

# ***Core and shoulder girdle muscle activation during mat leg pull-front, long stretch and hundred exercises on the Pilates reformer and mat***

A Report submitted to Balanced Body, Inc., by Christine Romani-Ruby, MPT, ATC and Ben Reuter, PhD, CSCS, \*D, ATC

## **INTRODUCTION**

Pilates is the fastest growing method of mind body fitness, and is practiced daily by over five million Americans . The IDEA Health and Fitness Industry Trend Report in 2004 found that two thirds of all fitness facilities include Pilates programming (1). Joseph Pilates developed the instructional method with twelve pieces of exercise equipment and over 500 exercises. This is the origin of the Pilates fitness regimen that is sweeping the nation today.

Pilates, originally called Contrology, was developed in the late 1920's, when the medical community was focused on treating the ailment. Contrology introduced the idea of treating the cause of the ailment and attempting to prevent the problem through wellness activities (3). Now, seventy years later the medical community is focused on treating the cause rather than the symptoms. The prevention of disease through wellness is recommended by the United States Department of Health and Human Services (2).

Pilates matwork has spread rapidly in the fitness arena. Most instructors tell participants that matwork is the hardest form of Pilates. They suggest that people interested in Pilates begin on the reformer. Pilates instructors allude to the feedback provided by the springs and moving carriage of the reformer. Participants are taught that the equipment reinforces proper movement patterns.

One of the concerns of fitness and rehabilitation professionals interested in introducing Pilates into their practices is the lack of information about the physiological characteristics of Pilates. Although Pilates has existed for over 80 years, it has not been investigated thoroughly by the scientific community. The purpose of this research was to measure the activation of key shoulder girdle and core muscles while performing the Pilates leg pull-front, long stretch and hundred exercises on the reformer and on the mat. Muscle activation between experienced Pilates participants and active adults with no previous Pilates experience was also compared.

## METHODS

Surface electromyography (EMG) measures the electrical activity of muscles. The more active or greater force a muscle produces the greater the EMG activity. EMG is a common clinical and research tool for measuring the activation of muscles during functional movement. This study measured the EMG activity of four muscles, upper trapezius, serratus anterior, external oblique, and rectus abdominus. These muscles are believed to be active during Pilates exercises and are often involved in postural dysfunction.

There were 20 volunteer participants in the study, equally divided into two groups. The first group, with an average age of 39.5 years had 4.7 years of Pilates experience. The second group, with an average age 35.5 years had no Pilates experience. Eight of the 10 Pilates trained individuals were instructors, and all experienced Pilates participants were trained in the same Pilates method.

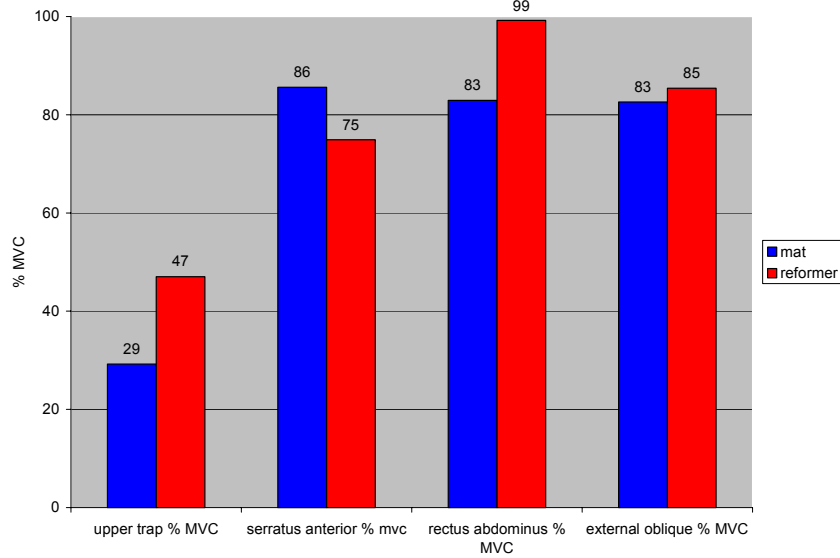
The participants completed the informed consent, and had the procedures of the study explained to them. Using a standard protocol, surface EMG electrodes were applied to the muscles on the right side of the body for measurement with the Noraxon TeloMyo 900™ EMG machine (Noraxon EMG and Sensor Systems, Scottsdale, AZ). Prior to testing, the maximum voluntary muscle contraction of each of the four muscles was measured. Participants warmed up by completing eight repetitions each of footwork and running on the Allegro Reformer (Balanced Body, Inc., Sacramento, CA).

EMG activity of all four muscles was recorded as the participants completed eight repetitions of four Pilates exercises in a randomized order. The four exercises included, appropriately modified versions of mat leg pull-front, reformer long stretch, mat hundred and reformer hundred. For the mat leg pull-front the participants held a plank position for three breaths. During the long stretch exercise the participants moved the reformer while holding a plank position with the feet against the shoulder rests and the hands on the footbar. The only modification for both the hundred exercises was positioning the hips and knees at 90 degrees of flexion.

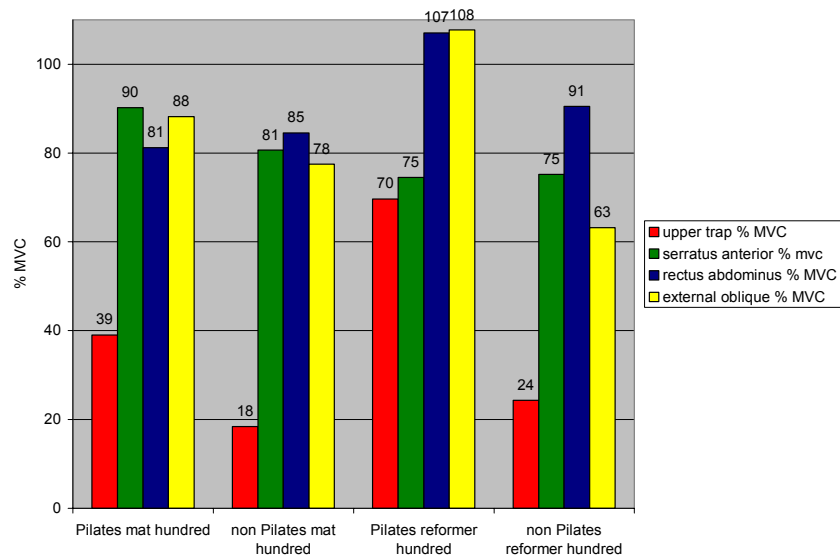
For each exercise, participants watched a brief instructional video and then completed the repetitions while following the recorded verbal cues of an instructor. The EMG data was rectified and smoothed following standard protocols using the Myoresearch XP software (Noraxon EMG and Sensor Systems, Scottsdale, AZ). The software was used to calculate the percentage of maximum voluntary muscle contraction for each muscle during each exercise. The participants were videotaped during the testing to allow further analysis of exercise technique.

Results of the study showed an increase in the recruitment of the upper trapezius, the rectus abdominus and the external oblique muscles with the use of the Allegro reformer for the hundred compared to the hundred on the mat (Figure 1). This increase was visibly higher with the experienced Pilates participants (Figure 2).

**Figure 1:** Comparison of % maximum voluntary muscle contractions during mat hundred and reformer hundred for all participants

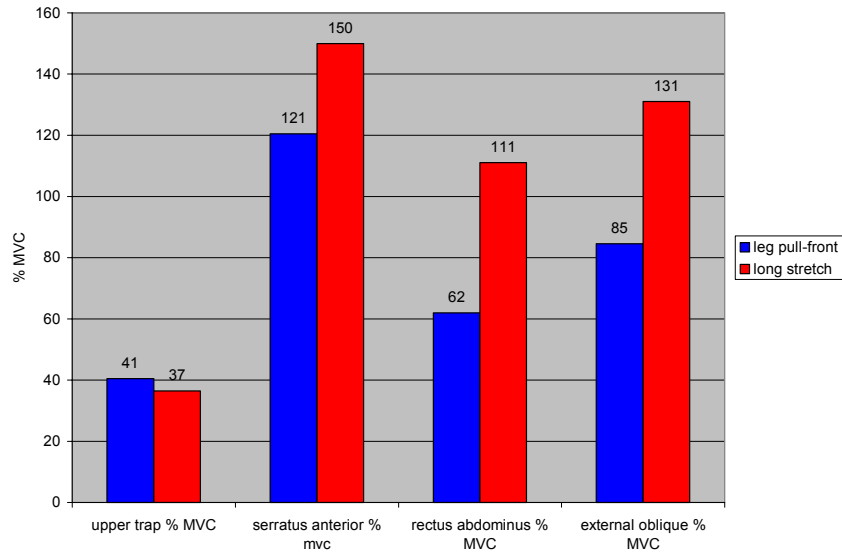


**Figure 2:** Comparison of % maximum voluntary muscle contractions during mat hundred and reformer hundred between Pilates participants and non Pilates participants

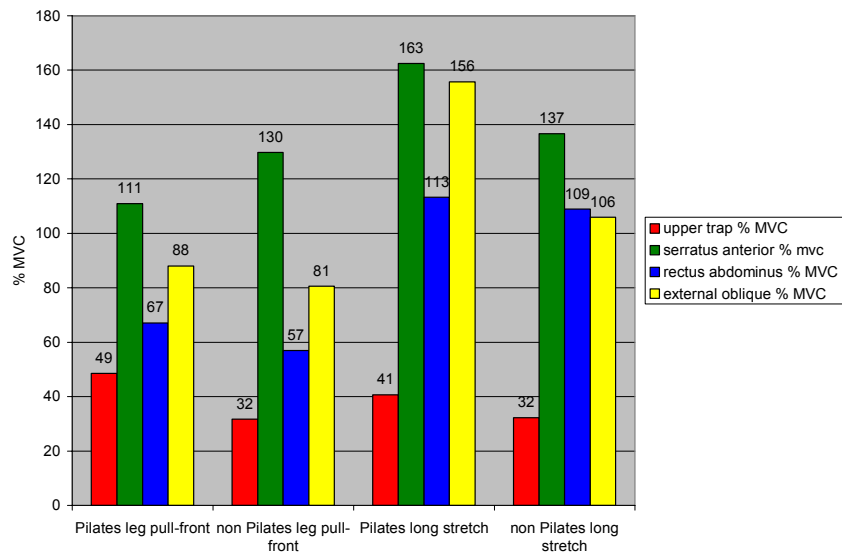


The study also found an increase in the recruitment of the serratus anterior, the rectus abdominus, and the external oblique with the use of the reformer for long stretch verses leg pull-front on the mat (**Figure 3**). This increase was again visibly higher with the experienced Pilates participants (**Figure 4**).

**Figure 3:** Comparison of % maximum voluntary muscle contractions during leg mat pull-front and reformer long stretch for all participants



**Figure 4:** Comparison of % maximum voluntary muscle contractions during mat leg pull-front and reformer long stretch between Pilates participants and non Pilates participants



## DISCUSSION

To be accepted and utilized by fitness and rehabilitation professionals it is important for the effects of Pilates exercises to be thoroughly investigated. This study was one of the first to begin to identify the physiological characteristics of Pilates exercises for both experienced Pilates participants and novices. It was also the first to evaluate similar exercises on the mat compared to the Allegro reformer.

Based on the higher percentage of maximum voluntary muscle contraction values for key muscles on the reformer, this study indicates that the reformer may be used as an instructional tool. The reformer may provide feedback to the participant by encouraging proper muscle activation and body alignment. The combination of the moving carriage and the participant pulling on the ropes enhances spinal movement and flexibility. The perturbation of the carriage encourages both shoulder and spinal stability and control.

The hundred exercise on the reformer offers resistance through pulling on the ropes, which engages the abdominal muscles. The backward motion of the carriage facilitates flexion of the spine. Once in the full c-curve position (spinal flexion), the reformer provides a system of continuous feedback. Attempting to maintain a motionless carriage helps to promote a stable shoulder girdle and a flexed spine.

A larger percentage of maximum voluntary contraction was noted for the rectus abdominus and the external oblique during the hundred on the reformer when compared to mat hundred. It is possible that the reformer facilitates a more effective c-curve which would require greater abdominal muscle activation. This is important clinically to improve spinal mobility and core strength for functional activity and posture. In addition this increased spinal flexion is important for reducing the risk of injury caused by anterior shear on the lumbar spine (4).

The upper trapezius muscle activity was greater when performing the hundred on the reformer compared to hundred on the mat. When performing the hundred, it is important to avoid excessive lower cervical spine flexion which increases the risk of cervical translation (4). It is possible that the greater activation of the trapezius limits lower cervical spine flexion. A common cue used by Pilates instructors during the hundred exercise is to reach out of the top back of the head. This may explain the greater trapezius activation in the experienced Pilates participants.

The long stretch exercise on the reformer provides movement at the glenohumeral joint in a closed kinetic chain, whereas the glenohumeral joint is fixed via isometric muscle contractions during the leg pull-front. The movement of the reformer carriage challenges both dynamic and static stability of the spine and shoulder girdle. The unique resistance of the springs as the carriage moves causes a concentric contraction in one direction and facilitates an eccentric contraction in the opposite direction. The Pilates participant is guided by the movement of the carriage. The opening movement of the carriage provides proprioceptive feedback. If the reformer carriage opens too far, the participant loses exercise form. If the participant does control the carriage, the carriage will close rapidly making a loud noise.

Greater muscle activation was measured for the serratus anterior, rectus abdominus and external oblique during the long stretch on the reformer when compared to the activation of these muscles during the leg pull-front on the mat. The dynamic upper extremity weight bearing position during the long stretch exercise may explain the greater activation of the serratus anterior when compared to the static activity during the leg pull-front. In addition, the movement of the shoulder joint into forward flexion during the long stretch incorporates upward rotation of the scapula for scapulohumeral rhythm. Scapulohumeral rhythm requires additional activation of the serratus anterior and the upper trapezius (4).

The interdigitation of the external oblique with the serratus anterior and the latissimus dorsi creates an additional demand on the external oblique during the long stretch exercise (4). As the serratus anterior activity increases, the external oblique activity also increases. The latissimus dorsi is responsible for shoulder extension, and would be the primary muscle recruited to pull the carriage of the reformer into the closed position. The muscle activation patterns of the serratus anterior and external oblique muscles of the Pilates trained individuals showed greater activity than those of the novice participants. This suggests that regular practice of the long stretch on the reformer may reinforce proper motor patterns.

## **PRACTICAL APPLICATIONS AND RECOMMENDATIONS**

- The feedback provided by the reformer during the hundred exercise enhances the activation of the rectus abdominus when compared to the hundred exercise on the mat. This was more evident with the experienced Pilates participants.
- Upper trapezius activation during the hundred exercise was greater on the reformer. This is important because activation of the trapezius limits translation of the lower cervical vertebrae during cervical spine flexion. This was more evident with the Pilates trained participants, possibly due to the common Pilates cue to reach out of the top back of the head.

- The leg pull-front and long stretch exercises are both effective exercises for activating the serratus anterior and external oblique.
- The long stretch exercise may be more beneficial than the leg pull-front because the feedback of the moving carriage encourage activation of not only the serratus anterior and latissimus dorsi, but also the external oblique. The dynamic characteristics of this exercise requires greater muscle activation than the leg pull-front.
- Typically greater muscle activation was noted in all the participants during the reformer exercises, with the greatest activations generally seen in the experienced Pilates participants. It is possible that the novice participants were not able to utilize all of the potential benefits of the reformer. In the future it would be interesting to see this study replicated with a group of participants with 6-12 months of Pilates experience.
- Future research should examine the activation of the latissimus dorsi because of its interdigitation with the serratus anterior and external oblique.
- This study should be considered as a preliminary step toward future research examining the use of the reformer as a tool for treatment of patients with spinal instability or shoulder girdle dysfunction.

Funding for this project was provided by a grant from Balanced Body, Inc.

**Christine Romani-Ruby, MPT, ATC** is an Assistant Professor and Academic Clinical Education Coordinator for the CAPTE accredited Physical Therapist Assistant program at California University of Pennsylvania. She has co-authored two books and several videos and is the co-founder of PHI Pilates, a corporation that offers continuing education on Pilates. She can be reached at [romaniruby@cup.edu](mailto:romaniruby@cup.edu). Christine recently earned the distinction as a Gold Standard PMA Certified Pilates Instructor.

**Ben Reuter, PhD, CSCS, \*D, ATC** is an assistant professor in the Department of Health Science and Sport Studies at California University of Pennsylvania. He teaches courses in the Exercise Science and Health Promotion. Ben currently serves as an associate editor for the *Strength and Conditioning Journal*, a publication of the NSCA.

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