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The Effects of Plyometric and Treadmill Training on Balance and Reaction Time in High School Aged Athletes

Andrea E. Richter
University of North Dakota

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THE EFFECTS OF PLYOMETRIC AND TREADMILL TRAINING ON
BALANCE AND REACTION TIME IN HIGH SCHOOL AGED ATHLETES

by

Andrea E. Richter
Bachelor of Science in Physical Therapy
University of North Dakota, 2000

An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Master of Physical Therapy

Grand Forks, North Dakota
May
2001
This Independent Study, submitted by Andrea E. Richter in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

[Signatures]

(Faculty Preceptor)

(Graduate School Advisor)

(Chairperson, Physical Therapy)
<table>
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Signature: [Signature]

Date: 12-12-00
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</tr>
</tbody>
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ACKNOWLEDGEMENTS

I would like to thank my preceptor, Meridee Danks, for all her patience and support during this project and Alyson for making sure this paper was written in proper format. Thanks, to all the staff at Altru's Sports Acceleration for their help and cooperation with this study. To all the athletes who took the time to participate in our study. Finally, to my research partners for doing all the assessment in the summer so I could work on my tan.
ABSTRACT

High school athletes’ involvement in sports acceleration training has grown in recent years. Athletes use acceleration programs to help gain an edge over their competition. One way to gain that edge is by improving balance and reaction time. These two components are important in a wide variety of sports. Both help to minimize injury and increase the skill level and performance of the athlete. Although balance and reaction time are essential in sports, there is currently no research available involving these components.

The purpose of this study is to determine if the Altru Health Institute’s Sports Acceleration plyometric and treadmill training program increases balance and reaction time in high school athletes. The NeuroCom® Balance Master was utilized to test balance and reaction time. Data were obtained by assessing nineteen high school athletes involved in the Sports Acceleration program at Altru Health Institute during the summer of 2000.

Both balance and reaction time significantly improved after an acceleration program consisting of plyometric and treadmill training. It is recommended that further research studies are undertaken on this subject to improve the training and ultimately the performance of athletes.
CHAPTER I

INTRODUCTION

The focus of many athletes is to be the best at their sport and to outperform the competition. Michael Jordan, Mia Hamm and Michael Johnson are just a few who have surpassed their counterparts to be known as the best. They have accomplished this through rigorous training and dedication. Numerous training programs are available today that are directed at heightening an athlete's performance by making them quicker, stronger and faster than the opponent.

High school athletes' involvement in sports acceleration training has grown in recent years. These athletes use the program to help gain an edge over their competition. One type of sports acceleration training is the Frappier Acceleration® (Frappier Acceleration® Inc., Fargo ND) program, which incorporates both plyometric and treadmill training into its protocols. Plyometrics are used to increase the explosive power of an athlete and treadmill training increases the speed of the athlete. An improvement in strength, flexibility, confidence, agility and proprioception are also experienced by the program's participants.

Balance is an important part of everybody's daily life because it is a part of all movement, whether static or dynamic. Static balance is when the individual's center of gravity is maintained over the base of support.1 Dynamic balance occurs when the body is in motion and the center of gravity falls outside the base of support. Since sports are
dynamic in nature, balance is a necessary component of athletic ability. Injuries are often a result of poor balance which leads to poor development of skill.

Reaction time is necessary for a person to rapidly respond to gravity and external forces. Athletes must be able to react quickly and accurately to these external forces such as opponents and playing surfaces. The best athletes possess the ability to quickly adapt to the demands of their sport. Reaction time has an essential association with balance in that the quicker the body is able to react to outside forces that displace one's balance, the quicker balance will be recovered.

Problem Statement

Although there are numerous acceleration programs available to athletes that focus on improving their skill level, there is no current research available that studies the effects that these programs have on balance and reaction time. Both of these components are key elements in any sport competition and are important aspects to be considered when training an athlete.

Purpose of Study

The purpose of this study is to determine if the Altru Sports Acceleration plyometric and treadmill training program increases balance and reaction. High school athletes, both male and female, participating in the training program were recruited for this study.

Significance of Study

Since balance and reaction time are crucial elements in sports competition, it is necessary to determine if plyometric and treadmill training have an effect on them and if so, what type of effect. Physical therapists, athletic trainers and coaches will all come
into contact with athletes to help prepare them for their sport. The results from this study
can aid these professionals in adapting training programs that will enhance balance and
reaction time in the athlete which will increase their skill level and decrease their risk of
injury.

Research Questions

There are two questions that exist in this study. 1) Does plyometric and treadmill
training improve balance in high school athletes? 2) Does plyometric and treadmill
training improve reaction time in high school athletes?

Hypothesis

The null hypotheses in this study is there will be no significant improvement in
balance and reaction time in a high school athlete following his/her completion of a
plyometric and treadmill training program. The alternate hypothesis is there will be a
significant improvement in balance and reaction time in a high school athlete following
his/her completion of a plyometric and treadmill training program.
CHAPTER II

LITERATURE REVIEW

This study addresses several topic areas including sports acceleration, plyometrics, treadmill training, balance, reaction time, and the NeuroCom® Balance Master (Neurocom International Inc., Clackamus Ore). Each topic will be discussed separately in this chapter, in order to provide the reader with a better understanding and background of the information provided throughout the study.

Sports Acceleration

The specific training program that this study focused on was Frappier Acceleration® at Altru Health Institute in Grand Forks, ND. The program was developed by Frappier in 1986 originating in Fargo, ND and can now be found across the United States and in parts of Canada and Europe. Many college and professional sport teams have incorporated this type of program into their facilities and training. The Frappier Acceleration® program is designed for all athletes participating in any sport and at any level. It focuses on increasing an athlete’s strength, speed, quickness and flexibility. Athletes also gain increased proprioception and anaerobic tolerance, improved running biomechanics and body composition, and a boosted self-esteem. Training sessions typically last six to eight weeks and depending on the athlete’s sport and goals can include any of the following training components: Super Treadmill, plyometrics, strength
training and sprintcord application. Plyometrics and treadmill training are further discussed in this chapter.

The basis for the Frappier Acceleration® program is the Specific Adaptation to Imposed Demand (SAID) principle, which targets the lactate and ATP-PC systems through high intensity, short duration exercises. The lactate and ATP-PC systems are anaerobic metabolic pathways that the body utilizes for energy during high levels of activity that are sustained for two minutes or less. Anaerobic pathways are not dependent on oxygen for energy production, whereas aerobic pathways are. The lactic acid system provides its energy during high-level activities such as sprinting that last one to two minutes. The ATP-PC system supplies its energy during the same high-level activities that are ten seconds or less. The Frappier Acceleration® workout sets range from four to twenty seconds in length, which stresses the anaerobic pathways.

Plyometrics

Taber's Cyclopedic Medical Dictionary defines plyometrics as a stretching and shortening exercise technique that combines strength with speed to achieve maximum power in functional movements. It further states that this regimen combines eccentric training of muscles with concentric contraction. Plyometrics began in East Europe and became widespread in the late 60's and early 70's. It was first referred to as jump training, and in 1975 Wilt created the term plyometrics. These exercises have gained popularity and been incorporated into numerous training programs aimed at making an athlete stronger and quicker.

Plyometrics allow a muscle to reach its greatest strength in the shortest amount of time and decrease the amount of time that an athlete spends in contact with the ground.
when running or jumping.\textsuperscript{8-10} The basis behind plyometrics is the utilization of the stretch reflex through the stretch-shortening cycle.\textsuperscript{6,8,10-12} All muscles contain stretch receptors called muscles spindles, which sense the change in length of a muscle and the rate of change in length. The stretch reflex occurs when a muscle’s fibers are placed on stretch, increasing the activity of the muscle spindle that then stimulates a contraction of the stretched muscle and relaxation of the shortened muscle. An example of this is the knee jerk reflex. The tapping of the quadriceps tendon causes it to stretch resulting in a contraction of the muscle. When a person performs plyometric exercises, there is a rapid lengthening or eccentric contraction of the muscle, which increases the potential energy of the muscle. This potential energy is then used to produce a powerful shortening or concentric contraction of the muscle. This process is referred to as the stretch-shortening cycle. The various jumps in place or rebound jumping used in plyometrics are structured to stimulate this stretch-shortening cycle and through repeated training, increase the explosive power of the athlete.

Similar to treadmill training, plyometrics are anaerobic in nature because they utilize the creatine phosphate energy system.\textsuperscript{8} Enough time between sets should be given to allow for complete recovery to avoid stressing the aerobic system and to prevent a decrease in the quality and explosiveness of the movement. The types of drills an athlete can perform include jumps-in-place, standing jumps, multiple hops and jumps, bounding, box drills and depth jumps. The drills teach athletes how to move their feet out from under their center of gravity challenging the individual’s dynamic balance and reaction time.\textsuperscript{9} Specific drills and equipments used in plyometric training are included in the Methodology Chapter of this paper.
Treadmill Training

The treadmill training portion of the acceleration program increases an athlete’s ability to maintain highest speed for a longer duration or repeated short periods. An athlete becomes quicker through the training by learning to increase stride length and frequency which enables more ground to be covered in a little amount of time. Treadmill training also stresses the anaerobic system allowing the athlete to at maximum speed for longer periods of time. Athletes that are quicker and faster will have the advantage over their opponents. As previously described under plyometrics, the treadmill training used in Frappier Acceleration® also utilizes the stretch reflex through the high speeds, high incline levels, and the use of sprint cords. Further discussion of these components is addressed in the Methodology Chapter of this paper.

Balance

Balance is one of the most critical components to an individual's daily functions in life because it is the basis for all movement. It is the relationship that exists between the human organism to gravity and the environment. The ability of an individual to maintain balance depends on: 1) somatosensory, visual, and vestibular input; 2) an intact central nervous system; and 3) the musculoskeletal system. The somatosensory, visual and vestibular systems are responsible for providing feedback regarding the support surface, the body's relation to the outside environment and orientation of the head in space. With this input, the central nervous system develops a motor plan, which is then carried out by the musculoskeletal system. Impairment in any of these systems leads to a deficit in one's ability to maintain balance in regards to external and/or internal responses.
Balance is even more critical when an individual partakes in high-level activities, such as athletics. If an athlete has poor balance, this can lead to poor skill development increasing the risk for potential injury. During sports competition, the athlete is continually reacting to gravity and outside forces such as opponents or the playing surface. Nottingham states "...people who have better balance respond to training and learn sport skills more quickly than those with poor balance."

Reaction Time

Reflexes are innate and not under a person's voluntary control. They happen automatically in response to a stimulus and cannot be improved through training. In contrast, reaction time requires thought in order for a specific movement to occur and can be improved through specific training. Fussman relates reaction time to "...a shortstop who dives for a hard grounder, then flips to second from his knees to start a double play." Even though this action has nothing to do with reflexes, it is so quick and automatic that it appears to happen without a second thought from the baseball player. Athletes that are able to quickly react in any direction and accommodate to the constantly changing demands imposed on them by their sport will outperform their opponent. Plyometrics are one way to help improve an individual's reaction time. Researchers feel that the repetition of the exercises makes the neural-muscular pathways more efficient, which strengthens skill and improves quickness. There is also a strong connection between balance and reaction time. If the body is able to respond to imbalancing forces quickly, the faster balance will be recovered and subsequently, the less risk exists to sustain an injury.
NeuroCom® Balance Master

The computer system used in this study to collect data was the NeuroCom® Balance Master (NBM). It is a clinically accepted machine used in physical therapy to assess and treat balance disorders. The NBM and actual testing procedure is further discussed in the Methodology Chapter of the paper. One of the advantages of using the NBM or any computerized testing system is that it provides objective data that an individual is unable to assess with the eyes or hands and the information is easily quantified. The two NBM tests that the researchers chose to analyze balance and reaction time in the participants were limits of stability (LOS) and the forward lunge test. Each test will be discussed separately.

Limits of Stability

Limits of stability is a dynamic balance test that measures an individual’s intentional control of his/her center of gravity including speed, direction and distance. The NBM manual defines limits of stability as the region in space through which a normal person can move his/her center of gravity without altering the base of support. It is the maximum distance a person can lean in a given direction without losing balance, stepping or reaching. This test has five components or subtests, which include reaction time, movement velocity, endpoint excursion, maximum excursion and directional control. These are explained in further detail in Appendix A.

Forward Lunge

In order for an individual to adequately perform this test, appropriate strength, range of motion, balance, coordination and control are necessary. During the test, the stance leg must have enough strength and coordination to quickly accept and transfer the
person’s body weight from and to the lunge leg. The lunge leg is required to stretch forward, quickly accept the person’s body weight, absorb the impact forces and utilize them to reverse this motion by pushing the body weight backward and step backward. The individual must also maintain the trunk in an upright posture. The data from this test can be used functionally to assess if an individual is capable of participating in sport or occupational activities and if that person is at an increased risk for injury. The lunge has four subtests on the both the right and left sides, which include distance, contact time, force impulse and impact index. These tests are further explained in Appendix A.
CHAPTER III

METHODOLOGY

This study was approved by the University of North Dakota and Altru Health System’s Institutional Review Board (IRB) for the use of subjects under the age of 18 years old. A copy of the IRB application and letter of approval has been included in Appendix B. Prior to testing, all subjects were informed about the aspects of this study, and that their participation was voluntary. Written permission was obtained from both the participant and his or her legal guardian prior to testing. A copy of the consent form is provided in Appendix C.

Subjects

Participants in this study were selected from high school athletes taking part in the Frappier Acceleration® (Frappier Acceleration® Inc., Fargo ND) program at Altru Health Institute during the summer of 2000. Specific requirements for this study were as follows:

1. 18 years of age or younger
2. participating in upcoming high school sport
3. registered for both the plyometric and treadmill training (eight plyometric sessions, twelve treadmill sessions).

A total of 25 subjects were recruited for pre-assessment. Nineteen subjects consisting of ten males and nine females completed the entire program and were post-assessed. The
length of the training program varied from six to nine weeks depending on the participant’s scheduling. The six subjects that were not post-assessed either did not complete the program, moved from the area, or were unavailable for post-assessment testing.

Instrumentation

All subjects were tested on the NeuroCom® Balance Master version 7.0 (NeuroCom International Inc., Clackamus Ore). The NeuroCom® Balance Master (NBM) is a clinically accepted machine, commonly used in physical therapy, that provides objective data on balance. It can be used as both a diagnostic and a rehabilitative tool. The NBM consists of two nine-inch by sixty-inch force plates connected to a computer operating system. When a subject performs testing activities on the force plate, a variety of information is interpreted by the computer such as comparing strength differences between legs, balance and coordination problems, and reaction time to a visual stimulus.

Visual feedback is provided to both the tester and the subject on the computer screen.

One advantage in using the NBM to analyze an athlete is that the information received can be used to evaluate an entire activity, not just a single muscle group. This can give much more functional information than something that focuses on only one specific joint or movement.

The NBM has been found to be both reliable and valid in clinical studies. In a study performed by Liston et al involving balance of post-stroke patients, the NBM was compared against two other manually administered tests commonly used in physical therapy to determine balance: the Berg Balance Scale and the Gait Velocity Test. The
NBM was found to have a very strong reliability in all tests involving dynamic shifts of center of gravity, especially in the limits of stability test. Validity of the dynamic activities was also found to be accurate with the NBM. This study shows that the NBM can be considered an appropriate and reliable tool used to measure and study balance. Figure 1 is a picture of the NBM.

Figure 1. NeuroCom® Balance Master
Pilot Study

The testers followed the NBM manual and completed an instrumentation course to become proficient in its operation. The instrumentation course was a two-credit course provided at the University of North Dakota Physical Therapy Department as a way to learn about and become familiar with the NBM. A pilot study was performed in order to determine inter-reliability and intra-reliability of the two testers for the limits of stability and lunge tests.

Ten subjects ranging in ages between 21 and 60, consisting of both males and females, were tested for the pilot study. All testing was performed on the NBM in the research room of the University of North Dakota Physical Therapy Department. Each subject performed both the limits of stability and the forward lunge test for each of the two researchers administering the tests. The subjects were then tested once again by both researchers at least two days after the initial testing.

**Intra-rater Reliability**

A Pearson correlation coefficient was calculated from a repeated measures analysis of variance (ANOVA) in order to assess test-retest reliability for each tester. Results are shown in Tables 1 and 2.

**Inter-rater Reliability**

A Pearson correlation coefficient was calculated from a repeated measure ANOVA to determine reliability between each tester. Results are shown in Tables 3 and 4.
Table 1. Intra-rater Reliability for Limits of Stability

<table>
<thead>
<tr>
<th>Limits of Stability</th>
<th>Tester 1</th>
<th>Tester 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement Velocity Forward</td>
<td>.8918</td>
<td>.7019</td>
</tr>
<tr>
<td>Movement Velocity Backward</td>
<td>.5500</td>
<td>.9475</td>
</tr>
<tr>
<td>Movement Velocity Left</td>
<td>.7465</td>
<td>.7180</td>
</tr>
<tr>
<td>Endpoint Excursion Forward</td>
<td>.7652</td>
<td>.8093</td>
</tr>
<tr>
<td>Endpoint Excursion Backward</td>
<td>.7061</td>
<td>.7478</td>
</tr>
<tr>
<td>Maximal Excursion Backward</td>
<td>.7504</td>
<td>.8031</td>
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<tr>
<td>Maximal Excursion Right</td>
<td>.7920</td>
<td>.5567</td>
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<tr>
<td>Directional Control Forward</td>
<td>.8662</td>
<td>.7405</td>
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<tr>
<td>Directional Control Backward</td>
<td>.5483</td>
<td>.6867</td>
</tr>
<tr>
<td>Directional Control Right</td>
<td>.7626</td>
<td>.8187</td>
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Table 2. Intra-rater Reliability for Lunge

<table>
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<tr>
<th>Lunge</th>
<th>Tester 1</th>
<th>Tester 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance – Right side</td>
<td>.9121</td>
<td>.9766</td>
</tr>
<tr>
<td>Distance - Left side</td>
<td>.9465</td>
<td>.9405</td>
</tr>
<tr>
<td>Impact Index – Right side</td>
<td>.9192</td>
<td>.8994</td>
</tr>
<tr>
<td>Impact Index – Left side</td>
<td>.8220</td>
<td>.9105</td>
</tr>
<tr>
<td>Contact Time – Right side</td>
<td>.9570</td>
<td>.8518</td>
</tr>
<tr>
<td>Contact Time – Left side</td>
<td>.8366</td>
<td>.8087</td>
</tr>
<tr>
<td>Force Impulse – Right side</td>
<td>.9570</td>
<td>.8711</td>
</tr>
<tr>
<td>Force Impulse – Left side</td>
<td>.8473</td>
<td>.8544</td>
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Table 3. Inter-rater Reliability for Limits of Stability

<table>
<thead>
<tr>
<th>Limits of Stability</th>
<th>Tester 1 - Tester 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement Velocity Forward</td>
<td>.8887</td>
</tr>
<tr>
<td>Movement Velocity Backward</td>
<td>.7250</td>
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<tr>
<td>Movement Velocity Left</td>
<td>.8164</td>
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<tr>
<td>Endpoint Excursion Forward</td>
<td>.9159</td>
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<td>Endpoint Excursion Backward</td>
<td>.6617</td>
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<tr>
<td>Maximal Excursion Backward</td>
<td>.8421</td>
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<tr>
<td>Maximal Excursion Right</td>
<td>.7226</td>
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<tr>
<td>Directional Control Forward</td>
<td>.8670</td>
</tr>
<tr>
<td>Directional Control Backward</td>
<td>.8499</td>
</tr>
<tr>
<td>Directional Control Right</td>
<td>.6968</td>
</tr>
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</table>
Table 4. Inter-rater Reliability for Lunge

<table>
<thead>
<tr>
<th>Lunge</th>
<th>Tester 1 – Tester 2</th>
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</thead>
<tbody>
<tr>
<td>Distance – Right side</td>
<td>0.9812</td>
</tr>
<tr>
<td>Distance – Left side</td>
<td>0.9590</td>
</tr>
<tr>
<td>Impact Index – Right side</td>
<td>0.9056</td>
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<tr>
<td>Impact Index – Left side</td>
<td>0.9388</td>
</tr>
<tr>
<td>Contact Time – Right side</td>
<td>0.9156</td>
</tr>
<tr>
<td>Contact Time – Left side</td>
<td>0.7791</td>
</tr>
<tr>
<td>Force Impulse – Right side</td>
<td>0.9229</td>
</tr>
<tr>
<td>Force Impulse – Left side</td>
<td>0.8402</td>
</tr>
</tbody>
</table>

Pearson Correlation Coefficient Interpretation

There are no standard values set for acceptable reliability when calculating Pearson correlation coefficient. Values vary between 0.00, which represents no correlation at all, and 1.00, which represents 100% correlation. Using the Pearson correlation coefficient interpretation listed in Table 5, values were obtained for intra-rater and inter-rater reliability of both the limits of stability and lunge test. The limits of stability test shows moderate to very high reliability with numbers ranging from 0.5483-.9475. The lunge test shows high to very high reliability with numbers ranging from 0.8402-.9812.

Table 5. Inter-rater Correlation Coefficient Interpretation

<table>
<thead>
<tr>
<th>Description of Strengths</th>
<th>Correlation</th>
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<tbody>
<tr>
<td>Little if any</td>
<td>0.00-0.25</td>
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<tr>
<td>Low</td>
<td>0.26-0.49</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.50-0.69</td>
</tr>
<tr>
<td>High</td>
<td>0.70-0.89</td>
</tr>
<tr>
<td>Very High</td>
<td>0.90-1.00</td>
</tr>
</tbody>
</table>

Pre-Assessment

All athletes were assessed on the NBM prior to the beginning of their training at Altru Health Institute’s Sports Acceleration program. Subjects were given a random
number based on their order of testing, in order to maintain subject confidentiality. The athlete’s height and date of birth were recorded on his/her NBM file. Completing the limits of stability and forward lunge tests on the NBM assessed the subjects’ current balance and reaction time. Athletes were required to be bare foot during the test, to ensure conditions would be equal during their post-assessment. By being bare foot, variables such as shoe height and traction were eliminated.

Each of the two tests used in this study, limits of stability and forward lunge, were performed as described in the NBM operator’s manual. Each athlete performed the limits of stability test twice, the first being a practice round and the second being the scored trial. The forward lunge was performed with three lunges on each leg and the score was averaged between the three trials. An in-depth copy of the procedures for the limits of stability and forward lunge, as stated in the NBM operator’s manual, is found in Appendix D.

Verbal directions for completing each test were scripted and read to the athlete, prior to testing, to ensure the two researchers were giving the same directions to every athlete. A copy of the scripted verbal instructions, given to the subjects before each test, is found in Appendix E.

Sports Acceleration Protocol

The Sports Acceleration protocol at Altru Health Institute is one of the many clinics by Frappier. A typical protocol entails eight plyometric sessions and twelve treadmill sessions. Each session varies slightly in duration, intensity, and technique. The basic concept behind the program is based on the principle of Specific Adaptation to
Imposed Demand, which states that specific metabolic pathways are targeted in order to produce speed.\(^5\)

**Plyometrics**

The plyometric portion of Frappier Acceleration\(^\text{®}\) training consists of a specially designed plyo floor, boxes of varying heights, various floor patterns, and resistance cords similar to the sprintcords used in the treadmill portion. The patterns used by the athletes during their training sessions are numbered, and correspond to the numbers listed in the sample protocols.

Figure 2 is an example of a floor pattern used in a lower extremity plyometric session at Frappier Acceleration\(^\text{®}\). Each space in the pattern represents a different number. Figure 3 shows the numbers that each space represents in Figure 2. The trainer uses the pattern to create a program in which the athlete must jump into a preset order of the different spaces. A copy of a typical plyometric session using this floor pattern is found in Appendix F.

![Figure 2. Four square plyometric pattern](image1)

![Figure 3. Four square plyometric pattern with numbers](image2)
Plyometric floor patterns can vary in the number of spaces and degree of difficulty. Changing the shape of the figure and making the spaces farther apart are two ways to challenge the athlete. Figure 4, the Munoz pattern, shows a more advanced floor pattern used in lower extremity plyometrics. As with Figure 2, each of the different spaces is assigned a different number. Figure 5 shows the numbers assigned to the different spaces in Figure 4. An example of an actual plyometric work out using this floor pattern is found in Appendix F.

Another component that is often used in plyometric training is the use of boxes of varying heights from six inches to 24 inches. When an athlete jumps on or off a box, the stretch reflex allows potential energy to be stored in the quadriceps muscle. This increase in energy results in a stronger contraction of the quadriceps muscle. Figure 6 is a picture of several different box heights in which the athlete may use to jump on or off during a plyometric session.
Treadmill Training

The Super Treadmill, which was designed by Acceleration Products® Inc. (Acceleration Products® Inc., Fargo ND), provides a speed range from 0-28 miles per hour and can be raised to an angle of inclination of 40 percent and a decline angle of 10 percent. During training, these unequaled treadmills can be raised and lowered hydraulically to allow the athlete to train at a variety of inclinations. This training tool is an essential component to the Frappier Acceleration® program. Figure 7 is a picture of the Super Treadmill used in the Frappier Acceleration® program.

The Super Treadmill is designed to help athletes improve their speed while reducing 30 to 60 percent of force at the knee upon foot strike. The incline capabilities of the Super Treadmill, combined with running at increased speeds while holding on to the front grab bar and emphasizing hip flexion, hip extension, and bounding, help each athlete learn and maintain several key components of running. These components include knee drive, proper pelvic and trunk position, forceful contraction of the lower
extremity, optimal stride length, and properly coordinated upper extremity movement.

An example of a treadmill training session is included in Appendix G.

Another key component of the treadmill running program is the application of sprintcords. These cords are used during each level of training from the beginner’s level one, through the advanced level four. Sprintcords are equipment used during running treadmill sessions and also during plyometric floor work. The cords are attached to the athlete’s thighs and lower legs approximately halfway between the hip and knee joints, and halfway between the knee and ankle joints. The athletes complete the runs in their session at the prescribed speed and elevation, while holding on the front grab bar. These cords are patented resistance training equipment, and can also be implemented for sport-specific training.

Sprintcords are designed to allow proprioceptive recruitment of certain neuromusculature associated with sprinting and other sport related motions. This is
achieved by loading the hip flexors throughout their range of motion until maximum hip flexion is accomplished. With the sprintcords continuously pulling against the motion of hip flexion after the pre-swing phase of running, there is a marked extension of the hips before the recovery phase. Figure 8 is a picture of an athlete using the sprintcords while bounding on the Super Treadmill.

Figure 8. Athlete bounding on Super Treadmill with sprintcords

Along with the running program, hamstring cords are used to complement the training and give extra strengthening to the hamstring musculature. Repetitions of knee flexion using these cords for resistance are interspersed throughout the training, such as between sets on the treadmill.

Post-Assessment

Post-assessment was performed under the same conditions as the pre-assessment on each subject after completion of his or her last session at Altru Health Institute's Sports Acceleration program. Before performing the two tests, each subject was read the
list of verbal instructions, as was performed in the pre-assessment. After completing the two tests, each subject was shown the data and given a brief explanation of the results.

Data Analysis

The results of this study show a comparison of the pre- and post-assessment of the limits of stability and lunge tests. Since the data was not normally distributed, a nonparametric Wilcoxon test and a paired samples $t$ test were used to calculate the means, standard deviation, $z$-scores, probabilities, and standard error for each test. A two-tailed hypothesis was used and the level of significance was set at $p<.05$ for all tests. The results were then used to answer the research questions stated in the introduction.

Reporting of Results

Upon completion of this study, a summary of the results will be completed and sent to Altru Health Institute's Sports Acceleration program and Frappier Acceleration® Inc. Copies of this independent study will be given to both the preceptor of this research project and the University of North Dakota Health Sciences Library. This study was completed to partially fulfill the requirements for the University of North Dakota School of Medicine and Health Sciences Master of Physical Therapy Program.
CHAPTER IV

RESULTS

The data from this study was collected from two NBM assessments. A nonparametric Wilcoxon test was used to determine if there were significant differences between pre- and post-assessment for the limits of stability and lunge tests.

Subject Profile

A total of nineteen subjects participated in this study consisting of ten males and nine females. The mean age was fifteen with a standard deviation of one. Athletes were involved in several different sports including football, basketball, track, volleyball, softball, baseball and golf. Basketball had the highest involvement followed by football. The average height was 5'10" for the males and 5'8" for the females. All participants reported no significant past medical history.

Research Questions

Does plyometric and treadmill training significantly improve balance in high school athletes? Does plyometric and treadmill training significantly improve reaction time in high school athletes? Dynamic balance is assessed through the lunge and limits of stability tests. Reaction time is primarily assessed through the lunge tests. The results for the limits of stability and lunge tests are discussed separately.
Results for Limits of Stability

The means and standard deviations for the selected variables are reported in Table 6. The data was not normally distributed so a nonparametric Wilcoxon test was used to see if a significant difference was present between the pre and post assessments. The z-score and probability are also reported in Table 6. Tests that showed significant results are also indicated in the table.

Table 6. Results for Limits of Stability Pre- and Post-Assessment Tests: Mean, Standard Deviation, z-scores and Probability.

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Time</th>
<th>M</th>
<th>SD</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement Velocity</td>
<td>1</td>
<td>7.04</td>
<td>1.89</td>
<td>-1.97</td>
<td>0.05a</td>
</tr>
<tr>
<td>Forward (seconds)</td>
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<td>7.94</td>
<td>2.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement Velocity</td>
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<td>6.06</td>
<td>1.63</td>
<td>-1.31</td>
<td>0.19</td>
</tr>
<tr>
<td>Back (seconds)</td>
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<td>5.59</td>
<td>1.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement Velocity</td>
<td>1</td>
<td>9.90</td>
<td>2.85</td>
<td>-2.03</td>
<td>0.04b</td>
</tr>
<tr>
<td>Left (seconds)</td>
<td>2</td>
<td>8.78</td>
<td>2.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endpoint Excursion</td>
<td>1</td>
<td>73.16</td>
<td>18.23</td>
<td>-0.58</td>
<td>0.56</td>
</tr>
<tr>
<td>Forward (%LOS)</td>
<td>2</td>
<td>76.37</td>
<td>20.34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Endpoint Excursion</td>
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<td>69.32</td>
<td>20.83</td>
<td>-0.24</td>
<td>0.81</td>
</tr>
<tr>
<td>Back (%LOS)</td>
<td>2</td>
<td>70.26</td>
<td>20.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximal Excursion</td>
<td>1</td>
<td>82.00</td>
<td>18.13</td>
<td>-1.26</td>
<td>0.21</td>
</tr>
<tr>
<td>Back (%LOS)</td>
<td>2</td>
<td>79.64</td>
<td>15.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximal Excursion</td>
<td>1</td>
<td>112.37</td>
<td>7.69</td>
<td>-0.42</td>
<td>0.68</td>
</tr>
<tr>
<td>Right (%LOS)</td>
<td>2</td>
<td>111.79</td>
<td>7.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Directional Control</td>
<td>1</td>
<td>75.32</td>
<td>8.61</td>
<td>-1.64</td>
<td>0.10</td>
</tr>
<tr>
<td>Forward (%LOS)</td>
<td>2</td>
<td>78.11</td>
<td>10.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Directional Control</td>
<td>1</td>
<td>66.05</td>
<td>18.18</td>
<td>-1.24</td>
<td>0.21</td>
</tr>
<tr>
<td>Back (%LOS)</td>
<td>2</td>
<td>67.32</td>
<td>20.11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Directional Control</td>
<td>1</td>
<td>73.53</td>
<td>7.85</td>
<td>-1.16</td>
<td>0.25</td>
</tr>
<tr>
<td>Right (%LOS)</td>
<td>2</td>
<td>75.16</td>
<td>10.80</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

M=mean, SD=standard deviation, z=z-score, p=probability, LOS=limits of stability
a=Test 1 showed a significant improvement in score compared to Test 2
b=Test 1 showed a significant regression in score compared to Test 2
Results for Lunge

The means and standard deviations for the selected variables are reported in Table 7. The data was not normally distributed so a nonparametric Wilcoxon test was used to see if a significant difference was present between the pre- and post-assessment tests. The z-score and probability are also reported in Table 7. Tests that showed a significant result are indicated in the table as well.

Table 7. Results for Lunge Pre- and Post-Assessment Tests: Mean, Standard Deviation, z-scores and Probability.

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Time</th>
<th>M</th>
<th>SD</th>
<th>z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>1</td>
<td>55.16</td>
<td>9.58</td>
<td>-2.47</td>
<td>0.01a</td>
</tr>
<tr>
<td>Right Side (%BH)</td>
<td>2</td>
<td>60.79</td>
<td>5.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance</td>
<td>1</td>
<td>55.05</td>
<td>8.80</td>
<td>-2.14</td>
<td>0.03b</td>
</tr>
<tr>
<td>Left Side (%BH)</td>
<td>2</td>
<td>59.47</td>
<td>5.97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact Index</td>
<td>1</td>
<td>38.58</td>
<td>13.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right Side (%BW)</td>
<td>2</td>
<td>38.42</td>
<td>11.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact Index</td>
<td>1</td>
<td>35.21</td>
<td>12.48</td>
<td></td>
<td></td>
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<tr>
<td>Left Side (%BW)</td>
<td>2</td>
<td>35.95</td>
<td>9.79</td>
<td>-0.65</td>
<td>0.52</td>
</tr>
<tr>
<td>Contact Time</td>
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<td>0.76</td>
<td>0.56</td>
<td>-1.79</td>
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<tr>
<td>Right Side (seconds)</td>
<td>2</td>
<td>0.60</td>
<td>0.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact Time</td>
<td>1</td>
<td>0.75</td>
<td>0.34</td>
<td>-2.68</td>
<td>0.01c</td>
</tr>
<tr>
<td>Left Side (seconds)</td>
<td>2</td>
<td>0.60</td>
<td>0.15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Force Impulse</td>
<td>1</td>
<td>82.58</td>
<td>55.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right Side (%BWseconds)</td>
<td>2</td>
<td>66.37</td>
<td>15.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Force Impulse</td>
<td>1</td>
<td>79.11</td>
<td>31.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left Side (%BWseconds)</td>
<td>2</td>
<td>66.47</td>
<td>14.62</td>
<td>-2.42</td>
<td>0.02d</td>
</tr>
</tbody>
</table>

M=mean, SD=standard deviation, z=z-score, p=probability, BH=body height, BW=body weight
a=Test 1 showed a significant improvement in score compared to Test 2
b=Test 1 showed a significant improvement in score compared to Test 2
c=Test 1 showed a significant improvement in score compared to Test 2
d=Test 1 showed a significant improvement in score compared to Test 2

Balance showed a significant change in score between pre- and post-assessment in the following tests: movement velocity forward and left, distance with the right and left leg, contact time with the left leg, and force impulse with the left leg. All of these
tests indicated an improvement in score except movement velocity left, which indicated a regression in score. Reaction time showed a significant improvement in score between pre- and post-assessment in the following tests: distance with the right and left leg, contact time with the left leg, and force impulse with the left leg.
CHAPTER V
DISCUSSION

This study addressed two research questions. 1) Does plyometric and treadmill training significantly improve balance in high school athletes? 2) Does plyometric and treadmill training significantly improve reaction time in high school athletes? The first question was answered by the limits of stability and forward lunge test results. The second question was answered primarily by the forward lunge test results. The results for each test and how they answer the research questions are further discussed.

The limits of stability only had two of the ten reliable tests show significant results. Movement velocity forward showed a significant improvement in score when comparing pre- and post-assessments as the mean score increased from 7.04 degrees per second to 7.94 degrees per second. This showed that the subjects' balance did significantly improve following plyometric and treadmill training. Movement velocity left showed a significant regression in score with a decrease in mean score from 9.90 degrees per second to 8.78 degrees per second. This showed that the subjects had a harder time shifting their weight to the left. The decreased ability to shift to the left could have been due to the fact that the NBM was not calibrated correctly, as a majority of the individuals had difficulty moving to the left as compared to the right.

Four out of the eight reliable tests for the lunge showed significant results. Distance significantly improved on both the right and left sides. Contact time and force...
impulse significantly improved on the left side. Distance showed improvement through an increase in mean score, indicating that the subjects typically stepped farther forward during the post-assessment than compared to the pre-assessment. On the right side, the mean score increased from 55.16% body height to 60.79% body height and on the left side it increased from 55.05% body height to 59.47% body height. An improvement in contact time was shown on the left side through a decrease in mean score from 0.75 seconds to 0.60 seconds. This indicated that a significantly less amount of time was spent in contact with the force plate when the subjects lunged forward with their left lower limb. Force impulse showed improvement by a decrease in mean score from 79.11% body weight seconds to 66.47% body weight seconds on the left side. This meant that the subjects typically did more work in a shorter period of time during the post-assessment when compared to the pre-assessment. Balance and reaction time are needed in order to perform a lunge accurately and quickly. Therefore, it can be assumed that balance and reaction time did significantly improve following plyometric and treadmill training. An improvement in strength, flexibility, confidence and control of both lower limbs also could have contributed to the tests' significant results.

When looking at the forward lunge, the left side in general showed more of a significant improvement than the right side, which could be related to limb dominance. Right hand dominance is generally more common than left hand dominance. As a result, the athlete may be more confident when performing the tests with his/her right side. The right side may also be near its optimal performance level, whereas the left side has greater room for improvement. The researchers did not know the subject's hand
dominance; therefore we were unable to directly relate our findings to this phenomena. Further investigation would be needed to determine this.

Although research has shown that plyometrics and treadmill training improve flexibility, strength, agility, power, speed and confidence in athletes, there are no current studies available that specifically relate this type of training in high school athletes to balance and reaction time. Therefore, the researchers are unable to relate their findings to other studies.

Limitations and Recommendations

There are several limitations that existed in this study, which are related to the subjects, the researchers, or the study itself. The limitations along with the recommendations for each are further discussed.

Subjects

Since the subjects were only of high school age, they may not have understood the full implications of the study, therefore they may not have taken it seriously enough and may not have given their maximal effort for each trial. Testing athletes at the college age level or higher could help ensure that the subjects fully understand what is required of them and why. The athletes that were tested may not have been given enough practice to conquer the learning curve that exists with the NBM, especially for the LOS test. Hence, the data that was collected may not have been what the athlete was fully capable of performing. More practice time should be given to the athletes to minimize the learning curve when using the NBM. This could also ensure that the subjects fully understand how to perform each test to the best of their ability.
Researchers

Another limitation to this study was that the researchers were only moderate to highly reliable with the pilot study in ten out of the twenty tests for the limits of stability. This limited the amount of data that could be analyzed from the actual study. Future researchers should be reliable in all tests that are to be performed during the study to help reduce the amount of skewed results and increase the amount of data that can be used for analysis. The use of only one tester could help decrease any variability that can occur and will allow testing to be more consistent. The lack of research available on this topic also posed a limitation on this study. There was no guide for the researchers to follow on how to run the study, what tests to use, or what to expect with the results.

Study

A small subject group was used in this study, which gave little room for error. Increasing the sample size in future studies will decrease the amount of variability and possibly give more significant results. Also, the study was run only during the summer, which limited the number of subjects recruited and included athletes that were primarily training for the fall sports season. Running the study for a longer period of time throughout the year would allow for the recruitment of athletes involved in a wider variety of sports and increase the sample size. The use of a control group would give a baseline for comparison, which can aid in interpreting the results and in showing a significant change in scores. The control group participants can perform traditional exercises such as weight lifting and regular treadmill training versus the Super Treadmill training used in the Frappier Acceleration® program.
The tests that were used in this study may not have been ideal for assessing balance and reaction time. The limits of stability test is generally used to assess pathological balance and not normal balance. This probably contributed to the reason why very few of the limits of stability tests showed significant results. The use of more functional tests that specifically relate to balance and reaction time may provide more noteworthy results. These could include plyometric drills, obstacle course, and/or specific sport skills. The researcher(s) could also look at the number of completed trials in a given time frame, how well the subjects performed them, and how many times balance was lost during the trails.

Conclusion

Many athletes use sports acceleration training programs to gain an edge over their competition. One way to gain this edge is by improving balance and reaction time. These two components are often overlooked and are very important to any athlete. Balance and reaction time help to reduce the risk of injury and increase the skill level of the athlete. Therefore, it is vital to know what type of training can be used to improve them to aid in decreasing the athlete’s risk of injury and improving his/her skill level.

The focus of this study was to determine if plyometric and treadmill training improved balance and reaction time in high school athletes that participated in Altru Health Institute's Sports Acceleration program during the summer of 2000. Nineteen subjects were assessed with the limits of stability and forward lunge tests using the NBM. The results indicated that balance and reaction time did significantly improve following plyometric and treadmill training. However, there were several limitations that existed in
this study. Further research that incorporates the above recommendations is suggested to further aid this area of investigation.
LUNGE TEST DESCRIPTIONS

**Distance:** The average length the lunge leg takes during the forward step. Measured as a percent of body height.

**Impact Index:** The average maximal force that the lunge leg transmits as it contacts the force plate surface during the forward step. Measured as a percent of body weight.

**Contact Time:** The average amount of time that the lunge foot is in contact with the force plate during the forward step. Measured in seconds.

**Force Impulse:** The average amount of work that the lunge leg performs during the landing and push off phase of the movement. Measured as a percent of body weight and seconds.
Forward Lunge

Data Range Note:
No Data Range.

Post Test Comments:
LIMITS OF STABILITY TEST DESCRIPTIONS

Reaction Time: The amount of time in seconds between the appearance of the blue circle in the highlighted target signaling the patient to move and the initiation of movement.

Movement Velocity: The average speed measured in degrees per second the individual moves his/her center of gravity between 5% and 95% of the distance to the primary target.

Endpoint Excursion: The distance measured in % of limits of stability the individual moves his/her center of gravity on the primary attempt to reach the target.

Maximum Excursion: The farthest distance measured in % of limits of stability the individual is able to move his/her center of gravity during the trial.

Directional Control: The comparison between the amount of movement that is in the direction of the target and the amount of movement that is away from the target. This is measured in as a percent.
Name: 
ID: 
Date of Birth: 
Height: 
Comments: 

Diagnosis: 
Operator: 
Referral Source: 
File: 
Date: 
Time: 

Limits Of Stability

<table>
<thead>
<tr>
<th>Transition</th>
<th>RT (sec)</th>
<th>MVL (deg/sec)</th>
<th>EPE (%)</th>
<th>MXE (%)</th>
<th>DCL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (F)</td>
<td>2.25</td>
<td>5.0</td>
<td>58</td>
<td>87</td>
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<tr>
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<td>NS</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>3 (R)</td>
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</tr>
</tbody>
</table>

100% LOS

Data Range Note: No Data Range.

Post Test Comments:
ALTRU HEALTH SYSTEM

APPROVAL TO CONDUCT RESEARCH STUDY
AT ALTRU HEALTH SYSTEM

Name: Meridee Danks, M.P.T. Date: May 8, 2000

Address: P.O. Box 9037, School of Medicine and Health Sciences

Telephone Numbers: Work (701) 777-3861 Home (701) 772-0263

Department/College Physical Therapy

Project Title: The Effects of Sports Acceleration Training on Balance and Reaction Time in High School Athletes

Your request to conduct the above named study at an Altru Health System facility involving employees or patients as participants, and/or requiring facility resources has been reviewed. The following action has been taken:

✓ Permission to conduct the study is granted

☐ Permission to conduct the study will be granted upon completion of the following:

________________________________________________________________________

☐ Permission to conduct the study is denied for the following reason(s):

________________________________________________________________________

________________________________________________________________________

RECOMMENDATIONS/REMARKS:

________________________________________________________________________
Institutional Review Board
Research Project Action Report

Date: May 5, 2000

Principal Investigator: Marcus Sorenson, Jay Armstrong
Andrea Richter
Department: Physical Therapy
Phone #: 746-7888

Address to which notice of approval should be sent: Altru Health System Research Department

Research Coordinator: Same as Above
Phone #: 777-2831

Project Title: The Effects of the Sports Acceleration Training Program on Balance and Reaction Time in High School Aged Athletes

The above referenced project protocol and informed consent was reviewed by the Altru Health System Institutional Review Board on 6/19/00 and the following action was taken:

✓ Project approved. Next Scheduled review is on 6/19/00 12-15-00

If no date is given, then review will be required in 12 months. (See REMARKS SECTION for any special condition.)

☐ Project approved. EXPEDITED REVIEW NO.

☐ Project approved. EXEMPT CATEGORY NO.

☐ Project approval deferred. (See REMARKS SECTION for further information.)

☐ Project denied. (See REMARKS SECTION for further information.)

☐ Amendment approved

☐ Administrative change approved

☐ Protocol revision approved

☐ Revised consent form approved

☐ Adverse event reviewed - Date of event

☐ Other

REMARKS:
Any changes in protocol, adverse occurrences or deaths in the course of the research project must be reported immediately to the IRB chairperson or the IRB office (780-6161).

Signature of Chairperson or Designated IRB Member
Altru Health System Institutional Review Board

Date

If the proposed project is to be part of a research activity funded by a federal agency, a special assurance statement or a completed 596 Form may be required. Contact IRB office to obtain the required documents.
Institutional Review Board
Research Project Action Report

Date: May 30, 2000
IRB # PT-013

Principal Investigator: Jay Armstrong, Andrea Richter, Marcus Sorenson
Department: Physical Therapy
Phone #: 746-7888

Address to which notice of approval should be sent: Altru Health System Research Department
Research Coordinator: Same as above
Phone # 777-2831

Project Title: The Effects of the Sports Acceleration Training Program on Balance and Reaction Time in High School Aged Athletes

The above referenced project protocol and informed consent was reviewed by the Altru Health System Institutional Review Board on and the following action was taken:

☐ Project approved. Next Scheduled review is on_____________________________.
If no date is given, then review will be required in 12 months. (See REMARKS SECTION for any special condition.)

☐ Project approved. EXPEDITED REVIEW NO. ________________________________
Next scheduled review is on______________________________

☐ Project approved. EXEMPT CATEGORY NO. ________________________________
No periodic review scheduled unless so stated in REMARKS SECTION.

☐ Project approval deferred. (See REMARKS SECTION for further information.)

☐ Project denied. (See REMARKS SECTION for further information.)

☐ Amendment approved
☐ Administrative change approved
☐ Protocol revision approved
☒ Revised consent form approved & letter
☐ Adverse event reviewed - Date of event:______________________________
☐ Other

REMARKS:
Any changes in protocol, adverse occurrences or deaths in the course of the research project must be reported immediately to the IRB chairperson or the IRB office (780-6161).

Signature of Chairperson or Designated IRB Member
Altru Health System Institutional Review Board

Date: 12/11/00

If the proposed project is to be part of a research activity funded by a federal agency, a special assurance statement or a completed 596 Form may be required. Contact IRB office to obtain the required documents.
Institutional Review Board

Human Subjects Review Form

For new projects or procedural revisions to approved projects involving human subjects.

Jay Armstrong, Andrea Richter, Marcus Sorenson

Principal Investigator: Jay - 746-7888
Andrea - 588-4604
Marcus - 777-9800

Phone #: 5/4/00

Address to which notice of approval should be sent: P. O. Box 9037, Grand Forks, ND 58202-9037

Institution: University of North Dakota
Department: Physical Therapy

Research Coordinator(s): Same as above

Phone #: 777-2831

Proposed Project Dates: June 1, 2000 - October 1, 2000

Project Title: The Effects of the Sports Acceleration Training Program on Balance and Reaction Time in High School Aged Athletes

IRB Project Number: __________

Funding Agencies (if applicable): __________

Type of Project: ☐ New Project ☐ Continuation ☐ Renewal ☐ Student Research Project
☐ Dissertation or Thesis Research

Reports: ☐ Administrative Change ☐ Protocol Revision ☐ Revised Consent Form
☐ Amendments or Change in Project

Dissertation/Thesis Advisor, or Student Advisor: Meridee Danks, MPT (777-3861)

Proposed Project: ☐ Involves New Drugs (IND) ☐ Involves Non-Approved Use of Drug
☐ Involves a Cooperating Institute ☐ None of the Above

If any of your subjects fall in any of the following classifications, please indicate the classification:
☐ Minors (< 18 Years) ☐ Pregnant Women ☐ Mentally Disabled ☐ Fetuses ☐ Mentally Retarded
☐ Prisoners ☐ Students ☐ Abortuses ☐ Control Group

If your project involves any human tissue, body fluids, pathological specimens, donated organs, fetal material, or placental materials, check here ___.

☐ Expedited Review requested under item ___ (number) of HHS Regulations (see attached explanation)

☐ Exempt Review requested under item ___ (number) of HHS Regulations (see attached explanation)

If your project has been/will be submitted to another Institutional Review Board(s), please list name of Board(s):

UND cooperative agreement

Status of submission to another IRB: ☐ Submitted; Date __________ ☐ Approved; Date __________ ☐ Pending

Any additional information should be documented on a separate sheet of paper.

1. ABSTRACT (Limit to 200 words or less and include justification or necessity for using human subjects. Attach additional sheet if necessary.)

High school age athletes' involvement in Sports Acceleration training has grown in recent years. Athletes use the Sports Acceleration program to help gain an edge over their competition. One way to gain that edge is by improving balance and reaction time. These two components are important in a wide variety of sports. They help to minimize injury and increase the skill level and performance of the athlete. The purpose of this study is to determine if the Altru Health Institute's Sports Acceleration plyometric and treadmill training increases balance and reaction time in high school age athletes. Data will be obtained by assessing high school athletes involved in the Sports Acceleration program at Altru Health Institute during the summer of 2000.
PLEASE NOTE:

Only information pertinent to your request to utilize human subjects in your project or activity should be included on this form. Where appropriate attach sections from your proposal including data collection instruments where applicable.

2. PROTOCOL: (Describe procedures to which humans will be subjected.)

Subjects: Subjects will include high school athletes participating in the Altru Health Institute Sports Acceleration program during the summer of 2000. Subjects will be involved in both plyometric and treadmill training. Weight training during the program is optional, and will not exclude subjects from this study. Each subject will be 18 years of age or younger. Involvement in the study will be voluntary and informed consent will be obtained through a signed consent form by subjects and the subject's parent or legal guardian. Recruitment will be through word of mouth by Altru staff and/or researchers and subjects will be tested prior to the start of their Sports Acceleration training. Thirty subjects or more will be needed for this study. Subjects who do not complete the Sports Acceleration program will be dropped from the study.

Testing Procedure: Subject's balance and reaction time will be assessed on the NeuroCom Balance Master. It is a clinically accepted and reliable machine that is commonly used in physical therapy to assess balance. The subject stands on a forceplate that sends various data to a computer software program that then interprets the data. Subject's balance and reaction time will be assessed with the following tests using standardized testing procedures.

1. Limits of Stability: In standing, subjects will be required to shift their body weight and lean in eight directions while maintaining balance and keeping feet firmly on the forceplate. Directions include forward, backward, sideways, and diagonal. This tests a subject's reaction time and dynamic balance.

2. Forward Lunge: Subjects will be required to step forward as fast and as far as they can with one leg, then return to the starting position. There will be six trials total, three with the left leg and three with the right leg. This tests a subject's functional balance and reaction time.

All testing will be done at the Altru Health Institute physical therapy department. Subjects will be assessed on the first day of their respective training programs through Sports Acceleration. This assessment will be done during the initial Sports Acceleration evaluation, which is prior to their first training session. During the initial testing, each subject will be given a practice session and then be scored on the limits of stability and forward lunge tests. Final testing will be done during the sixth and final week of the Sports Acceleration training program.

Data Analysis: Data will be presented using descriptive and analytical statistics with an alpha level of .05. All subject information will remain confidential and a number known only by the researchers will identify individual data. Results will be reported in a way that ensures subject confidentiality. All data will be kept in a locked file at the University of North Dakota Department of Physical Therapy and data will be destroyed after three years.
3. **BENEFITS:** (Describe the benefits to the individual or society.)

Upon completion of this study, the data obtained will help determine the effectiveness of Sports Acceleration training in improving balance and reaction time for high school athletes. The possible improvements in balance and reaction time obtained through this training may increase skill level and performance in each athlete's respective sport and possible reduction of injuries. This study can be used as reference for future studies pertaining to balance and reaction times in training program participation.

4. **RISKS:** (Describe the risks to the subject and precautions that will be taken to minimize them. The concept of risk goes beyond physical risk and includes risks to the subject's dignity and self respect, as well as psychological, emotional or behavioral risk. If data are collected which could prove harmful or embarrassing to the subject if associated with him or her, then describe the methods to be used to insure the confidentiality of data obtained, including plans for final disposition or destruction, debriefing procedures, etc.)

The risks associated with this study are minimal, but those that do exist will be controlled. The physical risks include loss of balance and/or fall, and will be controlled by the use of a spotter during each assessment. Clear and thorough instructions for the testing procedure and the subject's role in the research project will be given verbally before he or she is assessed on the NeuroCom Balance Master. Keeping all information confidential and not attaching names to any of the data collected will protect participant's respect and dignity. All participants will be informed of the confidentiality associated with this research. Subjects will be scheduled so that their privacy will be maintained and they will be provided a safe and controlled environment in which to be assessed. Information on the right to withdraw from this study at any time will be contained in the consent form that each participant will sign prior to the initial assessment.
5. **CONSENT FORM:** A copy of the CONSENT FORM to be signed by the subject (if applicable) and/or any statement to be read to the subject should be attached to this form. If no CONSENT FORM is to be used, document the procedures to be used to assure that infringement upon the subject's rights will not occur.

Describe who will be obtaining consent, where signed consent forms will be kept, and for what period of time. Attached is a copy of the consent form that will be distributed to all prospective participants for the research project along with the Sports Acceleration consent form. All consent forms and data collected will be kept in a locked office at the University of North Dakota Department of Physical Therapy. Information will be kept for a period of three years and after that time, it will be destroyed.

6. For FULL IRB REVIEW, forward the *signed* original and 13 copies of this completed form and, when applicable, 13 copies of the proposed consent form, questionnaires, etc., and any supporting documentation to:

For EXEMPT or EXPEDITED REVIEW forward a *signed* original and a copy of the consent form, questionnaires, etc., and any supporting documentation to:

Eleanor Tveit, IRB Secretary
1000 South Columbia Road
Grand Forks, ND 58201
701-780-6161

The policies and procedures on Use of Human Subjects in Altru Health System Institutions apply to all activities involving use of Human Subjects performed by personnel conducting such activities. No activities are to be initiated without prior review and approval of the Altru Health System Institutional Review Board.

Signatures:

Principal Investigator: [Signature]
Date: 5-4-00

Project Director: [Signature]
Date:

Research Coordinator: [Signature]
Date:

Student Advisor (where applicable): [Signature]
Date: 5-4-00
APPENDIX C
Dear Athlete,

You are receiving this letter because you are participating in the Sports Acceleration program at Altru Health Institute. During the summer of 2000, graduate students from the University of North Dakota Physical Therapy Program will be cooperating with the Sports Acceleration program at Altru Health Institute on a research project. We will be studying the effects of the plyometric portion of Sports Acceleration training on balance and reaction time in high school athletes. These two components are important to success no matter which sport you participate in at the high school level. They help each athlete to get an edge over their competition and minimize the chance of injuries. Your participation in this study will help gain knowledge of the Sports Acceleration plyometric training and its benefits to all athletes.

Enclosed is an information and consent form to participate in this study. Please read over this carefully and if you choose be a part of this research, bring the consent form signed by yourself and your parent or legal guardian to the first day of your Sports Acceleration training.

Thank you for your consideration and we strongly urge you be a part of our research project. If you have any questions or concerns, please feel free to call the graduate students at the following numbers: Jay Armstrong (701)746-7888, Andrea Richter (701)588-4604, Marcus Sorenson (701)777-9867 or contact our advisor Meridee Danks at (701)777-3861.

Sincerely,

Jay Armstrong, Andrea Richter, Marcus Sorenson
University of North Dakota Physical Therapy Students

Enclosure (1)
Information and Consent Form

Title: The Effects of the Sports Acceleration Training Program on Balance and Reaction Time in High School Aged Athletes

You are invited to participate in a study conducted by Andrea Richter, Jay Armstrong, and Marcus Sorenson, all graduate students in Physical Therapy at the University of North Dakota. The purpose of this study is to determine the effects of the Sports Acceleration program on balance and reaction time in high school aged athletes. The balance testing will be performed on the NeuroCom® Balance Master. It is a clinically accepted and reliable machine that is commonly used in physical therapy to assess balance and reaction time.

Participants involved in the plyometric and treadmill portion of the Sports Acceleration training program at Altru Health Institute, who are 18 years or younger, will be eligible for this study. Subjects will be tested on the NeuroCom® Balance Master on the first day, prior to the start of their Sports Acceleration training program, and then again during the sixth and final week of the program. All testing will be done at the Altru Health Institute Physical Therapy Department. Subjects who do not complete the training program will be dropped from the study.

Participation in this study is voluntary and you are free to discontinue participation at any time, up until final data has been collected. Participation in this study will in no way affect your relationship with the University of North Dakota, or Altru Health Institute.

Your involvement in this study will help to determine the effects of Sports Acceleration training on balance and reaction time. There will be few, if any, discomforts or inconveniences associated with participation in this study. Testing will take approximately 20 minutes for each of the two sessions. Participants will be tested on dynamic and functional balance. Clear and thorough instructions will be given before each of the two tests.

The results of this study and any subject information will remain confidential. A random number will be assigned to you and will be used to represent your data. Only the investigators will have access to this information. Records will be stored in a locked office at the Physical Therapy Department at the University of North Dakota. These records will be destroyed three years after the study has ended, unless they are required for future studies.
The risks associated during participation of this study are minimal, but those that do exist will be controlled. The physical risks could include loss of balance and falling. A spotter will be present during the testing process to ensure subject safety. Should injury occur during the testing process, you will receive appropriate medical attention. The investigators, along with Altru Health Institute and the University of North Dakota, are not responsible for any such injury. You, or any third party payer, will be responsible for payments of any treatment needed.

The investigators are available to answer any questions you might have concerning this study now, or in the future. Questions may be answered by contacting Marcus Sorenson at (701)777-9867, Jay Armstrong at (701)746-7888, Andrea Richter at (701)588-4604, or our advisor Meridee Danks at (701)777-3861.

I have read all the above and all of my questions have been answered. My signature indicates that I willingly agree to participate in this study explained to me by Marcus Sorenson, Jay Armstrong, and/or Andrea Richter. I understand that my medical records and study records are confidential. However, representatives of the study sponsor, the U.S. Food and Drug Administration (FDA), or the Institutional Review Board (IRB) may need to inspect my medical and/or study records. By signing this consent, I am allowing this inspection.

Participant's Signature

Date

I have read all the above and all of my questions have been answered. My signature indicates that I give my permission and consent to allow my child to participate in this study.

Parent or Guardian's Signature

Date
TEST ADMINISTRATION PROCEDURE

Limits of Stability

According to the NBM manual, the limits of stability test (LOS) measures the extent a person can lean in a given direction without losing balance, stepping, or reaching for support. A person was placed on the NBM force plate as per instructions by the NBM initial LOS screen. During this test, the patient's center of gravity (COG) was shown as a cursor on a monitor found directly in front of them. As the subject shifted his/her weight, the cursor on the monitor showed the displacement of their COG.

Throughout the test, eight targets were displayed on the screen in a clockwise manner, 45 degrees apart from each other. The LOS consists of eight trials conducted in the following manner: forward, forward-right, right, backward-right, backward, backward-left, left, forward-left. Figure 7 is an example of what the LOS screen looks like in reference to the different boxes the person will try to get the target into. Once the subject was ready to begin, the tester clicked the mouse, which caused a "GO" and a blue circle in the designated target to appear on the screen. The subject shifted his/her weight as fast and as straight as possible to move the cursor to the designated target. The subject held the cursor in that target for eight seconds, so the machine could properly record the information. After the eight seconds, the individual then moved the cursor to the original, starting position and prepared to move to the next target. The first round of eight trials was a practice round, while the second round was a scored round. The practice round was to ensure the scoring was the actual dynamic ability, and not the ability to figure out the cursor control.
According to the NBM, the forward lunge test measures the following four components: distance, time, impact force and force impulse. The average length of a forward step expresses a percent of total body height. The average maximum force displaced during the forward lunge is a representation of a percentage of total body weight. By measuring these components, objective data can be produced to show changes in foot speed, body control, and coordination.

The subject was placed with his/her heels aligned to the back of the NBM force plate. After the subject was ready to begin the test, the tester clicked the mouse, which started the test. A "GO" sign was then shown on the monitor in front of the subject. The subject then stepped forward as far and as fast as he/she could, and then returned to the original starting position. Testing consists of three trials with the left foot, and then three trials with the right foot. The three trials were then averaged together.
APPENDIX E
VERBAL INSTRUCTIONS FOR SUBJECTS

Limits of Stability

The first test you will be performing is the limits of stability. You will stand with both of your feet on the Balance Master. At no time during the test can you lift either of your feet off the Balance Master. As you shift your weight, the image of the person on the screen will move. You are allowed to use your arms and shift your hips as much as you would like, but you must not move your feet. Once the blue circle appears in the box, try to move the person as fast and as straight as you can. When each trial is finished, hold the person motionless in the center square until the next trial begins. You will try to keep the person motionless in the box until the person disappears. You will be tested in eight directions starting forward. The first attempt at all eight positions will be a practice round. You will then be tested and scored on the next try.

Hold the person in the center square until the computer says 'GO' then move the image of the person as fast and as straight as you can and hold it in box #_. Are you ready? (Repeat for each trial, eight times)

Forward Lunge

The second test you will be performing is the lunge test. You will begin with your heels on the line farthest back with your feet shoulder width apart. Once the screen says go, you will step with your left foot as far and as fast as you can forward and then step back to the starting position. You will perform this three times with the left leg and then three times with the right leg.
Hold steady until the screen says 'GO', then step forward and backward as fast and as far as you can, and hold steady at the starting point. (Repeat for each trial, three times each leg)
APPENDIX F
AN EXAMPLE OF LEVEL II SESSION #1 PLYOMETRIC SESSION

In the protocol for level II session #1, using the four square formation for repetition E, the athlete would be told to jump between the four boxes starting in box one and jumping to the other three boxes consecutively. The athlete would jump from number to number on the floor with both legs as many times as they can in the allotted time, which in this case is five seconds. The ideal way to complete this exercise is by moving the lower extremity only while keeping the trunk in place over the center of the square. This would, in effect, cause the athlete's lower extremities to resemble a cone shape while moving their feet from number to number.
PLYOMETRICS
Developed by: John P. Frappier, M.S.
Exercise Physiologist

Name: ________________________________ Date: _______________________

Session 3, Level 1

1. 1 leg Plyo press @62% BW 2 sets 8 reps R____ L____
2. 1 leg Plyo press @77% BW 2 sets 8 reps R____ L____
3. 1 leg 6" Box 2 sets 12 reps R____ L____
4. 2 leg 12" Box 2 sets 12 reps ______
5. 2 legs 18" Box 2 sets 12 reps ______
6. 2 legs 24" Box 2 sets 12 reps ______

** Attempt to simulate sprint striding technique **
7. 1 leg Plyo press TR @77% BW 3 sets 8 reps R____ L____
8. Box Jump 12" or Box 1-2, 2 foams Max in 15 sec. ______
9. 1 leg Plyo press @100% 1RM 1 set 3 reps R____ L____
10. 1 leg Plyo press @92% 1RM 1 set 3 reps R____ L____
11. 1 leg Plyo press @85% 1RM 1 set 3 reps R____ L____
12. Four Square

A. Box 1-2 Max in 10 sec. ______
B. Box 1-2-3 Max in 10 sec. ______
C. Box 1-2-3-4 Max in 10 sec. ______
D. Box 1-3 Max in 10 sec. ______
E. Box 1-2 Max in 15 sec. R____ L____
F. Box 1-2-3-4 Max in 15 sec. R____ L____

13. Box Jump (Sprint Strides)
A. 24" 14 Reps ______
B. 20" 14 Reps ______
C. 12" 14 Reps ______
D. 8" 14 Reps ______
14. 2 legs Plyo press @77% 1RM 4 sets 5 reps ______
15. Box jump 12" or Box 1-2 2 foams Max in 10 sec. ______

Notes:
____________________________________________________________________
____________________________________________________________________
____________________________________________________________________
Session #1  Level II  Pre-training Test

I. Four Square Formation

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<thead>
<tr>
<th>BOTH LEGS</th>
<th>Box</th>
<th>Average</th>
<th>Time</th>
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</tr>
</thead>
<tbody>
<tr>
<td>A. Box 1-2</td>
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<td></td>
<td>6 sec.</td>
<td>2</td>
</tr>
<tr>
<td>B. Box 1-4</td>
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<tr>
<td>C. Box 1-2-3</td>
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</tr>
<tr>
<td>D. Box 1-3-2</td>
<td>5 sec.</td>
<td></td>
<td>5 sec.</td>
<td>1</td>
</tr>
<tr>
<td>E. Box 1-2-3-4</td>
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<td>5 sec.</td>
<td>1</td>
</tr>
<tr>
<td>F. Box 1-4-3-2</td>
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<tr>
<td>G. Box 1-3</td>
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<td>H. Box 4-2</td>
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II. Munoz Formation

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<td>B. Box 1-4</td>
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<tr>
<td>C. Box 2-5</td>
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<td>F. Box 1-2-3-4-5-6</td>
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III. Krumrie Formation

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Notes:
AN EXAMPLE OF LEVEL 1, PROGRAM 8 TREADMILL SESSION

During this session, the athlete would warm up first, then complete all the repetitions and sets at each of the listed speed, elevations, and durations. For example, during run number five, treadmill would be set at 11.5 miles per hour with an elevation of 25%. The athlete would complete four sets of the required time at this treadmill setting. The time for this run is shown to be :06/:04 (RUN/HOLD), which means that after the athlete mounts the treadmill, as soon as he/she lets go of the front grab bar, the time starts. The person runs for the first six seconds without assistance, and then holds on to the front grab bar for the last four seconds, then dismounts the treadmill.
ACCELERATION TRAINING PROGRAM
PROTOCOL NUMBER 3

WORK OUT SHEET

NAME: __________________________________________ DATE: ________________

WORK OUT NUMBER: LEVEL ONE PROGRAM EIGHT

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<th>%ELEV.</th>
<th>TIME</th>
<th>POST H.R.</th>
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NOTES:

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__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

(POST H.R. times are approximate and may vary slightly depending on individual performance.)

(RUN/HOLD/HOLD/2 HF/2 HE)
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