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John L. Haubenstricker
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The Relationship between Skill Level in Taekwondo and Selected Measures of Agility and Balance in College Students

By
Yong- Jin Yoon

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ABSTRACT

THE RELATIONSHIP BETWEEN SKILL LEVEL IN TAEKWONDO AND SELECTED MEASURES OF AGILITY AND BALANCE IN COLLEGE STUDENTS

By

Yong-Jin Yoon

The purpose of this study was to determine whether skill in Taekwondo is associated with agility and/or balance ability. The subjects were volunteer males and females in three Taekwondo clubs. The subjects were organized into four groups based on their Taekwondo skill level. Subjects were tested on their agility, dynamic and static balance. One-way MANOVA was used to compare agility and balance performance across the skill levels. Performance on the agility, static balance, and dynamic balance measures was not significantly different between the skill groups. However, subjects who had experience in other martial arts or in single and dual competitive sports involving a lot of agility and balance showed better scores than subjects with previous experience in team sports or other individual sports such as archery and weight lifting. Pearson Product-Moment correlation coefficients were computed to measure relationships between the two agility tests, static balance and dynamic balance, and agility and dynamic balance. Results revealed that there were positive correlations between the two agility tests ($r= .55$), static and dynamic balance ($r= .40$), and agility and dynamic balance ($r= .34$, $r= .32$).

To My Parents

Mr. Chang-Seon Yoon and Mrs. Bok-Young Lee

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CHAPTER I

INTRODUCTION

Research has shown that practicing agility and balance can improve athletic performance in a variety of sports. Agility is an important ability in most physical activities, including dual and team sports. These activities require quick starts and stops, rapid changes of direction, and efficient footwork; all essential for successful performance (Phillips & Hornak, 1979). Experts such as Johnson & Nelson (1986) agree that ... "balance is an important ability that is used in everyday activities, such as walking and standing, as well as in most games and sports" (p.236). Also, agility and balance are believed to be very important for the participant in martial arts.

The martial arts include many different styles ranging from Taekwondo, the Korean form of fighting which emphasizes kicks and punches, to Aikido, a set of noncombative, defensive throwing techniques (Richman & Rehberg, 1986). Today Taekwondo is practised throughout the world as a means of self-defense, as a sport, and as a program of physical conditioning.

Although the relationship of agility and balance to soccer, volleyball, and swimming has been documented (McCloy & Young, 1954; Mohr & Haverstick, 1956; LeSueur, 1974), only heresay evidence has been presented to link agility and balance to the martial arts. In fact, until recently, little scientific research had been done on the martial arts. Moreover, most of the studies that have been conducted have focused their attention on psychological factors such as self-esteem (Richman & Rehberg, 1986; Duthie, Hope, & Barker; 1978), aggression and success (Kules, 1983), meditation (Gabert, Sylvia, & Liegerot, (1984)), relaxation (Weinberg, Seabourne, & Jackson, 1981), personality (Beard, 1982), and achievement (Ko, 1986). A few studies have examined skills such as techniques of kicking during competition (Hallander, 1988; Hwang, 1987; Reinoehl, 1988). Gabert, Sylvia, & Liegerot (1984) found the visual reaction time performance of Karate (Japanese martial arts) subjects to be superior in latency response to previously published test scores for baseball, football, swimming, and general population subjects.

Studies on the relationship between sports and agility or balance ability have focused on traditional physical activities such as gymnastics, wrestling, dance, badminton, and tennis. To date, no study has attempted to investigate Taekwondo which is a form of the Korean martial arts, with regard to agility and balance. Because of the dearth of specific knowledge concerning Taekwondo and the elements of agility and balance, this study was designed to investigate this relationship.

Need for the Study

Agility and balance are important physical attributes in many athletic events. They also are believed to be very important for the participant in Taekwondo. This study seeks to determine the importance of these abilities to proficiency in Taekwondo. If significantly greater agility and balance performances are demonstrated by the higher skilled Taekwondo individuals when compared to the lesser skilled participants, then it may be possible that practice and improvement in agility and balancing skills can aid in the acquisition of Taekwondo skills.

Purpose of the Study

The purpose of this study was to determine the relationship of agility and static and dynamic balancing ability to skill level in Taekwondo among college students.

Hypotheses

The following hypotheses were investigated:

1. Higher level Taekwondo groups have greater agility than lower level Taekwondo groups.

2. Higher level Taekwondo groups have greater static and dynamic balance than lower level Taekwondo groups.

3. There is a positive relationship between agility and dynamic balancing ability.

4. There is a no relationship between static and dynamic balancing ability.

Assumption of the Study

It was assumed that agility, static balance and dynamic balance could be defined and measured.

Limitation of the Study

The study was limited to volunteer subjects in three Taekwondo clubs at Michigan State University.

Definition of Terms

Agility: the physical ability that enables `rapid and precise change of body position and direction. (Johnson & Nelson, 1986, p. 226)

Static Balance: the physical ability that enables one to hold a stationary body position. (Johnson & Nelson, 1986, p.236)

Dynamic Balance: the ability to maintain balance during movement, as in walking a fence or leaping from stone to stone while crossing a brook. (Johnson & Nelson, 1986, p. 236)

Taekwondo: the Korean martial art and a form of self-defense. Translated literally, Tae means "to kick or smash with the feet", Kwon refers to "punching or destroying with the hand or fist", and Do means "way or method". It is the technique of unarmed combat for self-defense which is an accumulation of well organized, deliberately-styled forms intended to do the work usually accomplished by mechanical weapons. (Ko, 1986, p.53)

Skill Level: A subject's skill level based on belt color. For this study, the levels were divided into subgroups: 1) white and yellow belts (novice), 2) green and blue belts (intermediate), 3) red and brown belts (advanced), and 4) black belt (expert).

CHAPTER II

REVIEW OF LITERATURE

A very limited amount of research has been conducted in relation to the present problem. For a better understanding of the present study, this review of literature is organized in the following manner : (1) agility and its relationship to sports, (2) balance, static balance, dynamic balance, and their relationship to sports, (3) relationships among measures of balance, (4) correlations between balance and agility, and (5) summary.

Agility and its Relationships of Sports

Agility is generally considered to be an important factor in physical fitness and motor ability. Coaches of different sports point out the importance of agility for good performance in their respective sports. (Chelladurai, Yuhasz, & Sipura, 1977).

Agility has been defined in various ways. Johnson & Nelson (1969) defined agility as "the physical ability which enables an individual to rapidly change body position and direction in a precise manner" (p.100). Agility also has been defined as "the rapidity and ease with which the individual can change the direction or movement of the body or its parts" (Yuhasz,1973, p.23), or "the rapid and accurate movement of the total body in response to a stimulus" (Chelladurai, 1976, p.36).

Fleishman defined the speed of total body change of direction as "the ability to make repeated rapid movement which involves muscle flexibility" (1964, p.79). Moreover, McCauliff (1968) defined agility as "the ability to rapidly and accurately change the position or direction of the body through large range of movement" (p.4).

Chelladurai, et al. (1977) classified agility in relation to various stimulus fields as follows, "simple agility where there is no variation in the stimulus field, temporal agility where there is variation only in the timing of appearance of the stimulus, spatial agility involving only spatial variation, and universal agility which is a response to both temporal and spatial variation" (p.1320).

In the past, it was believed that agility was almost entirely dependent on heredity. However, numerous research studies revealed that agility can be improved through practice, training, and instruction. Some investigators examined the development of agility through intervention programs. Hilsendager, Strow, and Ackerman (1969) studied the relationship of agility to speed and strength, using thirty-one tests in a six-week program. The purpose of the study was to determine whether exercises designed specifically to develop strength and speed were as effective for improving agility as exercises designed specifically to develop agility. They concluded that agility can best be developed by programs designed specifically for that purpose.

Physical educators and coaches used to believe that the muscular development associated with weight training was harmful to skill coordination. However, Masley, Hairabedian, and Donaldson (1953) found that weight training tended to favorably affect the coordination of performers. In addition, Frost (1977) reported superior development of agility with a combined weight and flexibility training program than with either method performed separately.

Studies have shown a positive relationship between agility and performance in athletic events. Keller (1942) investigated the relationship of quickness of bodily movement to success in athletics. His findings indicated that athletes were faster than nonathletes on agility measures. Furthermore, participants in baseball, basketball, football, and track were significantly faster than gymnasts, swimmers, and wrestlers. McCloy and Young (1954) used the Edgren side-step test as an index of agility to predict performance outcome in games and skills. They found the test to be highly correlated with the prediction of basketball potentiality and suggested that it may also be correlated with ability in tennis, hockey, soccer, speedball, and football.

Mohr and Haverstick (1956) investigated the relationship between height, jumping ability, agility, and volley skills in 102 women university students enrolled in eight-week volleyball courses. The volley skills consisted of repeated volleys at three feet and seven feet from a target. A significant relationship ($r = .42$) was found between agility and volleying skill at the three-foot distance.

Several studies have linked agility to tennis playing ability. Baumann (1975) reported a significant positive correlation between tennis performance and agility ability. Buti, Elliott, and Morton (1984) reported that elite prepubescent tennis players have better agility than normal prepubescent schoolchildren.

On the other hand, several studies showed no improvement in agility after sport activity training. Tiburzi (1969) did not find improvement of agility ability after a five-week program of fencing. Beise and Peaseley (1937) investigated the relationship of reaction time, speed, and agility of big muscle groups to skills in individual sports such as tennis, golf, and archery. The subjects were selected from the university physical education classes. The test was given at the beginning of the season's activities and repeated after a seven-week instructional period. During classes, each student was exposed to fourteen hours (two hours a week) of training. They found no significant effect on either speed or agility after seven weeks of training.

Balance

Balance is defined by Larson and Yocom (1951) as the "ability of the individual to control organic equipment neuromuscularly" (p.161). Scott and French (1950) attribute this neuromuscular ability specifically to semicircular canal functioning, kinesthetic sensations, visual perceptions, and the coordination of the response to these stimuli. Cureton (1947) states that balance emphasizes mental control and poise, kinesthesis, and the anatomical and physiological capacities that regulate acts of balance. Wells (1955) concluded that the ability to maintain equilibrium under unfavorable

circumstances is a basic skill in physical activity.

Research has shown that there are at least two types of balance-- static and dynamic. Static balance is the ability to maintain body equilibrium in a relatively fixed position whereas dynamic balance is the ability to balance while in motion (Stallings, 1982). Balance is obtained through the combined effort of simple reflexes, proprioceptive information relayed to the cerebrum and cerebellum, functioning of the reticular formation and vestibular apparatus, voluntary movements, and visual information (Singer, 1980).

Several researchers have suggested that vision is an important factor in balance performance (Homick & Reschke, 1977; Weissman & Dzendolet, 1972; Nashner, 1982). Ribadi, Rider, and Toole (1987) investigated static and dynamic balance in sighted, sighted blindfolded, and congenitally blind students using the stork stand and the stabilometer as measures of balance. The results revealed significant differences between all three groups. The sighted group demonstrating superior balance on both measures, and the blind subjects performed significantly better than the sighted blindfolded group for dynamic balance.

Several studies have been made on the development of balancing ability. Riley (1952) reported in her study involving elementary children that balance ability increases with grade level. Seashore (1947) suggested that the learning of balance tasks significantly improves between the ages of 12 and 17 years and the ability to balance may be most efficient between the ages of 15 and 18 years. After the age of 19, no systematic change in balancing behavior has been found. Also, Bachman (1961) found a significant upward trend in the amount of learning of balance skills for both sexes between 12 and 17 years. However, Espenschade's study (1947) showed little change in balance over the age range of 10 to17 years. Woollacott, Debu, and Shumway-Cook (1987) suggested that maintaining balance during incongruous sensory signals does not seem to mature until about seven to ten years of age.

Generally speaking , there is a common belief that women have better balance than men because of their lower center of gravity due to their structural anatomy. Fearing (1924) found women had a slight advantage over men in ability to static balance. However, Wapner and Witkin (1950), using an unstable platform, showed men had better balance than women. Travis (1944, 1945) compared men's and women's performance on the rotary chair and the stabilometer. He reported no sex differences on the rotary chair performance and a slight difference favoring the women on the stabilometer. Bachman (1961) investigated the influence of age and sex on balance with three hundred twenty subjects. He found no sex difference in balance learning ability in the age range of 6 to 26 years. More recently, Eckert (1979) investigated the theorized inverse relationship of balance and stability. He reported that females outperformed males on the stabilometer, however, males performed better than females on the ladder climb.

Height, weight, foot length, tension, and age all have been identified as factors influencing balancing ability. Travis (1945) found that height, weight, and foot length have no effect on static balance but seem to be of considerable importance in dynamic balance. He found that weight affects dynamic balance in men. Seashore (1947) reported that weight and height were related to dynamic balance ($r = .59$, $r = .61$) at lower ages (5-12 yrs.), but not as closely related ($r = .20$, $r = .15$) at adolescent ages (13-18 yrs.). In contrast, Espenschade, Dable, and Schoendube (1953) concluded that neither height nor weight ($r = .04$, $r = -.02$) were important in dynamic balance (beam walking task). However, they found that balance improved with chronological age between the ages of 11 and

16 years, but the rate of gain for boys between the ages of 13 and 15 years was noticeably slowed. They also found that dynamic balance correlated substantially with physical abilities important in physical education programs.

Some investigators have suggested that excessive fatigue reduces balance control. Wyrick (1969) studied the effect of ankle strength on the balancing performance of fifty-six college female subjects using the Bass Stick test. She found ankle strength to be unrelated to the balance performance of her subjects. However, the results revealed that performance level was influenced by the order of task presentation. Wyrick concluded : "... the practice effect from taking a balance test last in order facilitates performance more than concomitant fatigue inhibits it" (Wyrick, 1969, p.623). William (1980) also reported no significant relationship between dynamic balance and ankle strength after an eight-week ankle strengthening exercise program. Miller and Bird (1976) questioned the importance of ankle strength and suggested that the knee and hip flexors and extensors are the most important muscle groups for performing dynamic balance tasks.

At one time, it was generally believed that balance was inherited and that there was very little the average person could do to improve his or her balance. However, numerous studies have shown that balance can be significantly improved via practice in training programs. Garrison's experiment (1953) indicated that the balance ability of college women could be improved with the teaching of balance exercises and principles. He had taught generalized tumbling stunts, such as the tip-up and headstand. The improvement occurred particularly in the dynamic balance area. He found that both experimental and control groups improved in static balance after the experimental groups had been taught exercises designed to improve balance. It appeared that significant learning occurred after the first administration of the balance tests. Also, Bailey(1963) reported a significant difference, which she attributed to practice, between the first and sixth one-minute trial of a static balance test.

The evidence has shown that balance can be improved with practice. Wyrick (1970) suggested that improvement of balance can best be accomplished through practice of a balance activity. Shick and Stoner (1977) and Teichman (1986) agree that improvement in balance can best be accomplished through the practice of balance tasks. These investigators believed that if balance could be improved, it would seem logical that subsequent motor performance also could be enhanced. The effect of previous practice and the effect of practice during the trial should be determined with precision.

One study demonstrated that balance can be improved without training on specific balance oriented tasks. McLeod (1988) examined the effect of a visual skills training program on balance performance using a four-week video tape visual skills training program. The results revealed a significant improvement in the dynamic balance performance scores of the subjects.

Static Balance

Static balance was defined by Bass (1939) as "that balance in which equilibrium is maintained for one position of the body" (p.33). One of the first major attempts to analyze balance was done by Bass (1939). She performed a factor analysis of balance using scores from several stick balance tests and various dynamic balance tasks. Her analysis revealed that static balance involved four factors : 1)the three semicircular canals, 2)kinesthetic sensitivity and response, 3)foot tensions reenforcing the goal response, balance, and 4)vision. In addition, Bass concluded that static balance was an important, if not essential, element in dynamic balance.

Seashore (1947) defined static balance as being composed of three components: physical, neuromuscular, and psychological. The physical component was defined as the state of the body acted upon by forces of which the resultant force is zero. The neuromuscular component referred to the maintenance of a specified body position in which the antagonist muscles are so engaged that there is minimal local and general body sway. The psychological component was defined as the postural orientation of the body when the organism is motivated to remain motionless.

Several researchers have reported a positive relationship between static balance and gross motor ability. In an investigation of static balance, Estep (1957) had instructors rate high school girls according to their general motor ability. From these ratings the subjects were classified into high and low groups and measured for body sway using the Miles' ataxiameter. The results revealed a positive relationship between mean sway and high motor ability, indicating the importance of static balance in motor ability.

Specific programs designed to improve static balance have achieved the best results. Mueller (1983) and Khalsa, Morris, and Sifft (1988) found significant improvement in static balance to occur only when a specific program was designed to facilitate this objective. These studies also showed that a general activity program does not improve static balance.

Dynamic Balance

Dynamic balance was defined by Bass (1939) as the ability to keep one's equilibrium while changing from one balanced position to another, or while changing through a series of positions. Also, Seashore (1947) defined dynamic balance as being composed of three segments: physical, neuromuscular, and psychological. The physical component of dynamic balance was defined as the state of the body when the weight is so distributed that the resultant of the forces is varying from moment to moment. The neuromuscular component was defined as the maintenance of an organized postural orientation under conditions in which the activity pattern of the muscles is continually changing. The psychological component was defined as the postural orientation of the body, when the organism is performing a specified motor activity, which involves relatively large motions of all or part of the body which act to disturb the gross orientation of the organism. (p.247)

In another study, utilizing a beam-walking task designed by Seashore, Espenschade et al. (1953) measured dynamic balance in adolescent boys. They found balancing ability was substantially related to physical abilities as determined by performance in physical education classes. Balance scores correlated .62 with physical education grades received at the termination of a unit. Also, Black (1983) reported that dynamic balance significantly improved in an experimental group of subjects after a twelve-day (50 hour) outdoor adventure program. Vance (1977) suggested that dynamic balance increases with age (7 to 16 yrs.) with some evidence of a decline or leveling off in performance during puberty.

Relationship of Balance to Sports

Investigators have shown balance to be an important component of motor ability. Bass (1939) concluded that dynamic and static balance involve the same factors although some additional factors in dynamic balance are possibly more complex and of a different type. Balance can be considered a fundamental physical ability which underlies proficient performance of many gross motor skills, including many skills necessary for successful performance in sports and physical activities (Klein, 1971).

If balance is important in athletic activities, then athletes should perform better than nonathletes on tests of balance.

Slater-Hammel (1956) investigated dynamic balance performance with three groups of male college students : a) varsity athletes, b) physical education majors, and c) liberal arts majors. He reported that varsity athletes performed significantly better than physical education majors and liberal arts majorson the balance measures, and that physical education majors performed significantly better than liberal arts majors. Also, he concluded that balance is an essential component of motor ability.

Numerous studies have attempted to determine the contribution of physical activities to improvement in balance. Since Espenschade (1947) reported that dynamic balance seemed to be a part of motor coordination in certain skills, it was logical that later investigations examine the role balance plays in specific sport skills. Mumby (1953) studied the potential to predict wrestling skill with a measure of balancing ability, obtained by having subjects assume the wrestling crouch position on a stabilometer. He found that skilled wrestlers have better balancing ability than lesser-skilled wrestlers. Also, Johnson (1977) reported that successful wrestlers had better balance than the unsuccessful wrestlers. However, Garrison (1953) reported that improvement in balance resulting from practice in balance skills did not affect students' skill in badminton and modern dance. On the other hand, Greene (1962) reported that skilled badminton players have better static balance ability than unskilled badminton players. Matz (1954) found that a training program in gymnastics increased rail walking scores beyond the increases that might be attributable to maturation; however, since there was no control group, it was impossible to determine how much of the improvement was attributable to the gymnastics program. Gross and Thompson (1957) found that individuals having superior dynamic balance swim better and faster than individuals with poorer balance.

Valentine (1961) analyzed the direct effect that dance activity had on static balance. The subjects tested were enrolled in a regular physical education class. Included in the design of the experiment was the use of a control group for analysis. Three tasks were utilized, the Bass Stick, a beam walking task, and a standard unstable platform. Results confirmed that skaters and dancers possessed significantly better balance scores than did members of the control group. Also, Bovee (1971) investigated the effects of social dance on selected physical responces in 76 freshman college students. The social dance group met twice per week for 8 weeks and the control group was in an archery class for the same period of time. The results revealed that social dance made significantly greater contributions to balance than did archery.

Relationship among Measures of Balance

Many investigators (Bass, 1939; Cowell, 1962; Drawatsky & Zuccato, 1967; Travis, 1945; Tyler, 1961) have suggested that static balance is often unrelated to various measures of dynamic balance because dynamic balance is a complex phenomenon comprised of many factors. Correlations between dynamic and static balance tests were low, and factor analyses found that the loadings for dynamic and static balance differed. Positive, but low, relationships between static balance scores and scores on tests of other types of balance were reported.

Travis (1945) reported low correlations (- .04, - .10) between static and dynamic balance when comparing stabilometer performance and body sway. Drowatzky and Zuccato (1967) studied the intercorrelation of static balance and dynamic balance in fifty seventh grade girls. They measured static balance with the stork stand, diver's stand, and Bass Stick test, and measured dynamic balance using a sideward leap task, the Bass Stepping Stone test, and a balance beam walking test. The results showed low intercorrelations between static and dynamic balance (see Table 1) (Drawatzky & Zuccato, 1967). Only one correlation was significant --between the Sideward Leap and Bass Stepping Stone test. They concluded that each test measures a different type of balance. However, they suggested that static balance factors are partly responsible for dynamic balance.

Table 1
Intercorrelations for various static and dynamic balance measures

Test	Diver's Stand	Bass Stick	Sideward Leap	Bass Stepping Stone	Balance Beam Walk
Stork Stand	.1392	-.1166	.2601	.1961	.0272
Diver's Stand		-.1245	-.0282	-.0702	-.1357
Bass Stick			-.0395	.2229	-.1903
Sideward Leap				.3083*	.1932
Bass Stepping Stone					.1802

*Significant at the .05 level.

Travis (1945) also found that the dynamic component of balance is quite unrelated to the static balance component after studying body sway and stabilometer performances. Tyler (1961) investigated balance intercorrelations with 184 subjects. The results yielded a correlation coefficent of .30 between static and dynamic balance.

Correlations between Balance and Agility

The relationship between balance and agility has been a concern in empirical investigations. Cumbee, Meyer, and Peterson (1957) performed a factor analysis of motor coordination variables on scores obtained from 92 third and fourth grade pupils. Using a multiple group method of factoring, they found total body balance to correlate positively with speed of change and direction. This correlation was .324 and was considered statistically significant. Also, Hunt (1963) reported that balance is slightly but positively related to agility.

Summary

The review of literature indicated that agility and balance are very important abilities in most sports activities. Several studies have shown that agility and/or balance can improve with athletic performance (Baumann, 1975; Buti et al., 1984; Greene, 1962; Gross et al., 1957; Johnson, 1977; Keller, 1947; McCloy et al., 1954; Mumby, 1953; Slater-Hammel, 1956). On the other hand, other studies showed no improvement after athletic training (Beise et al., 1937; Garrison, 1953; Tiburzi, 1969). Also, some investigators suggested that agility and/or balance can be best improved when a specific program is designed to facilitate that objective (Garrison, 1953; Hilsendager et al., 1969; Khalsa et al., 1988; McLeod, 1988; Mueller, 1983; Teichman, 1986; Wyrick, 1970). Although most of these studies were concerned with various sports, no study has attempted to investigate the martial arts. Therefore, the study of relationships between one of the martial arts (Taekwondo) and agility and/or balance may have implications for training in the martial arts.

CHAPTER III

METHODS AND PROCEDURES

The purpose of this study was to investigate the relationship of agility, and static and dynamic balancing ability to Taekwondo skill level among college students. In this chapter, the methods and procedures followed in conducting the study are described under the following headings: (1) subjects, (2) design, (3) testing materials, (4) testing environment, (5) data collection, and (6) data analysis.

Subjects

The subjects in this study were 42 male and 6 female volunteers from three Taekwondo clubs at Michigan State University. They ranged in age from 18.25 to 42.08 years with a mean age of 23.44 years (S.D.=5.46) for the males and 21.43 (S.D.=5.24) for the females. All the subjects were students enrolled at Michigan State University, and all but 6 were caucasian.

Permission to approach the members of the Taekwondo clubs was sought from the master instructors. After obtaining permission, the investigator met with the members, either individually or in groups, to explain the purpose of the study and enlist their participation. The subjects were informed of their right to withdraw from the study without penalty or recrimination. A sign-up schedule for testing and a consent form (Appendix A) were made available to those members who volunteered to participate. All individuals who volunteered were tested.

The subjects were grouped by their level of proficiency in Taekwondo according to the color of belt obtained, as follows : novice (white or yellow belt), intermediate (green or blue belt), advanced (red or brown belt), and expert (black belt). Because skill level requirements in the Korean martial arts are the same for males and females, the performance scores of the males and females were combined for the subsequent analyses. However, their scores also were grouped by gender and compared to available normative data.

Design

The research model for this study was an Ex Post Facto one way design with the four skill groups representing the independent variable. Univariate and/or multivariate analysis of variance

(ANOVA and MANOVA, respectively) were used to differentiate among the groups on two agility and two balance performance scores which served as the dependent variables. A Pearson Product Moment Correlation matrix was used to determine the relationships between the measures of balance and agility.

Testing Materials

Testing materials consisted of a demographic information sheet (Appendix B), a score sheet (Appendix C), a sequence of procedures for administering the tests (Appendix D), information about each of the four tests (Appendix E), and a form for recording the sports activity history of each subject (Appendix F).

Two agility and two balance tests were selected based on a review of the literature. Many studies have shown the importance of agility in sports performance. Taekwondo requires that participants be able to make rapid changes in direction with their whole bodies, body parts, and their feet.

Agility was assessed using the Side Step Test and the Quadrant Jump Test, as modified by Johnson and Nelson (1969). The better performance of two trials was taken as a subject's score on each test. Detailed information about each test is located in Appendix E.

Both dynamic and static balance were assessed. The Modified Sideward Leap Test (Johnson & Nelson, 1969) was used to measure dynamic balance. A reliability coefficient of r= .88 for college students was reported by Scott and French (1959). The subject's score was the sum of two trials with the left foot and two with the right foot. Static balance was measured using the Stork Stand Test (Johnson & Nelson, 1969). Bosco and Gustafson (1983) suggested that the Stork Stand Test is both a practical and reasonable test of static balance. A test-retest reliability coefficient of .87 was obtained by Jensen (1970) when the best of three trials on one day was compared to the best of three trials on a subsequent day. In the current study, the best of three trials was used as a subject's score. These tests are explained in further detail in Appendix E.

A brief sports activity history was obtained from each subject to determine potential factors that may have influenced the development of agility and balance prior to the current study (see Appendix F). For example, subjects with extensive experience in other martial arts and/or agility demanding sports may perform well on the agility tests even though they are classified as "novices" in the Taekwondo.

Testing Environment

All testing was done in the Center for the Study of Human Performance at Michigan State University. Four stations with appropriate floor markings were set up in the area designated for testing motor performance.

A pilot study was conducted in January, 1989 to permit the investigator and his assistants to become thoroughly familiar with the administration of each test and to establish a general sequence of procedures to follow during actual data collection. Five individuals participated in the pilot study, but were not included in the actual study. Based on feedback received from the participants in the pilot study, it was decided to administer the tests in the same order to all subjects. Most of the subjects performed to do the agility tasks first and the Stork Stand last, because the Stork Stand caused local muscle fatique. The order was the Side Step Test, Quadrant Jump Test, Modified Sideward Leap Test, and the Stork Stand Test.

Data Collection

All testing and data collection took place between January 26, 1989 and February 13, 1989. The subjects were tested individually, but within groups of two to four during a scheduled period. Upon their arrival at the Center for the Study of Human Performance, the investigator repeated the purpose of the study and explained the tests to the subjects. The subjects were then asked to complete the demographic data sheet. The tests were then demonstrated in the order in which they were to be taken. The subjects were given two or three practice trials on each test to make certain they understood what they were to do. All trials were videotaped to assist in the accuracy of scoring. After completion of the testing, the subjects were given a sports activity history form to complete and then thanked for their participation. Arrangements were made to report the outcome of the study to them.

Data Analysis

Descriptive statistical analyses were employed to provide basic information about the agility and balance of students participating in Taekwondo and to permit comparisons with similar age groups in other reports.

A one-way multivariate analysis of variance (MANOVA) or separate one-way analysis of variance (ANOVA) procedures were used to determine performance differences among the four groups on the four dependent variables (depending on the interrelationships of the agility and balance scores). Discriminant function analysis or post hoc tests were to be applied when significant group differences were obtained with the MANOVA or ANOVA procedures, respectively (Borg & Gall, 1983).

A Pearson Product Moment Correlation matrix was computed to determine the relationships between the four dependent variables. Significance level was set at .05 for all the analyses.

CHAPTER IV

RESULTS AND DISCUSSION

Analysis of Data

The purpose of this investigation was to determine the relationship of agility and static and dynamic balancing ability to skill level in Taekwondo among college students. The statistical procedures and analyses outlined in the Chapter Three were applied to the data. The Statistical Package for Social Science (SPSSX) program at the Michigan State University Computer Center was used for these analyses.

Descriptive Statistics for the Performance Variables

Table 2 shows the means and the standard deviations for all of the selected variables. The mean performance values for the males on the agility and balance tests were higher than those for the females. However, due to the small number of available female subjects, no further comparisons were made between the males and females. Because skill level requirements in the Taekwondo are the same for males and females, the performance scores of the males and females were combined for the subsequent analyses.

Table 2
Means and standard deviations of the selected variables

	Male		Female		Total	
Variables	Mean	S.D.	Mean	S.D.	Mean	S.D.
Age (months)	281.24	65.51	257.17	36.58	278.23	62.86
Weight (pounds)	162.90	20.41	129.83	19.18	158.77	22.91
Height (inches)	70.00	2.54	65.50	2.66	69.44	2.94
Side Step	27.40	3.26	24.66	1.21	27.06	3.21
Quadrant Jump	28.02	3.79	24.50	2.26	27.58	3.80
Stork Stand	38.31	30.43	21.83	8.23	36.25	29.07
Sideward Leap	51.71	5.56	48.50	3.89	51.31	5.45

Johnson and Nelson (1986) reported norms for college age students on the Side step, Quadrant Jump, Stork Stand, and Modified Sideward Leap (see Appendix G). The performances of the subjects in the present study compared favorably with those reported by Johnson and Nelson. For both males and females, the mean performance of the Taekwondo groups on each test equaled or exceeded the intermediate performance level of the college students reported by these investigators.

Multivariate Analysis of Variance

The purpose of this study was to examine the relationship of agility and balance to skill level in Taekwondo. The means and standard deviations for the skill level groups on the tests of agility and balance are presented in Table 3. The SPSSX program, MANOVA, was used to examine the data. The MANOVA procedure simultaneously examines differences among groups on multiple dependent variables. The Wilks' Lambda statistic was utilized to determine significant differences. Significance was set at the .05 level.

Table 3
Means and standard deviations for the skill level groups on the tests of agility and balance

Skill Group	N	Side Step		Quadrant Jump		Stork Stand		Sideward Leap	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Expert	7	28.00	3.21	28.29	3.55	37.57	32.69	49.71	6.45
Advanced	9	26.89	2.15	27.11	3.37	40.33	21.79	50.11	4.14
Intermediate	14	27.21	3.12	28.50	4.52	26.64	27.48	51.71	6.12
Novice	18	26.67	3.82	26.83	3.60	41.17	32.36	52.22	5.30
Total	48	27.06	3.21	27.58	3.80	36.25	29.07	51.31	5.46

Examination of Hypothesis 1

The first hypothesis --that higher skill level Taekwondo groups have greater agility than lower skill level Taekwondo --was tested using a one-way MANOVA with performance on the Side Step and Quadrant Jump as the dependent variables. The results are presented in Table 4.

The multivariate test results indicated that the predictor set did not have a statistically significant impact on the dependent variables at the .05 level, $F(6, 86) = .379$, $p = .890$. Both of the eigenvalues (.042, .011) have relatively little variability associated with them. In summary, there was no significant difference among the skill levels on the agility measures. The first hypothesis was not supported.

Table 4
MANOVA for group (level) differences on the Side Step and Quadrant Jump

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Wilk's Lambda	.94911	.37927	6.00	86.00	.890

Examination of Hypothesis 2

The second hypothesis was that higher level Taekwondo groups have greater static and dynamic balancing ability than lower level Taekwondo groups. The Stork Stand and Modified Sideward Leap tests were used to measure static and dynamic balance, respectively. The results of the one-way MANOVA are presented in Table 5.

Table 5
MANOVA for group (level) differences on the Stork Stand and Sideward Leap

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Wilk's Lambda	.89975	.77745	6.00	86.00	.590

The multivariate test results indicate that the predictor set did not have a statistically significant impact on the dependent variables. The multivariate F ratio indicated that there was no significant effect at the .05 level, $F(6, 86) = .777$, $p = .590$. Both of the eigenvalues (.084, .026) have little variability associated with them. In summary, there was no significant difference among the skill levels on the static and dynamic balance measures. Thus, the second hypothesis was not supported.

Intercorrelation of Performance Variables

Examination of Hypotheses 3 and 4

The third and fourth hypotheses were that there would be (a) a positive relationship between agility and dynamic balancing ability and (b) no relationship between the static and dynamic balancing ability. The Pearson Product-Moment correlation coefficients presented in Table 6 were used to evaluate these hypotheses.

Table 6
Intercorrelations between agility and balance measures

	Quadrant Jump	Stork Stand	Sideward Leap
Side Step	.5521**	.3832**	.3445**
Quadrant Jump		.3293*	.3223*
Stork Stand			.4047**

*Significant at the .05 level.
**Significant at the .01 level.

A coefficient correlation of .55 ($p < .01$) was found between the Side Step and Quadrant Jump, both measures of agility. Also, the results showed that the Sideward Leap (dynamic balance) scores correlated $r = .34$ ($p < .01$) with the Side Step scores and $r = .32$ ($p < .05$) with the Quadrant Jump scores. Therefore, hypothesis 3, that there would be a positive relationship between agility and dynamic balancing ability was tenable, although the coefficients were of a relatively low magnitude. Also, the Stork Stand (static balance) scores correlated $r = .40$ ($p < .01$) with the Sideward Leap (dynamic balance) scores. Therefore, hypothesis 4, that there was no relationship between the static and dynamic balancing ability was not supported. However, the size of the correlation coefficient indicates that only 16 percent of the variance for static and dynamic balance is shared in common.

Relationships between Motor Skills and Sports Activity History

The results of the MANOVA analyses showed that performance on the two agility, the static balance and the dynamic balance measures were not significantly different among the Taekwondo skill levels. Because experience in other sports may have had an impact on agility and balance performance, the experience of the subjects in other sport activities was examined. Table 7 shows the average number of seasons or years of experience they had in other sport activities. The results indicated that the subjects with the highest skill level in the Taekwondo (level 4) had fewer years of experience in other sports than the subjects in the other skill levels.

The responses of the subjects on the brief sports activity history they completed were categorized into one of four groups as follows.

History 1 : other martial arts such as Judo, Akido, and Isshinrue (one of the Japanese martial arts).

History 2 : single or dual competitive sports involving a lot of agility and balance such as wrestling, cycling, skiing, water skiing, skating, fencing, surfing, tennis, and racketball.

History 3 : team sports such as soccer, volleyball, basketball, football, and baseball.

History 4 : other sports which place less emphasis on agility and/or balance such as swimming, track & field, cross country, golf, jogging, and weight lifting.

Table 7
Means and standard deviations of years or seasons of sports experience for Taekwondo skill levels

Level	N	Mean	S.D.
Expert	7	6.86	5.70
Advanced	9	14.00	12.32
Intermediate	13	12.31	9.05
Novice	17	8.24	4.98
Total	46	10.30	8.33

Means and standard deviations for each sport history group on the agility and balance measures were calculated and are presented in Table 8. The subjects in the sports History 1 and 2 groups showed better scores than those in the History 3 and 4 groups on the Side Step, Quadrant Jump, and Stork Stand. Also, the subjects in History 1 showed slightly better scores than those in History 2, 3, or 4 on the Modified Sideward Leap.

Table 8

Means and standard deviations for agility and balance measures by sports history groups

Sports Group*	N	Side Step Mean	Side Step S.D.	Quadrant Jump Mean	Quadrant Jump S.D.	Stork Stand Mean	Stork Stand S.D.	Sideward Leap Mean	Sideward Leap S.D.
History 1	4	30.00	4.32	28.00	4.36	81.75	47.94	53.25	5.12
History 2	19	27.79	2.49	29.00	3.43	33.53	22.81	51.11	4.81
History 3	7	24.57	2.57	25.43	1.99	31.71	26.58	51.29	7.30
History 4	16	26.63	3.50	26.94	4.11	32.38	25.33	50.94	6.06

* Categorized by years of most sports experience.

Since the mean of the static balance (Stork Stand) scores (81.75) for subjects with previous experience in the martial arts (History 1) was much higher than those of the other sports categories, a one-way (Stork Stand by Sports History) analysis of variance was conducted. The results are presented in Table 9. There was a significant difference between the sports history groups on the Stork Stand, $F(3, 42)=4.080$, $p= .012$. Application of Tukey post hoc test procedures revealed that the History 1 group performed significantly better in static balance than the other three groups. Also, the mean of the Side Step scores (30.00) for subjects with previous experience in the martial arts (History 1) was slightly higher than those in the other sports categories. A one-way (Side

Step by Sports History) analysis of variance was conducted and the results are also presented in Table 9. There was a significant difference between the sports history groups on the Side Step, $F(3, 42)=3.263$, $p= .031$. Results of the Tukey post hoc tests revealed that the History 1 group was significantly better in performing the Side Step test than were members of the History 3 group, but not better than that of individuals in the groups 2 and 4. On the other hand, there were no significant differences between the sports groups on the Quadrant Jump and Sideward Leap.

Table 9

Analysis of Variance for group (History) differences on the agility and balance measures

Source	d.f	F	Sig.
Side Step	3, 42	3.263	.031
Quadrant Jump	3, 42	2.074	.118
Stork Stand	3, 42	4.080	.012
Sideward Leap	3, 42	.184	.907

Discussion of Results

The purpose of this section is to compare the results of this study with the related literature. Comparisons will be made for agility, balance, relationships among measures of agility and balance, and sport history.

Agility

Several studies have shown that agility is related to successful performance in sports (Baumann, 1975; Buti et al., 1984; Keller, 1942; McCloy et al., 1954; Mohr et al., 1956). However, the results of the present study did not differentiate among skill groups in Taekwondo. It might be helpful to examine the results of this study in practical terms. It could be assumed that, since a lot of turning movements are made in Taekwondo, the subjects studied need a different type of agility than the one assessed. This study has shown that agility, as measured by the Side Step and Quadrant Jump tests, considered by itself would not serve as a deciding factor for identifying Taekwondo ability.

Since males and females must meet the same criteria for attaining belt levels, gender differences were not a primary forcus of this study. However, the availability of the data for both males and females permitted a preliminary analysis of sex differences in performance on the Side Step and Quadrant Jump tests. The results of *t*-test analyses revealed that the males performed better than the females on both of these agility tests (see Table 10).

Balance

Several studies have reported significant relationships between performance in sports and balance ability (Greene, 1962; Johnson, 1977; Klein, 1971; Mumby, 1953). Balance also is believed to be an important factor for success in the martial arts. However, neither static nor dynamic balance were found to be a deciding variable in Taekwondo skill ability in this study.

There is common belief that women have better balance than men (Fearing, 1924). Although several studies have reported no sex differences in balance (Bachman, 1961; Travis, 1944, 1945), Eckert (1979) reported females were better than males on the stabilometer, and males were better than females on the ladder climb. The results of this study suggest that males are significantly better than females in static balance (Stork Stand) but are not different from females in dynamic balance (Table 10).

Relationships among Measures of Agility and Balance

Several studies have pointed out that static balance is unrelated to dynamic balance (Bass, 1939; Drawatsky et al., 1967; Travis, 1945; Tyler, 1961). However, the results of the present study showed that static balance was positively related ($r = .4047$) to dynamic balance.

Table 10
Results of t-test for the performance of males and females on measures of agility and balance

Variables	Sex	N	Mean	Stan. Error	DF	t Value	p.
Side Step	M	42	27.4047	.503	18.33	3.88	.001
	F	6	24.6667	.494			
Quad Jump	M	42	28.0238	.585	9.64	3.23	.009
	F	6	24.5000	.922			
Stork Stand	M	42	38.3094	4.694	29.74	2.85	.008
	F	6	21.8333	3.361			
Sideward Leap	M	42	51.7143	.858	8.27	1.78	.111
	F	6	48.5000	1.586			

Cumbee et al. (1957) and Hunt (1963) suggested that balance was related to agility. The results of this study showed that the correlations (Table 8) between the agility tasks and the balance tasks also were positive, but of low magnitude (r= .38, r= .34, r= .33, and r= .32).

Relationships between Motor Skills and Sports Activity History

The results of this study must be accepted with some caution because differential experiences in other sports among the subjects may have affected the results. The results of the Sports History

Survey support this concern. Subjects who were categorized in History 1 (other martial arts) or in History 2 (single or dual competitive sports involving a lot of agility and balance) showed better scores than subjects who were categorized in History 3 (team sports) or in History 4 (other sports which are less dependent on agility and/or balance). These results agree with the several studies which reported that athletes, who participated in sports involving a lot of agility and/or balance, performed better than non-athletes on agility and/or balance tasks (Beise et al, 1937; Buti et al., 1984; Greene, 1962; Johnson, 1977; Keller, 1942; Klein, 1971; Masley et al., 1953; Mohr et al., 1956; Slater-Hammel, 1956). Furthermore, the results indicated that subjects who had experience in other martial arts performed better on the Stork Stand than the other history groups. This experience may have affected the static balance results because a lot of balance motion is involved in martial arts skills.

Summary of Findings

The following is a summary of the findings of the present study:

1. The mean performance of the Taekwondo groups in the present study equalled or exceeded the mean performance of college students reported by other investigators.

2. Performance on the agility , static balance, and dynamic balance measures was not significantly different among the Taekwondo skill groups.

3. There were positive correlations between the two agility tests ($r= .55$), static and dynamic balance ($r= .40$), and agility and dynamic balance ($r= .34$, $r= .32$) using Pearson Product- Moment correlation coefficients.

4. Subjects who had experience in other martial arts or in single and dual competitive sports involving a lot of agility and balance showed better scores than subjects with previous experience in team sports or other individual and dual sports that are less dependent on agility or balance.

5. The t-test results revealed that male scores on the two agility and the static balance tests were higher than those for the females, although the number of female subjects were small ($n=6$).

CHAPTER V

Summary, Conclusions and Recommendations

Summary

A review of the literature indicated that there is very little research information concerning the martial arts. The purpose of this investigation was to determine the relationship of agility and static and dynamic balance to Taekwondo skill level among college students, using performance on the Side Step, Quadrant Jump, Stork Stand, and Modified Sideward Leap tests as the dependent variables. The subjects involved in the study consisted of 42 male and 6 female volunteer students who were members of Taekwondo clubs at Michigan State University. The subjects were assigned by skill level (belts) to one of four groups: novice, intermediate, advanced, and expert.

The first hypothesis for this study was that higher level Taekwondo skill groups would have greater agility ability than lower level Taekwondo skill groups. A one-way MANOVA revealed that there was no significant difference in agility among the skill groups.

The second hypothesis was that higher level Taekwondo skill groups would have greater static and dynamic balancing ability than lower level Taekwondo skill groups. The one-way MANOVA revealed that there was no significant difference between the skill groups in their performance on static balance and dynamic balance tests.

The third and fourth hypotheses, respectively, were that there was a positive relationship between agility and dynamic balancing ability, but no relationship between the static and dynamic balancing ability. Pearson Product-Moment correlation coefficients revealed that the third hypothesis was tenable because dynamic balance correlated .35 with the Side Step and .32 with the Quadrant Jump. On the other hand, the fourth hypothesis was untenable because there was a correlation of $r = .41$ between static balance and dynamic balance.

Conclusions

The relationships between Taekwondo skill level and performance on tests of agility and balance were not significant. Based on the results of the MANOVA and correlational analyses, the following conclusions seem justified:

1. Agility and balance (static, dynamic) are not significantly related to Taekwondo skill abilities as signified by belt level.

2. There is low positive relationship between the measures of agility and dynamic balance (r= .3445, r= .3223).

3. Dynamic balance and static balance are positively related (r= .4047).

4. There is a positive correlation between the two agility tests, Side Step and Quadrant Jump (r= .5521).

5. Subjects who had experience in other martial arts or in single and dual competitive sports involving a lot of agility and balance showed better scores than subjects with previous experience in team sports or other individual and dual sports that are less dependent on agility or balance.

Recommendations

The following recommendations are suggested for further study :

1. A similar study needs to be conducted using a large sample of subjects to firmly establish the relationship between Taekwondo skill level and agility or balance.

2. Since age might be related to collegiate Taekwondo skill level or agility and balance tasks, a study should be undertaken where age level is controlled.

3. An experimental study with pre- and post tests is needed to determine the effects of Taekwondo training on agility and balance.

4. Finally, new tests of agility and balance that reflect Taekwondo skills need to be developed.

APPENDIX A

Consent Form

Appendix A

Consent Form

I,____________________ , freely consent to participate as a volunteer in a study of Taekwondo playing ability and its relationship to agility and balance.

The study involves participation on tests of agility and balance. I further understand that my participation in this study will be independent and that all results will be treated with strict confidence and anonymity in any reports or publications dealing with this project.

The study and my participation in the study have been defined and fully explained to me and I understand this explanation. I understand that my participation is voluntary and does not guarantee any beneficial results, but that I will be provided with the opportunity to obtain information regarding the results of this study. I further understand that I am free to withdraw my consent and discontinue my participation at any time without penalty or recrimination.

I understand that if I am injured as a result of my participation in this research project, Michigan State University will provide emergency medical care. I also understand that any other medical expenses incurred will be the responsibility of my own health insurance program.

__________ Date   ____________________ Signature of Subject

Investigator : Yong-Jin Yoon, Graduate Student of
Health Education, Counseling Psychology &
Human Performance, Michigan State University
355-0762

APPENDIX B

Demographic Information Sheet

Appendix B

Demographic Information Sheet

1. Name : ______________________

2. Subject Number : ______________

3. Level : ( ) White or Yellow Belt

   ( ) Green or Blue Belt

   ( ) Red or Brown Belt

   ( ) Black Belt ________ Degree

4. Birth Date : ____/____/____

5. Weight : __________ Pounds

6. Height : __________ Inches

APPENDIX C

Score Sheet

Appendix C

Score Sheet

Subject Number : ______________ Date : __/__/__

1. Agility

a. Side Step Test

Trial 1. ____(Pts) — ____ (Errors) = ______ (Score)

Trial 2. ____(Pts) — ____ (Errors) = ______ (Score)

b. Quadrant Jump Test

Trial 1. ____(Pts) — ____ (Errors) = ______ (Score)

Trial 2. ____(Pts) — ____ (Errors) = ______ (Score)

2. Static Balance

Stork Stand Test

Trial 1. ________

Trial 2. ________

Trial 3. ________

3. Dynamic Balance

Modified Leap Test

Trial 1. __/__/__ (RT)

Trial 2. __/__/__ (RT)

Trial 3. __/__/__ (LF)

Trial 4. __/__/__ (LF)

APPENDIX D

Instructions for Administration of Tests

Appendix D

Instructions for Administration of Tests

1. Introduce yourself to the subject.

2. Explain the purpose of tests to the subject.

3. Complete the demographic data sheet for the subject.

4. Explain and demonstrate the method of tests to the subject.

5. Tell the subject he or she will have i)two trials of Side Step and Quadrant Jump Tests, ii)three trials of Stork Stand Test, and iii)four trials of Modified Sideward Leap Test.

6. Record the number or time on every trial (Administrator).

7. Record the number of errors on every trial (Assistant).

8. Thank the subject for his or her time.

APPENDIX E

Test Battery

Appendix E

Test Battery

1. Side Step Test

Objective : To measure the rapidity by which lateral movement can be made and changed to the opposite direction.

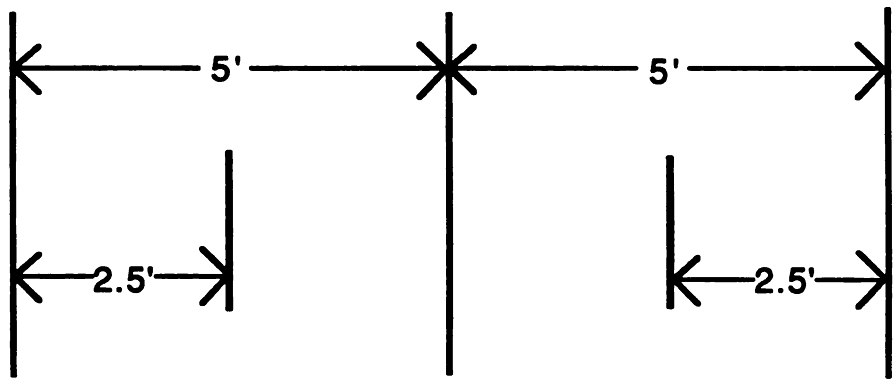
Equipment and Materials : Marking tape and a stopwatch.

Layout : Place three parallel lines five feet apart on the floor as shown in the diagram below.

Directions : From a standing position astride the center line, (a) the performer sidesteps on the signal "go" to the right until his foot has touched or crossed the outside line. (b) He then sidesteps to the left until his left foot has touched or crossed the outside line to the left. (c) He repeats these movements as rapidly as possible for 10 seconds.

Scoring : A 1-foot tick mark should be placed between the center and each outside line to facilitate the spreading of scores. Each trip from the center line across a marker counts as one. For example, moving to the right the performer crosses a tick mark for one point, the outside marker for two, back across the tick mark for three, the center marker for four, across the left tick mark for five, across the outside marker for six and so on until he hears the signal to stop at the end of 10 seconds. The better performance of two trials is recorded as the test score.

Notes : There is a one point penalty for each time one foot is crossed over the other and for each failure to get the proper foot on or across the outside marker.



2. Quadrant Jump Test

Objective : To measure the agility of the performer in changing body position rapidly by jumping.

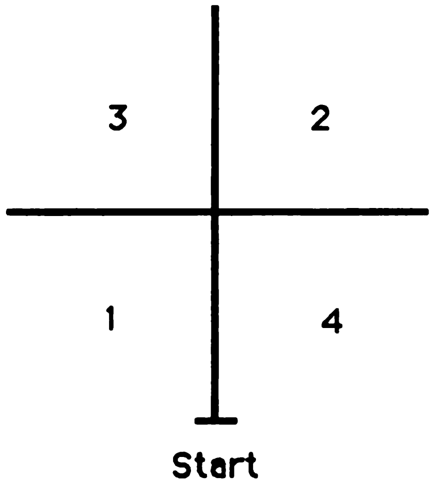
Equipment and Materials : Marking tape (1" width) and a stop watch.

Layout : Two 3 foot lines cross each other at right angles at their respective midpoints. A starting point and each of the quadrants are marked as shown in the diagram below.

Directions : The performer begins behind the starting line and on signal begins to jump with both feet into quadrant 1, then into 2, 3, 4 and back to 1. The pattern is continued for 10 seconds until the signal to stop is given.

Scoring : The score is the number of times the performer's feet land in a correct quadrant in 10 seconds minus 1/2 point for each time the feet land on a line or in an improper zone. The better performance of two trials is recorded as the test score.

Notes : A performer who slips, stops prematurely, or for some other reason was denied a fair trial should be given an additional trial. Assistants can be used to count to the number of jumps and the number of errors while the administrator gives the signals.



3. Stork Stand Test

Objective : To measure static balance of the performer supported on the ball of the foot of the dominant leg.

Equipment and Materials : A stopwatch.

Direction : The subject stands on the foot of the dominant leg and places the other foot on the inside of the supporting knee and the hands on the hips. On a given signal, he raises the heel from the floor and maintains balance as long as possible without moving the ball of the foot from its initial position or letting the heel touch the floor. Three trials are given.

Scoring : The score is the longest time in seconds between when the heel is raised and balance is lost on the best of three trials.

Notes : The performer cannot remove the hands from the hips during the test.

4. Modified Sideward Leap Test

Objective : To measure the ability to land accurately and to balance during and after movement.

Equipment and Materials : Anthropometer, tape measure, marking tape, stop watch, and small objects.

Layout : A landing spot (A) is marked on the floor with several starting points (X) marked at 3 inch intervals from 24 inches to 40 inches in a line from A. Two object marks (B, C) are placed 18 inches on either side of A in a line perpendicular to X. Place small object on B or C. The block should be 1" x 1" x 1".

Directions : Measure the subject's leg from the trochanter to the floor to determine the appropriate starting X. This spot should be the nearest X which corresponds most closely in distance to the length of the leg. The performer places the appropriate foot on the designated X mark and leaps sideward landing on spot A with the ball of the opposite foot. The subject then immediately leans forward and pushes the small object off spot B or C and maintains balance. The performer executes two trials on each side.

Scoring : The score for the performer is the total number of points accumulated across the four trials. On each trial the subject is awarded five points for covering spot A on the landing, five points for immediately lowering (within 2 seconds) and pushing the small object off B or C, and one point for each second the balance is held up to 5 seconds. The total possible score for the four trials is 60 points.

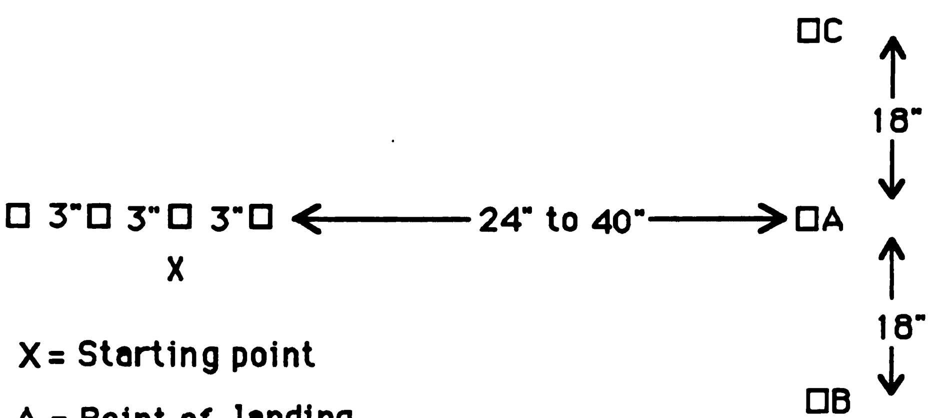
Notes : If subjects fail to cover spot A with the ball of the foot upon landing or fail to maintain a steady position, the five points for correct landing are sacrificed. However, they may reassume the correct position and, within 2 seconds, lower and push the object from B or C and continue for the balance time.

If performers take longer than 2 seconds to remove the object from B or C, five points are sacrificed, but they may continue for the balance time.

If performers lose their balance before 5 seconds elapse, the score for that part of the test is the number of seconds that balance was held.

Performers should be timed on the 5 second balance from the time they assume a steady position on the ball of the foot at spot A. Thus, if it takes 2 seconds to push the object from B or C, then they would have only 3 seconds left to maintain a balanced position.

The timer should count the seconds aloud.



X = Starting point

A = Point of landing

B & C = Point for pushing off small object

APPENDIX F

Sports Activity History

Appendix F

Sports Activity History

Name : ____________________ Subject Number : ____________

Directions : Please answer the questions below as accurately as possible. This information will be helpful in interpreting your performance on the Agility and Balance tests you took recently.

1. Have you received training in any martial arts or self-defense courses other than Taekwondo, Tang Su Do, or Karate? If yes, explain and indicate level of proficiency achieved, such as belt level.

   YES_____ NO_____ If yes, please explain : ____________________

   ____

2. Have you participated in any organized community, school or club activities (e.g. Little League Baseball, Dance Lessons, Gymnastics, Ice Skating, High School Football, Junior High Basketball)? If yes, please list the activity or activities, the number of seasons or years you participated and your success in the activity (e.g. First Team Varsity Baseball).

   YES_____ NO_____ If yes, please explain :

	Activity	Seasons/Years	Proficiency Level
i)	______________	__________	______________
ii)	______________	__________	______________
iii)	______________	__________	______________
iv)	______________	__________	______________
v)	______________	__________	______________

3. Please indicate any other activities you have been involved in that you think might have influenced your performance on the Agility and Balance tests.

   ____

Thank you for your cooperation. Please return to Yong-Jin Yoon.

APPENDIX G

Norm Scores from Johnson and Nelson

Norms from Johnson, B. L. and Nelson, J. K. (1986)

Raw Score Norms for Side Step Test

College Men	Performance Level	College Women
30 - Above	Advanced	24 - Above
26 - 29	Adv. Intermediate	20 - 23
16 - 25	Intermediate	14 - 19
12 - 15	Adv. Beginner	10 - 13
0 - 11	Beginner	0 - 9

Based on the scores of 125 college men and 125 college women at Corpus Christi State University, Corpus Christi, TX., 1976

Raw Score Norms for Quadrant Jump Test

College Men	Performance Level	College Women
31- Above	Advanced	33- Above
25- 30	Adv. Intermediate	27- 32
13- 24	Intermediate	14- 26
7- 12	Adv. Beginner	8- 13
0- 6	Beginner	0- 7

Based on the scores of 75 college men and 75 college women at Corpus Christi State University, Corpus Christi, TX., 1976

Raw Score Norms for Stork Stand Test

College Men	Performance Level	College Women
51 - Above	Advanced	28 - Above
37 - 50	Adv. Intermediate	23 - 27
15 - 36	Intermediate	8 - 22
5 - 13	Adv. Beginner	3 - 6
0 - 4	Beginner	0 - 2

Based on the scores of 50 college men and 50 college women at Corpus Christi State University, Corpus Christi, TX., 1976

Raw Score Norms for Modified Sideward Leap Test

College Men	Performance Level	College Women
58 - 60	Advanced	58- 60
53 - 57	Adv. Intermediate	51- 57
42 - 52	Intermediate	39- 50
37 - 41	Adv. Beginner	33- 38
0 - 36	Beginner	0- 32

Based on the scores of 50 college men and 70 college women at Corpus Christi State University, Corpus Christi, TX., 1976

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