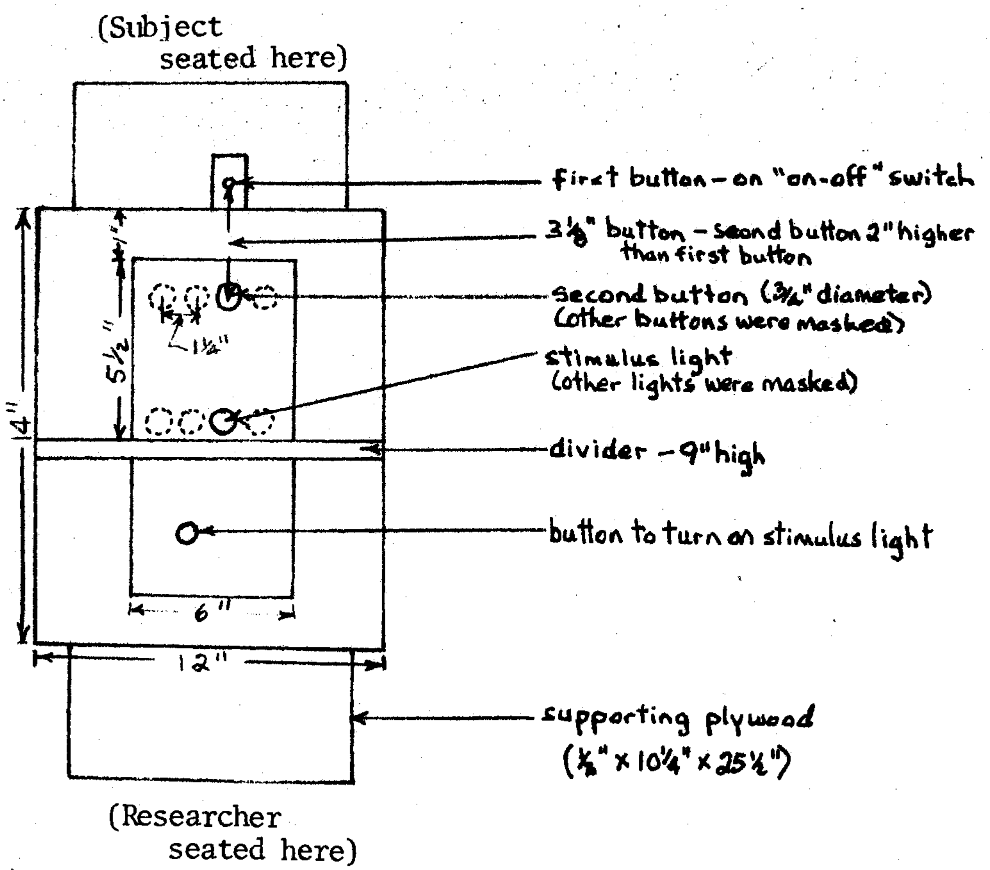
Perceptual-motor behavior

Although movement time was measured in Phases 1, 2 and 3 in the present study, decision (or reaction) time and total response time were also noted. Each subject was seated before a table and asked to place his finger (of his dominant or preferred hand) on a small button on the apparatus in front of him. Approximately 3 1/8 inches beyond this button in the frontal plane (see Figure 1) was another button and, beyond that, a stimulus light. (The second button and the stimulus light were actually one of four buttons and four corresponding lights as the apparatus could be used to study responses in choice situations. In this study, the additional three buttons and lights were covered to minimize confusion and to allow the focus to be on movement and "simple" decision or reaction time.) Hidden from the subject's view was a button which the experimenter pressed to turn on the stimulus light. (The basic apparatus was a Model 6302A, 5 choice timer made by Lafayette Instrument Co., Lafayette, Indiana.)

In response to the stimulus light, the subject moved his finger as quickly as possible from the first to the second button. Two timers (Models 20225A and 20225, six volts supplied internally, Lafayette Instruments Co., Lafayette, Indiana) were employed to record results to the nearest 0.01 second. One timer began when the stimulus light was turned on; it stopped when the subject moved his finger from the first button, i.e., to allow for the determination of decision time. The second timer was stopped by pushing the second button, i.e., to determine total response time. Both times were recorded for each trial as was the difference between them, i.e., movement time.

Each subject was given a brief explanation of the apparatus and told it was a test of "how fast you can move your finger". Phase 1 subjects were given two practice trials and Phase 2 and 3 subjects five practice trials; any questions about procedure were answered before the test trials began. Phase 1 subjects completed five test trials; this was increased to 20 test trials in Phases 2 and 3. Before each trial, the researcher said "Ready"; the time between "Ready" and the stimulus light being turned on was (subjectively) varied by the researcher and averaged a few seconds. A subject's scores for this measure consisted of the mean of the decision, movement and total response times for the test trials. (Trials in which subjects obviously missed the button or the researcher made an error were rerun.)

FIGURE 1: RESPONSE SPEED MEASURE



Background information

Subjects in Phases 2 and 3 were asked to complete the "Student Hockey Form" during the large group testing sessions (see Procedures). Seven questions were asked, with the first inquiring about the subjects' ages. (Ages of Phase 1 subjects were obtained from the hockey club.) The next two questions asked for the number of years subjects had been playing hockey and playing in an "organized league", respectively. Questions 4 and 5 asked subjects to indicate how many times they had played and practiced "last year". Question 6 asked players to rate themselves from zero to 20 (a high number meaning "good") according to "how good a player" they felt themselves to be. The last question asked subjects to indicate the position they usually played.

The five categories of responses to questions 4 and 5 were scored from one (few times played or few practices) to five (a relatively high number of times played or practices). These scores were added to the responses to questions 2 (years played) and 3 (years in an organized league) to produce an index of "experience".

Descriptive measures

Weight and height were noted in Phases 1, 2 and 3. As mentioned above, both height and weight were requested during the administration of other measures in Phases 2 and 3; these data were self-reported. Weight was self-reported in Phase 1 whereas height was obtained from team records. Weight and height for Phase 3 subjects were also recorded on registration forms. The researcher compared the latter records with self-reported values and averaged blantantly discrepant values.

Forearm girth was measured on the dominant arm in Phases 2 and 3 using standard anthropometric technique (Carter, 1975). This measure had been related in previous investigations (Ward and Ross, 1980) to power as measured by a vertical jump. The measure was attractive in that it could be administered quickly during one of the small group test sessions.

Hockey playing ability

The criterion measure, hockey playing ability, that was employed in Phase 1 was that used by Deshaies et al. (1978). This measure asked the respondent to rate a player on 17 individual and eight tactical skills using a four-point scale from zero, i.e., "Poor", to three, i.e., "Excellent". Combining these two scales, a possibility of 75 total points existed for each player. Deshaies et al. (1978) reported an inter-judge (N=5) reliability of 0.94 (N=116 players were tested). As explained above (see Procedures), the Phase 1 coach and his assistant were asked to complete the criterion measure. Each players' total rating points were compared with the total possible (according to the number of items on which ratings were received) to produce a percentage, which served as that player's rating.

Since instructors in Phase 2 and 3 had not known their players for an entire hockey season and since the instructors' time was limited, a simplified criterion measure was designed for these phases. Players' names were listed on a single sheet and the rater was asked to provide a rating of each player's overall hockey playing ability, considering, if they wished, "such factors as skating, stickhandling, passing, shooting, checking, and positional play in your rating". Ratings could have ranged from zero, i.e., "Very poor", to 20, i.e., "Very good". Ratings from each of the pair of instructors assigned to the two groups in Phase 3 were obtained and averaged to produce a single rating for each player. In Phase 2, ratings were obtained from at least two coaches or instructors involved with each player group (see Procedures); available ratings on each player were averaged to produce a single rating for each player.

Subjects in Phases 2 and 3 were asked to provide ratings of other players in their groups as to "how good a hockey player you think he is". Subjects also were instructed to use a scale from zero to 20, with high numbers meaning good players. The list of players' names included their own, so that another (see Background information) self rating was obtained.

Data Collection and Analysis

Keys were available to score the standardized paper-and-pencil inventories. The other measures required adding scores for each item based on the semantic differential scale employed. Total scores were recorded at the top of each subject's form. Forms were designed to record the times obtained from subjects on the perceptual-motor task for all trials; places were left to note mean times for each subject. Forms to record data from the Wingate Anaerobic Test were also designed; the number of revolutions for each five second period were noted and space was left to indicate anaerobic power and capacity for each subject. Times for the two trials of the skating speed test were recorded on separate forms along with the mean time for the two trials. Master sheets were designed to record scores from all instruments for each individual in a manner that was amenable for keypunching. (See Appendix C for copies of the recording forms.)

Scores on the master sheets were entered and stored on disc files for analysis at the Simon Fraser University Computing Centre. Data analysis involved the Biomedical Computer Programs P-Series (BMDP) (Dixon, 1977). Program BMDP9R was used to produce univariate statistics (means, standard deviations), Pearson product-moment correlations and regression data. BMDP9R employed only complete data sets to produce the "best" subset of predictor variables. Other subsets were also printed so that alternate testing batteries might have been considered: for example, two or three subsets of predictors might have differed slightly in their predictive power but the instruments they included might have fitted more or less easily into particular testing situations. An attempt was made to choose subsets which would maximize multiple R^2 in a statistically significant prediction equation (minimize the sum of residuals) that involved instruments which could apparently be combined to produce viable test batteries. (The BMDP9R program allowed a choice of three criteria to select the "best" subset of predictors, i.e., Mallow's Cp, multiple R^2 or adjusted R^2. The BMDP9R default criterion was Cp and this criterion was chosen for use in the present study. In reviewing the three criteria mentioned above, as well as others, Hocking (1972) concluded that no one criterion proved to be best. Since the BMDP9R program provided all three of the criteria mentioned above, selecting alternate subsets could have reflected a consideration of all three criteria.)

IV. Results

Univariate Statistics

Initially, the basic descriptive statistics (e.g., means, standard diviation) were examined for group differences and possible trends. (See Chart 1 (pp. 132-134) for descriptions of variables and units.) Tables 1a to 1e (pp. 136-140) presented univariate statistics for subjects in the three phases of the present study, including statistics for each of the five groups, i.e., Phase 1 - Group 1, Phase 2 - Groups 2 and 3, and Phase 3 - Groups 4 and 5. (Only subjects with complete data sets were included: the N's reported in the results were for complete data sets unless otherwise specified) Table 2a (p. 141) provided a comparison of the five group means for all variables and Table 2b (p. 142) the results of the examination for group differences among these means. (One-way analysis of variance (ANOVA) was performed using the BMDP1V program. This program also applied t-tests to all pairs of group means.) As was indicated in Table 2b, the phases were distinguishable by age, confirming the initial sampling process. Subjects in Group 1 were statistically significantly older than those in Groups 2 ($t=10.1, p<.001$), 3 (t=11.0,p<.001), 4 (t=32.4,p<.001) and 5 (t=35.1,p<.001), whereas subjects in Phase 2 (Groups 2 and 3) were statistically significantly older than those in Phase 3 (Groups 4 and 5) (t's varied from 23.2 to 26.3, p<.001 for all pairings). Group 4 was also statistically significantly older than Group 5 (t=2.6,p<.05).

Mean scores on the Wingate Anaerobic Test (1977) indicators of "anaerobic power" (POWER) and "anaerobic capacity" (CAP) showed the superiority, in general, of subjects in Phase 2 over those in Phase 3 on the latter measure (t's from 2.3 to 6.2, p<.05 for all pairings) and the superiority of Group 2, in particular, on the former measure. With respect to "anaerobic power", Group 2 had the largest mean score, statistically significantly higher than that of the older Group 1 (t=2.6, p<.05), as well as being higher than the means of Groups 3 (t=2.5, p<.05), 4 (t=4.9, p<.001) and 5 (t=6.2, p<.001). The mean "anaerobic capacity" score for Group 1 was also larger than that of Group 5 (t=3.0, p<.05), whereas Group 3 mean was larger than those of both Group 4 (t=2.4, p<.05) and Group 5 (t=3.7, p<.001).

Mean scores on the skating speed (SPEED) variable distinguished subjects by phase: the Group 1 mean was statistically significantly less than the other group means (t's from 2.5 to 11.4,p<.05 for all pairings), whereas means for groups in Phase 2 were statistically significantly less than those in Phase 3 (t's from 8.3 to 9.4, $p<.001$ for all pairings). (The Group 1 mean decreased from 5.08 to 4.93 seconds when an adjustment was made for distance skated, i.e., 105 feet in Phase 1 versus 102 feet in Phases 2 and 3.)

Of the response speed measures, decision time (DT) and total response time (TRT) differentiated between Phase 3 groups, especially Group 5, and the remaining groups. Group 5 was statistically significantly slower than all other groups on both these measures (t's from 2.6 to 8.2, $p<.05$ for all pairings), whereas Group 4 was statistically significantly slower on decision time and total response time than Groups 1, 2 and 3 and Groups 2 and 3, respectively (t's from 2.2 to 5.6, all p's <.05). Only one difference was noted with regard to movement time (MT) as Group 3 was slower than Group 5 ($t=2.0$, $p<.05$).

Group 3 had the highest mean score on the aggression scale (AGGR) but it was statistically significantly larger than only the Group 1 mean ($t=2.8$, $p<.005$). No statistically significant differences were found between groups on the Hockey Attitude Scale.

Group mean differences were varied for the five subtests (SS1,SS2,SS3,SS4,SS5) on the Sports Scale. Both Groups 1 and 5 had statistically significantly larger means than Group 2 (t's=2.8, 2.4; $p<.05$ for both pairings) and Group 4 (t's =2.7,2.3; $p<.05$ for both pairings) on the SS1 (aggression) subtest. The Group 1 mean was also larger than that of Group 3

($t=2.1$, $p<.05$). On SS2 (conflict) and SS4 (competition), Group 1 had the largest mean score, being statistically significantly larger than all other groups on SS2 (t's from 2.0 to 4.8, all p's $<.05$) and Groups 4 and 5 on SS4 (t's $=5.7, 2.3$; $p<.05$). Groups 2, 3 and 5 also had statistically significantly larger means than Group 4 on both the SS2 subtest (t's from 2.2 to 2.9, all p's $<.05$) and SS4 subtest (t's from 4.1 to 5.7, all p's $<.001$). On SS3 (competence), both Phase 3 groups had statistically significantly larger means than did Group 1 (t's $=2.1, 2.2$; p's $<.05$). Group 1 had the largest mean on SS5 (cooperation) but it was statistically significantly larger than only Group 3 ($t=2.5$, $p<.05$).

Chart 1

Key to Variable Abbreviations

VARIABLE ABBREVIATION	DESCRIPTION OF VARIABLE
GROUP	designated membership in Groups 1 to 5
AGE	chronological age of subject in months
POWER	"anaerobic power" (in kpm/min/kg), as defined by the Wingate Anaerobic Test
CAP	"anaerobic capacity" (in kpm/min/kg), as defined by the Wingate Anaerobic Test
SPEED	skating speed (in seconds)
DT	decision (or reaction) time (in .01 seconds)
MT	movement time (in .01 seconds)
TRT	total response time (the sum of DT + MT) (in .01 seconds)
AGGR	"aggression", as determined by coach's ratings (Phase 1) or self-ratings (Phases 2 and 3) (max. score = 5)
HAS	Hockey Attitude Scale (max. score = 30)
SS1	"aggression" subscale of Sports Scale (max. score = 5)
SS2	"conflict" subscale of Sports Scale (max.score = 5)

SS3	"competence" subscale of Sports Scale (max.score = 5)
SS4	"competition" subscale of Sports Scale (max. score = 5)
SS5	"cooperation" subscale of Sports Scale (max. score = 5)
EPIEX	"extroversion" subscale of Junior Eysenck Personality Inventory (max. score = 24)
EPIN	"neuroticism" subscale of Junior Eysenck Personality Inventory (max. score = 24)
EPIL	"lie" subcale of Junior Eysenck Personality Inventory (max. score = 12)
POMST	"tension" subscale of Profile of Mood States (max. score = 9)
POMSD	"depression" subscale of Profile of Mood States (max. score = 15)
POMSA	"anger" subscale of Profile of Mood States (max. score = 12)
POMSV	"vigor" subscale of Profile of Mood States (max. score = 8)
POMSF	"fatigue" subscale of Profile of Mood States (max. score = 7)
POMSC	"confusion" subscale of Profile of Mood States (max. score = 7)
RATKID	rating of hockey ability of subject by other group members (max. score = 20)
EXPER	index of hockey experience of subject

WEIGHT	weight of subject in kilograms
HEIGHT	height of subject in centimetres
FARM	forearm girth of subject's dominant arm in centimetres
RATINS	rating of hockey ability of subject by instructors/coaches (max. score = 20)

Table 1a

Univariate Statistics for Phase 1 - Group 1 (Complete cases N=16)

Variable	Mean	Standard Deviation	Smallest Value	Largest Value
AGE	223.81	11.62	203.00	238.00
POWER	52.96	7.46	40.00	63.80
CAP	41.75	4.22	33.40	51.20
SPEED	5.08	0.12	4.90	5.40
DT	18.63	2.65	15.60	26.20
MT	13.03	2.50	9.00	18.00
TRT	31.65	4.18	26.20	42.40
AGGF	3.25	1.13	1.00	5.00
HAS	18.13	3.16	11.00	22.00
SS1	3.87	1.54	0.00	5.00
SS2	2.75	1.06	1.00	5.00
SS3	2.94	1.12	1.00	5.00
SS4	3.81	0.75	2.00	5.00
SS5	4.88	0.34	4.00	5.00
WEIGHT	84.62	4.23	78.10	92.20
HEIGHT	184.64	6.48	175.30	200.70
RATINS	41.76	19.32	0.00	69.70

Table 1b

Univariate Statistics for Phase 2 - Group 2 (Complete cases N=20)

Variable	Mean	Standard Deviation	Smallest Value	Largest Value
AGE	196.15	2.85	188.00	200.00
POWER	58.24	8.19	45.00	78.10
CAP	46.80	4.52	38.60	57.00
SPEED	5.45	0.34	4.99	6.50
DT	17.37	1.83	14.70	21.00
MT	12.45	1.33	9.40	15.00
TRT	29.80	2.72	24.10	36.00
AGGR	3.80	0.77	3.00	5.00
HAS	17.40	2.91	12.00	23.00
SS1	2.55	1.73	0.00	5.00
SS2	1.95	1.19	0.00	4.00
SS3	3.25	1.25	1.00	5.00
SS4	3.20	1.28	1.00	5.00
SS5	4.40	0.99	2.00	5.00
EPIEX	18.80	2.91	13.00	23.00
EPIN	12.20	5.17	3.00	21.00
EPIL	3.20	1.79	0.00	7.00
POMST	13.15	5.25	5.00	22.00
POMSD	8.05	8.27	0.00	30.00
POMSA	7.90	8.40	0.00	32.00
POMSV	19.90	3.16	15.00	27.00
POMSF	9.75	5.31	0.00	21.00
POMSC	7.20	3.87	2.00	17.00
RATKID	14.75	1.11	12.40	16.90
EXPER	25.15	3.63	17.00	31.00
WEIGHT	69.78	6.53	59.00	84.00
HEIGHT	175.49	6.54	161.30	188.00
FARM	27.93	1.32	25.90	29.80
RATINS	15.60	1.84	12.00	18.30

Table 1c

Univariate Statistics for Phase 2 - Group 3
(Complete cases N=23)

Variable	Mean	Standard Deviation	Smallest Value	Largest Value
AGE	194.61	3.91	187.00	200.00
POWER	51.81	8.89	37.50	69.90
CAP	42.40	5.86	30.40	52.50
SPEED	5.57	0.43	5.06	6.82
DT	17.58	2.43	13.50	22.00
MT	13.67	2.31	9.80	20.70
TRT	31.21	3.86	25.00	39.00
AGGR	4.13	0.97	2.00	5.00
HAS	16.26	3.31	9.00	22.00
SS1	2.91	1.47	0.00	5.00
SS2	1.87	1.39	0.00	5.00
SS3	3.39	1.20	1.00	5.00
SS4	3.04	0.93	1.00	5.00
SS5	4.04	1.33	0.00	5.00
EPIEX	18.65	3.52	12.00	27.00
EPIN	11.13	4.31	3.00	19.00
EPIL	3.00	2.13	0.00	7.00
POMST	10.61	3.89	5.00	17.00
POMSD	7.87	6.93	0.00	25.00
POMSA	8.09	6.13	0.00	29.00
POMSV	20.09	3.40	15.00	28.00
POMSF	9.78	6.74	0.00	25.00
POMSC	6.04	3.25	1.00	14.00
RATKID	15.35	0.89	13.30	16.80
EXPER	24.83	2.66	20.00	29.00
WEIGHT	72.70	6.67	60.40	86.30
HEIGHT	178.93	5.45	169.50	189.20
FARM	27.93	1.48	25.50	30.90
RATINS	15.29	1.25	12.70	17.50

Table 1d

Univariate Statistics for Phase 3 - Group 4 (Complete cases N=27)

Variable	Mean	Standard Deviation	Smallest Value	Largest Value
AGE	140.37	8.84	124.00	158.00
POWER	51.30	15.46	29.80	99.90
CAP	38.47	7.66	22.50	54.40
SPEED	6.64	0.68	5.51	8.36
DT	21.14	2.30	17.30	26.10
MT	12.39	2.38	8.60	18.10
TRT	33.51	4.03	26.20	43.20
AGGB	3.63	0.88	1.00	5.00
HAS	16.59	3.62	11.00	25.00
SS1	2.67	1.30	0.00	5.00
SS2	0.93	0.96	0.00	3.00
SS3	3.74	1.06	1.00	5.00
SS4	1.67	1.36	0.00	4.00
SS5	4.48	1.05	0.00	5.00
EPIEX	17.67	2.76	12.00	22.00
EPIN	11.74	4.96	3.00	23.00
EPIL	3.96	1.74	1.00	9.00
POMST	8.93	4.63	0.00	22.00
POMSD	8.78	8.11	0.00	31.00
POMSA	9.44	6.59	1.00	22.00
POMSV	18.78	4.87	7.00	29.00
POMSF	9.00	4.42	1.00	17.00
POMSC	7.56	3.88	2.00	18.00
RATKID	13.50	2.62	7.10	18.90
EXPER	16.26	5.88	4.00	29.00
WEIGHT	37.14	5.63	27.20	49.90
HEIGHT	145.44	8.31	127.00	162.60
FARM	21.56	1.49	18.50	24.30
RATINS	14.81	2.71	8.50	20.00

Table 1e

Univariate Statistics for Phase 3 - Group 5 (Complete cases N=29)

Variable	Mean	Standard Deviation	Smallest Value	Largest Value
AGE	134.62	9.95	112.00	149.00
POWER	47.23	9.99	31.70	79.30
CAP	36.34	5.25	27.30	51.00
SPEED	6.69	0.37	6.13	7.63
DT	22.87	2.26	19.50	26.90
MT	13.21	2.44	10.30	20.20
TRT	36.05	3.49	30.80	44.50
AGGF	3.79	1.05	1.00	5.00
HAS	16.17	2.79	11.00	22.00
SS1	3.55	1.21	2.00	5.00
SS2	1.62	1.27	0.00	4.00
SS3	3.72	1.25	1.00	5.00
SS4	2.97	1.35	1.00	5.00
SS5	4.45	1.06	1.00	5.00
EPIEX	16.93	3.64	11.00	24.00
EPIN	13.52	4.99	5.00	24.00
EPIL	3.79	2.16	1.00	8.00
POMST	10.62	5.27	0.00	22.00
POMSD	10.76	8.69	0.00	40.00
POMSA	13.55	7.78	1.00	30.00
POMSV	19.41	4.46	11.00	31.00
POMSF	8.34	5.10	1.00	21.00
POMSC	7.66	3.97	1.00	18.00
RATKID	13.01	2.05	8.50	18.00
EXPER	17.21	4.22	8.00	24.00
WEIGHT	36.64	4.91	27.20	47.70
HEIGHT	144.08	8.28	127.00	162.60
FARM	21.18	1.20	19.10	24.10
RATINS	12.84	2.98	7.00	19.00

Table 2a

A Comparison of Means of All Variables for Phase 1 (Group 1), Phase 2 (Groups 2 and 3) and Phase 3 (Group 4 and 5)

	GROUP 1 (N=16)	GROUP 2 (N=20)	GROUP 3 (N=23)	GROUP 4 (N=27)	GROUP 5 (N=29)	TOTAL MEAN (N=115)
AGE[2]	223.81	196.15	194.61	140.37	134.62	171.08
POWER[1]	52.96	58.24	51.81	51.30	47.23	51.81
CAP[2]	41.75	46.79	42.40	38.47	36.34	40.62
SPEED[2]	5.08[4]	5.45	5.57	6.64	6.69	6.02
DT[2]	18.62	17.37	17.58	21.14	22.87	19.86
MT	13.03	12.45	13.67	12.39	13.21	12.95
TRT[2]	31.65	29.79	31.21	33.51	36.05	32.78
AGGR	3.25	3.80	4.13	3.63	3.79	3.70
HAS	18.12	17.40	16.26	16.59	16.17	16.77
SS1[1]	3.87	2.55	2.91	2.67	3.55	3.09
SS2[2]	2.75	1.95	1.87	0.93	1.62	1.72
SS3	2.94	3.25	3.39	3.74	3.72	3.47
SS4[2]	3.81	3.20	3.04	1.67	2.97	2.83
SS5	4.88	4.40	4.04	4.45	4.45	4.43
EPIEX	N/A[3]	18.80	18.65	17.67	16.93	17.91
EPIN	N/A	12.20	11.13	11.74	13.52	12.21
EPIL	N/A	3.20	3.00	3.96	3.79	3.54
POMST[1]	N/A	13.15	10.61	8.93	10.62	10.67
POMSD	N/A	8.05	7.87	8.78	10.76	9.00
POMSA[1]	N/A	7.90	8.09	9.44	13.55	10.02
POMSV	N/A	19.90	20.09	18.78	19.41	19.49
POMSF	N/A	9.75	9.78	9.00	8.34	9.14
POMSC	N/A	7.20	6.04	7.56	7.66	7.16
RATINS[2]	41.76	15.60	15.29	14.81	12.84	18.30
RATKID[2]	N/A	14.75	15.35	13.50	13.01	14.04
EXPER[2]	N/A	25.15	24.83	16.26	17.21	20.32
WEIGHT[2]	84.62	69.73	72.70	37.14	36.64	56.41
HEIGHT[2]	184.64	175.48	178.93	145.44	144.08	162.48
FARM[2]	N/A	27.93	27.93	21.56	21.18	24.22

1 ANOVA (BMDP1V) demonstrated statistically significant ($p<.05$) differences among group means for these variables.
2 ANOVA (BMDP1V) demonstrated statistically significant ($p<.01$) differences among group means for these variables.
3 Variables noted by N/A were not administered to Phase 1 subjects.
4 Since Phase 1 subjects skated 105 feet versus 102 feet in Phases 2 and 3, the Group 1 mean would have decreased to 4.93 seconds if an adjustment was made for distance (i.e., 5.08 x 102/105).

Table 2b

Differences of Group Means for All Variables: Groups with Means Significantly Greater than (GT) Means of Other Groups

VARIABLE	GROUP 1 MEAN GT	GROUP 2 MEAN GT	GROUP 3 MEAN GT	GROUP 4 MEAN GT	GROUP 5 MEAN GT
AGE	2,3,4,5	4,5	4,5	5	
POWER		4,5			
CAP	5	1,3,4,5	4,5		
SPEED[1]	2,3,4,5	4,5	4,5		
DT[1]				1,2,3	1,2,3,4
MT[1]			4		
TRT[1]				2,3	1,2,3,4
AGGR			1		
HAS					
SS1	2,3,4				2,4
SS2	2,3,4,5	4	4		4
SS3				1	1
SS4	4,5	4	4		4
SS5	3				
EPIEX	N/A[2]				
EPIN	N/A				
EPIL	N/A				
POMST	N/A	4			
POMSD	N/A				
POMSA	N/A				2,3,4
POMSV	N/A				
POMSF	N/A				
POMSC	N/A				
RATINS[3]	N/A	5	5	5	
RATKID	N/A	4,5	4,5		
EXPER	N/A	4,5	4,5		
WEIGHT	2,3,4,5	4,5	4,5		
HEIGHT	2,3,4,5	4,5	4,5		
FARM	N/A	4,5	4,5		

1 These variables involved speed; therefore, greater scores meant slower responses.
2 These measures were not administered to Group 1. (See footnote 3.)
3 Group 1 used a different rating scale and was not included in this comparison table.

No group mean differences existed between the Phases 2 and 3 groups on the subtests of the Junior Eysenck Personality Inventory (EPIEX, EPIN, EPIL) and few differences were noted with respect to the subtests of the Profile of Mood States (POMS) measure. (The Jr. EPI and POMS were not administered to Group 1.) The Group 2 mean on the POMST (tension) variable was statistically significantly greater than the Group 4 mean ($t=3.0$, $p<.01$). The Group 5 mean of the POMSA (anger) subtest was statistically significantly larger than means for Groups 2 ($t=2.7$, $p<.01$), 3 ($t=2.7$, $p<.01$) and 4 ($t=2.1$, $p<.05$).

Comparisons of means of Groups 2 to 5, which used a common instructor's rating scale or criterion measure (RATINS), showed that Group 5 had a statistically significantly lower mean than Groups 2, 3 and 4 (t's from 3.1 to 4.0, p's $<.01$). Mean scores of subjects rated by others in a subject's group (RATKID) indicated that means of groups in Phase 2 were statistically significantly higher than those in groups in Phase 3 (t's from 2.2 to 4.5, p's$<.05$). The experience measure (EXPER) also showed the superiority of Phase 2 group means over those of Phase 3 (t's from 6.3 to 6.9, p's $<.001$).

Both weight and height distinguished group means by phases. Group 1 was heavier than all other groups (t's from 6.4 to 27.1, $p<.001$ for all pairings), whereas Phase 2 groups' mean weights were statistically significantly larger than those of groups in Phase 3 (t's from 19.5 to 22.7, all p's $<.001$). A similar pattern was evident with respect to height, as Phase 1 mean height was greater than all other groups (t's from 2.4 to 17.9, all p's<.05) and Phase 2 groups were taller, on average, than Phase 3 groups (t's from 14.0 to 17.2, all p's <.001). Forearm girth (FARM) was not measured in Group 1: however, the trend was similar to those observed for height and weight, group means for Phase 2 were statistically significantly larger than those for Phase 3 (t's from 15.7 to 17.6, all p's<.001).

Table 3a

Correlation Matrix Between All Variables in Phase 1 - Group 1 (N=16)

	AGE	POWER	CAP	SPEED	DT	MT	TRT	AGGR	HAS	SS1	SS2	SS3	SS4
AGE	1.000												
POWER	0.294	1.000											
CAP	0.396	0.845**	1.000										
SPEED	0.056	-0.024	-0.185	1.000									
DT	0.023	-0.421	-0.311	0.248	1.000								
MT	-0.369	-0.454	-0.547*	0.185	0.321	1.000							
TRT	-0.206	-0.538*	-0.523*	0.267	0.825**	0.800**	1.000						
AGGR	0.090	0.108	0.264	0.089	-0.213	-0.031	-0.153	1.000					
HAS	-0.351	-0.287	-0.423	0.133	-0.206	0.138	-0.048	-0.403	1.000				
SS1	-0.083	0.172	0.014	-0.088	-0.195	0.022	-0.110	-0.556*	0.550*	1.000			
SS2	0.190	0.519*	0.279	-0.201	-0.423	-0.223	-0.401	0.167	0.109	0.385	1.000		
SS3	-0.134	0.475	0.484	0.041	-0.233	-0.398	-0.385	-0.040	0.284	0.456	0.432	1.000	
SS4	-0.333	0.058	-0.045	-0.043	0.144	-0.054	0.058	-0.178	0.151	0.151	0.021	0.381	1.000
SS5	0.145	0.461	0.384	0.105	0.166	-0.231	-0.033	0.260	-0.355	-0.032	0.092	-0.022	0.163
WEIGHT	0.095	-0.095	-0.195	0.544*	0.486	0.007	0.312	0.107	-0.429	-0.471	-0.319	-0.251	0.012
HEIGHT	-0.060	-0.239	-0.258	0.157	0.544*	0.473	0.627**	0.215	-0.276	-0.553*	-0.228	-0.264	0.316
RATINS	-0.011	-0.099	0.110	-0.499*	-0.194	0.210	0.002	0.385	-0.017	-0.174	0.069	-0.137	-0.280

	SS5	WEIGHT	HEIGHT	RATINS
SS5	1.000			
WEIGHT	0.246	1.000		
HEIGHT	0.029	0.512*	1.000	
RATINS	-0.117	-0.276	0.238	1.000

* These correlations were significant at the .05 level.

** These correlations were significant at the .01 level.

Table 3b

Correlation Matrix Between All Variables in Phase 2 - Group 2 (N=20)

	AGE	POWER	CAP	SPEED	DT	MT	TRT	AGGR	HAS	SS1	SS2	SS3	SS4
AGE	1.000												
POWER	0.370	1.000											
CAP	0.636**	0.641**	1.000										
SPEED	-0.222	0.119	-0.031	1.000									
DT	-0.178	-0.106	-0.311	0.245	1.000								
MT	0.010	-0.246	-0.480*	0.095	0.475*	1.000							
TRT	-0.114	-0.190	-0.444*	0.213	0.905**	0.805**	1.000						
AGGR	-0.226	0.095	-0.199	0.131	-0.285	0.119	-0.137	1.000					
HAS	-0.287	0.177	0.081	0.221	0.041	0.127	0.087	0.344	1.000				
SS1	-0.135	0.023	-0.220	-0.117	0.223	-0.072	0.116	-0.309	-0.443	1.000			
SS2	-0.230	-0.393	-0.407	-0.085	0.185	0.128	0.182	0.161	0.097	0.218	1.000		
SS3	0.063	0.056	-0.140	0.320	0.632**	0.480*	0.655**	0.110	-0.043	0.103	-0.026	1.000	
SS4	0.467*	-0.161	0.076	0.050	0.287	0.226	0.302	-0.492*	-0.263	0.209	0.283	0.098	1.000
SS5	-0.226	-0.161	-0.173	0.158	-0.036	-0.048	-0.048	0.248	0.542*	-0.257	0.240	0.042	-0.190
EPIEX	-0.028	0.370	0.359	0.142	0.126	-0.487*	-0.154	-0.042	-0.207	0.106	-0.276	0.202	-0.031
EPIN	0.184	0.149	-0.065	0.147	0.210	0.316	-0.296	0.077	0.211	0.169	0.429	0.155	0.296
EPIL	-0.171	-0.184	0.001	0.087	-0.182	-0.287	-0.264	-0.084	0.145	-0.393	-0.167	-0.234	0.073
POMST	0.055	-0.064	-0.055	-0.034	-0.414	-0.242	-0.396	0.451*	-0.224	0.147	0.312	-0.206	-0.091
POMSD	0.350	0.074	0.107	-0.405	-0.382	-0.128	-0.317	0.259	-0.388	-0.035	0.022	-0.057	-0.165
POMSA	0.242	-0.026	0.014	-0.286	-0.387	-0.052	-0.284	0.144	-0.310	0.152	-0.032	-0.013	0.002
POMSV	-0.086	0.150	0.101	0.044	0.017	-0.272	-0.121	0.230	0.165	-0.009	0.362	-0.260	0.018
POMSF	-0.018	-0.171	-0.257	-0.318	0.012	0.190	0.096	0.297	-0.092	0.371	0.689**	0.113	0.186
POMSC	0.092	-0.206	-0.184	-0.281	-0.275	-0.002	-0.184	0.103	-0.437	0.320	0.242	-0.098	0.034
RATKID	0.393	0.305	0.238	-0.440	-0.157	-0.069	-0.142	-0.074	-0.121	-0.004	-0.233	0.172	0.007
EXPER	0.023	-0.148	0.074	0.075	0.155	0.079	0.141	-0.083	0.303	0.129	0.038	0.281	0.287
WEIGHT	0.201	-0.063	-0.253	-0.166	0.074	0.214	0.153	0.069	-0.317	0.089	0.095	0.325	0.148
HEIGHT	-0.178	-0.413	-0.506*	-0.343	0.116	0.200	0.171	0.148	0.026	-0.079	0.272	0.253	-0.037
FARM	0.341	0.110	0.049	0.227	-0.134	0.089	-0.045	-0.046	-0.198	0.064	0.048	0.129	0.332
RATINS	0.298	0.417	0.143	-0.160	0.196	0.076	0.170	-0.034	0.025	-0.103	-0.405	0.452*	-0.055

	SS5	EPIEX	EPIN	EPIL	POMST	POMSD	POMSA	POMSV	POMSF	POMSC	RATKID	EXPER	WEIGHT
SS5	1.000												
EPIEX	-0.080	1.000											
EPIN	0.066	-0.424	1.000										
EPIL	0.012	0.119	-0.124	1.000									
POMST	0.048	-0.039	0.369	-0.054	1.000								
POMSD	-0.278	-0.100	0.228	-0.132	0.643**	1.000							
POMSA	-0.247	-0.224	0.329	-0.030	0.570**	0.845**	1.000						
POMSV	0.147	0.169	0.324	-0.098	0.495*	0.149	0.043	1.000					
POMSF	-0.159	-0.259	0.516*	-0.254	0.550*	0.517*	0.549*	0.259	1.000				
POMSC	-0.350	-0.285	0.340	-0.082	0.702**	0.797**	0.849**	0.126	0.678**	1.000			
RATKID	-0.196	0.070	-0.058	0.137	-0.021	0.420	0.417	-0.122	0.168	0.320	1.000		
EXPER	0.172	-0.166	0.270	0.157	-0.032	-0.119	0.283	0.024	0.190	0.129	0.177	1.000	
WEIGHT	-0.014	-0.021	-0.020	0.013	0.189	0.315	0.267	-0.052	0.228	0.421	0.675**	0.093	1.000
HEIGHT	0.288	-0.214	-0.148	0.187	-0.121	0.044	0.079	-0.117	0.195	0.113	0.497*	0.253	0.670**
FARM	0.078	-0.080	0.075	-0.138	0.256	0.183	0.253	0.055	0.121	0.321	0.400	0.123	0.688**
RATINS	-0.005	0.214	-0.015	0.100	-0.244	0.208	0.208	-0.099	-0.125	-0.005	0.814**	0.201	0.586**

	HEIGHT	FARM	RATINS
HEIGHT	1.000		
FARM	0.183	1.000	
RATINS	0.470*	0.265	1.000

* These correlations were significant at the .05 level.

** These correlations were significant at the .01 level.

Table 3c

Correlation Matrix Between All Variables in Phase 2 - Group 3 (N=23)

	AGE	POWER	CAP	SPEED	DT	MT	TRT	AGGR	HAS	SS1	SS2	SS3	SS4
AGE	1.000												
POWER	0.021	1.000											
CAP	-0.129	0.947**	1.000										
SPEED	-0.094	-0.043	-0.078	1.000									
DT	-0.089	-0.041	-0.014	0.393	1.000								
MT	-0.072	-0.378	-0.366	0.213	0.330	1.000							
TRT	-0.098	-0.254	-0.229	0.374	0.825**	0.805**	1.000						
AGGR	0.399	0.285	0.156	0.191	0.017	0.026	0.026	1.000					
HAS	-0.263	-0.136	-0.155	-0.099	-0.016	-0.011	-0.015	-0.224	1.000				
SS1	-0.030	0.083	0.131	0.062	0.111	-0.192	-0.045	0.295	-0.088	1.000			
SS2	-0.269	-0.056	0.069	0.228	-0.119	-0.083	-0.121	-0.088	-0.368	0.083	1.000		
SS3	0.102	-0.362	-0.330	-0.034	-0.322	0.149	-0.112	0.189	0.260	0.278	-0.023	1.000	
SS4	0.055	0.098	0.089	0.086	-0.010	-0.201	-0.127	0.297	0.085	0.169	0.286	0.107	1.000
SS5	0.170	0.022	-0.027	0.215	-0.102	0.077	-0.019	0.313	0.318	0.303	-0.291	0.560**	0.035
EPIEX	0.310	-0.164	-0.143	0.062	-0.239	-0.038	-0.175	0.240	0.113	0.423*	-0.130	0.562**	0.408
EPIN	0.009	0.094	0.146	0.170	0.261	0.006	0.168	-0.168	-0.178	0.081	0.420*	-0.389	0.214
EPIL	-0.218	-0.262	-0.311	-0.333	-0.060	0.167	0.059	0.088	0.245	0.159	-0.322	0.321	0.046
POMST	0.007	0.087	0.103	0.011	0.309	-0.053	0.167	0.062	0.118	0.002	0.393	-0.249	0.206
POMSD	0.114	-0.054	-0.032	-0.222	0.265	-0.180	0.061	-0.526**	0.339	-0.148	-0.134	-0.361	-0.140
POMSA	-0.052	-0.180	-0.124	-0.263	0.154	-0.126	0.024	-0.523*	0.387	-0.281	-0.052	-0.234	-0.089
POMSV	0.010	-0.418*	-0.488*	-0.202	-0.323	0.018	-0.194	0.176	0.277	-0.062	-0.257	0.461*	0.143
POMSF	-0.119	0.238	0.313	0.095	0.271	-0.024	0.158	0.025	-0.150	-0.098	0.515*	-0.423*	0.343
POMSC	0.037	0.050	0.085	-0.123	0.544**	0.070	0.385	-0.305	0.383	-0.094	-0.129	-0.133	-0.121
RATKID	-0.170	0.319	0.348	-0.228	-0.049	-0.413*	-0.280	-0.271	0.109	-0.259	-0.199	-0.377	-0.003
EXPER	0.015	0.541**	0.509*	0.121	-0.030	-0.079	-0.066	0.027	-0.057	-0.155	-0.215	-0.178	-0.089
WEIGHT	-0.208	-0.268	-0.309	0.097	0.107	0.070	0.107	-0.135	0.344	0.125	-0.197	0.013	0.037
HEIGHT	0.285	-0.451*	-0.556**	0.217	0.200	0.453*	0.396	0.132	-0.221	-0.027	-0.075	0.065	0.026
FARM	-0.185	0.243	0.223	-0.025	0.186	-0.186	0.003	-0.123	0.464*	0.199	-0.269	-0.120	0.125
RATINS	-0.029	0.300	0.256	-0.083	-0.100	-0.229	-0.205	-0.120	0.052	-0.357	-0.328	-0.278	0.051

	SS5	EPIEX	EPIN	EPIL	POMST	POMSD	POMSA	POMSV	POMSF	POMSC	RATKID	EXPER	WEIGHT
SS5	1.000												
EPIEX	0.440*	1.000											
EPIN	-0.397	-0.012	1.000										
EPIL	0.064	0.194	-0.356	1.000									
POMST	-0.365	-0.302	0.447*	-0.120	1.000								
POMSD	-0.330	-0.140	0.370	-0.074	0.534**	1.000							
POMSA	-0.457*	-0.255	0.471*	-0.028	0.493*	0.819**	1.000						
POMSV	0.150	0.337	-0.224	0.565**	-0.286	-0.169	0.117	1.000					
POMSF	-0.607**	-0.252	0.600**	-0.300	0.632**	0.169	0.282	-0.440*	1.000				
POMSC	-0.147	-0.236	0.346	-0.111	0.568**	0.740**	0.688*	-0.185	0.276	1.000			
RATKID	-0.266	-0.081	-0.134	-0.074	-0.108	0.265	0.197	0.009	0.120	0.087	1.000		
EXPER	0.182	0.022	-0.177	-0.193	-0.288	-0.016	-0.208	-0.205	-0.203	-0.115	0.437*	1.000	
WEIGHT	-0.104	0.180	-0.151	0.152	-0.040	0.125	0.020	0.249	-0.109	0.058	0.270	-0.273	1.000
HEIGHT	-0.238	0.161	0.051	0.062	0.000	-0.057	-0.108	0.203	-0.073	-0.073	-0.280	-0.341	0.570**
FARM	0.119	0.109	-0.031	-0.062	0.063	0.231	0.051	-0.068	0.017	0.354	0.368	-0.129	0.722**
RATINS	-0.161	0.089	-0.149	0.063	-0.224	0.108	0.033	0.057	0.062	-0.083	0.839**	0.443*	0.218

	HEIGHT	FARM	RATINS
HEIGHT	1.000		
FARM	0.089	1.000	
RATINS	-0.123	0.233	1.000

*These correlations were significant at the .05 level.

**These correlations were significant at the .01 level.

Table 3d

Correlation Matrix Between All Variables in Phase 3 - Group 4 (N=27)

	AGE	POWER	CAP	SPEED	DT	MT	TRT	AGGR	HAS	SS1	SS2	SS3	SS4
AGE	1.000												
POWER	0.536**	1.000											
CAP	0.577**	0.855**	1.000										
SPEED	-0.159	-0.350	-0.273	1.000									
DT	-0.748**	-0.496**	-0.581**	0.168	1.000								
MT	-0.644**	-0.458*	-0.466*	0.277	0.487**	1.000							
TRT	-0.805**	-0.553**	-0.606**	0.257	0.857**	0.867**	1.000						
AGGR	0.122	0.233	0.266	0.229	-0.143	0.133	-0.004	1.000					
HAS	-0.115	0.147	0.245	-0.147	0.048	0.123	0.104	0.131	1.000				
SS1	0.192	0.377	0.365	-0.061	-0.107	-0.264	-0.216	-0.145	0.084	1.000			
SS2	-0.342	-0.461*	-0.324	0.265	0.336	0.011	0.195	-0.215	0.080	-0.021	1.000		
SS3	-0.145	-0.254	-0.257	0.100	0.006	0.066	0.037	-0.148	-0.430*	-0.149	0.246	1.000	
SS4	0.360	0.289	0.336	-0.212	-0.175	-0.494**	-0.389*	-0.043	0.050	0.479*	0.158	-0.116	1.000
SS5	-0.020	0.146	0.100	0.129	-0.016	0.177	0.095	0.199	0.165	0.122	0.075	0.082	0.090
EPIEX	0.322	0.161	0.207	0.005	-0.329	0.092	-0.132	0.247	0.078	0.011	-0.577**	-0.123	0.010
EPIN	-0.279	-0.183	-0.124	0.122	0.250	0.257	0.295	-0.269	0.118	0.117	0.352	0.082	0.215
EPIL	-0.149	-0.361	-0.489**	0.277	0.260	0.264	0.300	0.166	-0.314	-0.124	0.229	0.370	-0.249
POMST	-0.399*	0.017	-0.122	-0.196	0.174	0.356	0.308	0.049	-0.069	0.219	-0.036	0.168	0.063
POMSD	-0.323	-0.270	-0.275	-0.024	0.119	0.236	0.202	-0.087	-0.310	-0.164	0.305	0.589**	-0.119
POMSA	-0.096	0.071	-0.005	-0.142	0.014	0.259	0.159	-0.050	-0.113	0.117	-0.147	0.260	0.103
POMSV	0.293	0.208	0.290	-0.010	-0.292	0.093	-0.111	0.195	0.329	0.176	-0.358	0.123	-0.110
POMSF	-0.010	0.265	0.082	-0.406*	0.040	-0.194	-0.091	-0.197	-0.238	0.341	-0.082	0.148	0.256
POMSC	-0.304	-0.216	-0.241	-0.013	0.098	0.265	0.208	-0.061	-0.216	-0.130	0.343	0.552**	-0.066
RATKID	0.219	0.265	0.496**	-0.053	-0.469*	-0.096	-0.326	0.306	0.116	0.057	0.026	0.107	0.115
EXPER	0.034	0.249	0.206	-0.145	-0.033	0.107	0.046	0.182	0.262	0.173	-0.406*	-0.051	0.021
WEIGHT	0.493**	0.419*	0.357	-0.017	-0.394*	-0.265	-0.382*	0.106	-0.123	0.029	-0.117	-0.212	0.085
HEIGHT	0.575**	0.447*	0.403*	-0.099	-0.577**	-0.358	-0.541**	0.075	-0.020	0.039	-0.112	0.059	0.171
FARM	0.399*	0.409*	0.327	-0.068	-0.184	-0.168	-0.206	0.228	-0.109	-0.037	-0.283	-0.305	0.159
RATINS	0.208	0.270	0.523**	0.008	-0.455*	-0.123	-0.333	0.336	0.086	-0.010	0.027	0.114	-0.015

	SS5	EPIEX	EPIN	EPIL	POMST	POMSD	POMSA	POMSV	POMSF	POMSC	RATKID	EXPER	WEIGHT
SS5	1.000												
EPIEX	0.190	1.000											
EPIN	-0.042	-0.406*	1.000										
EPIL	0.115	-0.331	0.123	1.000									
POMST	0.055	0.160	0.125	-0.029	1.000								
POMSD	-0.041	-0.203	0.309	0.321	0.628**	1.000							
POMSA	-0.126	0.085	0.274	-0.116	0.675**	0.582**	1.000						
POMSV	0.382*	0.535**	-0.168	-0.074	0.037	-0.080	0.028	1.000					
POMSF	-0.017	-0.063	0.144	-0.080	0.584**	0.444*	0.364	-0.011	1.000				
POMSC	0.121	-0.169	0.318	0.220	0.624**	0.834**	0.604**	-0.089	0.435*	1.000			
RATKID	0.005	0.162	-0.108	-0.344	-0.086	-0.031	-0.093	0.271	-0.076	-0.181	1.000		
EXPER	-0.096	0.344	-0.103	-0.190	0.207	-0.136	0.213	0.165	0.019	-0.302	0.347	1.000	
WEIGHT	0.210	0.071	-0.085	-0.164	-0.361	-0.321	-0.278	0.100	-0.038	-0.180	0.169	-0.399*	1.000
HEIGHT	0.319	0.134	-0.045	-0.153	-0.262	-0.169	-0.177	0.365	0.035	0.059	0.179	-0.375	0.798**
FARM	0.033	0.236	-0.068	-0.165	-0.185	-0.227	-0.106	0.075	0.012	-0.209	0.083	-0.236	0.838**
RATINS	-0.057	0.042	-0.046	-0.286	-0.135	0.046	-0.090	0.207	-0.043	-0.098	0.939**	0.323	0.147

	HEIGHT	FARM	RATINS
HEIGHT	1.000		
FARM	0.568**	1.000	
RATINS	0.186	0.059	1.000

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*These correlations were significant at the .05 level.

**These correlations were significant at the .01 level.

Table 3e

Correlation Matrix Between All Variables in Phase 3 - Group 5 (N=29)

	AGE	POWER	CAP	SPEED	DT	MT	TRT	AGGR	HAS	SS1	SS2	SS3	SS4
AGE	1.000												
POWER	0.058	1.000											
CAP	0.058	0.723**	1.000										
SPEED	-0.391*	-0.581**	-0.588**	1.000									
DT	-0.138	-0.300	-0.450*	0.507**	1.000								
MT	0.057	0.161	0.283	-0.104	0.099	1.000							
TRT	-0.051	-0.082	-0.093	0.256	0.719**	0.763**	1.000						
AGGR	-0.001	-0.004	0.168	-0.243	-0.247	0.086	-0.099	1.000					
HAS	0.190	0.485**	0.297	-0.447*	-0.238	0.028	-0.134	0.245	1.000				
SS1	-0.050	-0.015	0.203	0.063	0.049	-0.010	0.023	-0.047	-0.040	1.000			
SS2	0.269	0.017	-0.048	-0.211	0.168	-0.131	0.017	-0.088	0.029	0.304	1.000		
SS3	0.178	0.012	-0.220	0.261	0.258	0.023	0.182	0.009	0.137	-0.061	0.180	1.000	
SS4	0.238	-0.042	0.021	-0.287	-0.006	0.090	0.056	-0.056	0.144	0.449*	0.369*	-0.027	1.000
SS5	-0.038	0.116	0.076	-0.119	-0.227	0.093	-0.082	0.378*	0.300	-0.284	0.052	0.287	-0.139
EPIEX	0.338	0.239	0.328	-0.362	-0.261	0.019	-0.158	0.118	0.135	-0.040	0.002	0.066	0.123
EPIN	0.152	-0.226	-0.219	0.112	0.233	-0.043	0.122	-0.361	0.132	0.170	-0.070	-0.234	0.284
EPIL	-0.316	0.016	-0.162	0.086	-0.013	0.112	0.071	0.264	0.361	-0.255	-0.291	0.229	-0.015
POMST	0.339	-0.201	-0.154	0.051	0.155	-0.216	-0.055	-0.163	-0.046	0.118	0.368*	0.043	0.314
POMSD	0.254	-0.302	-0.284	0.335	0.187	-0.110	0.039	-0.351	-0.411*	0.020	0.027	-0.138	0.075
POMSA	0.297	-0.053	-0.095	-0.091	-0.084	-0.202	-0.202	-0.152	-0.083	0.182	0.134	-0.189	0.376*
POMSV	-0.173	0.273	0.419*	-0.114	0.066	0.114	0.121	0.233	0.284	0.187	-0.034	0.162	0.002
POMSF	0.378*	-0.116	-0.035	-0.045	0.199	0.001	0.126	-0.300	-0.345	0.061	0.242	-0.069	0.303
POMSC	0.360	-0.128	-0.098	0.135	0.054	-0.104	-0.042	-0.310	-0.169	0.137	0.222	-0.013	0.325
RATKID	0.616**	0.354	0.275	-0.578**	-0.290	0.058	-0.147	0.270	0.302	0.105	0.249	-0.028	0.267
EXPER	0.347	0.052	-0.005	-0.149	-0.277	-0.217	-0.328	0.123	0.321	-0.177	0.162	-0.084	-0.055
WEIGHT	0.461*	-0.237	-0.210	0.042	0.157	0.356	0.347	-0.150	-0.253	0.091	0.293	0.243	0.370*
HEIGHT	0.501**	-0.312	0.174	-0.131	-0.081	0.283	0.144	0.076	-0.260	0.166	0.316	0.134	0.218
FARM	0.345	-0.175	-0.190	0.116	0.106	0.463*	0.389*	-0.026	-0.136	0.124	0.139	0.310	0.281
RATINS	0.559**	0.415*	0.273	-0.660**	-0.289	0.132	-0.095	0.195	0.371*	-0.203	0.188	0.022	0.163

	SS5	EPIEX	EPIN	EPIL	POMST	POMSD	POMSA	POMSV	POMSF	POMSC	RATKID	EXPER	WEIGHT
SS5	1.000												
EPIEX	0.268	1.000											
EPIN	-0.330	0.047	1.000										
EPIL	0.418*	-0.410*	-0.089	1.000									
POMST	-0.238	0.058	0.264	-0.211	1.000								
POMSD	-0.510**	-0.190	0.337	-0.161	0.633**	1.000							
POMSA	-0.518**	0.043	0.175	-0.195	0.701**	0.710**	1.000						
POMSV	0.255	0.349	-0.204	-0.065	0.018	-0.405*	-0.177	1.000					
POMSF	-0.474*	-0.049	0.303	-0.317	0.657**	0.691**	0.550**	-0.251	1.000				
POMSC	-0.303	-0.004	0.314	-0.079	0.767**	0.813**	0.716**	-0.335	0.740**	1.000			
RATKID	0.197	0.276	-0.114	-0.076	-0.032	-0.158	-0.006	0.020	0.076	0.032	1.000		
EXPER	0.091	0.124	0.249	-0.136	-0.089	-0.114	-0.235	-0.084	-0.125	-0.119	0.380*	1.000	
WEIGHT	-0.081	0.009	0.157	-0.133	0.477**	0.427*	0.311	-0.154	0.621**	0.474*	0.086	-0.049	1.000
HEIGHT	-0.031	0.204	-0.029	-0.353	0.352	0.242	0.118	-0.003	0.502**	0.294	0.144	-0.009	0.610**
FARM	0.060	0.036	0.127	0.004	0.181	0.263	0.138	-0.094	0.331	0.279	0.071	-0.015	0.885**
RATINS	0.205	0.237	-0.155	0.036	-0.077	-0.153	-0.022	0.035	0.131	-0.058	0.868**	0.359	0.110

	HEIGHT	FARM	RATINS
HEIGHT	1.000		
FARM	0.441*	1.000	
RATINS	0.160	0.075	1.000

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* These correlations were significant at the .05 level.

** These correlations were significant at the .01 level.

Table 4a

Correlation Matrix Involving Common Variables in Phases 1, 2 and 3 - Groups 1 to 5 (N=115)

	AGE	POWER	CAP	SPEED	DT	MT	TRT	AGGR	HAS	SS1	SS2	SS3	SS4
AGE	1.000												
POWER	0.269**	1.000											
CAP	0.472**	0.815**	1.000										
SPEED	-0.826**	-0.339**	-0.493**	1.000									
DT	-0.648**	-0.389**	-0.567**	0.636**	1.000								
MT	-0.011	-0.265**	-0.229*	0.040	0.205*	1.000							
TRT	-0.488**	-0.431**	-0.544**	0.495**	0.854**	0.683**	1.000						
AGGR	-0.018	0.123	0.148	0.061	-0.149	0.091	-0.064	1.000					
HAS	0.133	0.164	0.135	-0.200*	-0.126	0.051	-0.065	-0.018	1.000				
SS1	0.027	0.074	0.028	-0.024	0.096	-0.065	0.038	-0.153	0.002	1.000			
SS2	0.354**	-0.076	0.030	-0.267**	-0.132	-0.026	-0.113	-0.063	0.029	0.235*	1.000		
SS3	-0.225*	-0.127	-0.232*	0.264**	0.172	0.038	0.147	0.042	-0.032	0.075	0.023	1.000	
SS4	0.391**	0.112	0.222*	-0.373**	-0.152	-0.049	-0.139	-0.070	0.082	0.351**	0.409**	-0.070	1.000
SS5	0.021	0.071	0.006	0.040	-0.016	0.048	0.014	0.199*	0.285**	0.032	0.017	0.216*	-0.012
WEIGHT	0.948**	0.203*	0.394**	-0.789**	-0.598**	0.076	-0.405**	-0.020	0.111	0.035	0.346**	-0.206*	0.398**
HEIGHT	0.920**	0.184	0.414**	-0.774**	-0.618**	0.110	-0.403**	0.046	0.073	-0.009	0.348**	-0.180	0.381**
RATINS	-0.150	0.231*	0.272**	0.058	-0.205*	0.004	-0.153	0.288**	0.009	-0.295**	-0.191	0.102	-0.177

	SS5	WEIGHT	HEIGHT	RATINS
SS5	1.000			
WEIGHT	0.006	1.000		
HEIGHT	0.015	0.953**	1.000	
RATINS	-0.111	-0.146	-0.060	1.000

* These correlations were significant at the .05 level.

** These correlations were significant at the .01 level.

Table 4b

Correlation Matrix Involving Variables in Phases 2 and 3 - Groups 2 to 5 (N=99)

	AGE	POWER	CAP	SPEED	DT	MT	TRT	AGGR	HAS	SS1	SS2	SS3	SS4
AGE	1.000												
POWER	0.308**	1.000											
CAP	0.549**	0.813**	1.000										
SPEED	-0.778**	-0.375**	-0.539**	1.000									
DT	-0.749**	-0.386**	-0.586**	0.676**	1.000								
MT	-0.001	-0.249*	-0.203*	0.053	0.195	1.000							
TRT	-0.567**	-0.422**	-0.549**	0.539**	0.858**	0.671**	1.000						
AGGR	0.146	0.140	0.159	-0.050	-0.186	0.122	-0.077	1.000					
HAS	0.062	0.205*	0.177	-0.150	-0.089	0.034	-0.048	0.094	1.000				
SS1	-0.139	0.057	0.014	0.101	0.179	-0.086	0.090	-0.028	-0.131	1.000			
SS2	0.216*	-0.145	-0.011	-0.140	-0.052	-0.005	-0.043	-0.022	-0.045	0.153	1.000		
SS3	-0.153	-0.177	-0.286**	0.219*	0.193	0.112	0.203*	0.013	-0.042	0.066	0.044	1.000	
SS4	0.304**	0.107	0.225*	-0.286**	-0.131	-0.056	-0.129	0.004	0.025	0.329**	0.375**	-0.051	1.000
SS5	-0.111	0.054	-0.017	0.142	0.006	0.063	0.038	0.255*	0.301**	-0.004	-0.047	0.275**	-0.071
EPIEX	0.282**	0.191	0.258*	-0.206*	-0.311**	-0.031	-0.252*	0.170	0.073	0.068	-0.141	0.133	0.132
EPIN	-0.114	-0.116	-0.121	0.160	0.259*	0.099	0.248*	-0.222*	0.068	0.167	0.232*	-0.082	0.244*
EPIL	-0.239*	-0.213*	-0.309**	0.180	0.142	0.092	0.154	0.105	0.093	-0.120	-0.219*	0.219*	-0.107
POMST	0.193	0.017	0.060	-0.198	-0.061	-0.017	-0.056	0.060	0.013	0.105	0.324**	-0.079	0.224*
POMSD	-0.108	-0.211*	-0.202*	0.074	0.158	-0.017	0.109	-0.217*	-0.221*	-0.036	0.037	0.032	-0.056
POMSA	-0.217*	-0.105	-0.182	0.088	0.167	-0.016	0.116	-0.153	-0.067	0.136	-0.018	-0.012	0.128
POMSV	0.109	0.131	0.174	-0.120	-0.160	0.067	-0.086	0.222*	0.276**	0.086	-0.060	0.115	0.038
POMSF	0.132	0.108	0.110	-0.180	0.022	-0.030	0.000	-0.066	-0.195	0.114	0.356**	-0.105	0.246*
POMSC	-0.116	-0.147	-0.151	0.077	0.174	0.031	0.146	-0.194	-0.112	0.072	0.128	0.103	0.038
RATKID	0.509**	0.345**	0.487**	-0.463**	-0.505**	-0.029	-0.397**	0.214*	0.140	-0.054	0.120	-0.065	0.199
EXPER	0.689**	0.284**	0.445**	-0.567**	-0.510**	0.029	-0.370**	0.166	0.207*	-0.065	0.115	-0.131	0.235*
WEIGHT	0.937**	0.227*	0.448**	-0.724**	-0.671**	0.090	-0.461**	0.125	0.036	-0.096	0.234*	-0.130	0.305**
HEIGHT	0.925**	0.203*	0.459**	-0.718**	-0.688**	0.100	-0.468**	0.171	0.006	-0.106	0.262*	-0.104	0.290**
FARM	0.920**	0.294**	0.509**	-0.705**	-0.657**	0.068	-0.462**	0.133	0.069	-0.099	0.184	-0.157	0.318**
RATINS	0.408**	0.399**	0.455**	-0.372**	-0.429**	-0.035	-0.343**	0.163	0.183	-0.225*	-0.006	0.017	0.033

	SS5	EPIEX	EPIN	EPIL	POMST	POMSD	POMSA	POMSV	POMSF	POMSC	RATKID	EXPER	WEIGHT
SS5	1.000												
EPIEX	0.213*	1.000											
EPIN	-0.167	-0.189	1.000										
EPIL	0.196	-0.177	-0.079	1.000									
POMST	-0.131	0.024	0.273**	-0.147	1.000								
POMSD	-0.274**	-0.190	0.327**	0.002	0.574**	1.000							
POMSA	-0.298**	-0.131	0.322**	-0.058	0.548**	0.728**	1.000						
POMSV	0.228*	0.370**	-0.109	0.034	0.080	-0.173	-0.037	1.000					
POMSF	-0.371**	-0.120	0.354**	-0.263**	0.578**	0.429**	0.374**	-0.134	1.000				
POMSC	-0.126	-0.168	0.339**	0.018	0.632**	0.800**	0.699**	-0.165	0.498**	1.000			
RATKID	-0.054	0.230*	-0.152	-0.205*	0.013	-0.051	-0.086	0.148	0.081	-0.081	1.000		
EXPER	-0.044	0.234*	-0.021	-0.214*	0.154	-0.150	-0.131	0.096	0.045	-0.192	0.515**	1.000	
WEIGHT	-0.115	0.226*	-0.112	-0.196	0.202*	-0.069	-0.199	0.114	0.146	-0.076	0.479**	0.609**	1.000
HEIGHT	-0.078	0.241*	-0.122	-0.231*	0.178	-0.094	-0.224*	0.157	0.170	-0.078	0.464**	0.579**	0.949**
FARM	-0.078	0.236*	-0.095	-0.211*	0.203*	-0.075	-0.199	0.096	0.139	-0.069	0.456**	0.607**	0.969**
RATINS	-0.001	0.226*	-0.151	-0.088	-0.084	-0.064	-0.128	0.092	0.068	-0.098	0.866**	0.411**	0.359**

	HEIGHT	FARM	RATINS
HEIGHT	1.000		
FARM	0.899**	1.000	
RATINS	0.361**	0.342**	1.000

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* These correlations were significant at the .05 level.

** These correlations were significant at the .01 level.

Table 5a

Factor Analysis Involving Common Variables in Phases 1, 2 and 3 - Groups 1 to 5 (N=115)

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6
WEIGHT	0.962	0.0	0.0	0.0	0.0	0.0
HEIGHT	0.945	0.0	0.0	0.0	0.0	0.0
AGE	0.938	0.0	0.0	0.0	0.0	0.0
SPEED	-0.771	0.0	0.0	0.0	0.0	0.0
RATINS	0.508	0.0	0.0	0.0	0.0	0.337
MT	0.0	0.886	0.0	0.0	-0.317	0.0
TRT	-0.357	0.861	0.0	0.0	0.271	0.0
CAP	0.302	0.0	0.845	0.0	0.0	0.0
POWER	0.0	0.0	0.825	0.0	0.0	0.0
SS4	0.299	0.0	0.0	0.626	0.0	0.0
SS1	0.0	0.0	0.0	0.557	0.0	0.0
SS2	0.301	0.0	0.0	0.504	0.0	0.0
DT	-0.562	0.524	0.0	0.0	0.586	0.0
SS5	0.0	0.0	0.0	0.0	0.0	0.0
SS3	0.0	0.0	0.0	0.0	0.0	0.0
AGGR	0.0	0.0	0.0	0.0	-0.290	0.0
HAS	0.0	0.0	0.0	0.0	0.0	0.375
VP	4.346	1.928	1.699	1.094	0.743	0.495

THE ABOVE FACTOR LOADING MATRIX HAS BEEN REARRANGED SO THAT THE COLUMNS APPEAR IN DECREASING ORDER OF VARIANCE EXPLAINED BY FACTORS. THE ROWS HAVE BEEN REARRANGED SO THAT FOR EACH SUCCESSIVE FACTOR, LOADINGS GREATER THAN 0.5000 APPEAR FIRST. LOADINGS LESS THAN 0.2500 HAVE BEEN REPLACED BY ZERO.

Table 5b

Factor Analysis Involving Variables in Phases 2 and 3 - Groups 2 to 5 (N=99)

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6	FACTOR 7	FACTOR 8
WEIGHT	0.988	0.0	0.0	0.0	0.0	0.0	0.0	0.0
FARM	0.958	0.0	0.0	0.0	0.0	0.0	0.0	0.0
HEIGHT	0.937	0.0	0.0	0.0	0.0	0.0	0.0	0.0
AGE	0.923	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SPEED	-0.708	0.0	-0.258	0.0	0.0	0.0	0.0	0.0
DT	-0.693	0.0	0.0	0.0	0.0	0.300	0.0	0.547
EXPER	0.572	0.0	0.0	0.0	0.0	0.0	0.0	0.0
POMSC	0.0	0.885	0.0	0.0	0.0	0.0	0.0	0.0
POMSD	0.0	0.868	0.0	0.0	-0.275	0.0	0.0	0.0
POMSA	0.0	0.773	0.0	0.0	0.0	0.0	0.0	0.0
POMST	0.0	0.731	0.0	0.0	0.0	0.0	0.343	0.0
POMSF	0.0	0.516	0.0	0.0	0.0	0.0	0.431	0.0
POWER	0.0	0.0	0.812	0.0	0.0	0.0	0.0	0.0
CAP	0.397	0.0	0.775	0.0	0.0	0.0	0.0	0.0
RATINS	0.269	0.0	0.0	0.926	0.0	0.0	0.0	0.0
RATKID	0.397	0.0	0.0	0.772	0.0	0.0	0.0	0.0
SS5	0.0	0.0	0.0	0.0	0.720	0.0	0.0	0.0
MT	0.0	0.0	0.0	0.0	0.0	0.972	0.0	0.0
TRT	-0.478	0.0	0.0	0.0	0.0	0.736	0.0	0.377
SS2	0.0	0.0	0.0	0.0	0.0	0.0	0.605	0.0
SS4	0.263	0.0	0.0	0.0	0.0	0.0	0.523	0.0
SS3	0.0	0.0	-0.344	0.0	0.285	0.0	0.0	0.0
AGGR	0.0	0.0	0.0	0.0	0.388	0.0	0.0	0.0
EPIEX	0.0	0.0	0.0	0.0	0.379	0.0	0.0	0.0
EPIN	0.0	0.337	0.0	0.0	0.0	0.0	0.314	0.0
HAS	0.0	0.0	0.0	0.0	0.390	0.0	0.0	0.0
SS1	0.0	0.0	0.0	0.0	0.0	0.0	0.392	0.0
EPIL	0.0	0.0	-0.285	0.0	0.0	0.0	-0.329	0.0
POMSV	0.0	0.0	0.0	0.0	0.431	0.0	0.0	0.0
VP	5.936	3.136	1.906	1.816	1.703	1.693	1.463	0.579

THE ABOVE FACTOR LOADING MATRIX HAS BEEN REARRANGED SO THAT THE COLUMNS APPEAR IN DECREASING ORDER OF VARIANCE EXPLAINED BY FACTORS. THE ROWS HAVE BEEN REARRANGED SO THAT FOR EACH SUCCESSIVE FACTOR, LOADINGS GREATER THAN 0.5000 APPEAR FIRST. LOADINGS LESS THAN 0.2500 HAVE BEEN REPLACED BY ZERO.

Relationships Between Variables

Tables 3a to 3e (pp. 145-152) presented the product-moment correlations between all pairs of variables in each of the five groups tested in the present study. All groups were combined and the correlation matrix for the 17 variables common to all phases and groups was presented in Table 4a (p. 155). To allow for an examination of relationships to include the additional measures administered to Phase 2 and 3 subjects, Table 4b (p. 157) was provided; the latter table presented a correlation matrix involving the 29 variables common to groups (2 to 5) in Phases 2 and 3.

As Table 4a indicated, numerous statistically significant relationships existed among the 17 variables. The results of a factor analysis (BMDP4M) on these data were presented in Table 5a (p. 159). Factor 1 seemed to load most heavily on variables of age and size, Factor 2 on movement time (MT) and total response time (TRT), Factor 3 on the anaerobic measures (POWER, CAP), Factor 4 on decision time (DT), and Factor 5 on three subscales (SS1, SS2, SS4) of the Sports Scale. Of particular interest in Table 4a were the relationships between the criterion measure (RATINS) and the remaining variables. (Group 1 scores on RATINS were scaled to allow their inclusion in the matrix.) Significant correlations were noted between the criterion measure and each of "anaerobic power" (POWER; $r=0.23$, $p<.05$), "anaerobic capacity" (CAP; $r=0.27$, $p<.01$), decision time (DT; $r=-0.21$, $p<.05$), aggression (AGGR; $r=0.29$, $p<.01$), and the aggression subscale of the Sports Scale (SS1; $r=-0.30$, $p<.01$).

An examination of Table 4b revealed that, of the additional measures administered to Phase 2 and 3 groups, only scores on the extroversion subscale of the Jr. EPI (EPIEX; $r=0.23$, $p<.05$), the experience measure (EXPER; $r=0.41$, $p<.01$), the subjects' peer rating scale (RATKID; $r=0.89$, $p<.01$), and the forearm girth measure (FARM; $r=0.34$, $p<.01$) were statistically significantly related to scores on the criterion measure (RATINS). The relationships noted in Table 4a between the criterion measure and scores on the POWER, CAP, DT and SS1 variables were also apparent in Table 4b. Considering subjects in only Phases 2 and 3 (Table 4b), statistically significant correlations with the criterion measure were also found for age ($r=0.41$, $p<.01$), skating speed (SPEED; $r=-0.37$, $p<.01$), total response time (TRT; $r=-0.34$, $p<.01$), weight ($r=0.34$, $p<.01$) and height ($r=0.36$, $p<.01$), in addition to those found in Table 4a. The statistically significant correlation found in Table 4a between the criterion measure and aggression (AGGR) was not apparent in Table 4b, when only Phase 2 and 3 subjects were considered.

Table 5b (p. 161) presented the results of a factor analysis (BMDP4M) of the Phase 2 and 3 data. The factors noted in Table 5a also seemed to be present in Table 5b, although the addition of 13 variables obviously made some differences. Forearm girth (FARM) and experience (EXPER) loaded most heavily on Factor 1, which, as in Table 5a, was predominantly composed of age and size variables, although decision time was also included in Table 5b. Factor 2 in Table 5b was loaded most heavily with new variables, including five of the POMS subscales (i.e., C-confusion, D-dejection, A-anger, T-tension, F-fatigue) and the neuroticism subscale (EPIN) of the Jr.EPI. Factors 3, 6 and 7 in Table 5b were similar to Factors 3, 2 and 4, respectively, in Table 5a. The subjects' peers rating scale (RATKID) dominated Factor 4 with the criterion measure (RATINS). Factor 5 had a mixture of contributors but the highest loading was from the cooperation subscale of the Sports Scale (SS5).

Inter-Rater Reliabilities

Table 6a (p. 167) presented the correlations between all available pairs of ratings of hockey ability (RATINS) provided by the instructors or coaches of each group. Correlations ranged from a low of 0.39 in Group 3 to a high of 0.88 in Group 4. (As mentioned previously, ratings were provided by one instructor in Group 3 by using a rating scale different from the criterion measure. These ratings were adjusted for comparison with ratings of others using the criterion measure; the relationship between ratings using the different scales was sufficiently low (r=0.38) to warrant omitting the non-criterion measure ratings from further analysis. The correlation presented in Table 6a for Group 3 was derived from examining all available remaining pairs of ratings. As was seen in Table 6a, the inter-rater correlation (r=0.39) remained low.)

Subjects in Phases 2 and 3 were asked to rate their peers on hockey ability. The correlations between the means of peers' ratings (RATKID) and the means of instructors' ratings (RATINS) were shown in Table 6b (pp.). The resulting correlations ranged from 0.78 in Group 2 to 0.92 in Group 4. Correlations were highest in Phase 3 groups.

Table 6a

Product-Moment Correlations Between Instructors' Ratings (RATINS) for all Phases and Groups

Phase 1	Phase 2		Phase 3	
Group 1	Group 2	Group 3	Group 4	Group 5
r=0.66 (N=9)	r=0.78 (N=24)	r=0.39 (N=14)	r=0.88 (N=31)	r=0.68 (N=29)

Table 6b

Product-Moment Correlations Between Instructors' Ratings (RATINS) and Subjects' Peer Ratings (RATKII) for Phases 2 and 3 - Groups 2 to 5

Phase 2		Phase 3	
Group 2	Group 3	Group 4	Group 5
r=0.78 (N=24)	r=0.81 (N=24)	r=0.92 (N=31)	r=0.90 (N=20)

Regression Analysis

Regression analysis was conducted on all phases combined to examine overall trends, on Phases 2 and 3 combined to look at the increased number of variables common to these phases, and on individual phases and groups to examine specific trends.

All phases and groups

The BMDP9R program (Dixon, 1977) was utilized to select the "best" subset of predictors using subjects in all phases and groups (N=115). RATINS, the criterion measure involving ratings of hockey ability, was the dependent variable and the remaining variables served as independent variables. The independent variables totalled 18 as two[1] variables indicating phase membership (i.e., X1,X2) were added to the analysis. The "best" subset of variables (based on Mallow's Cp (see p. 128)) was described in Table 7 (p. 171): seven variables were involved in a multiple correlation (R) of 0.74 or accounted for 55 percent of the variance (R^2=0.55) in ratings of hockey ability across all phases and groups ($F_{7,107}$=18.65, p<.001). However, the

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[1]Since GROUP did not involve an interval scale, it was necessary to represent each phase by a combination of two variables, i.e., X1 and X2. Assignments were as follows: Phase 1 (Group 1) - X1=1,X2=0; Phase 2 (Groups 2 and 3) - X1=0,X2=1; and, Phase 3 (Groups 4 and 5) -X1=0,X2=0.

presence of X1 and X2 as statistically significant items ($p<.05$) among the seven predictor variables meant that the phases were, in fact, different and meaningful analysis was not possible through combining data from all phases.

Phases 2 and 3

The BMDP9R "best" subsets program was also applied to the complete data sets of subjects in Phases 2 and 3 (Groups 2 to 5) (N=99) so that analysis including the additional measures administered to these subjects was available. The GROUP[2] variable, used to indicate phase membership was included to make a total of 28 independent variables; the dependent variable was the criterion measure or RATINS. (RATKID, the subjects' ratings of their peers' hockey ability was not included in this analysis because of general high correlations between RATINS and RATKID.) Table 8 (p. 172) contained a description of the "best" subset of variables; they numbered eight and produced a multiple correlation of 0.68 with the criterion measure or accounted for 47 percent of the variance (R^2=0.47) in hockey ability ratings ($F_{8,90}$=9.90, $p<.001$). Again, however, GROUP was a statistically significant ($p<.001$) member of the "best" predictor subset, thus indicating substantial differences between Phases 2 and 3 data.

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[2]GROUP was used to distinguish membership in Phase 2 or 3. GROUP was given a value of 1 for membership in Phase 2 (Groups 2 and 3) and a value of 2 for membership in Phase 3 (Groups 4 and 5).

This being the case, other subsets were not investigated as data from the two phases were not amenable to combined analysis.

Table 7

Regression Analysis Involving All Phases - Groups 1 to 5 (N=115): Description of "Best" Subset of Predictor Variables

Variable	Regression Coefficient	Standard Error	p of t-Statistic for Var.	Contribution to R^2
AGE	0.070	0.030	0.021	0.023
CAF	0.113	0.043	0.011	0.028
MT	0.409	0.173	0.020	0.023
TRT	- 0.198	0.111	0.076	0.013
SS1	- 0.322	0.160	0.047	0.017
X1	-12.485	2.631	0.000	0.095
X2	- 4.320	1.748	0.015	0.026
Intercept	2.582	5.593	0.645	

Multiple Correlation (R) - 0.74
Squared Multiple Correlation (R^2) - 0.55

Analysis of Variance

Source	df	SS	MS	F	p
Regression	7	771.49	110.21	18.65	0.000
Residual	107	632.34	5.91		

Table 8

Regression Analysis Involving Phases 2 and 3 - Groups 2 to 5 (N=99): Description of "Best" Subset of Predictor Variables

Variable	Regression Coefficient	Standard Error	p of t-Statistic for Var.	Contribution to R^2
GROUP	7.671	1.810	0.000	0.106
AGE	0.067	0.029	0.026	0.030
CAP	0.154	0.038	0.000	0.097
SS1	- 0.442	0.147	0.002	0.057
SS3	0.276	0.177	0.123	0.014
EXPER	0.147	0.048	0.003	0.055
WEIGHT	0.181	0.058	0.002	0.058
FARM	- 0.480	0.242	0.051	0.023
Intercept	-53.374	16.149	0.001	

Multiple Correlation (R) - 0.68
Squared Multiple Correlation (R^2)- 0.47

Analysis of Variance

Source	df	SS	MS	F	p
Regression	8	308.25	38.53	9.90	0.000
Residual	90	350.17	3.89		

Phase 1

The application of BMDP9R to Phase 1 (Group 1) was not possible because sample size (N=16 complete cases) was too small relative to the number of variables. Different variables were deleted from subsequent BMDP9R runs but no statistically significant combination of variables was found.

Phase 2

The BMDP9R program was applied to data in Phase 2 (Groups 2 and 3) (N=43) and resulted in the "best" subset of predictors described in Table 9 (p. 175). The combination of 12 variables produced a multiple correlation (R) of 0.89 or accounted for 79 percent of the variance (R^2=0.79) in ratings of hockey ability in Phase 2 ($F_{12,30}$ =9.37, $p<.001$). Since GROUP did not appear as one of the predictors, the two groups (Groups 2 and 3) in Phase 2 were considered as a single unit for purposes of analysis.

Although the "best" subset in Phase 2 contained 12 variables, six of the variables were actually subscales of other measures (SS1, SS2, SS3 and SS5 were subscales of the Sports Scale; POMST and POMSF were two of the six POMS subscales). Thus, the 12 variables were actually accounted for by eight measures. (An examination of the t-statistics for each variable showed that HAS and SS3 were not statistically significant at the .05 level. R^2 would have been decreased by their removal but the elimination of HAS would reduce the number of measures employed to eight.) The effects on R^2 and on the number of involved measures by adding or deleting variables from the "best" subset were shown in Table 10 (p. 176). Four example subsets were presented but many other combinations were, of course, possible. As indicated in Table 10, the addition of two variables (EXPER, CAP) to form subset B resulted in the addition of only one measure (EXPER; CAP and POWER were derived from the same measure) while increasing the R^2 to 0.83. (Two variables, CAP and SS3, were statistically non-significant in this combination but both were part of other measures.) An R^2 of 0.76 was attainable by decreasing the number of variables and measures by one (subset C), whereas a combination of 10 variables but six measures (subset D) resulted in an R^2 of 0.74. All the subsets in Table 10 were significant.

Little improvement on subset B's R^2 value was noted when variables or measures were added; R^2 increased to only 0.86 when 20 variables

Table 9

Regression Analysis Involving Phase 2 - Groups 2 and 3 (N=43): Description of "Best" Subset of Predictor Variables

Variable	Regression Coefficient	Standard Error	p of t-Statistics for Var.	Contribution to R^2
POWER	0.105	0.019	0.000	0.212
MT	- 0.190	0.079	0.022	0.041
AGGR	- 0.651	0.181	0.001	0.030
HAS	- 0.105	0.052	0.053	0.029
SS1	- 0.360	0.092	0.000	0.107
SS2	- 0.616	0.147	0.000	0.124
SS3	0.244	0.128	0.066	0.025
SS5	0.604	0.182	0.002	0.077
POMST	- 0.080	0.036	0.034	0.035
PCMSF	0.173	0.040	0.000	0.132
WEIGHT	0.240	0.036	0.000	0.313
FARM	- 0.746	0.177	0.000	0.125
Intercept	18.276	3.409	0.000	

Multiple Correlation (R) - 0.89
Squared Multiple Correlation (R^2) - 0.79

Analysis of Variance

Source	df	SS	MS	F	p
Regression	12	78.87	6.57	9.37	0.000
Residual	30	21.05	0.70		

Table 10

Effects on R^2, Number of Variables and Number of Involved Measures of Adding to or Deleting from "Best" Subset of Predictors in Phase 2 Groups 2 and 3 (N=43)

Some Possible Subsets

	"Best"	A	B	C	D
	POWER	POWER	POWER	POWER	POWER
	MT	MT	CAP[1]	MT	AGGR
	AGGR	AGGR	MT	AGGR	SS1
	HAS[1]	HAS	AGGR	SS1	SS2[1]
	SS1	SS1	HAS	SS2	SS5
	SS2	SS2	SS1	SS3[1]	POMST
	SS3[1]	SS3[1]	SS2	SS5	POMSA[1]
	SS5	SS5	SS3[1]	POMST	POMSF
	POMST	POMST[1]	SS5	POMSF	WEIGHT
	POMSF	POMSF	POMST	WEIGHT	FARM
	WEIGHT	EXPER[1]	POMSF	FARM	
	FARM	WEIGHT	EXPER		
		FARM	WEIGHT		
			FARM		
R^2 of Subset	0.79	0.81	0.83	0.76	0.74
No. of Variables	12	13	14	11	10
No. of Measures	8	9	9	7	6
Variables Added	-	EXPER	EXPER,CAP	-	POMSA
Variables Deleted	-	-	-	HAS	MT,HAS,SS3
Subset Statistics F	9.37	9.27	9.45	8.96	8.96
Subset Statistics df	12.30	13,29	14.28	11,31	10,32
Subset Statistics p	0.000	0.000	0.000	0.000	0.000

[1] These variables had statistically non-significant ($p>.05$) t-statistics when used in the subset noted.

Table 11

Regression Analysis Involving Phase 2 - Groups 2 and 3 (N=43): Description of Subset B of Predictor Variables

Variable	Regression Coefficient	Standard Error	p of t-Statistic for Var.	Contribution to R^2
POWER	0.138	0.029	0.000	0.145
CAP	- 0.092	0.052	0.089	0.019
MT	- 0.220	0.076	0.008	0.052
AGGR	- 0.664	0.177	0.001	0.088
HAS	- 0.125	0.050	0.019	0.039
SS1	- 0.397	0.090	0.000	0.123
SS2	- 0.580	0.140	0.000	0.108
SS3	0.242	0.121	0.055	0.025
SS5	0.539	0.177	0.005	0.058
POMST	- 0.071	0.034	0.047	0.027
POMSF	0.165	0.039	0.000	0.113
EXPER	0.093	0.044	0.045	0.028
WEIGHT	0.213	0.037	0.000	0.212
FARM	- 0.621	0.176	0.001	0.078
Intercept	17.737	3.524	0.000	

Multiple Correlation (R) - 0.91
Squared Multiple Correlation (R^2) 0.83

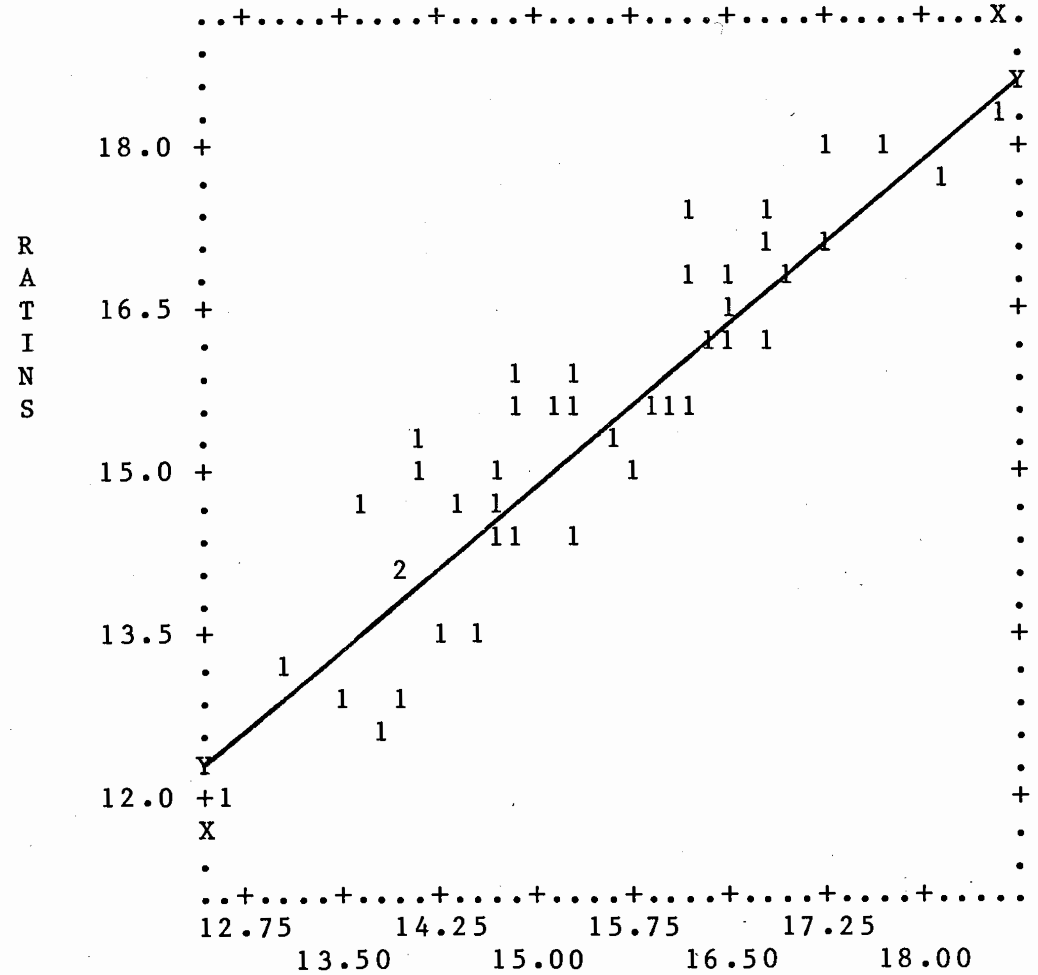
Analysis of Variance

Source	df	SS	MS	F	p
Regression	14	82.46	5.89	9.45	0.000
Residual	28	17.45	0.62		

Figure 2

Predicted Ratings (PREDICTD) Based on Subset B (Phase 2) versus Actual Ratings (RATINS) of Hockey Ability in Phase 2 - Groups 2 and 3 (N=43)

FIGURE 2
PREDICTED RATINGS (PREDICTD) BASED ON SUBSET B (PHASE 2) VERSUS ACTUAL RATINGS (RATINS) OF HOCKEY ABILITY IN PHASE 2 - GROUPS 2 AND 3 (N=43)



N= 43
COR= .908

	MEAN	ST.DEV.	REGRESSION LINE	RES.MS.
X	15.433	1.4012	X= .82532*Y+ 2.6958	.35132
Y	15.433	1.5424	Y= 1.0000*X+ 954E-9	.42568

were employed (but Mallow's Cp increased from 5.55 to 13.92, the additional six variables added little to prediction). Subset B was chosen as an illustrative subset which appeared to present to high R^2 while utilizing a "manageable" number of measures. Statistics for subset B were shown in Table 11 (p. 177); a graphical representation of predicted ratings using this subset of variables (PREDICTD) versus actual ratings of hockey ability (RATINS) was presented in Figure 2 (p. 178). (Although subset B contained two variables (CAP and SS3) which did not add statistically significantly to the regression equation, scores for both variables could be obtained by the administration of other measures. Thus, without affecting test protocols, they were contributing to an increase in R^2.)

Phase 3

Attempts to run BMDP9R using complete data sets from Phase 3 (Groups 4 and 5) subjects (N=56) were unsuccessful when all available 28 variables were employed. (BMDP9R set "tolerance" limits on the extent to which variables could have been interrelated ($1-R^2$); when tolerance limits were violated, the program was terminated. The program could have been attempted again with the specified variables removed.) The BMDP9R program was employed, after removing four variables (POWER, POMSA, WEIGHT, FARM), to analyze the relationship of 24 independent variables to the criterion measure. Table 12 (p. 182) presented the description of the "best" subset of predictors with Phase 3 subjects. Six variables combined to produce a multiple correlation (R) of 0.70 or accounted for 49 percent of the variance (R^2 =0.49) in hockey ability ratings of Phase 3 subjects ($F_{6,49}$ =7.70, p<.001). The presence of GROUP as a variable in the "best" subset was noted; however, GROUP did not make a statistically significant (t=-1.67,p=. 101) contribution to the prediction equation and was, therefore, removed. Description of the subset without GROUP was provided in Table 13 (p. 183). (Note that, upon removing GROUP, R and R^2 decreased to 0.68 and 0.46 respectively.) Groups 4 and 5 were, therefore, considered as one unit.

Other possible subsets were presented in Table 14 (p. 184) with information on the effect of adding or deleting variables on R^2 and on the number of measures. Each subset was run through regression analysis initially with GROUP as a variable. GROUP was not statistically significant (p>.05) in each case and removed from the subsequent analyses, the results of which were presented in Table 14. All the subsets were significant. As was noted, R^2 could have been increased to 0.58 (subset C) by the addition of seven variables or

Table 12

Regression Analysis Involving Phase 3 - Groups 4 and 5 (N=56): Description of "Best" Subset of Predictor Variables

Variable	Regression Coefficient	Standard Error	p of t-Statistic for Var.	Contribution to R^2
GROUP	-1.187	0.710	0.101	0.029
AGE	0.069	0.035	0.056	0.040
CAP	0.186	0.055	0.001	0.122
SS1	-0.686	0.266	0.013	0.070
SS2	0.689	0.290	0.022	0.059
EXPER	0.153	0.062	0.018	0.063
Intercept	1.365	6.121	0.824	

Multiple Correlation (R) - 0.70
Squared Multiple Correlation (R^2) - 0.49

Analysis of Variance

Source	df	SS	MS	F	p
Regression	6	239.28	39.88	7.70	0.000
Residual	49	253.83	5.18		

Table 13

Regression Analysis Involving Phase 3 - Groups 4 and 5 (N=55): Description of "Best" Subset (Without Group) of Predictor Variables

Variable	Regression Coefficient	Standard Error	p of t-Statistics for Variable	Contribution to R^2
AGE	0.085	0.035	0.019	0.064
CAP	0.196	0.055	0.001	0.137
SS1	-0.820	0.258	0.003	0.110
SS2	0.587	0.289	0.047	0.045
EXPER	0.137	0.063	0.034	0.052
Intercept	-5.666	4.528	0.217	

Multiple Correlation (R) - 0.68
Squared Multiple Correlation (R^2)- 0.46

Analysis of Variance

Source	df	SS	MS	F	p
Regression	5	224.80	44.96	8.38	0.000
Residual	50	268.32	5.37		

Table 14

Effects on R^2, Number of Variables and Number of Involved Measures of Adding to or Deleting from "Best" Subset (Without GROUP) of Predictors in Phase 3 - Groups 4 and 5 (N=56)

Some Possible Subsets

	"Best"	A	B	C
	AGE CAP SS1 SS2 EXPER	CAP MT TRT SS1 SS2 POMST[1] POMSF EXPER	AGE[1] CAP MT TRT[1] AGGR[1] SS1 SS2 SS3[1] POMST[1] POMSF[1] EXPER	AGE[1] CAP MT TRT AGGR[1] SS1 SS2 SS3[1] POMST POMSF EXPER[1] HEIGHT
R^2 of Subset	0.46	0.50	0.55	0.58
No. of Variables	5	8	11	12
No. of Measures	4	5	7	8
Variables Added	-	MT,TRT POMST, POMSF	MT,TRT, SS3, POMST, POMSF	MT,TRT,AGGR, SS3,POMST, POMSF,HEIGHT
Variables Deleted	-	AGE	-	-
Subset Statistics F	8.38	5.97	4.89	4.89
df	5,50	8,47	11,44	12,43
p	0.000	0.000	0.000	0.000

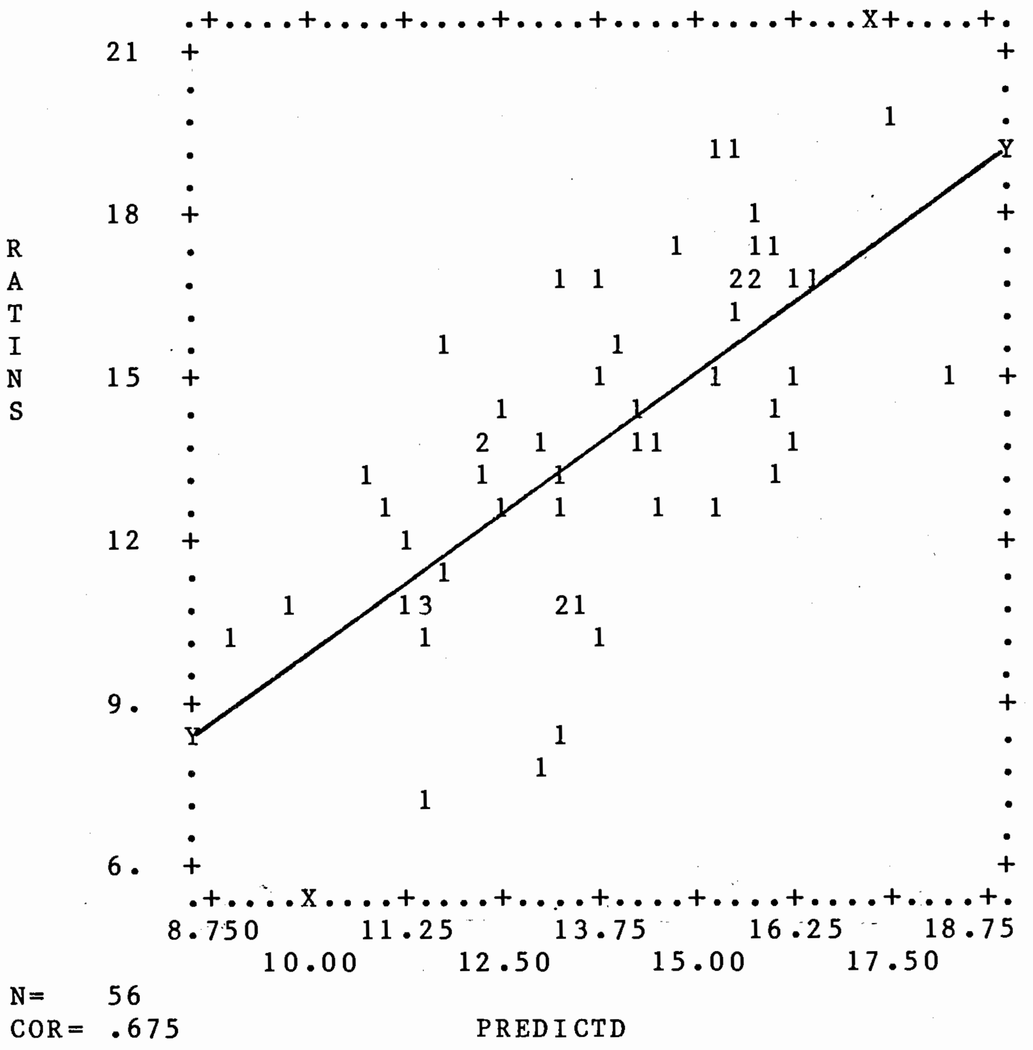
[1] These variables had statistically non-significant (p>.05) t-statistics when used in the subset noted.

four measures to the "best" subset. However, the addition of seven variables also resulted in five variables having statistically non-significant ($p>.05$) t-statistics. Thus, although increasing R^2, these five variables did not add statistically significantly to the prediction equation. In short, then, the "best" subset or subset A (in which a non-significant variable (POMST) could have been derived from a measure which included a statistically significant variable (PCMSF)) seemed preferable to longer subsets with R^2's inflated by a number of statistically non-significant variables. A graphical representation of ratings predicted from the "best" subset (PREDICTD) versus actual ratings (RATINS) of hockey ability of Phase 3 subjects was presented in Figure 3 (p. 186).

Figure 3

Predicted Ratings (PREDICTD) Based on "Best" Subset (Phase 3) versus Actual Ratings (RATINS) of Hockey Ability in Phase 3 - Groups 4 and 5 (N=56)

FIGURE 3
PREDICTED RATINGS (PREDICTD) BASED ON "BEST"SUBSET (PHASE 3) VERSUS ACTUAL RATINGS (RATINS) OF HOCKEY ABILITY IN PHASE 3 - GROUPS 4 AND 5 (N=56)



N= 56
COR= .675

	MEAN	ST.DEV.	REGRESSION LINE	RES.MS.
X	13.793	2.0217	X= .45587*Y+ 7.5051	2.2651
Y	13.793	2.9943	Y= 1.0000*X-954E-9	4.9688

V. Discussion

The findings presented in Chapter 4 were discussed below. Particular reference was made to the relationships between the findings and the general and specific hypotheses stated in Chapter 1. Comments were also made about the variables employed and the observed results. The subsets or test batteries which emerged from regression analyses were discussed in terms of their utility in the field.

Findings and the General Hypothesis

Since the general hypotheses (stated in Chapter 1) provided the focus for the present investigation, the findings were discussed initially in relation to that hypothesis. The general hypothesis was that accurate estimations of ratings of hockey playing ability were obtainable from scores on an isolated battery of measures, i.e., the variance in perceived hockey playing ability was explicable by scores on a battery of tests purporting to measure anaerobic power and capacity, specific hockey skills, psychological factors and perceptual-motor ability. The findings suggested qualified support for this hypothesis; although differences among the three categories of subjects tested prohibited the discovery of a single prediction equation applicable across all categories, prediction equations were found that explained considerable proportions of the variance in hockey ability ratings within categories of subjects.

An immediate implication of the failure to find a generalized prediction equation was that the regression equations obtained were "population specific". That this might have been the case would have agreed with a statement by Katch and Katch (1980) that "It is well documented that prediction equations derived on one segment of the population do a relatively poor job when used to predict other population values" (p. 258). The latter authors argued for the need to examine the predictive validity or cross-validation of regression equations by applying the equations in other samples from the same population and rigorously investigating the procedures and findings. Among the suggestions of Katch and Katch (1980) was that large (over 75), randomly selected samples be employed for cross-validation. Obviously, then, an extension of the present paper would have involved an attempt to cross-validate the regression equations which emerged from the current data by applying them to other samples.

Perhaps the discovery of "population specific" equations seemed less unlikely when the populations were quite different. Arguments might have been advanced that such was the case in the present study. Tables 2a and 2b (pp. 141 & 142) in Chapter 4 provided some indication that differences did exist between the phases and groups employed, although such evidence depended on the appropriateness and validity of the instruments used. It seemed clear, however, that the selection procedures and phase membership were determined in distinctly different ways. In Phase 1, subjects were part of a team and successful performance was crucial for a future career as a hockey player; in Phase 2, subjects were invited on the basis of superior performance for their age but were brought together in relatively large groups for learning experiences; Phase 3 subjects were the youngest, were self-selected, had a variety of backgrounds and skill levels in hockey, and were part of broad summer camp experience. Given the differences between phases, the lack of a generalized equation to predict the hockey ability of players in these diverse settings seemed less unexpected.

Speculation might also have included a discussion of the measures and methodologies employed. Data on available reliability and validity statistics were presented earlier in this report; discussion of the recently developed measures, in particular, took place below. The omission of variables in the present study which might have been more effective predictors of hockey ability was a matter for further research.

Methodological problems appeared to be especially evident in Phase 1. The reduction of sample size to 16 complete data sets limited the utility of the sample. The use of a smaller number of variables in this phase restricted comparisons with other phases. The employment of a different criterion measure also presented difficulties. Although the longer form used in Phase 1 was ostensibly more precise than the criterion measure used in Phases 2 and 3, the time required to complete it and the apparent lack of applicability of some categories reduced its usefulness. Adapting scores on this measure for comparisons across all phases had unknown effects. In short, Phase 1 data were of questionable value and appeared to seriously restrict effective analysis in this study across three categories of players.

The data from Phase 2 seemed most promising. The emergence of an R^2 of 0.83 between subset B (see Table 11, p. 177) and the criterion measure (RATINS) was the most impressive finding in the study. Speculation as to reasons for this finding might have included the relative eliteness, in terms of skills, and homogeneity of the sample, the expertise of the raters, and the possibility that the test battery was most appropriate and sensitive to players at that level. Although cross-validation was warranted, the selection of another sample depended on a description of the common population. A cross-validation sample chosen solely on the basis of age level of the players (Midget) might not have served as well as the elite sample tested in the present study. Cross-validation, then, might have been attempted on samples of both select, superior players and non-select players from the appropriate age level of competition (Midget).

The strength of R^2 in Phase 3 subsets of predictors was less impressive; a modest increase in R^2 of the "best" subset was possible but the addition of variables to achieve this increase resulted in the emergence of statistically non-significant ($p>.05$) t-statistics for some of the subset variables. It was noted that AGE and EXPER, an index of hockey experience, were among the five variables that composed the "best" subset of predictors. The inclusion of these variables appeared to emphasize the importance of maturation and learning in the prediction of hockey ability in subjects at this age level. As Table 2b indicated, Groups 4 and 5 were statistically significantly different on seven variables, including age. Therefore, it might be argued that, despite the statistical non-significance ($p>.05$) of GROUP in the regression analysis of Phase 3 data, the combination of Groups 4 and 5 in Phase 3 resulted in less homogeneity than did the combination of Groups 2 and 3 in Phase 2. The differences found between Groups 4 and 5, as well as others that might have been undetected, might have contributed to the explanation of only approximately half of the variance ($R^2=0.46$) in hockey ability ratings of Phase 3 subjects by the "best" subset of predictors.

Findings and the Specific Hypotheses

Six specific hypotheses were stated in Chapter 1 of this paper to provide operational definitions of the strength of the relationships under investigation. The first specific hypothesis was that the employed battery of measures would have accounted for more than 55 percent of the variance in hockey ability ratings, the latter figure having been reported by Deshaies et al. (1978). As discussed above, this figure was surpassed in Phase 2 of the present study, in which 83 percent of the variance (R^2=0.83) in ratings was accounted for by subset B. In Phase 3, the figure of Deshaies et al. was not surpassed as the preferred subsets, i.e., the "best" subset and subset A, accounted for 46 percent (R^2=0.46) and 50 percent (R^2=0.50) of the variance in ratings, respectively. No statistically significant regression equation was found in Phase 1, although this sample was composed of players at the same level of play as in the Deshaies et al. (1978) study. Possible reasons for the Phase 1 finding were discussed above.

The second specific hypothesis was that the employed measures of "anaerobic power" and "anaerobic capacity" would have correlated more strongly with hockey ability ratings than the value (r=0.42) reported by Deshaies et al. (1978) between ability and anaerobic power (as measured by the Margaria et al. (1966) test). As discussed earlier, the present study employed the Wingate Anaerobic Test (1977) to obtain indices which were called "anaerobic power" (POWER) and "anaerobic capacity" (CAP). Tables 3a to 3e (pp. 145 to 153) and Tables 4a and 4b (pp. 155 to 157) presented the correlations between variables within groups and across phases. Correlations between ratings (RATINS) and POWER in Group 2 (r=0.42), RATINS and CAP in Group 4 (r=0.52), and RATINS and POWER in Group 5 (r=0.42) equalled or surpassed the Deshaies et al. (1978) figure; the correlation between RATINS and CAP in Phases 2 and 3 combined (r=0.46) also surpassed the Deshaies et al. figure. However, statistical significance was noted with respect to only the Group 4 (r=0.52,p<.01), Group 5 (r=0.42,p<.05), and combined Phase 2 and 3 (r=0.46,p<.01) figures. Although correlations of the strength found by Deshaies et al. were not noted within all groups in the present study, POWER and CAP were both statistically significantly correlated with hockey ability ratings when all phases were combined (see Table 4a) or when Phases 2 and 3 were combined (see Table 4b). In short, only qualified support for the second hypothesis was found. Differences between the present study and that of Deshaies et al. (1978), which included sample composition and differences in the rating and anaerobic measures that were related, might have been influential in the lack of total consistency in findings of the two studies.

The third specific hypothesis was that the skating speed measure employed, being the same as that used by Deshaies et al.

(1978), would have shown a similar strength of correlation (r=-0.55) with hockey ability as that obtained by the latter authors. The present findings showed that the correlation between skating speed (SPEED) and ratings of hockey ability (RATINS) exceeded the Deshaies et al. figure for only Group 5 (r=-0.66,p<.01). Although not reaching the magnitude reported by Deshaies et al., statistically significant correlations between SPEED and RATINS were also noted in Group 1 (r=-0.50, p<.05) and when data from Phases 2 and 3 were combined (r=-0.37,p<.01). The implications of the findings were unclear. Since statistically significant correlations were found in only two of the five groups, the suggestion appeared to be that skating speed was generally less important than other variables in contributing to ratings of hockey ability. It was a moot point as to whether the raters were not able to differentiate between players on the basis of skating speed, whether speed was not an important consideration in their ratings, or whether skating skill was not sufficiently developed in subjects within phases, in comparison to other skills, to allow for differentiation. It was interesting that the correlation between SPEED and RATINS was statistically significant in Phase 1, as this sample was at the same level (Junior) as the sample tested by Deshaies et al. (1978). Phase 1 also employed the Deshaies et al. criterion measure, an instrument which specifically asked for ratings on different aspects of skating; the criterion measure employed in

Phases 2 and 3, however, merely mentioned skating as one factor that might have been considered in deciding on ratings. Thus, the possibility existed that the differences in the rating scales might have contributed to the findings. Phase 1 raters, the coaches, also had a season to become familiar with the skills of their players, whereas raters in Phases 2 and 3 had only a week with their players, observing them mostly in pratice (rather than game) conditions. The small Phase 1 sample size limited speculation about the finding of a speed/ratings relationship in this sample providing confirmation for the findings of Deshaies et al.; further replicative studies could have addressed this matter. The finding of a statistically significant correlation between SPEED and RATINS when data from Phases 2 and 3 were combined seemed to reflect the relatively strong correlation (r=-0.66) in Group 5; correlations in the other groups in these phases were low (r's of 0.01, -0.08, -0..16)..

The fourth specific hypothesis was that one or a combination of the employed psychological measures correlated more strongly with hockey ability than the relationship (r=-0.35) reported by Deshaies et al. (1978) between a measure of achievement motivation and hockey ability. An examination of the present data revealed correlations between SS3 (the competence subscale of the Sports Scale) and RATINS of 0.45 in Group 2 and between HAS (the Hockey Attitude Scale) and RATINS of 0.37 in Group 5. Correlations between AGGR (ratings of aggression) and RATINS ($r=0.29, p<.01$) and between SS1 (the aggression subscale of the Sports Scale) and RATINS ($r=-0.30, p<.01$) were also statistically significant when data from all phases were combined, as were the correlations between SS1 and RATINS ($r=-0.23$, $p<.05$) and between EPIEX (the extroversion subscale of the Jr.EPI) and RATINS ($r=0.23, p<.05$) when Phase 2 and 3 data were combined.

The relationships between the criterion measure and combinations of psychological variables were examined by using these psychological variables as independent measures and the criterion measure as the dependent variable in regression analyses. (Data from individual groups were not examined because of small sample sizes.) Combinations of psychological variables did not produce statistically significant F-statistics ($p>.05$) when phases were considered separately. When Phase 2 and 3 data were combined, a multiple correlation of 0.51 was noted between all psychological variables and RATINS ($F_{16,82}=1.80, p=.046$); however, only two variables, HAS (Hockey Attitude Scale) and POMST (the tension subscale of POMS), had statistically significant t-statistics ($t=-2.20, 2.51$; p's$<.05$). When data from all phases were combined, a multiple correlation of 0.39 was found ($F_{7,107}=2.60, p=.016$); only SS2 and SS3 (the conflict and competence subscales, respectively, of the Sports Scale) had statistically significant t-statistics ($t=2.27, -2.08$; $p<.05$).

Hence, when data were combined across all phases or across Phases 2 and 3, relationships between combinations of psychological variables and the criterion measure were stronger than that reported by Deshaies et al. (1978)(r=0.35).

The R of 0.51 (or R^2 of 0.26) which resulted when Phase 2 and 3 data were combined did not appear to be substantial when, as Morgan (1980, p. 23) contended, personality traits had consistently accounted for 20 to 45 percent of the variance in sports performance. Since the psychological variables employed in the present study included measures other than just personality traits, the findings were not impressive. It might have been, as Morgan (1980) also stated, that the combination of psychological with physiological variables resulted in improved prediction; this appeared to be the case in the present study.

The fifth specific hypothesis was that the employed measures of perceptual-motor ability correlated more strongly with hockey ability than the relationship (r=-0.22) reported by Deshaies et al. (1978). Instances of correlations greater than the latter figure were found but, because of relatively small sample sizes, some of the relationships were statistically non-significant (p>.05). Significant relationships were found between DT (decision time) and RATINS (r=-0.46,p<.05) in Group 4, between DT and RATINS (r=-0.43,p<.01) and TRT (total response time) and RATINS (r=-0.34,p<.01) when Phase 2 and 3 data were combined. A statistically significant correlation of -0.21

($p<.05$), approximating the figure of Deshaies et al. (1978), was found between DT and RATINS when data from all phases were combined. Thus, the hypothesis was given only qualified support; decision time (DT) showed similar relationships with hockey ability ratings that of Deshaies et al. when data were combined across groups but, except for Group 4, not when data for individual groups were considered. Nonetheless, it was interesting to note some similar results despite differences in the present study and that Deshaies et al., when these studies used different perceptual-motor measures. It might have been argued that the hockey content of the tachistoscopically presented slides was unimportant in the Deshaies et al. study and that simple reaction time, as measured in the present study, would have served as well.

The sixth and final specific hypothesis was that the other hypotheses stated above were valid in hockey players of different ages and skill levels. Group differences with respect to each hypothesis were discussed above. Support for the sixth hypothesis was strongest when evidence was provided by combining data from Phases 2 and 3 (see Table 4b, p. 157). Significant correlations were noted between hockey ability ratings and each of "anaerobic power" ($r=0.40, p<.01$), "anaerobic capacity" ($r=0.46, p<.01$), skating speed ($r=-0.37, p<.01$), psychological variables ($r=-0.23, p<.05$) for SS1; $r=0.23, p<.05$ for EPIEX; $R=0.51$, $p<.05$ when psychological variables were combined), and perceptual-motor measures ($r=-0.43, p<.01$ for decision time; $r=-0.34, p<.01$ for total response time). However, the strength of these correlations did not compare with those reported by Deshaies et al. (1978) in all cases. Although generally lower in magnitude than those for Phases 2 and 3, statistically significant correlation were noted between hockey ability ratings and variables in three of the categories mentioned above when data from all phases were combined (see Table 4a, p. 155); there was a non-significant correlation between ratings and skating speed ($r=0.06; p>.05$).

Thus, the specific hypotheses were not supported in the present study when data from all groups were considered individually or combined. The relationships noted when data from Phases 2 and 3 were combined clearly supported the second and fifth specific hypotheses, ie., correlations between ratings of hockey ability and anaerobic measures and between hockey ratings and perceptual-motor ability, repectively.

Since the specific hypotheses were formulated to provide operational definitions, this lack of total consistency was not interpreted as critical. The present study was not a specific replication of the Deshaies et al. (1978) study despite the guidance received from the methodology and findings reported by the latter authors.

Comments on the Employed Measures

Measure of anaerobic systems

The present study employed the Wingate Anaerobic Test (1977). As discussed above, the test designers proposed, albeit cautiously, that indices of both anaerobic power and anaerobic capacity could have been derived from a single administration of the test. The present paper did not attempt to add to the data on reliability or validity that were presented by the test designers (Bar-Or, 1978); hence, the terms, "anaerobic power" and "anaerobic capacity", were used in the present paper merely as descriptors of the test indices and were not intended to support claims of validity for these terms.

Data available from the present study seemed to indicated the utility of the Wingate test. Either or both of the test indices, POWER and CAP, appeared in the regression equations using Phase 2 (see Table 11, p. 177) or Phase 3 (see Table 13 p. 183) data. CAP could have been eliminated from the former equation as it was a statistically non-significant contributer ($t=-1.76, p=0.89$); POWER had to be dropped from the list of independent variables in Phase 3 before the regression analysis program would run. These findings might have suggested a relationship between the two indices which was evident when the correlation matrices were examined (see Tables 3a to 3e (pp. 145 to 153) and Tables 4a and 4b (p. 155 & 157). Correlations were high when data across all phases ($r=0.82, p<.01$) or across Phases

2 and 3 (r=0.81,p<.01) were considered. Correlations between POWER and CAP varied from 0.64 to 0.95 (p<.01 in all cases) when individual group data were considered. Other reports on the relationships between these indices were not available. However, Katch and Weltman (1979) noted a correlation of only 0.30 (N=16; p>.05) between their measure of "peak anaerobic power" and "anaerobic capacity" (highest six second output and total output from a two minute all-out ergometer test). Thus, some question of the independence of POWER and CAP in present data was apparent.

Data from the present paper compared favourably with those in the test description (Wingate Anaerobic Test, 1977). For 10 to 12 year old males (N's not available), the literature reported "anaerobic capacity" scores of approximately 38.0 ± 5.0 kpm/min per kg, compared to Group 4 and 5 values of 38.5 ± 7.7 and 36.3 ± 5.3, respectively, in the present study. (Figures on "anaerobic power" were not provided by the test designers.)

Experience in the present study confirmed the attractiveness of the Wingate test as an instrument for use on-site. As explained above, a subject could have completed the test protocol (warm-up, rest, test) in ten to 12 minutes; the rest period was also utilized for the completion of paper-and-pencil measures. Subjects were cooperative and their willingness to take part seemed to reflect, to some extent, the brevity of the test. One difficulty of note concerned the precision in setting the resistance on the ergometer. The setting tended to waiver during the 30 second test duration, probably due to the effect of heat (resistance) on the belt. Care had to be taken to maintain the appropriate setting.

Specific skills

The present study employed the forward skating speed measure proposed by Merrifield and Walford (1969). Although, as discussed above, skating speed was statistically significantly correlated with hockey ability ratings when Phase 2 and 3 data were combined, the correlations were statistically significant in only two groups considered individually and quite low in the others. Whether this finding reflected systematic differences between the groups in the relation between skating speed and hockey ability ratings or reflected random sampling effects was a moot point. The failure of skating speed to appear as a variable in the regression equations of either Phases 2 or 3 implied the relative unimportance of skating speed as a predictor of hockey playing ability, at least in terms of the samples employed in the present study or when used in combination with the variables employed in the present investigation.

One possible source of influence on the present findings was the relatively small ice surface on which each of the phases was tested. Thus, instead of the 120 feet course skated by subjects in other studies (Deshaies et al., 1978; Merrifield and Walford, 1969), subjects in the present study skated only about 105 feet (Phase 1) or 102 feet (Phases 2 and 3). It might well have been that the addition of another 15 feet or so would have served to further differentiate players on the basis of skating skill.

Inter-trial correlations for all available data were as follows: Group 1 - r=0.62, N=20; Group 2 - r=0.90, N=23; Group 3 - r=0.95, N=22; Group 4 - r=0.81, N=28; Group 5 - r=0.91, N=31; all phases - r=0.95, N=124. Thus, except for Group 1, reliabilities between trials were higher than the test-retest correlation (r=0.74) reported by the test's designers (Merrifield and Walford, 1969).

The skating speed measure appeared to separate effectively players at various levels; Phase 1 players were statistically significantly faster than all others and Phase 2 players were faster than those in Phase 3 (see Table 2b, p. 142). Obviously, motivation was a factor in a test of this nature. Subjects in the present study generally appeared to be well-motivated; the presence of their peers and instructors might have helped to assure motivated subjects. (However, the relatively low (r=0.62) inter-trial correlation noted in Phase 1 might have reflected, to some extent, less motivation among these players than in other phases, i.e., the practice atmosphere was relaxed and performance on the measure was not critical to their hockey careers.)

The forward skating speed test proved to be simple to administer, especially if assistants were briefed in advance. In all phases, groups of up to 30 players were tested (two trials each) in less than 15 minutes per group.

Hence, although the test proved to be an easily administered on-site measure of skill, the present findings implied that skating speed was not a predictor of hockey ability, at least when combined with the measures employed in the present paper. The importance of distance in administering this measure remained to be determined by future research. As mentioned earlier, the relative influences on the findings of factors such as the raters' knowledge of their players' skills and the raters' consideration of skating speed in their ratings were unknown. It may be, as Merrifield and Walford (1969) suggested, that a more complex skill, such as stickhandling, would have better differentiated players according to overall hockey ability.

Psychological variables

The aggression measure (AGGR) of Scaramella and Brown (1978) was statistically significantly correlated with hockey ability ratings ($r=0.29$, $p<.01$) when data from all phases were combined (see Table 4a, p. 155); however, it was not statistically significantly correlated with hockey ability when groups were considered individually (see Tables 3a to 3e, pp. 145 to153). Aggression was not a strong contributor to the factors noted in Tables 5a and 5b. Although not a statistically significant member of the "best" subset of predictors in Phase 3 (see Table 13, p. 183), aggression was a statistically significant variable in both the "best" subset ($t=-3.59$, $p=.001$) and subset B ($t=-3.75, p=.001$) in Phase 2 (see Tables 9 and 11, p. 175 & 177).

Although the aggression measure contributed to the regression equation in Phase 2, some questions seemed appropriate about findings related to this variable. The necessity of changing the measure from coaches' ratings in Phase 1 to self-ratings in Phases 2 and 3 had unknown effects on comparisons across all phases. However, as Table 2b (p. 142) indicated, means from only Groups 1 and 3 were statistically significantly different ($t=2.81$, $p<.01$). The Group 1 mean was the lowest of all five groups, a finding that appeared somewhat inconsistent with Group 1's reputation as an "aggressive" team. Speculation might have suggested that self-ratings in Phases 2 and 3 were somewhat inflated and less objective than the coach's ratings employed in Phase 1.

Additional concern for the aggression measure arose from an examination of the correlation matrices (see Tables 3a to 3e, 4a and 4b) and the results of factor analysis (see Tables 5a and 5b, pp. 159 & 161). There seemed to be little evidence of a relationship between "aggression" ratings and scores on the "aggression" subscale of the Sports Scale (SS1). In fact, the only statistically significant correlation noted was in Group 1 but in the negative direction ($r=-0.56, p<.05$). This finding was complicated by the need for further validation of the SS1 subscale. Thus, although showing some promise as a predictor, the aggression measure awaited further study.

Although the Hockey Attitude Scale (HAS) appeared as a significant contributor to subset B in Phase 2 ($t=-2.49, p<.05$), it was a statistically non-significant variable in the Phase 2 "best" subset ($t=-2.02, p>.05$) and did not appear at all in the "best" subset in Phase 3. Scores on HAS were statistically significantly correlated with hockey ability ratings in Groups 5 ($r=0.37, p<.05$) but correlations were low and statistically non-significant when data in other groups, both singly and combined, were considered. Relationships with other variables were noted. Although HAS and SS5 (cooperation subscale of Sports Scale) were statistically significantly correlated when data from all phases were combined ($r=0.29$, $p<.01$) and when Phase 2 and 3 data were combined ($r=0.30$, $p<.01$) neither this finding nor other trends were observed in individual group data. In short, its appearance in the Phase 2 selected subset of predictors offered some promise but, in general, support was weak for this measure. Revision of the measure might have resulted in its being an improved representative of an "environment specific" inventory (see Rushall and Fox, 1980).

When data aross all phases were combined, the correlation between SS1 (the "aggression" subscale of the Sports Scale) and hockey ratings was statistically significant (r=-0.30, p<.01). A similar result (r=-0.23, p<.05) was found when Phase 2 and 3 data were combined. Considering data from individual groups, a statistically significant correlation was found in Group 2 between SS3 (the "competence" subscale of the Sports Scale) and hockey ability (r=-0.45, p<.05). Both SS1 and SS2 ("conflict" subscale) appeared in the "best" subsets of predictors in Phase 2 and Phase 3 regression analyses. SS5 ("cooperation") was also a statistically significant predictor in Phase 2 (t=3.31, p<.01); SS3 was included in the Phase 2 regression equation but had a statistically non-significant t-statistic (t=1.91, p>.05).

The Sports Scale appeared to offer promise as a predictor of hockey ability. It also seemed sensitive to group differences (see Table 2b). The intercorrelations shown in Tables 2a and 2b (pp. 141 & 142) among the scale's subtests appeared to support Butt's (1979) model of sports motivation (see Butt, 1979, p. 27). Significant correlations between Sports Scale subtests and Jr.EPI or POMS subtests were noted but consistent trends within and across groups were not apparent. A comparison of the total means of the present data (N=115) with those reported by Butt (1979) for 67 males (a mixture of university students and seven to 16 year old competitive swimmers) showed the present sample with relatively higher scores on SS1, SS3, SS4 and SS5 (aggression, competence, competition and cooperation) and lower scores on the SS2 (conflict) subscale. The Sports Scale was simple to administer and appeared worthy of inclusion in future studies involving the prediction of hockey ability.

Additional psychological measures administered to only Phases 2 and 3 included the Junior Eysenck Personality Inventory (Jr.EPI) and the Profile of Mood States (POMS). Although the extroversion subscale of the Jr.EPI was statistically significantly related to hockey ability ($r=0.23$, $p<.05$) when Phase 2 and 3 data were combined, there was no other evidence to support its utility as a predictor of hockey ability. However, an examination of Table 5b (p. 161) indicated that the three subscales of the Jr.EPI loaded on factors in which other variables were dominant. As Table 4b (p. 157) confirmed, intercorrelations with other variables employed in the present study undoubtedly minimized the contribution made by the Jr.EPI. Comparisons between present data and the Jr.EPI standardization figures (see Eysenck, 1963) showed Phase 2 subjects scoring higher on all three subtests than norms for boys of the same age. In Phase 3, the Group 4 mean on the extroversion subscale was similar to the norms whereas Groups 5's mean was relatively low; both groups, but especially Group 5, had means above the standardization values on the neuroticisim scale, and; both groups were lower than "normal" values on the lie subscale. (The generally low values on the lie scale augured well for the validity of the present subjects' responses on the paper-and-pencil measures.)

As Tables 4b and 5b indicated, many of the POMS subscales appeared to be highly correlated; these findings tended to disagree with those of the test designers (McNair et al., 1971) that the subscales represented six factors. Despite the failure of any POMS subscale to correlate with hockey ability in paired correlations, the "tension" (POMST) and "fatigue" (POMSF) subscales were both statistically significant (POMST t=-2.02,-2.07; p<.05; POMSF t=4.34,4.26; p<.01) predictors in the Phase 2 preferred subsets ("best" and subset B). Although both these subscales appeared in subset A of Phase 3 predictors, neither was a member of the "best" Phase 3 subset. The emergence of POMST as a predictor was interesting since Nagle et al. (1975) found this subscale was a strong prediction of success in wrestling.

Significant correlations between POMS subscales and other variables were noted but no trends were apparent within and across groups. The test designers (McNair et al., 1971) did not provide appropriate data for comparisons with subjects at the ages found in the present study. (However, comparisons of total means (see Table 2a, p. 141) with a sample of college men (N=340) showed the Phase 2 and 3 combined means to be lower on the tension, depression, fatigue and confusion subscales, higher on the vigor subscale, and similar to the college sample on the anxiety subscale.)

The use of the POMS might have been more effective in combination with other variables but the POMS showed some promise in the present study. Concern was noted, however, when the instrument was employed with Phase 3 subjects in the present study. Although McNair et al. (1971) claimed that "a 7th grade education" (p. 5) was sufficient to understand the POMS, the instrument was basically for use with adults. Many subjects in Phase 3 did not know the meaning of terms employed in the POMS. Interpretation was given without direction but the impact of language difficulty on the test respondent was unknown. In the present study, the POMS was administered during small group sessions so that more personal assistance with vocabulary was available. Nonetheless, virtually all subjects appeared to complete the scale honestly. Future use with younger (than 15 year old) subjects might have included careful consideration of expected reading levels. In addition, future research might have addressed the need for all six subscales.

Perceptual-motor ability

The reponse speed measure employed in the present study included the components of decision or reaction time (DT), movement time (MT) and total response time (TRT). When individual groups were considered, a statistically significant correlation between DT and hockey ability ($r=-0.46, p<.05$) was noted for only Group 4. When data from all phases were combined or when Phase 2 and 3 data were combined, the DT versus RATINS relationships were statistically significant (all phases, $r=-0.21$, $p<.05$; Phases 2 an 3, $r=-0.43$, $p<.01$) in both instances. TRT was also statistically significantly related to hockey ability ($r=-0.34$, $p<.01$) when Phase 2 and 3 data were considered.

The results of the regression analysis revealed MT as a statistically significant member of the "best" subset ($t=-2.42$, $p<.05$) and subset B ($t=-2.88$, $p<.01$) in Phase 2. MT was not a member of the "best" subset in Phase 3 data but did emerge in the other subsets noted in Table 14 (p. 184) (subset A, $t=2.45$, $p<.05$). The appearance of MT, rather than DT, in the regression equations was less surprising when Tables 5a and 5b (pp. 159 & 161) were examined. DT tended to load highly on factors containing several other strong contributors, including other correlates (weight) of hockey ability, whereas MT was the dominant variable in another factor. Thus, MT appeared to add more as an independent factor when combined with other variables to produce the observed regression equations than did DT.

Hence, in general, the present findings seemed to support other results (Deshaies et al., 1978; MacGillivary, 1965) which suggested that perceptual-motor variables were related to hockey ability. As mentioned earlier, although MacGillivary (1965) termed his predictor, "movement time", it actually involved a substantial skill component. Perhaps a simpler task, such as the one employed in the present study, would have served as well.

Although inconclusive, the present results seemed to dispute the position that there was an "essentially zero" (Henry, 1961) relationship between movement time and decision time. When data from all phases were combined, a statistically significant correlation (r=0.21, p<.05) was found between DT and MT. Such was not the case, however, when Phase 2 and 3 combined data were examined. Considering individual group data, statistically significant correlations between DT and MT were noted in Group 2 (r=0.48, p<.05) and in Group 4 (r=0.49, p<.01) but not in the other groups.

The present data appeared to support only partially the finding of Fulton and Hubbard (1975) that reaction and movement times decreased from ages nine to 17. As Table 2b (p. 142) indicated, the youngest boys (Group 5) were statistically significantly slower than all the other groups, even Group 4, with respect to DT (t's from 2.8 to 8.3, all p's<.01); however, no trends were apparent in movement time scores. (A concern with comparing Phase 1 data with those of the other groups was that only five test trials were used in Phase 1 as opposed to 20 trials in Phases 2 and 3. As reported by Haywood and Teeple (1976), a minimum of eight trials "will yield a score representative of performance over 35 trials" (p. 856). However, the latter authors did allow that the first two of the eight trials served as practice trials. Therefore, although Phase 1 subjects fell only slightly short of this figure with two practice and five test trials, there scores might be suspect because of the relatively few trials.)

In practice, the response speed measure employed in the present study appeared to be relatively easy to administer and enjoyed by the subjects. Subjects seemed to be well-motivated and some perceived the measure as a contest of quickness. The portability of the apparatus contributed to the attractiveness of the measure. In short, the response speed measure offered promise as a predictor of hockey abilty. The emergence of either movement time or decision time as predictors might have been determined, however, by the complex of other measures employed.

Rating scale

As discussed earlier, the employment of a different criterion measure in Phase 1 as opposed to the other phases brought into question comparisons across all phases. The shift to the simpler criterion measure used in Phases 2 and 3 was thought necessary to ensure the cooperation of busy instructors in these testing situations. The simpler measure appeared to offer no problems for the rater whereas the Phase 1 measure, proposed by Deshaies et al. (1978), was considerably more time-consuming and included categories ("penetration in offensive zone") which might have been unclear to the rater. Inter-rater reliabilities tended to be higher in Phases 2 and 3 than in Phase 1 (see Table 6a, p. 167) but future investigations were needed to determine the relative reliabilities of the two criterion measures. The low inter-rater reliability in Group 3 (r=0.39) undoubtedly reflected the failure of the head coach to complete the criterion measure. Thus, the reliability figure reported had to be based on available pairs of ratings (N=14) given by raters who were not all as familiar with the team as the head coach was.

Another difference regarding the criterion measure concerned the time of its use relative to the completion of the other measures. In Phase 1, the criterion measure was distributed some months after the other measures so that raters would have become familiar with the players. This design was that used by Deshaies et al. (1978) and was aimed at assessing the predictive validity of the measures on which the players were tested. Since players in Phase 2 and 3 were together for only a week, the criterion measure was completed near the end of the week (concurrent validity). Thus, the judgments made after months of working with players might have been considerably different than those made after a few days, regardless of differences in the criterion measures. Measures might also have been different when given in a team setting where winning was undoubtedly important (Phase 1) than in learning or temporary settings (Phases 2 and 3).

Although Phase 2 mean ratings were higher than those in Phase 3, only the differences between the mean of Group 5 and the means of Groups 2, 3 and 4 were statistically significant (t's from 3.1 to 4.0, p's <.01). Thus, ratings appeared to be relative rather than given in comparison to some absolute standard. (In searching for a standard of comparison on the peer-rating scale, one 13 year old said, "We'd all be zero's if we compared ourselves to Guy LaFleur".) The researchers did not direct raters as to the standards they were to employ.

The simpler criterion measure was also amenable to use a peer-rating scale with subjects. Table 6b presented the correlations between instructors' ratings and those of the players. It was particularly interesting to note correlations of 0.92 and 0.90 with regard to Groups 4 and 5, respectively. These figures implied that players' ratings of hockey ability, even from boys as young as 10 to 13 years, were consistent with those of their instructors. This was not to deny inter-rater variability but to state that mean ratings produced such consistency when samples of the present sizes were used.

The assessment of the rating scales used in the present study would have been less difficult without the problems discussed above. Although the simpler criterion measure seemed promising as a relatively quick means of obtaining hockey ability ratings, further study was needed to evaluate the measure's reliability.

Other variables

Descriptive measures, such as age, experience, weight, height and forearm girth, did not appear consistently as statistically significant correlates of hockey ability when individual group data were considered nor when data were combined across all phases. When Phase 2 and 3 data were combined, however, statistically significant correlations were noted between hockey ability and each of age ($r=0.41$, $p<.01$), experience ($r=0.41$, $p<.01$), weight ($r= 0.36$, $p<.01$), height ($r=0.36$, $p<.01$) and forearm girth ($r=0.34$, $p<.01$). Experience, weight and forearm girth were all statistically significant (t's from 2.10 to 5.83; p's <.05) variables in subset B of Phase 2 predictors, whereas age and experience were statistically significant ($t=2.43$, 2.18; $p<.05$) contributors to the "best" subset in Phase 3.

It appeared, then, that size (weight) and power or relative muscularity (as represented by forearm girth) were more important predictors of hockey ability in Phase 2, when elite players from a small age range were tested, and age was relatively more important in Phase 3 when younger players with diverse skill levels and less homogeneity of age were represented. The effects of age in older players who were less select was a topic of study for subsequent investigations.

Utility of the Batteries of Predictors

Prediction of hockey ability ratings showed most promise in Phase 2. Of the subsets or batteries of predictors showed in Table 10, subset B was chosen for illustration. This battery was composed of 14 variables which were derived from nine measures, all of which could have been administered off-ice. The paper-and-pencil measures, including the Hockey Attitude Scale, the Sports Scale, the POMS, and the experience measure, could have been administered in a group setting in 10 to 15 minutes, assuming a reading level similar to the Phase 2 subjects tested in the present study. This estimation included all POMS and Sports Scale subscales; time would be reduced, of course, by using selected POMS subscales but this would have necessitated some alterations to the copyrighted version (McNair et al., 1971). If the aggression scale was to be self-reported, it could have been added to the above combination of measures with little affect on administration time.

The remaining measures were to be administered individually, although small groups could have been utilized as in the present study. As discussed in Chapter 3, the Wingate Anaerobic Test (1977) required about 12 minutes per subject; both indices (POWER and CAP) were derived from the same test. The response speed measure could be completed in about five minutes by each subject. Both the Wingate Test and the response speed test required equipment which was portable. A relatively private testing site was preferred so that equipment, especially bicycle ergometers, could have remained in one place throughout the testing period.

To save time, the paper-and-pencil measures could have been completed while small groups of subjects awaited testing on the Wingate test or response speed measure. Forearm girth and weight could be obtained during small group settings. Thus, if all measures were administered in two sessions which centered around the completion of either the Wingate test or response speed measure, the 14 variable battery of tests (Subset B) could be completed in two 15 minute sessions per subject. Times could have varied, of course, depending on availability of equipment and assistance.

Scoring of the paper-and-pencil measures was straightforward; a scoring key was available for the POMS. POWER and CAP were determined by following instructions given by the test designers (Wingate Anaerobic Test, 1977).

In short, the battery discussed (subset B, Phase 2) offerred a manageable protocol for estimating hockey ability. Further study was needed to determine the reliability of the measures employed in the present study and the generalizability of the present findings to other samples. However, if the batteries found in the present study were to have gained support from additional investigations, another method for estimating hockey ability could have been forwarded. Thus, where selection of players could not be based on subjective ratings or where such ratings might have been augmented by other evidence, such a battery of tests would have been valuable. In addition, specific items in the battery (POWER) might have been amenable to change. Thus, training could have attempted to maximize scores on variables that had consistently emerged as predictors of hockey ability.

VI. Summary and Conclusions

The present study investigated batteries of measures as predictors of ice hockey ability. The measures employed were diverse but focused on four major domains: anaerobic systems, specific skills, psychological variables and perceptual-motor ability. The criterion measure, hockey ability, was determined by the ratings of coaches or instructors.

The subjects tested comprised three categories of male hockey players, differentiated by age and level of play. The study was described as three phases to accommodate the three categories of players, i.e., Phase 1 (Juniors, N=24), Phase 2 (Midgets, N=48) and Phase 3 (nine to 13 year olds attending summer hockey school, N=60). Measures from which 17 variables were derived were administered to Phase 1 subjects; an additional 12 variables were included in Phases 2 and 3. All measures were administered on-site; only one measure was administered on the ice.

The data were analyzed to provide univariate statistics and correlation matrices for all phases combined, for Phase 2 and 3 combined, for each phase and for each group within a phase (there were two groups in each of Phases 2 and 3). Regression analysis, using program BMDP9R (Dixon, 1977), was conducted on data in individual and combined phases to examine any overall or specific trends. This program provided the "best" and other subsets of predictors so that various subsets or batteries of tests could have been selected based on other considerations (expense, time required) besides their predictive power.

Significant batteries of predictors were found in Phases 2 and 3. The selected subset in Phase 2 had a multiple correlation of 0.91 (R^2=0.83) with ratings of hockey playing ability ($F_{14,28}$=9.45, $p<.001$). The "best" subset in Phase 3 had a multiple correlation of 0.68 (R^2=0.46) with hockey ability ratings ($F_{5,50}$=8.38, $p<.001$).

Discussions of the findings included a concern for sample specificity, the relation of the findings to the stated hypotheses, the performance of individual measures and the utility of a battery of tests on-site. Further research was needed to determine the validity of the present findings in other samples. Some of the measures employed showed promise as predictors of hockey ability in the batteries which emerged and others did not. The utility of a selected Phase 2 battery was discussed in terms of the time required for its administration on-site. It was proposed that scores on the 14 variables in this battery could have been obtained in two 15 minute test sessions per subject. Such a battery could have been employed to augment other information, such as observers' opinions, in selecting players for teams or by itself when no other information was available. If particular items in a battery were amenable to change, training might have focused on improving scores on those variables.

Recommendations included the need for cross-validation of the present findings using similarly selected samples. Further investigations could have systematically varied age and selection procedures to examine the generalizability of any promising batteries. Measures could have been systematically added or deleted from the present selection to optimize prediction.

Appendix A - Letters and Consent Forms

<u>U.B.C. HOCKEY SCHOOL STUDY</u>

4148 Ripple Road,
West Vancouver, B.C.,
June 16, 1980.

Dear Parent,

Your child will be attending the U.B.C. Hockey School this summer in Vancouver, B.C. My long-time interest in hockey has resulted in my studying performance in hockey as the subject for my M.Sc. thesis at Simon Fraser University. I have approached the people running the U.B.C. Hockey School in connection with my study. I believe that it is important that we study hockey more thoroughly in order that we understand and, therefore, improve the quality of the game in North America.

I would like to test some of the students who will be attending the U.B.C. Hockey School to try to determine which tests best predict performance on the ice. The tests are as simple and brief as I could make them. They include tests of attitudes, feelings, reaction time, skating speed and fitness. All the tests have been administered before and will be given this summer under my supervision. Although I believe the students will enjoy taking the tests, they are free to stop participating at any time if for any reason they don't want to continue.

The Hockey School has agreed, in principle, to my study. I will not interfere with any of the activities planned for your child: all my tests will be conducted in "free" time (e.g., between the morning practice and lunch) and will not require very much time for any child during any day. Individual test results will be confidential and only seen by the researchers; I would be happy to discuss the tests or the test results with you or your child. I plan to send a summary of my findings to all participants.

Your permission to involve your child in my study would be most appreciated. You may indicate your permission by signing the attached consent form and by sending the form with your child to the Hockey School. You may call me at 731-1131 (ext.281) or 926-9668 if you wish to discuss this further.

Thank you for your cooperation .

Sincerely,

Robert Stevens,
Graduate Student,
Kinesiology Dept.,
Simon Fraser University.

PARENTAL CONSENT FORM - U.B.C. HOCKEY SCHOOL

I understand that Robert Stevens, a graduate student in Kinesiology at Simon Fraser University, will be conducting some tests as part of his study at the U.B.C. Hockey School this summer. This is to grant permission for my child, ______________________________, to take part in this study, with the understanding that he can stop his participation at any time.

Signed: ______________________________
(Parent/Guardian)

Date: ___________________________

STUDENT CONSENT FORM - U.B.C. HOCKEY SCHOOL

Mr. Bob Stevens has told me about his study on hockey and about the tests that he wants to use. I understand about the tests and would like to take part in the study. I also understand that I may stop taking part in the tests at any time.

Signed: ______________________________

Date: __________________________

504 East 15 th. Street,
North Vancouver, B.C.,
February 19, 1980.

Dear

I am doing a study on hockey as my thesis project at Simon Fraser University here in Vancouver and would greatly appreciate your help. My project involves two things: (1) conducting a number of tests on a hockey team, and (2) having coaches rate these players later in the season on skills like skating, passing, and defensive skills. I have done the first part of the project as the New Westminster Bruins were kind enough to let me test their players at the beginning of the season. Now I am approaching coaches like yourself who have seen the Bruins play a number of times this season and asking whether you can help me out.

Basically, here's what it will involve if you can spare the time to help me. I will give you a list of players that I tested at the beginning of the year and ask you to fill out both of the attached sheets for each player. The list will include only about 14 players as the Bruins' roster has changed quite a bit since the start of the year. I would still like ratings on former Bruins who are now playing for other WHL teams but were with New Westminster when I did my testing.

If you can help me with my project, please drop the enclosed card in the mail or call me collect at (604) 980-2986. I'll then send you enough forms and explain the categories on the attached sheets in more detail, if necessary. Perhaps, if you wish, you could call me the next time you're in town and we could get together then. I do appreciate any assistance you can give me as the coaches' ratings are crucial to my study. My aim is to be able to predict more accurately those players who are likely to be the best performers at some time in the future.

Thanks for your time - hope to hear from you soon.

Sincerely,

Appendix B - Instruments

Student's Name: ______________________

STUDENT HOCKEY FORM - U.B.C. HOCKEY SCHOOL

Please answer these questions about your background in hockey.

1. How old are you ? ______________ years

2. How long have you been playing hockey? ______________ years

3. How long have you been playing in an organized league? __________ years

4. About how many times did you play last year? (Put a check mark (☑) in one of the boxes below.)

   - ☐ I played about 0 to 5 times last year.
   - ☐ I played about 6 to 10 times last year.
   - ☐ I played about 11 to 20 times last year.
   - ☐ I played about 21 to 30 times last year.
   - ☐ I played over 30 times last year.

5. About how many times did you practice last year? (Put a check mark (☑) in one of the boxes below.)

   - ☐ I practiced about 0 to 5 times last year.
   - ☐ I practiced about 6 to 10 times last year.
   - ☐ I practiced about 11 to 20 times last year.
   - ☐ I practiced about 21 to 30 times last year.
   - ☐ I practiced over 30 times last year.

6. Give yourself a rating as a hockey player by using numbers from 0 to 20. A low number means that you don't think you are very good yet whereas a high number means that you think you are a good player. The higher the number, the better the player.

   Your rating of yourself ________________

7. What position do you usually play in hockey? ____________________

Student's Name: ____________________

STUDENT HOCKEY FORM - JUNIOR OLYMPIC PROGRAM

Please answer these questions about your background in hockey.

1. When were you born? month - ________, day - ________, year - ________

2. How long have you been playing hockey? ________________ years

3. How long have you been playing in an organized league? __________ years

4. About how many times did you play last year? (Put a check mark (☑) in one of the boxes below.)

   - ☐ I played about 0 to 20 times last year.
   - ☐ I played about 21 to 30 times last year.
   - ☐ I played about 31 to 40 times last year.
   - ☐ I played about 41 to 50 times last year.
   - ☐ I played over 50 times last year.

5. About how many times did you practice last year? (Put a check mark (☑) in one of the boxes below.)

   - ☐ I practiced about 0 to 20 times last year.
   - ☐ I practiced about 21 to 30 times last year.
   - ☐ I practiced about 31 to 40 times last year.
   - ☐ I practiced about 41 to 50 times last year.
   - ☐ I practiced over 50 times last year.

6. Give yourself a rating as a hockey player by using numbers from 0 to 20. A low number means that you don't think you are very good yet whereas a high number means that you think you are a good player. The higher the number, the better the player.

   Your rating of yourself ____________________

7. What position do you usually play in hockey? ____________________

1. Sports Scales

Instructions: Answer all the questions below by checking "yes" or "no". If the question is not applicable to your sport answer "no". If you feel the best answer is "sometimes" then check the "yes". Do not miss any questions.

During the **last month*** while participating (training or competing) in:

_ HOCKEY _ **did you ever feel?**

1.	Listless or tired?	yes	no
2.	Determined to come in first?	yes	no
3.	Thrilled?	yes	no
4.	Like helping someone else to improve?	yes	no
5.	Full of energy?	yes	no
6.	Moody for no real reason?	yes	no
7.	Like winning is very important to you?	yes	no
8.	Like part of, or very friendly towards, the group (partner, team or club)?	yes	no
9.	Impulsive?	yes	no
10.	Irritated that someone did better than you?	yes	no
11.	Happier than you have ever been?	yes	no
12.	Guilty for not doing better?	yes	no
13.	Powerful?	yes	no
14.	Very nervous?	yes	no
15.	Pleased because someone else did well?	yes	no
16.	That you were performing your best yet?	yes	no
17.	Like crying?	yes	no
18.	Like telling someone off?	yes	no
19.	More interested in your sport than in anything else?	yes	no
20.	Annoyed because you didn't win?	yes	no
21.	Like doing something to help the team or group?	yes	no
22.	That if anyone got in your way, you could let them have it (push them, hit them)?	yes	no
23.	You had accomplished something (a skill) new to you?	yes	no
24.	Like others were getting more than they deserved (more than their fair share of attention and reward)?	yes	no
25.	Like congratulating someone because they had done well?	yes	no

Name: ____________

HOCKEY ATTITUDE SCALE

Please answer the items below by putting a check (☑) in the box that best expresses how often you feel that way.

---

1. When I think that I've played really well, I try not to let the coach and the other players know how pleased I am with myself.

☐ Always ☐ Frequently ☐ Sometimes ☐ Never

2. I feel that just being selected to play on my team is a sufficient honour to make playing hockey worthwhile for me.

☐ Always ☐ Frequently ☐ Sometimes ☐ Never

3. When I'm training or practicing, I may often seem grouchy.

☐ Always ☐ Frequently ☐ Sometimes ☐ Never

4. To be honest, I don't really like training or practicing hard.

☐ Always ☐ Frequently ☐ Sometimes ☐ Never

5. I like to prepare for a game by being by myself.

☐ Always ☐ Frequently ☐ Sometimes ☐ Never

6. I like to set a goal or objective for myself before every game.

☐ Always ☐ Frequently ☐ Sometimes ☐ Never

7. I'd rather practice or train with somebody else than by myself.

☐ Always ☐ Frequently ☐ Sometimes ☐ Never

8. I try to get more information on all aspects of hockey (for example, training, shooting, skating, mental preparation).

☐ Always ☐ Frequently ☐ Sometimes ☐ Never

9. Before a game, I feel I've gone through the necessary preparation.

☐ Always ☐ Frequently ☐ Sometimes ☐ Never

10. Nothing really bothers me when I'm preparing or warming up for a game.

☐ Always ☐ Frequently ☐ Sometimes ☐ Never

AGGRESSION SCALE - COACH'S RATINGS

Instructions: Give a rating from 1 to 5 for each player listed below. For example, if a player is always able to respond aggressively in an aggressive situation, then put a 5 beside his name. If you feel that he is rarely able to respond aggressively, put a 1 beside his name.

Rating	Description
5	When faced with an aggressive situation, this player is always able to respond in an aggressive manner without become intimidated.
4	When faced with an aggressive situation, this player is almost always able to respond in an aggressive manner without becoming intimidated.
3	When faced with an aggressive situation, this player is usually able to respond in an aggressive manner without becoming intimidated.
2	When faced with an aggressive situation, this player is occasionally able to respond in an aggressive manner without becoming intimidated.
1	When faced with an aggressive situation, this player is rarely able to respond in an aggressive manner without becoming intimidated.

Player	Rating	Player	Rating

Student's Name: ____________________

STUDENT HOCKEY FORM - U.B.C. HOCKEY SCHOOL

Introduction: Most students come to the hockey school to have fun and to learn more about playing hockey. Some of you have played hockey for a few years while others are just starting. I suppose everyone needs practice to get better. For this study, we would like to get some idea as to how good a hockey player you are now. It will be interesting to see how much you have improved in a year or two.

We would like you to do two things on this form to help us compare all the players we have tested: (1) tell us what you think of the hockey ability of the other boys who have been at camp this week, and; (2) tell us how you like to play hockey.

---

(1) Give each player below a number from 0 to 20 to tell us how good a player you think he is. A low number means that you don't think that player is very good yet whereas a high number means that you think he is a good player now. You can give more than one player the same number rating or give everyone a different number rating.

Player's Name	Your Rating	Player's Name	Your Rating

(STUDENT HOCKEY FORM - cont'd)

(2) How often do you play hockey aggressively (hustling, fighting hard for the puck, etc.)? (Check one of the boxes below.)

- ☐ I always play aggressively.
- ☐ I almost always play aggressively.
- ☐ I usually play aggressively.
- ☐ I occasionally play aggressively.
- ☐ I rarely play aggressively.

How tall are you? ______________________

INDIVIDUAL SKILL EVALUATION CHART (Phase 1)

Player's Name: ______________________ No.: __________

Instructions: Rate player on each skill listed, judging the technical aspects and overall efficiency within the following four categories: Excellent (3), Good (2), Average (1), Poor (0).

Skills		Rating			
		Excellent (3)	Good (2)	Average (1)	Poor (0)
Skating: Starts	Forward				
	Backward				
Stops	Left				
	Right				
Turns	Left				
	Right				
Straight	Forward				
	Backward				
Acceleration					
Stickhandling: Precision					
Head position					
Passes: Precision					
Speed					
Shots: Precision					
Speed					
Checking: Body					
Stick					

Coach's signature: ______________________

TACTICAL SKILL EVALUATION CHART (Phase 1)

Player's Name: ______________________ No.: __________

Instructions: Rate player's ability to be in the position required during each of the game phases identified below. Your judgement should reflect the extent to which the player conforms to the requirements of the tactical system utilized. Place player in one of the following four categories: Excellent (3), Good (2), Average (1), Poor (0).

Game phases	Rating			
	Excellent (3)	Good (2)	Average (1)	Poor (0)
Offensive: Out of the zone				
Central zone				
Penetration in offensive zone				
Attack within offensive zone				
Defensive: Checking in offensive zone				
Backchecking				
Blue line defense				
Checking in defensive zone				

Coach's signature: ______________________

Rater's Name: ______________

RATINGS OF HOCKEY ABILITY (Phases 2 and 3)

Instructions: For each player listed below, please provide a rating of overall hockey playing ability. You may consider such factors as skating, stickhandling, passing, shooting, checking, and positional play in your rating. Use a scale from 0 to 20, where 0 means "Very poor" and 20 means "Very good" hockey playing ability.

Player's Name	No.	Rating

Appendix C - Data Collection Forms

DATA RECORDING FORM: Wingate Anaerobic Test

Subject	Weight	Ergometer Setting (Kp)	No. of Revolutions at 5 10 15 20 25 30	Power Output (Kpm/min/kg) 30 sec. 5 sec.

DATA RECORDING FORM: Skating Speed Test

Subject	Time (sec.) Trial 1	Trial 2	Mean Time (sec.)

DATA RECORDING FORM: Perceptual-motor task (Individual times)

Subject's Name: ______________________

Trial No.	Decision Time (.01 sec)	Movement Time (.01 sec)	Total Response Time (.01 sec)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
Mean Times			

DATA RECORDING FORM: MASTER FORM

Subject	Age	Anaerobic Power Output (Kpm/min/kg) 5sec	30sec	Mean Skating Speed (sec)	Per-Motor Mean Times (.01 sec) DT	MT	TRT	Psychological Tests Agg.	H.A.S.	S.S.	EPI	POMS	Hockey Playing Ability Ratings Ins.	Kids	Wt.	Ht.	Fore-arm Girth

Appendix D - Raw Data

```
GROUP SUBJECT AGE CAP POWER SPEED DT MT TRT AGGR HAS SPORTS SCALE EPIEX EPIN EPIL POMST POMSD POMSA POMSV POMSF POMSC RATINS RATKID EXPER WEIGHT HEIGHT FARM
10122551.740.54.9022.013.835.811552255                  39.7     86.3190.5
10221856.441.05.1017.812.430.232254445                  56.5     88.5188.0
10322153.939.95.0016.612.228.842255455                  48.2     78.1185.4
10422662.746.65.1017.209.026.251103345                  35.5     92.2190.5
10620342.335.35.2020.813.434.232052345                  17.5     88.5177.8
10721156.143.75.0017.210.627.822142345                  22.2     78.5175.3
10823751.442.95.0018.611.029.631932235                  69.7     84.0182.9
10921640.133.45.0017.818.035.832033134                  57.6     81.7188.0
11122348.241.85.1017.211.028.222252544                  37.5     82.2180.3
11223554.943.95.1018.413.431.841643225                  63.9     84.0180.3
11323858.343.75.0017.010.827.831554335                  19.0     84.0175.3
11720357.242.55.1015.617.433.041842345                  59.7     83.1188.0
11823860.941.55.4019.814.234.022053345                  00.0     88.5185.4
12022340.037.15.2026.216.242.441611245                  39.1     90.8200.7
12122763.851.25.0019.613.032.641654545                  54.5     79.5182.9
12423749.443.05.1016.212.028.251732245                  47.6     84.0182.9
20119765.449.15.8017.313.230.55230143519070408000016060217.015.12872.6177.829.0
20219564.748.56.5017.912.830.73182043418160510000617000615.514.02666.7165.129.2
20319965.449.15.9919.612.331.94165355523190021090826140816.014.42672.6168.929.8
20419350.645.05.4221.011.332.33173152522050405000019020318.014.93070.4185.426.0
20519356.345.05.3718.412.931.33183224420070208030724090715.514.62670.4175.329.1
20619648.248.25.4414.709.424.13153414518080416090719110912.013.92367.2175.328.9
20719762.351.95.3015.811.427.24142021321030116130320050613.013.61760.4161.326.7
20819448.039.15.3919.214.433.54181353517120411100718150717.316.02277.6188.028.8
20920064.350.05.1618.312.730.93124245222090410080318110917.616.92384.0180.329.1
21120057.057.05.2917.312.429.63220235519160510020421090314.514.53159.0168.926.6
21319548.438.65.4121.015.036.03155345417170209010215120613.012.42363.6170.226.1
21419760.046.35.3815.410.626.04152124522110719091123060616.514.92572.6177.828.4
21519454.542.75.4917.913.030.95210422515210422160727141114.513.92372.6177.827.4
21719756.345.05.6017.014.131.05172353516140013080920130614.513.82770.4180.328.4
21818859.243.05.5516.311.327.55215331522110417000421150713.514.02663.6174.626.1
21919878.153.05.3216.711.227.94191132422130307140820060318.015.41961.3170.225.9
22019752.945.85.2516.412.629.04154234215180419243220211715.515.63168.1175.327.4
22119867.547.85.0217.012.629.63205223513180110020520100616.715.82770.4177.828.5
22219960.648.64.9915.212.327.54153142519130221303017141618.316.82781.7179.129.7
22419645.042.25.3915.013.528.54171123516060411030517020615.014.52370.4180.327.5
30119654.743.76.8217.514.431.95115443521150010010017060212.713.32865.8182.925.5
30219555.346.16.2821.314.035.34202244422140014111015231017.016.22774.9179.129.1
30318749.743.36.1218.113.531.52192222518110308161118050617.516.82874.9169.528.6
30420039.432.85.5718.612.731.34174143517060312121119070714.715.32370.4177.827.0
30519554.342.55.7316.114.230.24144233421160209040521110416.215.92286.3188.030.9
30619042.937.55.7615.513.328.84223252517090207001024080613.414.52077.2175.328.9
30719053.642.06.0422.014.035.95163315216160516070820250715.115.32277.2181.629.0
30819352.944.95.6320.514.835.35094422212150216040615210514.714.82268.1180.326.0
30920038.730.45.7116.120.736.85180143520080409030323060315.214.22574.9189.226.3
31019644.136.75.7817.011.928.85153154423030606020428000216.816.12484.9188.028.4
31119869.952.05.5717.811.529.25162024517150007051021080616.816.02963.6172.727.9
31219455.044.95.3313.511.525.05152554519100314010524120515.415.82662.2170.226.2
31319637.534.95.3220.113.533.63175344523160210140920050913.214.52277.2182.929.2
31419556.344.15.3419.115.334.34214153519140717181721091414.213.92270.4177.828.8
31619967.552.55.0616.211.327.55165133423120409120820130616.216.62970.4172.128.2
31719555.348.85.1415.513.128.64173334320130017151417180814.715.52374.9177.829.2
31818849.243.75.3719.216.735.94183143517080608010722050414.014.92665.8174.026.7
31919538.634.05.1217.013.130.12160222015190314252924141015.716.02471.7183.425.8
32019544.237.75.1514.813.428.15165053527080705000124020116.014.92471.7179.126.9
32120060.044.55.5017.609.827.45182022516070214150718030715.015.32572.6177.829.2
32218760.646.85.0914.811.926.73203233314050410070518070416.116.32881.7177.829.5
32319756.646.35.2214.312.426.63101333317100205010215130215.515.02460.4175.326.2
32419555.345.15.5221.717.439.04132031415060207070418041115.616.02874.9182.928.9
40115599.953.46.1119.109.628.74183044517170307031620110715.013.92143.1161.323.5
40213041.735.77.0122.813.836.63153251515180508070612091213.010.80936.3144.819.9
40414671.441.75.6017.608.626.24143042417030511060317140416.516.12236.6144.820.5
40514267.244.85.5120.709.530.24153042520040310090417150516.515.12238.6142.222.9
40715869.342.37.1017.908.726.63144022520060407010418090608.507.10449.9162.624.3
40813848.038.06.4622.809.232.03204231412100402010219050213.311.91330.0137.218.5
40914344.437.05.8721.211.632.83212333513110304020212040617.016.01445.4154.922.5
41014343.740.16.2120.111.331.44160132519130206090815071014.013.01039.5147.321.8
41113960.247.16.0320.612.733.23243140520120408080229070817.014.92035.9152.421.2
41214052.835.27.4122.613.536.03113140518130305050720130617.015.51847.7152.423.1
41312729.825.86.9125.511.837.33170141314130404050216090611.509.30836.3144.822.3
41412839.131.78.0723.513.436.84122341412150711240807111316.513.31329.5132.019.8
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51712247.641.46.7023.014.137.14114221415080107080421070508.011.41634.1147.320.2
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52914746.341.56.5120.712.232.95135224522150116222320131314.016.31840.4152.422.2
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References

Adams, J.A. A closed-loop theory of motor learning. _J. of Mtr. Behr._, 1971, _3_, 111-150.

Alderman, R.B. _Psychological Behavior in Sport_. Philadelphia: Saunders, 1974.

Allard, F. Perception in volleyball: the nature of the skill. Unpublished paper, University of Waterloo, 1979.

Allard, F., Graham, S., and Paarsalv, M.E. Perception in sports: basketball. Unpublished paper, University of Waterloo, 1979.

Allport, G.W. _Personality: A Psychological Interpretation_. New York: Holt, 1937.

Astrand, P. -O. and Rodahl, K. _Textbook of Work Physiology: Physiological Bases of Exercise (2nd. Ed.)_. New York: McGraw-Hill, 1977.

Ball, J.R. and Carron, A.V. The influence of team cohesion and participation motivation upon performance success in intercollegiate ice hockey. _Can. J. Applied Sport Sciences_, 1976, _1_, 271-275.

Bar-Or, O. A new anaerobic capcity test - characteristics and application. Paper presented at the 21st. World Congress in Sports Medicine, Brasilia, Sept., 1978.

Bar-Or, O., Dotan, R., Inbar, C., Rothstein, A., Karlsson, J., and Tesch, P. Anaerobic capacity and muscle fibre type distribution in man. _Int. J. Sports Med._, 1980, _1_, 82-85.

Barrell, G.V. and Trippe, H.R. Field dependence and physical ability. *Perceptual and Motor Skills*, 1975, *41*, 216-218.

Baumgartner, T.A. and Jackson, A.S. *Measurement for Evaluation in Physical Education*. London: Houghton Mifflin, 1975.

Berkowitz, L. *Aggression: A Social Psychological Analysis*. New York: McGraw-Hill, 1962.

Berkowitz, L. Experimental investigations of hostility catharsis. *J. of Consult. and Clin. Psych.*, 1970, *35*, 1-7.

Bird, A.M. Development of a model for predicting team performance. *Res. Quart.*, 1977, *48*, 24-32.

Bird, E.I. Multivariate personality analysis of two children's hockey teams. *Perceptual and Motor Skills*, 1979, *48*, 967-973.

Boarman, A.M. The effect of folk dancing upon reation time and movement time of senior citizens. Unpublished doctoral dissertation, Oregon State University, 1977.

Butt, D.S. *Psychology of Sport: The Behavior, Motivation, Personality, and Performance of Athletes.* New York: Van Nostrand Reinhold, 1976.

Butt, D.S. Short scales for the measurement of sports motivation. Unpublished paper, University of British Columbia, 1979.

Byrne, D.G. Note on decision time/movement time relationships in normal and depressed subjects. *Perceptual and Motor Skills*, 1975, *41*, 907-910.

Byrne, D.G. Choice reaction times in depressive states. Br. J. soc. clin. Psychol., 1976, 15, 149-156.

Canaris, M.J. Frustration, aggression and the instrumental catharsis of aggression. Unpublished doctoral dissertation, University of Maryland, 1973.

Carron, A.V., Ball, J.R., and Chelladurai, P. Motivation for participation, success in performance and their relationship to individual and group satisfaction. Perceptual and Motor Skills, 1977, 45, 835-841.

Carter, J.E.L. The Heath-Carter Somatotype Method (Rev.Ed.). San Diego, Calif.; San Diego State U. Press, 1975.

Cattell, R.B. The Scientific Analysis of Personality. Chicago: Aldine, 1966.

Cerretelli, P., Pendergrast, C., Paganelli, W.C., and Rennie, D.W. Effects of specific muscle training on VO on-response and early blood lactate. J. Appl. Physiol Respirat.: Environ.Exercise Physiol., 1979, 47, 761-769.

Chien, I. The effect of training and competition on physiological measures in university varsity ice hockey players. Unpublished doctoral dissertation, University of Minnesota, 1978.

Cooper, L. Athletics, activity and personality: a review of the literature. Res. Quart., 1969, 40, 17-22.

Cratty, B.J. Perceptual-Motor Behavior and Educational Processes. Springfield, Illinois: C.C. Thomas, 1969.

Cratty, B.J. _Movement Behavior and Motor Learning (3rd.Ed.)._ Philadelphia: Lea and Febiger, 1973.

Cratty, B.J. _Psycho-Motor Behavior in Education and Sport._ Springfield, Illinois: C.C. Thomas, 1974.

Cratty, B.J. and Hutton, R.S. _Experiments in Movement Behavior and Motor Learning_. Philadelphia: Lea & Febiger, 1969.

Deshaies, P. Personal communication, 1979.

Deshaies, P. and Pargman, D. A comparison of four error scores in rod and frame testing. Paper presented at the International Congress of Physical Activity Sciences, Quebec City, July, 1976.

Deshaies, P., Pargman, D., and Thiffault, C. A psychobiological profile of individual performance in junior hockey players. _Psychol. Mtr. Behr. and Sport_, 1978, May, 36-50.

Desharnais, R. Psycholcgical preparation: a theoretical approach. _Mouvement_, 1975, Special hockey 2, 61-64.

Dickinson, J. The role of two factors in a gross motor aiming task. _Br. J. Psychol._, 1969, _60_, 465-470.

Dixon, W.J. (Ed.) _BMDP - 77: Biomedical Computer Programs P-Series_. Berkeley: U. of Calif., 1977.

Dollard, J., Doob, J.W., Miller, N.E., Mowrer, G.H., and Sears, R.R. _Frustration and Aggression_. New Haven: Yale Univ. Press, 1939.

Dorion, A. A study of ice-hockey: interrelationship of the physical, physiological and anthropometrical elements of bantam aged ice-hockey players. Master's thesis (in progress), University of Alberta, 1979.

Doroschuk, E.V. and Marcotte, G.G. An agility test for screening ice-hockey players. Can. Assoc. Health, Phys. Ed. and Rec. J., 1965, 32, 8.

Duthie, R.B. Selected personality traits of martial artists as measured by the adjective check list. Unpublished doctoral dissertation, Texas A&M University, 1976.

Edmunds, G. Extraversion, neuroticism and different aspects of self-reported aggression. J. of Pers. Assessment, 1977, 41, 66-70.

Ehrenkranz, J., Bliss, E., and Sheard, M.H. Plasma testosterone: correlation with aggressive behavior and social dominance in man. Psychosom. Med., 1974, 36, 469-475.

Enos, E.F. The development and evaluation of a battery of hockey skill tests. Unpublished doctoral dissertation, Boston University School of Education, 1973.

Epuran, M. and Horghidan, V. Motivation factors in sport. In Kenyon, G.S. (Ed.), Contemporary Psychology os Sport: Proceedings of the Second International Congress of Sport Psychology, Washington, D.C., 1968, pp. 143-147. Chicago: The Athletic Institute, 1970.

Essen, B. Studies on the regulation of metabolism in human skeletal muscle using intermittent exercise as an experimental model. Acta Physiol. Scand., 1978, (suppl.

454), 1-32.

Essen, B. and Haggmark, T. Lactate concentration in Type I and II muscle fibres during muscular contraction in man. _Acta Physiol. Scand._, 1975, _95_, 344-346.

Eysenck, S.B.G. _Junior Eysenck Personality Inventory._ San Diego, Calif.: Educational and Industrial Testing Service, 1963.

Eysenck, H.J. and Eysenck, S.B.G. _Eysenck Personality Inventory._ San Diego, Calif.: Educational and Industrial Testing Service, 1963.

Ferguson, R.J., Marcotte, G.G., and Montpetit, R.R. A maximal oxygen uptake test during ice skating. _Med. Science in Sports_, 1969, _1_, 207-211.

Fleishman, E.A. _The Structure and Measurement of Physical Fitness_. Englewood Cliffs: Prentice-Hall, 1964.

Fleishman, E.A. Perceptual-motor abilities and learning. In Kenyon, G.S. (Ed.), _Contemporary Psychology of Sport: Proceedings of the Second International Congress of Sport Psychology_, Washington, D.C., 1968, pp. 545-558. Chicago: The Athletic Institute, 1970.

Flowers, K. Handedness and controlled movement. _Br. J. Psychol._, 1975, _66_, 39-52.

Fodero, J.M. An analysis of achievement motivation and motivational tendencies among men and women collegiate gymnasts. Unpublished doctoral dissertation, University of North Carolina at Greensboro, 1976.

Foss, L. and Fouts, G. Effects of frustration and cathartic apportunity on aggression. Psychol. Reports, 1977, 41. 319-326.

Fox, E.L. and Mathews, D.K. Interval Training: Conditioning for Sports and General Fitness. Philadelphia: Saunders, 1974.

Freund, H. and Gendry, P. Lactate kinetics after short strenuous exercise in man. Eur. J. Appl. Physiol., 1978, 39, 123-135.

Fujita, A. A study of the training effect upon selective body reaction time. Paper presented at the International Congress of Physical Activity Sciences, Quebec City, July, 1976.

Fulton, C.D. and Hubbard, A.W. Effect on puberty on reaction and movement times. Res. Quart., 1975, 46, 335-344.

Gollnick, P.S. and Hermansen, L. Biochemical adaptations to exercise: anaerobic metabolism. In Wilmore, J.H. (Ed.), Exercise and Sport Sciences Reviews, Vol. 1, pp. 1-43, New York: Academic Press, 1973.

Gosling, H. and Jenness, D. Temporal variables in simple reaction times of mentally retarded boys. Am. J. of Mental Deficiency, 1974, 79, 214-224.

Graydon, J. Spatial ability in highly skilled women squash players. Perceptual and Motor Skills, 1980, 50, 968-970.

Green, H.J. Metabolic aspects of intermittent work with regard to ice hockey. Can. J. Appl. Sport Sciences, 1979, 4, 29-34.

Green, H.J. and Houston, M.E. Effect of a season of ice hockey on energy capacities and associated functions. Med. Science *in Sports*, 1975, *7*, 299-303.

Green, H.J., Bishop, P., Houston, M., McKillop, R., Norman, R., and Stothard, P. Time-motion and physiological assessments of ice hockey performance. *J. Appl. Physiol.*, 1976, *40*, 159-163.

Guyot, G.W., Fairchild, L., and Hill, M. Physical fitness and embedded figures test performance of elementary school children. *Perceptual and Motor Skills*, 1980, *50*, 411-414.

Harris, R.C., Edwards, R.H.T., Hultman, E., Nordesjo, L.-O., Nylind, B., and Sahlin, K. The time course of phosphorylcreatine resynthesis during recovery of the quadriceps muscle in man. *Pflugers Archiv.*, 1976, 3*67*, 137-142.

Harrow, A.J. *A Taxonomy of the Psychomotor Domain.* New York: David McKay Co., 1972.

Harting, G.H. and Farge, E.J. Personality and physiological traits in middle-aged runners and joggers. *J. of Gerontology*, 1977, *32*, 541-548.

Haywood, K.M. and Teeple, J.B. Representative simple reaction and movement time scores. *Res. Quart.*, 1976, *47*, 855-856.

Heinrichs, R.D. Personality traits of selected collegiate golfers. Unpublished doctoral dissertation, University of Utah, 1975.

Henry, F.M. Influence of motor and sensory sets on reaction and speed of discrete movements. *Res. Quart.*, 1960, *30*, 459-468.

Henry, F.M. Reaction time-movement time correlations. Perceptual and Motor Skills, 1961, 12, 63-66.

Hermiston, R.T. Functional strength and skill development of young ice hockey players. J. Sports Med. & Phys. Fit., 1975, 15, 252-256.

Hermiston, R.T., Gratto, J., and Teno, T. Three hockey skills tests as predictors of hockey playing ability. Can. J. Appl. Sport Sciences, 1979, 4, 95-97.

Hocking, R.R. Criteria for selection of a subset regression: which one should be used? Technometrics, 1972, 14, 967-970.

Hollering, B.L. and Simpson, D. The effect of three types of training programs upon skating speed of college ice hockey players. J. Sports Med., 1977, 17, 335-340.

Holloszy, J.O. Biochemical adaptations to exercise: aerobic metabolism. In Wilmore, J.H. (Ed.), Exercise and Sport Sciences Reviews, Vol. 1, pp. 45-71. New York: Academic Press, 1973.

Howe, G. Let's Play Hockey. New York: Pagurian Press Ltd., 1972.

Hutchinson, W.W., Maas, G.M., and Murdoch, A.J. Effect of dry land training on aerobic capacity of college hockey players. J. Sports Med., 1979, 19, 271-276.

Iso-Ahola, S. Determinants of evaluation of team performance. Scand. J. Psychol., 1976, 17, 292-296.

Johnson, M.L. and Hartung, G.H. Comparison of movement times involving wrist and forearm actions. Perceptual and Motor

Skills, 1974, *39*, 202.

Jones, H.B. Athletic motivation inventory of female athletes and nonathletes. Unpublished doctoral dissertation, California School of Professional Psychology, 1974.

Katch, F.I. and Katch, V.L. Measurement and prediction errors in body composition assessment and the search for the perfect prediction equation. *Res. Quart. for Exercise and Sport*, 1980, *51*, 249-260.

Katch, V., Weltman, A., and Traeger, L. All-out versus a steady-paced cycling strategy for maximal work output of short duration. *Res. Quart.*, 1976, *47*, 164-168.

Katch, V., Weltman, A., Martin, R., and Gray, L. Optimal test characteristics for maximal anaerobic work on the bicycle ergometer. *Res. Quart.*, 1977, *48*, 319-327.

Katch, V. and Weltman, A. Interrelationship between anaerobic power output, anaerobic capacity and aerobic power. *Ergonomics*, 1979, *22*, 325-332.

Kaufman, M.J. Can we catch the Soviets? *Hockey*, 1979, *5*, 52-54.

Kedenburg, H.D. Androgen and aggressive behavior in man. Unpublished doctoral dissertation, Rutgers University, 1977.

Kerr, R. Motor skill learning and schema theory. *Can. J. Appl. Sport Sciences*, 1977, *2*, 77-79.

Kidd, B. and Macfarlane, J. *The Death of Hockey*. Toronto: New Press, 1972.

King, J.P. and Chi, P.S.K. Personality and the athletic social structure: a case study. Hum. Rel., 1974, 27, 179-193.

Kingston, G. Presentation at symposium on ice hockey, 22nd. Annual Meeting of the Can. Assoc. of Sports Sciences, Vancouver, Jan., 1980.

Kitagawa, K., Suzuki, M., and Miyashita, M. Anaerobic power output of young obese men: comparison with non-obese men and the role of excess fat. Eur. J. of Appl. Physiol. and Occup. Physiol., 1980, 43, 229-234.

Komi, P.V., Rusko, H., Vos, J., and Vihko, V. Anaerobic performance capacity in athletes. Acta physiol. Scand., 1977, 100, 107-114.

Lariviere, G., Lavallee, H., and Shephard, R.J. A simple skating test for ice hockey players. Can. J. Appl. Sport Sciences, 1976, 1, 223-228.

Lawther, J.D. Sport Psychology. New Jersey: Prentice-Hall, 1972.

Lehtonen, A. and Viikari, J. Serum lipids in soccer and ice-hockey players. Metabolism, 1980, 29, 36-39.

Levin, H. and Fleishmann, B. Childhood socialization. In Borgatta, E.F. and Lamberts, W.W. (Eds.), Handbook of Personality: Theory and Research. Chicago: Rand McNally, 1968.

Lorenz, K. On Aggression. New York: Bantam Books, 1966.

MacGillivary, W.W. The relationship of certain underlying capacities to ability level in complex gross motor skill. Master's thesis, University of Alberta, 1965.

MacNab, R.B.J. A longitudinal study of ice hockey in boys aged 8-12. _Can. J. Appl. Sport Sciences_, 1979, _4_, 11-17.

Magill, R.A. and Powell, F.M. Is the reaction time-movement time relationship 'essentially zero'? _Perceptual and Motor Skills_, 1975, _41_, 720-722.

Maloy, S.R. Selected personality and psychomotor distinctions in the successful goaltender. Unpublished doctoral dissertation, Boston University School of Education, 1976.

Marcotte, G.G. Maximum oxygen uptakes of ice hockey players. Unpublished doctoral dissertation, University of Michigan, 1973.

Margaria, R. Capacity and power of the energy processes in muscle activity: their practical relevance in athletics. _Int. Z. Angew. Physiol. einschl. Arbeitsphysiol._, 1968, _24_, 352-360.

Margaria, R., Aghemo, P., and Rovelli, E. Measurement of muscular power (anaerobic) in man. _J. Appl. Physiol._, 1966, _21_, 1662-1664. one should be used? _Technometrics_, 1972, _14_, 967-970.

Marino, G.W. Kinematics of ice skating at different velocities. _Res. Quart._, 1977, _48_, 93-97.

Marino, G.W. Acceleration-time relationships in an ice skating start. _Res. Quart._, 1979, _50_, 55-59.

Martens, R. and Simon, J.A. Comparison of three predictors of state anxiety in competitive situations. _Res. Quart._, 1977, 47, 381-393.

Martin, L.A. Effects of competition upon the aggressive responses of college basketball players and wrestlers. Res. Quart., 1977, 47, 388-393.

Mathews, D.K. and Fox, E.L. The Physiological Basis of Physical Education and Athletics (2nd Ed.). Philadephia: Saunders, 1971.

Mathews, D.K. and Fox, E.L. The Physiological Basis of Physical Education and Athletics. Philadelphia: Saunders, 1976.

McCarthy, J.F. and Kelly, B.R. Aggression, performance variables, and anger self-report in ice hockey palyers. J. of Psychol., 1978, 99, 97-101.

McLaughlin, P. A myth on very thin ice. TV Guide, Feb. 16, 1980.

McNair, D.M., Lorr, M., and Droppleman, L.F. Profile of Mood States. San Diego, Calif.: Educational and Industrial Testing Services, 1971.

Meek, F. and Skubic, V. Spatial perception of highly skilled and poorly skilled females. Perceptual and Motor Skills, 1971, 33, 1309-1310.

Merrifield, H.H. and Walford, G.A. Battery of ice hockey skill tests. Res. Quart., 1969, 40, 146-152.

Merrill, M.D. Taxonomies, classifications and theory. In Singer, R.N. (Ed.), The Psychomotor Domain: Movement Behaviors, pp. 385-414. Philadelphia: Lea & Febiger, 1972.

Merriman, J.E. Relationship of personality traits to motor ability. Res. Quart., 1960, 31, 163-173.

Monti, P.M., Brown, W.A., and Corriveau, D.P. Testosterone and components of aggressive and sexual behavior in man. Am. J. Psychiatry, 1977, 134, 692-625.

Morgan, W.P. Efficacy of psychobiological inquiry in the exercise and sport sciences. Quest, 1973, 20, 39-47.

Morgan, W.P. Prediction of performance in athletics. Paper presented at the Applied Sciences Symposium of the Canadian Society for Psychomotor Learning and Sport Psychology Congress, Toronto, 1979.

Morgan, W.P. The trait psychology controversy. Res. Quarterly for Exercise & Sport, 1980, 50, 50-76.

Morgan, W.P. and Nagle, F.J. Prediction of maximal aerobic power in college swimmers. Unpublished report. Biodynamics Laboratory, University of Wisconsin, 1972.

Morris, H.H. Effects of practice and set upon reaction time and its fractionated components. In Christina, R.W. and Landers, D.M. (Eds.), Psychology of Motor Behavior and Sport - 1976, Vol. 1, Motor Behavior, pp. 259-268, Champaign, Illinois: Human Kinetics Publishers, 1977.

Mussen, P. and Rosenweig, M.R. Psychology: An Introduction. Lexington, Mass.: Heath, 1973.

Nagle, F.J., Morgan, W.P., Hellickson, R.O., Serfass, R.C., and Alexander, J.F. Spotting success traits in Olympic contenders. The Physician and Sports Med., 1975, 3, 31-34..

Naud, R.L. and Holt, L.E. A comparison of selected hockey skating starts. Can. J. Appl. Sport Sciences, 1979, 4, 8-10.

Naud, R.L. and Holt, L.E. A comparison of selected stop, reverse and start (SRS) techniques in ice hockey. Can. J. Appl. Sport Sciences, 1980, 5, 94-97.

Nebes, R.D. Vocal versus manual response as a determinant of age difference in simple reaction time. J. of Gerontology, 1978, 33, 884-889.

Newton, R. A kinanthropometric study of 13 of 15 year old ice hockey players. Unpublished master's thesis, San Diego State University, 1978.

Nixon, H.I. Team orientations, interpersonal relations, and team success. Res. Quart., 1977, 47, 429-435.

O'Connor, K.A. and Webb, J.L. Investigation of personality traits of college female athletes and nonathletes. Res. Quart., 1977, 47, 203-210.

Olsen, E.A. Relationship between psychological capacities and success in college athletics. Res. Quart., 1956, 27, 79-89.

Ostrow, A.C. Goal-setting behavior and need achievement in relation to competitive motor activity. Res. Quart., 1977, 47, 174-183.

Pargman, D., Bender, P., and Deshaies, P. Correlation between visual disembedding and basketball shooting by male and female varsity college athletes. Perceptual and Motor Skills, 1975, 41, 956.

Patterson, A.H. Hostility catharis: a naturalistic quasi-experiment. Per. and Soc. Psych. Bull., 1974, 1, 195-197.

Percival, L. The Hockey Handbook. South Brunswick, N.Y.: Barnes, 1960.

Pierson, W.R. and Rasch, P.J. Generality of a speed factor in simple reaction and movement time. Perceptual and Motor Skills, 1960, 11, 123-128.

Puleo, J.S. Acquisition of imitative aggression in children as a function of the amount of reinforcement given the model. Social Behavior and Personality, 1978, 6, 67-71.

Quinn, H. Exploding the myth of hockey supremacy. Macleans, Feb., 1979.

R.C.A.F. Beginning Hockey. Ottawa: Queen's Printer, 1966.

Reynolds, H.I. The effects of augmented levels of stress on reaction time in the peripheral visual field. Res. Quart., 1976, 47, 768-775.

Ross, W.D. Personal communication, 1980.

Rushall, B.S. An evaluation of the relationship between personality and physical performance categories. In Keyon, G.S. (Ed.), Contemporary Psychology of Sport: Proceedings of the Second International Congress of Sport Psychology, Washington, D.C., 1968, pp. 157-165. Chicago: The Athletic Institute, 1970.

Rushall, B.S. Environment specific behaviour inventories:

developmental procedures. Int. J. Sport Psychol., 1978, 9, 97-110.

Rushall, B.S. and Fox, R.G. An approach-avoidance motivations scale for sports. Can. J. Appl. Sport Sciences, 1980, 1, 39-43.

Rusko, H., Havu, M., and Karvinen, E. Aerobic performance capacity in athletes. Europ. J. appl. Physiol., 1978, 38, 151-159.

Russell, G.W. Machiavellianism, locus of control, aggression, performance and precautionary behaviour in ice hockey. Hum. Relat., 1974, 27, 825-837.

Russell, G.W. and Drewry, B.R. Crowd size and competitive aspects of aggression in ice hockey: an archival study. Hum. Relat., 1976, 29, 723-735.

Salmela, J.H. Application of a psychological taxonomy to sport performance. Can. J. Appl. Sport Sciences, 1976, 1, 23-32.

Salmela, J.H. and Fiorito, P. Visual cues in ice hockey goaltending. Can. J. Appl. Sport Sciences, 1979, 4, 56-59.

Sartain, A.Q., North, A.J., Strange, J.R., and Chapman, H.M. Psychology: Understanding Human Behavior. New York: McGraw-Hill, 1967

Scaramella, T.J. and Brown, W.A. Serum testosterone and aggressiveness in hockey players. Psychosom. Med., 1978, 40, 262-265.

Schmidt, R.A. A schema theory of discrete motor skill learning.

Psych. Review, 1975, *82*, 225-260.

Schneider, J.E. The effects of a season of competition on the aggressive responses of intercollegiate football players. Unpublished doctoral dissertation, George Peabody College for Teachers, 1973.

Segal, S.S. and Brooks, G.A. Effects of glycogen depletion and work load on postexercise O_2 consumption and blood lactate. *J. Appl. Physiol.: Respirat. Environ. Exercise Physiol.*, 1979, *47*, 514-521.

Seliger, V., Kostka, V., Grusova, D., Kovac, J., Machovcova, J., Pauer, M., Pribylovia, A., and Urbankova, R. Energy expenditure and physical fitness of ice hockey players. *Intern. Z. Agnew. Physiol.*, 1972, *30*, 283-291.

Sheldon, W.H. *The Varieties of Temperament: A Psychology of Constitutional Differences*. New York: Harper, 1942.

Shephard, R.J. Aerobic versus anaerobic training for success in various athletic events. *Can. J. Appl. Sports Sciences*, 1978, *3*, 9-15.

Silverman, R.F. *Psychology*. New York: Appleton-Century-Crofts, 1972.

Sinclair, G.D. and Moyls, P.W. Speed of response characteristics of goalkeepers: a descriptive and developmental report. *Can. J. Appl. Sport Sciences*, 1979, *4*, 60-65.

Singer, R.N. Balance skill as related to athletics, sex, height, and weight. In Kenyon, G.S. (Ed.), *Contemporary Psychology* of Sport: Proceedings of the Second International Congress of Sport Psychology, Washington, D.C., 1968. pp. 645-656. Chicago: The Athletic Institute, 1970.

Singer, R.N. Cognitive processes, learner strategies, and skilled motor behaviors. Can. J. Appl. Sport Sciences, 1980, 1, 25-32.

Sjoberg, H. Relations between heart rate, reaction speed, and subjective effort at different work loads on a bicycle ergometer. J. of Human Stress, 1975, 1, 21-27.

Spiruduso, W.W. and Clifford, P. Replication of age and physical activity effects on reaction and movement time. J. of Gerontology, 1978, 33, 26-30.

Straub, W.F. and Davis, S.W. Personality traits of college football players who participated at different levels of competition. Med. Science in Sports, 1971, 3, 39-43.

Surwillo, W.W. Developmental changes in the speed of information processing. J. of Psychol., 1977, 96, 97-102.

Sysler, B.I. An analysis of the relationship between aggressive sport fan behavior and personality. Unpublished doctoral disseratation, Temple University, 1977.

Tarasov, A. Road to Olympus. Toronto: Griffin House, 1969.

Tarasov, A. Tarasov's Hockey Technique. Toronto: Holt, Rinehart and Winston, 1973.

Tesch, P., Sjodin, B., Thorstensson, A., and Karlsson, J. Muscle fatigue and its relation to lactate accumulation and LDH activity in man. _Acta Physiol. Scand._, 1978, _103_, 413-420.

Thiffault, C. Tachistoscopic training and its effect upon visual perceptual speed of ice hockey players. Unpublished doctoral dissertation, University of Southern California, 1974.

Thomas, V. and Reilly, T. Circulatory, psychological & performance variables during 100 hours of paced continuous exercise under conditions of controlled energy intake & work output. _J. of Human Movement Studies_, 1975, _1_, 149-155.

Van Gorder, E.J. Self-esteem as a variable in response to frustration. Unpublished doctoral dissertation, California School of Professional Psychology, 1975.

Wade, M.G., Newell, K.M., and Wallace, S.A. Decision time and movement time as a function of response complexity in retarded persons. _Am. J. of Mental Deficiency_, 1978, _83_, 135-144.

Ward, R. and Ross, W.D. A contact sports classification procedure. Paper presented at the 22nd. Annual Meeting of the Can. Assoc. of Sports Sciences, Vancouver, Jan., 1980.

Welford, A.T. _Fundamentals of Skill_. London: Methuen & Co. Ltd., 1968.

Welford, A.T. _Skilled Performance: Perceptual and Motor Skills_. Glenview, Illinois: Scott, Foresman and Co., 1976.

Weltman, A., Moffat, R.J., and Stamford, B.A. Supramaximal training in females: effects on anaerobic power output, anaerobic capacity, and aerobic power. _J. Sports Med._, 1978, 18, 237-244.

Weltman, A. and Katch, V.L. Relationship between the onset of metabolic acidosis (anaerobic threshold) and maximal oxygen uptake. *J. Sports Med.*, 1979, *19*, 135-142.

Weltman, A., Stamford, B.A., and Fulco, C. Recovery from maximal effort exercise: lactate disappearance and subsequent performance. *J. Appl. Physiol.: Respirat. Environ. Exercise Physiol.*, 1979, *47*, 677-682.

Widmeyer, W.N. When cohesiveness predicts performance outcome in sport. Unpublished doctoral dissertation, University of Illinois at Urbana - Champaign, 1977.

Widmeyer, W.N. and Birch, J.S. The relationship between aggression and performance outcome in hockey. *Can. J. Appl. Sport Sciences*, 1979, *4*, 91-94.

Wilberg, R.B. The basic stance of age-group ice hockey goalkeepers. *Can. J. Appl. Sport Sciences*, 1979, *4*, 66-70.

Williams, J.M. Perceptual style and fencing skill. *Perceptual and Motor Skills*, 1975, *40*, 282.

Williams, R.S. The relationship between the human motor performance domains of leg strength and speed of body movement. Unpublished doctoral dissertation, University of Houston, 1974.

Wingate Anaerobic Test. Department of Research and Sports Medicine, Wingate Institute for Physical Education and Sport, Israel, 1977.

Witkin, H.A., Dyk, R.B., Faterson, H.F., Goodenough, D.R., and Karp, S.A. <u>Psychological Differentiation: Studies of Development</u>. New York: Wiley, 1962.

Wolman, B.B. (Ed.) <u>Dictionary of Behavioral Science</u>. New York: Van Nostrand Reinhold, 1973.

Wurtzel, A. Television violence and aggressive behavior. <u>Etc.</u> 1977, <u>34</u>, 212-225.

Zillman, D., Johnson, R.C., and Day, K.D. Provoked and unprovoked aggressiveness in athletes. <u>J. of Res. in Pers.</u>, 1974, <u>8</u>, 139, 152.