THE RELATIONSHIP OF LOWER LIMB FLEXIBILITY, STRENGTH AND ANTHROPOMETRIC MEASURES TO SKATING SPEED IN VARSITY HOCKEY PLAYERS

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The Relationship of Lower Limb Flexibility, Strength and Anthropometric Measures to Skating Speed in Varsity Hockey Players

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We, the undersigned, hereby certify our approval of this thesis and recommend its acceptance by the Faculty of University Schools:

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Abstract

The purpose of the study was to examine the relationship of flexibility, strength and anthropometric measurements of the lower limbs to the skating speed of hockey players. Seventeen university varsity hockey players were assessed for: leg and grip strengths using cable-tension methods; lower limb flexibility using Leighton's flexometer and technique; anthropometry of the legs; and skating speed under standing and flying start conditions with and without a stick over two distances, 40 feet and 25 metres. Time was recorded using photoelectric cells and a Universal Counter Timer Model 604A. The strength, flexibility, and anthropometric measures were the independent variables and the skating speeds were the dependent variables. Using a significance level of .05 the data were analyzed using the Pearson Product-Moment Correlation Coefficient and Stepwise Multiple Regression statistical methods. The resulting _r_'s indicated that 1) flexibility was specific to each joint measured, 2) there was a general strength factor and a general skating body type, 3) two of the skating speed tests encompassed many factors of the other six, 4) flexibility was related to a little degree to strength and anthropometry, 5) strength and anthropometry were related, and 6) flexibility and anthropometry were not related to skating speed. The regression analyses accounted for all of the variance in each dependent variable but the variables entered were different in order and in contributory weight in each analysis. Skating

speed was indicated as being specific to the distance and conditions under which it was performed.

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Chapter 1

INTRODUCTION

Statement of the Problem

The purpose of the study was to examine the relationship of flexibility, strength and anthropometric measurements to the speed of skating of university ice hockey players.

Significance of the Study

Ice hockey coaches have been experimenting with various drills for years. Some coaches think that passing and teamwork are most important. Others believe that stickhandling and puck-carrying will enhance a team's chance of success. Still others have religiously trained their teams long and hard in the belief that conditioning is the main factor needed to win championships. These factors are all important components for success in ice hockey. Skating ability, however, could be considered the single most important attribute necessary for a hockey player. Many game situations such as racing for a loose puck, breaking into the open to receive a pass, and skating to backcheck an opponent require a player to skate quickly in a straight line. It is obvious that a faster skater would have a definite advantage in these and numerous other situations in the game of ice hockey.

Several factors influence the skating speed of a hockey player. The power produced by a player when he extends his thrusting leg is important. Greater power in this movement causes the player to move forward more quickly. A strong muscle can exert a large force which should produce great power and high speed. If a force is applied over a long distance the power produced will be greater than if the same force is only applied over a short distance. The distance through which the muscles of a certain joint can exert force is limited by the range of motion of that joint. Therefore, the strength of the muscles and the flexibility of the joints of the legs should affect the speed at which hockey players skate.

A biomechanical analysis of skaters (Pagé, 1975) produced results which partially support the idea that flexibility varies directly with speed. It was found that faster skaters seemed to take wider strides, lean forward more with the upper part of the body, flex the thrusting knee more prior to the initial thrusting action and extend the thrusting knee more quickly through a wider range of knee extension.

Certain anthropometric characteristics could also be indicators of skating speed. The lengths of the levers involved in skating are important. The relative positions of the muscle insertions on longer leg segments should be roughly proportional, however, thereby minimizing the mechanical advantage of longer levers. The girth of anatomical segments indicates to an extent the muscle mass of that segment. It is a generally accepted tenet that the strength of a muscle varies directly with its mass. Therefore, the girth of the leg segments, along with the strength, flexibility and other anthropometric measurements of the legs of hockey players, could be correlated to speed of skating.

Coaches have avoided the area of improving skating style for a number of years. One of the reasons for this neglect is the belief that skating ability is an inherent attribute of players. Another is the fact that coaches lacked knowledge about techniques for improving skating. The recent trend towards power skating clinics for hockey players indicates that attempts are being made to correct this problem.

This study contributes further knowledge of observable and measurable factors which may affect the skating speed of hockey players. The results of this study will beneficially affect the future coaching of hockey to help to predict and improve skating speed.

Delimitations

1) The scope of this study was delimited to the performance of all 17 Lakehead University ice hockey players except goalies on measures of strength, flexibility, anthropometric characteristics and skating speed.

2) The independent variables were the strength, flexibility and anthropometric measurements of the legs of the subjects.

3) There was a possibility that some of the subjects may have been injured and not able to participate in the study.

4) The dependent variable was the performance of the

players on the specific skating speed tests.

Limitations

1) It was assumed that the subjects were representative of university ice hockey players; that they followed instructions closely and performed to the best of their abilities; and that the skating speed tests administered were valid tests of skating speed of hockey players.

2) A significance level of .05 was adopted for statistical analyses.

Definitions

Flexibility refers to the range of movement in an articulation which can be normally achieved.

Strength is the maximum force the muscles can exert in a single maximum contraction.

Skating Speed is determined by dividing the distance covered by the elapsed time of a skater skating forward with maximum effort along a linear course.

Anthropometric Measurements are specific measurements of the dimensions of certain body parts.

Chapter 2

REVIEW OF LITERATURE

Many studies relating flexibility, strength and anthropometric measurements to performances of various types of athletes have been done. But no study has examined these combined criteria in relation to the skating speed of hockey players. Reviewing the research done on these topics was of particular value to this study because such a relationship was examined.

Flexibility is an important facet of an athlete's physiological make-up. It has been directly measured by various devices. A protractor-type of device was used by Dorinson and Wagner (1948). Dinkheller (1969), Dickinson (1963) and Wilmer and Elkins (1947) used a gravity-type goniometer, a tractograph goniometer and an optical goniometer respectively to measure flexibility directly. These and other types of direct measurement have been summarized and criticized to some extent by Myers (1961).

Indirect measurement of flexibility has also been used in some studies. Dinkheller (1969) used the forward sit test, and the standing bending reach was used by Liverman (1973) in her study. The Kraus Weber floor touch test and the Wells sit and reach test used by Mathews, Shaw and Bohner (1957) are two other examples of indirect flexibility measurement methods.

The instrument and technique developed by Leighton (1942) has been highly refined and is being used widely in flexibility testing.

Liverman (1973) used this technique and also indirect methods to measure flexibility. A trend towards an increase in power with an increase in flexibility was indicated in the results. Burley, Dorbell, and Farrell (1961), who measured flexibility using the flexometer and examined power and speed using indirect measures, found no relationship between the three characteristics.

Burley et al. (1961), Laubach and McConville (1966a, 1966b) and Mathews, Shaw and Bohner (1957) found no relationship between flexibility and anthropometric measures. Conversely, Hansen (1957) and Tyrance (1958) both reported a relationship between the same two variables.

That flexibility is specific to each joint of the human body was reported by Harris (1969). Haliski and Sigerseth (1950), Pickens (1950), Syverson (1950) and Williams (1950) used the flexometer to measure the flexibility of athletes in different sports. Williams summarized the combined data and reported that, in terms of range of motion, the rankings of swimmers, body builders, football, baseball and basketball players varied depending upon the joint considered. It can then be said that flexibility is specific to joint and activity and that the present study involving ice hockey players has added to the knowledge about flexibility of athletes.

Muscle strength is an integral part of an athlete's capacity to perform in most sports activities. Strength measurements have been used in medicine for years as indicators of recovery and in physical education as classifying devices and as indices of growth and physical performance. For these reasons, strength testing techniques have been developed extensively. Alderman and Banfield (1969) examined the reliability of cable-tension and dynamometric methods and reported reliability coefficients of .74 to .98. Glencross (1966) used an instrument called the power lever to test subjects in his study. Clarke (1950, 1953) has highly refined the cable-tension methods in various studies. Kroemer's paper (1970) summarizes and describes the advantages and shortcomings of the various types of strength testing techniques, equipment and reporting methods. Through studies such as Ikai and Steinhaus (1961), Kroemer (1970) and Kroll (1970) the problems and controls associated with strength testing have been clarified to the extent that obtaining reliable data is possible.

The relationship between speed of movement and strength measured in the same movement has been examined in various studies. Clarke and Henry (1961) and Eckert (1964) indicated that speed of movement of a limb is directly proportional to the strength value obtained from the same movement. However, Colgate (1966), Hunsicker and Greey (1957), Pierson and Rasch (1962), Smith (1961), Smith and Whitley (1965) and Start, Gray, Glencross and Walsh (1966) found that strength did not necessarily have a relationship to speed of movement.

A variety of anthropometric measurements have been examined in relation to the strength of the legs. Clarke (1957), Smith (1961) and Start et al (1966) found that there was no relationship between leg strength and some anthropometric measurements.

There has been an increase in the amount of research that has been done in the field of ice hockey in recent years. This increase has been due in part to a more scientific approach to the game adopted by North Americans. This change was no doubt prompted by the surprisingly rapid rise in the prowess of European hockey teams who use such an approach.

A number of attempts have been made to compile batteries of tests that would distinguish the ability levels of hockey players. Cantrelli (1967), Haché (1967), Merrifield and Walford (1969) and Siciliano (1971) all included in their studies tests of skating speed similar to the one which was used in this study.

Various authors have examined different aspects of skating ability. Saint-Denis (1956) examined two methods of starting from a stationary position in ice hockey. He found that subjects who ran for a few strides on the tips of their skates were faster over a short distance than subjects who began skating immediately. Naud (1974) examined three starting methods and three methods of stopping and reversing direction in ice skating. He found that the sideways start was faster than the straight ahead or cross-over method of starting.

For reversing direction quickly the stop-thrust and glide method was found to be more efficient that either of the two cross-over methods tested. Pagé (1975), in a biomechanical study, reported that a large portion of the variance in forward skating speed could be accounted for by differences in the width of the strides taken, the angle of inclination of the lower leg, the recovery time of the skate blade and the angle of abduction of the leg. The study by Nicol (1974) determined the velocities attained by speed skaters while developing a type of timing method using photo-electric cells and a Universal Counter Timer Model 604A.

The present study examined the relationship of flexibility, strength and anthropometric measures of the legs to the skating speed of university ice hockey players. The outcome provides more information to assist in the future coaching of ice hockey players.

Chapter 3

METHODOLOGY

Subjects

A total of 17 players, comprising the whole Lakehead University varsity ice hockey team except goalies were used as subjects. They ranged in age from 19 to 24, in weight from 65.8 to 96.2 kg and in height from 172 to 196 cm. Complete data on the subjects' physical characteristics can be found in Table A in Appendix E. Permission to conduct the study near the end of the competitive season of the team was obtained from the coach.

Testing Location and Apparel

The flexibility, strength and anthropometric tests were administered in two rooms at Lakehead University's C.J. Sanders Fieldhouse. Subjects were required to wear shorts, T-shirts, socks and running shoes for these tests. The skating speed tests were conducted at the Port Arthur Arena in Thunder Bay. The subjects were required to wear a complete set of hockey equipment for the tests. Subjects were asked not to eat, drink or exercise during the one and a half hour period before taking any of the tests.

Flexibility, Strength and Anthropometric Measurements

The instrument and technique developed by Leighton (1966) were used to measure flexibility in this study. The reliability of the tests of ankle, knee and hip joint flexibility has been found to be high, ranging between .913 and .996.

The standard order of the flexibility tests was as follows: ankle dorsi-flexion, ankle inversion-eversion, hip extension-flexion, hip adduction-abduction, hip rotation and knee flexion.

Only the flexibility of the right leg was tested. The tester gave standard instructions on the procedure before administering each test. Because Atha and Wheatley (1976) found that subjects' scores on flexibility tests increased considerably throughout the first four trials but did not increase significantly after the fifth trial, five trials were given to each subject on each test. The format for administration of the flexibility tests is described in Appendix A.

The tests for leg strength were variations of the cable-tension tests developed by Clarke (1953). The objectivity coefficients for the respective tests are: hip flexion .90; hip extension .94; hip adduction .89; hip abduction .82; knee flexion .97; hip inward rotation .95; hip outward rotation .95; knee extension .94; ankle plantar flexion .93; and ankle dorsi-flexion .93.

The tests were administered in a standard order. This order was: hip flexion, hip extension, hip adduction, hip abduction, knee flexion, hip inward rotation, hip outward rotation, knee extension, ankle plantar flexion and ankle dorsi-flexion. The tests were administered only on the right side of each subject.

Standard instruction on the procedure of the test was given to each subject by the tester prior to each test. Two trials were given to each subject on each test. The format for administration of the tests is described in Appendix B.

Eight anthropometric measurements were taken. The standard order and format of administration is described in Appendix

C. The anthropometric measurements were taken on the right leg of each subject using a cloth tape measure.

Skating Speed Tests

Eight different tests were administered to each subject. The tests were performed over two different distances and under two conditions. The standard order of administration was: 40 Feet Standing Start, 40 Feet Flying Start, 25 Metres Standing Start and 25 Metres Flying Start. This order was repeated twice, the first time with a stick and the second time without a stick. A description of the tests, their administration and the layout of the ice can be found in Appendix D. Each subject performed each test until two trials were recorded which were less than one-tenth of a second apart. It is assumed that this criterion indicated that the subject's performance reached a plateau at his fastest speed. The instructions were given in a standard manner for all subjects. The timer used was a Universal Counter Timer Model 604A manufactured by the Computer Measurement Company of Los Angeles.

Organization and Controls

The flexibility, strength and anthropometric tests were administered on two different days. One half of the subjects were tested on one day and the remainder on the other day. Four subjects were scheduled at each testing session. Three testing sessions took place on each day. The subjects were randomly assigned to three testers. Each tester administered one type of test to all the subjects. This system produced random variation in the order which the subjects received the tests. The objectivity and reliability of the three individuals who tested flexibility were established prior to the data-gathering sessions. The strength and anthropometric measurements were administered by the same tester each day.

Recorders were present in all sessions on both days to expedite the testing procedures.

The skating tests were administered to all subjects on the same day. The subjects were tested in groups of four. The order in which the subjects executed the trials was the same for each test. In this way each subject received a rest between trials while the other three subjects performed their trials.

As all instructions were given to the subjects verbally, interaction of the testers with the subjects was unavoidable. This interaction was considered to be equal across subjects, however, as none of the testers was well acquainted with any of the subjects.

Analysis of Data

The scores used for analysis purposes were the best values recorded in each of the skating speed, flexibility and strength tests. The relationship of strength, flexibility and anthropometric scores to skating speed values were analyzed using the Pearson Product - Moment Correlation Coefficient and Stepwise Multiple Regression methods. The analyses were done using the computer programs, the Statistical Package for the

Social Sciences (SPSS-H) and one of the Biomedical Computer Programs (BMDO2R). Both programs supplied means and standard deviations for all variables as well as a matrix of intercorrelations for all variables. Stepwise multiple regression analyses were performed using all strength, anthropometric, and flexibility values as independent variables with each of the eight skating tests as dependent variables.

Chapter 4

RESULTS

The mean, standard deviation and range were computed for each variable and can be seen in the raw data tables in Appendix E.

Pearson Product-Moment Correlation Analyses

With .05 being used as the significance level many significant intercorrelations were discovered between the 36 variables. The correlations which were significant are listed in Tables 1-6.

Only one significant intercorrelation occurred between flexibility measures. Ankle flexion-extension was correlated to ankle inversion-eversion with a coefficient of .46. This single correlation suggested that there is no general flexibility factor of the hip, knee and ankle joints but that each joint had its own characteristic flexibility.

Twenty-two intercorrelations were found to be significant between strength variables. Hip flexion, hip extension, knee flexion, ankle plantar flexion and both grip strengths were the main variables involved. The *r*'s ranged from .4238 to .7888 with most falling between .44 and .57. The occurrence of 22 out of a possible 66 significant correlation coefficients suggested a general strength factor of the legs and grips. It seemed that the strengths of the muscle groups in the legs of hockey players are related, i.e. if a player is strong in one leg muscle group he is likely to be strong in the other muscle

Table 1

Significant Correlations (Alpha = .05, DF = 15) between Flexibility Variables and All Variables

Variable	to Variable	r
Ankle Flexion-Extension	Ankle Inversion-Eversion	.4600
	Ankle Dorsi-Flexion Strength	.4348
Hip Flexion-Extension	Hip Inward Rotation Strength	.4403
	Hip Outward Rotation Strength	.4979
Hip Adduction-Abduction	Hip Adduction Strength	-.6394
Hip Rotation	Hip Flexion Strength	.4588
	Ankle Plantar Flexion Strength	.5075
	Ankle Dorsi-Flexion Strength	.6277
	Hip Inward Rotation Strength	-.6424
Knee Flexion-Extension	Hip Adduction Strength	-.5447
Hip Rotation	Height	.6040
	Total Leg Length	.6055
	Lower Leg Length	.5105
	Foot Length	.4807
	Total Foot Length	.4113
Ankle Inversion-Eversion	Thigh Length	.4547
Ankle Flexion-Extension	25 Metre Standing Start With a Stick	-.4205
Hip Adduction-Abduction	25 Metre Standing Start With a Stick	.4804
Hip Rotation	25 Metre Standing Start Without a Stick	-.5543

Table 2

Significant Intercorrelations (Alpha = .05, DF = 15) between Anthropometric Variables

Variable to	Variable	r
Weight	Height	.7106
	Total Leg Length	.6110
	Thigh Length	.6880
	Lower Leg Length	.6579
	Foot Length	.6682
	Total Foot Length	.7351
	Thigh Girth	.8469
	Calf Girth	.7497
Height	Total Leg Length	.9048
	Thigh Length	.7282
	Lower Leg Length	.9114
	Foot Length	.8685
	Total Foot Length	.8754
	Calf Girth	.4242
Total Leg Length	Thigh Length	.7482
	Lower Leg Length	.8498
	Foot Length	.9145
	Total Foot Length	.8925
	Calf Girth	.4226
Thigh Length	Lower Leg Length	.5621
	Foot Length	.7964
	Total Foot Length	.7390
	Calf Girth	.4694
Lower Leg Length	Foot Length	.7900
	Total Foot Length	.8421
	Calf Girth	.4568
Foot Length	Total Foot Length	.9373
	Calf Girth	.5346
Total Foot Length	Thigh Girth	.4579
	Calf Girth	.6215
Thigh Girth	Calf Girth	.6579

Table 3

Significant Intercorrelations (Alpha = .05, DF = 15) between Strength Variables

Variable to	Variable	r
Hip Flexion	Hip Extension	.4803
	Hip Abduction	.5166
	Knee Extension	.5074
	Ankle Plantar Flexion	.5805
	Ankle Dorsi-Flexion	.4238
	Left Grip	.4715
Hip Extension	Knee Extension	.4594
	Knee Flexion	.4737
	Ankle Plantar Flexion	.5299
	Right Grip	.4251
Hip Abduction	Right Grip	.4368
	Left Grip	.5582
Hip Adduction	Ankle Dorsi-Flexion	.4737
Hip Outward Rotation	Knee Flexion	.5152
Hip Inward Rotation	Knee Flexion	.6877
	Ankle Dorsi-Flexion	-.4195
Knee Extension	Knee Flexion	.4438
	Ankle Plantar Flexion	.5021
Knee Flexion	Left Grip	.4879
Ankle Plantar Flexion	Right Grip	.5686
	Left Grip	.7733
Right Grip	Left Grip	.7888

Table 4

Significant Correlations (Alpha = .05, DF = 15) between Strength and Anthropometric Variables

Variable to	Variable	r
Hip Flexion	Weight	.7212
	Height	.5594
	Total Leg Length	.5810
	Thigh Length	.4245
	Lower Leg Length	.5052
	Foot Length	.5117
	Total Foot Length	.6015
	Thigh Girth	.5527
	Calf Girth	.6575
Hip Extension	Weight	.5447
	Height	.5201
	Total Leg Length	.4529
	Thigh Length	.4725
	Lower Leg Length	.4478
	Foot Length	.5370
	Total Foot Length	.4930
	Thigh Girth	.4281
	Calf Girth	.4996
Hip Abduction	Weight	.4751
	Thigh Length	.4426
Hip Adduction	Thigh Girth	.4336
Hip Outward Rotation	Thigh Girth	.4568
Hip Inward Rotation	Thigh Girth	.4753
Knee Flexion	Thigh Girth	.4152
	Calf Girth	.4657
Ankle Plantar Flexion	Weight	.6722
	Height	.7422
	Total Leg Length	.8403
	Thigh Length	.6990
	Lower Leg Length	.6226
	Foot Length	.7717
	Total Foot Length	.7446
	Calf Girth	.4935
Right Grip	Weight	.5833
	Height	.5083
	Total Leg Length	.4322
	Thigh Length	.6753
	Foot Length	.4197
	Total Foot Length	.4651
Left Grip	Weight	.6970
	Height	.6722
	Total Leg Length	.7745
	Thigh Length	.7673
	Lower Leg Length	.6088
	Foot Length	.7146
	Total Foot Length	.7390
	Thigh Girth	.4697

Table 5

Significant Correlations (Alpha = .05, DF = 15)
between Strength and Speed Variables

Variable	to Variable	r
Hip Flexion	40 Foot Flying Start Without a Stick	.4258
	25 Metre Flying Start Without a Stick	.4737
Hip Extension	40 Foot Flying Start With a Stick	.4342
	25 Metre Flying Start With a Stick	.4134
Hip Adduction	25 Metre Standing Start With a Stick	-.4252
Hip Outward Rotation	40 Foot Flying Start Without a Stick	.4343
Hip Inward Rotation	25 Metre Standing Start With a Stick	.4453
Knee Extension	25 Metre Flying Start With a Stick	.4829
	25 Metre Flying Start Without a Stick	.5134
Knee Flexion	25 Metre Standing Start Without a Stick	.4349
	25 Metre Flying Start With a Stick	.4463
	25 Metre Flying Start Without a Stick	.4784
Ankle Dorsi-Flexion	25 Metre Standing Start With a Stick	-.8097

Table 6

Significant Correlations (Alpha = .05, DF = 15) between Speed Variables and Anthropometric and Speed Variables

Variable	to Variable	r
40 Foot Standing Start With a Stick	Lower Leg Length	-.4695
25 Metre Flying Start Without a Stick	Thigh Girth	.4159
40 Foot Standing Start With a Stick	40 Foot Standing Start Without a Stick	.5973
	40 Foot Flying Start With a Stick	.8205
	25 Metre Flying Start With a Stick	.5208
40 Foot Standing Start Without a Stick	40 Foot Flying Start With a Stick	.5869
	40 Foot Flying Start Without a Stick	.4557
	25 Metre Flying Start With a Stick	.5171
40 Foot Flying Start With a Stick	40 Foot Flying Start Without a Stick	.5342
	25 Metre Standing Start Without a Stick	.5287
	25 Metre Flying Start With a Stick	.8451
	25 Metre Flying Start Without a Stick	.5783
40 Foot Flying Start Without a Stick	25 Metre Standing Start Without a Stick	.7131
	25 Metre Flying Start With a Stick	.7612
	25 Metre Flying Start Without a Stick	.9192
25 Metre Standing Start Without a Stick	25 Metre Flying Start With a Stick	.7682
	25 Metre Flying Start Without a Stick	.7291
25 Metre Flying Start With a Stick	25 Metre Flying Start Without a Stick	.7847

groups.

Thirty-one significant intercorrelations between anthropometric variables were found. Thigh girth was the only measure which did not correlate significantly to all other measures. The coefficients were distributed fairly evenly within the range of .4226 to .9145. These relatively high correlation coefficients suggest that the range of body types of the hockey players competing at the university level is quite restricted. The players studied here were all of relatively the same build. No extreme cases of tall, skinny players or short, fat players occurred in this sample.

Out of 28 intercorrelations computed between speed variables 16 were significant. The r's ranged from .5171 to .9192 with most falling close to either .55 or .75. Of these 16 significant correlations, 11 involved two tests, the 40 Foot Flying Start With a Stick test and the 25 Metre Flying Start With a Stick test. Five of the 11 coefficients were above .76. This high degree of relationship between these two tests and the other skating speed tests suggested that many factors of all tests were incorporated in these two tests.

Nine significant correlation coefficients between flexibility and strength measures were distributed evenly from .4348 to .6424. Three were negative coefficients indicating an inverse relationship between flexibility and strength in those cases. Since 72 coefficients of this kind were computed, the results indicated that a small relationship between flexibility and strength existed.

Only six of the 48 coefficients computed between flexibility and anthropometric measures were found to be significant. They ranged in magnitude from .4113 to .6055. Similarly, only three significant flexibility to speed coefficients were found. They ranged from .4205 to .5543. Two were negative. The small magnitude and number of significant coefficients in both these cases suggested that flexibility was dependent to a low degree on body size and type and was also related to a small degree to the skating speeds of hockey players.

Forty-seven of 96 correlation coefficients between strength and anthropometric measures were found to be significant. They ranged from .4152 to .7745 with most falling between .42 and .60. The strength variables hip flexion, hip extension, ankle plantar flexion, right grip and left grip were each correlated significantly to almost every anthropometric measure. This suggested that strength in general - and especially those variables mentioned above - were fairly related to anthropometric measures.

Eleven positive and two negative significant correlations out of 96 were found between strength and skating speed variables. The range was from .4134 to .8097 with most being no greater than .48. Hip flexion, hip extension, knee flexion and knee extension were the main variables involved. This implied that a certain degree of relationship existed between strength and skating speed. If strength did affect skating speed the flexion and extension of the hips and knees seemed to be most important while the ankle movements were scarcely involved. It will be noted that the correlation coefficient between ankle dorsi-flexion strength and speed in 25 Metre Standing Start With a Stick skating was .8097 while without a stick it was .3695. The reason for this finding could be due to a difference in balance or arm movement or upper body movement or all of the above of the skaters.

Only two significant coefficients occurred between anthropometric and speed measures. The implication of this finding was that body shape was not an important factor contributing to the ability to skate fast.

Stepwise Multiple Regression Analyses

The stepwise multiple regression analyses revealed that different variables accounted for the variability in skating speed in each of the eight tests. The results can be seen in Tables 7-14 which summarize the steps of the analyses. Few patterns seemed evident in the tables. The analyses for 40 Foot Flying Start Without a Stick and 25 Metre Standing Start With a Stick took 17 steps; 25 Metre Flying Start Without a Stick, 14 steps; and each other skating speed test, 15 steps. Occurring frequently in the total regression analyses for various speed tests were: weight, height, hip flexion strength, hip extension strength, hip outward rotation strength and knee extension strength (in seven of the eight analyses); lower leg length, hip flexion-extension, hip adduction-abduction, and hip rotation (in six cases); and hip abduction strength and ankle dorsi-flexion strength (in five cases).

As can be seen in Tables 7-14 the contributing weights of the factors (i.e. the amount of the variance in the dependent variable accounted for by the factors) varied considerably between each skating test. Tables 15-22 show various regression equations and the occurrence of the variables which accounted for the largest portions of the variance in the dependent variable in each of the skating speed analyses. These regression equations indicated that different factors to differing degrees were particular to each skating speed test. Weight, lower leg length, hip rotation, hip flexion strength, hip extension strength and hip outward rotation strength occurred more frequently in the regression equations than the other variables.

Table 7

Stepwise Multiple Regression Analysis For
40 Foot Standing Start With A Stick
Summary Table

Step Number	Variable entered or removed	R	RSQ
1	Lower Leg Length	0.4695	0.2204
2	Hip Extension Strength	0.7152	0.5115
3	Weight	0.7896	0.6235
4	Thigh Length	0.8331	0.6940
5	Hip Adduction-Abduction	0.8735	0.7630
6	Ankle Plantar Flexion Strength	0.9023	0.8141
7	Calf Girth	0.9297	0.8643
8	Knee Flexion-Extension	0.9707	0.9423
9	Hip Adduction Strength	0.9839	0.9681
10	Hip Flexion-Extension	0.9963	0.9927
11	Hip Flexion Strength	0.9985	0.9972
12	Left Grip Strength	0.9997	0.9995
13	Ankle Flexion-Extension	1.0000	0.9999
14	Hip Outward Rotation Strength	1.0000	1.0000

Table 8

Stepwise Multiple Regression Analysis For
40 Foot Standing Start Without A Stick
Summary Table

Step Number	Variable entered or removed	R	RSQ
1	Weight	0.4050	0.1640
2	Hip Flexion Strength	0.7139	0.5096
3	Hip Extension Strength	0.8146	0.6636
4	Ankle Inversion-Eversion	0.8724	0.7611
5	Hip Abduction Strength	0.9122	0.8321
6	Hip Rotation	0.9316	0.8679
7	Hip Outward Rotation Strength	0.9685	0.9379
8	Lower Leg Length	0.9796	0.9596
9	Knee Flexion Strength	0.9868	0.9738
10	Height	0.9911	0.9824
11	Total Leg Length	0.9963	0.9925
12	Ankle Dorsi-Flexion Strength	0.9987	0.9974
13	Hip Flexion-Extension	0.9999	0.9999
14	Knee Extension Strength	1.0000	1.0000

Table 9

Stepwise Multiple Regression Analysis For
40 Foot Flying Start With A Stick
Summary Table

Step Number	Variable entered or removed	R	RSQ
1	Hip Extension Strength	0.4342	0.1885
2	Lower Leg Length	0.6585	0.4336
3	Total Leg Length	0.7397	0.5472
4	Hip Rotation	0.8270	0.6840
5	Foot Length	0.9181	0.8429
6	Knee Flexion Strength	0.9746	0.9498
7	Ankle Flexion-Extension	0.9831	0.9665
8	Total Foot Length	0.9890	0.9781
9	Weight	0.9963	0.9926
10	Ankle Dorsi-Flexion Strength	0.9986	0.9973
11	Thigh Length	0.9990	0.9981
12	Hip Outward Rotation Strength	0.9995	0.9990
13	Height	0.9998	0.9995
14	Hip Adduction-Abduction	0.9999	0.9999
15	Knee Extension Strength	1.0000	1.0000

Table 10

Stepwise Multiple Regression Analysis For
40 Foot Flying Start Without A Stick
Summary Table

Step Number	Variable entered or removed	R	RSQ
1	Hip Outward Rotation Strength	0.4345	0.1888
2	Ankle Flexion-Extension	0.5315	0.2825
3	Knee Flexion-Extension	0.6048	0.3658
4	Ankle Dorsi-Flexion Strength	0.6382	0.4073
5	Hip Flexion Strength	0.6660	0.4435
6	Weight	0.7270	0.5285
7	Right Grip Strength	0.8365	0.6998
8	Thigh Girth	0.9157	0.8386
9	Hip Abduction Strength	0.9620	0.9254
10	Hip Outward Rotation Strength * removed	0.9620	0.9254
11	Left Grip Strength	0.9684	0.9377
12	Height	0.9780	0.9565
13	Hip Inward Rotation Strength	0.9860	0.9722
14	Hip Adduction-Abduction	0.9943	0.9886
15	Lower Leg Length	0.9982	0.9965
16	Hip Rotation	0.9998	0.9996
17	Knee Extension Strength	1.0000	1.0000

Table 11

Stepwise Multiple Regression Analysis For
25 Metre Standing Start With A Stick
Summary Table

Step Number	Variable entered or removed	R	RSQ
1	Ankle Dorsi-Flexion Strength	0.8097	0.6556
2	Hip Flexion Strength	0.8625	0.7440
3	Hip Adduction-Abduction	0.8939	0.7990
4	Knee Flexion-Extension	0.9258	0.8570
5	Thigh Length	0.9516	0.9055
6	Hip Extension Strength	0.9625	0.9265
7	Hip Flexion Strength * removed	0.9625	0.9265
8	Knee Extension Strength	0.9736	0.9479
9	Ankle Inversion-Eversion	0.9788	0.9581
10	Hip Adduction Strength	0.9851	0.9703
11	Ankle Plantar Flexion Strength	0.9890	0.9780
12	Calf Girth	0.9911	0.9822
13	Hip Flexion Strength	0.9937	0.9875
14	Hip Outward Rotation Strength	0.9983	0.9966
15	Weight	0.9994	0.9987
16	Hip Abduction Strength	0.9999	0.9998
17	Knee Flexion Strength	1.0000	1.0000

Table 12

Stepwise Multiple Regression Analysis For
25 Metre Standing Start Without A Stick
Summary Table

Step Number	Variable entered or removed	R	RSQ
1	Hip Rotation	0.5542	0.3071
2	Ankle Inversion-Eversion	0.6811	0.4639
3	Knee Extension Strength	0.7513	0.5644
4	Calf Girth	0.7892	0.6229
5	Hip Flexion Strength	0.8209	0.6739
6	Hip Abduction Strength	0.8668	0.7514
7	Left Grip Strength	0.8968	0.8042
8	Weight	0.9327	0.8700
9	Ankle Flexion-Extension	0.9571	0.9160
10	Hip Outward Rotation Strength	0.9736	0.9479
11	Hip Extension Strength	0.9899	0.9799
12	Hip Adduction-Abduction	0.9950	0.9899
13	Hip Adduction Strength	0.9988	0.9976
14	Knee Flexion Strength	0.9995	0.9991
15	Height	1.0000	1.0000

Table 13

Stepwise Multiple Regression Analysis For
25 Metre Flying Start With A Stick
Summary Table

Step Number	Variable entered or removed	R	RSQ
1	Knee Extension Strength	0.4829	0.2332
2	Hip Rotation	0.5949	0.3539
3	Ankle Plantar Flexion Strength	0.6772	0.4586
4	Hip Inward Rotation Strength	0.7531	0.5672
5	Hip Extension Strength	0.7960	0.6336
6	Lower Leg Length	0.8663	0.7505
7	Hip Flexion Strength	0.9143	0.8360
8	Calf Girth	0.9499	0.9024
9	Ankle Inversion-Eversion	0.9819	0.9641
10	Hip Abduction Strength	0.9916	0.9834
11	Hip Flexion-Extension	0.9951	0.9902
12	Weight	0.9989	0.9978
13	Ankle Dorsi-Flexion Strength	0.9998	0.9995
14	Thigh Length	1.0000	0.9999
15	Height	1.0000	1.0000

Table 14

Stepwise Multiple Regression Analysis For
25 Metre Flying Start Without A Stick
Summary Table

Step Number	Variable entered or removed	R	RSQ
1	Knee Extension Strength	0.5135	0.2636
2	Thigh Girth	0.6128	0.3756
3	Height	0.6855	0.4699
4	Total Leg Length	0.8041	0.6466
5	Foot Length	0.8455	0.7149
6	Hip Adduction Strength	0.8927	0.7970
7	Total Foot Length	0.9173	0.8414
8	Lower Leg Length	0.9453	0.8937
9	Hip Outward Rotation Strength	0.9659	0.9329
10	Hip Extension Strength	0.9801	0.9607
11	Hip Rotation	0.9987	0.9974
12	Hip Adduction-Abduction	0.9996	0.9992
13	Hip Flexion Strength	0.9999	0.9998
14	Hip Inward Rotation Strength	1.0000	1.0000

Table 15

Regression Equations For 40 Foot Standing Start With A Stick

Variable	% of Variance in the Dependent Variable Accounted for by the Regression Equation		
	81.41% of Variance	94.23% of Variance	99.27% of Variance
Weight	0.01285	0.02381	0.01765
Height			
Total Leg Length			
Thigh Length	-0.02865	-0.03549	-0.02510
Lower Leg Length	0.01746	0.00647	0.02226
Foot Length			
Total Foot Length			
Thigh Girth			
Calf Girth		-0.04168	-0.05989
Ankle Flexion-Extension			
Ankle Inversion-Eversion			
Hip Flexion-Extension			0.00137
Hip Adduction-Abduction	0.00564	0.00496	0.00870
Hip Rotation			
Knee Flexion-Extension		0.00688	0.00772
Hip Flexion Strength			
Hip Extension Strength	-0.01136	-0.01149	-0.00970
Hip Abduction Strength			
Hip Adduction Strength			0.00468
Hip Outward Rotation Strength			
Hip Inward Rotation Strength			
Knee Extension Strength			
Knee Flexion Strength			
Ankle Plantar Flexion Strength	0.00328	0.00413	0.00466
Ankle Dorsi-Flexion Strength			
Right Grip Strength			
Left Grip Strength			
Constant	1.77068	2.21932	1.41581

Table 16

Regression Equations For 40 Foot Standing Start Without A Stick

Variable	% of Variance in the Dependent Variable Accounted for by the Regression Equation		
	83.21% of Variance	95.96% of Variance	99.25% of Variance
Weight	0.01638	0.01781	0.01545
Height			0.00615
Total Leg Length			-0.00529
Thigh Length			
Lower Leg Length		-0.00680	-0.00930
Foot Length			
Total Foot Length			
Thigh Girth			
Calf Girth			
Ankle Flexion-Extension			
Ankle Inversion-Eversion	-0.00219	-0.00324	-0.00282
Hip Flexion-Extension			
Hip Adduction-Abduction			
Hip Rotation		0.00358	0.00371
Knee Flexion-Extension			
Hip Flexion Strength	-0.00581	-0.00933	-0.00771
Hip Extension Strength	-0.00545	-0.00565	-0.00696
Hip Abduction Strength	-0.00121	-0.00033	-0.00093
Hip Adduction Strength			
Hip Outward Rotation Strength		0.00792	0.00441
Hip Inward Rotation Strength			
Knee Extension Strength			
Knee Flexion Strength			0.00199
Ankle Plantar Flexion Strength			
Ankle Dorsi-Flexion Strength			
Right Grip Strength			
Left Grip Strength			
Constant	1.89255	1.78770	1.40460

Table 17

Regression Equations For 40 Foot Flying Start With A Stick

Variable	% of Variance in the Dependent Variable Accounted for by the Regression Equation		
	84.29% of Variance	94.98% of Variance	99.26% of Variance
Weight			0.00181
Height			
Total Leg Length	-0.02273	-0.02616	-0.02456
Thigh Length			
Lower Leg Length	0.02379	0.02911	0.03096
Foot Length	0.03598	0.03130	0.03925
Total Foot Length			-0.02127
Thigh Girth			
Calf Girth			
Ankle Flexion-Extension			-0.00149
Ankle Inversion-Eversion			
Hip Flexion-Extension			
Hip Adduction-Abduction			
Hip Rotation	0.00316	0.00499	0.00495
Knee Flexion-Extension			
Hip Flexion Strength			
Hip Extension Strength	-0.00472	-0.00600	-0.00612
Hip Abduction Strength			
Hip Adduction Strength			
Hip Outward Rotation Strength			
Hip Inward Rotation Strength			
Knee Extension Strength			
Knee Flexion Strength		0.00218	0.00202
Ankle Plantar Flexion Strength			
Ankle Dorsi-Flexion Strength			
Right Grip Strength			
Left Grip Strength			
Constant	1.72573	1.68135	1.86236

Table 18

Regression Equations For 40 Foot Flying Start Without A Stick

Variable	% of Variance in the Dependent Variable Accounted for by the Regression Equation		
	83.86% of Variance	95.65% of Variance	98.86% of Variance
Weight	0.01314	0.01135	0.00682
Height		0.00168	0.00572
Total Leg Length			
Thigh Length			
Lower Leg Length			
Foot Length			
Total Foot Length			
Thigh Girth	-0.01547	-0.01151	-0.00872
Calf Girth			
Ankle Flexion-Extension	-0.00163	-0.00250	-0.00175
Ankle Inversion-Eversion			
Hip Flexion-Extension			
Hip Adduction-Abduction			-0.00139
Hip Rotation			
Knee Flexion-Extension	-0.00120	-0.00097	-0.00057
Hip Flexion Strength	-0.00597	-0.00734	-0.00777
Hip Extension Strength			
Hip Abduction Strength		0.00118	0.00162
Hip Adduction Strength			
Hip Outward Rotation Strength	-0.00154		
Hip Inward Rotation Strength			0.00455
Knee Extension Strength			
Knee Flexion Strength			
Ankle Plantar Flexion Strength			
Ankle Dorsi-Flexion Strength	0.00101	0.00144	0.00189
Right Grip Strength	-0.00393	-0.00429	-0.00576
Left Grip Strength		-0.00122	-0.00114
Constant	2.30332	1.97701	1.32399

Table 19

Regression Equations For 25 Metre Standing Start With A Stick

Variable	% of Variance in the Dependent Variable Accounted for by the Regression Equation		
	85.70% of Variance	95.81% of Variance	99.66% of Variance
Weight			
Height			
Total Leg Length			
Thigh Length		-0.08591	-0.05013
Lower Leg Length			
Foot Length			
Total Foot Length			
Thigh Girth			
Calf Girth			0.18698
Ankle Flexion-Extension			
Ankle Inversion-Eversion		0.00741	-0.00266
Hip Flexion-Extension			
Hip Adduction-Abduction	-0.03405	-0.05048	-0.06625
Hip Rotation			
Knee Flexion-Extension	0.02891	0.04030	-0.00238
Hip Flexion Strength	-0.01715		-0.02298
Hip Extension Strength		-0.01971	-0.03504
Hip Abduction Strength			
Hip Adduction Strength			-0.03246
Hip Outward Rotation Strength			0.03579
Hip Inward Rotation Strength			
Knee Extension Strength		0.00537	0.00704
Knee Flexion Strength			
Ankle Plantar Flexion Strength			-0.01237
Ankle Dorsi-Flexion Strength	0.03835	0.03115	0.04751
Right Grip Strength			
Left Grip Strength			
Constant	1.11359	3.29323	5.47164

Table 20

Regression Equations For 25 Metre Standing Start Without A Stick

Variable	% of Variance in the Dependent Variable Accounted for by the Regression Equation		
	80.42% of Variance	94.79% of Variance	98.99% of Variance
Weight		0.00623	0.00720
Height			
Total Leg Length			
Thigh Length			
Lower Leg Length			
Foot Length			
Total Foot Length			
Thigh Girth			
Calf Girth	0.03610	0.03479	0.03867
Ankle Flexion-Extension		-0.00349	-0.00402
Ankle Inversion-Eversion	-0.00437	-0.00436	-0.00436
Hip Flexion-Extension			
Hip Adduction-Abduction			-0.00198
Hip Rotation	0.00896	0.01113	0.01199
Knee Flexion-Extension			
Hip Flexion Strength	-0.00538	-0.00981	-0.01111
Hip Extension Strength			-0.00246
Hip Abduction Strength	0.00223	0.00392	0.00436
Hip Adduction Strength			
Hip Outward Rotation Strength		0.00704	0.00815
Hip Inward Rotation Strength			
Knee Extension Strength	-0.00156	-0.00161	-0.00118
Knee Flexion Strength			
Ankle Plantar Flexion Strength			
Ankle Dorsi-Flexion Strength			
Right Grip Strength			
Left Grip Strength	-0.00270	-0.00681	-0.00738
Constant	2.57413	2.42296	2.42132

Table 21

Regression Equations For 25 Metre Flying Start With A Stick

Variable	% of Variance in the Dependent Variable Accounted for by the Regression Equation		
	83.60% of Variance	96.41% of Variance	99.02% of Variance
Weight			
Height			
Total Leg Length			
Thigh Length			
Lower Leg Length	0.01792	0.01576	0.01563
Foot Length			
Total Foot Length			
Thigh Girth			
Calf Girth		0.02805	0.02907
Ankle Flexion-Extension			
Ankle Inversion-Eversion		-0.00170	-0.00182
Hip Flexion-Extension			0.00037
Hip Adduction-Abduction			
Hip Rotation	0.01011	0.01192	0.01203
Knee Flexion-Extension			
Hip Flexion Strength	-0.00345	-0.00611	-0.00690
Hip Extension Strength	-0.00404	-0.00514	-0.00517
Hip Abduction Strength			0.00061
Hip Adduction Strength			
Hip Outward Rotation Strength			
Hip Inward Rotation Strength	0.01672	0.01636	0.01538
Knee Extension Strength	0.00044	0.00030	0.00018
Knee Flexion Strength			
Ankle Plantar Flexion Strength	-0.00551	-0.00561	-0.00537
Ankle Dorsi-Flexion Strength			
Right Grip Strength			
Left Grip Strength			
Constant	1.78721	1.01608	0.97147

Table 22

Regression Equations For 25 Metre Flying Start Without A Stick

Variable	% of Variance in the Dependent Variable Accounted for by the Regression Equation		
	79.70% of Variance	96.07% of Variance	99.74% of Variance
Weight			
Height	0.01768	0.01756	0.02174
Total Leg Length	-0.02933	-0.03403	-0.03268
Thigh Length			
Lower Leg Length		0.02843	0.03772
Foot Length	0.03632	0.11936	0.14990
Total Foot Length		-0.09962	-0.14755
Thigh Girth	-0.02106	-0.02107	-0.02438
Calf Girth			
Ankle Flexion-Extension			
Ankle Inversion-Eversion			
Hip Flexion-Extension			
Hip Adduction-Abduction			
Hip Rotation			-0.00285
Knee Flexion-Extension			
Hip Flexion Strength			
Hip Extension Strength		-0.00217	-0.00259
Hip Abduction Strength			
Hip Adduction Strength	0.00217	0.00513	0.00693
Hip Outward Rotation Strength		-0.00590	-0.00833
Hip Inward Rotation Strength			
Knee Extension Strength	-0.00150	-0.00064	-0.00033
Knee Flexion Strength			
Ankle Plantar Flexion Strength			
Ankle Dorsi-Flexion Strength			
Right Grip Strength			
Left Grip Strength			
Constant	3.09044	3.28484	3.09934

Chapter 4

DISCUSSION

Analysis of the data gathered in this study had varied implications. The correlation coefficients computed supported some previous findings and refuted others.

Because there was only one significant correlation coefficient reported between two flexibility measures of the ankle this suggested that flexibility was specific to each joint of the legs. The lack of significant correlations between ankle, knee, and hip joint flexibility measures and the lack of intercorrelations between hip flexibility measures supported the tenet of Harris (1969) that there is no general flexibility capacity within the legs but rather, that each joint has its own characteristic flexibility component.

The occurrence of a large number (22) of significant intercorrelations between strength measures indicated that a general strength factor was evident in the legs and grips. This finding supported the contention of fitness testers who often use grip strength as a general index of strength. This practice is based on the premise that if certain major muscle groups are strong, the other major muscle groups of the body will be strong. The existence of significant correlations between the grip strength measures and leg strength measures indicated that grip strength could be used to predict leg strength.

The 31 significant intercorrelations between anthropometric measures suggested that the body types of the players were similar. It was noticeable that thigh girth was not significantly correlated with other anthropometric measures. It would seem, therefore, that these hockey players had leg structures and height and weight dimensions of similar proportions.

From the intercorrelations between the skating speed variables two things were noticeable. The lack of correlation between the 25 Metre Standing Start With a Stick test and every other test suggested that it measured something different to the other tests. The complete correlation of the 40 Foot and 25 metre Flying Start With a Stick tests to all other skating speed tests except the one previously mentioned, suggested that the two tests seemed to measure some aspects which existed in the other tests. The implication of this is that these two skating speed tests might possibly be administered apart from the other skating speed tests as central measures of skating speed if it was impractical for a coach to use all eight skating tests.

The lack of significant correlations between flexibility and strength measures implied that a little relationship existed between the two factors. These findings agreed with previous researchers (Laubach & McConville, 1966 b) who reported very little relationship between strength and flexibility. It seemed that in this sample the strength of a certain movement was not related to the maximum possible range of that movement.

The present study found only six significant correlation coefficients between flexibility and anthropometric measures. The findings of previous researchers (Hansen, 1957; Laubach & McConville, 1966 a; Mathews et al. 1957) varied in this respect. The present study supported the contention that flexibility is not related to anthropometry although the limited range of physiques in this study may have caused the correlation coefficients to be underestimated. The relationship would be clarified by a study using a greater variety of body types.

A relationship between certain strength and anthropometric measures was revealed because of the 47 significant correlation coefficients. These findings were contrary to the results of Clarke (1957) who found no such relationship. They agreed with Smith (1961) who reported a tendency for strength to be related to anthropometric measures. A relationship between these two variables indicated that as the subjects increased in size their strength increased. A small relationship between flexibility and speed of skating was found. This was supported by Burley et al. (1961) who found a low relationship between flexibility and speed of running. The assertion is made that speed of activity is related to a small degree to flexibility.

Past inquiries (Clarke & Henry, 1961; Eckert, 1964; Pierson & Rasch, 1962; Smith & Whitley, 1965; Start et al., 1966) examined relationships between strength and speed of movement. No general concensus about this relationship has been arrived at. The present findings, that a few relationships existed between strength and speed of skating, did little to clarify the problem because the skating tests involved the measurement of a different type of speed. The lack of significant correlations between the two factors indicated that a greater amount of absolute leg strength did not result in faster skating speed. Later in this discussion it will be indicated that, to a small degree, various leg strength measures were related to various skating speeds.

Burley et al. (1961) found no relationship between anthropometric measurements and speed of running. The occurrence of only two significant correlation coefficients in the present study suggested that no relationship existed between anthropometric measurements and speed of skating. That is, a small player is likely to be able to skate as fast as a large player.

From the results of the stepwise multiple regression analyses a number of interpretations and hypotheses can be made. There seemed to be a number of different factors affecting skating speed to varied, limited degrees. There were no main factors which were important in all skating speed tests or which accounted for a large part of the variance in each one.

The analyses indicated that weight was an important factor in the 40 foot tests. Weight was especially important in both 40 foot standing start tests in which it was entered as the first variable in one analysis and as the third variable in the other.

Hip extension strength occurred in all stepwise multiple regression analyses except the 40 Foot Flying Start Without a Stick test. It seemed that this variable was a contributing factor in skating speed under varied conditions at varied distances. Hip extension strength was entered in the analyses of 40 Foot Standing Start With a Stick, 40 Foot Standing Start Without a Stick and 40 Foot Flying Start With a Stick tests as the second, third and first variable respectively. Therefore, this variable seemed to be important in skating the shorter distance of 40 feet.

Knee extension strength occurred only in the regression analyses of the four 25 metre skating speed tests. Since it was the first variable entered in both the 25 metre flying start tests, it was indicated as an important factor in performance of the 25 metre skating tests, especially those involving flying starts.

It seemed possible that lower leg length, hip rotation, and hip flexion strength were factors which influenced skating speed. These variables each occurred in five of the eight stepwise multiple regression analyses. However no consistent pattern of inclusion in types of speed tests was evidenced involving any of these variables. Therefore, no logical conclusions could be made about their contributions to skating speed.

The results of the present study concurred with some aspects of Pagé's (1975) study and disagreed with others. Pagé stated that stronger legs and freedom of the hip during the thrusting action were two of the factors believed to determine skating speed. The present study found only certain strengths of the legs to be contributing factors to skating speeds and hence only partially supported his statement.

"Freedom of the hip" during the thrusting action of skating was also deemed to be important but this concept was not further defined in Pagé's thesis. If a definition of this term involved any of the hip flexibility or hip strength variables used in this study, a statement of support or non-support could be made on the basis of the present findings. A few significant correlations of the hip flexibility and hip strength measures to skating speed were found. Of the hip strength variables, only hip flexion and hip extension were entered early in any of the regression analyses. None of the hip flexibility variables were found to be entered early in the regression analyses with any consistency. Therefore, if a definition did encompass any of the variables of the present study, the findings indicated that no support existed for the original contention that "freedom of the hip" is an important factor in skating speed.

Of importance in the present study was, that with only 17 subjects, the variables provided were able to account for all of the variance in the dependent skating speed variables in all cases. This exploratory study had implications for future study. By using a large number of subjects and following the direction of the present study, a future researcher could expect to formulate regression equations with which to predict skating speeds. Such equations could be very useful to hockey coaches by indicating appropriate batteries of tests for a variety of skating capacities.

The lack of a few general factors affecting skating speeds supported the doctrine of specificity of exercise. The factors revealed in the stepwise multiple regression analysis for each skating speed test were different in order and contributory weights. This suggested that skating one specific distance was a distinct ability involving a unique set of weighted determining factors. Therefore, coaches who always have their players skate from one end of the rink to the other as their only skating drills might be making a grave mistake by training players to skate fast over only one distance i.e. the training content would not supply the practice at the variety of skills which are required for hockey.

The present findings reinforced the assertion that the mechanics of skating with a stick and without a stick, while involving some common factors, are essentially different. If this is true, the players whose coach lets them drop their sticks and gloves to do their skating drills may be practising inappropriately by training a skill different from the one which will be used in a game situation.

In the present study the skating speeds were measured strictly in straight line skating tests. The fact that skating in a curved line differs in some ways to straight line skating further complicates the study of skating. To date, researchers have avoided analyzing curved line skating techniques because of the difficulties involved in such analyses. However, research is needed on this specific skill. Coaches also need to expose players to this skill in training along with various other specific skating skills.

The study of Pagé (1975) analyzed biomechanically the factors affecting skating speed in actual on ice conditions. The present study dealt with the separate components of skating but examined them individually in dry land conditions. Besides the problem of small subject numbers in this study other factors may have affected the results. For instance, it is possible that a high order response of a certain trait is not essential to the mechanics of skating. A player may not need to exert the large force which he exhibited in the knee extension strength test during actual skating. It is possible that only a small part of that knee extension capacity is needed when exerted at the appropriate time and in sequence with other actions during actual skating. If this was demonstrated in future studies, it would seem feasible that coaches could be told what attributes a player should have to be able to skate fast. Those attributes could be tested off the ice. If a player possessed the appropriate capacities, the techniques of his skating could be refined on the ice resulting in a faster skater. At the junior hockey levels and higher, knowledge of the specific strength, flexibility, and anthropometric characteristics which were needed by players would enable a coach to assess the potential of players by simply testing these individual attributes. Such knowledge of players' potentials would be valuable, not only to individual coaches, but to professional hockey organizations who could decide more competently whether or not to pay large sums of money to obtain certain players' services.

Further research can clarify these issues and hockey coaching, especially the techniques for the improvement of skating, can benefit from the results.

Chapter 6

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to examine the relationship of flexibility, strength and anthropometric measurements of the lower limbs to the skating speed of hockey players.

Seventeen university hockey players were assessed for: leg and grip strengths using variations of Clarke's cable-tension strength tests; lower limb flexibility using Leighton's flexometer and technique; anthropometry of the legs; and skating speed under various conditions and over various distances using a Universal Counter Timer Model 604A and photoelectric cells. The strength, flexibility and anthropometric measures were the independent variables and the skating speeds were the dependent variables. Using a significance level of .05 the data were analyzed by the Pearson Product-Moment Correlation Coefficient and Stepwise Multiple Regression statistical methods.

Conclusions

Within the limitations and delimitations of this thesis a number of inferences were made from the results of the data analyses.

The Pearson Product-Moment Correlation analyses indicated various things. A lack of significant intercorrelations between flexibility measures suggested that flexibility was specific to each joint of the legs. A large number of significant intercorrelations between strength measures indicated the presence of a general strength factor in the subjects' legs and grips. A general body type was evidenced by the large number of significant intercorrelations between anthropometric measures. From the intercorrelations between skating speed measures the 40 Foot and 25 Metre Flying Start With a Stick tests were shown to incorporate many of the factors of the other tests. The small number of significant correlations between flexibility and both strength and anthropometric measures indicated that flexibility is slightly related to strength and anthropometry. A large number of significant correlations existed between strength and anthropometric measures indicating that a relationship existed between the two. There were a few significant correlations between flexibility, strength, and anthropometric measures and skating speed measures indicating that not all of them were related to skating speed.

The other analysis method, stepwise multiple regression, indicated that in each of the eight skating speed tests the variables which accounted for the variance were different in order and contributory weights. All of the variance in each skating speed measure was accounted for in the stepwise multiple regression analyses. No principal variables were common to a majority of the tests. Weight, lower leg length, hip rotation, hip flexion strength, hip extension strength and hip outward rotation strength were the variables which occurred most often in the analyses. Weight and hip extension strength seemed to be important factors determining skating speed in the 40 foot tests and knee extension strength was indicated as an important variable in skating speed in the 25 metre flying start tests.

The results of this study further indicated that skating speed was specific to the distance and to the conditions under which it was performed. These results suggest that further study on the subject of skating speed could augment the present study by 1) clarifying the relationships between the variables, 2) producing predictive equations for skating speed, and 3) providing techniques with which to assess hockey players' potentials.

Recommendations

The results of this study have indicated that the factors affecting the skating speed of hockey players were diverse and specific to performance conditions.

Further studies should be produced involving:

1) Many more subjects of varied age levels and abilities.
2) More distances and possibly curved line skating tests.
3) The creation of evaluative techniques for assessing the potentials of hockey players if the present results are supported.
4) The creation of a testing method of leg power.

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Appendix A

Flexibility Tests

The flexibility tests were administered according to the method developed by Leighton. These measurement techniques were as follows:

<u>Ankle Flexion - Extension</u>

The subjects sat with the right leg resting on the bench and the foot projecting over the end. The knee was kept straight and the left leg was extended downward with the foot resting on the floor. The instrument was fastened to the inside of the right foot. The subject then dorsi - flexed his foot to the extreme position and the dial was locked. The foot was then plantar flexed as much as possible; the pointer was locked before the subject relaxed and a reading was taken. The knee of the right leg was kept straight and no sideward turning of the foot was allowed throughout the movement.

<u>Ankle Inversion - Eversion</u>

The subject sat with his lower legs hanging over the end of the testing table and his calves touching the end board. Shoes were worn and the instrument was fastened to the front of the foot. The foot was then turned inward as far as possible and the dial was locked. The foot was then turned outward as far as possible; the pointer was locked before the subject relaxed and a reading was taken. Care was taken that the position of the lower leg was not changed during the movement.

Hip Extension - Flexion

The subject started in a standing position with his feet together, knees stiff and arms extended above the head with his hands clasped and palms up. The instrument was fastened to the right side of the hip at umbilicus height. The subject first bent backward as far as possible and the dial was locked. Then the subject bent forward as far as possible and the pointer was locked. The subject relaxed and a reading was taken. Care was taken that the knees remained straight, the feet were not shifted and the toes and heels were not raised throughout the movement.

Hip Adduction - Abduction

The subject started in a standing position with his feet together, knees straight and his arms at his sides. The instrument was fastened to the back of the right leg below the gastrocnemius on the ankle and the dial was locked. The subject moved the left leg sidewards as far as possible. The pointer was locked and then the subject relaxed and a reading was taken. Care was taken that the subject's body remained in an upright position, the knees remained straight and the feet remained in a position in line and parallel throughout the movement.

Hip Rotation

The subject started in a sitting position with the right leg resting on the bench and the right foot projecting over the end of the bench. The left leg was extended downward with the foot resting on the floor. The instrument was fastened to the bottom of the right foot. The right leg was turned outward as far as possible and the dial was locked. Then the subject rotated his right leg inward as far as possible, the pointer was locked and the subject relaxed while the reading was taken. Care was exercised that the knee and ankle joints remained locked and that the position of the hips did not change throughout the movement.

Knee Flexion - Extension

The subject lay in a prone position on the bench with his knees at the end of the bench and the lower legs hanging over the edge. The arms were at the subject's sides and his hands grasped the bench. The instrument was fastened to the outside of the right ankle. The subject then flexed his lower leg upward and backward to a position as near the buttocks as possible and the dial was locked. Then the leg was moved forward and downward until the leg was forcibly extended. The pointer was locked before the subject relaxed and the reading was taken. The position of the upper leg did not change during the movement.

Appendix B

Strength Tests

The strength tests were administered according to the following standard format:

Hip Flexion

The subject lay in a supine position with his arms folded on his chest and the hip and knee of his left leg flexed at the knee with the left foot resting on the table. The right leg was extended and adducted to 180 degrees at both the hip and knee. The cable and tensiometer were attached to the lower third of the subject's right thigh by means of a strap and to the table through a slit in the table top. The tester instructed the subject to flex his right leg by contracting against the measuring device with a maximum effort. The tester prevented the subject from lifting his shoulders by bracing them.

Hip Extension

The subject lay in the prone position with his arms at his sides and his knees fully extended so that his feet were over the end of the table. The right leg was in 180 degrees of extension and adduction. The cable and tensiometer were attached to the lower third of the subject's right thigh by means of a strap and to the table through a slit in the table top. The tester instructed the subject to attempt to extend his right leg by contracting against the measuring device with a maximum effort. The tester insured that the subject did not lift his hips by holding them down.

Hip Adduction

The subject lay on his right side with his right arm extended for a head rest and with his left arm flexed in a comfortable position on his left side. The left leg was in full extension at the knee and abducted slightly to avoid interference with the movement of the right leg. The right knee was fully extended and the right hip was in 180 degrees of extension and adduction. The strap of the testing equipment was around the lower third of the right thigh and the cable was attached beneath through the slit in the table top. The tester instructed the subject to adduct his right leg with a maximum effort. The tester took care that the subject maintained his body in a lateral plane perpendicular to the table and did not lift his hips or shoulders.

Hip Abduction

The subject lay on his left side with his left knee flexed to permit passage of the testing equipment through the slit in the table to the point of attachment. The left arm was extended for a head rest and the right arm was flexed in a comfortable position on the subject's side. The subject's right leg was fully extended at the knee and extended and adducted to 180 degrees at the hip with the strap of the testing equipment attached to the lower third of the thigh. The tester instructed the subject to attempt with a maximum effort to abduct his right leg. The tester insured that the subject maintained his body in a lateral plane perpendicular to the table and that the subject's hips and shoulders were braced and were not lifted.

Knee Flexion

The subject lay in a prone position with the knees extended just over the edge of the testing table and the head resting on folded arms. The right knee was flexed to 165 degrees with the strap of the pulling assembly around the calf midway between knee and ankle. The cable was attached to the hook in the floor. The tester instructed the subject to flex his lower leg with a maximum effort against the assembly. Care was taken that the subject did not lift his chest.

Hip Inward Rotation

The subject sat at the end of the table with his legs flexed to 90 degrees and his lower legs hanging free. There was a padded support under his knees and his hands were folded on his chest. The testing apparatus was attached around the right leg of the subject just above the ankle. The tester braced the right leg so that the subject did not adduct or flex the thigh at the hip. The tester instructed the subject to exert the maximum force possible outward against the cable which was attached to the wall at the subject's left.

Hip Outward Rotation

The procedure for this test was the same as for Hip Inward Rotation. However, the subject exerted force inward against the pulling assembly which was attached to the wall to his right.

Knee Extension

The subject sat at the end of the table leaning backwards and holding the sides of the table with his arms extended. The left leg was hanging free and the right leg was extended to 90 degrees with the testing strap around it midway between the knee and ankle joints. The pulling assembly was attached to a hook beneath the table. The tester was careful that the subject did not flex his arms nor lift his buttocks when instructed to maximally contract against the testing device.

Ankle Plantar Flexion

The subject lay in the supine position with his hips in 180 degrees of extension and adduction and his legs fully extended at the knee. The right foot was dorsi-flexed to 90 degrees and at the mid-position of eversion and inversion. The strap of the testing equipment was attached around the ball of the foot. The pulling assembly was attached at the other end to the wall above the subject's head. The subject was allowed to hold onto the table to stabilize himself. The tester instructed the subject to attempt to push downward against the pulling assembly with a maximum effort. The subject was not allowed to invert or evert his foot or raise his leg.

Ankle Dorsi-Flexion

The subject lay in a supine position with his hips in 180 degrees of extension and adduction and his knees fully extended. The right foot was dorsi-flexed at the ankle to 115 degrees and was at the mid-position between inversion and eversion. The strap of the testing equipment was attached around the foot just below the toes and the cable was attached to the wall at the subject's feet. The subject was allowed to stabilize himself by holding onto the table. The tester instructed the subject to attempt to pull upward with maximum effort against the cable assembly. The tester was careful that the subject did not invert or evert his foot or flex his leg at the knee while exerting force with his right foot.

Grip Strength

The subject stood with his feet shoulder width apart and the testing instrument gripped in the hand being tested. The other arm was at his side. The tester held the instrument solidly and instructed the subject to squeeze the instrument with a maximum effort. The tester insured that the instrument was adjusted so that subject's two most distal phalanges were around the bar of the apparatus prior to the test. The tester instructed the subject to contract against the apparatus with a maximum effort. The tester made sure that the subject did not touch his side with the instrument during contraction. Both right and left hands were tested.

A 30 second rest between trials and a one minute rest between tests were given to each subject during the strength testing.

Appendix C

Anthropometric Measurements

All subjects were instructed to remove their shoes and socks upon entering the testing room. The tester first determined the subject's weight and height. A Detecto - Medic scale, which is sold by Sports Equipment of Toronto Limited, was used to measure both the weight and height of the subject. The tester instructed the subject to stand with his feet flat and his shoulders back, looking straight ahead while his height was measured with the special attachment on the scale. For the remaining measurements the subject was instructed to stand in a relaxed position on a 10 inch wide bench with his legs straight and his feet flat. The tester determined the location of the greater trochanter, the lateral epicondyle and the lateral maleolus and marked a small X on each with a red felt pen. These marks were used as the reference points from which the measurements were taken. Total leg length was measured as the distance between the greater trochanter and the floor. The distance between the greater trochanter and the lateral epicondyle and between the lateral epicondyle and the lateral maleolus were taken as the measures of thigh length and lower leg length respectively. The tester measured the distance from the lateral maleolus to a point even with the end of the most distal phalange to determine foot length. Total foot length was measured as the distance from the most posterior part of the foot to a point even with the most distal phalange.

Thigh and calf girths were measured by the tester as the distance around the largest part of each, measured in a horizontal plane when the subject's leg was relaxed.

Appendix D

Skating Speed Tests

Certain preparations were necessary in order to ensure efficient administration of the skating tests. Velcro strips were used to attach the photo-electric cells to the boards. In this way minimum movement of the cells occurred when they were in place yet it was possible to move them quickly and easily. A mark was placed on the boards to indicate the finishing point used for all tests. The starting points 40 feet and 25 metres away were indicated in the same manner. The photo-electric cells were positioned according to the marks on the boards at a height of 60 centimetres. Other marks, 27 metres and 40 metres away from the finishing point, indicated the starting points for the two flying start tests. A piece of tape was placed on the boards one metre from each of the standing start points to indicate the boundaries of the starting box. Orange pylons were placed opposite all starting points and the finishing point two metres from the boards. The photo-electric cell which was placed at the finish line was not moved but the starting photo-electric cell was moved from the 40 foot starting mark to the 25 metre starting mark in order to test the subjects at the different distances. A diagram showing the location of the markings on the rink can be seen in Figure 1.

The subjects were given an optional five minute stretching and skating warm-up. The tester then described the tests briefly and told the subjects that they should give all-out efforts and skate as fast as possible. The subjects were told that they were required to have both hands on their stick at all times during the test. The stick blade was also required to remain in contact with the ice throughout each trial. The subjects were also told that failure to follow these instructions would result in the cancellation of such a trial. The subjects were allowed to choose the starting method they wished to use.

<u>40 Foot Standing Start Test</u>

Each subject entered the starting box which was outlined by the starting line and by a hockey stick lying on the ice parallel to the starting line and 1 metre behind it. If the subject set off the timing device prematurely he was not penalized but was cautioned to stay back from the photo-electric cell until he was ready to start. Once in the starting box each subject was told to skate down the course through the finish line as fast as possible whenever he was ready. The score was recorded immediately following each trial.

When the subjects completed the required number of trials the 40 Foot Flying Start Test was administered.

<u>40 Foot Flying Start Test</u>

Each subject was reminded of the rules regarding two hands on the stick and the stick touching the ice and told to skate up and stop beside the starting pylon. The tester told the subject that the timing equipment would not start until he passed the photo-electric cell which was 15 metres away at the starting point of the last test. The tester also instructed him to try to reach top speed before he passed the photo-electric cell and maintain that speed throughout the course. The subjectswere allowed to start whenever they were ready and the time of each trial was recorded immediately.

After the required trials were completed the subjects were told to relax and preparations were made for the next two tests.

25 Metre Standing Start and 25 Metre Flying Start Tests

The same procedures were followed as for the 40 Foot Standing and Flying Start Tests.

When all trials on the four tests were completed by the subjects with their sticks the subjects repeated all the tests without their sticks. They were required to continue wearing their hockey gloves throughout the remaining tests.

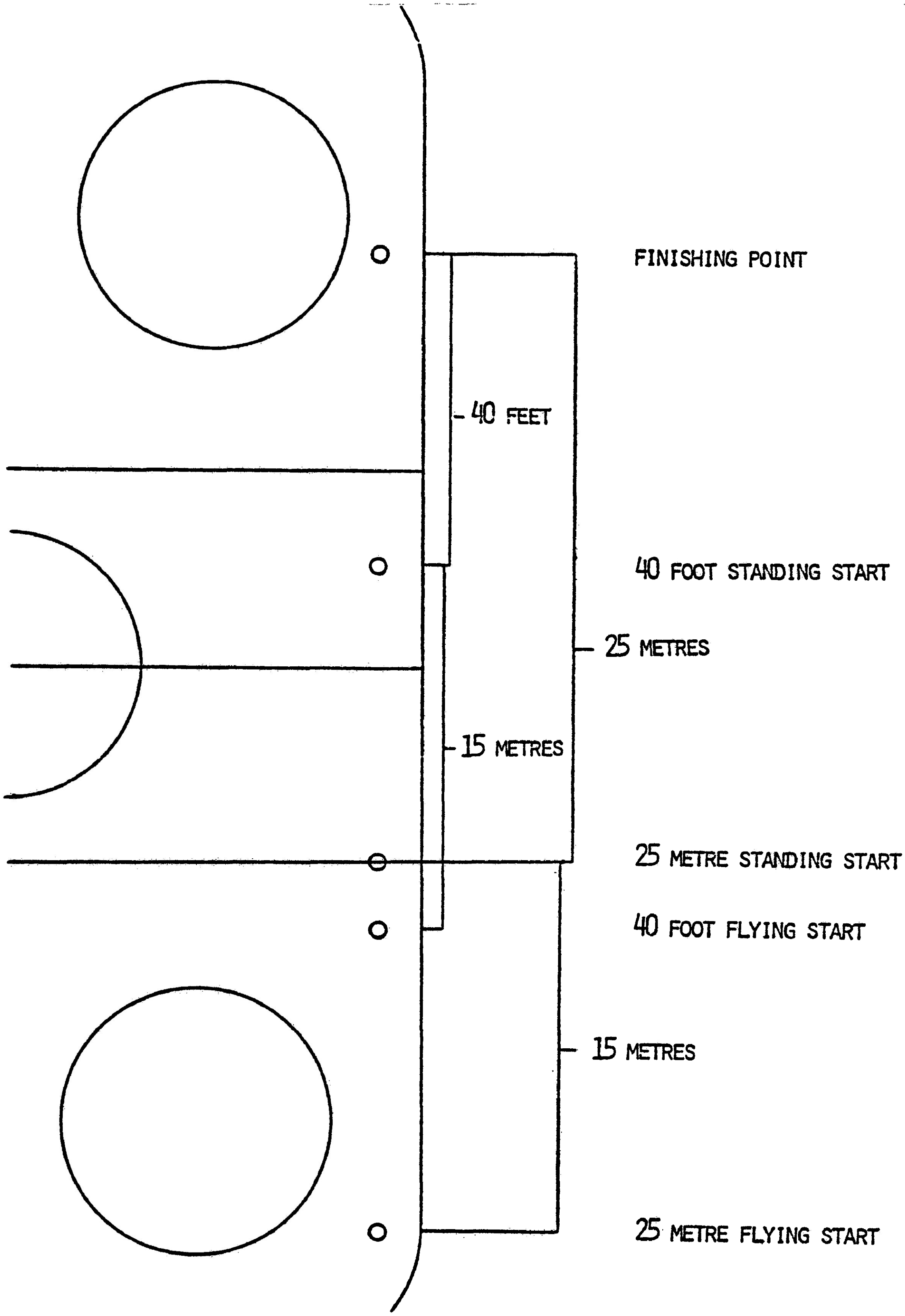

Figure 1. Layout of the Rink for the Skating Tests.

Appendix E

Raw Data

Table A

Anthropometric Data
(in cm and kg)

Subjects	Age	Weight	Height	Total Leg Length	Thigh Length	Lower Leg Length	Foot Length	Total Foot Length	Thigh Girth	Calf Girth
AC	19	81.2	180	91.5	41.5	44.5	23.0	29.0	60.0	39.5
JT	19	87.1	180	96.5	44.0	44.5	21.5	27.5	63.0	39.0
DS	23	74.8	174	91.0	40.0	44.5	21.0	27.0	57.0	38.5
DV	23	74.4	173	87.0	38.5	41.5	20.5	26.5	59.0	38.5
RP	20	73.9	178	93.0	44.5	42.5	22.5	28.0	58.0	36.0
BD	24	80.7	185	96.0	42.5	47.0	25.0	29.5	62.0	39.5
JH	22	81.2	183	92.5	40.5	45.5	21.5	27.5	63.5	37.0
KP	19	66.2	166	82.0	38.0	39.5	20.0	26.0	57.0	37.5
LM	19	65.8	172	87.0	38.0	42.5	21.0	27.0	56.0	34.5
SK	19	96.2	196	105.5	48.0	49.5	27.5	33.5	64.5	41.5
GO	22	70.3	177	90.5	42.0	43.5	22.0	27.5	56.0	38.0
CH	19	78.0	175	89.0	42.5	42.0	23.0	27.5	61.0	38.5
FC	19	83.9	168	85.0	41.0	39.5	21.0	27.0	66.0	39.5
DO	19	80.7	180	90.5	41.5	42.5	22.0	27.5	62.0	38.5
KC	22	72.1	168	88.0	42.0	40.0	21.0	26.5	59.0	39.0
RW	19	75.3	183	92.5	43.0	43.5	23.0	29.0	56.5	38.5
CK	19	69.4	174	89.0	42.0	40.0	21.5	27.5	53.5	35.0
Mean	20.4	77.1	177.2	90.4	41.7	43.1	22.2	27.8	59.6	38.1
S.D.	1.8	7.8	7.4	5.2	2.5	2.7	1.8	1.8	3.5	1.7

Table B

Flexibility Data
(in degrees)

Subject	Ankle Flexion-Extension	Ankle Inversion-Eversion	Hip Flexion-Extension	Hip Adduction-Abduction	Hip Rotation	Knee Flexion-Extension
AC	74	56	121	67	105	147
JT	78	63	146	57	78	154
DS	80	46	143	58	82	152
DV	88	62	111	45	102	151
RP	65	79	112	50	90	142
BD	69	70	149	64	90	162
JH	75	59	86	57	97	134
KP	65	54	123	66	65	147
LM	63	36	95	62	86	146
SK	72	73	85	60	102	144
GO	87	87	86	70	90	160
CH	81	74	125	64	93	146
FC	73	58	136	48	72	139
DO	85	66	127	69	92	142
KC	81	55	136	56	76	143
RW	61	34	92	50	87	147
CK	71	46	139	66	98	151
Mean	74.6	59.9	118.4	59.4	88.8	147.5
S.D.	8.4	14.4	22.4	7.7	11.0	7.1

Table C

Strength Data
(in kg)

Subj.	Hip Flex.	Hip Ext.	Hip Abd.	Hip Add.	Hip Out Rot.	Hip In Rot.	Knee Ext.	Knee Flex.	Ankle Plant Flex.	Ankle Dorsi-Flex.	Rt. Grip	Lt. Grip
AC	81.8	58.2	58.2	47.3	26.1	27.3	136.4	45.5	97.3	63.6	37.1	40.9
JT	59.1	63.6	86.4	33.4	26.1	37.9	103.2	63.6	94.1	44.3	74.2	56.4
DS	62.1	47.3	62.1	36.4	25.0	31.8	120.5	64.8	109.1	34.1	48.2	50.0
DV	63.6	50.0	47.3	67.0	26.1	22.7	111.4	46.4	101.0	101.0	53.4	47.3
RP	57.3	42.0	40.9	42.0	29.5	29.5	80.3	42.0	104.0	35.2	60.6	58.2
BD	64.8	71.6	31.8	22.0	37.9	31.8	136.4	80.3	109.1	37.9	53.4	54.5
JH	65.9	56.4	63.6	45.5	22.7	29.5	83.3	52.3	98.5	56.4	54.0	55.5
KP	49.1	37.1	57.3	53.4	26.1	33.4	115.9	67.0	69.3	30.7	40.7	38.6
LM	46.4	54.5	40.9	35.2	20.5	27.3	127.3	54.5	95.4	44.3	55.5	48.2
SK	81.8	65.9	107.0	53.4	28.8	32.6	159.1	87.9	145.5	69.3	75.7	92.4
GO	49.1	52.3	40.9	19.7	22.7	27.3	103.2	58.2	101.0	43.2	53.4	48.2
CH	49.1	53.4	47.3	38.6	22.7	30.7	103.2	57.3	103.2	49.1	49.1	46.4
FC	63.6	58.2	31.8	77.3	31.8	44.3	120.5	89.4	106.4	49.1	58.2	54.5
DO	72.7	60.6	83.3	28.0	28.0	30.7	210.9	71.6	118.2	46.4	55.5	50.0
KC	65.9	67.0	84.8	48.2	25.0	32.6	127.3	75.7	98.0	40.9	54.5	54.5
RW	59.1	67.0	40.9	37.1	22.7	32.6	145.5	58.2	113.6	36.4	57.3	47.3
CK	55.5	54.5	65.9	25.0	26.1	31.8	115.9	71.6	101.0	50.0	53.4	52.3
Mean	61.6	56.5	58.3	41.7	26.3	31.4	123.7	63.9	103.8	48.9	55.0	52.7
S.D.	10.5	9.2	21.6	15.4	4.1	4.7	30.3	14.2	15.0	16.9	9.6	11.5

Note: Flex. = Flexion, Ext. = Extension, Abd. = Abduction, Add. = Adduction, Out. = Outward, In. = Inward, Rot. = Rotation, Plant. = Plantar, Rt. = Right, Lt. = Left

Table D

Skating Speed Times
(in sec)

Subject	40 Foot Standing Start		40 Foot Flying Start		25 Metre Standing Start		25 Metre Flying Start	
	With Stick	Without Stick	With Stick	Without Stick	With Stick	Without Stick	With Stick	Without Stick
AC	2.42	2.21	1.56	1.52	4.05	4.06	3.11	3.02
JT	2.36	2.36	1.54	1.54	4.11	4.03	3.10	3.09
DS	2.51	2.30	1.54	1.51	4.10	4.03	3.09	3.00
DV	2.38	2.32	1.56	1.52	4.16	4.05	3.06	3.10
RP	2.35	2.30	1.49	1.49	3.97	3.88	2.99	3.02
BD	2.39	2.28	1.53	1.49	3.99	3.89	2.99	2.99
JH	2.40	2.30	1.54	1.54	3.99	4.02	3.09	3.06
KP	2.35	2.30	1.56	1.58	3.93	3.90	3.07	3.12
LM	2.39	2.26	1.52	1.52	3.88	3.90	3.00	3.04
SK	2.56	2.37	1.52	1.52	4.06	3.97	2.98	3.00
GO	2.31	2.22	1.50	1.51	3.94	3.83	3.01	3.02
CH	2.39	2.38	1.57	1.61	4.11	4.05	3.14	3.13
FC	2.36	2.41	1.47	1.46	4.06	3.77	2.96	2.89
DO	2.39	2.24	1.48	1.46	4.01	3.85	2.91	2.86
KC	1.99	2.05	1.33	1.44	3.68	3.80	2.84	2.88
RW	2.08	2.29	1.41	1.57	3.99	4.04	2.98	3.09
CK	2.36	2.32	1.53	1.58	3.96	4.06	3.09	3.13
Mean	2.35	2.29	1.51	1.52	4.18	3.95	3.02	3.03
S.D.	0.13	0.08	0.06	0.05	0.78	0.10	0.08	0.09