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Determining anthropometric and leg power differences between alpine ski racers and non-skiers

James L. Meyer
Ithaca College

DETERMINING ANTHROPOMETRIC AND LEG POWER DIFFERENCES BETWEEN ALPINE SKI RACERS AND NON-SKIERS

by

James L. Meyer

An Abstract

of a project submitted in partial fulfillment of the requirements for the degree of Master of Science in the School of Health, Physical Education and Recreation at Ithaca College

August 1978

Project Advisor: Dr. Edmund Burke

ABSTRACT

The purpose of this study was to determine if there is a significant difference in male alpine ski racers and non-skiers of the same age utilizing selected anthropometric and leg power measures.

The subjects (N=40) who participated in this investigation were 20 non-skiing students who were enrolled at Paul Smith's College, and 20 alpine skiers who had earned an "A" rating from the United States Ski Association. Selected measurements were taken to determine if there were anthropometric characteristics and leg power differences between groups.

To determine test administrator reliability, 20 students who were not involved in this research project were tested and retested with the same methods three days later. These results were analyzed utilizing Pearson product moment correlation coefficients. To determine the variables which were included in the multivariate analysis of variance (MANOVA), factor analysis was employed. The variables with the two highest loadings from each factor obtained were utilized in the MANOVA. In the event of a significant approximate F ratio, a univariate F ratio was computed in order to identify the precise nature of the differences. All alpha values were set at the .05 level of significance.

The results of this investigation indicated significant anthropometric differences between alpine ski racers and non-skiers using selected anthropometric and leg power measures. These differences were localized through univariate F ratios to include the following variables: height, mid-axillary and abdominal skinfolds.

DETERMINING ANTHROPOMETRIC AND LEG POWER DIFFERENCES BETWEEN ALPINE SKI RACERS AND NON-SKIERS

A Project Presented to the Faculty of
the School of Health, Physical
Education, and Recreation
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In Partial Fulfillment of the
Requirements for the Degree
Master of Science

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by

James L. Meyer

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Ithaca College
School of Health, Physical Education and Recreation
Ithaca, New York

CERTIFICATE OF APPROVAL

MASTER OF SCIENCE PROJECT

This is to certify that the Master of Science Project of

James L. Meyer

submitted in partial fulfillment of the requirements for the degree of Master of Science in the School of Health, Physical Education, and Recreation at Ithaca College has been approved.

Project Advisor:

Candidate:

Chairman, Graduate Programs in Physical Education:

Director of Graduate Studies:

Date: 8/4/78

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Chapter 1

INTRODUCTION

Interest in the composition, size, and shape of the human body has increased as a result of the advancement of anthropometric measurement techniques. The athlete may be considered a unique member of the human population in terms of the composition and build of his/her body. In addition, the knowledge of the build and composition of various types of athletes may be helpful in gaining a better understanding of the physical requirements demanded by a particular sport. The present study deals with the particular body builds of high level alpine ski racers as compared to non-skiers.

World class ski coaches and researchers such as Witherell (11) and Joubert (7) have felt that leg power is of vital importance to the alpine ski racer. Because of the improvements in equipment and ski technique, the role leg power plays in successful ski racing cannot be overemphasized. The present study also deals with possible leg power differences found between alpine skiers and non-skiers.

Scope of the Problem

The data were collected for the study in the Winter of 1977. The subjects (N=40) who participated in the investigation were 20 non-skier students who were enrolled at Paul Smith's College, and 20 alpine skiers who had earned an 'A' rating from the United States Ski Association. The subjects comprised two equal groups and ranged in age from 18 to 22 years. The mean age of the non-skiing group was 20.30 years, and 20.75 years for the alpine skiing group.

Statement of the Problem

The purpose of this study was to determine if there is a significant difference in male alpine ski racers and non-skiers of the same age utilizing selected anthropometric and leg power measures.

Hypothesis

H_1: There will be a significant difference in selected anthropometric and leg power characteristics of male alpine ski racers as opposed to male non-skiers of the same age.

Null Hypothesis

H_0: There will be no significant difference in selected anthropometric and leg power characteristics of male alpine ski racers as opposed to male non-skiers of the same age.

Assumptions of the Study

1. All data were accurately collected.

2. Body compositions of alpine skiers was typical of ski racers during peak training.

3. Body composition of non-skiers was typical of males of that age.

4. Subjects performed the vertical jump test to the best of their ability.

Definition of Terms

The following terms were operationally defined for the purposes of this investigation.

1. Alpine. The skiing discipline involving Slalom, Giant Slalom, and Downhill racing.

2. Alpine Ski Racer. A ski racer who has earned an 'A' rating by the United States Ski Association.

3. Non-Skier. A student who has never been Alpine skiing.

Delimitations of the Study

1. Only male students from Paul Smith's College were included as non-skiers in this study.

2. Only male members of the United States Ski Association were used as the alpine ski racers for this study.

3. Only subjects between 18-22 years of age were tested.

4. Only one measure of leg power was utilized.

Limitations of the Study

1. Results can be generalized to the students sampled.

2. Results can be generalized to the ski racers sampled.

3. Results can only be generalized to students between 18-22 years of age.

4. Leg power measurement was limited to a vertical jump test.

5. Vertical jump testing was administered after a day of racing for the ski racers.

Chapter 2

REVIEW OF RELATED LITERATURE

Introduction

The following is a review of available literature relative to the present study. This chapter is subdivided into the following areas: (1) anthropometric research, (2) muscular power research, (3) research involving alpine ski racing, and (4) summary.

Anthropometric Research

Exercise physiologists frequently concern themselves with the three major components of the body: fat, bone and muscle. In several recent studies, attempts have been made to measure the fat, muscle, and bone content of an individual by anthropometric techniques.

The ability to assess body fat and lean body weight in humans has been successfully achieved through a variety of methods, each based on a set of principles unique to that specific method. The most common methods used in research laboratories include measurements of total body water, total body potassium, helium dilution, radiography, and body density-specific gravity. Although these methods are accepted as accurate and reliable, they all share the common problems of requiring: (1) considerable time for a single determination, (2) relatively elaborate and expensive equipment, and (3) rather complex procedures. Because of these factors, the assessment of body fat and lean body weight has been restricted to a small number of subjects usually for the specific purpose of a particular research study.

The main advantage of the skinfold caliper technique for estimating body fatness is the speed and simplicity with which the measurements can be obtained (41). The use of skinfold estimates is based on the idea that the level of subcutaneous fat is indicative of the total fat content of the body. A number of studies have used other anthropometric techniques to measure subcutaneous fat thickness (18, 39) and reported a high correlation with the skinfold caliper measure.

The effectiveness of skinfold measurements is dependent, to some extent, on the sites measured. While the number and location of the sites is, in part, determined by the objectives of the study, several other factors should be considered (3):

1. The accessibility.

2. The precision with which the site may be located, and measured on different individuals.

3. The homogeneity of the skin and the subcutaneous fat in that area.

Behnke (14) and, Welham and Behnke (46) in 1942 were among the first to study the relationship between fitness and body composition. Studying professional football players, they found that according to ideal weight tables, the subjects were frossly overweight and were not considered fit for military service. On the other hand, the football players were found to have a very high body density, low body fat and a greater percentage of lean body mass than the average population. These studies stimulated further research of body composition, especially as it pertains to the differentiation between the trained and untrained individual.

These investigators recognized the need for simplifying the manner in which these assessments are made. Wilmore and Behnke (48) made use of various skinfold thicknesses, anthropometric circumferences and diameters for determining body composition. From these measurements, they developed an equation for estimating lean body weight. This method of predicting lean body weight through Behnke and Wilmore's equation correlated highly with measured lean body weight. After estimating the body composition of a variety of different subjects based on Wilmore and Behnke's prediction equation, they recommended that these equations must be used with caution until further study either confirms or denies their validity. In another study (47) of the same nature, Wilmore and Behnke applied several predictive equations to a sample of young men. Their results indicated that predictive accuracy decreases unless equations are applied to a sample similar to the one from which the equations were derived.

In a study by Michael and Katch (35), skinfold fat and circumferential girth measurements were combined to see if girths along with skinfolds would predict body density.

The subjects were 48 Caucasian high school boys, age 17 years. The results of this study showed that the iliac and chest skinfolds can be used to predict body density with a high degree of accuracy. Adding other skinfolds or girths increased the correlation slightly.

Finding the iliac, triceps, scapula, chest and abdomen skinfolds all relate well to body density in boys agrees with other studies. Pascale (37) reported that chest and triceps were the best measures (r=0.85). Sloan (39) reported on the use of the triceps and the scapula skinfolds and some improvements by adding the thigh skinfold measurement.

Michael and Katch (36) felt that rather than use prediction equations that differ slightly with different populations, it would seem desirable to combine the data from the studies in the literature and estimate the percent of fat from the sum of the skinfolds taken from the most used sites, i.e., triceps, scapula, and iliac. According to the investigators, these measurement sites seem to be usable in both sexes and at all ages.

In another study, Michael and Katch (32), found that the buttocks girth correlates with density in both young women and boys in California. The buttocks measurement correlates well with body weight, r = 0.87 in the study of 17 year old boys (46) and r = 0.91 in a study of young women (32).

Damon and Goldman (24) applied 10 anthropometric equations to an athletic population in an attempt to validate the equations densitometrically. Their results indicated that the simplest equations (using only two skinfolds) were better predictors than the more complex.

In a later study (1973) Katch and McArdle (33) predicted the body density of college-age male and women from simple anthropometric measurements. An interesting finding of this study is that the predictive equations derived from only circumferences include the same three measurement sites in the equations for both the men and women. This should be useful when large numbers of subjects are measured since these sites can be easily measured with an inexpensive tape measure.

When the present body composition data is compared to date from other samples of young men and women reported earlier in this review, it is observed that the New York subjects are similar to the mean body composition values reported by Wilmore and Behnke (48) for California men. The mean value of body fat for the men in the present study, however, was higher than the mean value reported by Pascale's (37) young soldiers.

Sloan (39) has suggested that 16 percent body fat may be regarded as the upper limit of fatness desirable for young men. Since his subjects were from a different geographic region (Capetown, South Africa) than Wilmore and Behnke (48) or those of the present study, this value may be too low when applied to other samples of similar age. The mean value of body fat reported by Sloan (39) is considerably lower than many previous studies. There would seem to be too few data available from various geographical regions to establish a firm basis for setting desirable limits of body fatness for young, healthy men.

At the conclusion of their study, McArdle and Katch (33) felt that regardless of the anthropometric measurements taken and the specific sites selected for measurement, predictive equations should only be applied to subjects similar in physical characteristics, including age and weight, to those on whom the equations are derived. The equations may not be as valid when applied to athletic young men and women who regularly engage in strenuous physical training or conditioning, or for very large or small individuals who could be visually classified as thin or obese.

In 1966 Behnke and Royce (13) studied the body size, shape and composition of several types of athletes. These athletes were mainly distance runners, basketball players, and weight lifters. The weight lifters anthropometric determination of both body weight and lean body weight was greatly influenced by their unusual degree of muscularity. These individuals were characterized by small hips, wrists, knees, calves,and ankles, and exceptionally large biceps. Three of the four weight lifters tested had highly developed chests, and two had very large forearms. Distance runners were characterized by excessive leanness, relatively small body size, and a deficiency of arm grith compared to chest size and leg development. All three basketball players tested were quite tall and lean, although the relative fat percentage was not much different from the mean value for a college age male (48). There do not appear to be any specific anthropometric measurement sites which differentiate the basketball player from the normal population of college age males other than height.

Boardman (17) pointed out that world champion athletes are build according to the requirements of the sport. For example, the heavy field sports attract large heavily muscled men; the jumping events attract more linear, long-limbed individuals, and long distance runners are linear with very light upper body musculature carrying very little excess fat. The observation that each sport tends to have its own unique pattern of success in relation to the sports physical requirements was further supported by DiGiovanna's (25) study on the factors influencing the success of college athletes.

Thompson, Buskirk, and Goldman (43) estimated the amount of body fat of 26 basketball and hockey players during a season. There was significant loss of fat as measured by the skinfolds of athletes before and after training.

Forsyth and Sinning (26) studied the use of skinfolds and skeletal measures for the estimation of fat and lean body weight in athletes. Two questions relative to the problem were considered: (1) Could selected regression equations derived from non-athletic populations give a valid estimation of body composition in athletes? and (2) Could a suitable regression equation for making such estimates be derived from a sample of athletes?

Subjects were 50 male athletes participating in varsity sports at Springfield College during the Spring of 1969. Except for one 29 year old subject, they ranged in age from 19 to 22 years. The sports represented were baseball (17 subjects), track and field (15 subjects), Spring football (11 subjects), and tennis (7 subjects). The analysis of results for each sport suggests that extreme caution must be used when estimating body composition in specialized groups by use of regression equations.

These investigators agreed with Wilmore and Behnke (47) that predictive equations attain maximum accuracy only when they are applied to samples similar to those from which they are derived. The results of this study strongly support their observation and suggest that such equations have reasonable accuracy only over a very limited range. Forsyth and Sinning concluded that it would be more appropriate to develop such equations according to the sport rather than trying to develop them for athletes as a group.

In 1959 Thompson (42) studied the changes in body fat from skinfold measurements of college athletes. The results of the study indicated that the higher ratio of lean body mass to fat in athletes is a result of vigorous exercise. Further evidence implied that lean body mass and fat content is not a permanent characteristic, but changes according to the type and intensity of exercise.

In 1973, Yoest (53) studied the relationship between cardio-vascular fitness and selected body measurement of eight grade boys and college men. It was determined that among the adult male subjects the measures of weight, body density, percent body fat and skinfold measurements of the triceps, mid-axillary and juxta nipple areas were significant at or beyond the .05 level of confidence. Of the college men used in this study the evidence seems to indicate that measures of body weight and fat significantly limit cardio-vascular performance on the Ohio State University Step Test.

This study further suggests that the subjects, adolescent or adult, who possessed larger percentages of lean body tissues, registered higher scores on the step test.

Clark (21) studied the relationship of anthropometric and strength measures to physical performance primarily involving the trunk and legs of college men. The experimental variables were 16 strength and 10 anthropometric tests. The analysis of data was by zero-order and multiple correlational procedures. High intercorrelations among the anthropometric variables were: standing height and leg length (.91); foot length with leg length (.88), hip width (.83), and standing height (.79); body weight with both hip width and thigh girth (.87); and adipose tissue over the abdomen and over the ilium (.81). The intercorrelations among the strength tests were not as high, the highest being .65 between trunk flexion and extension. The significant intercorrelations between anthropometric and strength variables were body weight and hip width which each appeared in four of these correlations; and trunk flexion and lateral flexion strengths which were included in three each. The highest correlations were .64 between body weight and trunk flexion strength and .58 between body weight and trunk lateral flexion strength.

Riendeau, Welch, Crisp, Crowley, Griffin, and Brockett (38) examined the relationships between percent body fat and selected motor fitness tests. A total of 61 young soldiers were tested on the following items: push-ups, squat thrusts, sit-ups, three standing broad jumps, 75 yard dash, and the 220 yard dash. The results showed that fat was a limiting factor in the performance of the motor fitness test used in this study. The skills that were most affected by fat were those that involved horizontal movement of the body, i.e., three standing broad jumps, 75 yard dash, and the 220 yard dash. In a later study, Wear and Miller (45) investigated the relationship of physique and development level to the performance of junior high school boys on four fitness tests: pull-ups, 50 yard dash, standing broad jump, and softball throw. The subjects were broken down into three groups: thin group, medium group, and heavy group. Those of medium build were found to be the best performers on each of the tests except the 50 yard dash where they were a close second to the thin group. The thin group was in second place on each of the other three tests. The difference in performance between medium and thin subjects was not significant on any of the tests. Medium subjects were significantly better than heavy subjects on all tests. Thin subjects were significantly better than heavy subjects on all tests except the softball throw. The results of this study agree with Riendeau (38) in that fat is a limiting factor in the performance of certain motor fitness tests.

Muscular Power

Muscular power is regarded as an important basic component of motor performance. The development of muscular power has always been one of the major areas of attention for physical educators and athletic coaches, who recognize the importance of this aspect of athletic performance. In 1932, McCloy (35) reviewed the recent studies of the Sargent test and concluded it was a test of the ability of the body to develop power relative to the weight of an individual. During his investigation, McCloy correlated the performance scores of 26 people on such variables as the 100 yard dash, the running high jump, the standing broad jump, and the eight pound shotput test. The author concluded that the Sargent test measures only the ability to develop power and does not measure motor educability or agility. If used in connection with other tests its results may well be of great usefulness in a program of physical education.

In 1940, VanDalen (44) also reviewed the recent studies of the Sargent jump. Seven variations of the Sargent jump were utilized to determine which test was the best measure of power. The data was collected from 106 senior high school boys ranging between the ages of 15 to 17 years of age. Each variation of the Sargent jump was taught to the group until the form was learned and the performance of the jump was mechanically satisfactory. The following variations of the Sargent jump, used in this study, were: Sargent 1/2 pound jump, Sargent jump, Sargent 1 1/2 pound jump, jump and reach, chalk jump, belt jump, and the wall jump. The results would seem to indicate that the Sargent jump when standardized, practiced, and correctly administered is undoubtedly a valuable test for predicting the ability to develop power.

The arm swing of the Sargent jump is important to the successful execution of the jump as indicated by the results of the Sargent and contracting belt jumps. The belt jumps are identical to the Sargent jumps with the exception that the vigorous arm action is prohibited. The differences between the Sargent jump and the weight jumps were so slight that the author saw no benefit in the use of weights.

Several deficiencies exist in the chalk and wall jumps as to their administration and execution that may prohibit an accurate measurement of the jump. VanDalen warned that these two jumps should not be used.

Gray, Start, and Glencross (27) conducted an investigation to determine the validity of a modified vertical jump as a measure of power. Five jump performance tasks were administered to 80 male college students. The subjects were randomly assigned to one of four groups. Each group was randomly assigned a particular order in which to take the jump performance tasks. The measure used to validate the jump was the vertical power test developed by the authors during a previous study (28). The independent variables were: (a) a modified vertical power jump, (b) the jump and reach, (c) the standing broad jump, and (d) the squat jump. Each performance was scored in two ways, in inches and in work done. Work done was calculated in foot-pounds by multiplying the distance of the jump by the body weight. The author made the following conclusions: (1) On the basis of reliability and validity, the modified vertical power jump appeared to be superior to the jump and reach test, the standing broad jump, and the squat jump as a measure of leg power, (2) the modified vertical power jump would be acceptable as a substitute for the vertical power jump as a test of leg power, (3) the modified vertical power jump is recommended for use in testing programs other than where the most rigorous measure is required, since it is easier to administer than the vertical power jump.

To compare the power of the body with the strength of specific leg muscles, McClements (34) utilized the vertical jump as a performance measure. Eighty-six college men were administered vertical jump trials and cable tension strength trials of the leg and thigh muscles. To calculate a power score, the investigator used the product of the vertical jump score and body weight. The subjects were separated into groups on the basis of the power score. Each group trained under one of the following conditions:

(a) extensor training, (b) flexor training, (c) flexor-extensor training, and (d) a normal physical conditioning program. Each group met twice a week for 19 weeks. Analysis of the data revealed no significant difference between the mean gains made by the extensor, flexor, and normal groups in extension and flexion strength. McClements concluded that the four training methods were equally effective in causing increases in the strength of the leg muscles used in vertical jump performance, and that strength gains do not ensure gains in power.

Smith (40) studied the relationship between explosive leg strength and performance in the vertical jump. The leg strength of 70 college men was measured in a position designed to involve the power thrust of the major muscle groups used in the vertical jump. The subjects then performed a modified Sargent jump that used no arm snap. The author concluded that individual differences in vertical jumping performance, as measured in this study, have little or no relationship to explosive leg strength. There is no significant correlation between height jumped and either the strength/mass ratio or simple strength. Since strength in action as measured by the vertical jump is found to be unrelated to dynamometric strength, this study supports the Henry and Whitley (30) hypothesis that the two types of muscular action are controlled by different neuromotor patterns.

Muscular power is regarded an an important basic component of motor performance. Gray, Start, and Walsh studied the relationship between leg speed and leg power (29). A sample of 62 medically fit male students comprised the experimental group. To familiarize the subjects with the two testing techniques, four practice periods spread over the two weeks prior to the experimental test were given on the ergometer and the vertical power jump. On the day of the test, the vertical power jump was administered according to the test instructions (28). On the same day, after a rest period, the speed test was given on the bicycle ergometer. Each member of the group had one set of three consecutive trials and, after a recovery period, had three further trails for retest purposes.

Leg speed as measured by the bicycle ergometer and leg power as measured by the vertical power jump correlated +.470, which was significant at the .001 level. This correlation was mathematically but not statistically lower than those obtained by other researchers that had investigated the relationship between leg speed and leg power. The low correlations in this study indicated a high specificity and a lower generality in these test items.

Costill (23) investigated the relationship of selected leg strength and leg power measures. Six performance tasks were administered to 76 male college freshman football players. These tests were: (a) vertical jump, (b) standing broadjump, (c) 40 yard dash, (d) squat lift, (e) anerobic power, and (f) vertical velocity tests. All tests were administered the same day.

The authors concluded that anerobic power was related to dynamic leg strength, while vertical velocity was related to speed but only moderately to explosive leg strength.

Chui (20) investigated the effect of systematic weight training on athletic power. Seven factors composed the criterion power measure. These were: (2) body weight, (b) the Sargent jump-standing, (c) the Sargent jump-running, (d) the standing broad jump, (e) an eight pound shotput, (f) a 12 pound shotput, and (g) a 60 yard sprint. The author claimed all the criteria to be valid items for measuring power.

> The inclusion of these six performance tests in the testing criterion was based on the thesis that power (the time rate of doing work, or, force items velocity), when applied by the body, is the essential mechanical factor in the projection of the individual's own body or of some other mass rapidly through space. All these events--sprinting, jumping, and throwing--require maximum, or nearly maximum, muscle contractions in a minimum time, and have been substantiated as valid items for measuring power (20: 189).

The subjects were administered the test battery. After initial testing, the subjects were divided into two groups. Group one was assigned a training program consisting of weight training. Group two was assigned a training program consisting of regular physical education participation. After a three month training period, the subjects were retested on the power battery.

Analysis of the data indicated mean increases of the weight training group of four inches in the standing broad jump and 7.2 centimeters in the standing Sargent test. Chui concluded that systematic weight training increased the potential power, whereas the training received in regular physical education class did not increase the potential power.

In a similar study, Capan (19) investigated the effect of systematic weight training on power, strength, and endurance. The test items included the standing broad jump, the standing Sargent jump, the running Sargent jump, and the eight pound shotput test. Two physical education classes were utilized in this investigation. One class consisted of 42 freshmen enrolled in a weight lifting class. The other class consisted of 29 freshmen enrolled in a physical conditioning class. Each class met twice a week for a total of 11 weeks.

Initial and final tests were administered. Data analysis revealed that with one exception, both groups increased their performance in the power events. Further analysis indicated that the weight training group increased more than the physical conditioning group. Therefore, this investigator's results are in agreement with Chui (20).

Berger (15) studied the relative effects of dynamic and static strength training on vertical jumping ability. Four activity classes, consisting of 89 male college students, were employed in this study. Three classes participated in weight training and one class performed general conditioning activities. The subjects were administered two trials on each of the strength tests and three trials on the power test. The static strength test consisted of dynamometer measurements. The dynamic strength test consisted of rising from a squat position to a standing position with barbells on the shoulders. The leg power test utilized was a modification of the leg power test developed by Gray, Start, and Glencross (28). The author concluded that dynamic overload training is more effective for increasing vertical jumping ability than static overload training. Bergner also found that a significant increase in static strength does not guarantee an improvement in vertical jump ability.

In a later study to determine whether static or dynamic leg strength was more highly related to leg power, Berger and Henderson (16) used sixty-six male students enrolled in physical education weight-lifting classes as subjects. They ranged in age from 18 to 21 years and in weight from 122 to 224 pounds. The subjects were given three different tests: a dynamic leg strength test, a static leg strength test, and a leg power test. The tests were administered in four different sequences in order to control for the improvement in strength expected from taking the tests. The tests were administered during a 15 day period. From the results of the study, the authors made the following conclusions: (1) Dynamic leg strength and static strength are both related to leg power, and neither dynamic leg power nor static leg strength is more related to leg power than the other.

Ball, Rich, and Wallis (12) studied the effects of Isometric Training on vertical jumping ability. The authors purpose was to determine if a program of isometric exercise sufficient to develop significant additional isometric strength would facilitate the function of the strengthened musculature in performing an explosive power movement. Sixty-three college men were divided into two groups on the basis of their initial ability to exert isometric force upward against shoulder pads of a specially constructed device. Measurements were made and the apparatus adjusted to fit each subject so that the knees were flexed to the angle at which a vertical jump is usually initiated. All subjects in the experimental and control groups were precisely measured in the vertical jump at the beginning and the conclusion of the six week training program. The experimental group trained on the apparatus three times per week for six weeks. The control group was not trained. The experimental group gained significantly in the ability to exert force, having a mean of 391.2 pounds at the beginning and a final mean of 469.9 pounds. This mean gain of over 77 pounds was significant at the .01 level of confidence. The scores of the control group did not change significantly. The results of this study showed that even though the subjects ability to exert force increased, there was no significant increase in vertical jumping ability.

Alpine Ski Racing

In the last few years, the United States has made a major effort to improve its ratings among ski nations of the world. These efforts are showing some signs of success. The most significant development in American ski racing in recent years has been the evolution of the ski racing academies (50). These schools specialize in providing the academic study, coaching and training facilities to allow a promising young ski racer to mold his life style around the environment that is necessary to develop into an international class skier. Hopefully these academies will become the sites where needed scientific research can be conducted.

In 1970, Georges Joubert [7] collaborated with the coaches of the Grenoble University Club and members of the Association of University Skiers in writing _Teach Yourself to Ski_. His treatment of ski racing is indepth and technical. The author breaks down the movements of the top ski racers and analyzes them for the reader. It is from this analysis that American ski technicians became aware of such movements as avalement and lateral projection.

Two years after Joubert's book was released in the United States, Warren Witherell published the classic American text on Alpine racing technique (11). The purpose of his book is: (1) to dissect and simplify the ideas Joubert put forth in his book on ski racing, (2) to provide competitive skiers with a guide to modern racing techniques, (3) and to offer recreational skiers a more natural and efficient way to ski than is now taught in most ski schools. Both authors agree that International class racers are constantly developing more efficient ski techniques. They are always striving for optimum balance, economy of motion, and the use of their skis to create turning forces. Witherell's clear and concise interpretations of Joubert's ideas makes this text invaluable to all racers and coaches.

Piantu Su: Ski Like the Best (1) is the most recent book available on ski racing. The section of ski technique is quite simple and readable with excellent illustration of the text by photos and sequence montages. The photos are predominantly of the currently reigning champions of the World Cup circuit. The bulk of the photos were taken from World Cup competitions of the 1975-76 season. The simple manner in which the technical material is presented may lead to the books only flaw. The technical language of ski racing has grown tremendously in the past 10 years in an effort to describe with precision the complex movements made by the world's best racers.

In 1976 Witherell (49) took five young ski racers to Portillo, Chile for three weeks of intense "sprint training." These racers had international Slalom and Giant Slalom points ranging from the low 30's to the 60's. The author feels that the best skiers in the world exhibit a mental attitude and athletic skills especially suited to sprint racing. In competition, the best skiers do not think very much about line or technique; they do not worry about falling; they are not conservative; they race, it seems, with reckless abandon. Most young racers carry too much mental baggage out of the starting gate. They have to think too much about line and technique. To relieve them of this self-conscious baggage, a coach must help each racer to understand line and technique in a very simple, uncomplicated way. Line must become instinctive. This is best done in simple uncomplicated, short courses.

Witherell (49) and Heib (50) stress the need for training on three to ten gate courses for racers at all ability levels. The goal is always to attack, to accelerate, to achieve maximum velocity. Short course training teaches optimum line and an attack attitude. Racers can attack 5-10 gate courses with much more confidence than 50 gate courses. The confidence they develop in the 10 gate course can then be expanded over a longer course.

Ski races are won by combining the shortest possible line with the highest possible speed (1, 7, 8, 11). To develop and maintain the highest possible speed is the ultimate goal of all ski racing technique. Three sources of speed are available to a racer: (1) the pull of gravity, (2) muscular power, (3) and the propelling action of a bowed ski. Gravity provides the simplest source of speed. If all factors are equal, one racer can go faster than another by choosing a more efficient line. At very slow speeds, poling action will provide acceleration. This uses the muscle power of the arms. At moderate speeds, skating turns provide acceleration whenever a strong push can be achieved with the powerful thrusting of the leg. In some parallel turns, the power of both legs is used simultaneously to increase pressure on, and then rebound from, the tails of the skis.

Witherell (11), Joubert (7), and Bear (1) suggest that one of the strongest elements of Gustavo Thoeni's racing technique is his frequent use of skating turns and lateral steps. Thoeni appears very light on his feet as he steps through Slalom gates. His movements are so graceful that his power is scarcely evident. Each of Thoeni's steps increases his speed. If they are skating steps there is forward thrust and direct acceleration.

The United States National Alpine Staff (9) believes the development of power is a prime ingredient of ski racing success. The National Team develops their potential power on a 12 month basis through weight training, leg routines, hill bounding, interval running, interval bike hill sprints, and wind sprints.

Dr. Marvin Clein (22) suggest that anthropometric and anatomical dimensions of a body can provide a mechanical advantage in the performance of certain activities. For example, the track sprinters narrow hips allow him to run a straight line more efficiently; a wide set of shoulders (relative to total body mass) permits the ski jumper more lift in the air, and the bowed legs of a football halfback provide an advantage in terms of lateral mobility.

Franz Klammer dominated international downhill racing beginning with his six victories in the first six World Cup downhill races of the 1974-75 season, and culminating in his thrilling victory in the Olympic Men's Downhill in Innsbruck in 1976. Roland Collombin, the world's best downhill racer before Klammer won only 4 races during the 1974-75 season and has been totally outclassed by Klammer ever since. How does the Austrian dominate so strongly?

In 1976 Joubert (31) did a film study of the similarities and differences between the two champions at the compression turn at Vald Isere. At 6 feet and 172 pounds, Franz Klammer is a very good athlete. He runs the 100 meters in 11.5 seconds, is broad shouldered and well-muscled.

Collombin is 176 pounds standing at 5 feet 8 inches. The author feels Collombin has been successful largely because he is so incredibly relaxed during his runs. This is due more to his natural athletic abilities and his strong optimism in all circumstances than to any technical expertise.

Joubert's film sequences illustrate on one hand the talent and technique of Franz Klammer, and on the other hand the difference between Collombin, a stocky, heavy, more traditional downhiller and the taller, lankier Klammer. In the compression turn at Vald Isere, Klammer has the advantage over Collombin because, although he is just as heavy, he is taller, looser, and more mobile.

Joubert concluded that strength, speed of movement, balance, and relaxed aggression are Franz Klammer's foremost qualities. These qualities blend into a fluid technique that has made Franz Klammer the top downhiller in the world.

Summary

Through this review, anthropometric, muscular power, and alpine ski racing studies have been investigated.

Behnke (14) and Wilham and Behnke (46) in 1942 were among the first to study the relationship between fitness and body composition. These investigators recognized the need for simplifying the manner in which these assessments were made. These authors (48) made use of various skinfold thicknesses, anthropometric circumferences and diameters for determining body composition. From these measurements they developed an equation for estimating lean body weight. Wilmore and Behnke applied several of these predictive equations to a sample of young men. Their results indicated that predictive accuracy decreases unless equations are applied to a sample similar to the one from which the equations were derived (47).

Several investigators (24, 32, 33, 36, 37, 39) have tried to determine if a specific skinfold or girth was a better overall predictor of body density. The iliac, tricep, scapula, chest, and abdomen skinfolds all related well to body density. Michael and Katch (32) found that the buttocks girth correlated well with body density in both men and women. Later studies (13, 17, 25, 43) investigated the body size, shape, and composition of several types of athletes.

Forsyth and Sinning (26) studied the use of skinfolds and skeletal measures for the estimation of fat and lean body weight in athletes. Two questions relative to the problem were considered: (1) Could selected regression equations derived from non-athletic populations give a valid estimation of body composition in athletes?, and (2) Could a suitable regression equation for making such estimates be derived from a sample of athletes? The authors concluded that it would be more appropriate to develop such equations according to the sport rather than trying to develop them for athletes as a group. Boardman (17) pointed out that world champion athletes are built according to the requirements of the sport.

Yoest (53), Clark (21), Riendeau (38), and Miller (45) examined the relationships between percent body fat and selected motor fitness tests. The results of these studies agreed that fat is a limiting factor in the performance of certain motor fitness tests.

The second part of this review was concerned with muscular power.

McCloy (35), VanDalen (44), and Gray, Start and Glencross (27) examined different variations of the Sargent jump to determine which was the most valid measure of power. The results indicated that the modified vertical power jump when standardized, practiced, and correctly administered, is undoubtedly a valuable test for predicting power. Several studies (23, 29, 30, 34, 40) investigated the relationship of selected leg strength and leg power measures to the vertical jump. These studies had varying results. McClements (34) found that his four training methods were equally effective in causing increases in the strength of the leg muscles used in the vertical jump, but that strength gains do not ensure gains in power. Smith (40) found that strength in action as measured by the vertical jump is unrelated to dynamometric strength. This is in agreement with Henry and Whitley (38) that the two types of muscular action are controlled by different neuromotor patterns.

Several investigators (12, 15, 16, 19, 20) studied the effects of different weight training programs on the development of athletic power. The results of these studies indicated that systematic weight training is the most effective method of increasing potential power.

The final section of Alpine ski racing reviews the latest literature available. Little material had been published previous to 1970 concerning the technical aspects of ski racing.

Joubert (7) published the first text in an effort to describe with precision the complex movements made by the world's best racers. Warren Witherell (11) followed suit with How the Racers Ski. This test is the most popular technical guide to modern ski racing. In 1976 Ruedi Bear (1) confirmed Witherell's ideas that the world's best racers combine superb fundamentals (especially balance and line) with gifted athletic ability. The laws of physics do not change. Balance, economy of motion, and use of the ski are still the keys to success. The author took his book one step further to a discussion of the racers mind. Here Ruedi deals with the human qualities of the sport and how they affect the development of the athlete.

The Journal of the United States Ski Coaches Association is the newest source of ski racing information available today. This publication is put out by the United States Ski Coaches Association in an effort to inform the coaches in the United States of new technical developments and ideas.

According to Witherell (50) we have closed most of the technical gap between the Americans and Europeans over the past five years. We are seeing more of the Europeans on television, films, and in the North American World Cup events. The author feels that the United States' biggest weakness now is not in technique, but in aggressiveness. Skiing is sprint racing (49). It is time to focus on developing the kind of relaxed aggression that seems so instinctive to many Europeans.

Chapter 3

METHODS AND PROCEDURES

This section describes the means by which this study was undertaken. More specifically this chapter deals with (1) selection of subjects, (2) testing instruments, (3) methods of data collection, (4) scoring of data, (5) treatment of data, and (6) summary.

Selection of Subjects

Twenty 18-22 year old male alpine ski racers with 'A' ratings were used as the ski racing subjects. Twenty 18-22 year old male non-skiers and non-varsity athletes from Paul Smith's College were used as the non-skiing subjects.

Testing Instruments

The testing instruments used to collect this data were: (1) Lange skinfold calipers, (2) a Gulick anthropometric tape measure, (3) weighing scale and (4) a modified vertical jump test.

Method of Data Collection

Test Reliability

In an effort to determine test administrator reliability, 20 students who were not involved in this research project were tested and retested with the same methods three days later.

Description of Tests

Anthropometric characteristics of the group were determined by the following measurements: height, weight, age, girths of the lower leg, upper leg, buttocks, waist, lower arm, upper arm, skinfolds of the triceps, gastrocnemius, thigh, chest, mid-axillary, supra illiac, and abdominal. Sitting height and a vertical jump test were then taken. The vertical jump test was administered by the subject standing against the wall with his arm extended upward for a measurement. He then jumped as high as he could and another measurement was taken. The greater the distance between the two measurements determined the best jump. Each subject was allowed three jumps.

Scoring of Data

Each subject's measurements were recorded on individual data cards. All data were then key punched and verified. Data processing then began. See Appendix A.

Treatment of Data

Test, retest scores for 20 subjects not participating in the experiment were analyzed utilizing Pearson product moment correlation coefficients. In an effort to determine the variables which should be included in the multivariate analysis of variance (MANOVA), factor analysis was employed utilizing a principle component solution rotated to simple structure with an oblique rotation. The minimum eigenvalue for factors to be extracted was set at 1.0. The variables with the two highest loadings from each factor obtained were utilized in MANOVA in an effort to determine if a significant overall difference exists between skiers and non-skiers. In the event of a significant approximate F ratio, a univariate F ratio would be computed in order to identify the precise nature of the differences. All alpha values were set at the .05 level of significance.

The Ithaca College computer was used for all statistical work. Statistical programs utilized were the following: for Pearson product moment correlation coefficients, the Pearson Corr program from SPSS was used; for factor analysis the Star Library Factor program from the Ithaca College Computer Center was used; and for MANOVA and univariate F ratios, the BMD 12V was used.

Summary

Alpine ski racers (N=20) with an 'A' rating were used as the ski racing subjects. Non-skiers and non-varsity athletes (N=20) from Paul Smith's College were used as the non-skiing subjects.

The testing instruments used to collect the data were: (1) Lange skinfold calipers, (2) Gulick anthropometric tape measure, (3) and a weighing scale to obtain anthropometric measurements, and (4) a modified vertical jump test to measure leg power.

To determine test administrator reliability, test retest scores for 20 subjects not participating in the experiment were analyzed utilizing the Pearson product moment correlation coefficient. A factor analysis utilizing a principle component solution rotated to simple structure with an oblique rotation was used to determine which variables should be included in the multivariate analysis of variance (MANOVA). The variables with the two highest loadings from each factor obtained were utilized in MANOVA. Univariate F ratio's were then computed in order to identify the precise nature of the differences between alpine ski racers and non-skiers. All alpha values were set at the .05 level of significance.

Chapter 4

ANALYSIS OF DATA

The findings of this investigation as well as all statistical analyses will be presented in this chapter. Each hypothesis that was presented in Chapter 1 will be accepted or rejected.

The mean and standard deviations of age, height, sitting height, and weight are shown in Table 1. As shown, the two groups of subjects were very similar in age and sitting height. The mean height for the ski racers was 176.70; the mean weight was 154.60. The mean height for non-skiers was 183.35; the mean weight was 165.40.

Table 2 shows the means and standard deviations of selected girth measurements of alpine skiers and non-skiers. Selected skinfold measurements of alpine ski racers and non-skiers are shown in Table 3.

Table 4 displays the test-retest correlation coefficients for selected anthropometric and leg power measures. Here the reliability of the test administrator was measured utilizing the Pearson product moment correlation coefficient. Reliability of measurements for this study ranged between .645 and .998.

Table 5 shows the results of the factor analysis used to determine the variables which would be included in MANOVA. The two highest loadings for each factor were selected for inclusion in MANOVA. Since only one variable had a loading of greater than .40 on factor 5, only one variable was chosen from this factor. Thus, the variables chosen for MANOVA were: skinfolds of the mid-axillary, supra-illiac, gastrocnemius and thigh, and girths of the upper arm and lower arm, sitting height, vertical jump and standing height. The MANOVA between ski racers and non-skiers using selected anthropometric and leg power measures chosen as a result of factor analytic findings is shown in Table 6. MANOVA was employed to determine if any overall significant differences occurred between alpine skiers and non-skiers. With eight and 30 degrees of freedom at the .05 level of confidence, an F ratio of 2.27 is needed to show a significant difference. Therefore, the F ratio of 3.9163 was significant. As a result, the null hypothesis that there would be no significant difference in selected characteristics of male alpine ski racers as opposed to male non-skiers of the same age was rejected.

In Table 7 univariate analyses are displayed which were computed between ski racers and non-skiers using selected anthropometric and leg power measures. The analyses resulted in a signifacant difference between alpine ski racers and non-skiers in height, mid-axillary skinfold and the abdominal skinfold. Therefore, the null hypothesis that there will be no significant difference in selected anthropometric and leg power characteristics of male alpine ski racers as opposed to male non-skiers of the same age was rejected.

Summary

The means and standard deviations of all the variables used in this study were presented in Tables 1, 2, and 3.

In Table 4 the reliability of the test administrator was measured utilizing the Pearson product moment correlation coefficient. Reliability for this study ranged between .645 and .998.

A factor analysis was then used to determine the variables which should be included in the multivariate analysis of variance. Nine variables were selected from Table 5.

A multivariate analysis of variance was them employed to determine if any overall significant differences occurred between alpine skiers and non-skiers. As shown in Table 6, the null hypothesis was rejected.

A univariate analysis of variance was utilized to determine the source of specific differences between alpine skiers and non-skiers. Table 7 shows differences in height, mid-axillary and abdominal skinfolds. Therefore, the null hypothesis of this investigation was rejected.

TABLE 1

AGE AND SELECTED ANTHROPOMETRIC CHARACTERISTICS

	SKIERS		NON-SKIERS	
	$\bar{x}$	SD	$\bar{x}$	SD
Age	20.75	1.41	20.30	1.38
Height	176.70	10.17	183.35	2.50
Sitting Height	88.45	3.75	88.90	11.90
Weight	154.60	9.42	165.40	9.01

TABLE 2

SELECTED GIRTH MEASUREMENTS

	SKIERS		NON-SKIERS	
	$\bar{x}$	SD	$\bar{x}$	SD
Lower Leg	35.14	2.03	38.37	2.05
Upper Leg	51.92	1.74	53.31	2.09
Waist	75.53	2.84	81.72	5.14
Upper Arm	29.70	1.07	30.41	1.91
Lower Arm	26.68	0.81	26.60	1.99
Buttocks	88.10	3.14	94.81	7.13

TABLE 3

SELECTED SKINFOLDS

	SKIERS		NON-SKIERS	
	$\bar{x}$	SD	$\bar{x}$	SD
Triceps	9.00	1.08	9.80	1.24
Gastrocnemius	9.25	1.25	9.85	1.57
Thigh	12.30	0.98	13.40	2.37
Chest	7.90	1.86	9.80	1.96
Mid-Axillary	7.95	1.93	9.60	1.93
Supra Illiac	8.25	1.71	10.30	2.75
Abdominal	6.95	1.57	11.10	3.29
Subscapula	8.35	1.73	11.80	3.35

TABLE 4

TEST-RETEST CORRELATION COEFFICIENTS FOR SELECTED ANTHROPOMETRIC AND LEG POWER MEASURES (N=20)

VARIABLE NO.	VARIABLE	r
1	Height	.959
2	Weight	.998
3	Lower Leg Girth	.838
4	Upper Leg Girth	.981
5	Waist Girth	.984
6	Upper Arm Girth	.645
7	Lower Arm Girth	.915
8	Buttock Girth	.978
9	Sitting Height	.956
10	Tricep Skinfold	.908
11	Gastrocnemius Skinfold	.890
12	Thigh Skinfold	.910
13	Chest Skinfold	.877
14	Mid-Axillary Skinfold	.954
15	Supra-Illiac Skinfold	.943
16	Abdominal Skinfold	.983
17	Subscapula Skinfold	.909
18	Vertical Jump	.759

TABLE 5

FACTOR ANALYSIS OF SELECTED ANTHROPOMETRIC AND LEG POWER MEASURES IN 60 SUBJECTS

VARIABLE	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Age	-.473	.266	-.032	.275	-.186
Height	.182	.043	.193	-.156	-.873*
Weight	.660	.174	.515	-.159	-.364
Lower Leg Girths	.133	.341	.652	.182	-.376
Upper Leg Girths	.311	.593	.524	-.049	.080
Waist Girths	.747	-.133	.438	.192	-.220
Upper Arm Girths	.185	.015	.765*	-.030	-.143
Lower Arm Girths	.033	.473	.653*	.004	.295
Buttocks Girths	.625	.106	.582	.238	-.257
Sitting Height	.172	-.037	-.053	-.716*	-.288
Triceps Skinfold	.671	.395	-.167	.094	-.010
Gastrocnemius Skinfold	.341	.795*	.127	.072	-.075
Thigh Skinfold	.105	.830*	.198	-.056	-.088
Chest Skinfold	.364	.156	-.247	.562	-.280
Mid-Axillary Skinfold	.901*	.182	.067	-.068	-.055
Supra-Illiac Skinfold	.826*	.171	.264	-.243	-.077
Abdominal Skinfold	.793	.360	.342	-.109	-.100
Subscapula Skinfold	.738	.241	.100	.210	-.209
Vertical Jump	.036	-.500	.334	.668*	.036

* Variables chosen to represent each factor.

- Indicates loading of .40 or greater.

TABLE 6

MANOVA BETWEEN SKI RACERS AND NON-SKIERS USING SELECTED ANTHROPOMETRIC AND LEG POWER MEASURES CHOSEN AS A RESULT OF FACTOR ANALYSIS FINDINGS

Source	Approximate F - Statistic	Degrees of Freedom	
Groups (Subjects by Groups)	3.9163	8	30

*Approx. F $\geq$ 2.27 = .05 level of significance

*Approx. F $\geq$ 3.17 = .01 level of significance

TABLE 7

UNIVARIATE ANALYSIS BETWEEN SKI RACERS AND NON-SKIERS USING SELECTED ANTHROPOMETRIC AND LEG POWER MEASURES

VARIABLE	F RATIO	PROBABILITY
Height	8.06	.01
Upper Arm Girth	2.11	N.S.
Lower Arm Girth	.02	N.S.
Sitting Height	.03	N.S.
Gastrocnemius Skinfold	1.80	N.S.
Thigh Skinfold	3.78	N.S.
Mid-Axillary Skinfold	7.30	.05
Abdominal Skinfold	25.90	.01
Vertical Jump	2.66	N.S.

Chapter 5

DISCUSSION OF RESULTS

This chapter includes a discussion of the results of this investigation which were presented in Chapter 4. These results will be compared to the related literature discussed in Chapter 2 as follows: (1) anthropometric similarities and differences, and (2) leg power differences between alpine ski racers and non-skiers. A brief summary will follow.

Anthropometric Similarities and Differences

Forsyth and Sinning (26), studied the use of skinfolds and skeletal measures for the estimation of fat and lean body weight in athletes. Two questions relative to the problem were considered: (1) Could selected regression equations derived from non-athletic populations give valid estimation of body composition in athletes?, and (2) Could a suitable regression equation for making such estimates be derived from a sample of athletes? The authors concluded that it would be more appropriate to develop such equations according to the sport rather than trying to develop them for athletes as a group.

Later studies (14, 17, 25, 43) investigated the body size, shape, and composition of several types of athletes.

These athletes seemed to have characteristics that were unique to themselves as a group. Boardman (33) noted that the heavy field sports attract large heavily muscled men; the jumping events attract more linear long-limbed individuals; and the long distance runners are linear with very light upper body musculature carrying very little excess fat. The importance of these anthropometric characteristics increase as the athlete advances towards higher levels of athletic competition. At these higher levels, participants within events show an even stronger likeness in terms of body type. This reflects a process of natural selection and indicates the necessity of an appropriate body build in order to reach selected levels of physical performance.

According to this investigator, Alpine ski racers also seem to fall into a particular body build pattern. Of the selected skinfold measurements found in Table 2 and 3 respectively, the standard deviations of the alpine ski racing group ranged from .81 to 3.14. The standard deviations of the non-skier group ranged from 1.91 to 7.13. The results of Table 2 and 3 indicate that there is much less variation in body build among alpine skiers as opposed to non-skiers. At first glance the means of Table 2 and 3 suggest that the selected girth and skinfold measurements of the alpine ski racers are all significantly smaller than those of the non-skiers. This would seem to be the case except that the average heights of the ski racers and the non-skiers is 176.70 cm. and 183.35 cm., respectively. This difference in height is favorable to a ski racer in that it enables him to maintain a lower center of gravity. This characteristic also enables the skier to maintain a more advantageous aerodynamic position at higher speeds due to his smaller size in the "egg" type position.

Table 7 indicates that there is a significant difference in height, mid-axillary, and abdominal skinfolds. These results indicate that alpine ski racers are significantly smaller, and have less fat content on their upper body. Other anthropometric differences utilized in this investigation were in the upper arm girth, sitting height, and gastrocnemius and thigh skinfolds. However, none of these were found significant at the .05 level.

The findings of this investigation and the findings in the literature seem to agree with Boardman (17) in that world champion athletes are built according to the requirements of the sport.

Factor analysis showed that the 19 variables originally selected could be reduced to 5 orthognal constructs. Factor 1 included age, weight, waist and buttocks girths, and skinfolds of the triceps, mid-axillary, supra illiac, abdominal, and subscapula regions. This factor seemed to measure the amount of fat present on the upper body. Vertical jump, girths of the upper leg and lower arm, and skinfolds of the gastrocnemius and thigh were measured by Factor 2. These measurements seem to indicate a relationship between the build of the lower torso and vertical jumping ability. Factor 3 included weight, and girths of the lower leg, upper leg, waist, upper arm, lower arm, and buttocks. This Factor measured the size of the limbs of the human body. Factor 4 showed a relationship between sitting height and a skinfold measurement of the chest. A precise description of this Factor would seem to be rather difficult. Height was the only significant measurement in Factor 5.

Leg Power Differences

Ski races are won by combining the shortest possible line with the highest possible speed (1, 7, 8, 11). To develop and maintain the highest possible speed is the ultimate goal of all ski racing technique. Three sources of speed are available to a racer: (1) the pull of gravity, (2) muscular power, (3) and the propelling action of a bowed ski.

At very slow speeds, poling action will provide acceleration. This uses the muscular power of the arms. At moderate speeds, skating turns provide acceleration whenever a strong push can be achieved with the powerful thrusting of the leg. In some parallel turns, the power of both legs is used simultaneously to increase pressure on, and then rebound from, the tails of the skis. Witherell (11), Joubert (7), Bear (1) and the United States National Alpine Staff (9) agree that the development of leg power is a prime ingredient of ski racing success.

The results of this study surprisingly indicate a leg power difference of 3.450 between alpine skiers and non-skiers which is not significant at the .05 level. A number of factors could account for this: (1) the athletes for this study were tested after a day of racing which might have impaired their vertical jumping ability, (2) leg power alone may not be a determining factor of ski racing ability. Leg power combined with certain neuromotor patterns to create a superb sense of timing might be a more accurate determining factor of ski racing ability, (3) the individual differences in vertical jumping performance, as measured in this study, have little or no relationship to the explosive leg power needed in ski racing. The explosive leg movements used in ski racing are rarely executed from the same position as a vertical jump. Often a racer's body is leaning in or out and at the same time, leaning back or forward. These positions are somewhat different from the stationary, both feet on the floor type of jump that was used to measure leg power. This aspect of the study supports the Henry and Whitley (30) hypothesis that the types of muscular action required in ski racing and in the vertical jump are controlled by different neuromotor patterns.

SUMMARY

In this chapter, the investigator discussed the findings of the study. The chapter was divided into the following areas: (1) anthropometric similarities and differences, and (2) leg power differences between alpine ski racers and non-skiers.

The results of this investigation are in agreement with the literature (14, 17, 25, 43) in that athletes involved in a particular sport have anthropometric characteristics that are unique to themselves as a group.

No significant difference in leg power was found between alpine ski racers and non-skiers. The possible reasons for these results were stated.

Discussion has been presented in this chapter relative to the findings of this investigation. In Chapter 6, conclusions will be drawn based on these results and implications for further research will be presented.

Chapter 6

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter summarizes the present investigation, drawing conclusions from the results and proposing recommendations for further study.

SUMMARY

The purpose of this study was to determine if there is a significant difference in male alpine ski racers and non-skiers of the same age utilizing selected anthropometric and leg power measures. The subjects (N=40) who participated in this investigation were 20 non-skiing students who were enrolled at Paul Smith's College, and 20 alpine skiers who had earned an 'A' rating from the United States Ski Association. The subjects comprised two equal groups and ranged in age from 18 to 22 years. The mean age of the non-skiing group was 20.30 years, and 20.75 years for the alpine skiing group. All data was collected in the winter of 1977.

To determine if there were anthropometric characteristics and leg power differences between groups, the following measurements were taken: height, weight, age, girths of the lower leg, upper leg, buttocks, waist, lower arm, upper arm, skinfolds of the triceps, gastrocnemius, thigh, chest, mid-axillary, supra illiac, and abdominal. Sitting height and a vertical jump test were then taken.

In an effort to determine test administrator reliability, 20 students who were not involved in this research project were tested and retested with the same methods three days later.

The test retest scores for the 20 subjects not participating in the experiment were analyzed utilizing Pearson product moment correlation coefficients. To determine the variables which were included in the multivariate analysis of variance (MANOVA), factor analysis was employed. The variables with the two highest loadings from each factor obtained were utilized in the MANOVA. In the event of a significant approximate F ratio, a univariate F ratio was computed in order to identify the precise nature of the difference. All alpha values were set at the .05 level of significance.

The results of this investigation indicated significant anthropometric differences between alpine ski racers and non-skiers using selected anthropometric and leg power measures. These differences were localized through univariate F ratios to include the following variables: height, mid-axillary, and abdominal skinfolds.

Conclusions

Within the realm of the present study, the following conclusions are warranted:

1. There is a significant difference between male alpine ski racers and non-skiers of the same age utilizing

selected anthropometric and leg power measures.

Recommendations for Further Study

In view of the findings of this investigation, certain recommendations are presented with regard to further study.

1. The sample size should be enlarged to either support or refute the results of the present investigation.

2. The use of the vertical power jump as a measure of leg power for alpine ski racing should be investigated.

3. A similar study could be done to determine if an anthropometric or leg power difference exists among the three disciplines of Alpine ski racing: Slalom, Giant Slalom, and Downhill.

4. Other measures of leg power should be used such as isokenetic measurements which can be made with the use of the Cybex equipment manufactured by Lumex Corporation.

APPENDIX A

Figure 1

SAMPLE SUBJECT DATA CARD

NAME ____________________ ALPINE SKIER _____

AGE __________ NON-SKIER _____

HEIGHT __________ cm

WEIGHT __________

GIRTHS		SKIN FOLDS	
Lower Leg	________	Triceps	________
Upper Leg	________	Gastrocnemius	________
Waist	________	Thigh	________
Upper Arm	________	Chest	________
Lower Arm	________	Mid-Axillary	________
Buttocks	________	Supra-Illiac	________
		Abdominal	________
		Subscapula	________
Sitting Height	________	Vertical Jump	________

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