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Electromyographic Analysis of Lower Extremity Muscle Activity during Plyo Press Jump and a Vertical Jump

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ELECTROMYOGRAPHIC ANALYSIS OF LOWER EXTREMITY MUSCLE ACTIVITY DURING A PLYO PRESS JUMP AND A VERTICAL JUMP

by

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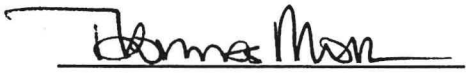
This Scholarly Project, submitted by Steve Thomas, Leigh Griffith, Daniel Sinness, and Kristen Olson in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Advisor and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.



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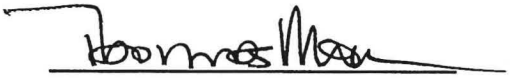

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PERMISSION

Title	Electromyographic Analysis of Lower Extremity Muscle Activity During a Plyo Press Jump and a Vertical Jump
Department	Physical Therapy
Degree	Master of Physical Therapy

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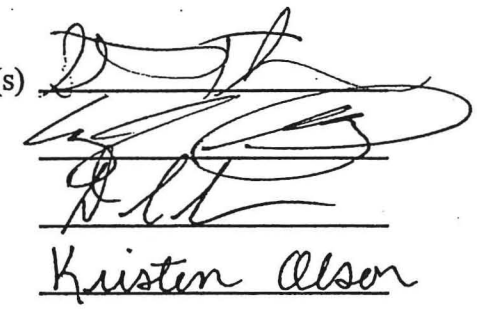
Signature(s) 

Kristen Olson

Date 12-15-03

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ACKNOWLEDGEMENTS

We would like to thank Dr. Thomas Mohr, our graduate advisor, who was so instrumental in setting up the study and guiding us through the various steps. We would also like to thank Frappier Acceleration and their staff, for allowing us the opportunity to conduct this study with the use of their equipment and facility. To all of our parents, for their support through all of our endeavors, we are truly appreciative of everything that you have done for us.

ABSTRACT

Many training programs have been developed to aid in training the athlete with their goal of maximizing strength and performance. The Plyo Press machine was developed for training athletes enrolled in the Frappier Sports Acceleration Program. This machine was designed to couple strength training with plyometrics to enhance dynamic muscle activity and speed.

There has been limited research on the Plyo Press machine to support these claims. Therefore, the purpose of our study was to compare muscle recruitment during a vertical floor jump versus a plyojump in the Ply Press leg machine. EMG analysis of selected lower extremity muscles was conducted to provide information of the muscle activity and recruitment pattern evoked during exercises on the Plyo Press.

Eight healthy male subjects that were familiar with the Plyo Press machine were asked to participate in this study. Each subject performed a series of vertical jumps and then plyojumps on the Plyo Press. An analysis of the normalized EMG data was conducted using the Norquest software package. The results of this study revealed that there was significantly more muscle recruitment of the gluteus maximus, semitendinosus, and anterior tibialis during the vertical jump as compared to the Plyo Press. The Plyo Press does not appear to offer any advantage of increased muscle recruitment for athletic training.

CHAPTER 1

INTRODUCTION

Competitive sports make a tremendous demand on an athlete's overall physical condition, vitality, endurance, and mental power. Only athletes in the finest condition can withstand the demands of the strenuous season and excel in their particular sport. One of the fundamental components to an athlete's fitness level is muscle power and strength. Muscular power is the maximal force that a muscle or muscle group can generate at a specified velocity.[1] A strength training program is characterized by near-maximal muscle contractions with high resistance extended over a small number of repetitions. This training elicits increases in the cross-sectional area of the exercised muscles, with Type II (fast-twitch) muscle fiber areas increasing more readily and at a faster rate than Type I (slow-twitch) muscle fibers. Individuals with the largest muscle cross-sectional area generate the greatest muscle force.[2] Type II motor units produce a greater force output and contract with greater velocity than Type I motor units and also demonstrate the greatest recruitment during strength training. Fast twitch fibers have a high power output (ability to generate force at higher speeds), compared to a low power output elicited by slow twitch fibers.[1]

Training programs target dynamic activity to prepare athletes for the demands of competitive sports. Dynamic activity requires a combination of both strength and power to effectively train. This is why many different exercises and machinery are used to achieve the desired result of increased strength and power.

The vertical jump is a sport specific activity that can be used to increase strength and an athlete's vertical. The combination of concentric (positive work) and eccentric (negative work) contraction of lower extremity muscles are used to generate work while the body moves in a vertical plane.[3]

Plyometrics were developed as a type of exercise that enables a muscle to reach maximal force in as short a time as possible.[1] The ability to quickly apply force to improve speed and strength is the major goal of plyometric training.

The Plyo Press leg machine was developed in order to specifically train strength and power of the lower extremities by using plyometric training. The Plyo Press combines a leg press exercise (lowering and lifting a set amount of weight from full knee extension to 90° of knee flexion, then back to full knee extension) with a plyojump exercise (a vertical jump against resistance while on the Plyo Press) to obtain maximal lower extremity muscle recruitment. The Plyo Press is claimed to be an ideal machine to obtain maximal strength and power training results by using dynamic activity exercise.[4]

The lack of scientific evidence supporting the claims made by the Plyo Press manufacturers is the reason why this research is being conducted. If this machine is proven to be superior to other training mechanisms it could be a valuable component in training athletes. Therefore, the purpose of this research study is to compare the muscle activity in the lower extremity musculature during a vertical floor jump and a Plyo Press jump.

CHAPTER II

LITERATURE REVIEW

Electromyography

Electromyography (EMG) is the recording of electrical activity of a muscle. When a muscle contracts, small levels of electricity (microvolts) are generated by the muscle. That voltage is measurable and is referred to as EMG. Surface electrodes placed on the skin over the muscle are used to sense the electrical activity of the muscles. The best placement for recording electrical current activity is a point just distal to the motor point of each muscle. These motor points can be defined in two ways: 1) the area at which the nerve to that muscle is most superficial; or 2) the most sensitive spot on the muscle.[5] The EMG signals are collected by a software program where the amplitude, frequency, and pattern of the activity can be viewed and quantified. Researchers and clinicians use EMG to evaluate the function of muscles during various activities, aiding in neuromuscular training and rehabilitation.[6,7]

EMG is a reliable method of measuring the amount of muscle recruitment during a specific activity. Although, force production cannot directly be assessed from EMG data, the relationship between force production and the amount of motor units being recruited is directly linked.[8]

Vertical Jump

Sports that require a high level of force over a relatively short period of time, such as jumping, benefit from plyometric training.[9] Plyometric training consists of exercises that enhance an athlete's power and performance. That is, performing an exercise in the shortest period of time while generating the most force. One such activity that almost all sports utilize is a vertical jump.[3] To best enhance the performance of an activity like jumping, one must train specifically for that activity. This is because specific fibers used during the training activity are adapted metabolically and physiologically to that exercise. This principle is termed specificity of training.[2]

To incorporate exercises for the muscles involved in a vertical jump one must initially review the act of jumping. The subject starts in a vertical upright position. The jumping activity is then initiated by lowering the center of mass at the hips and knees. The acceleration phase takes place as the hips and knees begin to extend and the body's center of mass is directed upward. When the lower limbs are fully extended and the ankle joint is going into full plantar flexion, the body lifts off and the flight phase begins.[10]

A controlling factor for the flight phase is muscle force. The active muscles must have supplied enough force to overcome gravity, subsequently allowing loss of contact with the floor (flight phase). The power produced by the muscles is the determining factor for the amount of vertical height achieved. Following this action, the body will return to the take off surface and the landing phase begins. The initial contact of the foot with the floor or other surface generates a rapid rate of loading. The amount of loading

well exceeds 200% of the body weight and in a well-trained population this value will surpass 200% by a large margin.[10]

Typical Lower Extremity Muscle Activity

The quadriceps are powerful extensors of the knee. During a vertical jumping movement the knee has to extend to complete the flight phase, therefore making the quadriceps muscles very important.[11] Both the vastus lateralis (VL) and the rectus femoris (RF) are major knee extensors. However, the RF is also a hip flexor assisting the iliopsoas in flexing the thigh at the hip joint.[11]

The biceps femoris (BF) acts both as a hip extensor and a knee flexor. EMG indicates that BF activity increases during the second half of rising from a flexed knee position.[8] Accompanying the BF in the posterior compartment of the leg is the semitendinosus (ST). Like the BF, ST also extends the thigh and flexes the knee.

Unlike the BF and the ST, the gluteus maximus (GM) is only active during hip extension and is also a major lateral rotator at the hip. During a squatting activity, similar to the lowering of the center of mass in the initiation of a vertical jump, GM shows its highest activity during the middle portion of the movement versus a lower activity reading at the beginning and end of the squat.[12]

The muscles of the lower leg consist of the anterior tibialis (AT), the gastrocnemius (GS), and the soleus (SOL). The AT is the strongest dorsiflexor and inverter of the foot. The GS is a two joint muscle, therefore the muscle acts both as a knee flexor and as an ankle plantar flexor. Because the fibers of the GS run mainly oblique, contraction produces rapid movement, making it important for acceleration during a jumping activity. The SOL, running deep to the GS, acts along with the GS in

plantar flexing the ankle. Although the SOL is very strong, it is made up of primarily slow twitch fibers in its action of plantar flexing as compared to the GS.[11]

The Plyo Press

Research is ongoing to design programs to heighten athletic performance. An example of one such program is John Frappier's Sports Acceleration. One piece of equipment vital to the Acceleration program is the Plyo Press machine, a patented device used by the program to enhance dynamic performance. The Plyo Press is specifically designed to allow the integration of both strength training and plyometric activities. The Plyo Press has been shown to be a safe and effective means of training lower extremity muscles. In the injured athletic population, it can allow athletes to begin rehabilitation training before they are fully weight bearing. The Plyo Press also enables athletes to train lower extremity muscles in the same fashion as a leg press or squat, but with less stress on the lower back.[13,14,15]

The mechanics of the Plyo Press itself are what help make this machine safe and effective. The specific features that provide safety and effectiveness on the Plyo Press are the use of the three cams, the inclined sled, the elongated sled track, and the inclined foot plate. The cam system is designed to give varying load at different knee angles: at 90° of knee flexion the load is at 80%, at 45° of knee flexion the load is at 100%, and at 0° of knee flexion (full extension) the load is at 120%. The sled supports the upper body and back at an incline of 15°.

The elongated sled track and the foot plate make the plyo press effective for plyometric activities. The length of the sled track is 108 inches, enabling the athlete to perform jumps on the plyo press. The foot plate is at an angle of 15° from vertical; this

angle puts the ankle into slight plantar flexion and forces the knee to flex during contact after a plyojump, thus preventing hyperextension of the knee during plyometric activities.[16]

CHAPTER III

METHODS

Subjects

Eight healthy, male volunteers gave written informed consent to be included in this study. The criteria for inclusion of the study were: Subjects between the ages of 18 and 30; Subjects who had previous training and knowledge of the Plyo Press during exercise; Subjects involved in athletic competition at any level. The study was approved by the Institutional Review Board at the University of North Dakota and all testing was performed at Sports Acceleration in Fargo, ND (See Appendix). The descriptive statistics for the subjects is shown in Table 1.

Table 1: Descriptive Statistics of Subjects

	Mean	Range
Age	21.25	19 - 30

Instrumentation

All trials were performed on a Plyo Press (Acceleration Products, Inc. Fargo, ND 58103). The vertical floor jumps and single leg squats were performed on a hard, level surface.

Plyo Press

The subjects were placed in the Plyo Press with their hips and knees flexed to 90° (Figure 1). The amount of weight added to the Plyo Press was equal to their body

weight. The subjects were then told to begin and end each individual jump on the Plyo Press with the sled at its resting point (hips and knees flexed to 90°). The subjects continuously jumped to their maximal exertion for 30 seconds while EMG recordings were taken (Figure 2).

Vertical Floor Jump

The vertical floor jump was performed on a hard, level surface. The subjects were told to begin and end each jump at 90° of hip and knee flexion between each vertical jump (Figure 3). The subjects were then told to perform continuous, maximal exertion vertical floor jumps for 30 seconds while EMG recordings were taken (Figure 4).

Single Leg Squat

The single leg squat was performed by each subject in order to determine a baseline EMG level at each muscle. The subject performed three single leg squats with their right leg. The subject was instructed to squat as low as they could and return to 0° of knee flexion (Figure 5). These baseline EMG readings were used to normalize the electromyographic readings between subjects.

Electromyography

The electromyographic data was collected by Noraxon Telemyo 8™ telemetry unit (Noraxon USA, 13430 North Scottsdale Rd., Scottsdale, AZ 85254). The sampling rate was 1000 Hz.

EMG Normalization

The EMG signals were normalized using a comparison of muscle activity during the one legged squat as a reference value to the Plyo Jump and vertical jump. EMG

normalization is only used as an indicator of the levels of activation because muscle activity during a specific exercise can sometimes have normalized values that are higher than the reference value.

Electrode Placement

Skin on the right lower extremity was shaved of any excess body hair and cleansed with alcohol to prepare the subject for the placement of 17 electrodes. These electrodes included 16 surface electrodes and 1 ground electrode. Two surface electrodes were placed over 8 muscles on each subject. 1) Gluteus Maximus (GM) 2) Rectus Femoris (RF) 3) Vastus Lateralis (VL) 4) Biceps Femoris (BF) 5) Semitendinosis (ST) 6) Anterior Tibialis (AT) 7) Gastrocnemius (GS) 8) Soleus (SOL). The electrode placement sites are defined in Figure 6. These muscles were chosen based on previous studies performed on similar machines in which there would be a high likelihood that these muscles would activate during both the vertical jump and the Plyo Press activities. Table 2 describes the anatomical information for each muscle monitored.

Table 2: Muscles Monitored During EMG Analysis

Muscle	Origin	Insertion	Action	Innervation
Gluteus Maximus	Posterior crest of Ilium; Dorsal sacrum and coccyx; Sacrotuberous ligament	Iliotibial tract and Gluteal tuberosity	- Extends thigh - Laterally rotates thigh - Trunk extension	Inferior gluteal; $L_5 S_{1,2}$
Rectus Femoris	Anterior inferior iliac spine	Top of patella; Tibial tuberosity	- Flexes thigh - Extends leg	Femoral; $L_{2,3,4}$
Vastus Lateralis	Lateral lip of linea aspera; Greater trochanter	Lateral surface, top of patella; Tibial tuberosity	- Extends leg	Femoral; $L_{2,3,4}$
Biceps Femoris	Long head: Ischial tuberosity Short head: Lateral lip, lower ½ linea aspera	Head of fibula	- Flexes knee - Laterally rotates leg when knee is flexed - Long head aids with thigh extension	Long head: Tibial portion of sciatic; $L_5 S_{1,2}$ Short head: Common peroneal; $L_5 S_{1,2}$
Semitendinosis	Ischial Tuberosity	Medial proximal surface of the tibia	- Flexes knee - Medially rotates leg when knee is flexed - Extends thigh	Tibial portion of sciatic; $L_5 S_{1,2}$
Anterior Tibialis	Upper ½ lateral surface of tibia and adjacent interosseous membrane	First metatarsal and first cuneiform (plantar surface)	- Dorsiflexion - Inversion	Deep peroneal; $L_{4,5} S_1$
Gastrocnemius	Condyles of Femur	Calcaneal tuberosity	- Plantarflexion - Knee flexion	Tibial $S_{1,2}$
Soleus	Soleal line of tibia and upper ¼ of posterior fibula	Calcaneal tuberosity	- Plantarflexion	Tibial $S_{1,2}$

Data Analysis

The EMG signals were full wave rectified and smoothed using RMS averaging with a 50 msec window. The EMG data was exported to Noraxon Myosoft™ software for analysis and quantification of mean activity levels. For each subject, the level of EMG activity during each exercise trial was compared to the EMG activity during the baseline single leg squat. The EMG activity was converted to a percent (normalized) using the following formula:

$$\%\text{Change in EMG} = \frac{\text{EMG Activity for Trial} - \text{EMG Activity for Single Leg Squat}}{\text{EMG Activity for Single Leg Squat}}$$

The normalized values were entered into SPSS™ Statistical software for analysis. The statistical analysis performed was a paired sample t-test with a significance level (α) of .05. The independent variables were the Plyo Press jump and the vertical floor jump exercises. The dependent variable was the percent change from the dynamic baseline activity, obtained from the single leg squat.

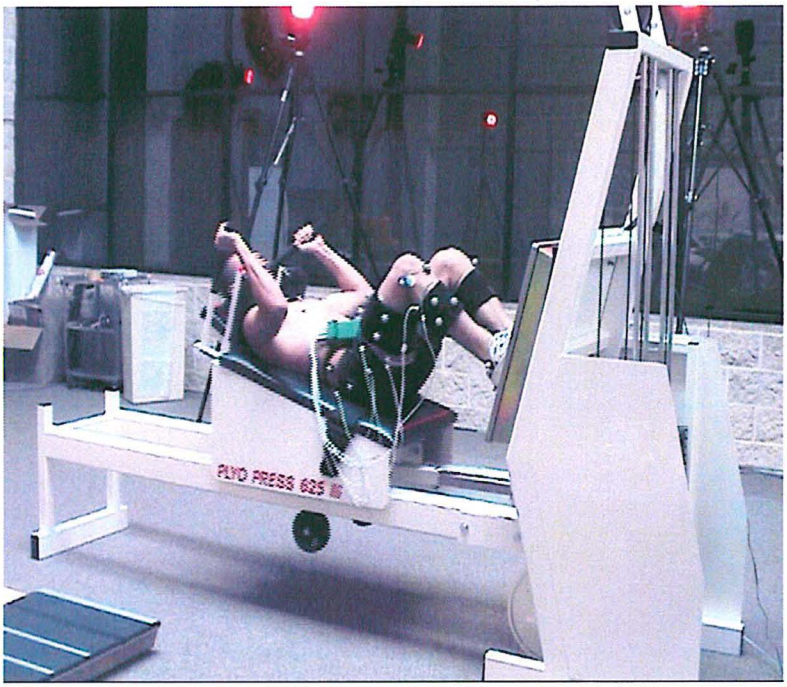


Figure 1. Starting position on the Plyo Press for the Plyo Press jump exercise.

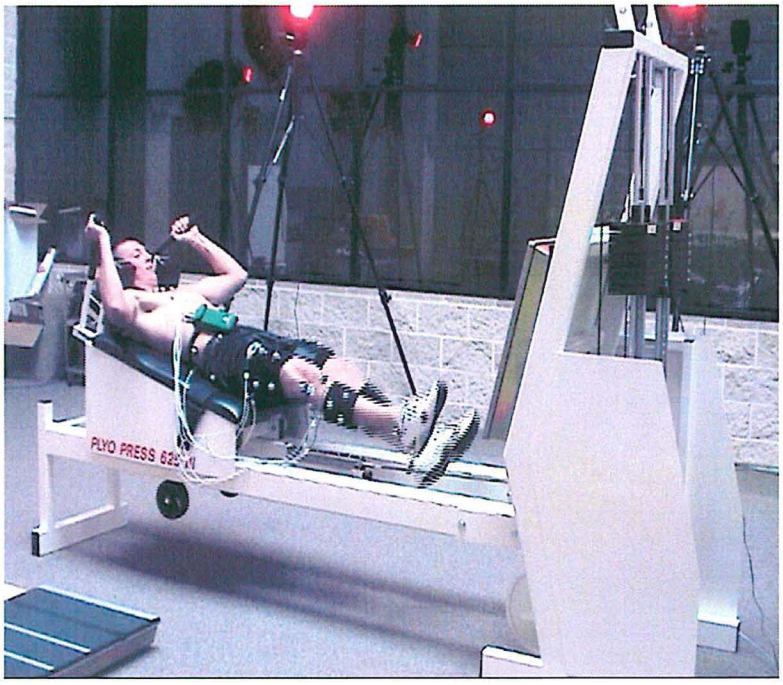


Figure 2. Mid position on the Plyo Press for the Plyo Press jump exercise.

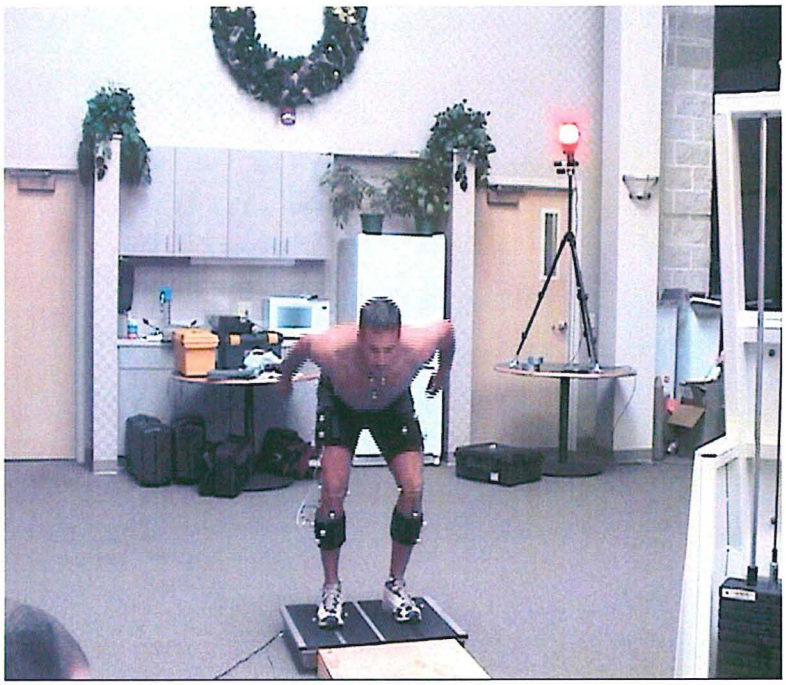


Figure 3. Starting position on the vertical floor jump exercise.

Figure 4. Mid position on the vertical floor jump exercise.

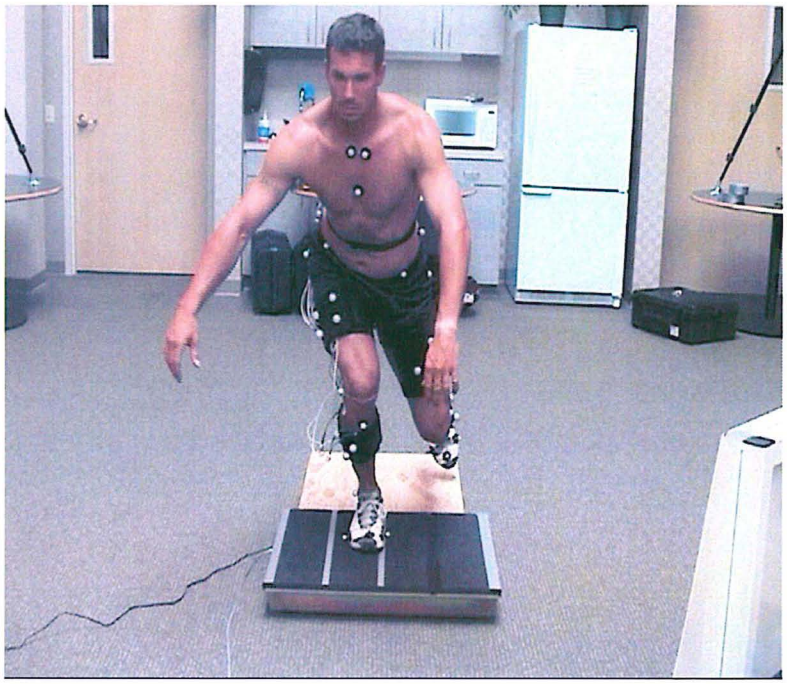
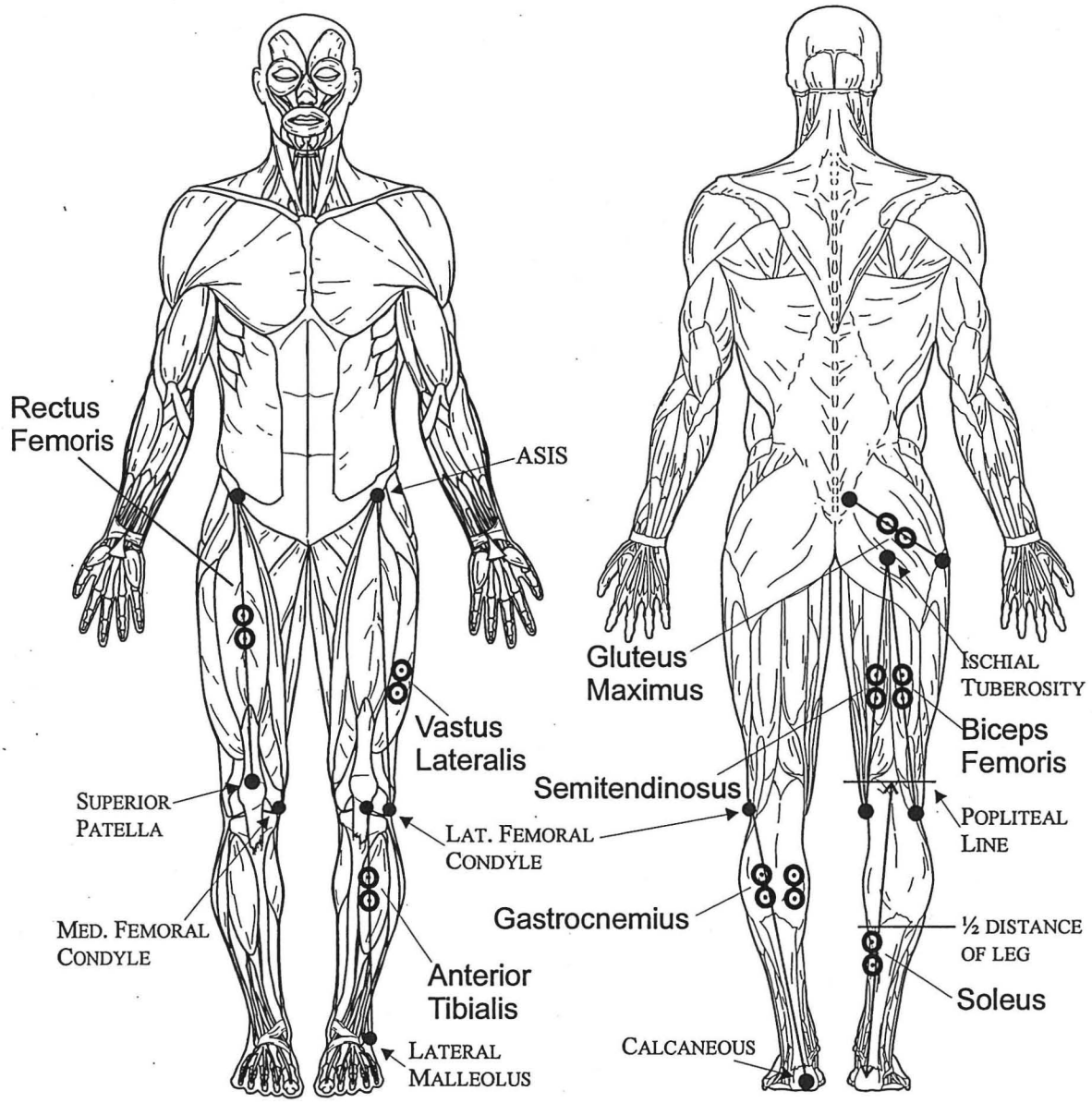


Figure 5. Position for the one-legged squat exercise.



Gluteus Maximus - midpoint of a line running from the inferior lateral angle of the sacrum to the greater trochanter
Biceps Femoris - midpoint of a line from the ischial tuberosity to the lateral femoral condyle
Semitendinosus - midpoint of a line from the ischial tuberosity to the medial femoral condyle
Rectus Femoris - midpoint of a line from the ASIS to superior pole of patella (minimum of 10 cm above the patella)
Vastus Lateralis -along a line ¼ the distance from the lateral knee joint line to the ASIS and over the belly of the vastus lateralis
Anterior Tibialis - over the muscle belly 1/3 the distance from the inferior patellar pole to the lateral malleolus
Gastrocnemius - over the muscle belly ¼ the distance of the leg (fibular head to calcaneous)
Soleus - just medial to the calcaneal tendon, ½ the distance of the leg (popliteal line to calcaneous)

1. Zipp P. Recommendations for the standardization of lead positions in surface electromyography. Eur J Appl Physiol. 1982;50:41-54.
2. Vakos J, Nitz A, Threlkeld J, Shapiro R, Horn T. Electromyographic activity of selected trunk and hip muscles during a squat lift. Spine. 1994;6:687-695.
3. Basmajian JV, Blumenstein R. Electrode Placement in EMG Biofeedback. Baltimore, MD: Williams & Wilkins; 1980.

Figure 6. Electrode Placement for Lower Extremity Muscles

CHAPTER IV

RESULTS

Plyo Press Jump vs. Vertical Floor Jump

Figure 7 shows the results of the comparison of the percent change of EMG activity during the Plyo Press jump and vertical floor jump. The greatest percent change in muscle activity for a Plyo Press jump occurred in the RF, while the least percent change for the Plyo Press jump occurred in the AT. The greatest and least percent change in muscle activity for the vertical floor jump occurred in the GS and the AT respectively. The greatest differences in muscle activity between the two forms of exercise were found in the RF, BF, and ST.

The results of the t-test analysis is presented in Table 1. The paired samples t-test was found to be significant (2-tailed) for the GM, ST, and AT with the vertical floor jump producing more EMG activity than the Plyo Press jump. All other muscle groups tested (RF, VL, BF, GS, SOL) showed no significant difference in muscle activity.

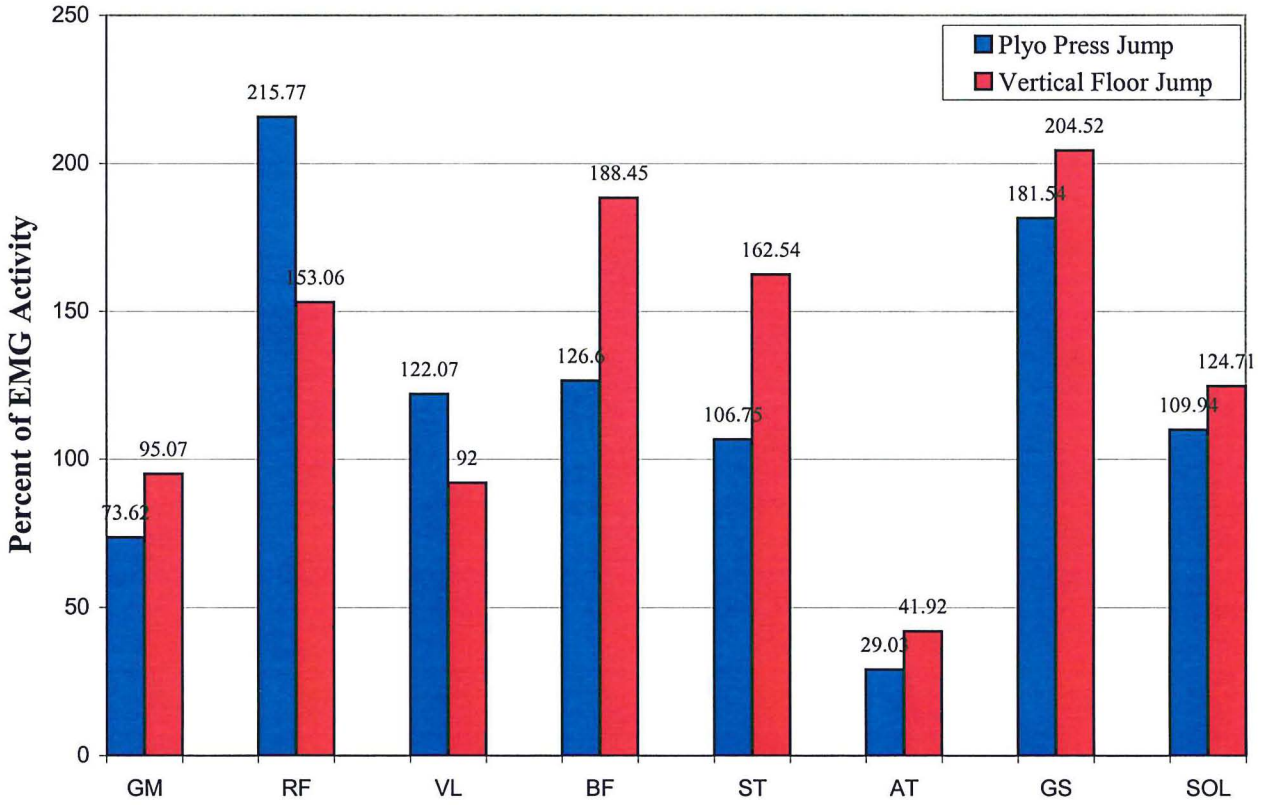


Figure 7. A comparison of the EMG activity in the tested muscles during the Plyo Press Jump and Vertical Floor Jump.

Table 3. Results of *t*-tests for Paired Samples Comparing the Means of EMG Activity During the Plyo-Jump and Vertical Floor Jump (EMG activity was normalized as a percent of the EMG activity recorded during the stationary squatting activity).

Muscle & Condition	n	Percent of Squatting EMG Activity		t	df	p
		Mean	Standard Deviation			
GM PJ	7	73.62	31.38	-9.67	6	.000 [a]
GM FJ	7	95.07	28.51			
RF PJ	7	215.77	122.09	1.95	6	.100
RF FJ	7	153.06	43.96			
VL PJ	8	122.07	44.57	2.07	7	.077
VL PJ	8	92.00	16.33			
BF PJ	8	126.60	50.01	-1.59	7	.154
BF FJ	8	188.45	113.89			
ST PJ	8	106.75	55.56	-6.46	7	.000 [a]
ST FJ	8	162.54	60.92			
AT PJ	8	29.03	14.11	-3.78	7	.007 [a]
AT FJ	8	41.92	19.09			
GS PJ	8	181.54	72.83	-.818	7	.440
GS FJ	8	204.52	65.45			
SOL PJ	8	109.94	36.41	-2.02	7	.083
SOL FJ	8	124.71	43.59			

[a] Probability value significant at $P \leq .05$.

CHAPTER V

DISCUSSION

EMG Normalization

EMG analysis of the vertical floor jump and the Plyo Press leg press revealed greater muscle activity during the vertical floor jump in the GM, ST, and AT muscles. Other factors, besides the difference in activity, contributed to this difference. EMG activity may have been influenced by the number of jumps performed within the thirty second trials, with the Plyo Press jumps taking a longer time to perform than the vertical floor jumps (approximately 5 Plyo Press Jumps to 9 vertical floor jumps). The average EMG activity has an increased chance of having higher values for the vertical floor jumps because of the higher number of vertical floor jumps. This is due to the fact that increasing the velocity of contraction increases the EMG activity.

Factors affecting the signal of the EMG include: distance the signal has to travel, the thickness of the adipose layer under the subjects skin, the interface between the electrode and the skin, the type of the electrode medium used, the adhesive material used, and the size and material of the electrode.[17] Subject perspiration and movement may have caused some of the electrodes to lose proper contact and thus creating signal interference.

Statistical significance was influenced by the limited amount of subjects used. The subjects were selected by means of convenience more so than randomization which can also affect significance. The number of jumps performed between the Plyo Press

jump and the vertical floor jump were not equal, due to the increased friction of the Plyo Press compared to the vertical floor jump which has no friction. The force of gravity acts on the weights on the Plyo Press, where as it works directly on the subject's body during the vertical floor jump causing a discrepancy in the amount of jumps performed in a one minute time interval. Subjects endurance level may have also affected the significance.

Our results indicated that muscle recruitment is not increased during the Plyo Press leg exercises when compared to a vertical floor jump, however this is not to say that this machine is not useful for training an athlete. Ivasdahl[4] indicated that the Plyo Press recruited less muscle activity of the erector spinae muscles which is beneficial by reducing risk of injury to the low back through muscular strain or intervertebral disc pathologies due to increased disc pressures. Another advantage of the Plyo Press versus the vertical floor jump is the ease and ability to load substantial weight for muscle strengthening without using a weight vest or ankle and arm weights, which could potentially also cause an injury.

The advantages of using a vertical floor jump over the Plyo Press are that they can be done anywhere, it doesn't cost anything, and it is a more sport specific movement.

CHAPTER VI

CONCLUSIONS

The purpose of this study was to provide a comparison of muscle activity in the GM, RF, VL, VF, ST, AT, GS, and Sol between a Plyo Press jump and a vertical floor jump. The results of this study indicates that the vertical floor jump recruits more muscle activity in the GM, ST, and AT when compared to the Plyo Press jump.

APPENDIX

University of North Dakota Human Subjects Review Form

Please Note: The policies and procedures of the University of North Dakota apply to all activities involving the use of Human Subjects performed by faculty, staff and students conducting such activities under the auspices of the University. No activities are to be initiated without prior review and approval as prescribed by the University's policies and procedure governing the use of human subjects. When preparing your Human Subjects Review Form, use the attached "IRB Checklist".

Please provide the information requested below:

Principal Investigator: Thomas M. Mohr, Lee E. Nagle, Thayne L. Bosh, Kelly C. Jorschumb, Tonya M Kunze

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School/College: Medicine Department: Physical Therapy

Student Adviser (if applicable): Thomas M. Mohr

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E-mail address:

School/College: Medicine Department: Physical Therapy

Project Title: Electromyographic and Motion Analysis of Trunk and Lower Extremity Muscle Activity Using the Plyo Press and the Agaton Max Series Leg Press.

Proposed Project Dates: Beginning Date: 06/02 Completion Date: 06/03

Funding agencies supporting this research:

(A copy of the funding proposal for each agency identified above MUST be attached to the proposal when submitted.)

___ YES or _x_ NO Does the Principal Investigator or any researcher associated with this project have a financial interest in the results of this project? If yes, please submit on a separate piece of paper an additional explanation of the financial interest (other than receipt of a grant)

If your project has been or will be submitted to another Institutional Review Board (s), Please list those boards below along with the status of each proposal.

_____ Date Submitted: ___ Status: ___Approved ___Pending
_____ Date Submitted: ___ Status: ___Approved ___Pending

Type of Project: Please Check Yes or No to the following.

_x_ YES or ___ NO New Project

___ YES or _x_ NO Dissertation/Thesis

___ YES or _x_ NO Continuation/Renewal

_x_ YES or ___ NO Student Research Project

___ YES or _x_ NO Protocol Change for previously approved project
(resubmit "Human Subjects Review Proposal" with changes bolded or highlighted and signed)

Cooperating Institution: **Frappier Acceleration, Fargo, North Dakota**

_x_ YES or ___ NO **Will any institution of agency personnel assist in the Proposed Project?**
Copies of letters indicating the willingness of the institution/agency to cooperate in the study and an understanding of the study MUST be attached. Letters must include the name and title of the individual signing the letter and, if possible, should be printed on letterhead.

Subject Classification: This study will involve subjects who are in the following special populations: Check all that apply.

_____ Minors (<18 years)
_____ Prisoners
_____ Pregnant Women/Fetuses
_____ Persons with impaired ability to understand their involvement and/or consequences of participation in this research
_____ UND Students
__x__ Other Athletes training at Frappier Acceleration in Fargo, ND.

For information about protections for each of the special populations please refer to the protected populations section on the Office of Research and Program Development website.

This study will involve: Check all that apply.

_____ New Drugs (IND)
_____ Non-approved Use of Drug(s)
_____ Recombinant DNA
_____ Fetal Tissue
_____ Stem Cells
_____ Other (Discarded tissue, fluids, blood, etc.)
__x__ None of the above will be involved in this study

I. Project Overview

Please provide a brief explanation (limit to 200 words or less) of the rationale and purpose of the study, introduction of any sponsor(s) of the study, and justification for use of human subjects and/or special populations (e.g., vulnerable populations such as minors, prisoners, pregnant women/fetuses).

In the quest to improve individual athletic performance, new training equipment and methodologies are being designed daily. The eccentric benefits of isotonic strength training have long been heralded but training eccentrically has been challenging. Measuring the effects of eccentric exercise has been difficult. The Agaton is a machine that has been specifically designed for concentric/eccentric training employing variable, independent loads in the two phases (concentric & eccentric) of lifting. The purpose of this research project is to provide data on motion analysis and muscle activity for the Agaton Max Series Leg Press and compare it with the Plyo Press. During the study subjects will perform three repititions at 82% concentrically and 140 and 200% eccenctrically of their 1-RM concentric maximum.

II. Protocol Description

Please provide a succinct description of the procedures to be used by addressing the instructions under each of the following categories. Individuals conducting clinical research please refer to the "Guidelines for Clinical-Research Protocols" on the Office of Research and Program Development website.

1. Subject Selection.

a) Describe recruitment procedures (i.e., how will subjects be recruited, who will recruit them, where and when they will be recruited and for how long) and include copies of any advertisements, fliers, etc., that will be used to recruit subjects.
It is anticipated that we will recruit twenty subjects (both male and female) between the ages of 18 and 30. The subjects for the study will be recruited by Frappier Acceleration and presently enrolled in their training program.

b) Describe your subject selection procedures and criteria, paying special attention to the rationale for including subjects from any of the categories listed in the "Subject Classification" section above.
The subjects will be chosen by their age, training and health status.

c) Describe your exclusionary criteria and provide a rationale for excluding subject categories.
Subjects will be healthy with no history of orthopedic or active trunk or lower extremity musculoskeletal pathologies that would interfere with the study or put the subject at risk for injury.

d) Describe the estimated number of subjects that will participate and the rationale for using that number of subjects.
Approximately 20 subujects will used so that the data will more closely represent the athletic population in general.

e) Specify the potential for valid results. If you have used a power analysis to determine the number of subjects, describe your method.
EMG and motion analysis have been proven valid and reliable in measuring muscle activity and motion of the joints.

2. Description of Methodology.

a) Describe the procedures used to obtain informed consent.
Subjects will read and sign the informed consent form. One of the researchers will be available to answer any questions posed by the subjects.

b) Describe where the research will be conducted.
Research will be performed at the training facility of Frappier Acceleration in Fargo, ND.

c) Indicate who will carry out the research procedures.
The principle investigators will be responsible for set-up and collection of the data.

d) Briefly describe the procedures and techniques to be used and the time required to complete them.
Prior to performing the experimental trials, the age, weight, and height of each subject will be recorded. We will be measuring the EMG activity of the following muscles: 1) quadriceps, 2) hamstrings, 3) gluteals, 4) abdominal and 5) back extensors as well as recording motion analysis of the: 1) trunk, 2) hip, 3) knee, 4) ilium and 5) ankle, during a squat activity on a Plyo Press, Agaton and during a maximum voluntary contraction.

To record the EMG activity, surface electrodes will be placed over each of the above muscles. The skin will be prepped by cleansing with alcohol. The EMG signals will be transmitted to the reciever unit and then fed into a computer for display and recording of the data. A maximum voluntary contraction (MVC) of each of the muscles listed will be done. The activity of the MVC will be assumed to be 100% EMG activity level for each muscle and will allow the comparison of the muscle activity generated during the experimental trial. 82%, 140%, and 200% of the one rep max will be used during the exercise testing. 82% of the 1 repetition maximum will be used for the concentric phase and both 140 and 200% will be used for the eccentric measurments.

The actual experiment will consist of doing three repetitions at each percentage of the one repetition maximum on the Agaton and Plyo Press. Subjects will be randomly selected to either the Plyo Press or Agaton. Rest breaks of 3-5 minutes will be provided between trials.

Descriptive statistics describing the subjects' anthropometric profiles will be provided. Statistical analysis will be performed on the integrated EMG activity during the trials and will be compared with the MVC data as a percentage using normalized EMG. The video image of the subject will be converted to a stickman-like figure, from which we can determine joint angles and velocity. The EMG data is synchronized with the video data to determine the level of EMG activity during the various exercise trials.

e) Describe audio/visual procedures and proper disposal of tapes.
Video Analysis will be used to measure lower extremity and trunk range of motion during the activity. Reflective markers will be attached to the trunk and lower extremity using double-sided adhesive tape. We anticipate placing markers on the trunk, hip, knee, ilium and ankle. Video cameras will be placed on the side of the subject and will film the subject's trunk and lower extremity markers and motion during the experimental trial. This will be recorded on videotape and will be transferred to a computer for analysis. The video file will be kept at the UND Physical Therapy Department for three (3) years and then destroyed.

f) Describe the qualifications of the individuals conducting all procedures used in the study.
The prinicipal investigators have taken course work and have been instructed in proper use of EMG and motion analysis equipment as well as set-up and data collection.

g) Describe compensation procedures (payment or class credit, etc.)
None

Attachments Necessary: Copies of all instruments (such as survey/interview questions, data collection forms completed by subjects, etc.) must be attached to this proposal.

3. Risk Identification.

a) Clearly describe the anticipated risks to the subject/others including any physical, emotional, and financial risks that might result from this study.
The risks to the subjects involved in this experiment are anticipated to be minimal. The selection criteria that will be used is designed to ensure that the lifts, techniques, and amounts of weight lifted by each participant is well within the subjects individual limits and capabilities.

b) Describe precautions you will take to minimize potential risks to the subjects (e.g., sterile conditions, informing subjects that some individuals may have strong emotional reactions to the procedures, debriefing, etc.).
Precautions will be taken by providing assistance ("spotters") if needed, and instruction on proper lifting and performance techniques before performing the exercises.

c) Indicate whether there will be a way to link subject responses and/or data sheets to consent forms, and, if so, what the justification is for having that link.
There will be no way to link the subjects to the test responses and/or consent forms.

4. Subject Protection

a) Describe procedures you will implement to protect confidentiality (such as coding subject data, removing identifying information, reporting data in aggregate form, etc.).
Each subject will be assigned a random number after signing the consent form. This number will be known only to the researchers and be kept confidential.

b) Indicate that the subject will be provided with a copy of the consent form and how this will be done.
The subject will sign a consent form, which will be kept by the researchers for the duration of the study, and will also be given an unsigned copy for their own records.

c) Describe the protocol regarding record retention. Please indicate that research data from this study and consent forms will both be retained in separate locked locations for a minimum of three years following the completion of the study.
The consent forms will be kept by Thomas Mohr in the Department of Physical Therapy, Medical Science North for a period of (3) years. A copy of the consent form is attatched.

Describe: a) the storage location of research data (separate from consent forms and subject personal data)
b) who will have access to the data
c) how the data will be destroyed
d) the storage location of consent forms and personal data (separate from research data)
e) how the consent forms will be destroyed

The data will be stored in the Department of Physical Therapy at the University of North Dakota for (3) years. Only the researchers will have access to the data. Both the data and the consent forms will be destroyed by shredding after the period of storage has expired.

d) Describe procedures to deal with adverse reactions (referrals to helping agencies, procedures for dealing with trauma etc.).
In the event that a trauma should happen emergency personel will be notified to ensure that the subject is given proper medical treatment.

e) Include an explanation of medical treatment available if injury or adverse reaction occurs and responsibility for costs involved.
In the event that this research activity results in physical injury medical treatment will be available, including first aid, emergency treatment, follow up care as it is to a member of the general public in similar circumstances. Payment for any such treatment must be provided by the participant and their third party payer, unless the reason for treatment is due to negligence on the part of the researchers.

III. Benefits of the Study

Clearly describe the benefits to the subject and to society resulting from this study (such as learning experiences, services received, etc.). **Please note:** payment is not a benefit and should be listed in the Protocol Description section under Methodology.

The data produced by this sudy will be beneficial in providing support for the utilization of the Agaton Max Series Leg Press in strength training as a dynamic strengthening tool. At the present time, research on this machine is needed to help provide knowledge about its design functions and promote its use in programs where safe and efficient strength training is incorporated. The results of this study will help to determine the difference in muscle recruitment of the Agaton and the Plyo Press compared to a MVC which can then support the use of the these two machines in a wide range of strengthening and rehabilitation programs. This data will also provide a base of information to proceed with research studies to determine further benefits of the use of the Agaton Max Series Leg Press on the athletic population.

IV. Consent Form

A copy of the Consent Form must be attached to this proposal. If no Consent Form is to be used, document the procedures to be used to protect human subjects. Refer to the ORPD website for further information regarding Consent Form Regulations.

Please note: Regulations require that all Consent Forms, and all pages of the Consent Forms, be kept for a minimum of 3 years after the completion of the study, even if subject does not continue participation. The Consent Form must be written in language that can easily be read by the subject population and any use of jargon or technical language should be avoided. It is recommended that the Consent Form be written in the third person (please see the examples on the ORPD website). A two inch by two inch blank space must be left on the bottom of each page of the consent form for the IRB approval stamp. The consent form must include the following elements:

a) An introduction of the principal investigator

b) An explanation of the purposes of the research.

c) The expected duration of subject participation.

d) A brief summary of the project procedures.

e) A description of the benefits to the subject/others anticipated from this study

f) A paragraph describing any reasonably foreseeable risks or discomforts to the subject.

g) Disclosure of any alternative procedures/treatments that are advantageous to the subject

h) A description of how confidentiality of subjects and data will be maintained. Indicate that the data and consent forms will be stored separately for at least three years following the completion of the study. Indicate where, in general, the data and consent documents will be stored and who has access. Indicate how you will dispose of the data. Be sure to list any mandatory reporting requirements that may require breaking confidentiality.

i) An explanation of compensation/medical treatment available if injury occurs

j) The names, telephone numbers and addresses of two individuals to contact for information (generally the student and student adviser). This information should be included in the following statement: "If you have questions about the research, please call (insert Principal Investigator's name) at (insert phone number of Principal Investigator)or (insert Adviser's name) at (insert Adviser's phone number). If you have any other questions or concerns, please call the Office of Research and Program Development at 777-4279."

k) If applicable: an explanation of who to contact in the event of a research-related injury to the subject.

l) If applicable: an explanation of financial interest must be included.

m) RE: Participation in the study:

1) An indication that participation is voluntary and that no penalties or loss of benefits will result from refusal to participate.

2) An indication that the subject may discontinue participation at any time without penalty with an explanation of how they can discontinue participation.

3) An explanation of circumstances which may result in the termination of a subject's participation in the study.

4) A description of any anticipated costs to the subject.

5) A statement indicating whether the subject will be informed of the findings of the study.

6) A statement indicating that the subject will receive a copy of the Consent Form.

By signing below you are verifying that the information provided in the Human Subjects Review Form and attached information is accurate and that the project will be completed as indicated.

Signatures:

_____ Date: _____
(Principal Investigator)

_____ Date: _____
(Student Advisor)

Requirements for submitting proposals:

Additional information can be found at Office of Research and Program Development website at www.und.nodak.edu/dept/orpd

Original Proposals and all attachments should be submitted to: Office of Research and Program Development (ORPD), P. O. Box 7134, Grand Forks, ND 58202-7134, or drop off at Room 105, Twamley Hall.

The criteria for determining what category your proposal will be reviewed as is listed on page 3 of the IRB Checklist. Your reviewer will assign a review category to your proposal. Should your protocol require Full Board review, you will need to provide additional copies. Further information can be found on the ORPD website regarding required copies and IRB review categories or you may call the ORPD office.

In cases where the proposed work is part of a proposal to a potential funding source, one copy of the completed proposal to the funding agency (agreement/contract if there is no proposal) must be attached to the completed Human Subjects Review Form if the proposal is non-clinical; 7 copies if the proposal is clinical-medical. If the proposed work is being conducted for a pharmaceutical company, 7 copies of the company's protocol must be provided.

Please Note: Student Researchers must complete the attached "Student Consent to Release of Educational Record".

Federal regulations require that key personnel involved in human subject research complete educational training. The UND IRB has chosen an online educational course, which can be found at www.miami.edu/citireg, for this training. The online Educational Modules must be completed before approval is granted for a proposal. In addition, Principal Investigators must provide a list of the key personnel involved in the project to ORPD, so the office can maintain records of those individuals that have completed training.

Memorandum

DATE: April 29, 2003

TO: John Madden, PhD
Chair, Institutional Review Board

FROM: Thomas Mohr, PT, PhD
Chairman, UND Physical Therapy

RE: Project Number IRB-200206-259

I am requesting a continuation of the above project. I will be working with a new group of physical therapy graduate students on this new project (Leigh Griffith, Kristen Olson, Dan Sinness, Steve Thomas). We will continue with work on the PlyoPress but will not be utilizing the Agaton equipment. For the continuation, we will be running a new set of subjects and analyzing the electromyography in relation to the force produced by the muscles.

The anticipated project dates are from May 15, 2003 to May 15, 2004. Please let me know if I need to submit additional information.

INFORMATION AND CONSENT FORM

TITLE: Electromyographic and Motion Analysis of Trunk and Lower Extremity Muscle Activity Using the *Plyo Press Leg Press.*

You are being invited to participate in a study conducted by **Leigh Griffith, Kristen Olson, Dan Sinness, Steve Thomas and Thomas Mohr from the Physical Therapy department at the University of North Dakota.** The purpose of this study is to study the muscle activity in the trunk and lower extremities using the *Plyo Press Leg Press.* We will be using video analysis to determine the position of the joints while performing the exercise. Only normal, trained, healthy subjects will be asked to participate in this study. If you have any previous history of orthopedic or active trunk or lower extremity musculoskeletal pathologies that would interfere with the study or put you at risk for injury, you will not be eligible for this study. The benefit for you, as the participant, will be the experience of being involved in a scientific study and knowing that you will be contributing to the body of knowledge in exercise physiology and physical therapy.

You will be asked to perform a maximum voluntary contraction before you begin the exercise on the *Plyo Press Leg Press*. You will then perform three repetitions concentrically (muscle shortening) at 82% of the one repetition maximum followed by three repetitions eccentrically (muscle lengthening) at 140% and 200% of the one repetition maximum.

The study will take approximately one hour of your time. You will be asked to report to Frappier Acceleration in Fargo, ND at an assigned time. You will then be asked to change into dark colored gym shorts for the experiment. We will first record your age, gender, height and weight. During the experiment, we will be recording the amount of muscle activity and the position of the joints while you are performing each exercise.

Although the process of physical performance testing always involves some degree of risk, the investigators in this study feel that the risk of injury or discomfort is minimal. In order for us to record the muscle activity, we will be placing electrodes on your trunk and lower extremity. The recording electrodes are attached to the surface of the skin with an adhesive material. We will need to shave the areas where the electrodes are being placed. We will also be attaching reflective markers at various points on your trunk and lower extremity. These devices only record information from your muscles and joints, they do not stimulate the skin. A video camera will be used to film your walking and the reflective markers will be used as a template to construct stickman like figures from the position of the markers. After we get the electrodes and markers placed, we will give you a training session on the *Plyo Press Leg Press*. The amount of exercise you will be asked to perform will be moderate to maximum. There may be slight redness of the skin following the removal of the electrodes, but this will only be temporary.

Your name will not be used in any reports of the results of this study, and the video files will be converted to stickman like diagrams for analysis and stored on a computer. Your real, photographic image will not be used in reporting of the findings of the study. The

computer files and consent forms are kept in the University of North Dakota Physical Therapy Department for a period of three (3) years. After that time, the electronic media is erased and the paper files are shredded. Any information that is obtained in connection with this study and that can be identified with you will be confidential and will be disclosed only with your permission. The data will identified by a number known only by the researcher. The researcher or participant may stop the experiment at any time if the participant is experiencing discomfort, pain, fatigue, or any other symptoms that may be detrimental to his/her health. Your decision whether or not to participate will not prejudice your future relationship with the Physical Therapy Department or the University of North Dakota. If you decide to participate, you are free to discontinue participation at any time without prejudice.

The researcher involved is available to answer any questions you have concerning this study. In addition, you are encouraged to ask any questions concerning this study that you may have in the future. Questions may be asked by calling Dr. Thomas Mohr at (701) 777-2831. A copy of this consent form is available to all participants in the study.

In event that this research activity (which will conducted at Frappier Acceleration) results in physical injury, medical treatment will be available, including first aid, emergency treatment and follow up care as it is to a member of the general public in similar circumstances. Payment for any such treatment must be provided by you and your third party payer, unless the reason for treatment is due to negligence on the part of the researchers. By signing this document, you are not giving up any legal rights you may have in case of negligence or other legal fault of anyone that is involved in the study.

ALL OF MY QUESTIONS HAVE BEEN ANSWERED AND I AM ENCOURAGED TO ASK ANY QUESTIONS THAT I MAY HAVE CONCERING THIS STUDY IN THE FUTURE. MY SIGNATURE INDICATES THAT, HAVING READ THE ABOVE INFORMATION; I HAVE DECIDED TO PARTICIPATE IN THE RESEARCH PROJECT.

I have read all of the above and willingly agree to participate in this study explained to me by one of the researchers.

_____

Participant's Signature Date

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