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THE RELATIONSHIP BETWEEN BALANCE AND FUNDAMENTAL MOTOR SKILL PERFORMANCE OF CHILDREN WHO ARE DEAF

By

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ABSTRACT

THE RELATIONSHIP BETWEEN BALANCE AND FUNDAMENTAL MOTOR SKILL PERFORMANCE OF CHILDREN WHO ARE DEAF

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The purpose of this study was to investigate the relationship between the balance and fundamental motor skill performances of children who are deaf. The sample included 56 girls and 50 boys aged 4 to 12 years. Static balance was measured using a stork stand test, and dynamic balance was measured using a heel-toe beam-walk test. The Developmental Sequences of Fundamental Motor Skills Inventory (Seefeldt & Haubenstricker, 1974) was used to assess the subjects' performances on running, galloping, hopping, skipping, jumping, catching, throwing, striking, punting, and kicking. Chi-square analyses revealed that: (a) static balance was related to the performances of each of the ten fundamental motor skills that were assessed, and (b) dynamic balance was only related to the hop, skip, and throw. These results suggest that instructional activities for children who are deaf should be designed to improve both balance and fundamental motor skills.

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CHAPTER I

INTRODUCTION

The first five years of life generally are regarded as the period during which the fundamental motor skill patterns emerge (Wickstrom, 1975). Some of the fundamental motor skills include the locomotor skills of running, skipping, hopping, galloping, and jumping, and the object control skills of catching, striking, throwing, kicking, and punting. The ability to balance has also been shown to develop before the age of five years (Frankenburg & Dodds, 1967; Keogh, 1969). A broad base of balance and fundamental motor skill provides the foundation for later participation in the games, dance, and sport activities of our culture. Successful involvement in leisure and sport activities can lead to a lifetime of physical, social, and emotional well-being.

The opportunity for some deaf people[1] to attain the maximum benefits of sport and physical activity may be limited. Deaf children have displayed difficulties in both fundamental motor skill acquisition and balance ability. Research has shown that deaf children display delays in the acquisition of mature levels of fundamental motor skills (Butterfield, 1987; Dummer, Haubenstricker, & Stewart, 1989). Butterfield (1987) found that in the skills of kicking, jumping, catching, and hopping, deaf children displayed fewer mature patterns than expected for children of equal chronological age. Dummer, Haubenstricker, and Stewart (1989) found that deaf youngsters demonstrated deficiencies in hopping, leaping, horizontal jumping, skipping, striking, bouncing, catching, kicking, and throwing. In general, researchers have found that deaf children displayed balance deficiencies as compared to their hearing counterparts (Long, 1932; Boyd, 1967; Lindsey & O'Neal, 1976).

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[1]The author is aware of the importance of using "people first" language. However, for ease in reading this manuscript, "people who are deaf" will be referred to as "deaf people."

The inability to acquire mature levels of fundamental motor skills at earlier ages may be due to the inability to balance. Only one study has linked the inability to balance with the inability to acquire mature levels of fundamental motor skills for deaf children. This study by Butterfield (1987) showed that, for a selection of 10 fundamental motor skills, the higher the level of performance, the greater the score in balance. It is imperative that this relationship be examined so that early attempts can be made to improve the balance and fundamental motor skills of deaf people.

Need for the Study

Only one study has examined the relationship between the ability to balance and the ability to perform fundamental motor skills for deaf children (Butterfield, 1987). In this study by Butterfield, a direct relationship was found between balance and fundamental motor skill performance. However, the skills of punting and galloping, two fundamental motor skills important to the success in specific games and sports, were not examined. Also, the Scale of Intra-Gross Motor Abilities (SIGMA) (Loovis & Erving, 1979), which was the assessment tool used to examine the level of fundamental motor skill performance, does not provide an adequate assessment of mature skill for some test items, in that the highest performance level possible for some skills falls short of a truly mature movement pattern.

Further knowledge of the relationship between the performance of balance and fundamental motor skills for deaf children would allow physical education teachers to more effectively enhance balance and motor skill acquisition. If it is true that balance ability has an effect on the performance levels of fundamental motor skills for deaf people, then teachers and researchers should begin to focus their efforts on ways to most effectively enhance both balancing ability and fundamental motor skill acquisition. If practitioners are to be expected to base instructional content on empirical evidence, then this relationship must be investigated.

Purpose of the Study

The purposes of this study were to: (a) examine the balance characteristics and fundamental motor skill performance characteristics of deaf children aged 4 through 12 years, including the influence of gender and age on such characteristics; and (b) determine if balance relates to the level of performance of the fundamental motor skills of throwing, catching, striking, kicking, punting, running, jumping, skipping, galloping, and hopping of deaf children.

Hypotheses

It was the intent of this study to examine the following hypotheses:

(1) There is a positive relationship between age and the ability to balance. As age increases, the ability to balance for deaf children also increases.

(2) There is no difference in the ability to balance between males and females.

(3) There is a positive relationship between fundamental motor skill performance and static balance performance for deaf children.

(4) There is a positive relationship between fundamental motor skill performance and dynamic balance performance for deaf children.

(5) There is a positive relationship between age and the ability to perform the fundamental motor skills for deaf children. As age increases, the ability to acquire mature levels of fundamental motor skill increases.

(6) There is no difference between males and females in the ability to perform the fundamental motor skills for deaf children.

In addition, descriptive data were obtained relative to degree of hearing loss, age at onset of hearing loss, and cause of hearing loss.

Overview of Research Methods

This is a cross-sectional, descriptive study designed to obtain data on the balance and fundamental motor skill performance of deaf children. Data from the study originally conducted by

Dummer, Haubenstricker, and Stewart (1989) were used. The independent variable in this analysis was balance performance, with level (1, 2, 3, 4, or 5) of fundamental motor skill performance the dependent variable.

The subjects in this study were grouped according to their balancing ability. Subjects were categorized as balancers if they could maintain a stork stand for ten seconds (static balance) or if they could perform 10 heel-toe steps on a balance beam (dynamic balance).

The fundamental motor skills of running, hopping, jumping, skipping, galloping, throwing, catching, striking, kicking, and punting were assessed using the Developmental Sequences of Fundamental Motor Skills Inventory (DSFMSI) (Haubenstricker & Seefeldt, 1976; Sapp, 1980; Seefeldt & Haubenstricker, 1974; Seefeldt & Haubenstricker, 1976a; Seefeldt & Haubenstricker, 1976b; Seefeldt & Haubenstricker, 1976c; Seefeldt, Reuschlein, & Vogel, 1972), a qualitative assessment instrument. Videotaped performances of each of the students were analyzed. Students' scores were rated according to the quality of performance they displayed, with 1 representing an immature skill level, and 3, 4, or 5 (depending on the skill) representing a mature skill level. If, for example, they displayed behavior meeting the criteria for a Stage 3 throw, they would be given a "3" for their performance.

Once balance performances and fundamental motor skill performances had been assessed, a chi-square analysis was performed to determine whether a relationship existed between balance and the performance of each fundamental motor skill. This research plan is described in detail in Chapter III of this study.

Delimitations

The population for this study was delimited to deaf children who attended two schools for deaf students, one in the United States (School A) and one in Canada (School B). The population of students was delimited further due to parental consent. Only those students given permission to participate by their parents were subjects for this study. The study was further delimited by the test battery designed to measure balance. The only measures of balance videotaped were the stork stand on the preferred foot with eyes open and the balance beam walk.

Limitations

The investigator was aware of the following potential weaknesses in the study.

(1) The effects of the facilities used for the testing sessions on the test of balance and performance of the fundamental motor skills of the subjects is unknown. This is especially true for the performances of the skills of kicking and throwing due to the limited space (20 -30 meters) available for the throw for distance and kick for distance results. Subjects may not have exerted themselves fully because they felt confined by the finite space available. The quality of the performances may have been affected. Conversely, the wall may have acted as a motivator. Some subjects may have strived to hit the wall, exerting themselves fully.

(2) Neither the tests of balance nor of fundamental motor skills had been standardized for deaf people. Although students were instructed using their preferred mode of communication, it is unknown whether instructions were fully understood. However, subjects were given additional demonstrations and instructions if it was clear that they misunderstood the original directions.

Definitions

Fundamental Motor Skills - The fundamental motor skills are the locomotor skills of running, skipping, hopping, jumping, and galloping, and the object control skills of catching, throwing, kicking, striking, and punting.

Static Balance - In this study static balance was measured using a stork stand test. Subjects stood on one foot, placing hands on hips, and the ankle of the resting foot near the knee. Subjects were timed to see how long they could maintain this stance. The clock was started when the ankle of the resting foot was placed near the knee. The clock was stopped when the resting foot moved out of position, or when the support foot was moved from its original position.

Dynamic Balance - Dynamic balance was assessed using a balance beam walk. Subjects walked the length of a 3.04 m beam using heel-toe steps. The number of steps taken across the beam before the subject stepped off or stopped walking heel-toe were counted.

CHAPTER II

REVIEW OF LITERATURE

The research topics examined in this review of literature include the balancing ability of both deaf and hearing children, and the influence of age and gender on their ability to balance; the performance of fundamental motor skills of both deaf and hearing children, and the influence of age and gender on the ability to perform the fundamental motor skills; and the influence of balance ability on performances of fundamental motor skills.

Balance Skills of Children and Youth

The ability to balance can conceptually be broken down into two types, static and dynamic. Static balance, as defined by Seashore (1947), is the maintenance of a specified body position in which the antagonistic muscles are so engaged that there is minimal local or general body sway. Dynamic balance, as defined by Bass (1939), is the ability to keep one's equilibrium while changing from one balanced position to another or through a series of positions taken successively.

Identification of the two types of balance was derived from several studies in which the results of several balance tests were subjected to correlational and factor analytic statistical techniques. The tests used for the two different types of balance are unique. Tests of static balance, include the balance board, the balancometer, the stabilometer, and the stick balance. Tests of dynamic balance include the balance beam test, rail walking test, leap test, and stepping stone test (Drowatsky & Zuccato, 1967; Hempel & Fleishman, 1955). Correlations between the two types of tests were low, and factor analyses found that factor loadings differed. In this review, the findings of Bayley (1935, 1969), Frankenburg & Dodds (1967), McCaskill and Wellman (1938), and Keogh (1969) will be highlighted to describe the development of balancing abilities. Other studies will be summarized to describe age and gender differences in the ability to balance.

Development of Balancing Ability

An individual's progress in achieving various balancing tasks are listed in Table 1 and described here. Generally, children can stand briefly on one foot by their second birthday (Bayley, 1969) and they can maintain that position for 5 seconds by 38 months. At 54 months the duration is extended to 10 seconds (Frankenburg & Dodds, 1967). Usually, children at 23 months can walk following a line on the floor, with their feet placed on either side of the line. Only at 27 months can they walk the line backwards with footsteps astride (Bayley, 1969). Walking forward heel-toe is more difficult and is only partially achieved by 43 months (Frankenburg & Dodds, 1967). Keogh (1969) discovered that 65% of boys and 87% of girls could walk heel-toe for ten steps at age 5. Other studies have shown that standing and walking on a walking board or balance beam occurs at 28 months and 38 months, respectively (Bayley, 1935).

Age and Gender Differences in Balancing Ability

The two tasks that have been most often used to measure the balance capabilities of children are walking on a beam and maintaining a balanced position on a stabilometer. The studies that have examined these dynamic and static balance measures will be described here.

Heath (1949) and Goetzinger (1961) studied boys and girls ages 8-14 years with normal hearing. The balance beam was used to measure balance in both of these studies. The beam width and the test procedures were the same in both studies. In each study, subjects walked three different beams: 10.16 cm, 5.08 cm, and 2.54 cm in width, respectively. Each subject was given three attempts on each of the beams. The number of meters walked along each of the beams in each of the trials were calculated.

Table 1

Age of Achievement for Balancing Tasks

Balancing Task	Age in Months	Study
Stand on one foot:		
Momentarily	22-23	Bayley,1969
1 second	30	Frankenburg & Dodds,1967
5 seconds	38	Frankenburg & Dodds,1967
10 seconds	54	Frankenburg & Dodds,1967
Walk a line on the floor:		
Forward: astride	23	Bayley,1969
Backward: astride	27	Bayley,1969
Circular path: forward	37	McCaskill & Wellman,1938
Heel-toe: Forward	43	Frankenburg & Dodds,1967
Backward	56	Frankenburg & Dodds,1967
Stand on walking board:		
Tries to stand	18	Bayley,1969
Both feet for a few seconds	24	Bayley,1969
Walk on a walking board:		
Attempts steps	28	Bayley,1935
Attempts steps partway	38	Bayley,1935

The results were similar in both studies. Boys and girls had a similar pattern of improvement with age. The overall pattern of change was uneven from year to year, with smaller mean increases from ages 8 to 9 and 10 to 11. The mean differences between boys and girls were small in these studies; however, the boys scored slightly higher in both studies.

Keogh's (1965) study measured the ability of boys and girls ages 5 to 11 years to hop on one foot a distance of fifty feet, maintain a stork stand on balance beam, and walk heel-toe on a balance beam. Keogh found a gradual improvement across ages. The findings in this study were similar to those by Heath (1949) and Goetzinger (1961), in that the mean differences between boys and girls were small. In Keogh's study, however, the girls scored slightly better than the boys.

DeOreo and Wade (1971) studied 150 boys and girls ages 3-5 years. The tests of balance included a forward beam walk using beams of varying widths, a backward beam walk, and ability to balance on a stabilometer. While findings from this study indicated that there was a gradual improvement with age, there were no significant differences between the scores of the boys and girls except in the measure of static balance. The mean scores showed the girls superior to boys on nearly all test items of static balance.

Other studies have shown that there is a gender difference in static balance. Morris, Williams, Atwater, and Wilmore (1982) found that on the stork stand test of static balance, 6 year old girls performed significantly better than 6 year old boys.

In summary, the studies reviewed indicate that, in general, balance performances improve with increasing age from 3 to 14 years, however the changes are gradual, and year to year performance differences are usually small and insignificant (DeOreo and Wade, 1971; Keogh, 1965). When balance performance is looked at across a wide range of ages and tasks, there is little or no difference between boys and girls in balance performance. If the nature of the task is considered, however, there is a tendency for girls to demonstrate better performance than boys on static balance tasks (DeOreo and Wade, 1971; Morris et al., 1982).

Fundamental Motor Skills of Children and Youth

Data collected by Seefeldt and Haubenstricker (1982) provide normative findings on the performance of the fundamental motor skills of children. Approximately 150 children performing the various fundamental motor skills were examined. The results of this study showed developmental sequences for the locomotor skills of running, hopping, skipping, galloping, and jumping, and the object control skills of catching, throwing, kicking, punting, and striking. Figure 1 displays the ages at which 60% of children in this mixed-longitudinal sample were able to perform the nine fundamental motor skills. The numbers on each bar of the illustration correspond to developmental stages; 1 denotes the least mature stage, and 3, 4, or 5 denotes the most mature stage for each skill.

Several trends are suggested from the data illustrated in Figure 1. In terms of gender, boys tend to attain each stage of overhand throwing and kicking earlier than girls; whereas, girls tend to attain each stage of hopping and skipping earlier than boys. The difference between boys and girls is most marked for overhand throwing. The attainment of specific stages, especially Stages 2 and 3 of the fundamental motor skills of running, jumping, catching, and striking shows much similarity between boys and girls. There is more variation between boys and girls at the ages in which the final or mature stages are attained. Girls attain the final two stages of catching earlier than boys, but attain the earlier stages at the same age as boys. In contrast, the difference between boys and girls for attaining the mature form of the standing long jump is small.

In terms of age, development of the fundamental motor skills progresses rapidly during early childhood and continues into middle childhood with respect to several skills. Most fundamental motor skills ordinarily develop by age 6 or 7, although the mature patterns of some skills do not develop until later. The data illustrated in Figure 1 show the ages at which 60% of children attain specific developmental levels for fundamental motor skills.

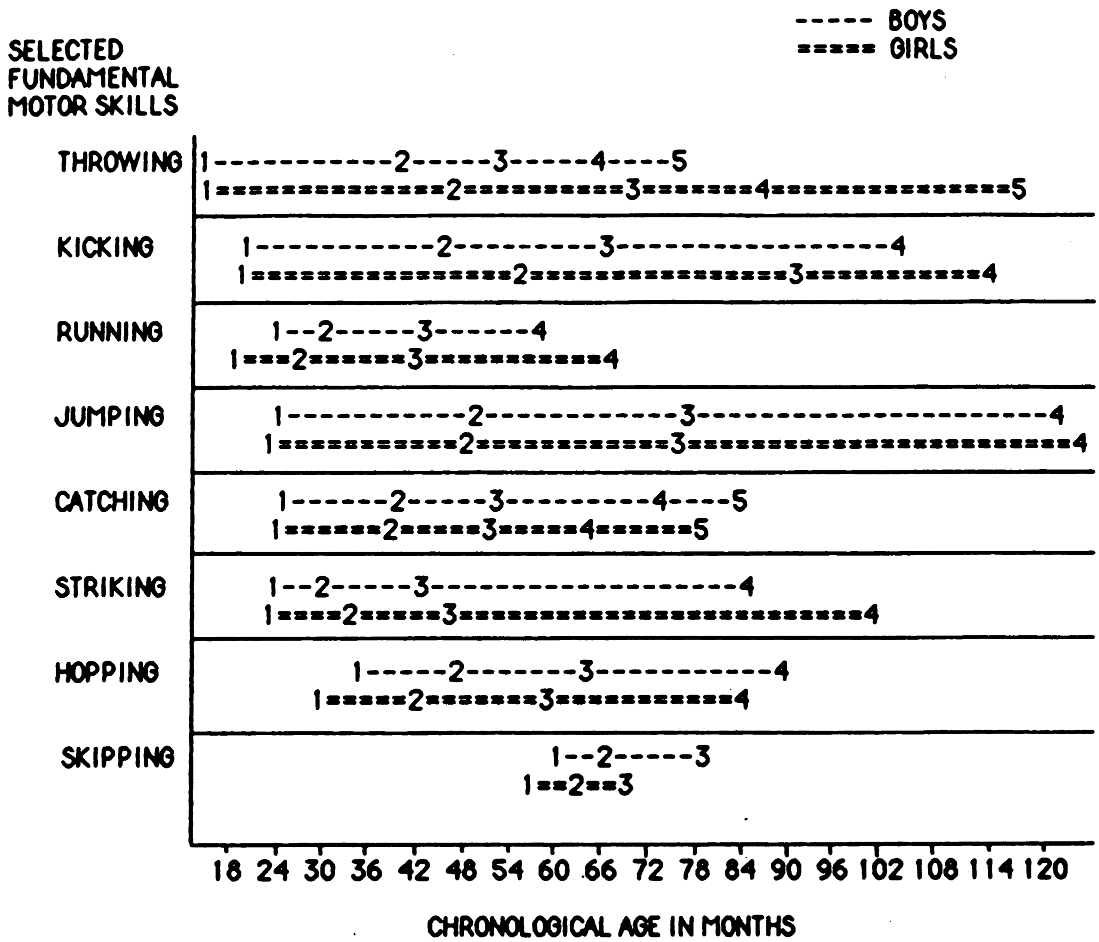


Figure 1. Ages at which 60% of children attain levels of fundamental motor skills (Seefeldt & Haubenstricker, 1982).

Relationship Between the Performances of Balance and Fundamental Motor Skill

The role of balancing ability on the performance of fundamental motor skills was examined by Ulrich and Ulrich (1985). In their study, Ulrich and Ulrich administered a test of 15 items measuring balancing ability and developmental level of gross motor skills in 33 girls and 39 boys aged 3-5 years. The balance tasks included all eight items from the balance subtest of the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978). The performance of several of the fundamental gross motor skills were assessed using stage descriptions developed by Seefeldt and Haubenstricker (Haubenstricker & Seefeldt, 1976; Sapp, 1980; Seefeldt and Haubenstricker, 1974; Seefeldt & Haubenstricker, 1976a; Seefeldt & Haubenstricker, 1976b; Seefeldt & Haubenstricker, 1976c; Seefeldt, Reuschlein, and Vogel, 1972).

Findings revealed a significant linear relationship between age and ability to balance, but no difference was found with respect to gender and the ability to balance. However, a significant gender difference was found for four of the movement skills. Mean values indicated that boys were more advanced in throwing, kicking, and striking, and girls were more proficient in skipping. Results indicate, that when age was factored out, balance was found to be significantly related to the level of performance of fundamental motor skills. The stages of hopping on the preferred and nonpreferred foot, jumping, and striking were significantly related to balancing ability.

Balance Skills of Deaf Children

There have been several studies of balance as it relates to deaf children and youth (Long, 1932; Morsh ,1936; Myklebust ,1946; Boyd ,1967; Vance ,1968; Grimsley ,1972; Case, Dawson, Schartner & Donaway ,1973; Lindsey & O'Neal ,1976; Brunt & Broadhead, 1982; Potter and Silverman ,1984; and Butterfield ,1987). The results of these studies suggest that hearing people balance better than deaf people.

The information relative to the studies that examine the balance abilities of deaf children is summarized in Table 2. The relationship of age to balance, and gender to balance, are highlighted in the following paragraphs.

In terms of gender, the early studies conducted by Long (1932), Morsh (1936), and Myklebust (1946), found that boys aged 5-21 yielded better balance performances than girls of the same ages. In these studies, both static and dynamic balance measures were used (Balance

Table 2

Research on balance abilities of deaf people

Researcher	n	Ages	Test	Results		
				Deaf/Hearing	M/F	Age
Long, 1932	174 M=100 F=74	8-18	Balancing Board	Hearing>Deaf	M>F	-
Morsh, 1936	132 M=146 F=156	-	Dunlap Balancing Board	Hearing>Deaf	M>F	Old>Young
Myklebust, 1946	203 M=105 F=93	5-21	Heath Railwalking Test	-	M>F	Old>Young
Boyd, 1967	180 M=180	8-10	Oseretsky Scale	Hearing>Deaf	-	-
Vance, 1968	88	5-12	Stork stand	Hearing>Deaf	-	-
Grimsley, 1972	60 M=30 F=30	12-15	Dyna-balometer	Deaf aided by visual cues>hearing		
Case et al., 1973	60 M=60	16-18	Iowa-Brace Test	Hearing>Deaf	-	-
Lindsey & O'Neal, 1976	108 M=58 F=50	8	Oseretsky Test	Hearing>Deaf	M=F	-
Brunt & Broadhead, 1982	154 M=85 F=69	7-14	Bruininks-Oseretsky	Hearing>Deaf	M=F	Old>Young
Potter et al., 1984	34	5-9	SCSIT	Hearing>Deaf	-	-

board, Heath Rail-Walking Test). In the more recent studies conducted by Lindsey and O'Neal (1976), Brunt and Broadhead (1982), and Potter and Silverman (1984), no significant gender differences were found for the ability to balance for subjects 5-14 years of age. The instruments used in these studies (Bruininks-Oseretsky Test of Motor Proficiency, Southern California Sensory Integration Test) also measured both static and dynamic balance .

The more recent findings of insignificant differences between gender groups and the ability to balance for deaf people by Lindsey and O'Neal (1976), Brunt and Broadhead (1982), and Potter and Silverman (1984) are consistent with those of researchers who examined this same relationship for people who could hear. Heath (1949), Goetzinger (1961), and Keogh (1965) found no significant difference between gender groups and the ability to balance. Only DeOreo and Wade (1971) and Morris, Williams, Atwater, and Wilmore (1982) have found differences between genders in the abilities to balance. In these isolated cases, girls were superior to boys in the ability of static balance.

In summary, in terms of age and it's relationship to balance, findings have consistently shown that balance improves with age. This result would seem obvious in light of the fact that with age comes practice and experience. Almost all of the studies affirm the positive correlation between age and balance. Morsh (1936), Myklebust (1946), Brunt and Broadhead (1982), and Butterfield (1987) found this to be true. In fact, the results from Butterfield (1987) yielded mean performances that increased with age for both static and dynamic balance. These findings are consistent with studies of Heath (1949), Goetzinger (1961) and Keogh (1965) which were designed to measure the balancing abilities of people who could hear. However, no positive conclusion can be drawn with respect to gender differences and balance, since the results of the studies are not completely consistent.

Fundamental Motor Skills of the Deaf

The only published studies that have been revealed on the fundamental motor skills of deaf children were reported by Butterfield (Butterfield, 1986; Butterfield, 1987; Butterfield & Ersing,

1986) and Dummer, Haubenstricker & Stewart (1989). Butterfield (Butterfield,1986; Butterfield, 1987; Butterfield & Ersing, 1986) studied 132 children who were deaf between the ages of 3 and 14 years. The subjects were individually evaluated on the 11 gross motor items of the Ohio State University Scale of Intra Gross Motor Assessment (OSU SIGMA) (Loovis & Ersing, 1979). Using this scale, the fundamental motor skills were rated qualitatively from Level 1 (least mature) to Level 4 (most mature). For each skill, the 4 respective levels reflected sequential motor development, and a score of 1, 2 ,3 or 4 was awarded for the predominant motor behavior. Butterfield concluded that for the skills of kicking, jumping, catching, and hopping, the deaf displayed fewer mature patterns than expected for chronological age. Butterfield also concluded that cause of deafness did not affect the development of basic gross motor patterns. Chi-square analyses indicated no gender differences in performances of the fundamental motor skills.

Dummer, Haubenstricker, and Stewart (1989) also studied the acquisition of fundamental motor patterns by deaf students. Like Butterfield (1986), they used a qualitative assessment tool, the Test of Gross Motor Development (TGMD) (Ulrich, 1985), to test the motor performances of 210 deaf youngsters, ages 3-22 years. Skilled performance on the TGMD is represented by attainment of all the criteria for a particular motor skill. Normative data is provided for the age at which 60% of nonhandicapped children attain all criteria for each locomotor and object-control skill. It was found that only on the skills of running, galloping, and sliding did the deaf students perform as well as their counterparts from the normative sample. Deaf youngsters demonstrated deficiencies in the other locomotor skills assessed by the TGMD: hopping, leaping, horizontal jumping, and skipping; and in each of the five object control skills: striking, bouncing, catching, kicking, and throwing. It was also noted that although the deaf subjects did not achieve mature skill levels on most skills by the same ages as the normative sample, their performance levels improved with increasing chronological age.

In summary, Butterfield (Butterfield,1986; Butterfield, 1987; Butterfield & Ersing, 1986) found delays in the acquisition of catching, jumping, kicking, and hopping. Dummer, Haubenstricker, and Stewart (1989) also found delays in the acquisition of skipping, striking, throwing, bouncing, and leaping. The differences in the results of the studies could be attributed in part to the different assessment instruments used. Both tests used in these studies measured qualitative performance attributes. However, the Test of Gross Motor Development (TGMD)(Ulrich, 1985) criteria for mature levels for some of the skills, throwing, in particular, are more stringent than the OSU SIGMA. Also, the skills of leaping and bouncing were assessed using the TGMD, but were not assessed by Butterfield.

Relationship of Balance to Fundamental Motor Skill of the Deaf

Although there have been numerous studies dealing with balance and motor ability, there has only been one study that has assessed the fundamental motor patterns as they related to balance of deaf people. This study resulted from the research done by Butterfield (1987).

The primary purpose of the study undertaken by Butterfield (1987) was to describe the fundamental motor and static and dynamic balance characteristics of hearing impaired children ages 3 through 14. The Ohio State University Scale of Intra Gross Motor Assessment was used to assess qualitative performance differences. The Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978) was used to assess balance. The basic design for this study was a cross-sectional, correlation design whereby a set of predictor variables (age, sex, hearing loss, static balance, and dynamic balance) were correlated with level of fundamental motor skill performance (Level 1, 2, 3, 4, of the OSU SIGMA), the criterion variable. Data from the fundamental motor skill and balance assessments were subjected to linear discriminant analysis. From this analysis, structure coefficients were interpreted for the significant discriminant functions. Only structure coefficients with a value greater than .30 were used in the interpretation.

Butterfield (1987) found that the 132 children studied exhibited delays in the acquisition of mature skill levels in catching, kicking, jumping, and hopping, but had achieved mature skill levels in other fundamental motor skills. Also, for all 10 skills, age, static balance, and dynamic balance gave meaning to the function. For all 10 skills, the higher the SIGMA level, the older the child was likely to be, and the greater her or his performance score in dynamic and static balance. Thus, a direct relationship between static and dynamic balance and motor skill development was discovered. Butterfield failed to identify any significant differences between males and females for any of the fundamental motor skills or balance tasks. Also, a significant difference among age levels favored the older groups, consistent with earlier findings.

Butterfield (1987) found a direct relationship between static and dynamic balance and fundamental motor skill performance. Butterfield also found delays in the acquisition of the skills of catching, kicking, jumping, and hopping. Unfortunately, the skills of punting and galloping, two fundamental motor skills important to the success in specific games and sports, were not examined. Also, the Scale of Intra-Gross Motor Abilities (SIGMA) which was the assessment tool used to examine level of fundamental motor skill performance does not provide an adequate assessment of mature skill levels for some test items, in that the highest performance level possible for some skills falls short of a truly mature movement pattern.

Summary

In summary, as age increases, the ability to balance for both deaf and hearing children also increases. The majority of the studies that have examined the relationship between the ability to balance and gender have shown that no differences exist between males and females in terms of balance ability for hearing people. When experiments have controlled for IQ and hearing loss, no difference in balance ability has been found between deaf males and females. Although age and gender are related to balance ability for deaf people as they are for hearing people, much research has shown deaf people to display deficient balance ability when compared to hearing people.

The fundamental motor skill performances of boys and girls have been found to improve with age for both hearing and deaf individuals. In terms of gender, hearing boys tend to attain each stage of overhand throwing and kicking earlier than hearing girls; whereas, hearing girls tend to attain each stage of skipping and hopping earlier than hearing boys. In the only study that has examined the relationship between gender and fundamental motor skill for deaf people, no differences were found for boys and girls for any of the fundamental motor skills. Deaf people have been shown to be delayed in attaining mature levels of several of the fundamental motor skills as compared to hearing people.

Only one study has examined the fundamental motor patterns as they relate to balance of deaf people, although a more thorough understanding of the relationship between the ability to balance and perform fundamental motor skills may help to enhance the skills of deaf people (Butterfield, 1987). In this study, static and dynamic balance were found to be related to the performance of fundamental motor skills for deaf people.

CHAPTER III

METHODS

This study used data collected by Dummer, Haubenstricker, and Stewart (1989). This investigator assisted in the collection of data for the Dummer et al. study. The performance of fundamental motor skills and balance skills of 210 deaf children were assessed. The subjects were students from two schools for deaf students, one in the United States (School A) and one in Canada (School B) who met the following criteria: a primary diagnosis of deafness (hearing loss of greater than 55 decibels); absence of significant motor, vision, behavioral, or learning impairments; and parental consent. Additional data on degree of hearing loss, etiology of deafness, and age of onset of hearing impairment of these subjects were provided by school records. The sample of 210 children and youth included 93 girls and 117 boys aged 3-22 years.

Subjects

Ths subjects for this study were students from the larger group examined by Dummer et al. who met the additional criterion of chronological age of 4-12 years. See Table 3 for the distribution of subjects by age, gender, and school. The actual sample of 106 children included 56 girls and 50 boys aged 4-12 years. Degree of hearing loss could only be determined for 86 subjects, whose better ear average was 99.17 decibels. For 18 subjects the degree of hearing loss could not be assessed by an audiological examination, and for 2 subjects the degree of hearing loss was not available in school records. The cause of deafness was unknown in 50% of the cases, genetic in 25%, meningitis in 11%, rubella in 8%, cytomegalovirus in 3%, and other causes (e.g., Waardenburg syndrome, anoxia, prematurity) in 4% (See Table 4). Age at onset was prelingual for 83%, postlingual for 9%, and unknown for 8% (See Table 5).

Table 3

Distribution of Subjects by Age, Gender, and School

	School A (United States)		School B (Canada)		
Age	F	M	F	M	Total
4	2	2	0	1	5
5	2	1	2	7	12
6	1	0	3	5	9
7	0	3	5	2	10
8	3	1	7	3	14
9	3	2	5	4	14
10	1	1	6	5	13
11	1	3	4	5	13
12	1	2	9	4	16
Total	14	15	41	36	106

Table 4

Cause of Hearing Loss

Cause	%	n
Unknown	50	53
Genetic	25	26
Meningitis	11	12
Rubella	8	8
Other	4	4
Cytomegalovirus	3	3

Table 5

Age of Onset of Hearing Loss

Age at onset	%	n
Prelingual	83	88
Postlingual	9	10
Unknown	8	8

Instrumentation

The information in this section first describes the tests used to collect data and then presents the assessment instruments used to reduce the performances of balance and fundamental motor skill for data analyses.

Tests of Balance and Fundamental Motor Skills

Static balance

To test static balance, students performed a timed stork stand on the preferred foot with eyes open. The subjects stood on a flat, orange marker approximately 20 cm in diameter that was placed on the floor. Subjects stood on one foot, placing their hands on their hips and the ankle of their resting foot near their knee. A stopwatch was started when the ankle of the resting foot was placed near the knee and the stopwatch was stopped when the resting foot moved out of position, or when the support foot was moved from its original position. Students who could balance for longer than 10 seconds were motioned to stop their performance. Each subject was given two trials. All performances were videotaped to allow for further scrutiny.

Dynamic balance

Dynamic balance was assessed using a balance beam. The beam was made of wood and measured 3.04 m long, 3.81 cm wide, and 15.24 cm high. A step was placed adjacent to the end of the beam. The top of the step was flush with the top of the beam. This allowed the subjects to take their first step without having to step up onto the beam.

Subjects walked the length of the balance beam using heel-toe steps. The number of steps taken across the beam before the subject stepped off or stopped walking heel-toe were counted. Subjects could place their arms in a way best suited to them. Each subject was given two trials. All performances were videotaped for further examination.

Fundamental motor skills

Subjects participated in locomotor and object-control activities to determine level of fundamental motor skill performance. Performances of the following skills were examined:

running, galloping, hopping, skipping, throwing, kicking, punting, catching, striking, and jumping. Running, galloping, hopping, and skipping were administered in an area designated for locomotor skills. Throwing, kicking, punting, catching, and striking were administered in an area designated for object-control skills. Jumping was administered in the area designated for balance assessment. All performances were videotaped. See Appendix B for a diagram of the testing facility.

Running. Subjects ran a 13.7 m dash. Cones were used to delineate the course. Subjects started behind a designated line. Subjects were cued to start by the action of the test administrator who stood near the finish line. Subjects started to run when the hand of the test administrator was lowered. A brightly colored glove was worn so that subjects could view the start easily. Subjects ran as fast as they could through the course of cones. The entire performance from starting line to finish was videotaped. Each subject ran through the course two times.

Galloping. Subjects galloped through a straight course approximately 13.7 m long. Subjects galloped, leading with their left leg, from starting line to finish line. Subjects then turned around and galloped, leading with their right leg, to the starting line. Each subject galloped through the course two times.

Hopping. Subjects hopped through a straight course approximately 8 m long. The subjects hopped to a designated line on their left foot. Subjects would turn around when they reached the designated line and hop back to the starting line on their right foot. Each subject hopped through the course two times.

Skipping. Subjects skipped through a straight course approximately 13.7 m long. Each subject skipped to the finish line, stopped, and then turned around and skipped back to the starting line. Each subject skipped through the course two times.

Jumping. Subjects performed a standing long jump at the station designated for balance assessment. A starting line was taped onto a standard gym mat approximately 6 cm from the end of the mat and running parallel with the end of the mat. Subjects placed toes up to the line and jumped as far as they could along the length of the mat. Each subject performed three jumps.

Throwing. Each subject threw a ball the size of a softball. The subjects threw the ball as far as they could. The subjects stood in a designated area and threw the ball toward a wall on the opposite end of the gym. Each subject threw three balls.

Kicking. Subjects kicked a 20 cm playground ball off a tee. The subjects kicked the ball in the direction of the wall on the opposite side of the gym. Subjects were allowed to take preparatory steps before kicking the ball. Each subject kicked three balls.

Punting. Subjects punted a 20 cm playground ball. The subjects punted the ball in the direction of the wall on the opposite side of the gym. Each subject punted three balls.

Catching. Subjects caught a 15 cm ball. The subjects were thrown a ball by the test administrator while standing in a designated area. Subjects were allowed to move their feet to catch the ball. Each subject attempted to catch three balls.

Striking. Subjects attempted to hit a 20 cm ball. Subjects used a bat to hit the balls toward the opposite wall. Subjects were positioned adjacent to home plate. The test administrator threw underhand pitches to the subjects from a distance of 3-5 m. Each subject attempted to strike three balls.

Data Reduction

Static balance

The subject's best performance on the stork stand (i.e., the performance that lasted the longest amount of time) was used for data analyses. The performances were qualitatively examined to determine if the form displayed was appropriate. Excessive movement of the support foot would indicate the end of the performance. Placement of the non-support foot on the floor also indicated the end of the performance. The score for performance on the stork stand was then used to place the subject into one of two groups. A score of less than 10 seconds placed a subject into a group labeled "static nonbalancers". A score of 10 seconds or more placed a subject into a group labeled "static balancers". Grouping the subjects as either "static balancers" or "static nonbalancers" allowed for chi-square analyses.

<u>Dynamic balance</u>

The subject's best performance on the balance beam (i.e., the greatest number of steps taken along the beam) was used for data analysis. The score for performance on the balance beam was then used to place the subject into one of two groups. A score of less than 10 steps would place a subject into a group labeled "dynamic nonbalancers." A score of 10 steps or more placed the subject into a group labeled "dynamic balancers."

The balance scale limitations of 10 seconds for static balance, and 10 steps for dynamic balance, were not chosen arbitrarily. Because the data was collected on videotape before this study was initiated, no change in the procedures for testing could be made. At the time of testing, subjects were told to stop balancing shortly after the 10 second mark. The time limit of 10 seconds was then used accordingly in this study. Also, because the length of the balance beam was 10 feet long, allowing some subjects (those with large feet) to take a maximum of 10 steps, 10 steps was chosen as the cut off line between dynamic balancers and nonbalancers. Neither tests of balance have been examined for reliability.

This investigator timed and recorded all of the performances on the stork stand and balance beam from the videotape footage. The beginning or ending of a performance was not recorded on the videotape in only a few instances (n=8) due to an error in filming the original performance. A referral was made back to the data collected at the time of recording in these instances. The score for the performance collected at the time of videotaping, that is, the number of seconds in static balance; the number of steps taken across the balance beam, was used for analysis.

<u>Fundamental motor skills</u>

To determine level of fundamental motor skill performance the Developmental Sequences of Fundamental Motor Skills Inventory (DSFMSI) (Haubenstricker & Seefeldt, 1976; Sapp, 1980; Seefeldt & Haubenstricker,1974; Seefeldt & Haubenstricker, 1976a; Seefeldt & Haubenstricker, 1976b; Seefeldt & Haubenstricker, 1976c; Seefeldt, Reuschlein, & Vogel, 1972) (Appendix C) was used. This test is a qualitative, criterion-referenced assessment tool. It determines the quality of performance of the fundamental motor skills of running, hopping, jumping, skipping, galloping, throwing, catching, striking, kicking, and punting. This developmentally-based test divides each skill into sequential performance stages. The lowest stage, Stage 1, refers to the least mature stage, and the highest stage, Stage 3, 4, or 5 (depending on the skill), refers to the most mature stage. Each stage is defined by performance criteria stated in behavioral form. For example, in the skill of hopping, one who displays a Stage1hop would have an erect body, arms held at shoulder height, and the nonsupport leg held in front of the body with the thigh parallel to the floor. A person whose hop was labeled Stage 4 would display a substantially greater amount of body lean, arm opposition with swing leg, hands held at waist level or below, and the thigh of the nonsupport leg held vertically with the foot behind the support leg. Figure 2 illustrates the criteria for each stage for the skill of hopping.

Stage	Description
1	Thigh of nonsupport leg held anterior to body and parallel to surface, hands held near shoulder height, little distance achieved
2	Thigh of nonsuport leg held lower in front in a diagonal position with foot near buttocks, trunk inclines forward, bilateral arm force
3	Thigh of nonsupport leg is vertical with knee flexion of 90 degrees or less, trunk inclined well forward, arms aid in force production moving up and down bilaterally
4	Nonsupport leg swings pendularly to aid in force production, arms carried close to body

Figure 2. Stages of Development for Hopping.

Appendix C lists the stages of development for running, skipping, galloping, jumping, catching, throwing, kicking, punting, and striking.

A professor, and expert in the assessment of motor performance, rated all of the performances of the fundamental motor skills using the Developmental Sequences of Fundamental Motor Skills Inventory (DSFMSI) (Haubenstricker & Seefeldt, 1976; Sapp, 1980; Seefeldt & Haubenstricker, 1974; Seefeldt & Haubenstricker, 1976a; Seefeldt & Haubenstricker, 1976b; Seefeldt & Haubenstricker, 1976c; Seefeldt, Reuschlein, & Vogel, 1972). The subject's best score was used for analysis. Scores were denoted by the highest stage at which the subject completed the requirements. The professor who rated the performances was involved in the initial development of this material. To check the objectivity of this assessment tool, percent agreement between the scores as rated by the expert in motor performance assessement and the scores as rated by this investigator was determined. To obtain percent agreement this investigator scored seven subjects on all ten items of the DSFMSI. Three trials of each subject's performance of each of the fundamental motor skills were observed from the videotape footage. Percent agreement was calculated by dividing the number of agreements by both raters for each skill by the total number of agreements plus disagreements. The quotient was then multiplied by one hundred and the resulting figure was the percentage of agreement between the evaluators. Results yielded scores of 1.00 for running, throwing, catching, and galloping. Skipping, jumping, and punting resulted in scores of .857, while the score for both hopping and striking was .723. Kicking resulted in a score of .714.

The DSFMSI was chosen as the tool to assess fundamental motor skill because it provides an accurate assessment of mature form for the 10 fundamental motor skills examined in this study. This assessment tool has withstood preliminary validation on a mixed longitudinal sample for the skills of jumping, catching, throwing, and kicking (Haubenstricker, Branta, & Seefeldt, 1983; Haubenstricker, Seefeldt, & Branta, 1983; Haubenstricker, Seefeldt, Fountain, & Sapp, 1981).

Procedures

Before testing began, all of the people involved with data collection were trained in the administration of the balance and fundamental motor skill assessment instruments described.

Training took place on the campus of Michigan State University. Test administrators, interpreters, and videotapers were present for this training session. Everyone qualified by education, experience, and training for their specific jobs. All of those involved with test administration were trained in specific aspects of the tests. The interpreters were trained in vocabulary appropriate to testing instructions. Interpreters were familiar with American Sign Language, Signed English, and pidgin signing (the common communication system used at both schools) and were trained in the administration of the particular tests. A practice session occurred after initial instruction in test administration. Teams of test administrators, interpreters, and videotapers were grouped together.

The tests were administered in the gymnasium at each school. The gymnasium was divided into three stations: the locomotor station, the object-control station, and the balance station (see Appendix B). Three people were designated to administer the tests at each station, a test administrator, an interpreter, and a videotape operator. The test administrator recorded any necessary results, and assisted with demonstrations. Checklists were used to ensure that students completed all activities. The interpreter gave instructions and demonstrations. The language and mode of communication preferred by the individual students were used. The videotaper recorded all performances.

Subject wore pinnies with identification numbers for all testing. Students were escorted through the tests in groups of approximately four students. Subjects would move as a group from station to station until all activities had been completed. Tests were run simultaneously at the three stations so that 12 students could be individually assessed on the entire battery of tests within 60 to 90 minutes. An explanation of the skills to be performed at the particular station was given before beginning. A demonstration of the skill that was to be performed was given. Subjects were then sent through the course one by one. Additional explanations and trials were given if a subject appeared not to understand the expectations. Every performance was videotaped.

Data Analyses

Hypothesis testing

Hypothesis 1. There is a positive relationship between age and the ability to balance for deaf children ages 4 through 12 years. The ability to balance will increase as age increases. To examine this hypothesis, a 9 (age, 4 through 12 years) by 2 (balancer, nonbalancer) chi-square analysis was conducted to determine the relationship between age and balancing ability.

Hypothesis 2. There is no difference between deaf males and deaf females ages 4 through 12 years in the ability to balance. A 2 (gender, male/female) by 2 (balancer, nonbalancer) chi-square analysis was conducted to determine the relationship between gender and balancing ability.

Hypothesis 3. There is a positive relationship between fundamental motor skill performance and static balance performance for deaf children ages 4 through 12. To examine this hypothesis, a 3 (for the stage level of the skills of galloping and skipping), 4 (for the stage level of the skills of running, hopping, jumping, striking, punting, and kicking), or 5 (for the stage level of the skills of catching and throwing) by 2 (balancer, nonbalancer) chi-square analysis was conducted to determine the relationship between balance and fundamental motor skill.

Hypothesis 4. There is a positive relationship between fundamental motor skill performance and dynamic balance performance for deaf children ages 4 through 12 years. To examine this hypothesis, a 3 (for the stage level of the skills of galloping and skipping), 4 (for the stage level of the skills of funning, hopping, jumping, striking, punting, and kicking), or 5 (for the stage level of the skills of catching and throwing) by 2 (balancer, nonbalancer) chi-square analysis was conducted to determine the relationship between balance and fundamental motor skill.

Hypothesis 5. There is a positive relationship between age and level of performance of fundamental motor skills. The level of fundamental motor skill performance increases as age increases. To examine this hypothesis, a 3 (for the stage level of the skills of galloping and skipping), 4 (for the stage level of the skills of running, jumping, kicking, punting, hopping, and striking), or 5 (for the stage level of the skills of catching and throwing) by 9 (age, 4 through 12 years) was performed to determine if a relationship existed between age and level of performance of fundamental motor skills.

Hypothesis 6. There is no difference between deaf males and deaf females in the ability to perform the fundamental motor skills of running, galloping, hopping, skipping, jumping, throwing, catching, kicking, striking, or punting. A 2 (gender, male/female) by 3 (for the skills of skipping and galloping), 4 (for the stage level of the skills of funning, jumping, kicking, punting, hopping, and striking), or 5 (for the stage level of the skills of catching and throwing) chi-square analysis was conducted to determine if a relationship existed between the variables.

CHAPTER IV

RESULTS

Chi-square analyses were performed to examine the relationships between variables for each of the hypotheses listed in Chapter 1. A statement of support or non-support for each hypothesis will begin the discussion of the findings for each analysis. Statistical results will be reported. Descriptive information, including tables listing frequencies or percentages, will be listed for each analysis.

Age and balancing ability. The data obtained in this study support the hypothesis of a positive relationship between age and balance ability. In general, as age increased, the frequency of subjects who were able to balance also increased. Also, the frequency of those who were deficient in balance decreased. The results of chi-square analyses indicated a significant relationship between age and ability to balance ($\chi^2(8, N = 106) = 15.80, p = .04$) for the analysis between age and dynamic balance ($\chi^2(8, N = 106) = 30.98, p = .00$) and for the analysis between age and static balance. Table 6 lists the frequencies of balance performances at each age level, 4 through 12 years of age.

Table 6

Frequencies of balance performances listed by age

	Balance performance					
	Dynamic			Static		
Age	Balancer	Nonbalancer	Total	Balancer	Nonbalancer	Total
4	-	5	5	-	5	5
5	1	11	12	2	10	12
6	2	7	9	2	7	9
7	-	10	10	2	8	10
8	3	11	14	6	8	14
9	5	9	14	6	8	14
10	6	7	13	9	4	13
11	6	7	13	9	4	13
12	2	14	16	14	2	16
Total	25	81	106	53	53	106

Gender and balancing ability. The data obtained in this study support the hypothesis of no difference between males and females in the ability to balance. Results of chi-square analyses indicated there is no significant relationship between gender and dynamic balance (χ^2(1, N = 106) = .67, p = .41) or between gender and static balance (χ^2(1, N = 106) = 2.42, p = .11). Table 7 lists the frequencies of static and dynamic balancers and nonbalancers for each gender.

Table 7

Frequencies of balance performances listed by gender

	Balance performance					
	Static			Dynamic		
Gender	Balancer	Nonbalancer	Total	Balancer	Nonbalancer	Total
Male	21	29	50	10	40	50
Female	32	24	56	15	41	56
Total	53	53	106	25	81	106

<u>Fundamental motor skills and static balance.</u> The data obtained in this study support the hypothesis of a positive relationship between fundamental motor skills and static balance for all ten fundamental motor skills examined. The percentage of balancers attaining the most mature level was greater than that of the nonbalancers for each of the fundamental motor skills. The results of chi-square analyses are listed below.

Throwing:	$\chi^2(4, N = 106)$	=	29.08,	$p = .00$
Catching:	$\chi^2(4, N = 106)$	=	37.92,	$p = .00$
Striking:	$\chi^2(3, N = 106)$	=	10.21,	$p = .01$
Kicking:	$\chi^2(3, N = 106)$	=	22.91,	$p = .00$
Punting:	$\chi^2(4, N = 104)$	=	20.04,	$p = .00$
Hopping:	$\chi^2(4, N = 105)$	=	27.75,	$p = .00$
Skipping:	$\chi^2(4, N = 105)$	=	33.28,	$p = .00$
Running:	$\chi^2(2, N = 105)$	=	7.02,	$p = .02$
Galloping:	$\chi^2(2, N = 105)$	=	22.63,	$p = .00$
Jumping:	$\chi^2(4, N = 106)$	=	17.93,	$p = .00$

Table 8 lists the frequencies of performances of the fundamental motor skills for balancers and nonbalancers. The percentages of balancers and nonbalancers attaining the most mature level of performance is also listed in Table 8.

Table 8

Frequencies of fundamental motor skill performances

by static balancers and nonbalancers

		Stage of fundamental motor skills						
Skill	Balance Category	0	1	2	3	4	5	%-mature level
Running	B (n = 52)	-	-	-	2	50		96%
	NB (n = 53)	-	-	1	10	42		79%
Skipping	B (n = 52)	-	2	14	36			69%
	NB (n = 53)	15	2	26	10			19%
Galloping	B (n = 52)	-	-	13	39			75%
	NB (n = 53)	-	5	32	16			30%
Hopping	B (n = 52)	-	-	5	9	38		73%
	NB (n = 53)	4	3	17	16	13		25%
Jumping	B (n = 53)	-	4	15	23	11		21%
	NB (n = 53)	1	17	19	14	1		4%

(table continues)

Skill	Balance category	0	1	2	3	4	5	%-mature level
Throwing	B (n = 53)	-	1	-	4	16	32	60%
	NB (n = 53)	-	14	3	11	15	10	19%
Catching	B (n = 53)	-	-	1	1	18	33	62%
	NB (n = 53)	-	6	5	15	20	7	13%
Striking	B (n = 53)	-	-	11	4	38		72%
	NB (n = 53)	-	3	21	6	23		43%
Kicking	B (n = 53)	-	-	1	8	44		83%
	NB (n = 53)	-	1	3	29	20		38%
Punting	B (n = 52)	-	2	4	38	8		15%
	NB (n = 52)	3	15	7	25	2		4%

Key: B = Balancer

NB = Nonbalancer

% - mature level = % of subjects exhibiting mature skill level

Fundamental motor skills and dynamic balance. The data obtained in this study support the hypothesis of a positive relationship between fundamental motor skill performance and dynamic balance performance only for the skills of hopping, skipping, and throwing. The data does not support the hypothesis for the other skills of running, galloping, jumping, striking, catching, kicking, and punting. The results of the chi-square analyses are listed below.

Throwing:	χ^2 (4, N = 106)	= 15.38, p = .00
Catching:	χ^2 (4, N = 106)	= 9.11, p = .06
Striking:	χ^2 (3, N = 106)	= 2.03, p = .56
Kicking:	χ^2 (3, N = 106)	= 3.98, p = .26
Punting:	χ^2 (4, N = 104)	= 3.46, p = .48
Hopping:	χ^2 (4, N = 105)	= 13.40, p = .01
Skipping:	χ^2 (4, N = 105)	= 9.95, p = .02
Running:	χ^2 (2, N = 105)	= 2.15, p = .33
Galloping:	χ^2 (2, N = 105)	= 5.66, p = .06
Jumping:	χ^2 (4, N = 106)	= 6.41, p = .17

Table 9 lists the frequencies of performances of the fundamental motor skills for balancers and nonbalancers. The percentages of balancers and nonbalancers attaining the most mature level of performance is also listed in Table 9.

Table 9

Frequencies of fundamental motor skill performances

by dynamic balancers and nonbalancers

		Stage of fundamental motor skill						
Skill	Balance Category	0	1	2	3	4	5	%-mature level
Running	B (n = 25)	-	-	-	1	24		96%
	NB (n = 80)	-	-	1	11	68		85%
Skipping	B (n = 25)	-	1	7	17			68%
	NB (n = 80)	15	3	33	29			36%
Galloping	B (n = 25)	-	-	7	18			72%
	NB (n = 80)	-	5	38	37			46%
Hopping	B (n = 25)	-	-	2	3	20		80%
	NB (n = 80)	4	3	20	22	31		39%
Jumping	B (n = 25)	-	-	1	8	12	4	16%
	NB (n = 80)	-	1	20	26	25	9	11%

(table continues)

Skill	Balance category	0	1	2	3	4	5	%-mature level
Throwing	B (n = 25)	-	-	-	-	12	13	52%
	NB (n = 81)	-	15	3	15	19	29	36%
Catching	B (n = 25)	-	-	1	1	8	15	60%
	NB (n = 81)	-	6	5	15	30	25	31%
Striking	B (n = 25)	-	-	6	2	17		68%
	NB (n = 81)	-	3	26	8	44		54%
Kicking	B (n = 25)	-	-	-	6	19		76%
	NB (n = 81)	-	1	4	31	45		56%
Punting	B (n = 25)	-	2	2	18	3		12%
	NB (n = 79)	3	15	9	45	7		9%

Key: B = Balancer

NB = Nonbalancer

% - mature level = % of subjects exhibiting mature skill level

Gender and fundamental motor skills. The data obtained in this study support the hypothesis of no difference between males and females in the ability to perform the skills of running, galloping, hopping, throwing, kicking, jumping, and punting. The percentages of males and females reaching the mature level of these fundamental motor skills are similar. Chi-square analyses revealed a significant relationship between gender and the skills of striking and skipping. For the skill of striking, a larger number of males than females are able to acquire the most mature skill level. In the skill of skipping, a larger percentage of females are able to acquire the most mature level when compared with the males. The results of the chi-square analyses are listed below.

Throwing:	$\chi 2\ (4, N = 106)$	$= 6.62, p = .15$
Catching:	$\chi 2\ (4, N = 106)$	$= 6.23, p = .18$
Striking:	$\chi 2\ (3, N = 106)$	$= 8.07, p = .04$
Kicking:	$\chi 2\ (3, N = 106)$	$= 0.94, p = .81$
Punting:	$\chi 2\ (4, N = 104)$	$= 6.18, p = .18$
Hopping:	$\chi 2\ (4, N = 105)$	$= 8.24, p = .08$
Skipping:	$\chi 2\ (4, N = 105)$	$= 13.33, p = .00$
Running:	$\chi 2\ (2, N = 105)$	$= 0.92, p = .62$
Galloping:	$\chi 2\ (2, N = 105)$	$= 3.37, p = .18$
Jumping:	$\chi 2\ (4, N = 106)$	$= 4.37, p = .35$

The frequencies of the subjects' fundamental motor skill performances, and the percentages of males and females who achieved the most mature level of fundamental motor skill, are listed in Appendix F.

Age and fundamental motor skills. The data in this study support the hypothesis of a positive relationship between age and level of performance of fundamental motor skills for all but one of the skills examined. Age was not found to be related to level of performance of the skill of running. In general, as age increased, the frequency of subjects who acquired mature levels of fundamental motor skills also increased. The results of the chi-square analyses are listed below.

Throwing:	$\chi^2 (32, N = 106) = 66.02, p = .00$
Catching:	$\chi^2 (32, N = 106) = 90.38, p = .00$
Striking:	$\chi^2 (24, N = 106) = 44.71, p = .00$
Kicking:	$\chi^2 (24, N = 106) = 69.02, p = .00$
Punting:	$\chi^2 (32, N = 104) = 89.28, p = .00$
Hopping:	$\chi^2 (32, N = 105) = 85.41, p = .00$
Skipping:	$\chi^2 (24, N = 105) = 70.85, p = .00$
Running:	$\chi^2 (16, N = 105) = 23.19, p = .10$
Galloping:	$\chi^2 (16, N = 105) = 57.61, p = .18$
Jumping:	$\chi^2 (32, N = 106) = 47.03, p = .04$

Table 10 lists the percentages of subjects who achieved the most mature level for the particular skills. The frequencies of the subjects' fundamental motor skills performances are listed in Appendix F.

Table 10

Percentage of deaf children who achieved most mature level of fundamental motor skill

	Age in years								
Skill	4 n=5	5 n=12	6 n=9	7 n=10	8 n=14	9 n=13	10 n=13	11 n=13	12 n=16
Run	40%	58%	56%	70%	64%	79%	62%	62%	73%
Gallop	0%	0%	11%	0%	21%	36%	54%	46%	67%
Skip	0%	0%	0%	0%	7%	43%	54%	62%	73%
Jump	0%	0%	0%	0%	0%	0%	0%	7%	0%
Hop	0%	0%	0%	20%	14%	14%	46%	46%	53%
Throw	0%	0%	0%	0%	14%	29%	0%	38%	25%
Catch	0%	0%	0%	0%	14%	29%	15%	31%	44%
Kick	0%	0%	0%	0%	36%	36%	23%	38%	63%
Punt	0%	0%	0%	0%	0%	0%	0%	0%	14%
Strike	20%	8%	0%	10%	14%	14%	0%	23%	38%

CHAPTER V

DISCUSSION

This investigation revealed the same findings for age as it relates to balance, both static and dynamic, and to fundamental motor skill performance as did previous investigations. In this study, as age increased, so too did the frequency of subjects who were balancers. The frequency of subjects who were nonbalancers decreased as age increased. These findings are consistent with the work of Morsh (1936), Myklebust (1946), Brunt and Broadhead (1982), and Butterfield (1987). In terms of the relationship between age and fundamental motor skill performance, the percentages of subjects performing at the most mature level increased, in general, from age 4 to age 12 for all of the skills examined. This finding concurs with the findings of Dummer, Haubenstricker, and Stewart (1989) and Butterfield (1987).

It has been shown that, in general, as one gets older, the performances of both balance and fundamental motor skills improve. Whether improvement is due to physical maturation or to exposure to, or practice of, the particular skills, or to a combination of both, is not known. If it is true that repeated instruction and practice can enhance the performances of both balance and fundamental motor skills for deaf children, then appropriate instructional activities could be developed to maximize learning at a rate faster than that of normal physical maturation.

The results from the analysis of the relationship between gender and balance performance agreed with the findings of Lindsey and O'Neal (1976), Brunt and Broadhead (1982), Potter and Silverman (1984), and Butterfield (1987). No significant gender differences in terms of either static or dynamic balance performance were revealed. Differences were found to occur in terms of the relationship between gender and fundamental motor skill performance. Males achieved the most mature level of performance in the skill of striking more than the females in this study. Females attained the most mature level of skipping to a greater extent than males. These findings disagreed with the results of a similar study by Butterfield (1987). Butterfield found no significant differences to occur between deaf males and deaf females for any of the fundamental motor skills examined. The finding of females to be more advanced in skipping is in agreement with Seefeldt and Haubenstricker (1982).

The ability to balance has not been shown to be different for the males and females in this study. The differences between males and females for the fundamental motor skills of striking and skipping must then be due to something other than the ability to balance. It may be that in the communities from which the subjects of this study came, cultural expectations occur which encourage males to participate in activities that require the ability to strike, such as T-ball, baseball, or softball. Cultural expectations may also exist that either encourage females to become proficient in skipping, or discourage males to be proficient skippers.

In terms of the relationship between fundamental motor skill performance and static balance, all ten fundamental motor skills were found to be related to static balance. This is in agreement with the findings of Butterfield (1987). Only the skills of hopping, skipping, and throwing were found to be related to dynamic balance. This finding disagrees with that of Butterfield (1987) who found the skills of throwing, catching, kicking, running, jumping, hopping, skipping, and striking to be related to dynamic balance. Butterfield did not analyze the skills of punting and galloping.

When attempting to explain the discrepancy between the results of this study and those of the study by Butterfield (1987), three factors need to be taken into consideration: the validity of the balance scale, the difference between the instruments used to assess fundamental motor skill performance, and the overall nature of balancing ability. The balance scale used in this study to distinguish between balancers and nonbalancers may not have been totally valid. In the study by Butterfield (1987), which used the Bruininks-Oseretsky Test of Motor Proficiency, subjects were given six points if they were able to walk six steps, the maximum number allowed on the test. If a subject displayed less than 10 steps, but greater than 6 steps, they were labeled nonbalancers in this study. To ascertain whether the designation of 6 steps as the cut-off point might be a more valid indication of dynamic balance, additional chi-square analyses were performed. In these analyses, subjects who took less than 6 heel-toe steps on the balance beam were labeled dynamic nonbalancers. Those subjects who walked for 6 or more heel-toe steps along the beam were labeled dynamic balancers.

The results of these chi-square analyses and the table which lists the frequencies of fundamental motor skill performances by dynamic balancers and nonbalancers using the modified balance scale are listed in Appendix G. Results show that a positive relationship exists between dynamic balance performance and the fundamental motor skills of throwing, kicking, hopping, skipping, galloping, and jumping. Although, additional skills, kicking, galloping, and jumping, were found to be related to dynamic balance performance, a discrepancy still exists between the findings of Butterfield (1987) and those of this study. The skills of catching and striking were found to be related to dynamic balance by Butterfield, but not by this investigator. This discrepancy may be attributed to the difference in motor performance characteristics between the subjects of this study and those studied by Butterfield.

Differences in the findings between the study by Butterfield (1987) and this study may be due to the assessment instrument used to examine fundamental motor skill performance. The assessment instrument used in the study by Butterfield (1987) does not provide an adequate assessment of mature skill levels for some test items. The most mature performance level possible for some skills does not completely describe the components necessary for a truly mature movement pattern. Comparing the most mature stage level descriptions for both assessment tools, the OSU SIGMA, generally, assessed only the force production phases of the skills, whereas the DSFMSI assessed the wind-up, force production, and follow-through components in every stage of each skill. This allowed for a more accurate assessment of development of fundamental motor skill performance.

An argument for the differences in findings between static and dynamic balance and the ability to perform the fundamental motor skills may be that balancing is task specific and must be measured differently for different skills. It may be argued that the static balance scales used in this study were able to assess a particular component of the balancing ability necessary for all of the fundamental motor skills examined. Conversely, it may also be argued that the dynamic balance measure used in this study, the heel-toe beam walk, was not a valid measure of the type of dynamic balance necessary for mature form for some of the fundamental motor skills studied. The balance ability necessary to perform well may change from task to task and therefore must be measured according to specific task requirements.

The finding of a relationship between the balancing abilities of standing one one foot and walking heel-toe on a balance beam, and the performance of the fundamental motor skills is an important one for the physical education teachers of deaf students. Physical education teachers who teach deaf students can use this finding to base instruction for students who display balance problems. If a physical education teacher encounters students who display motor skill patterns that are less mature than what they should be displaying for their ages, examining the students' abilities to balance is a realistic first step in enhancing their motor skill acquisition. Realizing that the ability to balance is only one component of a person's motor schema, an examination and finding of no balance deficiency would then allow the physical education instructor to examine other possible variables, including other motor ability characteristics, and prior instruction and experience.

CHAPTER VI

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to investigate the relationship between the balance and fundamental motor skill performances of deaf children ages 4 through 12 years. The subjects were 50 boys and 56 girls from two schools for students who are deaf, one in the United States and one in Canada. Each subject was tested to determine their performance abilities on selected balance and fundamental motor skills tasks. The performances of static balance were measured using a stork stand, and the performances of dynamic balance were measured using a heel-toe beam-walk test. The Developmental Sequences of Fundamental Motor Skills Inventory (Haubenstricker & Seefeldt, 1976; Sapp, 1980; Seefeldt and Haubenstricker, 1974; Seefeldt & Haubenstricker, 1976a; Seefeldt & Haubenstricker, 1976b; Seefeldt & Haubenstricker, 1976c; Seefeldt, Reuschlein, & Vogel, 1972) was used to assess the subjects' performances on running, galloping, hopping, skipping, jumping, catching, throwing, striking, punting, and kicking. Chi-square analyses were performed to examine the relationships between: (a) age and balance, (b) gender and balance, (c) performances of static balance and selected fundamental motor skills, (d) performances of dynamic balance and selected fundamental motor skills, (e) age and level of performance of fundamental motor skills, and (f) gender and level of performance of fundamental motor skills.

Conclusions

The small sample size, and the balance scale used, place definite restrictions on the value of the conclusions. However, within the limitations of the investigation, the following conclusions were drawn:

1. Age was significantly related to both static and dynamic balance.
2. No significant relationship between gender and static balance or between gender and dynamic balance was found.
3. Age was significantly related to level of performance of 9 of the 10 fundamental motor skills examined. Age was not significantly related to the skill of running.
4. A significant difference was found between males and females only in the skills of striking and skipping. Males were found to acquire the most mature level of striking more than females. Females were found to acquire the most mature level of skipping more than males. No significant difference was found between males and females in the other fundamental motor skills examined.
5. Static balance was significantly related to all 10 fundamental motor skills examined.
6. Dynamic balance was significantly related only to the skills of hopping, skipping, and throwing.

Recommendations

Some suggestions for further research include:

1. A study comparing the ability to balance to the performance of fundamental motor skills using balance measures appropriate to the movement requirements of the various fundamental motor skills.
2. A study examining the effect of the improvement of the ability to balance on the performance of fundamental motor skills. Conversely, the effect of the improvement of fundamental motor skill performance on the performance of balance.
3. A study controlling for the history and amount of physical education instruction, and extracurricular recreation and sport activity, when examining balance skills as they relate to fundamental motor skills.
4. An examination of early childhood education for deaf children to determine if instruction for deaf children is equivalent to the instruction given to hearing children.

APPENDICES

APPENDIX A

HUMAN SUBJECTS APPROVAL

APPENDIX A

HUMAN SUBJECTS APPROVAL

March 21, 1992

Dr. David Wright
UCRIHS
Michigan State University
232 Administration Building
East Lansing, MI 48824-1111

Dr. Wright:

I am writing to request exemption from full UCRIHS review. I am hoping to complete a study, in partial fulfillment of my master's degree requirements, using existing data from a study completed by Dr. Gail Dummer, Dr. John Haubenstricker, and Dr. David Stewart. The study referred to is "Fundamental Motor Skills of Deaf Children and Youth" IRB# 88-210. I will be using the data obtained in this study to complete a master's thesis titled "The Relationship Between Balance and the Fundamental Motor Skills of Children and Youth Who are Deaf." This thesis will analyze and describe the balance and fundamental motor skills of the children who were subjects in the earlier study.. Differences between the original study and this study are highlighted in the enclosed UCRIHS application.

The original protocol on the protection of human subjects and the letter of approval for the original study by Dr. Dummer, Dr. Haubenstricker, and Dr. Stewart have been attached.

Sincerely,

Paul G. Behen

Paul G. Behen

APPENDIX A

HUMAN SUBJECTS APPROVAL

MICHIGAN STATE UNIVERSITY

OFFICE OF VICE PRESIDENT FOR RESEARCH
AND DEAN OF THE GRADUATE SCHOOL

EAST LANSING • MICHIGAN • 48824-1046

August 10, 1992

Paul Behen
814 W. Addison #202
Chicago, IL 60613

RE: THE RELATIONSHIP BETWEEN BALANCE AND FUNDAMENTAL MOTOR SKILLS OF CHILDREN WHO ARE DEAF, IRB #92-368

Dear Mr. Behen:

The above project is exempt from full UCRIHS review. The proposed research protocol has been reviewed by a member of the UCRIHS committee. The rights and welfare of human subjects appear to be protected and you have approval to conduct the research.

You are reminded that UCRIHS approval is valid for one calendar year. If you plan to continue this project beyond one year, please make provisions for obtaining appropriate UCRIHS approval one month prior to August 3, 1993.

Any changes in procedures involving human subjects must be reviewed by UCRIHS prior to initiation of the change. UCRIHS must also be notified promptly of any problems (unexpected side effects, complaints, etc.) involving human subjects during the course of the work.

Thank you for bringing this project to my attention. If I can be of any future help, please do not hesitate to let me know.

Sincerely,

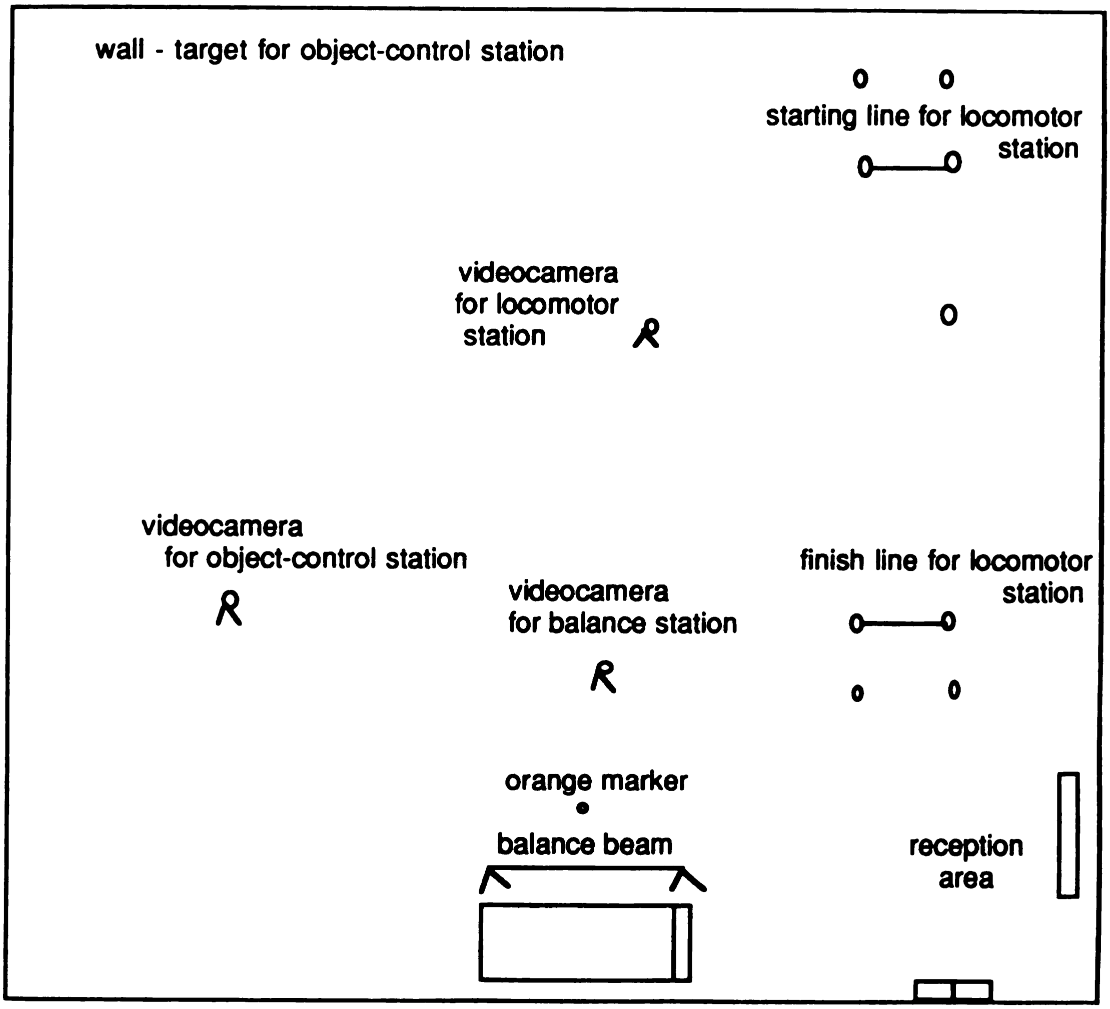
David E. Wright, Ph.D., Chair
University Committee on Research Involving
Human Subjects (UCRIHS)

DEW/pjm

cc: Dr. Gail Dummer

APPENDIX B

DIAGRAM OF TESTING FACILITY



APPENDIX C

DEVELOPMENTAL SEQUENCES OF FUNDAMENTAL MOTOR SKILLS INVENTORY (DSFMSI)
(Haubenstricker & Seefeldt, 1976; Sapp, 1980; Seefeldt & Haubenstricker, 1974; Seefeldt & Haubenstricker, 1976a; Seefeldt & Haubenstricker, 1976b, Seefeldt & Haubenstricker, 1976c; Seefeldt, Reuschlein, & Vogel, 1972)

Throw

Stage 1

The throwing motion is essentially posterior-anterior in direction. The feet usually remain stationary during the throw. Infrequently, the performer may step or walk just prior to moving the ball into position for throwing. There is little or no trunk rotation in the most rudimentary pattern at this stage, but children at the point of transition between Stages 1 and 2 may evoke slight trunk rotation in preparation for the throw and extensive hip and trunk rotation in the follow-through phase.

Stage 2

The distinctive feature of this stage is the rotation of the body about an imaginary vertical axis, with the hips, spine, and shoulders rotating as one unit. The performer may step forward with either an ipsilateral or contralateral pattern, but the arm is brought forward in a transverse plane. The motion may resemble a "sling" rather than a throw due to the extended arm position during the course of the throw.

Stage 3

The distinctive pattern in Stage 3 is the ipsilateral arm-leg action. The ball is placed into a throwing position above the shoulder by a vertical and posterior motion of the arm at the time that the ipsilateral leg is moving forward. This stage involves little or no rotation of the spine and hips in preparation for the throw. The follow-through phase includes flexion at the hip joint and some trunk rotation toward the side opposite the throwing arm.

Stage 4

The movement is contralateral, with the leg opposite the throwing arm striding forward as the throwing arm is moved in a vertical and posterior direction during the wind-up phase. There is little or no rotation of the hips and spine during the wind-up phase; thus, the motion of the trunk and arm closely resembles the motions of Stages 1 and 3. The stride forward with the contralateral leg provides for a wide base of support and greater stability during the force production phase of the throw.

Stage 5

The wind-up phase begins with the throwing hand moving in a downward arc and then backward as the opposite leg moves forward. This concurrent action rotates the hip and spine into position for forceful derotation. As the contralateral foot strikes the surface the hips, spine, and shoulder begin derotating in sequence. The contralateral leg begins to extend at the knee, providing an equal and opposite reaction to the throwing arm. The arm opposite the throwing limb also moves forcefully toward the body to assist in the equal and opposite reaction.

Catch

Stage 1

The child presents his/her arms directly in front of him/her, with the elbows extended and the palms facing upward or inward toward the midsaggital plane. As the ball contacts the hands or arms, the elbows are flexed and the arms and hands attempt to secure the ball by holding it against the chest.

Stage 2

The child prepares to receive the object with the arms in front of the body, the elbows extended or slightly flexed. Upon presentation of the ball, the arms begin a motion that culminates by securing the ball against the chest. Stage 2 also differs from Stage 1 in that the receiver initiates the arm action prior to ball-arm contact in Stage 2.

Stage 3

The child prepares to receive the ball with arms that are slightly flexed and extended forward at the shoulder. Many children also receive the ball with arms that are flexed at the elbow, with the elbow ahead of a frontal plane.

Substage 1: The child uses his/her chest as the first contact point of the ball and attempts to secure the ball by holding it to his/her chest with the hands and arms.

Substage 2: The child attempts to catch the ball with his/her hands. Upon failure to hold it securely , he/she maneuvers it to the chest, where it is controlled by hands and arms.

Stage 4

The child prepares to receive the ball by flexing the elbows and presenting the arms ahead of the frontal plane. Skillful performers may keep the elbows at the sides and flex the arms simultaneously as they bring them forward to meet the ball. The ball is caught with the hands, without making contact with any other body parts.

Stage 5

The same upper segmental action is identical to Stage 4. In addition, the child is required to change their stationary base in order to receive the ball. Stage 5 is included because of the apparent difficulty that many children encounter when they are required to move in relation to an approaching object.

Jump

Stage 1

Vertical component of force may be greater than horizontal; resulting jump is then upward rather than forward. Arms move backward, acting as brakes to stop the momentum of the trunk as the legs extend in front of the center of mass.

Stage 2

The arms move in an anterior-posterior direction during the preparatory phase but move sideward (winging action) during the inflight phase. The knees and hips flex and extend more fully than in Stage 1. The angle of takeoff is still markedly above 45 degrees. The landing is made with the center of gravity above the base of support, with the thighs perpendicular to the surface rather than parallel as in the reaching position of Stage 4.

Stage 3

The arms swing backward and then forward during the preparatory phase. The knees and hips flex fully prior to takeoff. Upon takeoff the arms extend and move forward but do not exceed the height of the head. The knee extension may be complete, but the takeoff angle is still greater than 45 degrees. Upon landing, the thigh is still less than parallel to the surface and the center of gravity is near the base of support when viewed from the frontal plane.

Stage 4

The arms extend vigorously forward and upward upon takeoff, reaching full extension above the head at liftoff. The hips and knees are extended fully with the takeoff angle at 45 degrees or less. In preparation for landing, the arms are brought downward and the legs are thrust forward until the thigh is parallel to the surface. The center of gravity is far behind the base of support upon foot contact, but at the moment of contact the knees are flexed and the arms are thrust forward in order to maintain the momentum to carry the center of gravity beyond the feet.

Kick

Stage 1

The performer is usually stationary and positioned near the ball. If the performer moves prior to kicking, the steps are short and concerned with spatial relationships rather than attaining momentum for the kick. The thigh of the kicking leg moves forward with the knee flexed and is nearly parallel to the surface by the time the foot contacts the ball. Knee joint extension occurs after contact, resulting in a pushing rather than a striking action. Upper extremity action is usually bilateral, but may show some opposition in older performers. The knee of the kicking leg continues to extend until it approaches 180 degrees. If the trunk is inclined forward following contact with the ball, the performer will step forward to regain balance. If the trunk is leaning backward, the kicking leg will move backward after ball contact to achieve body balance.

Stage 2

The performer is stationary. Initial action involves hyperextension at the hips and flexion at the knee so that the thigh of the kicking leg is behind the mid-frontal plane. The arms may move into a position of opposition in situations of extreme hyperextension at the hips. The kicking leg moves forward with the knee joint in a flexed position. Knee joint extension begins just prior to foot contact with the ball. Arm-leg opposition occurs during the kick. Knee extension continues after the ball leaves the foot, but the force of the kick usually is not sufficient to move the body forward. Instead, the performer usually steps sideward or backward.

Stage 3

The performer takes one or more deliberate steps to approach the ball. The support leg is placed near the ball and slightly to the side of it. The kicking foot stays near the surface as it approaches the ball resulting in less flexion than in stage two. The trunk remains nearly upright, thereby preventing maximum force production. The knee begins to extend prior to contact. Arm-leg opposition is evident.

Stage 4

The approach involves one or more steps with the final "step" being an airborne run or leap. This permits hyperextension of the hip and flexion of the knee as in stage two. The shoulders are retracted and the trunk is inclined backward as the supporting leg makes contact with the surface and the kicking leg begins to move forward. The movement of the thigh nearly stops as the knee joint begins to extend rapidly just prior to contact with the ball. Arm-leg opposition is present as in the previous two stages. If the forward momentum of the kick is sufficient, the performer either hops on the support leg or scissors the legs while airborne in order to land on the kicking foot. If the kicking foot is not vigorous, the performer may merely step in the direction of the kick.

Punt

Stage 1

The performer is stationary as the hands and foot prepare for the punting action. The ball is held with both hands at waist height or higher prior to placing it in position for punting. The ball may be manipulated in a variety of ways for punting: (a) it may be held in both hands as the punting foot is lifted forward and upward with hip and knee flexion. The punting force in this situation represents a push as the ball is contacted by the plantar side of the foot when the knee extends. (b) the ball may be tossed up and forward into the air. The performer then must move forward to get the body into punting position. (c) the performer may bounce the ball and attempt to punt it as it rebounds from the surface. Whatever the mode of placing the ball into a punting position, the primary characteristics of stage one are a stationary preparatory position and flexion at the hip and knee of the punting leg, placing these segments in front of the mid-frontal plane.

Stage 2

The performer is stationary during the preparatory phase. The ball is held in both hands and may be dropped or tossed forward or upward in preparation for punting it with the foot. The non-support leg is flexed at the knee, and the thigh is perpendicular to the surface or behind the mid-frontal plane as the leg is placed into punting position. As the punting leg moves forward its momentum may carry the performer forward for a step, but generally the force is upward, causing the punter to step backward after striking the ball.

Stage 3

The performer moves forward deliberately for one or more steps in preparation for punting the ball. The ball is generally released in a forward and downward direction. The knee is flexed at 90 degrees or less, but the thigh is farther behind the mid-frontal plane than in stage two, due to the stepping action. The follow-through of the striking leg will generally carry the punter ahead of the point where the ball was contacted.

Stage 4

The punter's approach is rapid, usually comprising one or more steps, culminating in a leap just prior to contacting the ball. If the leap does not precede the punt, the forward momentum may be enhanced by taking a large step. The ball is contacted at or below knee height as a result of the ball having been released in a forward and downward direction. The momentum of the swinging leg carries the punter off of the surface in an upward and forward direction after the punt.

Run

Stage 1

The arms are extended sideward at shoulder height (high-guard position). The stride is short, and of shoulder width. The surface contact is made with the entire foot, simultaneously. Little knee flexion is seen. The feet remain near the surface at all times.

Stage 2

Arms are carried at "middle guard" (waist level), the stride is longer and approaches the mid-saggital line. Contact is usually with the entire foot striking the surface simultaneously. Greater knee flexion is noted in the restraining phase. The swing leg is flexed and the movement of the legs becomes anterior-posterior.

Stage 3

The arms are no longer used primarily for balance. Arms are carried below waist level and may flex and assume a counter-rotary action. The foot contact is "heel-toe". Stride length increases and both feet move along a mid-saggital line. The swing leg flexion may be as great as 90 degrees.

Stage 4

Foot contact is heel-toe at slow or modest velocities but may be entirely on the metatarsal arch during sprint running. Arm action is in direct opposition to leg action. Knee flexion is used to maintain the momentum during the support phase. The swing leg may flex until it is nearly in contact with the buttocks during its recovery phase.

Insufficient movements common to running patterns are: inversion or eversion of the foot during the support phase. Inversion results in a medial rotation of the leg and thigh during the support phase and is characterized by an oblique rather than an anterior-posterior pattern as the leg is brought forward in the swing phase.

Eversion of the foot during the support phase results in lateral rotation of the leg and thigh. This pattern is often accompanied by an exaggerated counter-rotary action of the arms in an attempt to maintain a uniform direction.

Strike

Stage 1

The motion is primarily posterior-anterior in direction. The movement begins with hip extension and slight spinal extension and retraction of the shoulder on the striking side of the body. The elbows flex fully. The feet remain stationary throughout the movement with the primary force coming from extension of the flexed joints.

Stage 2

The feet may remain stationary or either the right or left foot may receive the weight as the body moves toward the approaching ball. The primary pattern is the unitary rotation of the hip-spinal linkage about an imaginary vertical axis. The forward movement of the bat is in a transverse plane.

Stage 3

The shift of weight to the front-supporting foot occurs in an ipsilateral pattern. The trunk rotation-derotation is decreased markedly in comparison to Stage 2 and the movement of the bat is in an oblique-vertical plane instead of the transverse path as seen in Stage 2.

Stage 4

The transfer of weight in rotation-derotation is in a contralateral pattern. The shift of weight to the forward foot occurs while the bat is still moving backward as the hips and spine and shoulder girdle assume their force-production positions. At the initiation of the forward movement the bat is kept near the body, and elbow extension and the supination-pronation of the hands does not occur until the arms and hands are well forward and ready to extend the lever in preparation to meet the ball. At contact the weight is on the forward foot.

Skip

Stage 1

A deliberate step-hop pattern is employed, an occasional double hop is present, there is little effective use of the arms to provide momentum, an exaggerated step or leap is present during the transfer of weight from one supporting limb to the other, the total action appears segmented.

Stage 2

Rhythmical transfer of weight during the step phase, increased use of arms in providing forward and upward momentum, exaggeration of vertical component during airborne phase, i.e. while executing the hop.

Stage 3

Rhythmical transfer of weight during all phases, reduced arm action during transfer of weight phase, foot of supporting limb carried near surface during hopping phase.

Gallop

<u>Stage 1</u>

The pattern resembles a rhythmically uneven run with the performer often reverting to the traditional running pattern. The tempo tends to be relatively fast and the rhythm inconsistent. The trail leg crosses in front of the lead leg during the airborne phase and remains in front at contact. The trail leg is flexed at $\leq$ 45 degrees during the airborne phase. Both feet generally contact the floor in a heel-toe pattern although either foot may strike the surface flat-footed.

<u>Stage 2</u>

The pattern is executed at a slow to moderate tempo with the rhythm often appearing choppy. The trail leg moves in front of, adjacent to, or behind the lead leg during the airborne phase, but is always adjacent to or behind the lead leg at contact. The trail leg is extended during the airborne phase, often causeing the trail foot to turn out and the lead leg to flex at $\leq$ 45 degrees. The feet usually contact the floor in a heel-toe/heel-toe or toe/toe combination. The transfer of weight may appear stiff and exaggerated. The vertical component is often exaggerated as the trunk extends to lift the body up.

<u>Stage 3</u>

The pattern is smooth, rhythmical, and executed at a moderate tempo. The trail leg may cross in front of or move adjacent to the lead leg during the airborne phase but is placed adjacent to or behind the lead leg at contact. Both the lead and trail legs are flexed at $\leq$ 45 degrees with the feet carried close to the surface during the airborne phase. The lead foot meets the surface with a heel-toe pattern followed by a transfer of weight to the ball of the foot.

Hop

Stage 1

The non-support knee is flexed at 90 degrees or less with the non-support thigh parallel to the surface. This position places the non-support foot in front of the body so that it may be used for support in the event that balance is lost. The body is held in an upright position with the arms flexed at the elbows. The hands are held near shoulder height and slightly to the side in a stabilizing position. Force production is generally limited so that little height or distance is achieved in a single hop.

Stage 2

The non-support knee is fully flexed so that the foot is near the buttocks. The thigh of the non-support leg is nearly parallel to the surface. The trunk is flexed at the hip resulting in a slight forward lean. The performer gains considerable height by flexing and extending the joints of the supporting leg and by extending at the hip joint. In addition, the thigh of the non-support leg aids in force production by flexing at the hip joint. Upon landing, the force is absorbed by flexion at the hips and the supporting knee. The arms participate vigorously in force production as they move up and down in a bilateral manner. Due to the vigorous action and precarious balance of performers at this stage, the number of hops generally ranges between two and four.

Stage 3

The thigh of the non-support leg is in a vertical position with the knee flexed at 90 degrees or less. Performers exhibit greater body lean forward than in stages one or two, with the result that the hips are farther in front of the support leg upon take-off. This forward lean of the trunk results in greater distance in relation to the height of the hop.

The thigh of the non-support leg remains near the vertical (frontal) plane, but knee flexion may vary as the body is projected and received by the supporting leg. The arms are used in force production, moving bilaterally upward during the force production phase.

Stage 4

The knee of the non-support leg is flexed at 90 degrees or less, but the entire leg swings back and forth like a pendulum as it aids in force production. The arms are carried close to the sides of the body, with elbow flexion at 90 degrees. As the non-support leg increases its force production, that of the arms seems to diminish.

APPENDIX D

SUBJECT INFORMATION

ID#	Age (yrs)	Gender	Cause of Deafness	Age at Onset	School	Better Ear Average (dB)
001	4	F	Genetic	Birth	A	Unknown
002	4	M	Genetic	Birth	A	Unknown
003	5	F	Genetic	5 Months	A	110
004	5	M	Genetic	Birth	A	100
005	5	F	CMV	10 Months	A	110
006	6	F	Genetic	6 Months	A	110
007	7	M	Other	18 Months	A	110
008	8	F	CMV	3 Months	A	110
009	8	F	Unknown	Birth	A	110
010	7	M	Genetic	Birth	A	95
011	8	F	Genetic	60 Months	A	75
012	9	F	Genetic	Birth	A	72
013	9	M	Genetic	Birth	A	110
014	9	F	Genetic	Birth	A	110
015	9	M	Genetic	Birth	A	68
016	11	M	Rubella	18 Months	A	100
017	8	M	Meningitis	12 Months	A	95
018	11	M	Unknown	Unknown	A	92
019	10	F	Genetic	Birth	A	110
020	11	F	Meningitis	8 Months	A	110
021	9	F	Meningitis	8 Months	A	110
022	11	M	Unknown	11 Months	A	110
025	12	M	Rubella	Birth	A	101
026	12	M	Rubella	Birth	A	100
049	4	M	Unknown	Birth	A	Unknown
050	4	F	Genetic	Birth	A	Unknown
051	7	M	Genetic	18 Months	A	110
056	10	M	Genetic	Birth	A	95
057	12	F	Unknown	Unknown	A	Unknown
102	12	F	CMV	Birth	B	88
103	12	F	Meningitis	10 Months	B	Unknown
105	12	M	Unknown	Birth	B	110
106	12	M	Unknown	12 Months	B	Unknown
109	12	F	Unknown	Unknown	B	Unknown
110	12	F	Unknown	Unknown	B	98
111	12	M	Unknown	8 Months	B	Unknown
117	11	M	Genetic	Birth	B	93
119	11	M	Genetic	Birth	B	91
120	11	M	Genetic	Birth	B	80
121	11	F	Unknown	Birth	B	105
122	11	F	Unknown	24 Months	B	95
123	11	F	Unknown	84 Months	B	106

125	12	M	Anoxia	Birth	B	80
126	12	F	Meningitis	3 Months	B	113
127	11	M	Unknown	Birth	B	103
128	11	M	Unknown	Birth	B	Unknown
129	12	M	Unknown	Birth	B	Unknown
130	12	F	Genetic	Birth	B	Unknown
131	12	F	Unknown	Birth	B	Unknown
152	7	F	Unknown	Birth	B	115
153	9	M	Unknown	Birth	B	85
154	7	F	Unknown	Birth	B	98
155	7	F	Meningitis	24 Months	B	105
156	7	F	Genetic	Birth	B	80
157	7	F	Meningitis	30 Months	B	95
158	7	M	Unknown	Birth	B	110
159	9	F	Unknown	Birth	B	86
160	9	M	Rubella	Birth	B	71
161	8	F	Unknown	Birth	B	82
162	8	F	Unknown	Birth	B	105
163	8	F	Unknown	Unknown	B	88
165	9	F	Rubella	Birth	B	85
166	8	F	Unknown	Birth	B	105
167	7	M	Unknown	Birth	B	110
168	9	F	Unknown	Birth	B	105
169	9	M	Genetic	Birth	B	88
170	9	M	Rubella	Birth	B	117
172	8	F	Unknown	Birth	B	85
173	8	F	Unknown	Birth	B	110
174	12	F	Unknown	Birth	B	Unknown
175	8	F	Unknown	Birth	B	Unknown
178	8	M	Rubella	Birth	B	78
179	9	F	Unknown	Birth	B	108
180	8	M	Unknown	Birth	B	115
181	8	M	Unknown	Birth	B	100
182	10	F	Meningitis	9 Months	B	Unknown
183	10	M	WAARD	Birth	B	110
184	10	M	Genetic	Birth	B	100
185	10	F	Genetic	Birth	B	70
186	10	F	Unknown	Birth	B	107
187	10	F	Unknown	18 Months	B	92
188	10	F	Unknown	30 Months	B	110
190	10	F	Unknown	Birth	B	115
191	10	F	Unknown	Birth	B	106
192	10	M	Unknown	18 Months	B	106
193	10	M	Unknown	Birth	B	68
195	11	F	Genetic	Birth	B	Unknown
196	9	F	Unknown	Birth	B	100
214	6	F	Meningitis	30 Months	B	Unknown
215	6	M	Meningitis	4 Months	B	Unknown
216	6	F	Unknown	Birth	B	118
217	6	M	Prematurity	Birth	B	80
218	6	F	Unknown	30 Months	B	90
219	6	M	Meningitis	24 Months	B	105
220	6	M	Meningitis	15 Months	B	105
221	6	M	Unknown	Unknown	B	Unknown

222	5	M	Unknown	Birth	B	103
223	5	M	Genetic	Birth	B	103
224	5	M	Unknown	42 Months	B	70
225	4	M	Genetic	Birth	B	55
226	5	M	Unknown	Birth	B	105
227	5	F	Rubella	10 Months	B	110
228	5	F	Unknown	Unknown	B	80
229	5	M	Unknown	Birth	B	102
230	5	M	Unknown	Unknown	B	90
231	5	M	Unknown	Birth	B	112

Key:

Gender -
- M = male
- F = female

Cause of Deafness -
- Genetic = deafness due to genetic reason
- CMV = deafness caused by exposure to cytomegalovirus
- WAARD = deafness due to Waardenburg syndrome
- Rubella = deafness due to rubella
- Meningitis = deafness due to meningitis
- Other = deafness caused by something other than those mentioned above
- Unknown = the cause of deafness is not known

School -
- A = school for the deaf in the United States
- B = school for the deaf in Canada

Better Ear Average -
- Unknown = the better ear average is not known

APPENDIX E

BALANCE AND FUNDAMENTAL SKILLS SCORES

ID#	Static	Dynamic	Throw	Catch	Kick	Punt	Strike	Run	Gallop	Skip	Jump	Hop
001	2	2	1	1	3	2	4	4	2	2	2	2
002	2	2	1	4	2	1	2	4	2	0	3	2
003	2	2	3	4	3	1	2	4	2	2	2	1
004	2	2	1	2	3	3	4	4	2	2	2	2
005	2	2	3	1	3	1	2	3	1	0	1	0
006	2	2	3	3	2	2	2	4	3	2	1	2
007	2	2	5	3	4	3	4	4	2	2	4	2
008	2	2	1	3	3	1	2	4	2	2	2	2
009	2	2	4	4	4	3	3	4	2	2	3	4
010	2	2	5	4	3	3	4	4	2	0	2	2
011	1	1	4	4	4	3	4	4	2	2	2	4
012	2	2	4	5	4	3	2	4	3	3	3	4
013	1	2	5	5	4	3	4	4	3	2	3	3
014	1	1	4	5	4	3	4	4	3	3	2	3
015	1	1	5	5	4	3	4	4	3	3	3	4
016	1	1	5	5	4	4	4	4	3	3	2	4
017	1	2	5	5	4	3	4	4	3	3	3	3
018	2	2	4	3	4	3	4	4	3	3	3	4
019	1	2	5	5	4	3	4	4	3	3	4	4
020	1	1	4	4	3	3	2	4	3	3	2	4
021	1	2	5	5	3	3	4	4	3	3	2	4
022	1	2	5	5	4	3	4	4	3	2	4	4
025	1	2	5	5	3	3	4	4	3	3	4	4
026	1	2	5	5	4	4	4	4	2	3	1	4
049	2	2	3	4	3	3	4	4	2	0	2	0
050	2	2	4	2	1	1	2	4	1	0	2	2
051	2	2	5	5	4	1	4	4	2	3	3	4
056	1	2	5	5	4	3	2	4	3	1	1	4
057	1	1	5	5	4	3	4	4	3	3	3	4
102	1	2	5	5	4	3	4	4	3	3	2	3
103	1	2	5	5	4	M	4	4	3	3	2	4
105	1	2	4	5	4	4	4	4	3	3	3	2
106	1	2	5	5	4	3	4	4	3	3	4	4
109	1	2	4	5	4	3	4	4	3	3	2	4
110	1	2	4	4	4	3	3	4	3	3	3	4
111	2	2	3	4	3	M	2	4	3	2	1	3
117	1	1	5	5	4	3	4	4	3	3	4	4
119	1	1	5	5	4	4	4	4	3	3	4	4
120	1	1	4	5	3	3	2	4	3	2	2	3
121	1	2	3	4	4	2	4	4	3	3	4	4
122	1	2	5	5	4	3	4	4	3	3	3	4
123	1	1	4	4	4	3	4	4	3	3	3	4
125	1	2	5	5	4	4	4	4	2	3	2	3
126	1	2	3	5	4	3	4	4	3	3	2	4
127	2	2	4	4	4	0	4	4	3	0	2	3
128	2	2	5	4	4	3	4	4	3	3	3	3

129	1	2	4	4	4	4	4	M	M	M	4	M
130	1	1	5	5	4	4	4	4	3	3	4	4
131	1	2	5	5	4	4	4	4	3	3	3	4
152	2	2	1	4	3	1	2	4	2	2	1	3
153	1	1	5	5	4	3	4	4	2	2	3	4
154	1	2	1	4	4	3	2	4	3	2	3	2
155	2	2	5	3	4	3	4	4	3	2	2	4
156	1	2	5	4	4	3	2	4	2	2	3	4
157	1	2	3	4	3	3	4	4	2	2	1	3
158	2	2	3	3	3	3	4	3	2	0	1	2
159	2	2	1	4	3	3	2	4	2	2	1	3
160	2	2	4	3	3	3	4	3	2	0	2	3
161	2	2	4	4	3	2	2	4	2	2	1	4
162	2	2	4	3	3	1	2	3	2	2	1	3
163	1	1	4	4	3	3	2	4	2	3	3	4
165	2	1	4	4	3	3	4	4	3	3	3	4
166	2	2	3	4	3	3	4	4	2	2	3	4
167	2	2	3	4	3	3	4	4	2	0	2	3
168	1	2	3	4	4	3	2	4	2	3	2	3
169	1	1	5	5	4	3	4	4	3	3	3	4
170	2	2	4	4	4	2	4	3	1	0	3	2
172	1	1	5	5	4	2	2	4	3	2	4	4
173	1	2	5	4	4	3	2	4	3	2	3	3
174	2	2	3	5	4	3	4	4	3	3	2	4
175	2	2	4	3	4	3	2	2	3	2	3	3
178	1	2	4	5	4	3	4	4	2	2	4	4
179	1	2	5	5	4	3	4	4	3	3	3	4
180	2	2	5	5	4	3	4	4	3	2	3	3
181	2	2	5	5	4	3	4	4	3	3	4	4
182	1	2	5	4	3	3	4	4	3	3	3	4
183	1	1	5	5	4	3	4	4	3	3	3	4
184	2	2	5	5	4	4	4	4	3	3	3	4
185	1	1	4	5	4	3	4	4	3	3	3	4
186	1	1	5	5	4	3	4	3	3	3	2	4
187	1	1	5	5	4	3	2	4	2	2	2	4
188	1	1	4	4	4	3	2	4	3	3	2	4
190	2	2	5	4	4	3	4	4	3	2	1	3
191	2	2	4	4	3	3	3	4	2	3	2	4
192	2	2	4	4	4	3	3	4	2	2	2	3
193	1	1	4	4	3	3	4	4	2	3	3	3
195	2	2	5	5	4	4	3	4	3	2	3	4
196	1	2	5	4	4	3	4	4	3	3	3	4
214	2	2	4	3	3	3	3	4	3	2	2	3
215	2	2	2	1	3	3	2	3	2	2	2	3
216	2	2	3	3	3	1	1	3	2	3	1	3
217	2	2	1	2	3	1	4	3	2	0	2	2
218	1	1	4	4	4	1	3	4	3	2	3	4
219	1	1	5	3	4	1	3	4	2	1	3	2
220	2	2	4	3	4	0	2	3	2	0	1	1
221	2	2	1	4	4	1	2	4	2	2	3	2
222	2	2	2	2	4	2	1	4	2	2	2	0
223	1	1	4	2	3	2	4	4	2	2	1	2
224	2	2	1	2	3	2	2	4	1	1	1	2
225	2	2	1	1	2	1	2	4	2	1	1	1

226	2	2	1	3	3	2	3	4	2	2	1	2
227	1	2	3	4	2	2	3	3	2	2	1	2
228	2	2	2	1	3	1	2	3	2	2	1	2
229	2	2	1	1	3	1	1	4	2	0	1	2
230	2	2	1	3	3	0	2	4	1	0	0	0
231	2	2	1	3	3	1	2	4	2	0	2	2

The static and dynamic balance scores represent whether the subject passed (1) or failed (2) that particular test. The criteria for passing and failing these tests is explained in the Methods section of this paper.

The fundamental motor skills scores represent the stage of performance that the subject displayed (0 being least mature and 5 being most mature). The criteria for stage classifications is explained in the Methods section of this paper. "M" has been used to indicate missing data.

APPENDIX F

FREQUENCIES OF FUNDAMENTAL MOTOR SKILL PERFORMANCES BY AGE AND GENDER

Table 11

Frequencies of fundamental motor skill performances by males and females

		Stage of fundamental motor skill						
Skill	Gender	0	1	2	3	4	5	%-mature level
Running	Males	-	-	-	17	32		65%
	Females	-	-	1	19	36		64%
Skipping	Males	13	7	17	12			24%
	Females	2	4	29	21			38%
Galloping	Males	-	7	28	14			29%
	Females	-	2	36	18			32%
Hopping	Males	3	4	13	21	4		16%
	Females	1	3	10	27	15		27%
Jumping	Males	1	15	14	19	1		41%
	Females	0	12	26	18	-		4%

(table continues)

Skill	Gender	0	1	2	3	4	5	%-mature level
Throwing	Males	-	10	5	5	21	9	18%
	Females	-	5	3	13	29	6	11%
Catching	Males	-	5	3	17	11	14	29%
	Females	-	3	3	19	26	5	9%
Striking	Males	-	4	10	24	12		24%
	Females	-	4	21	27	4		7%
Kicking	Males	-	1	5	30	14		29%
	Females	-	1	12	29	14		25%
Punting	Males	3	10	6	29	1		2%
	Females	-	13	16	25	1		2%

Table 12

Frequencies of fundamental motor skills performances by age

Running	Stage						
Age	0	1	2	3	4	5	Total
4	-	-	-	3	2		5
5	-	-	-	5	7		12
6	-	-	-	4	5		9
7	-	-	-	3	7		10
8	-	-	1	4	9		14
9	-	-	-	3	11		13
10	-	-	-	5	8		13
11	-	-	-	5	8		15
12	-	-	-	4	11		15
Total	0	0	1	36	68		105

Jumping	Stage						
Age	0	1	2	3	4	5	Total
4	-	2	3	-	-		5
5	1	8	3	-	-		12
6	-	4	3	2	-		9
7	-	3	4	3	-		10
8	-	3	3	8	-		14
9	-	2	6	6	-		14
10	-	3	5	5	-		13
11	-	-	5	7	1		13
12	-	2	8	6	-		16
Total	1	27	40	37 1			106

Striking	Stage						
Age	0	1	2	3	4	5	Total
4	-	1	2	1	1		5
5	-	4	4	3	1		12
6	-	1	4	4	-		9
7	-	2	1	6	1		10
8	-	-	8	4	2		14
9	-	-	3	9	2		14
10	-	-	5	8	-		13
11	-	-	3	7	3		13
12	-	-	1	9	6		16
Total	0	8	31	51	16		106

Hopping	Stage						
Age	0	1	2	3	4	5	Total
4	1	3	1	-	-		5
5	3	2	7	-	-		12
6	-	1	6	2	-		9
7	-	1	4	3	2		10
8	-	-	3	9	2		14
9	-	-	1	11	2		14
10	-	-	-	7	6		13
11	-	-	-	7	6		13
12	-	-	1	9	5		15
Total	4	7	23	48	23		105

Galloping	Stage						
Age	0	1	2	3	4	5	Total
4	1	4	-				5
5	5	7	-				12
6	2	6	1				9
7	-	10	-				10
8	-	11	3				14
9	1	8	5				14
10	-	6	7				13
11	-	7	6				13
12	-	5	10				15
Total	9	64	32				105

Skipping	Stage						
Age	0	1	2	3	4	5	Total
4	3	1	1	-			5
5	4	5	3	-			12
6	2	1	6	-			9
7	3	1	6	-			10
8	-	1	12	1			14
9	2	-	6	6			14
10	-	1	5	7			13
11	1	-	4	8			13
12	-	1	3	11			15
Total	15	11	46	33			105

Throwing	Stage						
Age	0	1	2	3	4	5	Total
4	-	3	1	-	1	-	5
5	-	6	3	2	1	-	12
6	-	2	2	2	3	-	9
7	-	2	2	1	5	-	10
8	-	1	-	3	8	2	14
9	-	1	-	3	6	4	14
10	-	-	-	2	11	-	13
11	-	-	-	2	6	5	13
12	-	-	-	3	9	4	16
Total	0	15	8	18	50	15	106

Catching	Stage						
Age	0	1	2	3	4	5	Total
4	-	2	1	2	-	-	5
5	-	4	3	4	1	-	12
6	-	2	1	6	-	-	9
7	-	-	-	8	2	-	10
8	-	-	1	4	7	2	14
9	-	-	-	5	5	4	14
10	-	-	-	1	10	2	13
11	-	-	-	4	5	4	13
12	-	-	-	2	7	7	16
Total	0	8	6	36	37	19	106

Kicking	Stage						
Age	0	1	2	3	4	5	Total
4	-	2	3	-	-		5
5	-	-	7	5	-		12
6	-	-	3	6	-		9
7	-	-	1	9	-		10
8	-	-	3	6	5		14
9	-	-	-	9	5		14
10	-	-	-	10	3		13
11	-	-	-	8	5		13
12	-	-	-	6	10		16
Total	0	2	17	59	28		106

Punting	Stage						
Age	0	1	2	3	4	5	Total
4	-	3	2	-	-		5
5	1	8	2	1	-		12
6	1	6	1	1	-		9
7	-	2	6	2	-		10
8	-	3	3	8	-		14
9	-	1	5	8	-		14
10	-	-	1	12	-		13
11	1	-	1	11	-		13
12	-	-	1	11	2		14
Total	3	23	22	54	2		104

APPENDIX G

RESULTS OF CHI-SQUARE ANALYSES USING MODIFIED BALANCE SCALE

Fundamental motor skills and dynamic balance. The data obtained in this study support the hypothesis of a positive relationship between fundamental motor skill performance and dynamic balance performance only for the skills of hopping, skipping, throwing, galloping, kicking, and jumping, when using the cut-off point of six steps. The data does not support the hypothesis for the other skills of running, striking, catching, and punting. The results of the chi-square analyses are listed below.

Throwing:	χ^2 (4, N = 106)	= 14.98, p = .00
Catching:	χ^2 (4, N = 106)	= 5.85, p = .21
Striking:	χ^2 (3, N = 106)	= 3.20, p = .36
Kicking:	χ^2 (3, N = 106)	= 8.30, p = .04
Punting:	χ^2 (4, N = 104)	= 5.90, p = .20
Hopping:	χ^2 (4, N = 105)	= 15.08, p = .00
Skipping:	χ^2 (3, N = 105)	= 7.72, p = .05
Running:	χ^2 (2, N = 105)	= 3.90, p = .14
Galloping:	χ^2 (2, N = 105)	= 6.81, p = .03
Jumping:	χ^2 (4, N = 106)	= 12.71, p = .01

Table 13 lists the frequencies of performances of the fundamental motor skills for balancers and nonbalancers. The percentages of balancers and nonbalancers attaining the most mature level of performance is also listed in Table 13.

Table 13

Frequencies of fundamental motor skill performances

by dynamic balancers and nonbalancers (modified balance scale)

Skill	Balance Category	Stage of fundamental motor skill 0	1	2	3	4	5	%-mature level
Running	B (n = 25)	-	-	-	1	32		96%
	NB (n = 80)	-	-	1	11	60		85%
Skipping	B (n = 25)	1	1	11	20			68%
	NB (n = 80)	15	3	29	26			36%
Galloping	B (n = 25)	-	-	10	23			72%
	NB (n = 80)	-	5	35	32			46%
Hopping	B (n = 25)	-	-	4	4	25		80%
	NB (n = 80)	4	3	18	21	26		39%
Jumping	B (n = 25)	-	1	10	16	7		16%
	NB (n = 80)	1	20	24	21	6		11%

(table continues)

Skill	Balance category	0	1	2	3	4	5	%-mature level
Throwing	B (n = 25)	-	1	-	1	14	18	52%
	NB (n = 81)	-	14	3	14	17	24	36%
Catching	B (n = 25)	-	-	1	4	12	17	60%
	NB (n = 81)	-	6	5	12	26	23	31%
Striking	B (n = 25)	-	-	9	2	23		68%
	NB (n = 81)	-	3	23	8	38		54%
Kicking	B (n = 25)	-	-	-	7	27		76%
	NB (n = 81)	-	1	4	30	37		56%
Punting	B (n = 25)	-	3	2	25	4		12%
	NB (n = 79)	3	14	9	38	6		9%

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