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

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AN ELECTROMYOGRAPHIC STUDY OF TRUNK MUSCLE ACTIVITY DURING EXERCISE ON THE FITNESS PLUS ROTARY TORSO UNIT

by

Melanie F. Rystedt
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This Independent Study, submitted by Melanie F. Rystedt 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.

Thomas Mohr
(Faculty Preceptor)

Thomas Mohr
(Graduate School Advisor)

Thomas Mohr
(Chairperson, Physical Therapy)

PERMISSION

Title	An electromyographic study of trunk muscle activity during exercise on the Fitness Plus Rotary Torso Unit
Department	Physical Therapy
Degree	Master of Physical Therapy

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ABSTRACT

Strengthening of trunk musculature is an important part of prevention and treatment for low back pain. Various machines have been developed to target the trunk muscles. The Rotary Torso Unit is being marketed by Fitness Plus Inc, however, no research has been conducted to validate the claims made by the manufacturer. Therefore, the purpose of this study was to measure and describe the muscle activity elicited while exercising on the Fitness Plus Rotary Torso Unit. For this study we used 14 healthy male subjects between the ages of 22 and 40 and with no prior history of back pathology.

The results of this study show that the Rotary Torso Unit is successful in recruiting the rectus abdominus, internal obliques, external obliques, and erector spinae musculature as was claimed by the company. The results indicate that the Rotary Torso Unit could be an effective tool for the abdominal muscle strengthening. Use of the Rotary Torso Unit in conjunction with other trunk strengthening machines may provide protection and strength of the lumbar spine during functional activities.

Chapter 1

INTRODUCTION

Low back pain (LBP) is thought to occur in almost 80% of adults at some point in their lives. [1] 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,[1] and heat modalities, [2] along with spinal manipulation and orthosis. [3] These treatments, however, have not been shown to be effective in the treatment or prevention of LBP when scientifically tested [2]. More recently, exercise programs have been shown to be effective against both chronic and acute LBP. [2,4,5] 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. [4-10] Cresswell et al, [6] state 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. [6,7] 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. During increased IAP, the abdominals, particularly the external obliques, tend to flex the trunk. This may be considered as an unwanted "by-product" of raising the IAP. To neutralize this "side action" the erector spinae contracts synergically.[11] A program termed Spinal Stabilization has been developed to enhance lumbar spine stability during active movements. [7,8] This program utilizes the abdominal musculature co-contracting with the erector spinae, latissimus dorsi, and the deep back musculature to allow this stability. [8]

Paul C. William's [4] 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 maximi 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 maximi and abdominals, thus passively stretching the erector spinae and hip flexors. [4]

Robin McKenzie [9] 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 lessening 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. [2]

Hans Kraus [5] 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 is to recognize muscle imbalances early and correct them before further damage is done. Through preventative trunk muscle strengthening, Kraus believes many low back injuries could be avoided.

Because trunk muscle strengthening has been shown to be an important factor in reducing and preventing 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. (See Table 1) It is important to recognize the various movements the complex musculature of the trunk can elicit. See table 2 for specific muscle actions.

Role of the Abdominals

The 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.[10] However, during a bilateral straight leg raise, the entire

Table 1. Origin, Insertion, and Innervation of Tested Muscles

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

*Information taken from Moore[12].

Table 2. Actions of Muscles Tested

MUSCLE	ACTION
Rectus Abdominus (RA)	Flexes trunk, compresses abdominal viscera
External Oblique (EO)	Compresses/supports abdominal viscera; flexes and rotates trunk to opposite side
Internal Oblique (IO)	Compresses/supports abdominal viscera; flexes and rotates trunk to same side
Erector Spinae (ES)	Bilaterally extends head and trunk, Unilaterally assists in lateral flexion of head and trunk
Gluteus Maximus (GM)	Extends and laterally rotates femur
Biceps Femoris (BF)	Flexes and laterally rotates knee, extends femur

* Information taken from Moore[12]

abdominal musculature is maximally activated to steady the pelvis. Guimaraes[13] found that the curl-up, or 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 whereas the internal oblique and transversus abdominus are considered the major stabilizers of the lumbar spine.[14] 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.[10] However, the external obliques of the contralateral side are quite active during this rotation exercise.[14] 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. [10,14]

Role of the Erector Spinae

The lumbar erector spinae (longissimus, iliocostalis) can be divided into four functional groups affecting the entire spine, however the focus of this study is on the lumbar musculature. The lumbar longissimus, during contraction, produces a vector force that 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.[14] 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. [7,10] This is due to lumbar spine kyphosis causing the posterior lumbar ligaments to be taut, therefore decreasing the need for erector spinae use.[7,10] 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.[7] With lateral rotation of the trunk, the action of the erector spinae is more unilateral, causing increased activity to the ipsilateral side.[7,8]

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.[7,10] When straightening up from the toe-touch position, the gluteus maximus shows significant activity throughout the motion. [10]

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.[10,14]

Through 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 that have been developed for the purpose of training 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 three prototype machines were designed to target specific trunk musculature, however there is no research that solidifies these claims. It is the focus of this study to measure and describe the muscle activity elicited during the use of one of these prototype machines, the Fitness Plus Rotary Torso Unit. The Rotary Torso Unit has been claimed by the Fitness Plus company to target the internal and external obliques, rectus abdominus, transverse abdominus, erector spinal group, and the deep posterior spinal group. The transverse abdominus and deep posterior spinal group have been excluded from this study due to inability to obtain accurate EMG readings though surface electrodes.

Chapter 2

METHODOLOGY

Subjects

Fourteen healthy subjects volunteered to participate in this study. All of the 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 (Table 3) and 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 Grand Forks Medical Park and the Institutional Review board procedures at the University of North Dakota. Each subject signed an informed consent form prior to voluntary participation in the study (Appendix).

Table 3. Subject demographic characteristics.

	AVERAGE	RANGE	STANDARD DEVIATION
Age (years)	26	22-40	4.93
Height (inches)	67	65-73	2.92
Weight (pounds)	165	115-210	22.46

Instrumentation

A prototype Fitness Plus, Inc. (P.O. Box 905, Valley City, North Dakota, 58072) exercise machine, the rotary torso unit, model FP105 was tested in this study. This unit has a maximal 75 pound weight resistance consisting of 5-pound increments (plates). It is relatively light and compact, weighing 190 pounds with weights included and measures 34 inches wide by 46 inches long and 49 inches in height (see figure 1).

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 rotary torso unit. The Noraxon Telemyo8 receiver collected the telemetried 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 Myosoft and Norquest data collection software that accompanies the Telemyo8 EMG system was used to analyze the digitized EMG signals in a variety of forms. An electronic metronome was used to standardize the speed of the repetitions.

Procedure

Electromyographic activity was limited by the available number of electodes to monitor six selected muscles, for this study we chose: 1)left side Rectus Abdominis (RA), right and left side External Oblique (EO), right and left side Internal Oblique (IO), and left side Lumbar Erector Spinae (ES). These muscles were chosen as per machine manufacturer's claims of muscles trained during exercise on this machine.

Electromyographic activity was recorded via pre-gelled silver-silver chloride surface electrodes (Multi Bio-Sensors, El Paso, TX 79913). To reduce skin impedance and ensue optimal contact with the electrodes, the skin over each electrode site was

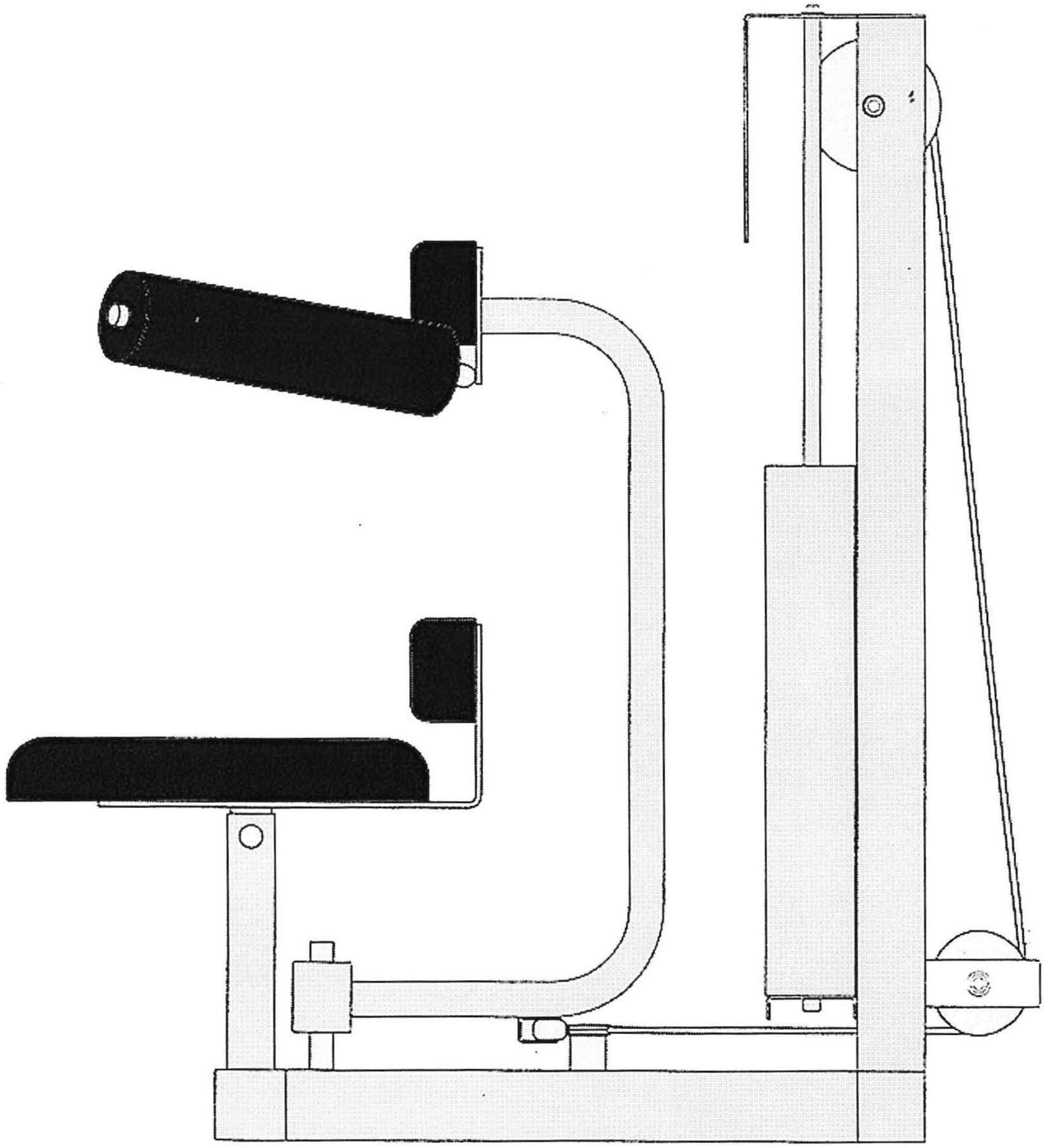


Figure 1. Rotary Torso Unit.

rubbed with alcohol and shaved of hair if needed. This was done prior to application of the EMG surface electrodes as recommended by previous authors of EMG studies.[16-19] Two surface electrodes were placed over one anatomical point of each individual muscle and placed one inch apart.[20] The pairs of electrodes were applied parallel to the direction of the selected muscle fibers at the anatomical points used for electrode placement.[16]claims that electrodes oriented parallel to the muscle fiber direction will record different motor units representing a better sample of the muscle activity andextraneous, volume-conducted activity picked up by both electrodes will be reduced as compared to aligning the electrodes perpendicular to the muscle fibers.

See figure 2 for electrode placements. The electrode placement sites used were those recommended by Vakos et al[7] to be the anatomical points in the muscles where the greatest amount of isolated muscle activity was elicited for the erector spinae and rectus abdominis. The electrode placement for the internal and external obliques were those described by Gilleard[17] and Snijders[18]. A single ground electrode was placed over the left lateral iliac crest, a relatively inactive site in order to minimize any electrical interference. Electrodes were secured with a self-adhesive backing.

An electrogoniometer was placed on the rotary torso machine in order to measure ROM of each repetition of the 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.

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

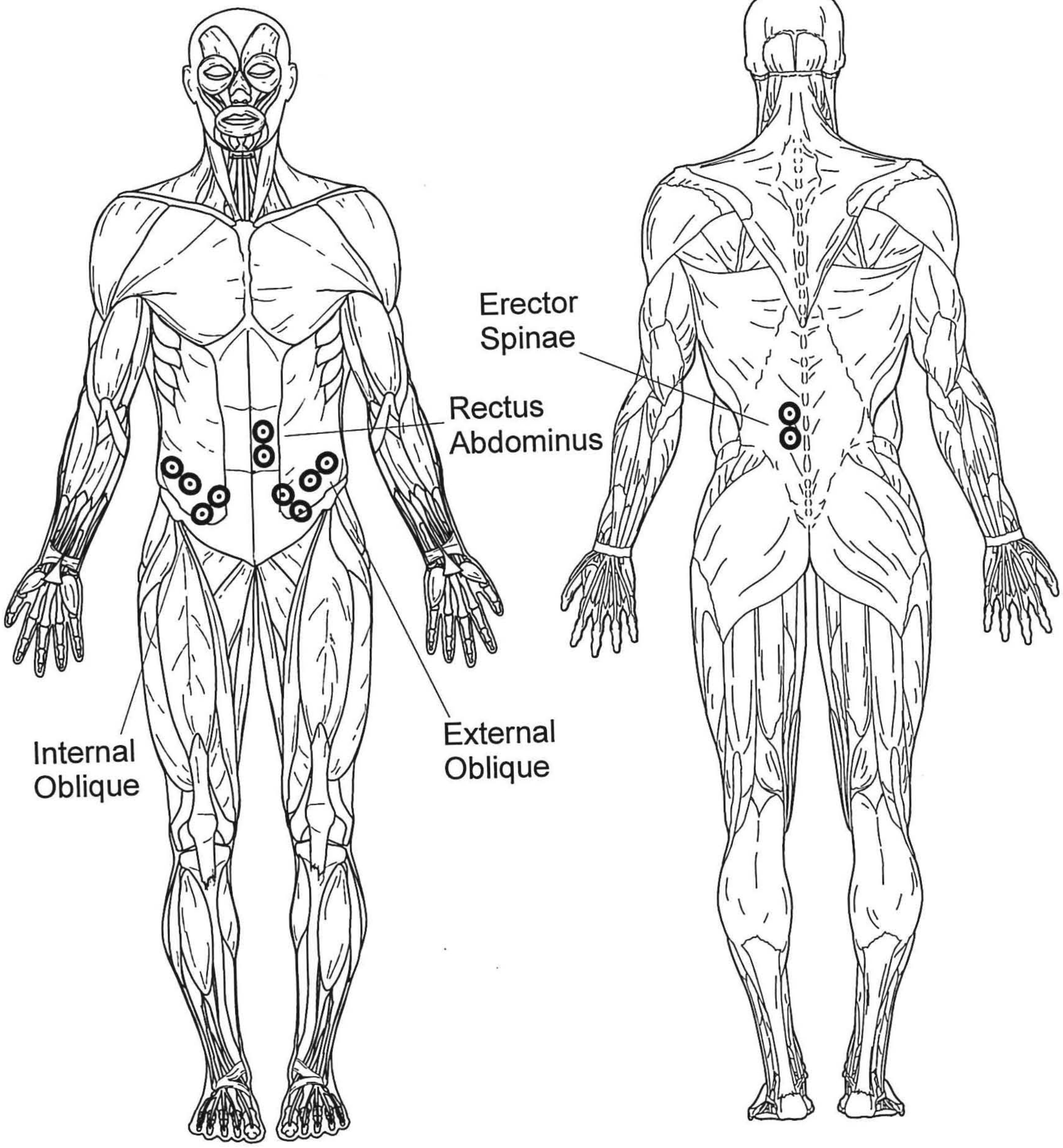


Figure 2. Electrode placement sites.

computer for display. The EMG data for each subject was recorded by the computer and stored on disk, for later analysis.

To enable us to normalize the EMG activity during the testing activities, all subjects first performed a maximal voluntary isometric contractions (MVC) against manual resistance for each of the tested muscle groups. The positions used to obtain the MVCs were taken from previous studies performed by Vakos et al[7] and in combination with other research, which intend to isolate the muscle and maximize its EMG activity.[7,14,20,21,22]

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 rectus abdominus, external obliques and internal obliques were tested with the subject positioned in supine with his head resting on the floor and arms resting at his sides. The subjects' pelvis were 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 clearancebetween his feet and the floor. The erector spinae 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 femoral epicondyles, while providing resistance at the T_7 vertebral level after the subject achieved 30 degrees of back extension. Activity was recorded during resisted back extension.

Prior to testing on the rotary torso unit, the maximal poundage of weight the subject was able to lift was determined. To do this the subject performed several times with variable weight to determine the maximum amount of weight he was able to lift and still complete full ROM for the exercise; possible maximal amount of weight being 75 pounds. This maximum weight was recorded and used for the second and third exercises(see table 4).

Following a practice trial on the rotary torso unit with 5 pounds (1 plate), 4 experimental testing activities were recorded through EMG. Table 5 shows the exercises in the order performed. Three repetitions of each exercise were performed by the subjects.

Each subject was instructed on how to perform the exercise repetition and the timing of the trials. The starting position for all exercise trials consisted of proper sitting position on the seat in an upright position with the back slightly arched, knees and hips at a 90 degree angle, and feet flat. For the first two exercises the subjects were placed in the standard position as recommended by Fitness Plus Incorporated, with arms around the cushion arms with 2 finger width distance between the subjects' axilla and the cushion arms. The third and fourth exercises were performed with the subjects' arms crossed over their chest in an effort to prevent contribution of trunk rotation by the shoulder muscles. Subjects were allowed to abduct their arms out, while maintaining crossed arms, to the cushion arms to increase stability. Seat height was adjusted appropriately and a stabilized block was placed under the feet when necessary to obtain 90 degrees at the hips and knees. Each subject was instructed to attempt to maintain a stable arm position and perform the exercise using their abdominal muscles.

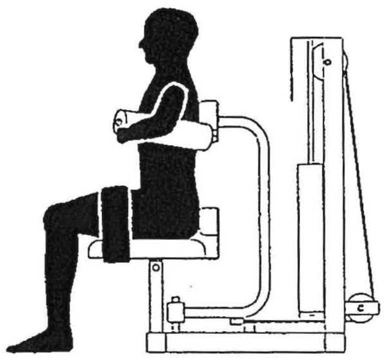
See figure 3 for sequence of exercise on the Rotary Torso Unit. One repetition of the exercise was completed by slowly rotating their trunk to their right, holding at end range, slowly returning to the initial midline position and then repeating the movement to

Table 4. Maximum weight lifted by each subject.

SUBJECT NUMBER	MAXIMUM WEIGHT LIFTED	SUBJECT NUMBER	MAXIMUM WEIGHT LIFTED
1	13	8	15
2	13	9	13
3	15	10	14
4	15	11	13
5	15	12	15
6	13	13	15
7	15	14	11

Table 5. Experimental exercises listed in testing order.

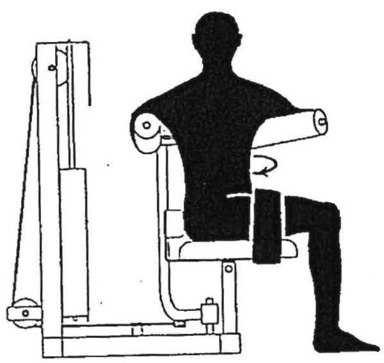
TEST #	WEIGHT	ARM POSITION
1	25 pounds	standard position
2	maximum weight	standard position
3	25 pounds	crossed over chest
4	maximum weight	crossed over chest



NEUTRAL POSITION

A.

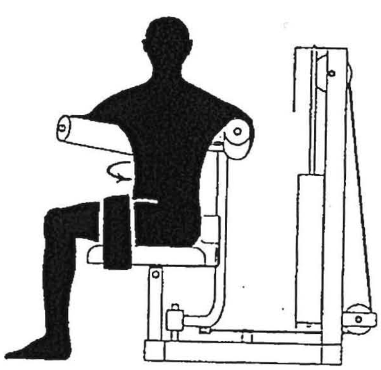
The subject started each exercise with their arms over the pads, the hips were stabilized with a belt and the feet were placed on the floor.



RIGHT ROTATION

B.

For the first part of the exercise, the subject rotated the trunk to the right.



LEFT ROTATION

C.

For the second part of the exercise, the subject rotated the trunk to the left.

Figure 3. Exercise sequence in the standard position.

their left, again returning to midline. Each of the five exercises were repeated three times with a brief rest between exercises. EMG was recorded during the activity. The pace of each trial was set by a metronome set at 48 beats per minute. The exercise timing sequence consisted of maintaining midline for 2 beats, rotating to their right for 2 beats, hold at end-range for 2 beats, return to midline position for 2 beats, maintaining midline for 2 beats, rotating to their left for 2 beats, hold at end-range for 2 beats, return to midline for 2 beats, and finally relax for 2 beats. The routine was then immediately repeated 2 more times to complete the trial. Each subject was allowed a practice trial with 5 pounds (1 plate) in order to become familiar on the machine with the correct timing. Continuous verbal instructions were given throughout all exercises.

Data Analysis

Descriptive analysis was used to make comparisons between 1) individual muscles recruited during the four tested exercises, 2) quantity of muscle activity with variable weight, 3) quantity of muscle activity with variable arm position, and 4) comparison of muscle activity in relation to degrees of rotation.

Analysis of the EMG data were performed using the Myosoft and Norquest software. One of the three trials performed for each exercise was selected for data analysis. The cycle used for data analysis of each exercise started at zero degrees of rotation (midline) as indicated by goniometric measurements, and ending after one full rotation, to the right and then left, ending again at zero degrees of rotation. In order to allow comparison between subjects it was necessary to normalize the EMG data.[22] To do this, the average muscle activity, in microvolts (uV), of the MVC and of the muscle activity during exercise trials on the rotary torso unit were calculated. Next the EMG data for each of the four muscle groups studied was normalized using the following formula:

$$\% MVC = \frac{\text{Average muscle activity during exercise trial}}{\text{Average muscle activity during MVC}} \text{ x } 100$$

The MVC 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.

Chapter 3

RESULTS

Muscle Activity During Exercise Trials in the Standard Position

Results are based on the data recorded and analyzed from all 14 subjects. The average muscle activity for each of the six muscles monitored during each exercise trial on the rotary torso unit is presented in Table 6 and Figure 4. Tables 9 and 10 show individual subject data.

Rectus Abdominus

The rectus abdominus was relatively inactive during all exercises regardless of the amount of added resistance. During the first exercise trial, with 25 pounds of resistance, there was an average activity of 8 %MVC. This increased to 15 %MVC when the resistance was increased to each subjects' maximum in the second exercise trial.

External Oblique

Both external obliques were active throughout both exercise trials. With 25 pounds of resistance the right external oblique elicited an average of 90 %MVC. This increased to 131% with maximum resistance. The left external oblique showed similar results with 91% average MVC during exercise trials with 25 pound resistance and 131% when resistance was increased to each subjects' maximum.

Internal Oblique

The right internal oblique elicited the highest %MVC of all muscles tested. With 25 pounds of resistance the average percent of MVC was 130%. This increased to 158 % with maximum resistance. The left internal oblique did not elicit as much activity as did the right, but was still considerably active with 77 %MVC during the first exercise trial and 116 % during the second exercise trial.

Erector Spinae

The erector spinae was active during both exercise trials with an average of 17% of MVC during the first exercise and 50% during the second exercise trial.

Overall, as was anticipated, there was a consistent pattern (the relative levels of muscle recruitment) of increased muscle activity when greater resistance was applied. During both exercise trials the level of muscle activity was greatest in the external and internal obliques followed by the erector spinae, and finally the rectus abdominus.

Muscle Activity During Exercise Trials with Arms Crossed Over Chest

The EMG activity with subjects' arms crossed is shown in Table 7 and Figure 5. The following discussion is a summary of the studied muscles with arms positioned accross their chest during rotation with 25 pounds and rotation with maximal resistance.

Rectus Abdominus

As in the standard position, the rectus abdominus remained relatively inactive regardless of the amount of resistance added. During the first exercise trial with 25pounds of resistance there was an average of 5 %MVC. This slightly increased to 8% when resistance was increased to each subjects' maximum.

External Obliques

The right external oblique, with 25 pounds of resistance elicited an average of 78 %MVC. This increased to 91% when maximal resistance was applied. The left external oblique elicited an average of 93 %MVC with 25 pounds of resistance, but decreased to 88% with maximal resistance.

Internal Obliques

The right internal oblique showed the highest level of activity when compared to the other tested muscles. The average %MVC with 25 pounds was 107%. This increased to 131% with resistance. The left internal oblique elicited an average of 58 %MVC with 25 pounds, increasing to 76% with maximal resistance.

Erector Spinae

The average %MVC for the erector spinae during the exercise trials with 25 pounds of resistance was 31%. When resistance was increased to maximum, the average %MVC increased to 47%.

Standard vs. Crossed Arms

The EMG activity, during all 4 exercise trials, revealed a pattern of general increased muscle activity when resistance was increased (figure 6 and table 8). In general, the greatest EMG activity elicited was by the internal and external obliques, the former being slightly greater, followed by the erector spinae and finally the rectus abdominus. Although there was a similarity in the patterns of muscle activity, there was generally less activity when subjects crossed their arms over their chest. The one exception was the left external oblique with 25 pounds when arms were crossed.

Timing of muscle activity

Timing of muscle activity (the cycle of when each muscle was active relative to range of motion) is shown in Figure 7. In the initial position, at 0 degrees of motion or midline, their was no muscle activity occurring with the exception of slight activity of the erector spinae. Activity of the oblique musculature began to occur with the onset of right rotation and continued to be active until return to neutral. The greatest amount of activity during right rotation occurred in the right internal oblique and the left external oblique The obliques are again active with initiation of left rotation, with the greatest elicitation in the left internal oblique and right external oblique, until return to neutral. The rectus abdominus was minimally active during rotation. The erector spinae was minimally to moderately active during both left and right rotation.

Table 6. Average % MVC With Subjects In Standard Position

	25 Pounds: Ave %MVC	Range	Standard Deviation	Max Weight: Ave %MVC	Range	Standard Deviation
RA	8%	1-19%	0.04782	15%	5-38%	0.08894
REO	90%	29-123%	0.26875	131%	57-187%	0.42875
LEO	91%	32-237%	0.61994	131%	71-412%	0.86578
RIO	130%	14-638%	1.71311	158%	19-694%	1.81159
LIO	77%	22-183%	0.51419	116%	42-312%	0.78699
ES	17%	4-35%	0.09233	50%	20-107%	0.24454

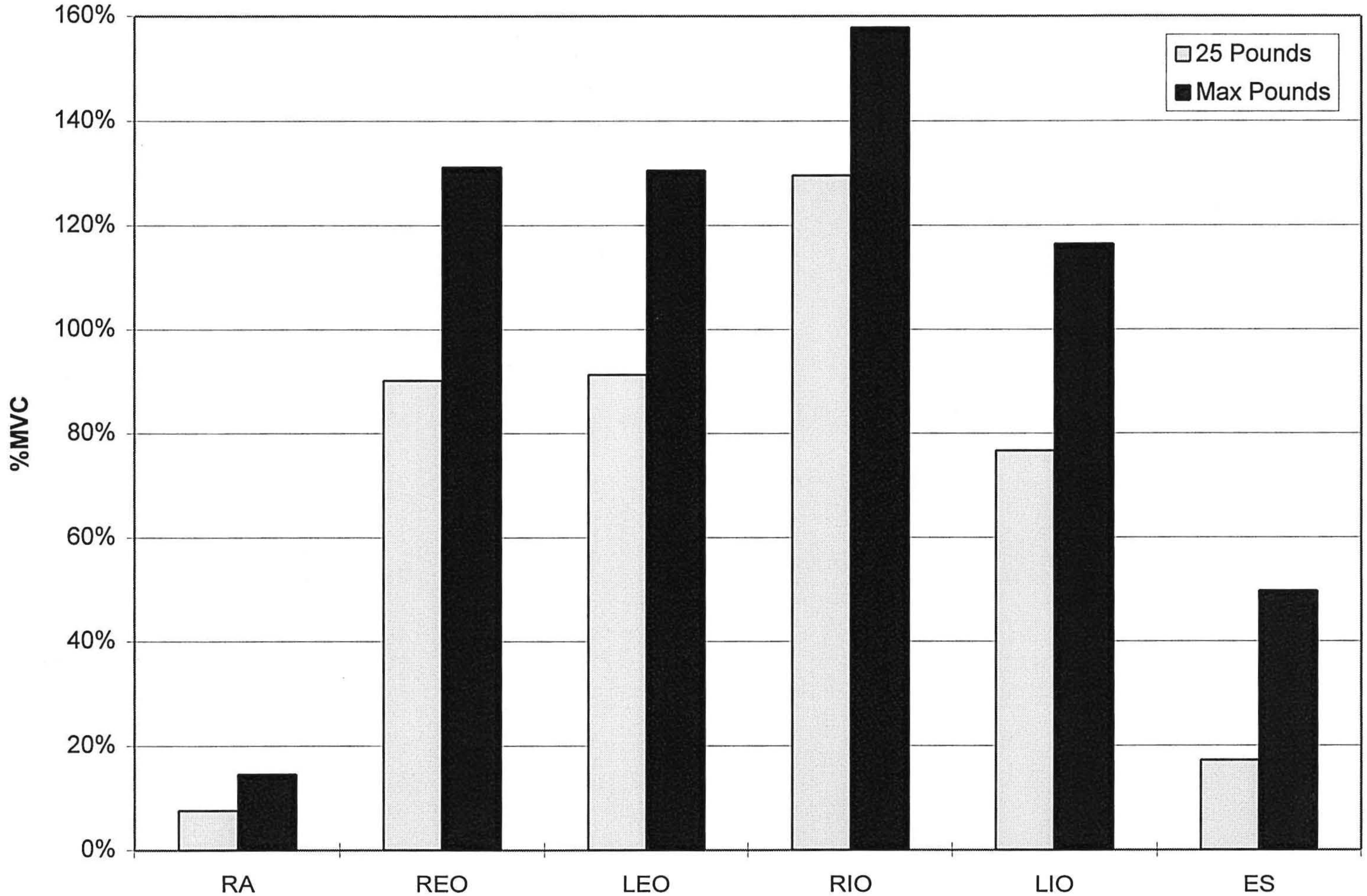


Figure 4. EMG activity in the standard position.

Table 7. Average % MVC With Subjects Arms Crossed Over Chest

	25 Pounds: Ave %MVC	Range	Standard Deviation	Max Weight: Ave %MVC	Range	Standard Deviation
RA	5%	1-11%	0.02539	8%	2-25%	0.06414
REO	78%	23-124%	0.29800	91%	47-173%	0.39974
LEO	93%	33-366%	0.87355	88%	42-273%	0.59648
RIO	107%	13-548%	1.47617	131%	15-504%	1.45936
LIO	58%	14-167%	0.47225	76%	23-297%	0.75004
ES	31%	7-63%	0.16329	47%	24-86%	0.20155

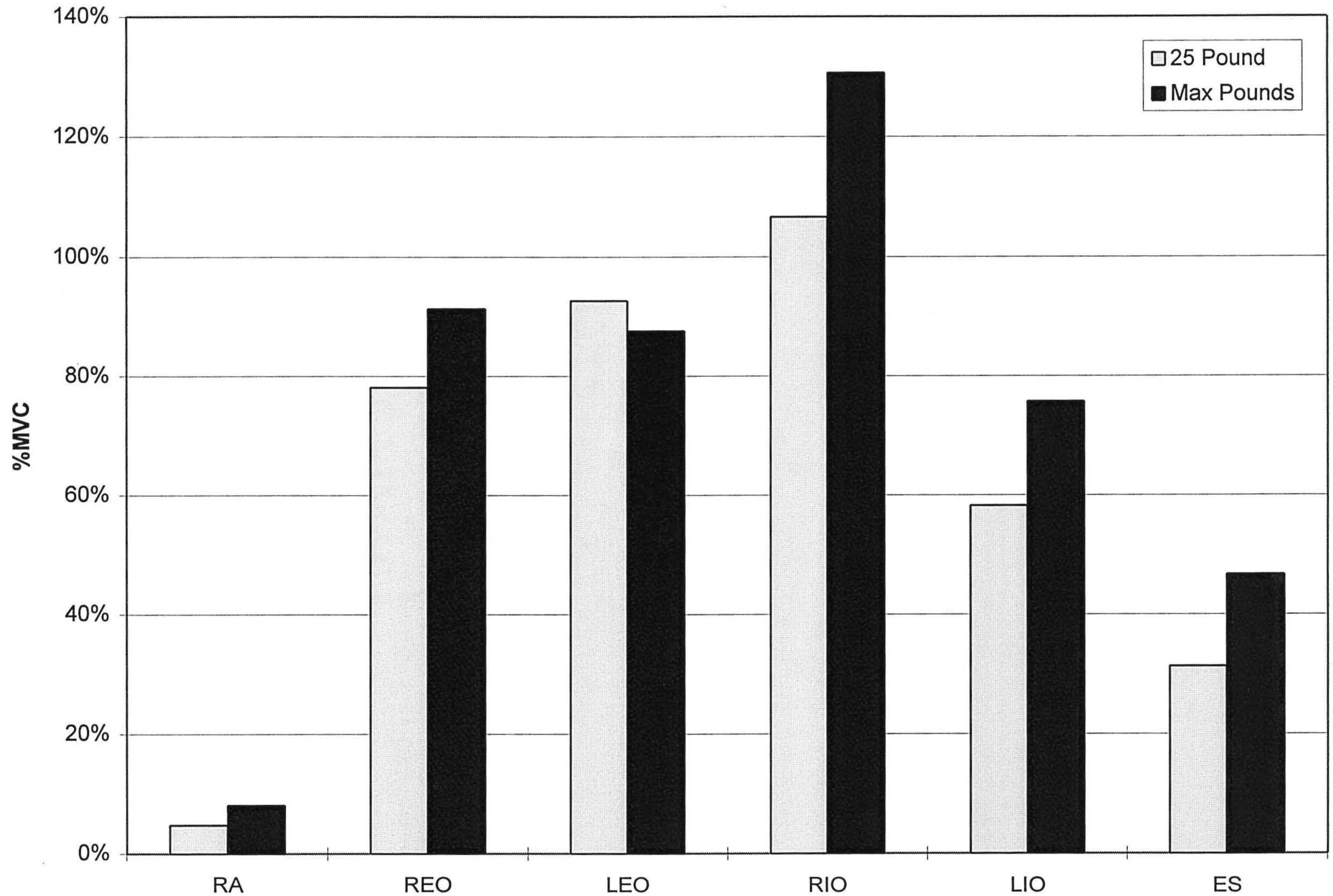


Figure 5. EMG activity in the crossed arms position.

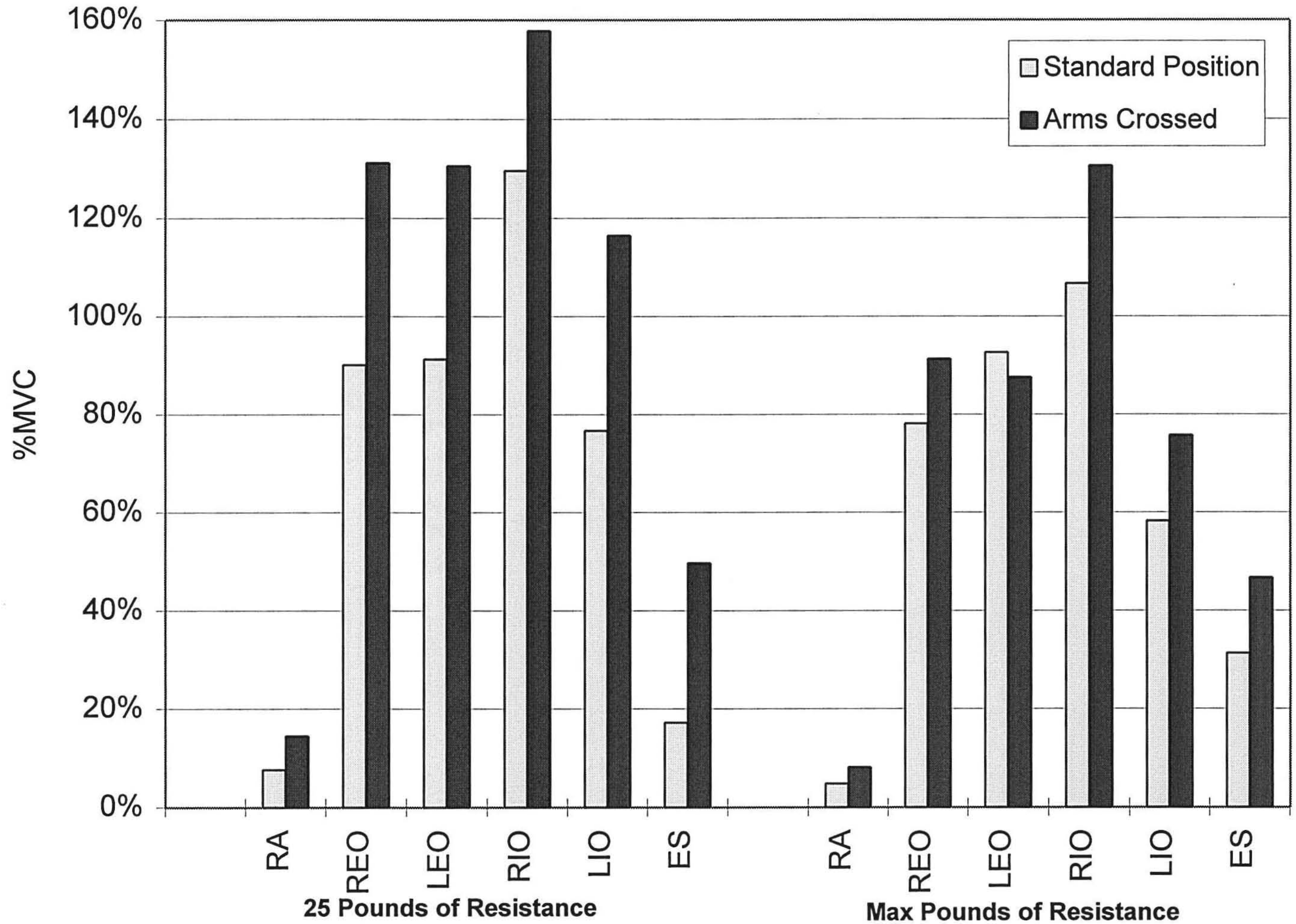


Figure 6. EMG activity for all exercises

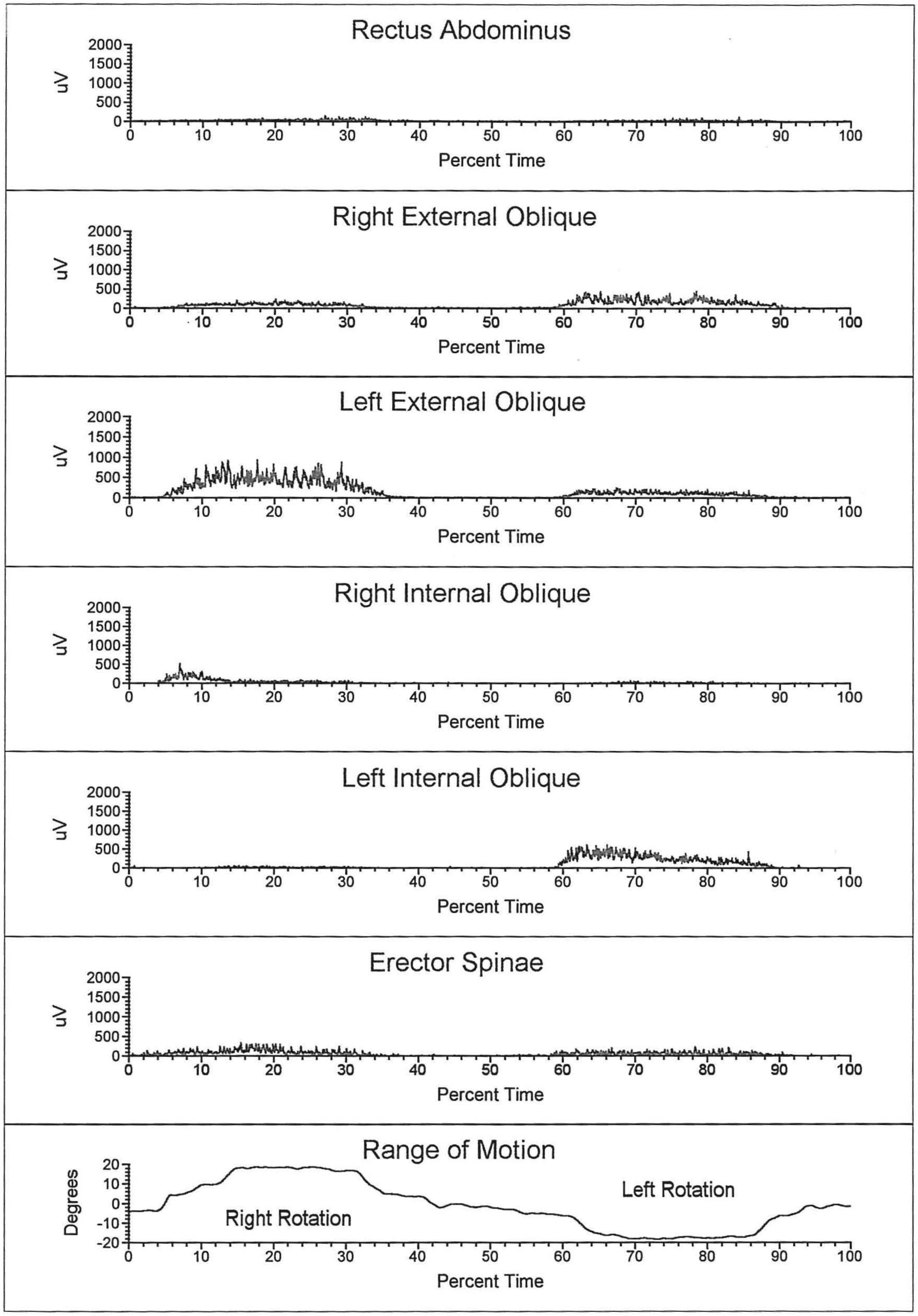


Figure 7. EMG activity and range of motion (N=1).

Table 8. % MVCs of all 14 subjects- standard position

1. 25 pounds resistance - standard position

Subject	RA	REO	LEO	RIO	LIO	ES
1	7%	117%	56%	104%	64%	26%
2	9%	75%	219%	34%	48%	11%
3	6%	92%	67%	14%	42%	10%
4	2%	103%	32%	55%	34%	13%
5	19%	59%	87%	36%	183%	35%
6	9%	113%	237%	86%	152%	35%
7	10%	95%	106%	69%	37%	10%
8	4%	108%	91%	70%	88%	16%
9	4%	120%	88%	638%	63%	13%
10	1%	29%	43%	46%	133%	23%
11	7%	29%	40%	16%	22%	14%
12	14%	86%	86%	311%	127%	15%
13	9%	123%	74%	66%	30%	4%
14	5%	71%	53%	270%	51%	15%

2. Max resistance - standard position

Subject	RA	REO	LEO	RIO	LIO	ES
1	12%	134%	86%	83%	89%	73%
2	38%	103%	174%	33%	81%	66%
3	18%	109%	78%	19%	72%	36%
4	6%	187%	71%	91%	104%	57%
5	26%	71%	124%	98%	312%	107%
6	12%	164%	412%	96%	109%	65%
7	15%	138%	99%	97%	42%	20%
8	5%	134%	142%	77%	102%	59%
9	6%	184%	139%	694%	106%	26%
10	6%	57%	81%	78%	205%	36%
11	15%	133%	75%	22%	49%	46%
12	20%	172%	137%	312%	234%	57%
13	15%	78%	105%	187%	58%	20%
14	10%	173%	103%	323%	68%	26%

Table 9. % MVCs of all 14 subjects- arms crossed

1. 25 pounds resistance - arms crossed

Subject	RA	REO	LEO	RIO	LIO	ES
1	5%	124%	75%	123%	51%	41%
2	6%	73%	171%	24%	22%	63%
3	4%	84%	58%	13%	22%	23%
4	5%	84%	36%	50%	40%	12%
5	5%	43%	45%	26%	105%	54%
6	7%	116%	366%	64%	95%	52%
7	1%	68%	78%	60%	28%	23%
8	6%	83%	88%	38%	22%	32%
9	3%	104%	71%	548%	58%	26%
10	1%	23%	43%	39%	128%	35%
11	6%	79%	37%	14%	22%	22%
12	11%	98%	124%	274%	167%	30%
13	2%	30%	33%	31%	14%	7%
14	5%	85%	71%	190%	42%	19%

2. Max resistance - arms crossed

Subject	RA	REO	LEO	RIO	LIO	ES
1	6%	123%	86%	128%	41%	68%
2	3%	50%	115%	15%	27%	54%
3	6%	73%	53%	28%	23%	24%
4	5%	173%	65%	91%	62%	29%
5	18%	54%	55%	67%	169%	86%
6	5%	102%	273%	103%	67%	50%
7	2%	85%	68%	72%	37%	24%
8	2%	83%	69%	21%	26%	70%
9	6%	62%	42%	504%	69%	40%
10	4%	47%	54%	75%	116%	47%
11	12%	140%	57%	24%	41%	46%
12	25%	146%	143%	386%	297%	67%
13	9%	58%	76%	85%	39%	27%
14	10%	82%	70%	229%	46%	24%

Chapter 4

DISCUSSION

Standard vs. Crossed Arms Position

The results show greater muscle activity of all muscles during exercise trials with subjects' arms around the cushion arms (standard position) as compared with arms crossed over their chests. This finding indicates that subjects should be allowed to place their arms over the cushion arm pads as described in the instructions provided by Fitness Plus, Inc.. However, I speculate that with the standard position other upper extremity muscles may be used to rotate the unit and, therefore, the results may have been different had the rotary torso unit been designed for the crossed arms position and provided for stabilization in this position. Further research would need to be done to test this hypothesis.

Muscle Recruitment

EMG results from all exercise trials show a considerable amount of activity in all of the oblique musculature as compared to activity elicited by the rectus abdominus. This result was expected as the literature indicates that the rectus abdominus plays a large role in trunk flexion but very little to no activity during trunk rotation. The obliques, however, have been found to play a major role in rotation of the trunk.[14] My results were consistent with the actions of the oblique musculature listed in Table 2.

Limitations

Normalization of EMG activity was performed in order to allow comparison of EMG activity between the subjects and muscle groups. In some instances the %MVC was greater than 100%. This has also been observed in other studies, and occurrences of EMG percent differences sometimes greater than 100 are not uncommon.[23] The problems include use of an isometric contraction to standardize a dynamic event, subject motivation, subject effort, joint angle, and the testing procedure used to obtain the maximum EMG signal used as the referencing standard.[7]

Design Considerations

Throughout the exercise trials there were various design aspects of the equipment that merit consideration. The first consideration is the number of plates on the machine. One half of the subjects in this study were able to exercise with full rotation against the maximal possible resistance (15 plates). This level of resistance may not be enough to provide an adequate training stimulus over a long period of time. If the machine is to be useful in strengthening trunk musculature in healthy individuals, Fitness Plus Inc. may want to consider the addition of more plates to this machine. However, for the treatment of acute back problems, the resistance provided is probably adequate.

I had concerns regarding the stabilization of the subjects' thighs during exercise on the Rotary Torso Unit. The stabilization belt had a tendency to slip from the mid thigh area to the lower thigh. This occurred due to the design of the metal buckle holding the belt. The metal ring had a tendency to turn within the buckle strap causing the belt to loosen, leading to insufficient stabilization of the belt. Revamping the belt should be taken into consideration as good thigh stabilization is important for isolation of the trunk musculature. Without proper stabilization there is a tendency to substitute with other muscles.

Another design consideration would be to consider an adjustment of the pads to fit individuals of varying heights. The seat was adjustable, however, for subjects who were shorter in height, it was difficult to obtain a flat foot position on the floor while still having the cushioned arms in the ideal location. Therefore, it is advised that either an adjustable foot plate or an adjustable arm pad be added on to this machine to allow proper fit for varying heights of individuals that may use this machine.

Future Research

Further EMG studies would need to be done in order to see if the current Rotary Torso Unit model introduces recruitment of shoulder extensor muscles, in particular, the latisimus dorsi which may effect the isolation of trunk rotator muscles. Future research could be done to compare the effectiveness of the Rotary Torso Unit to other similar machines. Lastly, it would be interesting to test EMG activity on this unit using subjects with low back pain since this is the population that the machine has been design for.

Clinical Implications

Based on the findings of this study, the Rotary Torso Unit appears to be an effective machine for recruitment of the internal and external obliques. It was also found to moderately recruit the Erector Spinae. This finding supports the claims made by the manufacturer. Recruitment of the Rectus Abdominus, however, was not found to be significant.

During traditional sit-up exercises, with rotation, an individual must be able to lift the weight of their trunk against gravity. This is often difficult for individuals with weak abdominals which frequently is a factor for persons with low back pain. The rotary torso unit specifically recruits the oblique muscles of the trunk and is capable of providing variable resistance for all levels of trunk strength. Also, trunk rotation sit-ups traditionally done in a supine position may recruit the hip flexors which may place undue strain on the lumbar spine. Since the exercise on the rotary torso unit places the hip flexors in a shortened position, the effect of these muscles is reduced. This also allows for greater isolation of abdominal muscle activity.[24]

The recruitment of the abdominal musculature indicate that the Rotary Torso Unit could play an effective role in the strengthening of these important trunk muscles with reduced lumbar spine stress. Increasing trunk muscle strength should offer protection to the lumbar spine during functional activities which is a goal in treating low back pain. Therefore, used in conjunction with other trunk strengthening machines, the Rotary Torso Unit may well be a useful tool in the rehabilitation of persons suffering from low back pain.

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:

- [X] 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

Elvira Pozeth 2-6-96

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)

_X_ 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:
_X_ NEW PROJECT __ CONTINUATION __ RENEWAL __ DISSERTATION OR THESIS RESEARCH _X_ 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
_X_ 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 _X_ UND STUDENTS (>18 YEARS)

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

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1. 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 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.

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 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.

5. **CONSENT FORM:** A copy of the **CONSENT FORM** to be signed by the subject (if applicable) and/or any statement to be read to the subject should be attached to this form. If no **CONSENT FORM** is to be used, document the procedures to be used to assure that infringement upon the subject's rights will not occur.

Describe 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.

6. 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:

[signature] DATE: 2/20/96

Principal Investigator

____________________ DATE: __________

Project Director or Student Adviser

(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

Grand Forks Medical Park

Institutional Review Board

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

☒ Project approved. EXPEDITED REVIEW NO. 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).

____________ 3/5/96
Signature of Chairperson or Designated IRB Member Date
Medical Park Institutional Review Board

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.

8012-0002 MAR 94

Grand Forks Medical Park

Institutional Review Board

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
☐ Dissertion 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

If any of your subjects fall in any of the following classifications, please indicate the classification:

☐ Minors (< 18 Years) ☐ Pregnant Women ☐ Mentally Disabled ☐ Fetuses ☐ Mentally Retarded
☐ Prisoners ☒ Students ☐ Abortuses ☐ Control Group

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

__X__ Expedited Review requested under item __3__ (number) of HHS Regulations (see attached explanation)

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

---

1. **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 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.

.EASE NOTE:

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

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

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 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.

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.

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