An Electromyographic Study of Trunk Muscle Activity during Exercise on the Fitness Plus Abdominal Unit

Michelle M. Baumgartner

University of North Dakota

Follow this and additional works at: https://commons.und.edu/pt-grad

Part of the Physical Therapy Commons

Recommended Citation


https://commons.und.edu/pt-grad/37

This Scholarly Project is brought to you for free and open access by the Department of Physical Therapy at UND Scholarly Commons. It has been accepted for inclusion in Physical Therapy Scholarly Projects by an authorized administrator of UND Scholarly Commons. For more information, please contact zeinelbyousif@library.und.edu.
AN ELECTROMYOGRAPHIC STUDY OF TRUNK MUSCLE ACTIVITY DURING EXERCISE ON THE FITNESS PLUS ABDOMINAL UNIT

by

Michelle M. Baumgartner
Bachelor of Science in Physical Therapy
University of North Dakota, 1996

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

Grand Forks, North Dakota
May
1997
This Independent Study, submitted by Michelle M. Baumgartner 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.

(Faculty Preceptor)

(Graduate School Advisor)

(Chairperson, Physical Therapy)
PERMISSION

Title An Electromyographic Study of Trunk Muscle Activity During Exercise on the Fitness Plus Abdominal Unit.

Department Physical Therapy

Degree Master of Physical Therapy

In presenting this Independent Study Report in partial fulfillment of the requirements for a graduate degree from the University of North Dakota, I agree that the Department of Physical Therapy shall make it freely available for inspection. I further agree that permission for extensive copying for scholarly purposes may be granted by the professor who supervised my work or, in his/her absence, by the chairperson of the department. It is understood that any copying or publication or other use of this independent study or part thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and the University of North Dakota in any scholarly use which may be made of any material in my Independent Study Report.

Signature Michelle Baumgartner

Date 12-18-96
# TABLE OF CONTENTS

List of Figures .............................................................................................................. v

List of Tables .............................................................................................................. vi

Acknowledgments ...................................................................................................... vii

Abstract ...................................................................................................................... viii

Chapter 1: Introduction .............................................................................................. 1

Chapter 2: Methods .................................................................................................. 9

Chapter 3: Results .................................................................................................. 21

Chapter 4: Discussion .............................................................................................. 30

Appendices ................................................................................................................. 34

References .................................................................................................................. 47
LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Fitness Plus Abdominal Unit</td>
<td>11</td>
</tr>
<tr>
<td>2. Electrode placement sites</td>
<td>14</td>
</tr>
<tr>
<td>3. Exercise technique on the Abdominal Unit</td>
<td>17</td>
</tr>
<tr>
<td>4. Average muscle activity during exercise variations</td>
<td>25</td>
</tr>
<tr>
<td>5. EMG and goniometric activity during one exercise repetition against</td>
<td>29</td>
</tr>
<tr>
<td>maximal resistance on the Abdominal Unit</td>
<td></td>
</tr>
</tbody>
</table>
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Origin, insertion, and innervation of selected trunk muscles</td>
<td>4</td>
</tr>
<tr>
<td>2. Actions of selected trunk muscles</td>
<td>5</td>
</tr>
<tr>
<td>3. Subject demographic characteristics</td>
<td>9</td>
</tr>
<tr>
<td>4. Maximum weight lifted by each subject</td>
<td>18</td>
</tr>
<tr>
<td>5. Exercise variations listed in testing order</td>
<td>18</td>
</tr>
<tr>
<td>6. Average percent of MVC for tested muscles during exercise</td>
<td>24</td>
</tr>
<tr>
<td>7. Subject data for crunch with 25 pounds of resistance</td>
<td>26</td>
</tr>
<tr>
<td>8. Subject data for crunch with maximum resistance - feet on top of the foot bar</td>
<td>27</td>
</tr>
<tr>
<td>9. Subject data for crunch with maximum resistance - feet hooked under the foot bar</td>
<td>28</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

This paper is dedicated to all those who helped to make it happen. I would like to give a special thanks to the faculty and staff at the University of North Dakota for all their knowledge and support throughout the past three years. I want to especially thank Dr. Tom Mohr, my graduate advisor, for all his help in completing this independent study. And to my family, for their continued love and support as well as the opportunity to pursue and excel in my education.
ABSTRACT

Strengthening of trunk musculature is an important part of prevention and treatment for low back pain. Various exercise machines have been developed to strengthen the trunk muscles. One such machine, the Abdominal Unit, has been marketed by a company in North Dakota, Fitness Plus, Inc. However, there is currently no research to validate the manufacturer’s claims as to muscles exercised through the use of their machine.

The purpose of this study was to measure and describe the muscle activity elicited while exercising on the Fitness Plus Abdominal Unit. Telemetried electromyography was used to study muscle activity in the rectus abdominis, internal and external obliques, and the erector spinae.

Fourteen male subjects performed maximal voluntary contractions (MVC) as a baseline of muscle activity. They were then tested during exercise on the Abdominal Unit with three variations: 1) 25 pounds of resistance, 2) maximum resistance, and 3) maximum resistance and the feet stabilized.

The recorded data was then analyzed and the percent of MVC was calculated for each muscle tested. Results showed marked activity in the abdominal musculature with minimal erector spinae activity, during all three exercise variations. Increased resistance elicited increased muscle activity in all muscles tested. The effect of stabilizing the feet produced no consistent results.
The Fitness Plus Abdominal Unit is successful in recruiting the superficial abdominal muscles as per manufacturer’s claims indicating that it could be an effective tool for strengthening the abdominal muscles.
CHAPTER 1

INTRODUCTION

Low back pain (LBP) is thought to occur in almost 80% of adults at some point in their lives. The high incidence of LBP makes it one of the leading reasons to visit a physician and is considered the most common and costly musculoskeletal problem affecting the working population. There is also an increased risk of subsequent injury once an individual has experienced an episode of back pain or impairment.

To prevent or minimize the effects of LBP, several treatment programs exist, including back schools, pre-work screening, braces, and exercise programs. The role of the physical therapist in the rehabilitation of persons with LBP include the use of various modalities and exercise techniques. Traditional treatment has included traction, bed rest, TENS, drug therapy, and heat modalities, along with spinal manipulation and orthosis. These treatments, however, have not been shown to be effective in the treatment or prevention of LBP when scientifically tested. More recently, exercise programs have been shown to be effective against both chronic and acute LBP. These programs utilize mainly trunk musculature strengthening to promote optimal strength ratios in the trunk, thus stabilizing the spine.

Many sources agree that developing trunk strength is important in the prevention and treatment of low back pain. Cresswell et al stated that “increased intra-abdominal pressure (IAP) has been discussed since the mid 1950s as a mechanism for reducing forces
on the spine and thereby minimizing injury.” The IAP increases as a direct result of muscular strength in the abdominals, especially in the obliques. However, if a strength program consists of merely an agonist group without regard to the antagonist group, muscle imbalances will occur which will counteract the purpose of the program. A program termed Spinal Stabilization has been developed to enhance lumbar spine stability during active movements. This program utilizes the abdominal musculature co-contracting with the erector spinae, latissimus dorsi, and the deep back musculature to allow this stability.

Paul C. William’s stresses the importance of maintaining a proper lumbosacral angle when in a static posture. He states, “the erector spinae and hip flexors are the most important extensors, while the anterior abdominals and the glutei maximii are the most important flexors of the lumbosacral spine.” Therefore, treatment emphasis is directed at reducing lumbosacral extension, thus shifting the center of gravity forward and reducing the posterior stress in the lumbar intervertebral discs. An exercise program with this focus in mind would attempt to strengthen the glutei maximii and abdominals, thus passively stretching the erector spinae and hip flexors.

Robin McKenzie developed an exercise program based on the relief of symptoms in patients with low back pain. His program focuses on positions and repetitive movements that “centralize” the pain if it is radicular, or lessen pain if it is not. The treatment goal is to develop an individualized treatment regimen comprised of those movements that alleviate pain. Through this progressive strengthening and stretching process, the patient’s pain will eventually be eliminated.
Hans Krauss developed an assessment and treatment technique based on the relative strength or flexibility of muscle groups. He stated that “if (LBP) patients are subjected to a series of tests in which muscles are examined for weakness and tightness...much additional information may be gained.” He felt that one important role of a practitioner was to recognize muscle imbalances early and correct them before further damage is done. Through preventative trunk muscle strengthening, Kraus believed many low back injuries could be avoided.

Because trunk muscle strengthening has been shown to be an important factor in reducing LBP, it is important for physical therapists to fully understand trunk muscle function. However, the role of the trunk musculature varies greatly depending on the type of activity performed. For example, the rectus abdominus can either flex the trunk or posteriorly rotate the pelvis, depending on the stabilizing forces. The anatomic origin and insertion of the various muscles contribute to this variation in function (Table 1). It is also important to recognize the various movements the complex musculature of the trunk can elicit (Table 2).

**Role of the Abdominals**

The superficial abdominal musculature (rectus abdominus, internal oblique, external oblique) has been a focus of many exercise protocols. To effectively strengthen these muscles, many different exercises have been used. Some of these include the standard sit-up, head raise, leg raise, and the use of many fitness machines designed for this purpose. With head raising, only the rectus abdominus is thought to be recruited. However, during a bilateral straight leg raise, the entire abdominal musculature is maximally activated to steady the pelvis. Guimaraes et al found that the curl-up, or
Table 1.- Origin, insertion, and innervation of selected trunk muscles.*

<table>
<thead>
<tr>
<th>MUSCLE</th>
<th>ORIGIN</th>
<th>INSERTION</th>
<th>INNERVATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectus Abdominis</td>
<td>Pubic Symphysis, Pubic Crest</td>
<td>Xiphoid Process, Ribs 5-7</td>
<td>Primary Rami of Lower 6 Intercostal, Ilio-hypogastric, Ilio-inguinal</td>
</tr>
<tr>
<td>External Oblique</td>
<td>External Surfaces of Ribs 4-12</td>
<td>Anterior Half of Iliac Crest, Abdominal Aponeurosis</td>
<td>Primary Rami of T6-12, L1-2</td>
</tr>
<tr>
<td>Internal Oblique</td>
<td>Lumbar Fascia, Anterior 2/3 of Iliac Crest, Inguinal Ligament</td>
<td>Ribs 9-12, Linea Alba</td>
<td>Primary Rami of T6-12, L1-2, Ilio-hypogastric, Ilio-inguinal</td>
</tr>
<tr>
<td>Erector Spinae</td>
<td>Sacrum, Crest of Ilium, Spines of T11-L5</td>
<td>All Ribs, Transverse Process C4-6, Spinous Process C2-T8, Occiput</td>
<td>Posterior Rami of Respective Spinal Level</td>
</tr>
<tr>
<td>Gluteus Maximus</td>
<td>Iliac Crest, Dorsal Sacrum &amp; Coccyx, Sacrotuberous Ligament</td>
<td>Lateral Tibial Condyle, Gluteal Tuberosity</td>
<td>Inferior Gluteal Nerve</td>
</tr>
<tr>
<td>Biceps Femoris</td>
<td>Ischial Tuberosity, Linea Aspera, Lateral Supracondylar Line</td>
<td>Lateral Head of Fibula</td>
<td>Long Head: Tibial Division of Sciatic Nerve. Short Head: Common Peroneal Division of Sciatic Nerve</td>
</tr>
</tbody>
</table>

*Information taken from Moore.12
<table>
<thead>
<tr>
<th>MUSCLE</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectus Abdominus (RA)</td>
<td>Flexes trunk, compresses abdominal viscera</td>
</tr>
<tr>
<td>External Oblique (EO)</td>
<td>Compresses/supports abdominal viscera; flexes and rotates trunk to opposite side</td>
</tr>
<tr>
<td>Internal Oblique (IO)</td>
<td>Compresses/supports abdominal viscera; flexes and rotates trunk to same side</td>
</tr>
<tr>
<td>Erector Spinae (ES)</td>
<td>Bilaterally extends head and trunk, Unilaterally assists in lateral flexion of head and trunk</td>
</tr>
<tr>
<td>Gluteus Maximus (GM)</td>
<td>Extends and laterally rotates femur</td>
</tr>
<tr>
<td>Biceps Femoris (BF)</td>
<td>Flexes and laterally rotates knee, extends femur</td>
</tr>
</tbody>
</table>

* Information taken from Moore.¹²
crunch, elicited the greatest amount of rectus abdominus activity while eliciting the least amount of rectus femoris activity when compared to eleven other abdominal exercises including a traditional hook-lying position sit-up.

The prime movers of trunk flexion are the rectus abdominus and the lateral fibers of the external oblique. The major stabilizers of the lumbar spine are the internal oblique and transversus abdominus (deep abdominal muscle). During forced trunk rotation exercises, the internal obliques of the ipsilateral side are very active while external obliques are slightly active and the rectus abdominus is inactive. The abdominal musculature has also been shown to be an antagonist to the extensors of the spine during both rotation and extension of the spine.

**Role of the Erector Spinae**

The lumbar erector spinae (longissimus, iliocostalis) can be divided into four functional groups affecting the entire spine, however I will focus only on the lumbar musculature. The vector force produced by the lumbar longissimus is directed vertically, resulting in extension and compression forces on the spine. The lumbar iliocostalis have a similar role in trunk extension, however they also act as a neutralizer of forward flexion as the abdominals rotate the trunk. Neither of these muscle groups appear to posteriorly translate the vertebrae.

Various studies have been conducted to show the effectiveness of different exercises on recruiting the erector spinae. Once the spine is fully flexed, the hip extensors become the prime movers for spinal extension. This is due to lumbar spine kyphosis causing the posterior lumbar ligaments to be taut, therefore decreasing the need for erector spinae use. With the lumbar spine in lordosis, the erector spinae are more
active and decreased stress is placed on the posterior elements of the lumbar spine when moving into extension. With lateral rotation of the trunk, the action of the erector spinae is more unilateral, causing increased activity to the ipsilateral side.

**Role of the Gluteus Maximus**

The gluteus maximus is a primary extensor of the hip, but only when heavily or moderately resisted. It is more easily recruited during trunk extension with the spine terminally flexed. When straightening up from the toe-touch position, the gluteus maximus shows significant activity throughout the motion.

**Role of the Hamstrings**

The hamstring musculature (Biceps Femoris, Semitendinosis, Semimenbranosis) act on both the hip and knee joint. However, I will focus on the actions at the hip joint. During gait, the hamstrings are recruited for hip extension and knee flexion. However, when standing with the trunk flexed and both knees extended, these muscles act to stabilize the pelvis and move the trunk into extension.

Through my review of the literature, it is well established that the abdominals, trunk extensors, gluteals, and hamstrings are important in maintaining trunk stability. It is this stability that helps prevent LBP by maintaining trunk control during functional activities. One role of the physical therapist is to help the patient with LBP develop the proper muscle balance and strength. In order to accomplish this, an effective exercise regimen must be developed.

There are numerous types of exercise equipment on the market to train trunk musculature, each claiming superior training capabilities. A small company in North Dakota, Fitness Plus, Inc., has started to market a series of exercise machines aimed at the
rehabilitation of trunk musculature in patients with LBP. These machines have some unique characteristics, which the company feels makes them applicable for clinical use. Each of the prototype machines were designed to target specific trunk musculature, however there is no research that solidifies these claims. Therefore, the purpose of this study is to measure and describe the muscle activity elicited during the use of one of the Fitness Plus machines, the Abdominal Unit.
CHAPTER 2

METHODS

Subjects
Fourteen, healthy subjects volunteered to participate in this study. All participants were enrolled in the University of North Dakota Physical Therapy program in Grand Forks, North Dakota. All subjects were male between the ages of 22 and 40 (mean age of 26). All participants reported no history of back pathology that would interfere with the study, or put the subject at risk for injury. Each subject served as his own control. Participants were informed of the testing procedures and their rights as a participant in accordance with both the Institutional Review board procedures at the University of North Dakota and Grand Forks Medical Park. Each subject signed an informed consent form prior to voluntary participation in the study (see appendix).

Table 3.- Subject demographic characteristics.

<table>
<thead>
<tr>
<th></th>
<th>AVERAGE</th>
<th>RANGE</th>
<th>STANDARD DEVIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>26</td>
<td>22-40</td>
<td>4.93</td>
</tr>
<tr>
<td>Height (inches)</td>
<td>67</td>
<td>65-73</td>
<td>2.92</td>
</tr>
<tr>
<td>Weight (pounds)</td>
<td>165</td>
<td>115-210</td>
<td>22.46</td>
</tr>
</tbody>
</table>

Instrumentation
A prototype Fitness Plus, Inc. (P.O. Box 905, Valley City, North Dakota, 58072) exercise machine, the Abdominal Unit, model FP102, was tested in this study. This unit
has five, 5-pound plates and five, 10-pound plates, for a maximum of 75 pounds of resistance during the abdominal exercise. It is relatively light and compact, weighing only 220 pounds (including the weights) and measuring 28 inches wide by 49 inches long (Figure 1).

Electromyography (EMG) signals were used to determine the activity of the abdominals and back extensors. A Noraxon Telemyo8 telemetry unit (Noraxon USA, 13430 North Scottsdale Rd., Scottsdale, AZ, 85254) was used to collect the electromyographic data. A Penny and Giles M180 electrogoniometer (Penny & Giles Inc., 2716 Ocean Park Blvd, Santa Monica, CA, 90405) was used to measure range of motion (ROM) of the abdominal unit. The Noraxon Telemyo8 receiver collected the telemetered information from the EMG electrodes and the electrogoniometer. This information was then digitized by a DT2801-Analog to a digital interface board installed in a NET 486DX computer. The Norquest and Myosoft data collection software that accompanies the Telemyo8 EMG system was used to analyze the digitized EMG signals in a variety of forms. Since speed of contraction plays a role in EMG activity elicited, an electronic metronome was used to standardize the speed of the repetitions.

Procedure

Electromyographic activity was monitored in four selected muscle groups: 1) Rectus Abdominis (RA), 2) External Oblique (EO), 3) Internal Oblique (IO), and 4) lumbar Erector Spinae (ES). These abdominal muscles were chosen as per machine manufacturer’s claims of muscles trained during exercise on this machine. The erector spinae muscle was also tested in order to determine activity during this exercise. The RA
Figure 1.- Fitness Plus Abdominal Unit.
and ES muscle activity was measured on the left side and the internal and external obliques were measured bilaterally for a total of six electrode placement sites.

Electromyographic activity was recorded via pre-gelled silver-silver chloride surface electrodes (Multi Bio-Sensors, El Paso, TX 79913). To reduce skin impedance and ensure optimal contact with the electrodes, the skin over each electrode site was rubbed with alcohol, and shaved of hair if needed, prior to application of the EMG surface electrodes.\textsuperscript{15-18} Two surface electrodes were placed around one anatomical point of each individual muscle and placed one inch apart.\textsuperscript{19} The pairs of electrodes were applied parallel to the direction of the selected muscle fibers at the anatomical points used for electrode placement. Gersch\textsuperscript{15} claims that electrodes oriented parallel to the muscle fiber direction will record different motor units representing a better sample of the muscle activity, and extraneous, volume-conducted activity picked up by both electrodes will be reduced as compared to aligning the electrodes perpendicular to the muscle fibers.

The electrode placement sites used were those recommended by Vaskos et al\textsuperscript{17} to be the anatomical points in the muscles where the greatest amount of isolated muscle activity elicited for the erector spinae and rectus abdominis. The electrode placement sites for the internal and external obliques were those described by Gilleard\textsuperscript{17} and Snidjers.\textsuperscript{18} The following locations were used in this study for electrode placement: 1) rectus abdominis muscle (left side only), 2cm cranial and 2cm lateral to the umbilicus, 2) bilateral external oblique muscles, 5cm cranial to the anterior superior iliac spine (ASIS), 3) bilateral internal oblique muscles, in the center of a triangle bounded by the lateral edge of the rectus sheath, the inguinal ligament and a line joining the ASIS to the umbilicus, and 4) over the muscle belly of the erector spinae muscle (left side only),
horizontally aligned with the L3-4 interspace, 4cm lateral to the midline (Figure 2). A single electrode was placed over the left lateral iliac crest as a ground. Electrodes were secured with a self-adhesive backing.

An electrogoniometer was placed on the abdominal machine in order to measure ROM of each repetition of the abdominal exercise. One arm of the goniometer was placed on a stationary segment of the machine with the other arm on a moveable portion of the machine arm adjacent to the push pad.

To record EMG and electrogoniometer activity, the EMG signals were transmitted from the surface electrodes and electrogoniometer to the receiver unit, and then into the computer for display. The EMG data for each subject was recorded by the computer and stored on disk for later analysis.

In order to compare the EMG activity between subjects, the EMG data was normalized. Maximum voluntary contractions (MVCs) were used to provide a base for the normalization so that subject data could be compared. Several studies have determined the positions which recruited the most muscle activity:

**Rectus Abdominis (RA)** - Most active with supine bilateral straight leg-raise.\(^{12,20,21}\)

**External Oblique (EO)** - Most active during straining (Valsalva maneuver), supine bilateral straight leg-raise,\(^{12,20,21}\) lateral bending to the ipsilateral side, as well as trunk rotation to the contralateral side.\(^{12,20}\)

**Internal Oblique (IO)** - Most active with straining, trunk rotation, trunk flexion\(^{12,20}\) and supine bilateral straight leg-raise.\(^{10,20,21}\)

**Erector Spinae (ES)** - most active in resisted prone back extension.\(^{7}\)
Figure 2.- Electrode placement sites.
The position used to obtain the MVC for the erector spinae was taken from a study performed by Vakos et al.\textsuperscript{7} The abdominal musculature MVC positions were those described in previous studies.\textsuperscript{10,20,21}

The MVC data for each muscle was tested and recorded individually. Each subject was instructed to maximally resist the tester, holding the contraction for 5 seconds. The same tester was used for all MVC testing. The RA, EO, and IO were tested with the subject positioned in supine with his head resting on the floor and his arms resting at his sides. The subject’s pelvis was stabilized and the researcher provided manual resistance to the chest and the lower legs of the subject simultaneously, while the subject attempted to maintain 6 inches of clearance between his feet and the floor. The ES was tested by positioning the subject in prone with his hands on his occiput. The researcher stabilized the subject’s legs, holding them just proximal to the knee joint, while providing resistance at the T\textsubscript{7} vertebral level after the subject achieved 30 degrees of back extension.

For the test procedure, each subject was first instructed on how to perform the exercise repetition on the Abdominal Unit and the timing of the trials. The starting position consisted of sitting on the seat, facing the weight stack, in an upright position with the back slightly arched and both arms crossed over the push pad. The top of the push pad was set at clavicle height as per manufacturer’s recommendation. This height could be changed by adjusting the seat height. Both feet were placed on top of the foot bar of the machine. Each subject was instructed to attempt to maintain a stable arm position and perform a crunch using their abdominal muscles. Throughout this study, completing a “crunch” on the abdominal unit is defined by performing an exercise
repetition consisting of sitting in an upright position, contracting the anterior trunk muscles resulting in flexion of the spine, and then returning to an upright position while eccentrically contracting the anterior trunk muscles (Figure 3).

Prior to recording muscle activity during exercising on the abdominal unit, the maximum amounts of resistance each subject was able to lift was determined. Half of the subjects were able to perform a crunch with the maximum amount of weight available on the machine, 75 pounds. The other seven subjects were able to complete a crunch with a 65 pound maximum. Each subject’s maximum lifting weight was recorded and used in the testing trials (Table 4).

Experimental testing activities on the abdominal unit consisted of three different exercises: 1) abdominal crunch with 25 pounds of resistance with the feet resting on top of the foot bar, 2) abdominal crunch with maximum weight with the feet resting on top of the foot bar, and 3) abdominal crunch with maximum weight and the feet hooked under the foot bar, resting on the ground (Table 5).

One repetition of the abdominal exercise was completed by slowly flexing the trunk downward towards the hips, holding at the end range, and then slowly returning to the initial upright position while maintaining the abdominal contraction as able. Each of the three exercises was repeated three times with a brief rest between exercises. EMG activity was recorded during the exercises. The pace of each trial was set by a metronome set at 48 beats per minute. The exercise timing sequence consisted of forward flexion of the trunk for 2 beats, hold at end-range for 2 beats, return to upright position in 2 beats, and finally relax for 2 beats. Each subject was allowed a practice trial
The subjects were instructed to:

Sit on the stool with their arms resting on the push bar

Slowly push against the push pad through the full range of motion

Slowly return to the upright position

Figure 3.- Exercise technique on the Abominal Unit.
Table 4.- Maximum weight lifted by each subject.

<table>
<thead>
<tr>
<th>SUBJECT NUMBER</th>
<th>MAXIMUM POUNDS LIFTED</th>
<th>SUBJECT NUMBER</th>
<th>MAXIMUM POUNDS LIFTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>65</td>
<td>8</td>
<td>75</td>
</tr>
<tr>
<td>2</td>
<td>65</td>
<td>9</td>
<td>75</td>
</tr>
<tr>
<td>3</td>
<td>65</td>
<td>10</td>
<td>65</td>
</tr>
<tr>
<td>4</td>
<td>75</td>
<td>11</td>
<td>75</td>
</tr>
<tr>
<td>5</td>
<td>75</td>
<td>12</td>
<td>65</td>
</tr>
<tr>
<td>6</td>
<td>65</td>
<td>13</td>
<td>75</td>
</tr>
<tr>
<td>7</td>
<td>75</td>
<td>14</td>
<td>65</td>
</tr>
</tbody>
</table>

Table 5.- Exercise variations listed in testing order.

<table>
<thead>
<tr>
<th>TEST #</th>
<th>RESISTANCE</th>
<th>FOOT POSITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25 pounds (5 plates)</td>
<td>Feet on top of foot bar</td>
</tr>
<tr>
<td>2</td>
<td>Maximum weight (65 or 75 pounds)</td>
<td>Feet on top of foot bar</td>
</tr>
<tr>
<td>3</td>
<td>Maximum weight (65 or 75 pounds)</td>
<td>Feet hooked below foot bar, resting on the ground</td>
</tr>
</tbody>
</table>
with 5 pounds (1 plate) of resistance in order to pace themselves with the correct timing.
Continuous verbal instructions were given throughout all exercises.

**Data Analysis**

Descriptive analysis was used to make comparisons between: 1) the individual muscle activity recruited during the three exercises, 2) the quantity of muscle activity with variable weight, and 3) the quantity of muscle activity with variable foot position.

Normalization of EMG data is necessary to allow comparison between subjects Noe. The EMG data for each of the four muscle groups studied were normalized for all subjects individually using a method utilized by Vakos et al. First, the EMG activity was calculated, using the Myosoft software, for each subject from the activity recorded during the maximal voluntary contraction (MVC) for each muscle. The maximal voluntary contraction was defined as the mean of the 50 peak amplitudes during 2 seconds of the recorded contraction. To eliminate the ramping effect, neither the first or last second was used in the analysis.

Next, the average individual muscle activity for each of the 3 tests was determined in a similar fashion as the above mentioned MVCs. The mean of the 50 peak amplitudes during the second repetition of the three trials in each exercise was calculated. A trial consisted of one full repetition through the range of motion as determined by the electrogoniometer.
To obtain the normalized value, the average EMG activity obtained for each muscle during the trial was divided by the average MVC value for that muscle and expressed as a percentage.\(^7\) Below is the formula utilized:

\[
\% \text{ Normalized MVC} = \frac{\text{Average EMG activity during test repetition}}{\text{Maximal voluntary contraction (MVC)}} \times 100
\]
CHAPTER 3

RESULTS

The results are based on the data recorded and analyzed from all 14 subjects tested. The average percent of MVCs for each muscle monitored during the testing is presented numerically in Table 6, and graphically in Figure 4. Tables 7-9 show individual subject data for percent of MVC in each muscle tested during the exercise variations.

Rectus Abdominus

The rectus abdominus was most active when lifting the maximum weight with the feet resting on top of the foot bar (96.8%). It was least active in the crunch with 25 pounds of resistance (30.7%). The rectus abdominus consistently demonstrated less average percentage of MVC than the right and left internal and right external obliques during the exercises. The effect of hooking the feet was minimal.

Internal obliques

The right internal oblique showed the highest average percent MVC during all the exercises tested. This muscle showed the most activity with the maximum weight and the feet hooked under the foot bar (145.0%). The left internal oblique was the third most active muscle, following the right internal oblique and the right external oblique, during all of the exercises. The left internal oblique displayed the most activity when lifting maximum weight with feet resting on top of the foot bar (102.3%). Both the right and
left internal obliques demonstrated the least activity with the abdominal crunch with 25 pounds of resistance (right, 51.9%; left, 38.7%). The effect of hooking the feet appeared to have a minimal effect on muscle activity in the internal obliques.

**External obliques**

The right and left external obliques were most active when lifting maximum weight and the feet hooked under the foot bar (right, 130.8%; left, 97.1%). In comparing individual muscle activity during the exercise, the right external oblique consistently demonstrated the second highest average percentage of MVC throughout all three exercises tested. The exercise that elicited the least amount of EMG activity in the external obliques was the exercise with 25 pounds of resistance (right, 39.7%; left, 23.4%). The effect of hooking the feet was most apparent in the external oblique muscles.

**Erector spinae**

The erector spinae showed minimal muscle activity during all exercise bouts. Up to a maximum of an average of 6% MVC was seen when lifting maximum weight with the feet hooked under foot bar. Only 1% of MVC was seen when exercising with 25 pounds of resistance. The effect of foot position was minimal.

**Effect of increasing resistance**

Muscle activity increased in all muscles with increasing loads during exercise. This was most evident in the right internal and left external oblique muscles where the average percent MVC activity increased by 90.7% and 73.7%, respectively, with an increase in resistance from 25 pounds to maximal resistance with the feet hooked under the foot bar. The right external and left internal oblique demonstrated a 67.8% and 61.5%
increase in average MVC, respectively, with the same increase in resistance with the feet not anchored. The rectus abdominus increased by 62.1%, while the erector spinae demonstrated only a 4.9% increase in average MVC with and increase from 25 pounds of resistance to maximum resistance with the feet stabilized.

**Effect of foot stabilization**

During the exercises, the feet were positioned either 1) unhooked and resting on the foot bar, or 2) hooked below the foot bar resting on the ground, during the tests with maximum resistance. The effect of foot position was minimal (Table 6, Figure 4). The greatest change was observed in the right and left external oblique (23.3% and 15.3% increase respectively) when the subject hooked the feet under the bar with the feet resting on the ground. Less than a 2.4% increase in average percent MVC was seen in the right internal oblique and erector spinae, and less than 2.1% decrease was found in the rectus abdominus and left internal oblique when changing the foot position from resting on top of the foot bar to hooking the feet underneath the foot bar.

**Muscle activity throughout the range of motion**

Figure 5 demonstrates the integrated EMG activity in each muscle tested during one repetition of trunk flexion against maximal resistance. It also shows trunk ROM during one repetition. Marked EMG activity is seen in all of the abdominal muscles throughout the exercise repetition, whereas minimal erector spinae activity is elicited. Generally, a slight increase in EMG activity of the abdominal muscles is evident in the first portion of this particular repetition indicating more concentric, versus eccentric, muscle activity. This was not apparent in the erector spinae muscle.
Table 6.- Average percent of MVC for tested muscles during exercise.

<table>
<thead>
<tr>
<th>EXERCISE</th>
<th>AVG. %MVC RA</th>
<th>AVG. %MVC REO</th>
<th>AVG. %MVC LEO</th>
<th>AVG. %MVC RIO</th>
<th>AVG. %MVC LIO</th>
<th>AVG. %MVC ES</th>
</tr>
</thead>
<tbody>
<tr>
<td>25lbs. resistance feet on bar</td>
<td>30.7</td>
<td>39.7</td>
<td>23.4</td>
<td>51.9</td>
<td>38.7</td>
<td>1.1</td>
</tr>
<tr>
<td>Maximum resistance feet on bar</td>
<td>96.8</td>
<td>107.5</td>
<td>81.8</td>
<td>142.6</td>
<td>102.3</td>
<td>5.5</td>
</tr>
<tr>
<td>Maximum resistance feet hooked</td>
<td>92.8</td>
<td>130.8</td>
<td>97.1</td>
<td>145.0</td>
<td>100.2</td>
<td>6.0</td>
</tr>
</tbody>
</table>
Figure 4.- Average muscle activity during exercise variations.
Table 7.- Subject data for crunch with 25 pounds of resistance.

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>RA %MVC</th>
<th>REO %MVC</th>
<th>LEO %MVC</th>
<th>RIO %MVC</th>
<th>LIO %MVC</th>
<th>ES %MVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>56.70</td>
<td>270.73</td>
<td>85.60</td>
<td>94.11</td>
<td>77.85</td>
<td>3.50</td>
</tr>
<tr>
<td>2</td>
<td>54.45</td>
<td>55.89</td>
<td>22.87</td>
<td>51.22</td>
<td>42.22</td>
<td>1.13</td>
</tr>
<tr>
<td>3</td>
<td>21.58</td>
<td>28.08</td>
<td>11.86</td>
<td>22.67</td>
<td>18.69</td>
<td>0.47</td>
</tr>
<tr>
<td>4</td>
<td>20.36</td>
<td>21.03</td>
<td>10.86</td>
<td>70.79</td>
<td>41.81</td>
<td>1.26</td>
</tr>
<tr>
<td>5</td>
<td>18.50</td>
<td>13.91</td>
<td>11.29</td>
<td>72.05</td>
<td>175.04</td>
<td>3.15</td>
</tr>
<tr>
<td>6</td>
<td>14.48</td>
<td>27.20</td>
<td>65.26</td>
<td>25.90</td>
<td>28.33</td>
<td>0.76</td>
</tr>
<tr>
<td>7</td>
<td>20.33</td>
<td>4.33</td>
<td>5.32</td>
<td>23.90</td>
<td>6.09</td>
<td>0.20</td>
</tr>
<tr>
<td>8</td>
<td>15.42</td>
<td>12.15</td>
<td>12.68</td>
<td>4.44</td>
<td>3.08</td>
<td>0.18</td>
</tr>
<tr>
<td>9</td>
<td>5.58</td>
<td>1.02</td>
<td>0.79</td>
<td>15.00</td>
<td>9.28</td>
<td>0.55</td>
</tr>
<tr>
<td>10</td>
<td>22.40</td>
<td>11.46</td>
<td>5.00</td>
<td>83.79</td>
<td>43.95</td>
<td>0.73</td>
</tr>
<tr>
<td>11</td>
<td>19.41</td>
<td>6.93</td>
<td>4.19</td>
<td>16.20</td>
<td>16.84</td>
<td>0.11</td>
</tr>
<tr>
<td>12</td>
<td>52.03</td>
<td>73.17</td>
<td>46.31</td>
<td>95.13</td>
<td>25.09</td>
<td>1.93</td>
</tr>
<tr>
<td>13</td>
<td>57.66</td>
<td>18.30</td>
<td>28.18</td>
<td>50.55</td>
<td>9.23</td>
<td>0.34</td>
</tr>
<tr>
<td>14</td>
<td>50.79</td>
<td>11.93</td>
<td>16.65</td>
<td>101.16</td>
<td>44.29</td>
<td>0.80</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>30.7</td>
<td>39.7</td>
<td>23.4</td>
<td>51.9</td>
<td>38.7</td>
<td>1.1</td>
</tr>
<tr>
<td>STD. DEV.</td>
<td>0.188</td>
<td>0.694</td>
<td>0.253</td>
<td>0.340</td>
<td>0.442</td>
<td>0.011</td>
</tr>
<tr>
<td>RANGE</td>
<td>5.58-</td>
<td>1.02-</td>
<td>0.79-</td>
<td>4.44-</td>
<td>3.08-</td>
<td>0.11-3.50</td>
</tr>
<tr>
<td></td>
<td>57.66</td>
<td>270.30</td>
<td>85.60</td>
<td>101.16</td>
<td>175.04</td>
<td></td>
</tr>
</tbody>
</table>
Table 8.- Subject data for crunch with maximum resistance- feet resting on top of the foot bar.

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>RA %MVC</th>
<th>REO %MVC</th>
<th>LEO %MVC</th>
<th>RIO %MVC</th>
<th>LIO %MVC</th>
<th>ES %MVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>32.06</td>
<td>63.20</td>
<td>13.58</td>
<td>34.26</td>
<td>41.68</td>
<td>0.85</td>
</tr>
<tr>
<td>2</td>
<td>219.75</td>
<td>267.01</td>
<td>187.10</td>
<td>134.41</td>
<td>126.43</td>
<td>14.34</td>
</tr>
<tr>
<td>3</td>
<td>200.22</td>
<td>76.71</td>
<td>49.03</td>
<td>25.05</td>
<td>41.59</td>
<td>5.00</td>
</tr>
<tr>
<td>4</td>
<td>70.69</td>
<td>72.89</td>
<td>45.08</td>
<td>155.36</td>
<td>102.00</td>
<td>7.08</td>
</tr>
<tr>
<td>5</td>
<td>50.24</td>
<td>52.34</td>
<td>41.67</td>
<td>123.24</td>
<td>325.51</td>
<td>12.22</td>
</tr>
<tr>
<td>6</td>
<td>96.21</td>
<td>55.94</td>
<td>252.49</td>
<td>141.52</td>
<td>80.48</td>
<td>9.71</td>
</tr>
<tr>
<td>7</td>
<td>55.51</td>
<td>72.37</td>
<td>32.93</td>
<td>87.72</td>
<td>42.53</td>
<td>1.15</td>
</tr>
<tr>
<td>8</td>
<td>92.61</td>
<td>98.68</td>
<td>84.44</td>
<td>14.72</td>
<td>41.13</td>
<td>0.00</td>
</tr>
<tr>
<td>9</td>
<td>61.53</td>
<td>92.09</td>
<td>49.58</td>
<td>195.00</td>
<td>119.65</td>
<td>2.54</td>
</tr>
<tr>
<td>10</td>
<td>66.36</td>
<td>37.35</td>
<td>22.33</td>
<td>186.75</td>
<td>149.52</td>
<td>1.46</td>
</tr>
<tr>
<td>11</td>
<td>240.76</td>
<td>138.88</td>
<td>40.55</td>
<td>183.80</td>
<td>98.32</td>
<td>6.06</td>
</tr>
<tr>
<td>12</td>
<td>69.56</td>
<td>253.00</td>
<td>154.65</td>
<td>405.47</td>
<td>66.40</td>
<td>7.02</td>
</tr>
<tr>
<td>13</td>
<td>28.92</td>
<td>69.42</td>
<td>72.67</td>
<td>56.89</td>
<td>24.33</td>
<td>2.37</td>
</tr>
<tr>
<td>14</td>
<td>70.36</td>
<td>155.42</td>
<td>98.71</td>
<td>252.57</td>
<td>172.53</td>
<td>7.71</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>98.6</td>
<td>107.5</td>
<td>81.8</td>
<td>142.6</td>
<td>102.3</td>
<td>5.5</td>
</tr>
<tr>
<td>STD. DEV.</td>
<td>0.700</td>
<td>0.721</td>
<td>0.698</td>
<td>1.039</td>
<td>0.786</td>
<td>0.044</td>
</tr>
<tr>
<td>RANGE</td>
<td>32.06-240.8</td>
<td>37.35-267.0</td>
<td>13.58-252.5</td>
<td>14.72-405.5</td>
<td>24.33-325.5</td>
<td>0.00-12.53</td>
</tr>
</tbody>
</table>
Table 9.- Subject data for crunch with maximum resistance- feet hooked under the foot bar.

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>RA %MVC</th>
<th>REO %MVC</th>
<th>LEO %MVC</th>
<th>RIO %MVC</th>
<th>LIO %MVC</th>
<th>ES %MVC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>58.76</td>
<td>245.44</td>
<td>104.67</td>
<td>117.77</td>
<td>91.59</td>
<td>5.41</td>
</tr>
<tr>
<td>2</td>
<td>218.05</td>
<td>158.03</td>
<td>137.25</td>
<td>141.71</td>
<td>136.88</td>
<td>12.37</td>
</tr>
<tr>
<td>3</td>
<td>169.60</td>
<td>74.91</td>
<td>45.86</td>
<td>21.10</td>
<td>34.25</td>
<td>3.7</td>
</tr>
<tr>
<td>4</td>
<td>80.08</td>
<td>89.06</td>
<td>85.19</td>
<td>127.74</td>
<td>111.54</td>
<td>7.16</td>
</tr>
<tr>
<td>5</td>
<td>50.54</td>
<td>56.75</td>
<td>43.67</td>
<td>80.00</td>
<td>173.68</td>
<td>11.77</td>
</tr>
<tr>
<td>6</td>
<td>110.58</td>
<td>64.33</td>
<td>305.63</td>
<td>177.95</td>
<td>103.08</td>
<td>5.32</td>
</tr>
<tr>
<td>7</td>
<td>39.72</td>
<td>148.26</td>
<td>37.08</td>
<td>83.4</td>
<td>29.18</td>
<td>1.47</td>
</tr>
<tr>
<td>8</td>
<td>49.52</td>
<td>148.87</td>
<td>114.38</td>
<td>14.26</td>
<td>61.61</td>
<td>2.55</td>
</tr>
<tr>
<td>9</td>
<td>57.67</td>
<td>137.45</td>
<td>76.14</td>
<td>175.22</td>
<td>123.27</td>
<td>3.49</td>
</tr>
<tr>
<td>10</td>
<td>70.69</td>
<td>59.2</td>
<td>33.69</td>
<td>179.12</td>
<td>172.88</td>
<td>3.62</td>
</tr>
<tr>
<td>11</td>
<td>211.09</td>
<td>128.54</td>
<td>34.33</td>
<td>182.12</td>
<td>100.39</td>
<td>3.97</td>
</tr>
<tr>
<td>12</td>
<td>84.64</td>
<td>293.08</td>
<td>164.02</td>
<td>426.03</td>
<td>76.44</td>
<td>12.53</td>
</tr>
<tr>
<td>13</td>
<td>28.27</td>
<td>72.41</td>
<td>78.69</td>
<td>52.59</td>
<td>15.58</td>
<td>2.36</td>
</tr>
<tr>
<td>14</td>
<td>70.36</td>
<td>155.42</td>
<td>98.71</td>
<td>252.57</td>
<td>172.53</td>
<td>7.71</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>92.8</td>
<td>130.8</td>
<td>97.1</td>
<td>145.0</td>
<td>100.2</td>
<td>6.0</td>
</tr>
<tr>
<td>STD. DEV.</td>
<td>0.621</td>
<td>0.706</td>
<td>0.723</td>
<td>1.058</td>
<td>0.531</td>
<td>0.038</td>
</tr>
<tr>
<td>RANGE</td>
<td>28.37-</td>
<td>59.2-</td>
<td>33.69-</td>
<td>14.26-</td>
<td>15.58-</td>
<td>1.47-</td>
</tr>
<tr>
<td></td>
<td>218.1</td>
<td>293.08</td>
<td>305.6</td>
<td>426.0</td>
<td>173.7</td>
<td>12.53</td>
</tr>
</tbody>
</table>

28
Figure 5.- EMG and goniometric activity during one exercise repetition against maximal resistance on the Abdominal Unit (data from one subject only).
CHAPTER 4

DISCUSSION

In this study, muscle activity increased with increased resistance in all four muscle groups tested during exercise on the Abdominal Unit. The results of this investigation support previous studies which demonstrated a direct relationship between increased force and normalized muscle activity. Wells found that the superficial abdominal muscle activity was increased when resistance was added to the chest when performing trunk flexion in a supine position. My study, however, cannot be directly compared to an anti-gravity sit-up where the weight of the trunk is lifted, as my subjects performed trunk flexion in a gravity-assisted seated position.

The rectus abdominis, internal oblique, and external oblique muscles all displayed marked activity during the resisted trunk flexion exercises. This supports a previous study by Wells who found that the rectus abdominis, and the external and internal obliques work together to flex the lumbar and thoracic spine. The erector spinae was not expected to demonstrate marked muscle activity in this study and the results indicated this hypothesis to be correct. The abdominal and the erector spinae muscles have opposite roles in trunk flexion and extension, acting as agonists and antagonists of this motion, respectively. As the abdominals contract to perform forward trunk flexion, the erector spinae muscle is reciprocally inhibited in order to perform a controlled movement into forward flexion. Since the push pad is elevated by the weights during
return to starting position, the erector spinae group is not needed during trunk extension
(Figure 5).

The results of this study also demonstrated no significant change in abdominal
muscle activity when the feet were stabilized under the foot bar versus left unanchored
(Table 9, Figure 4). Three of the five abdominal muscles tested demonstrated a slight
increase in average muscle activity as a result of hooking the feet under the foot bar. This
is inconsistent with a study performed by Walters\textsuperscript{24} who demonstrated that in hook-lying
position, an increase in abdominal muscle activity is needed when the feet are not
anchored in comparison to when they are stabilized. Stabilization of the feet increases
the hip flexor muscle activity, thus requiring less abdominal activity to perform the
movement. The subjects in my study were tested in a seated position with the hips flexed
to 90 degrees, with or without foot stabilization. This flexed hip position shortens the
iliopsoas and places it at an optimal angle for hip flexion torque. However, although the
angle of insertion is optimal, the muscle is now in a shortened position and therefore
capable of generating less tension. The results of this study would indicate that the added
stabilization provided by hooking the feet apparently does not alter the muscle activity to
any major extent. Therefore, when using the Abdominal Unit, subjects may be allowed
to place the feet in a position of optimal comfort; either above or below the foot bar.

Often normalized values may be higher than the MVC values due to the difficulty
in the standardization of test contractions.\textsuperscript{25} This occurred in the present investigation.
Tables 7-9 demonstrate frequent occurrence of percent of MVCs higher than the MVC
itself (> 100\%) primarily in the two tests that required exercising against maximal
resistance. Although MVC levels greater than 100\% were elicited, the relative level of
muscle contractions should stay consistent, since the electrodes were monitored from the same positions throughout the study.

**Future Research**

Future research concerning this Abdominal Unit may include analysis of the hip flexors, back, and chest muscle activation during exercise. The latissimus dorsi, teres major, and pectoralis major may play a role in depressing the push pad in order to perform trunk flexion in substitution for or in adjunct with the abdominal musculature.

**Clinical Implications**

Traditionally, various forms of sit-up exercises have been recommended to strengthen the abdominal muscles. This may require the patient to lift the weight of their trunk against gravity which may not be possible for a person with weak abdominals. An advantage of strengthening the abdominals from an upright position, such as that performed while using this Abdominal Unit, is that the exercise is performed in a gravity-assisted position and resistance can be determined by either the patient or the therapist. Sit-ups from a straight leg position recruits the hip flexors which tend to increase the lumbar lordosis, and can aggravate a low back condition. Since this machine allows exercises to be performed with the hips flexed it may relieve the lumbar extension tendency.

Exercising on the Fitness Plus Abdominal Unit appears to be an effective method of recruiting the abdominal muscles. Therefore, the Abdominal Unit would appear to be an effective method of strengthening the abdominal muscles. By strengthening the abdominals, the intra-abdominal pressure is increased which results in decreased forces
on the spine.\textsuperscript{6,7} The use of the Abdominal Unit in conjunction with other trunk strengthening units or exercises may provide protection and strength of the lumbar spine.
APPENDIX
UNIVERSITY OF NORTH DAKOTA'S
INSTITUTIONAL REVIEW BOARD

DATE: February 5, 1996

PROJECT NUMBER: IRB-9602-139

NAME: Thomas M. Mohr

DEPARTMENT/COLLEGE: Physical Therapy

PROJECT TITLE: An Electromyographic Study of Trunk Muscle Activity During Exercise on the Fitness Plus Rehab Equipment

The above referenced project was reviewed by a designated member for the University's Institutional Review Board on 2/6/96 and the following action was taken:

☑ Project approved. EXPEDITED REVIEW NO. 3. Next scheduled review is on February 1997.

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

☐ Project approved PENDING receipt of corrections/additions in ORPD and approval by the IRB. This study may NOT be started UNTIL IRB approval has been received. (See REMARKS SECTION for further information.)

☐ Project approval deferred. This study may not be started until IRB approval has been received. (See REMARKS SECTION for further information.)

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

REMARKS: Any changes in protocol or adverse occurrences in the course of the research project must be reported immediately to the IRB Chairman or ORPD.

Excellent Consent form!

cc: Dean, Medical School

Signature of Chairperson or designated IRB Member Date
UND's Institutional Review Board

If the proposed project (clinical medical) 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 ORPD to obtain the required documents. (7/93)
EXPEDITED REVIEW REQUESTED UNDER ITEM _3_ (NUMBER[S]) OF HHS REGULATIONS

EXEMPT REVIEW REQUESTED UNDER ITEM _____ (NUMBER[S]) OF HHS REGULATIONS

UNIVERSITY OF NORTH DAKOTA
HUMAN SUBJECTS REVIEW FORM
FOR NEW PROJECTS OR PROCEDURAL REVISIONS TO APPROVED PROJECTS INVOLVING HUMAN SUBJECTS

PRINCIPAL INVESTIGATOR: Thomas M. Mohr  TELEPHONE: (701) 777-2831  DATE: 1-5-96

ADDRESS TO WHICH NOTICE OF APPROVAL SHOULD BE SENT: P.O. Box 9037, University of North Dakota

SCHOOL/COLLEGE: Medicine  DEPARTMENT: Physical Therapy  PROPOSED PROJECT DATES: 2/96 to 2/98

PROJECT TITLE: An Electromyographic Study of Trunk Muscle Activity During Exercise on the Fitness Plus Rehab Equipment

FUNDING AGENCIES (IF APPLICABLE): Fitness Plus, Inc., Valley City, ND

TYPE OF PROJECT:  _ NEW PROJECT  _ CONTINUATION  _ RENEWAL  _ THESIS RESEARCH  _ STUDENT RESEARCH PROJECT  _ CHANGE IN PROCEDURE FOR A PREVIOUSLY APPROVED PROJECT

DISSERTATION/THESIS ADVISER, OR STUDENT ADVISER: Thomas M. Mohr, Ph.D.

PROPOSED PROJECT: _ INVOLVES NEW DRUGS (IND)  _ INVOLVES NON-APPROVED USE OF DRUG  _ INVOLVES A COOPERATING INSTITUTION

[IF ANY OF YOUR SUBJECTS FALL IN ANY OF THE FOLLOWING CLASSIFICATIONS, PLEASE INDICATE THE CLASSIFICATION(S):
  _ MINORS (<18 YEARS)  _ PREGNANT WOMEN  _ MENTALLY DISABLED  _ FETUSES  _ MENTALLY RETARDED  _ PRISONERS  _ ABORTUSES  _ UND STUDENTS (>18 YEARS)

[IF YOUR PROJECT INVOLVES ANY HUMAN TISSUE, BODY FLUIDS, PATHOLOGICAL SPECIMENS, DONATED ORGANS, FETAL MATERIAL, OR PLACENTAL MATERIALS, CHECK HERE ___

I. ABSTRACT: (LIMIT TO 200 WORDS OR LESS AND INCLUDE JUSTIFICATION OR NECESSITY FOR USING HUMAN SUBJECTS.

A small company in North Dakota, Fitness Plus, Inc., has started to market a series of exercise machines targeted at chiropractic and physical therapy clinics. Although the machines are similar to other strengthening equipment, the new machines have some unique characteristics, which the company feels makes them more applicable for clinical use. Although the machines are starting to be marketed, there is no available research that describes the muscle activity during the exercise regimens. In order to study the effectiveness of these machines, the company has offered our Department a small contract to study select muscle activity during exercise on the various pieces of equipment. Since these machines are currently being sold to clinics for use with patients who have back pain and for other patients who are need of trunk and lower extremity muscle strengthening, it is imperative that we utilized human subjects in this research. The purpose of this research is to describe the muscle activity that occurs during exercise on the Fitness Plus Rehab Equipment. Currently, there are five machines that we will be studying: 1) low back unit, 2) abdominal unit, 3) cervical unit, 4) multi-hip unit, and 5) rotary torso unit. We will use telemetried electromyography to study muscle activity in the abdominal muscles, back muscles, hamstrings and gluteal muscles. The information gained from this study will be of use to clinical physical therapists in prescribing exercise programs for their patients. The study will be done at the Medical Center Rehab Hospital where the equipment is located.
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 (if seeking outside funding).

2. PROTOCOL: (Describe procedures to which humans will be subjected. Use additional pages if necessary.)

SUBJECTS:
It is anticipated that we will recruit 20 male and female volunteers, ages 19-40 years. The subjects will be recruited from physical therapy students enrolled in the professional physical therapy program at the University of North Dakota.

METHODS:
We will measure the electromyographic (EMG) activity in these muscle groups: 1) abdominals (rectus and obliques), 2) erector spinae and latissimus dorsi, 3) hamstrings, 4) gluteus maximus, and 5) shoulder extensors. Trunk range of motion will also be analyzed.

To record the EMG activity, surface electrodes will be placed over the motor points of each muscle under study. The EMG signals will be transmitted to the receiver unit (Noraxon Telemyo 8) and then relayed into a computer for display and for recording data. Prior to beginning the experimental trials, each subject will be asked to perform a maximal voluntary contraction (MVC) of each monitored muscle. The activity recorded during the MVC will be considered as 100% EMG activity level, with which the EMG activity during the exercise can be compared. This procedure is done to normalize the EMG data for later analysis.

An electrogoniometer (Penny & Giles Model 180) will be used to measure trunk range of motion during the exercise. The electrogoniometer will be attached to the trunk and thigh above and below the hip joint, respectively using double sided adhesive tape. This will allow measurement of trunk flexion during the exercise. The electrogoniometer will be calibrated prior to beginning the experimental trial to assure accuracy of measurement.

Prior to the trials, each subject’s age, height, and weight will be recorded. During the experimental trials, the subject’s right sided muscles will be used for data collection. Before beginning the experiment, each of the subjects will be given a short training session on proper exercise using the machine.

The actual experiment involves applying the electrogoniometer device to each subject. The skin overlying the muscles will be cleansed with alcohol before attachment of the self-adhesive pre-gelled EMG electrodes over the motor points. The subject will be asked to elicit a MVC of each monitored muscle which will be recorded on the computer as a reference voltage level. The actual experiment will consist of the following trials: 1) 3 trials of using the machine with no weights attached, 2) 3 trials of using the machine with weights attached, and 3) 3 trials with changes in body position. The speed of the exercise will be timed using a metronome.

Subjects will be allowed two minute rest periods between the experimental trials to avoid a fatigue factor. Finally, the subjects will be given a rest period while the electrodes and electrogoniometer devices are removed.

Descriptive statistics characterizing the subject’s anthropometric profiles will be provided. Statistical analysis (t-test & ANOVA) will be performed on the following dependent variables: 1) normalized EMG activity, and 2) electrogoniometric measurements. The electromyographic data will also be analyzed to determine the optimal body position and motion with each of the machines.
I. BENEFITS: (Describe the benefits to the individual or society.)

The results of this study will help to determine if the Fitness Plus Rehab equipment is effective in recruiting selected trunk and lower extremity musculature. At the present time, there is no available research data on these machines, and therefore their use in the clinic is unsupported. If these machines are found to recruit the selected muscles during use, it will validate their use with patients.

II. 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 psycho-logical, 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 risk to the subjects in this experiment will be minimal. Machines similar to the ones we will be testing have been on the market for years and are currently used in many hospitals, sports medicine facilities and fitness centers. The timing and the resistance used for the exercises will be well controlled for these experiments, and should pose minimal, if any, risk to the normal subject. During the course of the experiment, subjects will be accompanied by an assistant for added safety. The EMG and electrogoniometer equipment will cause no discomfort to the subjects, since they are only monitoring devices. The subjects will be asked to wear gym shorts during the experiment, and every effort will be taken to preserve subject dignity during the course of the experiment. The experimental trials will be conducted at the Medical Center Rehabilitation Hospital, Department of Physical Therapy.

III. 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 on the subject's rights will not occur.

Describe where signed consent forms will be kept and for what period of time.

The consent forms will be kept by Dr. Thomas Mohr at the University of North Dakota, Department of Physical Therapy, Room 148, Medical Science Building for a period of two (2) years. A copy of the consent form is attached.

For FULL IRB REVIEW forward a signed original and thirteen (13) copies of this completed form, and where applicable, thirteen (13) copies of the proposed consent form, questionnaires, etc. and any supporting documentation to:

Office of Research & Program Development
University of North Dakota
Box 8138, University Station
Grand Forks, North Dakota 58202

On campus, mail to: Office of Research & Program Development, Box 134, or drop it off at Room 101 Twamley Hall.

For EXEMPT or EXPEDITED REVIEW forward a signed original and a copy of the consent form, questionnaires, etc. and any supporting documentation to one of the addresses above.
The policies and procedures on Use of Human Subjects of the University of North Dakota apply to all activities involving use of Human Subjects performed by personnel 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 procedures governing the use of human subjects.

SIGNATURES:

Principal Investigator

DATE: 2/20/96

Project Director or Student Adviser

DATE: __________ __

(Revised 8/1992)
INFORMATION AND CONSENT FORM

TITLE: An Electromyographic Study of Trunk Muscle Activity During Exercise on the Fitness Plus Rehab Equipment.

You are being invited to participate in a study conducted by Thomas Mohr, a physical therapy professor at the University of North Dakota along with graduate students Melanie Rystedt and Michelle Baumgartner. The purpose of this study is to study muscle activity in your trunk while you are exercising on some specialized strengthening equipment. We hope to describe the activity of five muscle groups to determine if the muscles are active and, if so, when they are active during the course of an exercise bout on the various fitness Plus machines. Only normal, healthy subjects will be asked to participate in this study.

You will be asked to exercise on the Fitness Plus equipment with for several trials with variable weight and positioning. The speed of the exercise will be timed using a metronome. Each trial will last approximately 30 seconds. You will be given a short rest between trials.

The study will take approximately one-half hour of your time. You will be asked to report to the Sports Acceleration Department of the Medical Center Rehabilitation Hospital at your assigned time. You will then be asked to change into 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 you have when you exercise on two of the five machines.

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 eight electrodes on your trunk. Before we can apply the electrodes, we may use a small stimulator to electrically stimulate the muscles to locate the best spot to place the electrodes. The stimulator will cause a mild tingling sensation. The recording electrodes are attached to the surface of the skin with an adhesive material. We may also attach a measuring device to your trunk with an adhesive material. These devices only record information from your muscles and joints, they do not stimulate the skin. After we get the electrodes attached, we will give you a brief training session to teach you how to exercise on the particular machine. The amount of exercise you will be asked to perform will be minimal.

Your name will not be used in any reports of the results of this study. Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission. The data will be identified by a number known only by the investigators. The investigators 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 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 investigator 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 the event that this research activity (which will be conducted at the Medical Center Rehabilitation Hospital) results in a physical injury, medical treatment will be available, including first aid, emergency treatment, and follow up care as it is to members of the general public in similar circumstance. Payment for any such treatment must be provided by you and your third party payment, if any.
ALL OF MY QUESTIONS HAVE BEEN ANSWERED AND I AM ENCOURAGED TO ASK ANY QUESTIONS THAT I MAY HAVE CONCERNING 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 Dr. Thomas Mohr.

Participant’s signature ___________________________ Date ____________

Witness (not the scientist) ___________________________ Date ____________
Research Project Action Report

Date: March 4, 1996  IRB#: MI-010

Principal Investigator: Thomas M. Mohr  Department: Physical Therapy  Phone #: 777-2831

Research Coordinator: ___________________________  Phone #: _______

Project Title: An Electromyographic Study of Trunk Muscle Activity During Exercise on the Fitness Plus Rehab Equipment

The above referenced project protocol and informed consent was reviewed by the Medical Park Institutional Review Board on ___________ and the following action was taken:

☐ Project approved. Next Scheduled review is on ________________________

☐ Project approved. EXPEDITED REVIEW NO. 3

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

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
Medical Park Institutional Review Board

Date 8/5/96

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.
Human Subjects Review Form
For new projects or procedural revisions to approved projects involving human subjects.

Principal Investigator: Thomas M. Mohr Phone #: (701) 777-2831 Date: 1-5-96
Institution: University of North Dakota Department: Physical Therapy
Research Coordinator: Rick Ness, P.T. Phone #: (701) 780-2315
Proposed Project Dates: 2/96 to 2/98

Project Title: An Electromyographic Study of Trunk Muscle Activity During Exercise on the Fitness Plus Rehab Equipment

Funding Agencies (if applicable): Fitness Plus, Inc., Valley City, ND

Type of Project: ☐ New Project ☐ Continuation ☐ Renewal ☐ Student Research Project
☐ Dissertation or Thesis Research ☐ Completed Project
☐ Reports (Adverse events, deaths, complications)
☐ Amendments or change in project

Dissertation/Thesis Adviser, or Student Advisor: Thomas M. Mohr, Ph.D.

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

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

Your project involves any human tissue, body fluids, pathological specimens, donated organs, fetal material, or placental materials, check here ☑:

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

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

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

A small company in North Dakota, Fitness Plus, Inc., has started to market a series of exercise machines targeted at chiropractic and physical therapy clinics. Although the machines are similar to other strengthening equipment, the new machines have some unique characteristics, which the company feels makes them more applicable for clinical use. Although the machines are starting to be marketed, there is no available research that describes the muscle activity during the exercise regimens. In order to study the effectiveness of these machines, the company has offered our Department a small contract to study select muscle activity during exercise on the various pieces of equipment. Since these machines are currently being sold to clinics for use with patients who have back pain and for other patients who are need of trunk and lower extremity muscle strengthening, it is imperative that we utilized human subjects in this research. The purpose of this research is to describe the muscle activity that occurs during exercise on the Fitness Plus Rehab Equipment. Currently, there are five machines that we will be studying: 1) low back unit, 2) abdominal unit, 3) cervical unit, 4) multi-hip unit, and 5) rotary torso unit. We will use telemetered electromyography to study muscle activity in the abdominal muscles, back muscles, hamstrings and gluteal muscles. The information gained from this study will be of use to clinical physical therapists in prescribing exercise programs for their patients. The study will be done at the Medical Center Rehab Hospital where the equipment is located.
PROTOCOL: (Describe procedures to which humans will be subjected.)

METHODS:
We will measure the electromyographic (EMG) activity in these muscle groups: 1) abdominals (rectus and obliques), 2) erector spinae and tissimus dorsi, 3) hamstrings, 4) gluteus maximus, and 5) shoulder extensors. Trunk range of motion also be analyzed.

To record the EMG activity, surface electrodes will be placed over the motor points of each muscle under study. The EMG signals will be transmitted to the receiver unit (Noraxon Telemyo 8) and then relayed into a computer for display and for recording data. Prior to beginning the experimental trials, each subject will be asked to perform a maximal voluntary contraction (MVC) of each monitored muscle. The activity recorded during the MVC will be considered as 100% EMG activity level, with which the EMG activity during the exercise can be compared. This procedure is done to normalize the EMG data for later analysis.

An electrogoniometer (Penny & Giles Model 180) will be used to measure trunk range of motion during the exercise. The electrogoniometer will be attached to the trunk and thigh above and below the hip joint, respectively using double sided adhesive tape. This will allow measurement of trunk flexion during the exercise. The electrogoniometer will be calibrated prior to beginning the experimental trial to assure accuracy of measurement.

Prior to the trials, each subject's age, height, and weight will be recorded. During the experimental trials, the subject's right sided muscles will be used for data collection. Before beginning the experiment, each of the subjects will be given a short training session on proper exercise using the machine.

The actual experiment involves applying the electrogoniometer device to each subject. The skin overlying the muscles will be cleansed with alcohol before attachment of the self-adhesive pre-gelled EMG electrodes over the motor points. The subject will be asked to elicit a MVC for each monitored muscle which will be recorded on the computer as a reference voltage level. The actual experiment will consist of the following trials: 1) 3 trials of using the machine with no weights attached, 2) 3 trials of using the machine with weights attached, and 3) 3 trials with changes in body position. The speed of the exercise will be timed using a metronome.

Subjects will be allowed two minute rest periods between the experimental trials to avoid a fatigue factor. Finally, the subjects will be given rest period while the electrodes and electrogoniometer devices are removed.

Descriptive statistics characterizing the subject's anthropometric profiles will be provided. Statistical analysis (t-test & ANOVA) will be performed on the following dependent variables: 1) normalized EMG activity, and 2) electrogoniometric measurements. The electromyographic data will also be analyzed to determine the optimal body position and motion with each of the machines.
3. **BENEFITS:** (Describe the benefits to the individual or society.)

The results of this study will help to determine if the Fitness Plus Rehab equipment is effective in recruiting selected trunk and lower extremity musculature. At the present time, there is no available research data on these machines, and therefore their use in the clinic is unsupported. If these machines are found to recruit the selected muscles during use, it will validate their use with patients.

---

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 risk to the subjects in this experiment will be minimal. Machines similar to the ones we will be testing have been on the market for years and are currently used in many hospitals, sports medicine facilities and fitness centers. The timing and the resistance used for the exercises will be well controlled for these experiments, and should pose minimal, if any, risk to the normal subject. During the course of the experiment, subjects will be accompanied by an assistant for added safety. The EMG and electrogoniometer equipment will cause no discomfort to the subjects, since they are only monitoring devices. The subjects will be asked to wear gym shorts during the experiment, and every effort will be taken to preserve subject dignity during the course of the experiment. The experimental trials will be conducted at the Medical Center Rehabilitation Hospital, Department of Physical Therapy.
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.

The consent forms will be kept by Dr. Thomas Mohr at the University of North Dakota, Department of Physical Therapy, Room 1521, Medical Science North Building for a period of two (2) years. A copy of the consent form is attached.

For FULL IRB REVIEW, forward the signed original of this completed form and copies as outlined in the attached instructions 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

Policies and procedures on Use of Human Subjects in Medical Park 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 Medical Park Institutional Review Board.

Signatures:

Principal Investigator: ___________________________ Date: 3/1/94

Project Director: ___________________________ Date: ___________________________

Ident Advisor (where applicable): ___________________________ Date: ___________________________
REFERENCES


