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A CROSS SECTIONAL COMPARISON OF FLEXIBILITY AND BALANCE IN

CHILDREN 10-14 YEARS OF AGE

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DEDICATION

I would like to dedicate my thesis to my parents. Dad, thank you for the sacrifices you have made my entire life. You are truly the best role model a girl could have. I truly appreciate the support and confidence you and Mom gave me throughout the years. You both pushed me to strive for greatness and always encouraged me to never give anything less than my best. To my late mother, thank you for being an inspiration to be a go-getter and achiever just like you! This one is for you. I miss you every day. Remember: one day at a time!

ACKNOWLEDGEMENTS

A CROSS SECTIONAL COMPARISON OF FLEXIBILITY AND BALANCE IN

CHILDREN 10-14 YEARS OF AGE

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ABSTRACT

Purpose: To determine the effects of age on flexibility and balance in children ages 10-14. This study also determined the validity of the Y-balance test by comparing it to the standard back-saver sit and reach (BSSR) and the balance error scoring system test (BESS). **Methods:** 84 participants males (n=41) and females (n=43) ages 10-14 years old from a school in Chardon, Ohio, volunteered through a convenience sample to complete the study. Each subject had to complete three different tests in a randomized order during their regular physical education class. To compare the results of the three tests, gender and the age groups, a two-way anova, and a Pearson correlation were used. **Results:** The males scored significantly higher (p=0.037) than the females on the Y-balance test, while the females scored significantly higher (p=0.000) than the males on the BSSR and the BESS. There was no correlation between the Y-balance and either the BSSR or the BESS, r values less than 0.1. **Conclusion:** It can be concluded that the females scored significantly higher on the BSSR and the BESS, but the males scored significantly higher on the Y-balance. When comparing age groups, the Y-balance score significantly increased with age with the exception of the 13 year olds. For the BSSR and BESS, scores decreased in the categories of flexibility and balance in the older age groups. The validity of the Y-balance test as an accurate measure of flexibility and

balance, compared to the BSSR and BESS respectively, was not demonstrated in this study.

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CHAPTER I

INTRODUCTION

1.1 Background Information

With an increasing rate in obesity and a decrease in physical education classes in school districts across the nation, it is important to analyze why programs are being cut.[24] In the past, teachers or principals created their own curriculum and based their lesson plans on that curriculum. New standards and evaluations of students in physical education classes are being mandated by the state of Ohio. This coincides with the standards set forth by the Society of Health and Physical Educators (Shape America).[24] Within these standards, six skill-related and five health-related physical fitness components are incorporated. Therefore, physical education programs should focus on the skill-related and health-related physical fitness components. The six skill-related components are agility, power, speed, balance, coordination, and reaction time.[10] The five health-related physical fitness components are cardiorespiratory endurance, muscular endurance, muscular strength, body composition, and flexibility.[17] Regardless of a

specific teacher or district, the students will be exposed to and potentially develop the essential skills because they follow the state standards.

According to Shape America, there are five Physical Education state standards.[24] Standard one expects that a student will be able to demonstrate competency in a variety of skills, one of which is balance.[24] Standard three expects that a student can demonstrate the skills and knowledge to achieve physical fitness, one of the components focusing on flexibility.24 In order to be proficient, the student must display balance and flexibility ability.

Balance refers to maintaining one's equilibrium while the body is either moving or stationary.[10] Furthermore, balance is dependent on neural input from auditory, visual, sensory, and motor processes and involves both motor skills and movement patterns.[26] For example, without balance, a football player would not be able to score touchdowns.[20] Moreover, flexibility allows joints to move through a full range of motion.[21] Measuring flexibility and balance in students at any grade level is beneficial. In the past, teachers used a balance test such as the balance beam test, and a flexibility test such as the back-saver sit and reach. The company Move2Perform has created a test to measure flexibility and balance in one assessment referred to as the Y-balance test. Since the new Y-balance test measures both components simultaneously, using this assessment would prove beneficial in saving time for teachers.

The Y-balance test has not been used in a classroom setting to measure flexibility and balance. However, it has been used in many rehabilitation studies after an injury has occurred and in clinical settings to predict risk of injury.[4, 19, 25] Poor flexibility and balance are associated with increased risk of lower back injuries. Teachers can use the Y-

balance test to measure flexibility, balance, and predict injury risk. Then, teachers can incorporate more balance and flexibility activities into their curriculum as needed, which will help students increase their flexibility and balance while making them less prone to injury. For these reasons, the Y-balance test should be piloted in a school setting.

1.2 Statement of the Problem

With obesity rates increasing in the United States, there has been a demand to dramatically change the physical education curriculum and to focus more on the five health-related physical fitness components and the six skill-related components. The health-related components are cardiorespiratory endurance, muscular strength, muscular endurance, flexibility and body composition.[17] Skill-related components are agility, balance, coordination, power, speed, and reaction time.[10] Poor flexibility increases an individual's risk of lower back pain. Knowing the effects age has on flexibility and balance with 10-14 year old children will prove to be useful indicators to physical education programs. Additionally, balance is important because it is dependent on the visual and auditory channels of the brain and is necessary to maintain the body's equilibrium during both static and dynamic activities.[26] Although the Y-balance test measures flexibility and balance simultaneously and can predict risk of injury, there is currently no gold standard test that measures both balance and flexibility.18

1.3 Purpose of Study

The purpose of this study was to determine the effects of age and gender on flexibility and balance in children ages 10-14 years. This study also sought to determine the validity of the Y-balance test by comparing it to the standard back-saver sit and reach

(BSSR) which measures flexibility, and the balance error scoring system test (BESS), which measures balance.

1.4 Hypotheses

1. Females will have higher flexibility and balance scores than males.

2. As children age from 10-14 years, there will be an increase in flexibility and balance.

3. The Y-balance test scores will be a valid measure of balance and flexibility as compared to the BSSR and BESS, respectively.

1.5 Definitions

Static Balance: maintaining one's equilibrium while the body is stationary.[10]

Dynamic Balance: maintaining one's equilibrium while the body is moving.[10]

Static Flexibility: slow movement that lengthens muscles to move joints freely through range of motion[21]

Dynamic Flexibility: moving joints through full range of motion.[21]

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

The literature review will discuss differences between males and females with regard to maturation, gender, body mass index, balance, and flexibility. It will also examine the relationship between flexibility and balance when implementing curriculum and after school programs for school-aged students. Finally, the validity and reliability of flexibility and balance tests that have been used in previous studies will be discussed.

2.2 Maturation

When conducting fitness tests in the youth population, it is important to consider their maturation rate. Fisher [5] reviewed the exercise physiology in children, grades K-6.

Fisher[5] noted that during maturation, children's bodies change rapidly. But, do maturation and chronological age affect each other? Jones et al. [13] found that a correlation

does indeed exist between physical fitness levels, maturation levels, and chronological age. In this study, 152 boys and 161 girls, ages 11-16 years, completed six tests. Height was measured using the Brecknell measuring device, and weight was measured using the Brecknell balance scale.[13] Sexual maturity was measured using Tanner photographs, which asks the subjects to identify which picture represents their physical maturity.[13] In addition, the handgrip test measured strength in both hands; the vertical jump test measured power; and a 20 meter shuttle run tested speed.[13] The results showed there was a significant, positive relationship between all measurements indicating that as maturation increased, test scores improved.[13] The boys had a significantly higher correlation between maturation and performance: shuttle run test r = 0.56, vertical jump r= 0.56, and grip strength r=0.73.[13] The correlation coefficients for girls were significantly lower compared to the boys: shuttle run test r= 0.27, vertical jump r=0.24, and grip strength r=0.46.[13] The study found that maturation in boys influenced their physical fitness, but they did not find the same impact on girls.[13] The study concluded this may be due to the significant relationship between sexual maturity and performance of physical fitness tests.[13] . It has also been found that there is a lack of intrinsic motivation for age 12-13 years when participating in physical activity.[13]

2.3 Gender Differences

Muscular strength is needed to complete the Y balance-test because the stable leg must balance and support the majority of the body weight while the other leg is moving. Fisher noted that children increase their muscular strength with growth-induced hypertrophy during maturation.[5] The main issue is that children experience growth spurts at various times, which is why interpreting any type of fitness test score can be

complicated, especially when placing youth in age groups. According to SHAPE America, it is recommended that students engage in exercise that promotes flexibility and muscular strength at least three times a week.[5,20] The main message is that children are not adults and growth changes occur at various times. Therefore, results can change from the beginning of the year to the end of the year.[5]

In 2012, a study[15] tested health-related physical fitness to track developmental changes over a three year period using the fitnessgram test. The 245 subjects were all sixth graders, age 11 years, 116 boys and 129 girls. This study lasted for three years, with a pretest at the beginning and two follow up tests each year. A modified sit and reach test was used to measure flexibility of the hamstrings. When comparing genders, the boys' scores decreased with the follow-up tests, whereas the girls' scores were increasingly higher for each follow-up test.[15] However, the overall comparison over the course of the three years (ages 11-14 years) showed the Spearmen rho coefficient did not significantly change from 0.52 to 0.68.[15]

A low score in flexibility for children and adolescents may relate to low back pain as they age.[3] A study[3] in 2010 examined 138 students, ages 12-16 years, 81 males and 57 females. This study sought to determine the joints and muscles involved in the BSSR test, a modified test to assess each limb separately, and the correlation between the BSSR and the standard sit and reach test scores.[3] All subjects performed a static stretching routine which focused on the back and leg muscles before they completed the test. Biological age was determined using Tanner stages; body mass was measured using a Seca scale; height was recorded using a stadiometer; body mass index (BMI) was computed. The BSSR and the standard sit and reach tests were performed in a random order with a 60 second break

in between.[3] Two trials were administered with the best score recorded. Overall, the results showed that there was no significant gender or age difference in flexibility scores.[3] There was no significant difference between the scores for the BSSR and the standard sit and reach tests. The study also showed a strong relationship between the hip muscles and joints in both flexibility tests (r=0.001)[3]

2.4 Body Mass Index/ Sit and Reach Scores

An important health-related physical fitness component is body composition, which is one of the components that must be focused on in the physical education curriculum. In 2007[27] a study compared health-related fitness from 1992 to 2002 between three age groups: 12, 14, and 16 year olds. This study randomly selected 14 schools in Lithuania, and each school randomly selected one class to participate in the study. There were 830 students: 256 12-year-olds, 312 14-year-olds, and 262 16-year-olds. On the first day, the students were measured for height, weight, standard sit and reach, and standing long broad jump. On the second day, the students completed sit-ups within 30 seconds and a 20-meter shuttle run test. Body Mass Index was computed from height and weight. There was an increase in BMI across all age groups, while the sit and reach test scores significantly decreased with age.[27] Thus, there was an inverse correlation between BMI and flexibility.[27]

A Taiwanese study[11] was conducted in 2010 to determine the correlation between BMI and the following tests: modified sit and reach, standing long jump, bent leg sit-ups, and 800/1600 meter run or walk. There were 24 students, ages 7-18 years, categorized into four age groups: 9-10, 11-12, 13-15, and 16-18 years.[11] The age groups were then categorized based on BMI percentiles: very low, BMI $<5^{th}$ percentile; low, BMI $\geq5^{th}<15^{th}$

percentiles; normal, BMI $\geq 15^{th} < 85^{th}$ percentile; high, BMI $\geq 85^{th} < 95^{th}$ percentiles; very high, BMI $\geq 95^{th}$ percentile.[11]

The results showed that the girls with low and high BMIs had lower sit and reach scores compared to girls with normal BMIs, regardless of age. When comparing age groups, the 16-18 year olds had the highest sit and reach scores overall. As for the boys, only the low and high end of the BMI showed higher sit and reach scores. The younger age group for the boys had a better sit and reach score, which is the opposite of what was found in the girls. The results showed that for the girls, sit and reach scores increased with age; while the younger (9-10 year old) boys had the best sit and reach scores. When comparing the overall sit and reach scores by gender, the girls were more flexible than the boys.[11]

2.5 Implementation of Programs and Curriculum

It is important for children to engage in physical activity at least 60 minutes per day, according to the Physical Activity Guidelines for Americans.[6] In order to improve physical fitness, physical activities need to be incorporated into physical education classes. One study[6] determined the correlation between the number of days a week a student had physical education and their physical fitness test scores. In 2,251 fourth and fifth grade students (1,122 males; 1,129 females). The test battery administered to the students was the fitnessgram, which consists of six individual tests. The students were categorized into three groups: group one, two or less weekly physical education classes for 33 minutes each; group two, more than two but less than five weekly physical education classes for 28 minutes each; group three, five days a week of physical education class for 30 minutes.[6]

The results showed that group one, who met for only two days, scored the lowest on the fitnessgram test. For BMI, females showed no differences when comparing groups. The males in group three, who met five days a week for physical education, had the lowest BMI. Group three, who met five days a week, had a mean BMI of 19.1. Group two, who met more than two but less than five times a week, had a mean BMI of 19.7; and group one, who met two or less days a week, had a mean of 20.1.[6] Overall, based on the BMI results, the groups that met the least amount during the week were slightly less fit when compared to the other groups. A limitation was that not all of the schools used the same curriculum for physical education. Even though the students had different amounts of time for physical education, it is not likely that a few minutes difference in physical education time would make a significant difference.

In 2005, Annesi et al.[1] examined the effects of a YMCA after school program. In children ages of 5 to 11 years, all enrolled in an after school program. Over a 12 week period, three days a week, for 45 minutes. The students were categorized into age groups where they performed cardiovascular activities every day and a resistance type of activity two out of three days during the week. They also incorporated behavioral skills training to work on personal time management issues one of three days during the week. This study found a significant increase in body mass index and strength, but no significant increase in flexibility over the 12 weeks. A limitation was that the program did not incorporate many stretching activities.[1]

In 2008,[23] a study was conducted to examine the implementation of a 32 week hamstring stretching exercise program for five minutes twice a week in their daily physical education class. There were 90 students (41 males; 49 females) that participated

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in this study. They were categorized into four groups: control group, 5th grade; control group, 2nd grade; experimental group, 5th grade; and experimental group, 2nd grade. The control groups did not take part in the program. The experimental groups participated in the program which was twice a week for three minutes at the beginning of class and two minutes at the end of class for 32 weeks. All groups completed a pre- and post-sit and reach test. Both control groups showed a lower score on their post-test, while the experimental group that completed the 32 week program showed a significant improvement in their sit and reach scores (+9.53 cm). From this study, it was determined that the implementation of a stretching program can increase flexibility. The authors concluded that the students may be at a decreased risk for future issues such as low back pain, spinal deformity, and herniated disks.[23]

In 2007, Reed et al. [22] assessed the relationship between the President's Council pedometer step recommendation per week and fitnessgram scores. In 298 students (140 males; 158 females), grades K-5. The fitnessgram consists of the Pacer, BMI, Curl-up, Trunk Lift, BSSR and Push-up tests.[22] For the fitnessgram, students had to receive passing scores in all six categories of the fitnessgram to achieve the healthy fitness zone. Pedometer steps were recorded for seven days continuously from morning until the students went to bed. To assist with accuracy, the parental guardians recorded the steps at night. The results showed that the boys took 284-3,650 more steps than the girls at all age groups. There were 121 students who met the recommended daily average amount of 14,553 steps and 177 students who did not. On average, the fitnessgram scores increased with age, except for the sit and reach test. There were only 77 students who were in the healthy zone in all categories for the Fitnessgram.[22] However, there was a positive

relationship between meeting the recommended pedometer steps and scoring in the healthy zone for the fitnessgram. [22]

2.6 Flexibility and Balance Test

Determining if a test is valid is important when conducting research. In 2004, Waelvelde et al.[28] assessed the validity of a Movement Assessment Battery for Children (M-ABC). This test has eight components, three for manual dexterity, two for ball skills, one for static balance, and two for dynamic balance. This test was designed for 4 to 12year olds, and there are two age bands for the M-ABC test with variations. There were a total of 133 third grade students (7-10 years old) that participated, categorized into two groups: normal motor development (n=43) and students who scored poorly in the ball catching skills (n=90).[28]

For static balance, the 7-8 year old students had to stand on one leg while the 9-10 year olds had to stand on one leg on a balance board. For the first dynamic balance test, the 7-8 year olds had to jump in squares while the 9-10 year olds had to hop in squares. For the second dynamic balance test, the 7-8 year olds had to heel-to-toe walk on a line, while the 9-10 year olds had to walk while balancing a ball on a board. In general, there was a moderate correlation between all of the balance tests in both age groups (7-8 year olds: -0.63; 9-10 year olds: -0.66).[28] The authors suggested a moderate correlation between all of the balance tests in both age groups due to over-generalizing testing results.[28] Because a student does well on one dynamic balance test, does not mean the student had good balance.[28]

Another study[7] examined reliability, consistency of test results, and validity of the BSSR test in 179 students, 87 males and 92 females, ages 6-12 years. Height, weight, and

age were recorded. Before the test, the students ran for two minutes then completed 10 full flexion and extension toe touches and 10 practice trials of the double leg sit and reach test. Then, the students were tested on their flexibility with the modified Schober test, lower back flexion, passive straight leg raise, active knee extension, true lumbar extension, true lumbar flexion double-leg sit and reach test, and the BSSR. All tests were completed in a random order. To test the reliability, 44 students were randomly selected to be retested within two to 10 days from the original test. The reliability for the BSSR test was similar to the double leg sit and reach test. However, it was found that the criterion referenced validity was unacceptable and should be reevaluated, the author recommended that the criterion needed to be made more difficult for boys and less difficult for girls 6-12 years old, due to the score results.[7]

Gilbert and Looney [16] conducted a follow-up study in 2012 to determine if higher quality cut-off scores could improve the criterion referenced validity of the BSSR test in 6-12 year olds. This study used the same data from the previous study.[7] The tests used were the passive straight leg raise (PSLR), back-saver sit and reach (BSSR), and active knee extension. These three tests were chosen because the PSLR and the BSSR measure hamstring flexibility for the right and left leg separately. The active knee extension and PSLR were used as the criterion test. The data showed that the girls had higher scores on the PSLR and BSSR test for the right and left leg compared to the boys.[16] As the previous study[7] showed, the reliability was significant for measuring hamstring flexibility for both legs. The data showed moderate validity coefficients (boys .67-.68, girls .47-.44) for the BSSR cut off scores with the most valid cut off scores for 6-12 year olds being 8-9 inches for both boys and girls.[16]

In 2009, a study[8] was conducted to determine the relationship between leg limb length and arm span to the modified BSSR scores. There were a total of 210 boys, ranging 12-18 years that took part in the study. Each student completed an eight minute warm-up that consisted of static stretches for the lower leg and back muscles. Each student had one practice trial, then completed three test trials of the CSR (standard sit and reach box), and the MBS (modified sit and reach, no box required) in a random order. The students were given five minutes of rest between each test. After the test, the students were measured for height, weight, arm span, and leg length. There was a significant relationship between the CSR (r=.23-.39) and MBS (r= .23-.44) when including limb length. For teachers or researchers, the MBS test can determine differences in hamstring flexibility from the right leg to the left leg that would not be determined using the CSR.[8]

Balance is the ability to keep the body's center of gravity over the base of support while completing various motor skills.[12] A study[12] had 6,915 subjects (girls, n= 3,499; boys, n=3,416), where the average age was 10 years. At least 5,402 of the 6,915 subjects participated in the assessment when they were 7 years old, as well. The 7 year olds participated in a 20 minute movement assessment battery for children (mABC). The mABC consisted of a heel to toe walking test, where the recorder counted the number of steps. When the subjects were 10 years old, the mABC used different tests such as walking along a beam, heel to toe, with eyes open and then closed.[12] The time it took the subject to walk across the beam was recorded. The subjects also had to stand on one leg, alternating from left to right with eyes open and then closed; the time was recorded, and ended once the subject let the free foot touch the ground.

The results showed that 80% of the subjects were able to successfully stand on their right leg with their eyes open, while 77.5% of the subjects could stand successfully on their left leg with their eyes open. Only 12.9% of the subjects were able to stand on their right leg successfully with their eyes closed, and only 11.7% could stand on their left leg successfully with their eyes closed. Balance scores significantly decreased with no visual input. The girls scored consistently better than the boys on all balance tests, and could hold the balance for 3.1 to 3.6 seconds longer.[12] The results showed no correlation (r value less than 0.1) between the mABC dynamic heel to toe walking balance test at 7 years old and the age 10 static balance measure tests.[12] This low correlation may be due to differences in the static versus dynamic balance tasks.

In 2013, a study[19] was conducted to assess the relationship between strength, balance, and mobility in 21 children, 8 females and 13 males, 7-10 years old. Before the test, each subject completed a standard five minute warm-up that focused on bipedal and monopedal balance and sub-maximal plyometric exercises. To determine strength, leg presses of three maximal effort repetitions, each held for three to five seconds, were performed. Maximal vertical countermovement jumps (CMJs) were also performed. The subjects performed three jumps with one minute rest in between and were instructed to jump as high as possible. For the steady-state balance tests, the subjects had three trials to stand in a bipedal step stance with their hands on their hips, looking forward. For the reactive balance, the subjects had to stand in a bipedal step stance on a balance platform, hands on hips, eyes looking forward. Finally, the proactive balance test was used to determine functional reach, measuring the maximal distance the subject could reach forward while maintaining a fixed based standing position. The study found no

significant correlations between balance, mobility, and strength.[19] There was also no significant correlations between the steady-state, reactive, and proactive balance tests.[19]

A study[9] in 2008 was conducted to explore gender differences in hamstring and quadriceps strength and the effects on static balance. In 368 subjects (184 males; 184 females), ages 7 to 12 year. Knee extension and flexion were used to determine the hamstring to quadriceps ratio (HQ) using a dynamometer. Each subject had five repetitions at 60º per second to measure muscle strength. Then, the subjects had a one minute rest and performed 30 repetitions at 240º per second to measure muscle endurance. To measure static balance, a movable platform with a tilt sensor was used. Each subject performed a one legged static balance test.

The results showed gender did not affect the performance of subjects age 7-11 years, but at 12 years of age, there was a significant difference.[9] The girls were stronger in extension while the boys were stronger in flexion and muscular endurance. In every age group, the girls had stronger quadriceps while the boys had stronger hamstrings. Compared to the boys, the girls overall had a lower balance index. The study did not determine maturation level, but the authors concluded that the results were independent of menarcheal status.[9] The authors suggested that the results may indicate that static balance is established at a young age and does not change much after maturation.[9]

Balance is a critical fundamental movement ability that children need to learn.[25] A study tested the reliability and validity of the University of North Carolina's Balance Error Scoring System (BESS), which consists of six balance tests that are held for 20 seconds each.[25] A firm floor surface was used to measure static balance while a foam surface was used to measure dynamic balance. Tests include double firm leg, single firm

leg with non-dominant foot, tandem firm both legs, double foam leg, single foam leg with non-dominant foot, and tandem foam both legs. All tests were performed with eyes open and then with eyes closed. The study had 46 students (24 females, 22 males), 9-10 years of age. The scoring was determined by the number of errors the students made. Errors consisted of lifting hands off hips, opening eyes during the eyes closed test, movement on the foam pad from the original position, lifting heel or forefoot, moving hips more than 30º of flexion or abduction, and remaining out of the test position for more than 5 seconds.   With the exception of the eyes open, tandem firm stance trial, reliability was good from .73 to .94, and .94-.99. The raw score protocol showed validity and reliability of this test for pre-pubescent students.[25] This test was determined to be cost-effective, valid, and reliable measuring static and dynamic balance for students. [25]

The SEBT is used to measure dynamic balance. When comparing two balance tests such as the SEBT and Y-balance test, it is important to note that the three main integration subsystems of balance are somatosensory, vestibular, and visual.[4] Both tests use dynamic balance and movement in the anterior (A), posteromedial (PM), and posterolateral (PL) direction. Coughlan et al. [4] compared dynamic balance using the SEBT and Y-balance test. There were 20 male subjects, ages 18-30 year, who volunteered from a local university. The subjects were randomly assigned to which test would be performed first and in the next seven days, the subjects performed the other test. Each test had three trials with two minute rest intervals between trials. The subjects reached further on the SEBT test in the anterior direction. For the posteromedial and posterolateral test, there was no difference in the reach distance. The difference in the anterior reach distance could be due to the flat base for the SEBT test, while the Y-

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balance test has a raised foot base and raised reach boxes to push during the test. Although the results showed that there were some differences in the anterior test, one test was not established as more appropriate for use over the other.[4]

The SEBT is used to measure dynamic balance. A study by Noronha et al. (2012)[20] was conducted to assess ankle range of motion and functional instability. There were 121 students, 57 males and 64 females, ages 18-24 year that completed the study. The researchers wanted to determine if the SEBT could predict risk of ankle sprain in healthy individuals. When using the SEBT test, the subjects were allowed three trials, and the longest distances were recorded. The subjects with a higher SEBT score were less likely to have a sprained ankle.[20] Therefore, this study found that 48% of subjects with a score lower than 80 had a greater risk of injury.[20] If a subject's reach distance was equivalent to at least 90% of their limb length, then there was a significant decrease in ankle sprain occurrences. Subjects with a previous history of a sprained ankle were at increased risk to have a new sprain because the ankle's static stabilizers were increasingly weaker than subjects with no history of an ankle sprain.[20]

2.7 Summary

Research on maturation indicates that students ranging from 10-14 years of age will experience growth spurts during puberty, which can affect their physical test results.[5, 13] Students who participated in physical fitness programs have better scores on their physical fitness tests than those who do not participate.[1,6] It is important that students take part in the same program if their results are to be compared. Balance and flexibility are a crucial part of a child's physical development. It is important to test these abilities yearly to determine changes with maturation and to diagnose poor development.

CHAPTER III

METHODS

3.1 Research Design

The study used a causal comparative design. The independent variable was age and gender. The dependent variables were flexibility and balance. The study was limited to 5th, 6th, 7th, and 8th graders at Notre Dame Elementary School located in Chardon, OH.

3.2 Subjects

The subjects were obtained through a convenience sample. There were 84 volunteers, 12-24 in each age group, ages 10-14, at Notre Dame Elementary School in Chardon, OH. The students turned in a consent form that their parents signed as well a student assent forms in order to participate in the study. The consent and assent form were approved by the Cleveland State University Institutional Review Board. No students

had to be excluded from the study because of an injury or a physical impairment that limited their balance or flexibility.

3.3 Procedures

Testing occurred in the school gymnasium during the student's regular physical education class. The tests used for the study were the Y-balance test for balance and flexibility, the back saver-sit and reach test (BSSR) for flexibility, and the balance error scoring system test (BESS) for balance.

The Y-balance test (Figure 1) was designed by Move2perform[18] to measure dynamic balance and flexibility for the lower limbs. The Y-balance test has a recommended formal test order that was followed. No shoes are allowed on the device during the practice trial or formal testing. When students are standing on the main platform with one foot, their toes must be behind the red line. The side-platforms are referred to as reach indictors, where the students place their foot on the side of the platform and push out when performing each trial.

Each student had six practice trials for each direction before the results were recorded. The test order consisted of three consecutive trials on the right foot, first to reach anterior, then switching to the left foot to reach anterior for three trials. Then, students returned to their right foot and reached posteromedial for three trials and switched to their left foot to reach posteromedial for three trials, as shown in Figure 1. Finally, the student returned to their right foot and reached posterolateral for three trials, and then switched to the left foot and reached posterolateral for three trials.

In the anterior trial, the reach indicator starts at zero and goes to 125 centimeters, but for the side reach indicators, it starts at zero and goes to 150 centimeters. A test trial

is faulted and needs to be retried if a student does one of the following: if the reach foot touches the ground; if the student falls off the platform; if the reach foot and reach indicator lose contact during the trials; if the student kicks or pushes the reach indicator; or if the student fails to bring the reach foot back to the starting position. The highest score of the three trials was recorded.
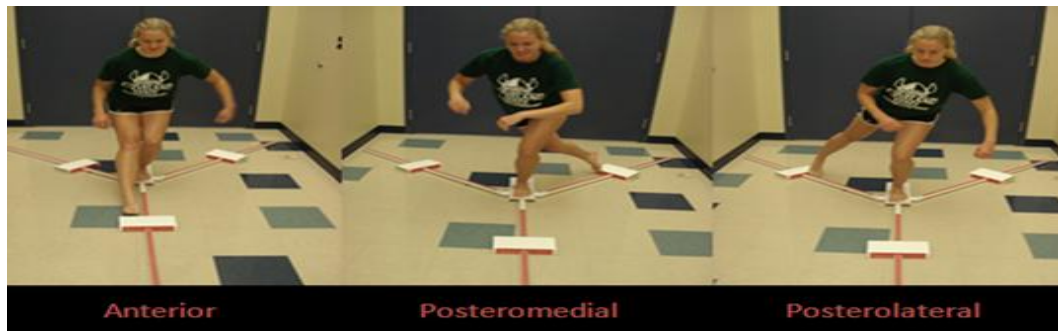

Figure 1. Y-Balance Test Device.

The purpose of the fitnessgram BSSR test (Figure 2) was to measure the flexibility of the hamstring muscles in both right and left legs. For the test, the students removed their shoes. A sit and reach box was used that has a 9 inch marker parallel to the face of the box against which the student's foot is placed.[29] One leg was straight with the sole of the foot touching the wall of the box. The opposite leg was bent so the sole of the foot was touching the ground two to three inches next to the straight leg. Students placed one hand over the other and reached forward pushing the measuring dial forward as far as they could. Each student attempted this four times, alternating legs. The highest score for each leg was recorded. In order to reach the fitnessgram healthy fitness zone, both legs must score in the zone.[29] The fitnessgram standard for the BSSR for 10-14 year old males is 8 inches. For 10 year old females, it is 9 inches, and for 11-14 year old females, it is 10 inches. [29]

Figure 2. Back-Saver Sit and Reach Device.

The BESS (Figure 3) was used to measure static balance. The student completed these three stances on a firm, flat surface with shoes removed: double leg stance, single leg stance, and tandem stance.[14] During the stance, the students kept their hands on their hips. For the double leg stance, feet were touching, next to each other and held for 20 seconds. For the single leg stance, the subject stands on their non-dominant leg while the dominant leg was held up at a 45º knee flexion and 20º hip flexion, held for 20 seconds.[14] For the tandem stance, the dominant foot was placed in front, the non-dominant foot was place behind.[14] The feet are positioned diagonally in the box and held for 20 seconds (Figure 3). The student received a point for every error that was made. Errors were counted as following: moving hands off hips, opening eyes during the closed eyes test, stepping or falling out of position, abduction or flexion of hip greater than 30º, lifting forefoot or heel off the surface, and remaining out of proper position for more than five seconds.[14] There is no standard for the BESS test, but the maximum total number of errors a for each position is 10.
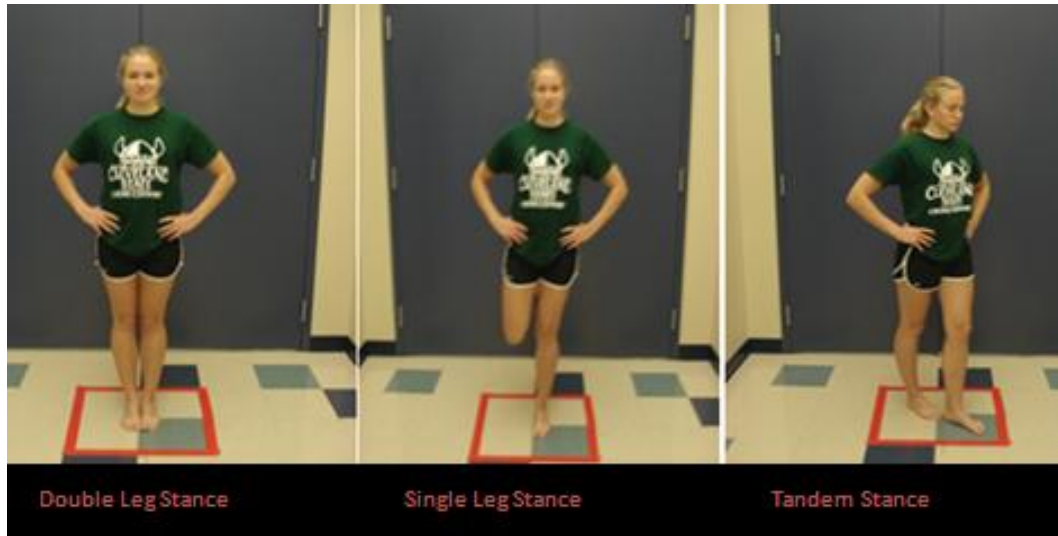
Figure 3. Balance Error Scoring System Device.

3.4 Data Analysis

Descriptive statistics were obtained. Inferential statistics (two-way ANOVA) were be used to assess differences due to the independent variables (age by gender) on the dependent variables (flexibility and balance). A Pearson correlation was used to validate the Y-Balance test against the BSSR test and the BESS test. PASW/SPSS (version 18.0) was used for all analyses with p≤.05 used as the level of significance.

CHAPTER IV

RESULTS & DISCUSSION

4.1 Subject Demographics

There were a total of 84 subjects, 43 females and 41 males, ages 10-14 years.

The gender breakdown of each age group and number of participants are shown in Table 1.

Table 1. Subject demographics.

Age Group	Males	Females	Total
10	8	4	12
11	5	8	13
12	10	14	24
13	8	10	18
14	10	7	17

4.2 Back-Saver Sit and Reach

The composite score for the BSSR equals the total of the highest score for both right and left legs. The results for the BSSR test (Figure 4) showed the females scored significantly (p=.000) higher score compared to the males in all age groups. A study in 2015[15] compared the flexibility of the hamstring muscle over a three year period, in 11 year old students. The study concluded that females' flexibility increased as they aged, while males' flexibility decreased over the three years.[15] The findings of the current study support this study, that as males increased in age, flexibility decreased.

When comparing age groups for the BSSR test there were no significant differences between any of the age groups (Figure 4). There was a decrease for ages 10-14, with a greater decrease for 13 year olds. As stated above, this could be due to puberty effects.[13] The results from the study showed that while there was an increase, it was not significant for both the males and females with the exception of the 13 year olds. It should be noted that Huang and Malina[11] found that as females aged, their flexibility increased, but as the males aged, their flexibility decreased. The results also showed that when comparing all females against males, the females scored higher on the BSSR test.
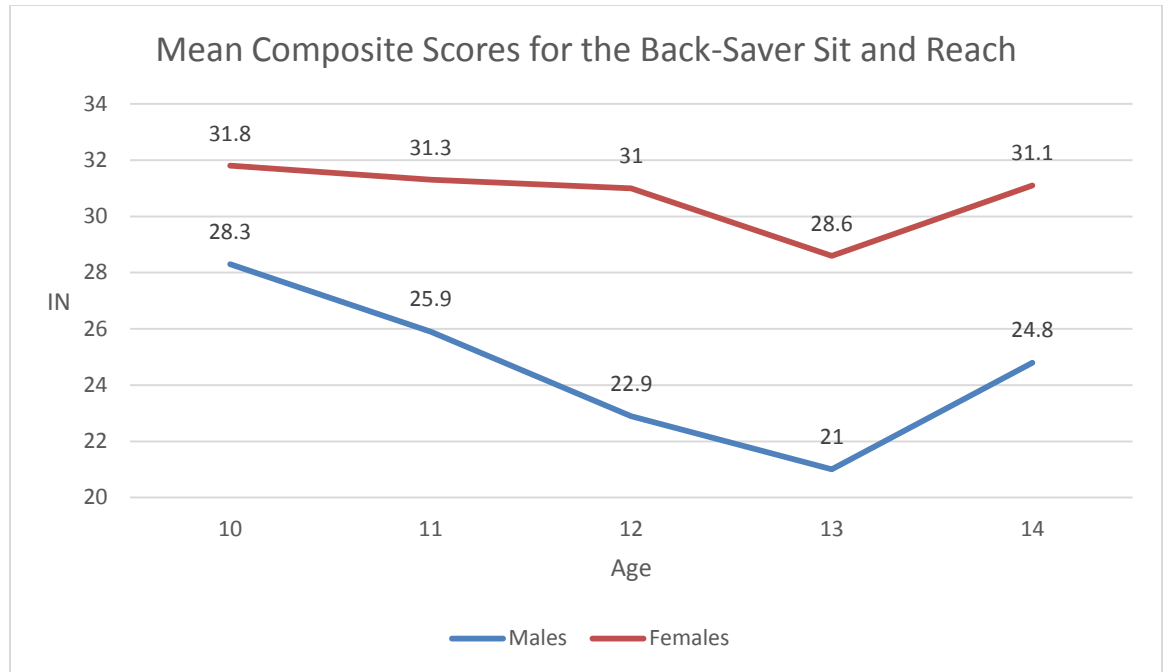
Figure 4. Mean Composite Scores for the Back-Saver Sit and Reach
*Significant difference (p<.05)

4.3 Balance Error Scoring System

The mean gender score for the BESS test (Figure 5), shows the number of errors committed. The females had less total errors compared to the males, making the females score significantly lower than the males (p=.0000). A study[12] in 2011 which measured the balance of 7-10 year old students showed the girls scored significantly better than the boys in all balance tests. This study supports these findings in that the females had better balance when compared to the males.

The results for each age group for the BESS are shown in Figure 5, both the females and males combined score showed an increase, indicating their balance scores declined with age. When comparing age groups, there was a significant difference comparing the 10 to the 14 year olds (p=.010), and the 11 to the 14 year olds (p=.004)

There was an increase in errors for the balance test, indicating that as age increases, balance declined. The participants balance may have been getting worse due to puberty and the fast development of growth spurts that change their center of gravity, which compromises the ability to keep their center of gravity over their base of support.[12]
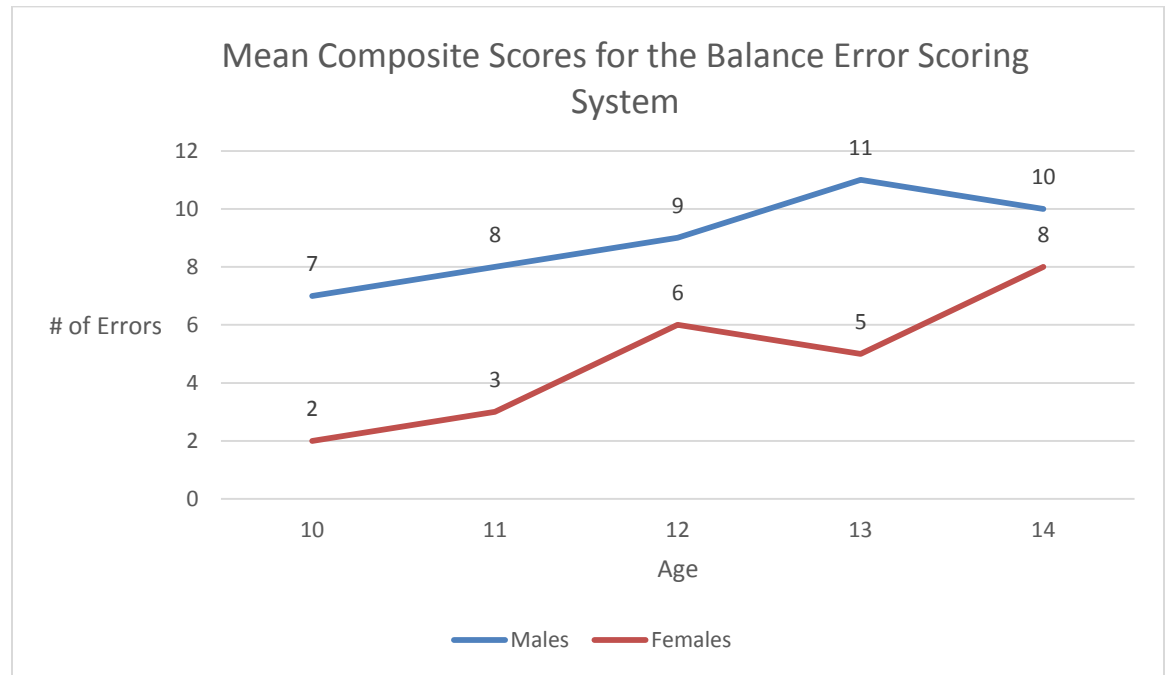

Figure 5. Mean Composite Scores for the Balance Scoring System
*Significant difference (p<.05)

4.4 The Y-Balance Test

The results for the composite Y-balance test are shown in Figure 6. The composite score equals the total of the three highest scores for the posteromedial, posterolateral, and anterior reach for both the right and left legs. The males scored significantly better on the Y-Balance Test (Figure 6) compared to the females (p=.037). This may indicate that the males have stronger hamstring muscles to perform the Y-balance test, which supports the results of Holm, and Vollestad.[9].who found that males had stronger hamstring muscles compared to females, which is needed for the Y-Balance test.[9] The males scored higher than the females on the Y-balance test, which measures

flexibility and balance simultaneously. This supports Fisher[5] who, found that the 11-16 year old male subjects had a significantly higher performance score compared to females. Overall, when looking at gender, it was shown that the males scored better on the Y-balance test, which measures both flexibility and dynamic balance.

Holm and Vollestad[9] showed that 7-12 year old females had stronger quadriceps while males had stronger hamstrings. This explains why the males scored higher on the Y-balance test, while the females scored better on the balance test individually.[9]

There were five different age groups compared in this study to determine if there was an increase in balance and flexibility as age increases. When looking at the breakdown of the age group results, the Y-balance test for the composite scores did not significantly increase, with the exception of the 13 year olds (Figure 6). This could be due to puberty effects, which supports Jones et al.[13], who cited a correlation with increase in physical fitness test scores as puberty develops. On average, 13 year old boys are experiencing puberty spurts, which accelerated strength development.[2] A growth spurt would affect their center of gravity, in return decreasing their balance, having a negative on their performance.[2]
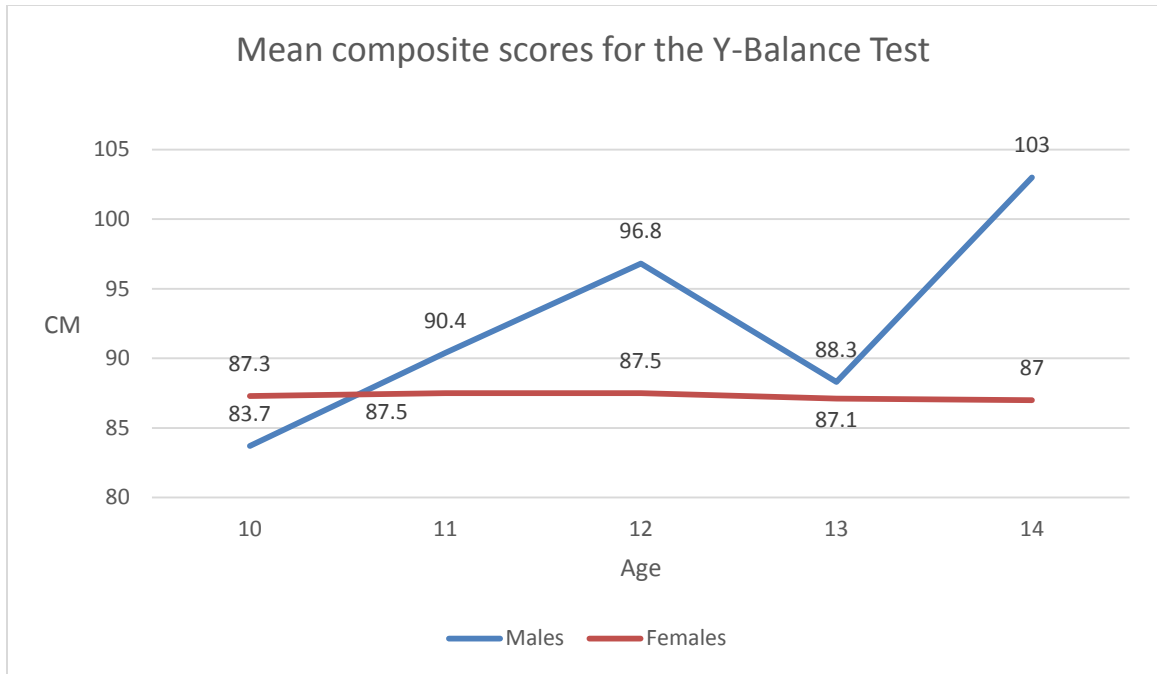
Figure 6. Mean composite scores for the Y-Balance Test
*Significant difference (p<.05)

Balance is a critical fundamental movement that needs to be developed through maturation.[25] A Pearson correlation was used to validate the Y-balance test against the BSSR and BESS. There was no significant correlation between the Y-balance test to either the BSSR or the BESS, r values less than 0.1.

This could be due to the fact that the Y-balance test is an over-generalized test, which is supported by Waelvelde et al.[28] who found that the test cannot accurately measure more than one skill. The theory behind the over-generalized test is that there is no way of knowing if someone scores well on the Y-balance test if it is due to good balance and flexibility, or if they are more skilled in one area, which can overcompensate for the other skill. The BESS test measures static balance, while the Y-balance test measures dynamic balance, may also explain the lack of correlation.

CHAPTER V

SUMMARY & CONCLUSION

5.1 Summary

Hypothesis one was that females will have higher flexibility and balance scores than males. The results supported the hypothesis that the females were higher on their flexibility scores for the BSSR test for both right and left legs, and the females had a better score than the males on the BESS test, which measures static balance. The males scored higher on the right and left leg for the Y-balance test compared to the females. However, the Y-balance test measures dynamic balance and flexibility simultaneously and cannot distinguish which attribute affects the score more than the other. Therefore, the Y-balance test cannot be a factor in determining if the hypothesis is accepted or rejected.

The second hypothesis was that as children age from 10-14 years, there will be an increase in flexibility and balance. The results showed an increase in the Y-balance test for the right and left leg with the 10, 11, 12, and 14 year olds, but the 13 year olds,

decreased. Therefore, when using the Y-balance test, the hypothesis that there would be an increase in flexibility and balance as children age was accepted.

The BSSR scores for the right and left leg decreased from ages 10-14 years. Therefore, when measuring flexibility using the BSSR, the hypothesis was rejected. The possible reason for the difference between the Y-balance and BSSR is that the BSSR measures static flexibility while the Y-balance measures both dynamic flexibility and balance.

As for the BESS test, there was a steady increase in errors, though not significant, from ages 11 to 14 years, indicating that balance decreased with age. This is in contrast to the Y-balance test; however, the BESS test measures static balance, not dynamic. Therefore, the hypothesis that there would be an increase in balance with age using the BESS test was rejected.

The third hypothesis was that the Y-balance test will be a valid measure of balance and flexibility as compared to the BSSR and BESS tests respectively. The Y-balance test claims to measure both balance and flexibility, so the individual flexibility (BSSR) and balance (BESS) scores were correlated to the Y-balance scores. There was no significant correlation for the Y-balance test to the BSSR or the BESS test. This could be due to the type of balance the Y-balance test measures versus the BESS test. The BESS test measures static balance, while the Y-balance test measures dynamic balance and flexibility simultaneously. Therefore, the hypothesis that the Y-balance test is a valid measure of flexibility and balance was rejected.

5.2 Limitation

One limitation to this study was the sample size, (n=84). In addition, not each age group had the same sample size. Therefore, the results may not properly reflect the larger population. When comparing gender, there was not an equal number of females vs. males in each age group. When working with children, a limitation is their motivation. Another limitation is the Y-balance test measures two components simultaneously, thus, it does not distinguish balance from flexibility.

5.3 Future Research Recommendations

The Y-balance test measures dynamic balance rather than static balance, and dynamic balance is more important in sports. It is recommended that a practical dynamic balance test be designed and validated. Future studies should increase the number of participants and measure their height and weight. Also, obtaining more detail on subjects' background may prove beneficial. For example, if a subject was an advanced cheerleader or gymnast, where flexibility needs to be at a high level in order to perform some routines that could impact the results.

5.4 Conclusion

It can be concluded that the females scored significantly higher on the BSSR and the BESS, but the males scored significantly higher on the Y-balance. When comparing age groups, the Y-balance score significantly increased with age with the exception of the 13 year olds. For the BSSR and BESS, scores decreased in the categories of flexibility and balance in the older age groups. The validity of the Y-balance test as an accurate measure of flexibility and balance, compared to the BSSR and BESS respectively, was not demonstrated in this study.

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Appendices

APPENDIX A

IRB Approval Letter

Cleveland State University
engagedlearning

Memorandum

Institutional Review Board

To: Kenneth Sparks
Health & Human Performance

From: Bernie Strong (b.r.strong@csuohio.edu, X3624) *BRS*
IRB Coordinator
Sponsored Programs & Research Services

Date: May 30, 2014

Re: Results of IRB Review of your project number: #29980-SPA-HS
Co-Investigator(s): Allison Lowe
Title: A cross sectional comparison of flexibility and balance in children 10-14 years of age.

The IRB has reviewed and approved your application for the above named project, under the category noted below. It has been determined that the research being performed under this protocol is Exempt. This determination does not expire and does not require an annual review.

However, by accepting this decision, you agree to notify the IRB of: (1) any additions to or changes in procedures for your study that modify the subjects' risk in any way; and (2) any events that affect that safety or well-being of subjects. Notify the IRB of any revisions to the protocol, including the addition of researchers, prior to implementation.

Thank you for your efforts to maintain compliance with the federal regulations for the protection of human subjects.

Approval Category: **Approval Date:**   **May 20, 2014**

 **X**   Exempt (b4)

cc: Project file

Appendix B

Recruitment Flyer

Volunteers Needed for a Study on Flexibility and Balance at Notre Dame Elementary School
## Grades: 5-8

I am Mrs. Allison Lowe, a student at Cleveland State University currently finishing up my Master's degree in the Department of Health and Human performance. I am inviting your child to participate in a research study at Notre Dame Elementary School. I will be researching the developmental rates of 10-14 year olds on their balance and flexibility. During your child's Physical Education class, they will complete three tests that will take about ten minutes total. Below you will see a picture of each test they will complete.
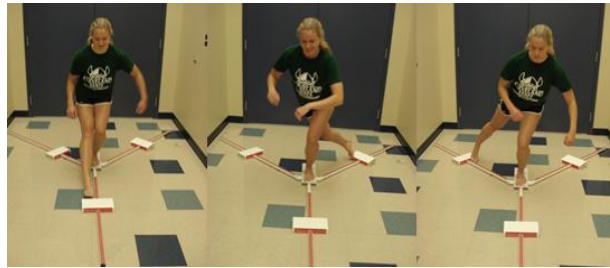
Above: The Y-balance Test measuring flexibility and balance.

Above: The Back-saver sit and reach measuring flexibility.
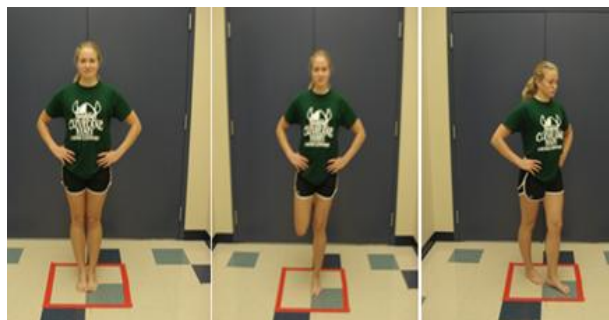
Above: The Balance Error Scoring System measuring balance.

If you have any questions please contact Mrs. Lowe at (440) 567-1533 or Dr. Ken Sparks at Cleveland State University (216) 687-4831.

APPENDIX C

School Approval Letter

Notre Dame Elementary School
Nurturing Dreams, Excellence and Success

Dear Allison,

As the principal at Notre Dame Elementary School, I give you approval to conduct a study to measure balance and flexibility using our students from 5th through 8th grade. The Y-balance test, the back-saver sit and reach test and the balance error scoring system will be the instruments used to collect the data. The data for this study will be collected in the fall of 2014.

We will administer approved consent forms to the parents or guardians and approved assent forms to the students. In order for a student to participate in the study, the parents or guardians must sign the consent form. We know and understand that all the data from this study will remain confidential.

Sincerely,

Barbara Doering

Barbara Doering

Principal

Notre Dame Elementary School

13000 Auburn Road • Chardon, OH 44024
Elementary Office: 440.279.1127 • Admissions 440.279.1129 • Fax: 440.286.1235
www.notredameelementary.org
Preschool Office 440.286.7101 Ext. 5920

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APPENDIX D

Assent Form

INFORMED MINOR ASSENT TO PARTICIPATE

Hello,

      I am Mrs. Allison Lowe, your physical education teacher. I am completing my Master's degree at Cleveland State University in the Department of Health and Human performance. I am inviting you to participate in a research study on 5th, 6th, 7th, and 8th grade students' flexibility and balance.

      Before you can decide whether or not to participate in this study, you need to understand the purpose of this study and how this study may help you, any risk to you, and what is expected of you. This process is called informed assent. Please read carefully and do not hesitate to ask anything about the information provided.

What do you have to do?

      During your Physical Education class, you will be asked to complete three test: the Y-balance test, and the modified back saver-sit and reach test, and the balance error scoring system test. This will take about 10 minutes.

The picture to the left, shows the Y-balance test. You will be able to practice six times on each leg in all three reach directions before the formal testing occurs. You will stand on the center balance pad and push the slides with your toes out in front (A) and repeat again pushing the slide to the rear using the opposite leg (B) and push the slide to the side (C).

The picture to the right, is the back-saver sit and reach test. You will remove you shoes, one leg is straight and the other leg is bent. With one hand over the other, you reach forward pushing the measuring dial forward as far as you can. You will have four tries, alternating each leg.
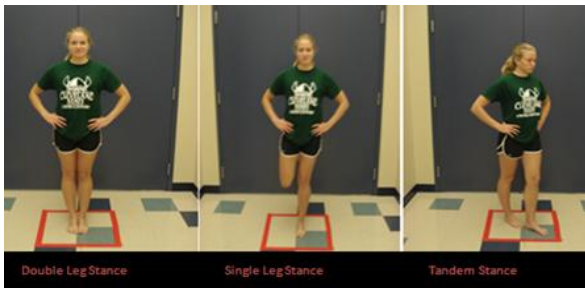
The picture to the left is the balance error scoring system. You will complete three stances on a firm, flat surface; the double leg stance (A), single leg stance (B), and tandem stance (C), with shoes off, trying to hold each stance for 20 seconds.

      When performing balance and flexibility tests, some people can over-extend and pull a muscle. It is important when you perform the test, you do not over-extend past the point of discomfort.

      Your test results will remain confidential, and if at any time you want to withdraw from the study that is okay! If you want to do this study please print and sign your name next to the X below, and date.
      If you have any questions please contact Mrs. Allison Lowe at (440)279-1127 or Dr. Ken Sparks at Cleveland State University (216) 687- 4831.

      Print Name: _____

      Sign Name: _____ Date: _____

APPENDIX E

Consent Form

INFORMED CONSENT FORM

Hello Guardians,

        I am Mrs. Lowe, your child's physical education teacher. I am currently completing my Master's degree at Cleveland State University in the Department of Health and Human performance. I am inviting your child to participate in my thesis on 5th, 6th, 7th, and 8th grade students' flexibility and balance. Below you will find the test procedures and what I need your child to do for this study. All information will remain confidential. The results will only be displayed as group data, and the student's name will never be given out.

The students need to do the following:

        During our Physical education class, students will be asked to complete three tests: the Y-balance test, the back saver-sit and reach test, and the balance error scoring system test. This will take about 10 minutes.

The picture to the left, shows the Y-balance test. Your child will be able to practice six times on each leg in all three reach directions before the formal testing occurs. They will stand on the center balance pad and push the slides with their toes out in front (A) and repeat again pushing the slide to the rear using the opposite leg (B) and push the slide to the side (C).

The picture to the right is the back-saver sit and reach test. Students will remove their shoes, one leg is straight and the other leg is bent. With one hand over the other, they reach forward pushing the measuring dial forward as far as they can. They will have four tries, alternating each leg.
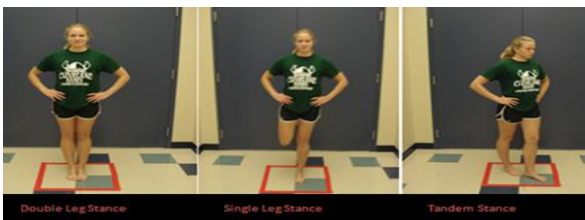
The picture to the left is the balance error scoring system. They will complete three stances on a firm, flat surface; the double leg stance (A), single leg stance (B), and tandem stance (C), with shoes off, trying to hold each stance for 20 seconds.

        When performing balance and flexibility tests, some people can over-extend and pull a muscle. It is important when students perform the test, to not over-extend past the point of discomfort. All students will do a warm-up and stretching routine before completing the test.

        If at any point your child would like to withdraw from the study, just let me know. If you consent to your child participating in this study, please fill in your student's name, sign and date below.

        By signing below you also are stating "I understand that if I have any questions about my child's rights as a research subject I can contact the CSU Institutional Review Board at 216-687-3630."

If you have any questions please contact Mrs. Allison Lowe at (440)279-1127 or Dr. Ken Sparks at Cleveland State University (216) 687- 4831.

        Student's Name (Print): _____

        Parent's Signature X_____ Date: _____