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Performance Prediction in Track and Field

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PERFORMANCE PREDICTION IN TRACK AND FIELD

by

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PERFORMANCE PREDICTION IN TRACK AND FIELD

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The study investigated the degree to which predicting performance in track and field relates to individual performances of track athletes. Predictive scores were determined for 26 male and 14 female athletes using prediction equations and test procedures developed by Henson, Turner, and Lacourse (1989a; 1989b). Predictive scores were compared to athletes' individual event point scores published in International Amateur Athletic Federation (IAAF) men's and women's multi-event scoring tables ("Scoring Table for Men's," 1962; "Scoring Table for Women's," 1971).

Each subject's height, weight and age were recorded as well as performances on the following tests: vertical jump, standing long jump, five bounds for distance, percent body fat, 60 meter dash and 30 meter dash, stride length and stride frequency. Data were collected on sprinters, hurdlers, jumpers, throwers and multi-eventers.

The male sprint group showed the only significant correlation. It was concluded that Henson et al. equations did not accurately predict performance.

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CHAPTER I

INTRODUCTION

Throughout the history of the modern Olympic Games, the United States has remained among the top ranking countries in track and field. For the period 1948-1984, the United States ranked first in terms of medals won and number of finalists, for both sexes combined (Landry, 1987). During the mid-80s, however, American dominance in track and field declined while Eastern European countries such as the former Soviet Union, now the Commonwealth of Independent States, and East Germany, now Germany, continued to improve.

During 1987 the United States men's world rankings in track and field dropped to an all-time low ("Scoring by Nation," 1988). When scoring rose in 1989 and 1990, the men placed in 15 of 22 events and were shut out of scoring in others ("Scoring by Nation," 1990; 1991b). In women's track and field, Americans have been ranked third behind the Soviet Union and East Germany for 10 straight years ("Scoring by Nation," 1991a). Even though United States women improved, East Germany and the Soviet Union continued to dominate.

Much of the success of eastern European countries has been attributed to a carefully planned long-range system of talent identification and talent development (Jarver, 1981; Smith, 1981). Thomson and Beavis (1985) reported several organized talent identification programs from such countries as East Germany, the Soviet Union, West Germany, Australia and the Netherlands.

Talent identification in track and field in the United States is not formalized as it is in many other countries throughout the world. The system of talent identification and development in the United States occurs through mass participation and natural selection (Henson, Turner, & Lacourse, 1989a; Smith, 1981). The majority of successful athletes find, through trial and error, the event for which they are naturally most suited (Tanner, 1964). Through this process, athletes who happen to reach national and international levels of competition are labeled elite. Only after having reached the top are these athletes evaluated and abilities further developed at United States Olympic training centers (Smith, 1981).

Research in eastern European countries has been directed towards identifying young talented athletes. Efforts in the United States need to be directed toward talent promotion and talent development; the problem is not finding talented athletes, it is developing the full potential of talented athletes who show an interest in track and field. Although it would appear desirable for the United States to apply a system of talent identification and selection similar to that of the aforementioned countries, successful results could not be expected because of social, educational and economic differences (Ruderman & Komarova, 1984). Thus, an organized means of developing potential talent is necessary if athletes are to reach their optimum potential.

In spite of a general upsurge in the development of sport sciences, a void continues to exist between the researcher and the coach. Testing done in the laboratory has often lacked practicality in the sport training setting. Even when research is applied, coaches have been hesitant to adapt such information to the training regime. At times, coaches forget that sport research should be done by experts, while other times sport researchers have little understanding of the factors which contribute to or affect sporting performances, compared to the practical acquired knowledge of coaches and athletes (Freeman, 1979).

Sports scientists are able to identify specific characteristics necessary for success in particular track and field events, but have no reliable method for predicting future performances by athletes. Although test batteries and normative data have been presented for track and field, according to Henson et al. (1989a) the studies failed to suggest a longitudinal model for predicting future success that was based upon rigorous statistical procedures. McWatt (1990) concluded that there were few universally agreed upon procedures and methods for predicting success in specific track and field events. Thus, attempts need to be made to discover a reliable method that will measure those characteristics necessary for success, in order to accurately predict future performance.

Henson et al. (1989a) utilized various tests, known to be indicators of track and field performance, to develop statistically based equations for predicting future performance. The tests included: vertical jump, standing long jump, five bounds for distance, percent body fat, 60-meter dash and 30-meter dash, stride length, and stride frequency. Using the statistical technique of multiple regression, the researchers developed a mathematical equation that differentially weighted the performance of the tests in predicting performance levels as measured with multi-event scoring tables. It was believed to be the first attempt to establish a predictive equation that had both a valid and objective performance measure.

Statement of the Problem

The problem of the study was to investigate the degree to which predicting performance in track and field relates to individual performances of men and women on Western Michigan University's 1990-1991 track teams. The study utilized the performance prediction equations developed by Henson, Turner, and Lacourse (1989b). Predictive scores were calculated for each athlete then compared to their individual event point scores published in the International Amateur Athletic Federation (IAAF) men's and women's multi-event scoring tables ("Scoring Table for Men's," 1962; "Scoring Table for Women's," 1971). Performance was predicted for sprints, hurdles, jumps, throws, and multi-events.

Purpose of the Study

The purpose of the study was to determine if Henson et al. (1989b) prediction equations could accurately measure and predict performance potential of track and field athletes at Western Michigan University, Kalamazoo.

Significance of the Study

Presently no scientific method exists for the track coach to objectively determine the specific potential of athletes. As a consequence, training has largely been a hit and miss process, and athletes have not always developed to their optimal potential. A review of the literature revealed that talent prediction is an important and beneficial procedure in helping athletes reach maximal performance potential. Henson et al. (1989a) attempted to establish a valid and objective means for measuring and predicting performance potential. Thus, in order to determine the validity of Henson et al. prediction equations, there exists a need to investigate the relationship between predicting performance and the actual performances of athletes. The present study attempts to provide information which may determine the reliability of performance prediction equations as well as assist the coach to predict performance potential.

Delimitations

The study was delimited to the following:

1. The subject pool was restricted to the men and women varsity athletes on Western Michigan University track and field teams.

2. Data collection was restricted to sprinters, hurdlers, jumpers, throwers, and multi-eventers.

3. The tests used to predict performance were those developed by Henson et al. (1989b).

Limitations

The study was limited by the following:

1. The subjects were tested during pre-season conditioning and may not have been in peak physical condition.

2. The performance prediction tests developed by Henson et al. (1989a) consisted of tests of leg power and anthropometric measures.

Assumptions

The researcher assumed that the subjects were in good physical condition and gave a maximum effort during the performance of each test.

Hypotheses of the Study

The researcher developed three hypotheses:

1. A positive relationship exists between the subjects' personal best performances in track events and scores on the Henson et al. (1989b) prediction equations.

2. Little or no difference exists between predicted scores and actual scores for each event: Sprints, 400m, high hurdles, intermediate hurdles, long jump/triple jump, high jump, pole vault, and throws.

3. Little or no difference exists between predicted scores and the average scores for the top eight places for each event in the 1986-1990 Mid-American Conference championships.

Definitions

Terms used in the study were defined as follows:

1. Multi-Event Point Tables: Multi-event tables equate points for an athlete's performance in an event. For example, for a male long jumper, a performance of 22 ft 7 3/4 in. corresponds to 800 points. As athletes' performances improve, more points are awarded. In the present investigation, the International Amateur Athletic Federation 1962 decathlon and IAAF 1971 Heptathlon tables were used.

2. Stride Length: One stride length is defined as the distance from foot strike of one leg to the foot strike of the opposite leg.

3. Stride Frequency: Frequency is defined as the total number of strides taken during the 30-meter fly.

4. 30-meter fly: The fly refers to a running start as opposed to a standing or stationary start.

CHAPTER II

REVIEW OF RELATED LITERATURE

The present chapter provides a brief overview of some of the identification, selection, and training programs currently used, along with some of the problems associated with them. In addition, this chapter identifies some of the essential factors influencing performance in track and field along with tests which measure such factors. The chapter presents specific tests and norm values used to identify potential track and field athletes in sprinting, jumping, and throwing events. Finally, the chapter presents a rationale for using prediction tests in track and field.

Talent Identification Programs

One of the earliest and most comprehensive studies to measure various aspects of physical fitness of athletes was conducted by Cureton (1948). Cureton administered a series of tests which measured physique, motor fitness, and cardiovascular characteristics of United States Olympic athletes, national champions, and sub-elite athletes. The study found that athletes in different sports or events showed specific event-related characteristics. Cureton concluded that certain tests provided a valid and objective means for distinguishing between high, average, and low levels of fitness of athletes.

Nicks and Fleishman (1962) and Fleishman (1963) investigated the relationship between physical fitness tests and physical proficiency. The researchers described 14 physical proficiency factors for physical fitness: (1) explosive strength, (2) dynamic strength, (3) static strength, (4) extent flexibility, (5) dynamic flexibility,

(6) speed of change of direction, (7) running speed, (8) speed of limb movement, (9) static balance, (10) dynamic balance, (11) balancing objects, (12) multiple limb coordination, (13) gross body coordination, and (14) endurance. The researchers concluded that commonly used fitness test batteries did not cover the range of possible fitness factors, and many of the tests used overlapped with one another in the factors measured.

Allsen (1975) attempted to conduct a long-term study of selected physiological and psychological traits of athletes. The main objective was to provide a functional profile using physiological data. It was suggested that such an analysis might allow the construction of a prediction equation that might be utilized to predict success in a given athletic endeavor.

Although researchers have identified important characteristics for athletic performance and developed tests to measure those characteristics, organized talent identification programs have not been employed in the United States to the extent that they have been in other countries. Formalized talent identification programs have been extensively used in the former Soviet Union, and former East and West Germany (Thomson & Beavis, 1985).

The Soviet Union

Gifted athletes and sports leaders were held in high regard in the Soviet Union by their countrymen. A strong belief existed in the equality of mental and physical culture such that talent in sport is treated no differently from talent in art, music or science (Riordan, 1980). With this ideology, talent identification within all of these areas has had high priority in the Soviet system.

In the former Soviet Union, the institution responsible for development of scientific methods of physical training was the State Central Institute of Physical

Education in Moscow ("The State Central Institute of Physical Education in Moscow," 1988). The government supported center was responsible for producing top specialists in coaching and the sports sciences.

Finding and developing talent in the Soviet Union was based on an extensive long-range development plan. A screening system was designed to sift out talent at an early age and to provide the right environment and opportunity for that talent to develop (Riordan, 1980).

Riordan (1980) identified a hierarchy of six sports schools in the Soviet Union. The most basic school was the children's and young people's sports school (CYPSS) designed so participants attended outside of regular school, much like a club. Above the basic school in the Soviet hierarchy were single sports schools known as specialist children's and young people's sports schools (SCYPSS) and sport oriented day schools (SODS). From the age of seven, children could attend a full-time, sport-oriented school which combined a normal school curriculum with extra instruction in sport.

Above the specialist training schools were the sports proficiency schools (SPS) and the higher sports proficiency schools (HSPS), which provided extra-curricular training and vacation courses. Students between 16 and 18 years attend SPS, while those 18 and over attend the HSPS. At the top of the hierarchy were the sports boarding schools (SBS), which adhere to the standard Soviet curriculum for normal schools, but allow an additional study load in sports theory and practice. The purpose of the SBS was to allow students to obtain their school-leaving certificate in addition to acquiring proficiency in a specific sport.

Jarver (1979, 1981) outlined the Soviet system for identifying potential track and field talent. The system was based on the establishment of an ideal model for each event. The model was established by taking into consideration statistical data on numerous Soviet and foreign world class athletes. Information included performance parameters and the rate of improvement at various ages. Consideration given to the biological age of young athletes permitted the setting of reasonably reliable standards of what could be expected from a potentially talented athlete at a certain age. Once the model was established for a particular event, the appropriate standards and rate of improvement were employed to choose talented individuals in three selection phases (Jarver, 1981).

Phase one, the basic selection phase, took place in primary school at the age of 8 to 10 years. During this phase, a mass screening of thousands of youngsters was undertaken to identify potential talent and determine which children were likely to succeed in sport. Observations were made by physical education teachers who were well trained in identifying potentially talented children. Simple tests were conducted in order to evaluate all-around performance capacities. The tests made no use of sophisticated equipment and did not require specialists to carry them out. The basic selection was made reasonably simple for coaches because the Soviet physical education curriculum covered a significant amount of track and field in the general physical development program.

Phase two, the primary selection phase, took place between the ages of 10 to 12 years. The evaluation was based on progress made in physical activity and sport specific tests. Sport specific tests were regarded as one of the most reliable factors in talent identification. Other factors taken into consideration were growth rate, biological age, and test results from psychological inventories. Psychological inventories were regarded to be least reliable. Those found suitable for sports schools or classes were directed towards a group of events. No event specializing was recommended because the researchers indicated that predictions were not entirely reliable at an age (10-12 years) when physical performance factors followed unpredictable developmental patterns. Although some students were eliminated during this selection, they were re-evaluated one year later to make allowance for late developers.

Phase three, the final selection, occurred at the age of 13 to 14 years. In phase three, the athlete began specialization in a number of events. The ages 12 to 14 years for boys and 11 to 13 years for girls were considered the best ages to make performance predictions and guide youngsters towards a particular event. Although unpredictable development patterns still occurred at this age, it was stated that a later selection would have a detrimental influence on skill development.

Jarver (1981) and Thomson and Beavis (1985) identified three factors contributing to the success of the Soviets system:

1. The use of a flexible educational system to identify and develop potential sporting talent, beginning at primary schools under the guidance of well qualified physical education teachers, and continuing at specialist sport schools and classes under the guidance of experienced coaches.
2. The use of a methodical three phase identification scheme.
3. The use of well established performance models for each event.

German Democratic Republic

The talent identification and development program employed in the former East German Republic was considered to be the best organized and most productive system of any country in the world (Thomson & Beavis, 1985). This was evidenced by the fact that, for a small state of approximately 17 million people, it produced more top athletes in international competitions than any other country except for the USSR (Tabachnik, 1991a).

High performance sport had top priority in East Germany (Hoberman, 1990). The success of the East German system has been attributed to an effective physical education program for children, and a tremendous cooperation between the sports school teachers and trainers in various sports clubs (Schmidt, 1979; Tabachnik, 1991a). Schmidt (1979) reported that East German athletes prepared for competition by training in sport schools and sport clubs. Scientific methods of training and education were developed at the College of Physical Culture, Leipzig (Hoberman, 1990).

Marder, Ryan, and Jarver (1977) outlined the following characteristics of the system for selection and training of elite sports participants in East Germany:

1. Students participated in a compulsory program of physical education in schools, having to meet high standards of performance at each level before advancing.

2. Potential talent was identified early among young persons, with the state completely controlling the lives of elite performers.

3. Talented individuals were enrolled and trained in a system of clubs for different sports. The club facilities were the best that could be provided, and each had a medical facility with physicians, to monitor training practices as well as treat illness and injury.

4. Continuous selection and training of potential top achievers took place, with ruthless elimination of athletes who did not measure up at each stage. The objectives were long range--to win more medals than any other country in the Olympic Games.

5. Elite performance training included scientific approaches based on medical, educational and technical methods. Research was performance oriented

consisting of representatives from all the concerned specialities, with medical science the most important.

6. Each sports club had a sports medicine center staffed by physicians and paramedical personnel with specialized training in sports medicine. The functions of the sports physicians were to: (a) prescribe and monitor conditioning programs that would keep athletes in excellent shape, (b) prevent and treat illness and/or injury, and (c) develop and test experimental procedures for performance enhancement, such as the use of drugs.

Marder et al. (1977) maintained that there was little interchange of sports science information among the Eastern bloc countries, and that the East Germans were contemptuous of the achievements of other countries, particularly the USSR. Smith (1981) rejected claims that East Germany's program included: ruthless elimination of candidates; the State's complete control over the participants' lives; and administration of ergogenic aids (e.g., steroids), without concern for the participant's health. Smith stated that the true strength of the East German sports program was attributable to intelligent application of evaluation and scientific principles.

Although the sports schools and clubs were very important to the East German sports program, they were not the only means for developing the country's talent . East Germany's Spartakiad Festival provided coaches with opportunities to review more than 500,000 prospective athletes. Impressive performers were offered invitations to special sports schools or local sports clubs (Smith, 1981).

(Note: Recent political changes in East Germany and the reunification with West Germany are such that the East and West German sports programs and teams have now been combined. How these changes will affect the German sport program in the 1990s remains to be seen.)

<u>The Federal Republic of Germany</u>

Despite the apparent success of sports schooling, talent identification and compulsory physical education in East Germany and USSR, these were not regarded as possible avenues for talent identification and promotion in West Germany (Thomson & Beavis, 1985). Thomson and Beavis (1985) noted that the West German system of physical education did not favor a sport emphasis and that it was not the task of the physical education program to specialize in sport but, instead, was to promote social interaction. The organization responsible for the development of top level sport was the Sporthochschule (German Sports College) in Cologne ("Sport in der Bundesrepublik Deutschland," 1975).

The West German Track and Field Federation developed selection criteria for all track and field events by using both quantitative and speculative data to identify potential talent (Foreman, 1989). The criteria were reported in a series of articles in <u>Die Lehre der Leichtathletik</u> in November and December of 1979 (Foreman, 1989; Jarver, 1979). Foreman noted that the talent identification tests were to be administered to teenage athletes twice each year. The results were then used to classify track and field performers by ability and potential. Athletes showing outstanding potential were then invited to train with the national team.

In addition to identifying talent, Foreman (1989) reported that the West German program sought to: (a) improve the interchange of scientific information between local, regional and national coaches; (b) develop criteria for placing athletes at specific competitive levels; and (c) provide a common approach to the teaching of technical skills. The West German selection program included films, videotapes, medical evaluation and health care for the athletes, but its impetus was towards a development of test batteries to isolate the specific factors which seem to predispose an individual to success in various track and field events (Foreman, 1989).

Problems in Talent Identification

Ruderman and Komarova (1984) stated that all track and field events present certain social, educational, physiological, and psychological selection problems. McWatt (1990) concluded that although high levels of success in track and field may depend on efficient talent selection, there have been few universally agreed upon procedures and methods for predicting success in specific track and field events.

According to Ruderman and Komarova (1984), inherited capacities that indicate a solid base for future development are only anatomical or morphological, while other capacities, including psychological qualities, combine with other capacities to allow for success in each event. Ruderman and Komarova maintained that performance aspects such as industriousness and awareness, are among those that can be developed through preparation. Genetic factors that limit the performance potential, however, cannot be changed. Consequently, high level performances are limited by inherited genetic factors, as well as the performance level that can be stimulated by efficient preparation and education.

Jarver (1981) evaluated the procedures of talent identification in the Soviet Union and outlined problems that were encountered.

1. One of the main problems was the inability to separate individuals with true potential talent from those who had high level test results, but failed to reach the predicted performance level. The problem was reflected through statistical evidence showing that over 50% of those chosen in early stages of talent identification and admitted to sports schools and classes never reached the expected performance levels, thus indicating the inability to predict at a young age. Riordan (1980) reported

dropout rates among first year students in all sports schools to be approximately 80%.

2. Another major problem was created by varied rates of improvement in physical performance capacities, with sharp upward surges in specific capacities at certain ages. Authorities differed in their views on exactly when sudden developments took place.

3. Besides the lack of precise and reliable methods to identify the future development and performance potential, there have been unsolved problems in determining the most suitable age to begin sport testing. Reasons for this were twofold: (1) talented youngsters showed excellent all-around ability in the 10 to 12 years age group, making it difficult to decide which sport they are particularly suited for; and (2) there has been no universal agreement on the correct age to begin event specific training.

4. The Soviet testing system lacked sophistication. Most tests during the selection stages were simple field tests, and the coach's eye still provided the most important information.

Factors Influencing Performance in Track and Field

Investigators have identified six general categories of factors influencing performance in track and field (Henson et al., 1989a; Thomson & Beavis, 1985; Ward, 1981): (1) physiological and biomechanical, (2) anthropometric and somatotype, (3) biological, (4) heredity, (5) psychological, and (6) sociological. Using factors which may predispose an individual to success in various track and field events, test batteries could be developed which isolate such factors and performance predicted (Foreman, 1989; Henson et al., 1989a).

Physiological and Biomechanical Aspects

Physiological profiles of successful performers provide an indication of the necessary features to achieve top performances in a certain sport, and furnish a comparison for aspiring participants (Thomson & Beavis, 1985). According to Ward (1981), physiology encompasses the multiple facets of the function of the human body. When applied to athletic training, it involves a knowledge of the requirements of adaptation to the various events, the changes which occur with conditioning, and an understanding of the specificity of training adaptations.

Three commonly studied physiological measurements have been max VO_2 uptake, blood lactate, and muscle biopsies. According to Astrand and Rodahl (1978), a certain amount of training to the oxygen-transport organs is necessary for all categories of athletes, regardless of the nature of the athletic event. Humphreys (1979) concluded similarly that training the O_2 transport mechanism was desirable for both aerobic and anaerobic performers, as well as for performers who need to use both systems simultaneously. Humphreys stated that a number of factors can interact to affect performance, and an athlete with a relatively low VO_2 max can compensate by having superior muscle metabolism, the right fiber components and efficient neural transmission.

Although VO_2 max values have been used to evaluate aerobic capacity, determination of blood lactate concentration has been considered to be more accurate. Determination of blood lactate levels establishes a value for the anaerobic threshold and is considered to be a reliable method of determining intensity of aerobic training as well as anaerobic training.

Muscle biopsies have also received attention for the prediction of athletic performance. Gollnick, Hermansen, and Saltin (1980) reported that relationships exist between characteristics of skeletal muscle fibers and sports performance, but there were insufficient data to establish any of the variables as predictors of successful performance. Gollnick et al. concluded that it would be erroneous to assume that only persons with a certain fiber composition could be successful in specific events.

Biomechanical analysis is another important aspect in the development of performance. Hay (1985) defined biomechanics as: "The science concerned with the internal and external forces acting on a human body and the effects produced by these forces" (p. 2). According to Hay, the study of biomechanics provides a sound and logical basis upon which to evaluate underlying techniques. Bal'sevich (1980) identified correct biomechanical characteristics as a fundamental component for maximum speed racing. Humphreys (1982) reported that biomechanical and physiological test results should be considered together to provide a more accurate, integrated picture of the factors affecting performance.

Anthropometric and Somatotype Characteristics

Researchers have investigated anthropometric and somatotype characteristics of athletes and have suggested characteristic physiques for different events. Malina (1975) described anthropometry as the systematized technique for taking measurements from man in order to quantitatively express the dimensions of the body. Such measurements have been generally divided into categories of mass (weight); lengths and height; breadths,widths or depths; circumferences or girths; curvatures or arcs; and soft tissue or skinfolds. Somatotyping has been described as a system of classifying physique by shape, instead of size (Tanner, 1964).

Tanner (1964) studied 137 elite male track and field athletes prior to the 23rd Olympic games in Rome in 1960. The researchers took 14 anthropometric measurements and determined athletes' somatotypes. There were marked differences in somatotype between competitors in different events. Sprinters were relatively short, with shorter legs and larger muscles than those of other runners. The 110 meter hurdlers were taller and had longer legs than the sprint group. The 400 meter men were described as large, long-legged, broad-shouldered and fairly heavily muscled. The 400 meter hurdlers closely resembled 400 meter flat runners, though were more slender. Distance runners were small, short legged, narrow-shouldered, and relatively lacking in muscle compared to other track and field athletes. High jumpers were tall, above 6 feet, and had the longest legs relative to trunk length than other athletes. The throwers differed greatly in physique from other athletes. As a group, the athletes were taller, heavier, had large muscles, long arms, and were fatter than the track athletes.

Pipes (1977) determined the body composition characteristics of 58 intercollegiate track and field athletes and concluded that body type may predispose an individual's ability to perform in an event. Siris and Gaidarska (1986) concluded that weight and height were important factors for athletic success. Aule and Loko (1983) stated that short athletes tend to be better coordinated, learn techniques faster and produce better short term results than their tall counterparts, although taller athletes have better potential.

Biological

There is often a significant difference between biological age and chronological age. This difference has a profound effect on the performance capabilities of young athletes. Alabin, Nischt, and Jefimov (1980) found testing to be most effective for children between ages 11 to 13. Thomson and Beavis (1985) stated that in defining limits for test scores and in establishing norm values on the basis of chronological age, individuals whose development is accelerated (biological age exceeding their chronological age) will be identified as talented and promoted accordingly. Alabin et al. (1980) mentioned that evaluation of the growth rate is particularly important to avoid overlooking youngsters who are late developers.

Heredity

Thomson and Beavis (1985) stated that the influence of heredity compared to that of environmental factors on performance was an area of particular interest in the selection and training of talented athletes. Researchers have attempted to determine the degree to which certain attributes are an expression of the genetic potential of an individual or are the result of different environmental stimuli.

According to Aule and Loko (1983), studies have shown that physique and certain performance capacities are inherited and genetically established. Inherited characteristics that are poorly influenced by outside factors (i.e., the environment) are physique, flexibility, aerobic capacity, reaction time, coordination, agility, speed characteristics, and relative strength. Those characteristics that react easily to outside influences are body weight and absolute muscle strength.

Klissouras (1976) mentioned that all capacities and physiological processes in man have a genetically determined ceiling, and that this performance "ceiling" suggests that rigorous sports training cannot contribute to functional development beyond a limit set by the genotype. Klissouras suggested that, since heredity cannot operate in a vacuum, there must be an appropriate environment for heredity factors to attain full expression.

Thomson and Beavis (1985) suggested that research ought to be directed toward developing criteria to determine whether or not the performance limits set by the gene pool in a given individual have been reached. If such limits have not been reached, further training could promote further increases in performance.

The significance of such observations is that genetic factors play a decisive role in the attainment and prediction of outstanding performance. Klissouras (1976) stated that the basic biophysical disposition must be present for the possibility of becoming an outstanding performer. It was added that, the appropriate training stimuli can profoundly affect the expression of the genetic potential for some adaptive responses to occur, but only within fixed hereditary limits.

Psychological

It is generally accepted by athletes, coaches, and sport psychologists alike that psychological factors play an important role in sport performance. Psychological attributes in sport have been considered equally, if not more important, than physiological factors in top level sport (Thomson & Beavis, 1958). Researchers have investigated the influence of anxiety on athletic performance (Hanin, 1986; Martens & Gill, 1976) and have attempted to predict performance based upon personality characteristics (Ward, Morrow, & Omizo, 1979).

Using the Sport Competition Anxiety Test (SCAT) developed by Martens (1977), Martens and Gill (1976) found that subjects who scored high on SCAT manifested higher levels of state anxiety in competitive situations than low SCAT scoring persons. In addition, it was determined that success/failure affected state anxiety levels before and throughout competition. The results of the study provided support for the SCAT as a reliable and valid predictor of state anxiety during pre-competition and competition.

Hanin (1986) used the State-Trait Anxiety Inventory (STAI), developed by Spielberger & Diaz-Guerrero (1976), to assess pre-performance anxiety for gymnasts, divers, rowers, weight-lifters, and figure skaters. Observations of high trait anxiety athletes, as compared with low trait anxiety athletes, suggested higher levels of situational anxiety. Using a retrospective analysis in which athletes recalled their emotional reactions from past competition, Hanin devised a plan to determine a zone of optimal functioning for pre-contest anxiety. High correlations were found between performance and zone of optimal functioning. Performance was good when an athlete's level of state anxiety was within that athlete's zone of optimal functioning.

Ward et al. (1979) attempted to determine the degree of relationship between successful performance and measures of personality characteristics. Olympic athletes in discus, hammer, javelin, and shot put were administered the Sixteen Personality Factor Questionnaire (Cattell & Eber, 1969) as well as three measurable constructs of motivation distortion, dogmatism, and locus of control. Ward et al. (1979) concluded that the personality constructs as measured showed little promise in prediction of average length of throw. In the absence of statistical significance, it was recommended that psychomotor, anatomical, and physiological measures be explored as potential variables for prediction of performance.

Sociological

McWatt (1990) identified socioeconomic environment as an important feature for champion athletes. The desire to succeed depended partly on the values and pressures of society. It was mentioned that the structure of society often presents the athlete with the alternative of one at expense of the other. Many talented athletes cannot manage sports training, school, and profession and often give up a sport before having reached the level of maximal performance (Thomson & Beavis, 1985).

Foreman (1980) identified self image as an important factor in selection of elite track and field athletes. Strong support from parents and friends, ability to deal with social situations, and peer pressure were especially important with female athletes.

Predictive Testing in Track and Field

Numerous investigators have attempted to isolate predictive factors for the selection of track and field athletes (Alabin et al., 1980; Aule & Loko, 1983; Field, 1989; Foreman, 1989, 1980; Henson et al., 1989a; Racev, 1985). Alabin et al. (1980) identified the following factors as predictors of track and field talent: height, weight, speed, stride frequency and stride length, reaction time, strength, power, endurance, coordination, psychological approaches, intellectual level, and biological growth rate. In addition, Alabin et al. assembled a test battery with norms for 11-to 12-year-olds. The tests included five steps, 60 meter dash, 300 meter run, trunk bend, height, and weight. The researchers recommended that the best age to make performance predictions was 11 to 13 years for boys and 10 to 11 years for girls.

Aule and Loko (1983) identified model anthropometric measurements and physical performance characteristics for selecting potentially talented athletes. The model characteristics were divided into three categories: (1) general to all sporting events, (2) general to a particular group of events, and (3) specific to a particular event. Norms based on model characteristics were used as selection criteria.

Field (1989) assembled a test battery to objectively evaluate the explosive power of athletes. The test battery was made up of three sections: (1) weightlifting, which included squats, push jerk and power cleans; (2) jumping, which included standing long jump, ablakov test, three bounds, and a timed 25-yard hop; and (3) running, which included 30-meter sprint from a standing start, and 30-meter sprint from a flying start. Field subjectively formulated categories into which athletes would fall based upon their performance in each of the three sections.

Foreman (1989) outlined some of the characteristics related to successful performance in terms of relative importance in various events. In the area of sprints and hurdles, natural speed, power, stride cadence, strength, movement time, and low percent fat were considered important. For middle and long distance runs, aerobic capacity, anaerobic power, natural speed, low percent fat, and strength were important factors. For jumpers, power, strength, morphological factors, natural speed, coordination, and low percent fat were important factors. For throwers the important factors for successful performance were power, strength, morphological factors, coordination, and natural speed.

Foreman (1980) identified field tests used by West Germans to help identify potential in prospective track and field athletes. Table 1 contains some of the test factors used by the West Germans to identify potential athletes. In addition, Foreman established selection criteria and performance standards that could be used for elite athletes in various track and field events. Foreman's tests included vertical jump, standing long jump, two handed overhead shot throw, five double leg bounds, standing triple jump, percent fat, and 50 yard sprint.

Racev (1985) reported a two phase selection procedure with simple field tests which could be used to find potential track and field talent for young athletes 9 to 12 years of age. The initial phase was responsible for spotting general sporting potential and included simple tests such as: standing long jump, vertical jump, 60 meter sprint, situps, and bent-arm hang. The second phase was designed to find young athletes suitable for specific track and field events. Selection was based on morphological, physiological, and psychological characteristics.

Table 1

Specific Test Factors for Selection of Potential Track and Field Athletes

High jump, long jump and triple jump	Throwing Events	Running events
30-meter sprint	30-meter sprint	50-meter sprint
5 single-leg bounds	Jump and reach	300-meter run
5 alternating-leg bounds	1000-meter run	600-meter run
Standing long jump	Standing long jump	5000-meter run
Thief vault	3 alternate-leg bounds	Jump and reach
Scissors jump of the bar	5 double-leg bounds	Standing long jump
800-meter run	Back-ward overhead shot put toss	3 alternate-leg bounds

Henson et al. (1989a) developed a method of predicting potential performance for track and field athletes. The researchers conducted a series of tests which measured leg power and anthropometric dimensions. The tests included height, weight, standing long jump, vertical jump, five bounds for distance, body composition, 60-meter dash and 30-meter dash, 30-meter fly, stride frequency, and stride length. The researchers developed mathematical equations using the statistical technique of multiple regression. Each formula differentially weighted the performance of the tests. Performance levels could then be predicted by looking up the formula score and the corresponding performance with multi-event scoring tables. The researchers concluded that it was possible to use a small number of simple tests of leg power to predict performance in track and field.

Sprints

Numerous investigators have examined predictive testing of performance in the sprints (Ionov, 1982; Radford, 1984; Tabachnik, 1979). Tabachnik (1979) recommended the use of the long jump and triple jump as predictive tests because of their close correlation with muscular strength, power, and running speed. Speed endurance, according to Tabachnik, could be determined using 60 and 100 meter sprints. Waibaum and Tschekulyov (1977) considered the 60 meter sprint from the blocks to be the best test for absolute speed.

Tabachnik (1979) suggested that reliable prediction of potential could be achieved taking into account the initial level of physical qualities (accounting for biological age) and the rate of progress during training. Other researchers, Ionov (1982) and Radford (1984) acknowledged the importance of natural ability as an important factor in determining sprint success.

According to Tabachnik (1979), sprint potential could most readily be identified by comparing athletes to a model of a sprinter. The model included parameters from world class sprinters, as well as relative weights so as to maximize performance capacity. Such parameters included height, body composition, stride length, stride frequency, and strength. Tabachnik considered both stride frequency and duration of the support phase important factors to look at, in order to avoid overlooking potential talent.

Bal'sevich (1980) identified the fundamental components of a potential sprinter for the Soviet Sports Schools. The qualities included: (a) anthropometric characteristics, (b) the level of development of the physical qualities that correspond with biomechanical characteristics fundamental to maximum speed racing, and (c) psychological characteristics typical of the model sprinter. Additional qualities included performances on 30-meter sprint with a standing start, 30 meter sprint with a flying start, standing long jump, and 10 jumps with feet together from squatting position.

Kusnezov, Petrovskiy, and Schustin (1982) identified a performance model for sprinters. Model parameters were based on competitive performance characteristics, specific conditioning level, technical level, and functional level of the neuromuscular system. The researchers concluded that it was difficult to establish reliable data for model parameters in sprinting.

Jumps

Researchers have also identified various factors and test batteries for identification of potential talent in jumpers. Jarver (1979) provided sample tests used in Soviet Youth Sports Schools along with norms for boys and girls from 10 to 11 years of age. These tests included height measurement, 30-meter sprint from the fly, 60-meter sprint from a stand, standing long and triple jump, pull-ups, and push-ups. In addition, Jarver identified West German tests for the long jump. The tests were divided into four areas: (1) basic tests, which were 30-meter sprint from a standing start, jump and reach, 1000-meter run for males, and 800-meter run for females; (2) event specific tests which included five hops on the right leg for distance, and five hops on left leg for distance; (3) anthropometric measures; and (4) best performance information.

Afanasiev (1982) identified three tests that Soviet specialists found to be closely correlated with high jump results: (1) speed-strength testing such as the vertical jump in place without using the arms, (2) strength testing using the barbell squat, and (3) dynamometric testing measuring the static strength of the foot. In working with many jumpers over several years, the researchers found a close positive relationship between speed-strength capabilities and results in the high jump.

McWatt (1990) presented methods and procedures for predicting success for New Zealand's high jumpers, based on anthropometric features, physiological capacities, socioeconomic environment, competition environment, and yearly performance progressions. Using 24 years of age as time of peak performance, McWatt developed tables of progression from 17 to 24 years of age to show annual progress required for athletes to reach an ultimate performance level.

Siris (1982) developed a two-stage long jump talent identification program based on factors of speed and acceleration. In the first phase, athletes who scored average or above average on a series of tests and who had favorable anthropometric measurements were selected for a specific training program. Upon completion of an 18 month training program, the amount of improvement was noted and the second phase of selection occurred by choosing those who had an acceptable degree of improvement.

Throws

Jarver (1979) presented sample tests used in Soviet Youth Sports Schools for selecting potential throwers. The tests included height, weight, arm span, 30-meter flying start, 60-meter standing start, standing long and triple jumps, shot throw backwards over the head, pull-ups, and push-ups.

Siris and Gaidarska (1986) identified model indicators for potential throwers used as evaluation and selection indicators in the Soviet Union. These model indicators included anthropometric measures of height and arm reach, as well as 30-meter sprint from a crouch start, standing long and triple jumps, medicine ball throw backward overhead, barbell squat, snatch, power clean, and bench press. In addition, control norms were provided for all throwing events for ages 11 to 17 years of age.

Ruderman and Komarova (1984) presented a methodology for selection of potential shot and discus throwers with recommended tests and a formula for improvement rates and physical performance capacities for young throwers. Potential for young throwers to succeed depended largely on anthropometric indicators and basic physical performance capacities, particularly movement speed, power, and strength indicators. Ruderman and Komarova suggested that reliable physical performance capacity tests were available to evaluate power,and movement speed. These tests include standing long jump, vertical jump, five steps and jump, shot throwing backwards over the head, and 30-and 60-meter sprints. Anthropometric standards for height, weight, and arm reach were also used to evaluate potential. The researchers determined performance improvement rates using the following formula:

$$\text{Improvement Rate} = \frac{100 \text{ X (end result - initial result)}}{0.5 \text{ X (initial result + end result)}} \%$$

The researchers cautioned that the improvement rate of the indicators of physical capacities was only effective in the evaluation of potential talent for athletes whose initial levels of development were already sufficiently high.

Morrow et al. (1982) evaluated anthropometric, strength, and performance data for 49 American discus, hammer, javelin throwers, and shot putters who participated in a pre-Olympic training camp. Results indicated significant differences in anthropometric and strength variables between event participants, with similar performances on motor performance variables. Strength correlated positively with performance for discus throwers. Fat weight correlated negatively with hammer performance. Leg strength, vertical jump, and long jump correlated positively with shot put performance. For javelin throwers, none of the variables was significantly related to performance.

Paish (1982) developed a throwing decathlon to provide an innovative and purposeful training program for throwers. The following events were included: double handed throw overhead backwards, kneeling put using dominant arm, throw through legs, standing discus throw, hammer style throw, forward two handed threw from behind neck, two handed chest throw, caber throw, kneeling throw with non-dominant arm, and overhead throw while lying on the back. In addition, Paish developed a scoring table in which athletes would be awarded points based on their performance. As performance increased, more points were awarded.

Jones (1988) developed the Test Quadrathlon which measured basic leg and back power using the following four events: (1) 30-meter sprint from stationary position, (2) standing long jump, (3) three continuous two-footed bounds, and (4) backwards overhead shot throw. Each test was given points, ranging from one tc 100, from which a total points score was calculated.

Multi-Events

Kuptshinov (1979) suggested a three phase process for identification and development of decathlon talent. Phase I consisted of identification of talent for beginners training ages 12 to 13 years. Phase II consisted of selection of talented athletes for specific decathlon training, ages 16 to 17 years. Phase III consisted of final selection and start of top performance training for the decathlon, ages 19 to 20 years. According to Kuptshinov, anthropometrical measurements were the most important factor in potential decathlon talent. Norms for ideal anthropometrical measures were given for each phase. In addition, satisfactory performances in single events were used as selection factors. Prediction of future potential was also based on rate of improvement using the same equation as Ruderman and Komarova (1984). Physical fitness components and norms were given for bench press, throwing the shot backward overhead, standing long and triple jumps, vertical jump, 30-meter sprint from a stand, and 30-meter fly.

Kuptshinov and Siris (1983) identified a long-term selection procedure for decathletes, to be achieved in a four-phase development program. Phase one was the period of basic preparation and development of many general characteristics. Phase two began specific development of decathlon skills. During phase three, high level performances were perfected. Phase four consisted of optimal performance training. Evaluation of potential talent in the first and second phases was based on performances on the following control tests: 30-meter flying sprint, 60-meter sprint form stationary position, standing triple jump, vertical jump, 5-kg shot throw forward and upward, 5-kg shot throw backwards over head, bench press, squat, 300-meter run, and a 5-minute run. Potential talent in phases three and four was based on the rate of improvement in the individual decathlon events.

Myers (1987) developed a test battery to identify talent, as well as to measure training progress for field-event and multi-event athletes. Testing was conducted over a two-day period with five events being measured each day. First day tests included: (a) a 30-meter sprint from a standing start indicated leg power and acceleration; (b) the standing long jump indicated leg power; (c) a 25-meter speed hop on one leg indicated leg power, acceleration, and coordination; (d) the shot throw backward overhead indicated total body power; and (e) a 150-meter sprint from a standing start indicated maximum speed, and speed endurance. Second day tests included the following: (a) a 30-meter flying sprint, an indicator for maximum speed; (b) the standing triple jump, an indicator of leg power, acceleration, and coordination; (c) the overhead forward shot throw, an indicator of total body power, upper body strength, and flexibility; (d) the football throw, an indicator of arm speed and throwing technique; and (e) a 600-meter run, an indicator of speed-endurance and anaerobic capacity.

Myers (1987) equated the athletes' performances to a point table that ranged from 0 to 1000 points. As athletes' performances improved, more points were awarded. Athletes scoring the highest tended to be multi-eventers, triple jumpers, and javelin throwers. Women who scored over 6000 points were considered excellent whereas, men who scored over 8000 points were considered excellent.

Freeman (1979) attempted to produce an equation to determine whether performance levels in the decathlon could be predicted on the basis of three events: (1) high jump, (2) 400-meter dash, and (3) discus throw. Freeman's equations yielded a multiple R of .56. Using the best mark of each individual, for the three events, Freeman found a multiple R of .76. The researcher concluded that the equations resulted in considerable inaccuracy.

Benefits of Testing for Track and Field Athletes

Testing athletes for potential is a method based on scientific facts rather than the traditional trial and error method. Tabachnik (1991a) stated that the naked eye or a haphazard system of screening for talent will allow many potentially outstanding prospects to fall between the cracks; thus a scientific approach is essential.

Investigators have concluded that it is possible to predict, with a high degree of accuracy, the ideal track and field event in which athletes have the greatest potential (Foreman, 1989; Henson et al., 1989a). Although athletic prediction is somewhat speculative, stated Foreman (1989), there is an event for everyone, and the coach must use every tool possible in helping those individuals find the events for which they have the greatest potential for success. Predictive testing is one such tool that may be used to find talented individuals.

Smith (1981) indicated that talent identification is not the only benefit of testing; it could also serve as a diagnostic device to help determine an athlete's original status and reveal changes produced by training. Tests can help coaches determine the state of preparation and level of development of athletes' physical qualities (Afanasiev, 1982). Sharkey (1986) reported that athletic performance evaluation can: (a) determine current fitness levels of athletes, (b) identify individual differences, (c) assess progress in training, (d) spot potential in newcomers, and (e) guide athletes to the proper position or event.

Summary

It may be concluded from the review of literature that several attempts have been made to develop guidelines in order to identify potentially talented individuals in track and field. Throughout the world, countries have employed formalized talent identification programs to find talent and provide the right environment for that talent to develop.

Although some success has been attained, the procedures and methods for predicting potential in specific track and field events have not been universally agreed upon. Methods for talent identification and selection are influenced by socio-cultural, educational, political, and economic factors in each country.

Researchers determined six factors that influenced performance in track and field: (1) physiological and biomechanical, (2) anthropometric and somatotype characteristics, (3) biological, (4) heredity, (5) psychological, and (6) sociological. Test batteries isolated those factors which seemed to predispose an individual to success in various track and field events. Using the six factors as a model, test batteries could be selected and predictions made. Test batteries were presented for sprinters, jumpers, throwers, and multi-eventers. Predictive testing is a tool through which coaches may identify potential talent, assess current fitness levels and guide athletes to the proper position or event.

CHAPTER III

METHODS AND PROCEDURES

The problem of the study was to investigate the degree to which predicting performance in track and field relates to individual performances of men and women on Western Michigan University's track and field teams, utilizing the performance prediction equations of Henson et al. (1989b). Appendix A contains a letter from the Human Subjects Institutional Review Board of Western Michigan University, Kalamazoo, giving approval for the study.

The methods and procedures have been organized in the following manner: (a) subject selection, (b) tests and procedures, (c) pretesting procedures, (d) instrumentation, and (e) data analysis procedures.

Subject Selection

The subjects in the study were volunteers from the 1990-91 men's and women's varsity track teams at Western Michigan University, Kalamazoo. The subjects were college age (18-24 years old) track and field athletes who possessed at least one year of experience as a track athlete. Each athlete participated in at least one of the following eight event categories: (1) sprints, (2) 400m, (3) high hurdles, (4) intermediate hurdles, (5) long jump and triple jump, (6) high jump, (7) pole vault, and (8) throws.

Tests and Procedures

Henson et al. (1989a) restricted testing to measures of leg power because it was found to be a primary determinant of track and field performance and could easily be tested. Anthropometric measures were also obtained because of the ease with which they could be obtained. Henson et al. chose a battery of tests based upon the scientific literature and personal experience in conducting predictive tests. The following 11 tests were presented at the 1989 Indiana University Track and Field Clinic (Henson et al., 1989b): (1) height, (2) weight, (3) vertical jump, (4) standing long jump, (5) five bounds for distance, (6) percent body fat, (7) 60-meter dash, (8) 30-meter dash, (9) 30-meter fly, (10) stride length, and (11) stride frequency. Henson et al. tests used in this investigation are described below.

Demographic Measures

Vital statistics for each subject were measured prior to physical measures. Measurements included: (a) height recorded to the nearest inch, (b) weight measured to the nearest pound, and (c) age recorded to the last year.

Vertical Jump

The athletes stood facing a wall with both hands extended over head. Measurements were placed on the wall in one inch increments. The height at which the fingertips touched was recorded to the nearest inch (standing height). From a standing position, athletes were given two trials in order to jump and reach as high as possible. The best of two attempts was recorded. The standing height was subtracted from the best attempt and the difference was recorded to the nearest inch as the vertical jump height.

Standing Long Jump

Athletes started from a standing position with feet together at the edge of the long jump pit without toes curling over. The subjects jumped as far as possible into the pit landing on both feet. The distance from the edge of the pit (the starting point), to the nearest point of landing in the pit was measured. The best of two trials was recorded to the nearest inch.

Five Bounds for Distance

The athletes started from a standing position with toes behind a starting line. The athletes took four consecutive bounds alternating right and left feet. On the fifth bound, athletes landed with both feet as in the standing long jump. The distance from the starting line to the nearest point where the feet landed on the fifth bound was recorded. The best of two trials was recorded to the nearest inch.

Percent Body Fat

Body fat was determined by measuring skinfolds. Skinfold measurements were taken for the tricep and subscapula for all subjects. Each measurement was taken three times and the average of the three was recorded. The formulas used for calculating percent fat were those of McArdle, Katch, and Katch (1981). Appendix C contains the formulas used for calculating percent body fat.

60-Meter Dash, 30-Meter Dash, 30-Meter Fly, Stride Length, Stride Frequency

The following procedures were used for measuring the 60-meter dash, 30-meter dash, 30-meter fly, stride length, and stride frequency:

1. From the starting line, marks were placed on the track at 30 and 60 meters. Timing lights and photo-electric sensors were placed at 30 and 60 meters. Two digital time clocks were wired to the timing lights and photo-electric sensors. A manually operated tone device initiated the time clocks. When the tone button was pressed, the time clocks started. When the beam of light was broken at 30 meters, the first clock stopped. When the beam of light was broken at 60 meters, the second clock stopped.

2. Athletes started from a standing position with toes behind a starting line. Athletes started sprinting upon hearing an electronic tone. The tone initiated the clocks. No blocks or spiked shoes were used.

3. A video camera was used to record the 30-meter fly. The video was analyzed to determine stride length and stride frequency. Stride length was determined by dividing the total number of strides for the 30-meter fly into the distance covered (i.e., 30 meters). Stride frequency was calculated by dividing the total number of strides for the last 30 meters by the 30-meter fly time (i.e., 60m time - 30m time).

4. The following results were recorded to the nearest 100th of a second: 60m dash time, 30m dash time, flying 30m time.

5. Stride length was measured to the nearest meter and stride frequency was measured in meters per second.

<u>Reliability of Prediction Equations</u>

Henson et al. (1989a) used factor analytic techniques to develop prediction equations for track and field athletes. It was determined that three underlying factors contributed to individual performances: (1) leg power, (2) anthropometric measures, and (3) neuromuscular coordination. These factors determined the variability in performances of the prediction tests.

Using a Principal Analysis with a Varimax Rotation, the researchers were able to determine the number of underlying tests that accounted for the variations in performance in the various track and field events. The prediction equations explained over 77% of the variance in performances, according to P. Turner (personal communication, May 21, 1991), for a larger and more heterogeneous population. The amount of variance explained across events for males ranged from 75 to 80%, while females ranged from 70 to 77%.

Pre-Testing Procedures

Prior to testing, all subjects were informed as to the purpose of the study and gave their consent to participate. (See Appendix B for a copy of the informed consent.) All tests were performed in the manner previously described. Each test was explained and demonstrated for the subjects. Subjects were given several practice trials before measurements were recorded. Testing occurred during track practice over a two day period. All subjects were instructed to give maximal performance on each test. The subjects were given two trials on each of the performance tests, with the best performance being recorded for purposes of this study.

Instrumentation

The following instruments were used to collect data:

1. A standard tape measure was used to record the standing long jump and five bounds for distance. All measurements were in inches.

2. A video camera was used to determine stride length and stride frequency during the 30-meter fly. This method was considered to be reliable and eliminated the possibility of error.

3. Lang skinfold calipers were used to measure skinfold thicknesses.

4. A Toledo weight scale was used to measure subject's weight in pounds.

5. Photo-electric sensors were wired to two digital timing clocks to measure the 60-meter dash, 30-meter dash, and fly times.

Data Analysis Procedures

Performance Criterion

Henson et al. (1989a) utilized multi-event scoring tables as a performance criterion in order to establish a valid and objective performance measure. Best performances were determined for athletes from the head coach. Using the International Amateur Athletic Federation (IAAF) multi-event scoring tables ("Scoring Table for Men's," 1962; "Scoring Table for Women's," 1971) points were determined for each athlete's top performance in an event. Thus, scores from the prediction equations estimated the athlete's potential points on the multi-event scoring tables (e.g., 800 points). The athlete's performance was then predicted (i.e., 800 points corresponded to 22'7 3/4 in. for a male long jumper).

In the present investigation, predictive scores were also compared to performances from 1986 to 1990 for first through eighth place finishers in the Mid American Conference. First through eighth place performances were averaged during the five year period. The performances were converted to a point score using the IAAF multi-event tables.

Statistical Analysis Procedures

The purpose of the statistical analysis was to determine if a relationship existed between the bivariate distribution. The variables were event score and predicted score. A Pearson product-moment correlation coefficient was determined using a Statistical Package for the Social Sciences computer program ("Statistical Package for the Social Sciences," 1991). [A correlation is a statistical summary of the degree of relationship or association between two variables (Hopkins, Glass, & Hopkins, 1987).] T tests were run to determine differences between predicted and event scores. Analysis of variance was used to determine if WMU scores differed significantly from MAC scores. The two independent variables were gender and event. The variable event consisted of seven levels: (1) sprints, (2) 400m, (3) high hurdles, (4) long and triple jump, (5) high jump, (6) pole vault, and (7) throws.

The two dependent variables were event score and predicted score. Event score was determined by converting the athlete's best performance in an event to a point score recorded from the IAAF multi-event tables. Predictive scores were derived from prediction equations of Henson et al. (1989b). A predictive score was calculated for each subject. Appendix D contains prediction equations that were used for each event category. Information from performance tests was used to calculate the individual's predicted performance in multi-event points relating to the IAAF tables.

CHAPTER IV

ANALYSIS OF DATA AND DISCUSSION OF RESULTS

The purpose of the study was twofold: (1) to determine predictive scores for each athlete, and (2) to compare the predictive scores to the individual event point scores published in the International Amateur Athletic Federation (IAAF) men's and women's tables ("Scoring Table for Men's," 1962; "Scoring Table for Women's," 1971). The results of the study will be explained in three parts: (1) the number of male and female subjects in each event category, (2) a descriptive analysis of predicted scores and individual event scores, (3) discussion of results.

Subjects

Twenty-six male and 14 female athletes were tested. Some athletes participated in more than one event, increasing the total number of observations to 47 males and 19 females. Male subjects ranged in age from 18 to 24 years with a mean of 20 years of age. Average height and weight for males was 72.69 inches and 177.15 pounds, respectively. Female subjects ranged in age from 18 to 21 years with a mean of 19 years of age. Average height and weight for females was 67.57 inches and 143.92 pounds, respectively. Table 2 contains the number of athletes tested for each gender and event. Mean performance scores for the vertical jump, standing long jump, five bounds, percent body fat, 60m sprint, 30m sprint, 30m fly, stride length, and stride frequency have been presented for each event in Appendices E and F. Appendix G contains mean performances for males in all eight events. Appendix H contains mean performances for females in all seven events.

Table 2

The Number of Athletes Tested in Each Event Category

Event	Male (n)	Female (n)
Sprints	6	5
400m Run	10	5
110m Hurdles	4	1
400m Hurdles	1	0
Long/Triple Jump	6	3
High Jump	5	2
Throws	10	3
Pole Vault	5	NA

Note. Women do not compete in the pole vault, therefore it was not applicable (NA).

A Descriptive Analysis of Predicted and Individual Event Point Scores

All predictive scores were derived from the prediction equations developed by Henson et al. (1989b). See Appendix D for prediction equations that were used for each event category. Using the appropriate equation, scores from the performance tests were calculated and the individual's predicted performance in multi-event points was recorded. Individual point scores were determined by matching a best individual score in each event with a corresponding score in the IAAF multi-event scoring table. Table 3 contains mean predicted and event scores, standard deviations and correlations for all males and events. The average predicted score for males was 728.18, while the average event score was 777.72. Table 4 contains mean predicted and event scores, standard deviations, and correlations for all females and events.

The average predicted score for females was 583.01 while the average event score was 766.05.

Table 3

Mean Predicted and Event Scores, Standard Deviations, and Correlations Between Predicted and Event Scores for Males

Event	(n)	M Predicted Score	SD	M Event Score	SD	Correlation
1. Sprints	6	682.20	41.25	771.66	155.83	.84*
2. 400m Run	10	683.68	41.41	797.00	108.80	.25
3. 110 Hurdles	4	688.54	47.77	793.50	88.11	.87
4. 400 Hurdles	1	691.37	-------	806.00	-------	----
5. Long/Triple Jump	6	673.29	71.30	764.00	160.63	.65
6. High Jump	5	769.35	142.13	784.20	155.86	.44
7. Pole Vault	5	859.14	55.05	847.80	173.43	-.13
8. Throws	10	766.66	94.46	722.90	77.00	.33
All Males	47	728.18	92.86	777.72	124.48	.30*

* $p < .05$ ** $p < .01$.

Correlations Between Predicted and Event Scores

A Pearson product-moment correlation was derived for males and females as a group, and for each event. Group correlations were derived by comparing predicted scores with event scores. Table 3 shows mean predicted scores and event scores as well as correlations between scores for all males and events. The correlation for males as a group was $r = .30$, (M predicted score = 728.18, M event score = 777.72) with a level of significance $p < .05$. A correction equation was used to correct for a homogeneous population (Hopkins et al., 1987). The formula was calculated using the mean and standard deviation for event scores of collegiate athletes reported by P. Turner (personal communication, April 5, 1991). The correlation rose to $r = .38$, $p < .05$.

Table 4

Mean Predicted and Event Scores, Standard Deviations, and Correlations Between Predicted and Event Scores for Females

Event	(n)	M Predicted Score	SD	M Event Score	SD	Correlation
1. Sprints	5	552.26	73.26	735.00	79.25	.59
2. 400m Run	5	537.43	27.14	734.00	44.62	-.66
3. High Hurdles	1	517.70	-------	737.00	-------	-----
4. 400 Hurdles	0	--------	-------	--------	-------	-----
5. Long/Triple Jump	3	506.55	76.00	807.00	67.50	.52
6. High Jump	2	837.29	14.19	939.50	34.64	-1.00
7. Throws	3	638.98	65.89	724.33	37.01	.91
All Females	19	583.01	110.67	766.05	84.11	.63*

* $p < .05$ ** $p < .01$

Event correlations were derived by comparing predicted scores and event scores for each event. Among the event correlations for males, the sprint group had the highest correlation, $r = .84$, and reached a significance level of $p < .05$ (M predicted score = 682.20, M event score = 771.66). No other event categories produced correlations that were significant at the .05 level of confidence (see Table 3).

The correlation for females as a group was much higher than males, $r = .63$ with a level of significance $p < .05$ (M predicted score = 583.01, M event score = 766.05). Table 4 shows mean predicted scores and event scores as well as the correlations between scores for each event for females. The correction equation was also applied to the female population to correct for homogeneity, producing a correlation of $r = .629$, $p < .05$. There were no significant correlations ($p < .05$) among events for females (see Table 4).

A two-tailed t test was used for testing differences in independent means. For males, t tests indicated significant differences between mean event scores and predicted scores for only two event categories: (1) 400m run $t(9) = -3.40$, $p < .05$; and (2) 110m hurdles $t(3) = -4.09$, $p < .05$. Hence, it appeared that predicted scores were similar to event scores. Table 5 contains a summary of t-test values for each of the eight event areas for males.

For females, t tests indicated significant differences between mean event scores and predicted scores for three event categories: (1) sprints $t(4) = -5.96$, $p < .05$; (2) 400 meter run $t(4) = -6.70$, $p < .05$, and (3) long/triple jump $t(2) = -7.44$, $p < .05$. Hence, for female athletes predicted scores and event scores did not appear to be similar to one another. Table 6 contains a summary of t-test values for each of the eight event areas for males.

Analysis of Variance

Point scores were determined for first through eighth place in each event at Mid-American track and field championships from 1986 to 1990. Point scores were determined from the IAAF multi-event scoring tables. A two-way analysis of variance was used to determine whether differences existed between Western Michigan University's track members and the scores of the top eight place holders in each event of MAC championships. Appendix E contains cell means for variances between MAC performance scores and WMU predicted scores for males.

Table 5

Differences Between Predicted Score and Event Score: Summary of t-Test Values for Eight Event Areas for Males

Event Area	Score	No. of Cases	Mean	SD	t value	df	2-tail prob.
Sprints	Pred.	6	682.20	41.25	-1.78	5	.135
	Evnt.	6	771.66	155.83			
400m Run	Pred.	10	683.68	41.41	-3.40	9	.008
	Evnt.	10	797.00	108.80			
110 Hurdles	Pred.	4	688.54	47.77	-4.09	3	.026
	Evt.	4	793.50	88.11			
400 Hurdles	Pred.	1	691.37	--------	------	0	-----
	Evt.	1	806.00	--------			
Long/Triple Jump	Pred.	6	673.29	71.30	-1.77	5	.137
	Evt.	6	764.00	160.63			
High Jump	Pred.	5	769.35	142.13	-.22	4	.839
	Evt.	5	784.20	155.86			
Pole Vault	Pred.	5	859.14	55.05	.13	4	.906
	Evt.	5	847.80	173.43			
Throws	Pred.	10	766.66	94.46	1.37	9	.204
	Evt.	10	722.90	77.00			

Table 6

Differences Between Predicted Score and Event Score: Summary of t-Test Values for Seven Event Areas for Females

Event Area	Score	No. of Cases	Mean	SD	t value	df	2-tail prob.
Sprints	Pred.	9	552.26	73.26	-5.96	4	.004
	Evnt.	9	735.00	79.25			
400 Run	Pred.	5	537.43	27.14	-6.70	4	.003
	Evnt.	5	734.00	44.62			
100 Hurdles	Pred.	1	517.70	-------	-------	0	------
	Evnt.	1	737.00	-------			
400 Hurdles	Pred.	0	--------	-------	-------	0	------
	Evnt.	0	--------	-------			
Long/Triple Jump	Pred.	6	506.55	76.00	-7.44	2	.018
	Evnt.	6	807.00	67.50			
High Jump	Pred.	2	837.29	14.19	-2.97	1	.207
	Evnt.	2	939.50	34.64			
Throws	Pred.	3	638.98	65.89	-4.18	2	.053
	Evnt.	3	724.33	37.01			

Table 7 contains the ANOVA for main effects and two-way interactions for males. From Table 7, main effects among males indicated a significant difference between scores in the MAC conference (M = 882.68) and predicted scores for WMU athletes (M = 727.74), F (1,53) = 52.77, p < .05. There was significant variance between event scores across all eight event categories for males, F (7, 53) = 3.74, p < .05. This was an expected result, due to the fact that each event was independent with respect to the amount of points that could be scored. Therefore, it was not necessary to determine which events were significantly different. There was no significant interaction effect between performance scores in the MAC and predicted scores, F (1, 53) = 1.29 and $p > .05$.

Table 7

ANOVA Summary Table for Males: Main Effects and Two-Way Interactions

Source of Variance	Sum of Squares	df	Mean Square	F	Sig of F
MAC Performance	332777.183	1	332777.183	52.778	.05
Event Performance	165190.611	7	23598.659	3.743	.05
MAC X Event	56941.815	7	8143.545	1.290	
Within	334175.283	53	6305.194		

Analysis of variance for females indicated a significant main effects difference between performance scores in the MAC (M = 842.00) and predicted scores (M = 582.58), F (1, 24) = 97.72, $p < .05$. There was a significant difference between event scores across all seven event categories for females, F (6, 24) = 4.92 and $p < .05$. This difference was expected due to the fact that each event was independent with respect to the amount of points that could be scored. There was no significant interaction effect between MAC performance scores and predicted scores, F (5, 24) = 2.81, $p > .05$. Appendix F contains cell means for variances between MAC performance scores and predicted scores for females. Table 8 contains the ANOVA for main effects and two-way interactions for females.

Table 8

ANOVA Summary Table for Females: Main Effects and Two-Way Interactions

Source of Variance	Sum of Squares	df	Mean Square	F	Sig of F
MAC Performance	494154.810	1	494154.810	97.729	.05
Event Performance	149405.341	6	24900.890	4.925	.05
MAC X Event	71182.491	5	14236.498	2.816	
Within	121352.800	24	5056.367		

Discussion of Results

A high relationship was expected between subjects' predicted scores and event scores. The results indicated a low relationship for males ($r = .30$) as well as for females ($r = .63$). For males, there was no significant difference between predicted scores and event scores for sprints, long and triple jump, high jump, pole vault and throws. Only two events for males had significant differences between predicted and event scores, the 400m run (M predicted = 683.68; M event = 797.00) [$t(9) = -3.40$, $p > .05$] and 110 hurdles (M predicted = 688.54; M event = 793.50) [$t(3) = -4.09$, $p > .05$]. It should be noted that the 400m hurdle event only had one subject; thus no correlations could be calculated.

Differences between predicted and event scores for females were significant for sprints, 400m run, and long and triple jump. Because only one subject participated in the high hurdles and no participants in the 400m hurdles, correlations and t tests could not be calculated. Female high jumpers (M predicted = 837.29; M event = 939.5) [$t(1) = -2.97$, $p < .05$] and throwers (M predicted = 638.98; M event

= 724.33) [t (2) = -4.18, p <.05] showed no significant differences between predicted and event scores.

Low correlations and significant differences between predicted and event scores seem to support the contention that predicting performance in track and field is a problematical undertaking. Ruderman and Komarova (1984) reported numerous factors including social, educational, physiological, psychological, genetic, and environmental influences that affect the selection of talented athletes. McWatt (1990) reported that there have been few methods for predicting success in track and field events that were universally agreed upon. In the Soviet Union, over 50% of those chosen to participate in sports schools and classes never reached the expected performance levels (Jarver, 1981). Freeman (1979) developed a predictive equation for multi-event athletes based on three events. These equations produced a correlation of r = .76 when comparing athletes' best performances to their predicted scores. Freeman concluded that the equations resulted in considerable inaccuracy for predicting performance levels in the decathlon. In light of these findings, and given the limitations of the present investigation, it can be concluded that Henson et al. (1989b) prediction equations did not accurately predict performance for Western Michigan University's track and field teams.

Several factors influenced the predictability of the equations:

1. As reported by Hopkins et al. (1987), the accuracy of correlation coefficients depends largely on the number of subjects and heterogeneity of the population. With small numbers, correlations are quite unreliable. The greater the variability of the sample, the greater the value of r. In this investigation the population was homogeneous and the number of subjects per event ranged from 1 to 10 and 0 to 5 for males and females, respectively. Correlations as high as r = .87 and

r = .91 for male high hurdlers and female throwers, respectively, were rejected at the .05 confidence level.

2. The athletes in the present investigation were not superior athletes. It was indicated from the ANOVA that the athletes at WMU scored significantly lower than the top eight place finishers in the MAC conference (see Tables 7 and 9). Therefore, a low relationship between predicted and event scores for WMU athletes was possibly attributable to low ability and skill or poor leg power.

3. The equations may not be accurate indicators of potential since Henson et al. (1989a) explained only 50% of the variation in performance with the prediction equations. The researchers concluded that performance was determined by additional factors such as perceptual motor abilities and psychological factors which, if included in the regression equations, could improve predictive capacity.

4. A small number of simple tests of leg power may not be sufficient enough to predict performance in track and field events. Foreman (1980) reported that West German coaches used several tests that were specific to an event, in order to identify potential talent. Henson et al. (1989a) concluded that the tests may be insufficient for predicting best event and recommended that additional tests be used to predict which were the best events for each athlete.

Despite these conclusions, Henson et al. (1989b) prediction equations indicated positive correlations between predicted and event scores. A low positive relationship (r = .30) was determined between predicted and event scores for males. A high positive relationship was determined for females (r = .63). Although relationships were not significant at a .05 confidence level, the investigation revealed high positive correlations for male sprinters (r = .84),110m hurdlers (r = .87), and long/triple jumpers (r = .65). Male 400-meter runners had the lowest positive correlation (r = .25). High positive relationships were determined for female throwers (r = .91) and sprinters (r = .59). The significance of high positive correlations is that Henson et al. (1989b) prediction equations may be best suited for predicting performances in sprinting events or in events which require explosive leg power. It may be noted that t-test analysis indicated no differences between predicted and event scores for male sprinters and female throwers. The 400-meter dash is not an event which would require the same type of explosive leg power as sprints or throws--hence, the low correlation between predicted and event scores. Henson et al. (1989a) found that over 90% of the variation in 60-meter dash performance was determined by performance on the 11 tests. In addition, these tests were measures of leg power.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of the study was to determine if Henson et al. (1989b) prediction equations could accurately measure and predict performance potential of track and field athletes at Western Michigan University, Kalamazoo. The study investigated the degree to which predicting performance in track and field related to individual performances of men and women on Western Michigan University's 1990-1991 track teams. Predictive scores were determined for each athlete and compared to the individual event point scores published International Amateur Athletic Federation (IAAF) men's and women's multi-event scoring tables ("Scoring Table for Men's," 1962; "Scoring Table for Women's," 1971). Henson et al. (1989a) concluded that it was possible to use a small number of simple tests of leg power to predict performance in track and field with relative accuracy. The researchers reported that the equations could be used with a performer of any age and level of competition.

Demographic measures including age, height and weight were recorded for all subjects. Each subject was measured on the following tests: vertical jump, standing long jump, five bounds for distance, percent body fat, 60-meter dash, 30-meter dash, 30-meter fly, stride length, and stride frequency. Using information from the tests and the appropriate prediction equation, predictive scores were calculated. Event scores were determined by converting athletes' best performances in an event to a point score recorded from the IAAF multi event point tables.

Findings

The findings of the study for males were as follows:

1. The correlation between predicted and event score for males ($r = .38$) and females ($r = .63$) was significant at a level of $p < .05$. These correlations were low, thus indicating a low relationship between event and predicted scores.

2. Among event categories, the male sprint group had the only significant correlation ($r = .84$, $p < .05$) between predicted score ($M = 682.20$) and event score ($M = 771.66$), compared with all other events. There was no difference between mean scores for the sprint group.

3. The 110m hurdler group had the highest correlation ($r = .87$, $p > .05$).

4. The pole vault group had the only negative correlation ($r = -.13$, $p > .05$).

5. Correlations for long and triple jump, high jump, throws, and 400m run were .87, .44, .33, and .25, respectively These correlations were also not significant at the $p < .05$ level of confidence. Because only one subject participated in the 400m hurdles, correlations could not be determined.

6. The analysis of variance indicated significant differences between MAC scores ($M = 882.68$) and predicted scores for WMU athletes ($M = 727.74$) for males.

7. t-test results indicated no difference between predicted and event means for male sprints, long and triple jump, pole vault, high jump and throws.

The findings of the study for females were as follows:

1. There were no significant correlations for female events. Female throws had the highest positive correlation ($r = .91$, $p > .05$) followed by sprints ($r = .59$, $p > .05$), and long and triple jump ($r = .52$, $p > .05$).

2. Negative correlations were found for high jump ($r = -1.0$, $p > .05$) and 400m run ($r = -.66$, $p > .05$).

3. The analysis of variance for females indicated a significant difference between MAC scores (M = 842.00) and WMU scores (M = 582.58).

4. t-test results indicated no difference between predicted and event means for high jump and throws.

Conclusions

Based on the findings of this study, the following conclusions were made:

1. The prediction equations of Henson et al. (1989b) resulted in considerable inaccuracy in predicting the performance potential of Western Michigan University's track and field athletes.

2. A positive relationship and no difference between subjects' event scores and predicted scores suggested that predictive testing, though presently ill-defined, may have some merit towards predicting performance in track and field.

3. Many factors play a role in predicting performance besides the 11 test factors used in the present investigation. Other factors which could have been measured that might have determined performance potential were: cardiovascular endurance, anaerobic power, motor skill ability, and psychological profiles. Henson et al. (1989a) recommended that tests of these factors be included in future predictive testing. Thus additional tests are needed to improve predictive capacity.

4. The men and women athletes of WMU are not top performers as compared to those who placed in the MAC conference meets.

Recommendations

The results of this investigation prompted the researcher to make the following recommendations for further study:

1. Further testing should be conducted using the prediction equations on a large group of athletes. Predictive testing in track and field should continue for all ages and levels of development so that a large data base for testing athletes may be obtained.

2. Additional tests are needed. Future testing should include tests of cardiovascular endurance, anaerobic power, motor skill ability, and psychological profiles.

3. Prediction equations need to be developed for specific populations. Coaches and researchers may want to develop equations based upon test results for their own group of athletes, such as high school, collegiate, or elite athletes.

Appendix A

Letter of Approval From Human Subjects Institutional Review Board

Human Subjects Institutional Review Board

Kalamazoo, Michigan 49008-3899

WESTERN MICHIGAN UNIVERSITY

Date: May 9, 1990

To: Ted Dahbs

From. Mary Anne Bunda, Chair Mary Anne Bunda

This letter will serve as confirmation that your research protocol, "Performance Prediction for Track and Field Athletes", has been approved as expedited by the HSIRB. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the approval application.

You must seek reapproval for any change in this design. You must also seek reapproval if the project extends beyond the termination date.

The Board wishes you success in the pursuit of your research goals.

xc: M. Dawson, HPER

HSIRB Project Number 90-04-16

Approval Termination May 9, 1991

Appendix B

Informed Consent Form for Subjects

Informed Consent

I understand that the purpose of the study is to determine the relationship of specific motor fitness abilities to success in track and field events. I understand that I will be asked to perform the following motor fitness tests: (1) vertical jump and reach, (2) standing long jump, (3) five bounds (leaps) for distance, and (4) 60 meter sprint for time. In addition, percent body fat measured by skinfolds, height, weight and age will be recorded. Each test will be conducted on the track inside Read Fieldhouse. Demonstration of proper execution for each test and practice time will be given.

I understand that the 60 meter dash will be measured on one day, the vertical jump and standing long jump on the second day, and five bounds for distance on the third day. Approximately 15 minutes per day will be required to complete the testing.

I understand that I may not benefit directly from this study, but that the research will provide a tool with which the coach can effectively evaluate the motor fitness levels of athletes, and determine an effective training program, thus helping athletes reach their full fitness potential for their respective events.

I understand that the risks involved during testing are those which might occur in track and field during normal practice and performance of events. Every effort will be made to minimize the risks involved by warming up prior to testing. In case of an emergency, an athletic trainer will be on duty. I understand that should an injury occur requiring medical attention, I am responsible for all medical expenses.

I understand that the data obtained will be of strict confidence between myself and the researcher. If I have any questions related to this study I can call Ted Dabbs at 685-9839 to answer any questions prior or during the testing period.

If I wish to drop out of the study I may do so at any time without penalty. I understand that my participation in this study is voluntary and that I may choose not to participate without jeopardizing my membership or position on the track team. I understand that the data from this study will be used to complete a thesis by Ted.J. Dabbs to earn a degree at Western Michigan University.

I have read this form and understand completely the procedures that I will be involved in. I agree to participate in this study.

DATE:____________ SIGNATURE:__________________________

Appendix C

McArdle, Katch and Katch Formulas for Calculating Percent Body Fat

Men: % Body Fat = .43(a) + .58(b) + 1.47

Women: % Body Fat = .55(a) + .31(b) + 6.13

a = Skinfold for Triceps

b = Skinfold for Subscapula

Appendix D

Henson, Turner, and Lacourse (1989b) Prediction Equations by Event Category

<u>Sprints</u>

Men (SLJ x 4.9678) + (Five Bounds x 0.3046) - (60 time x 133.1168) + 1010.0950 = Points

Women (SLJ x 3.8157) - (St 30 x 134.1166) + (SL x 8.5415) + (SF x 110.8153) - 170.5583 = Points

<u>400m Run</u>

Men (SLJ x 2.9262) + (Five Bounds x 0.5976) - (Fly 30 x 88.8492) - (60 time x 142.2417) - (SL x 6.1344) - (SF x 123.0560) + 2514.3782 = Points

Women (60 time x 82.3852) - (St 30 x 303.2141) + (SL x 14.6305) + (SF x 210.8445) - 574.7787 = Points

<u>High Hurdles</u>

Men (VJ x 3.5668) + (SLJ x 0.7467) + (Five Bounds x -0.1073) + (St 30 x -294.8744) + 1906.8449 = Points

Women (Five Bounds x 2.0713) - (60 time x 110.6528) + 704.0166 = Points

<u>Intermediate Hurdles</u>

Men (St 30 x -263.9045) + (Fly 30 x 1480.2400) + (SL x 64.6682) + (SF x 1187.4844) - 13483.3628 = Points

Women (Ht x 113.5512) + (Wt x 21.9133) - (VJ x 96.4892) - (SLJ x 57.1519) + (Five Bounds x 2.1196) - 3055.7840 = Points

<u>Long Jump/Triple Jump</u>

Men (VJ x 13.2340) + (Five Bounds x 1.3244) - (St 30 x 158.1370) + 299.5855 = Points

Women (SLJ x 9.3147) - (St 30 x 465.1540) - (FLY 30 x 292.7833) + (60 time x 263.4266) + 870.2074 = Points

High Jump

Men (Ht x 11.7856) + (VJ x 17.3513) + (SLJ x 3.7465) + (SL x 4.2370) - 1279.6151 = Points

Women (Ht x 17.4034) + (SLJ x 5.3567) + (Five Bounds x 0.7780) - 1134.1855 = Points

Pole Vault

Men(SLJ x 11.2467) + (Five Bounds x 0.9087) - (St 30 x 461.2882) - (Fly 30 x 252.2857) + (60 time x 311.6014) - 343.4741 = Points

Throws

Men (Wt x 2.7556) + (SLJ x 1.2167) + (Five Bounds x 0.5057) - 187.5702 = Points

Women (Wt x 3.1576) - (St 30 x 2541.3591) - (Fly 30 x 2424.1251) + (60 time x 2339.0486) + 1495.5913 = Points

Appendix E

Cell Means for Variances Between MAC Performance Scores and WMU Predicted Scores for Males

Appendix E

Cell Means for Variances Between MAC Performance Scores and WMU Predicted Scores for Males

		Event							
		1	2	3	4	5	6	7	8
M MAC Scores	882.68								
M WMU Predicted Scores	727.74								
M Event Scores		730.38	720.25	757.33	843.00	751.20	806.29	900.14	787.94
M MAC Score		875.50	905.50	895.50	919.00	868.50	899.50	1004.50	824.33
M WMU Score		682.00	683.20	688.25	691.00	673.00	769.00	858.40	766.10

Appendix F

Cell Means for Variances Between MAC Performance
Scores and WMU Predicted Scores for Females

Appendix F

Cell Means for variances between MAC Performance Scores and WMU Predicted Scores for Females

		Event							
		1	2	3	4	5	6	7	8
M MAC Scores	842.00								
M WMU Predicted Scores	582.58								
M Event Scores		631.43 750.78	645.43	690.43	854.50	641.40	885.75	0.00	
M MAC Score		830.50 806.83	916.50	777.00	854.50	844.50	934.50	0.00	
M WMU Score		551.80 638.67	537.00	517.00	0.00	506.00	837.00	0.00	

Appendix G

Mean Performance Scores for Male Subjects for the Vertical Jump, Standing Long Jump, Five Bounds, Percent Body Fat, 60m Sprint, 30m Sprint, 30m Fly, Stride Length, and Stride Frequency

Appendix G

Performance Means for Males

	Events							
Test	Sprints	400m run	110m Hurdles	400m Hurdles	Long/triple	High jump	Polevault	Throws
Vertical Jump	26.50	25.10	25.60	23.00	26.00	24.20	24.00	23.90
Standing Long Jump	110.00	105.60	109.80	103.00	108.50	104.40	106.60	104.80
Five Bounds	553.33	522.10	545.60	488.00	562.66	541.20	541.00	529.20
% Body Fat	7.28	6.97	7.50	6.14	6.57	7.88	8.36	10.69
60m Sprint	6.55	7.84	7.85	7.96	7.83	8.10	7.96	8.26
30m Sprint	4.56	4.55	4.55	4.63	4.52	4.65	4.59	4.71
30m Fly	3.26	3.29	3.30	3.33	3.31	3.44	3.36	3.55
Stride Length	88.01	88.01	88.19	84.74	86.96	86.35	82.41	82.62
Stride Frequency	4.12	4.09	4.08	4.20	4.11	4.00	4.29	4.05

Appendix H

Mean Performance Scores for Female Subjects for the Vertical Jump, Standing Long Jump, Five Bounds, Percent Body Fat, 60m Sprint, 30m Sprint, 30m Fly, Stride Length, and Stride Frequency

Appendix H

Performance Means for Females

	Events						
Test	Sprints	400m run	110m Hurdles	400m Hurdles	Long/triple	High jump	Throws
Vertical Jump	18.0	16.33	18.0	0	17.0	16.0	17.33
Standing Long Jump	80.2	82.33	82.0	0	83.5	79.0	84.33
Five Bounds	386.4	410.0	401.0	0	405.5	424.0	411.33
% Body Fat	14.38	16.35	14.11	0	16.25	16.98	19.86
60 Meter Dash	9.01	9.33	9.19	0	9.32	9.62	9.59
30 Meter Dash	5.08	5.26	5.23	0	5.28	5.45	5.42
30 Meter Fly	3.91	4.06	3.96	0	3.98	4.17	4.17
Stride Length	78.15	78.28	81.57	0	76.53	82.02	79.2
Stride Frequency	3.90	3.73	3.66	0	3.82	3.47	3.59

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