

**Effect of Horizontal Support on Abdominal Muscle Activation and Load During a
Vertical Chest Press Exercise on a Dual Adjustable Pulley Apparatus**

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Introduction

Within the overall category of strength training equipment, machines may be characterized as fully stabilized or unstabilized. Fully stable devices, either fixed path or cable-based, offer full body support in the presence of a seat or a bench. Unstabilized devices offer no supporting element. These devices are cable-based machines, typically with pulleys that adjust in a vertical direction. Users may elect to employ a seat, bench, or other support platform along with an exercise on an unstable device, but typically, exercises on these machines are performed in a free-standing fashion, with only the ground for support.

One of the advantages of the stable environment is that it can support high work loads, thus encouraging significant gains in strength. By contrast, free-standing exercises, such as the cable chest press, have been shown to limit the amount of load that can be managed, largely because of the need to maintain balance throughout the movement (Santana, et al, 2007).

Advocates of the free-standing exercise claim that the unstable nature of the task raises activation levels in the core musculature to a greater extent than stabilized exercise. Santana and colleagues (2007) did report higher abdominal muscle activity during a free-standing cable chest press as compared to a fully supported bench press. But, the authors measured a unilateral cable press against a bilateral bench press, and differences in muscle activity were seen only on one side of the abdominal wall. Thus, it is unclear as to whether the differences in muscle activation were due to the apparatus or the uneven loading conditions.

Other studies comparing abdominal muscle activity during chest pressing during stable or unstable conditions do indicate an increased level of activation associated with the unstable environment (Lehman, et al, 2006; Marshall and Murphy, 2006). These conditions, however, involve supine positions on inflated balls, as opposed to free-standing postures. Little other research exists, unfortunately, wherein free-standing configurations were evaluated.

Additionally, the research to date has explored differences between an unstable environment, either free-standing or set upon a moving surface, and a fully stabilized context, with bench or seat. No comparison, thus far, has been made between the two extreme conditions and a partially stabilized state. In this context, a partially stabilized chest press would involve a standing posture which is supported at some point along the back by an adjustable support pad, creating a base of support that is larger than the free-standing position, yet smaller than the seated or supine position. This partially stabilized position may span the gap between stable and unstable cable exercises.

The purpose of this investigation, therefore, was to examine the effects of horizontal support on the amount of weight lifted (load) as well as abdominal muscle activation when performing a cable chest press exercise under three conditions: free standing; fully stabilized, with the support placed between the scapulae; and partially stabilized, with the support positioned at the sacrum.

Methods

Twelve subjects, five men and seven women (averaging 22.6 ± 6.4 years of age), participated in this study. Participants had to be healthy, with no known injury that would have been aggravated by, or affected the outcome of this study. Prior to participation, each subject was debriefed on the study protocol and signed the informed consent document.

Each subject was required to perform a ten repetition maximum (10RM) exertion test, followed by three, temporally regulated repetitions, in three conditions: 1) free standing with torso in a vertical position and feet staggered at a distance relative to the subject's height (FS), 2) standing fully stabilized, with horizontal support between the shoulder blades (Sup S), and 3) standing partially stabilized, with horizontal support on the pelvis (Sup P). All exercises were performed using the Cybex Bravo Functional trainer.

Setting the Angle of Convergence

In order to insure consistent force application by the cable apparatus, the angle of convergence of the cable was adjusted to twenty-five degrees for all subjects. The angle of convergence is the angle formed between the line of the cable and a line, perpendicular to the trunk, in the sagittal plane.

The padded support was positioned at the level of the subject's sacrum, with the length of the support arm initially at the shortest setting. The pulleys were placed in a vertical position, and their height was set so that the cable came as close as possible to the subject's acromion process. With the weight of the machine at the lowest setting, the subject lightly grasped the handles, wrists pronated, with the humerus abducted to 60° and with the forearm parallel to the floor.

On cue, the subject pushed the handles forward horizontally, and in a straight line, until their arms were extended, with their hands shoulder width apart. This position was maintained while the tester measured the angle of convergence with a goniometer. If the angle of convergence varied above or below 25° by 1° or more, the horizontal position of the padded support was adjusted until the correct angle of convergence was established.

Establishing Stance for Free-Standing Position

The base of support was normalized for the free-standing condition so that the distance from heel to toe was one-third of the subjects' height. Using the horizontal pad position established while setting the convergence angle, a plumb line was employed to mark the center of stance on the floor. Once the heel-to-toe distance was calculated, in centimeters, marks were placed on the floor, equidistant from the center of stance indicator, denoting foot position in the sagittal plane.

EMG Electrode Placement

Surface electromyography (EMG) was used to measure activation levels in the rectus abdominis and external oblique muscles. The skin was prepared by shaving the area of electrode placement (if necessary), followed by wiping the site with a cotton ball and abrasive skin gel. Lastly, the skin was cleansed with rubbing alcohol.

Electrode position for the rectus abdominis was determined by palpating the abdomen close to the umbilicus. A pair of bipolar electrodes was placed laterally on both the left and right sides of the umbilicus at a distance of approximately 2 cm. The electrodes were oriented in parallel to the muscle fibers, and placed 2 cm apart on center.

Electrode position for the external oblique was determined by palpating the iliac crest and locating the anterior superior iliac spine. A pair of bipolar electrodes was placed 2 cm apart above the anterior superior iliac spine, halfway between the iliac crest and the ribs on both the

left and right sides of the body. The electrodes were placed at a slightly oblique angle so that they ran parallel to the muscle fibers. The placement of EMG electrodes over the rectus abdominis and external obliques is illustrated in figure 1.

Testing Procedures

Subjects performed a pre-testing warm-up on the Powerline Chest Press machine, according to the guidelines outlined in the ACSM's Resources for the Personal Trainer, 2nd Edition.

Subjects completed two sets of 10 repetitions at a prescribed resistance of 40 lbs for men and 20 lbs for women. The repetitions were performed at an established pace of 45 beats per minute, where 2 beats indicated one complete repetition. Each set was separated by a 2-minute rest interval.

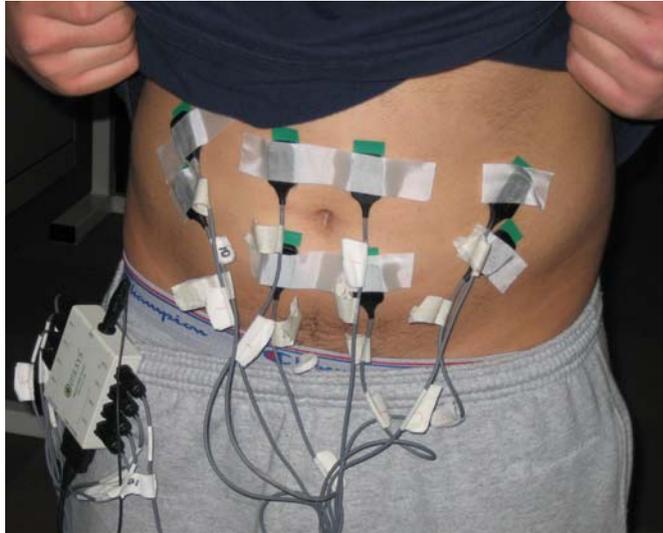


Figure 1. Abdominal EMG electrode placement

10 Repetition Maximum Testing

In order to determine the amount of weight that could be lifted while in each support position, ten repetition maximum testing was conducted.

The pulley height and convergence angle were established first. For the fully stabilized and partially stabilized conditions, the support arm was positioned in accordance with the convergence angle setting, and the subjects stood with their feet directly beneath their hips. For the free-standing condition, the support pad arm was lowered, and subjects assumed the position as outlined above in setting stance for the free-standing position.

With cable handles in hand, the subjects kept their torsos in a vertically oriented position. Their arms were abducted to 60°, and their forearms were held parallel to the floor. Subjects were instructed to begin with their shoulders as far into horizontal extension as comfort would permit.

This position was established and checked for each subject prior to strength testing in the free-standing (FS), partially stabilized (Sup P) and fully stabilized (Sup S) positions.

Description of the Movement

During the 10RM exertion test participants performed the chest press exercise to a set cadence of 45 beats per minute. This was important, not only in normalizing the manner in which strength was determined, but also in creating a constant stimulus to the trunk in order to accurately measure the amplitude of abdominal muscle activity.

At the first beat, the arms were to be fully extended, and at the second beat the arms were to be at the start position. The testing configurations for the three test conditions are illustrated in the figures below.

A relatively low initial workload, established at the discretion of the tester, was selected so that subjects could become familiar with the task. Weight was gradually added so long as the participant could perform the lift correctly for a maximum of 10 consecutive repetitions at a set pace of 45 beats per minute. If at any point during the 10RM exertion test a subject was unable to maintain the cadence, the test was terminated. The 10 repetition maximum was considered to be the greatest load that could be lifted ten times at the prescribed cadence. Subjects attempted to achieve their 10 repetition maximum load within five trials, with approximately 3-5 minutes of recovery between each trail.

After determining their 10 repetition maximum, the subjects were given a rest period of approximately fifteen minutes while the EMG electrodes were applied and tested for functionality. Once the EMG system was deemed to be functioning correctly, the subjects performed three repetitions at the established workload, following the 45 beats per minute cadence. Ten minutes of rest was given between strength tests, after which subjects repeated the procedures at a different degree of stability. The three stabilizing conditions were counterbalanced across all subjects in order to eliminate sequencing effects.

EMG Recordings

EMG data were recorded from the rectus abdominis and external oblique muscles. Differential amplification was conducted with a common mode rejection ratio of 110 dB. Raw data were acquired at a sampling rate of 1024 Hz. Using the raw EMG data, the mean square of the EMG amplitude was used to determine the differences in abdominal muscle activation.



Figure 2. Free standing (FS)



Figure 3. Partial stability, pad at pelvis (Sup P)



Figure 4. Full stability, pad at scapula (Sup S)

Results

The data for workload, as determined by 10 RM testing, are presented in Table 1, and depicted graphically in Figure 5. As indicated in the table, the combined workload (sum of both arms) for the free-standing condition was 20.8 pounds, while that of both the fully supported and partially supported conditions was 65 pounds. These differences were significant at the .01 confidence level.

Table 1. 10 Repetition Maximum for Free Standing (FS), Partial Support (Sup P), and Full Support (Sup S)

	10RM (lbs)	Difference vs. FS
FS	20.8	
Sup P	65.0 *	212 % *
Sup S	65.0 *	212 % *

* p < .01

The conditions of partial and full support both produced workloads that were 212% greater than the free standing position. There were no differences in workload between the two supporting conditions.

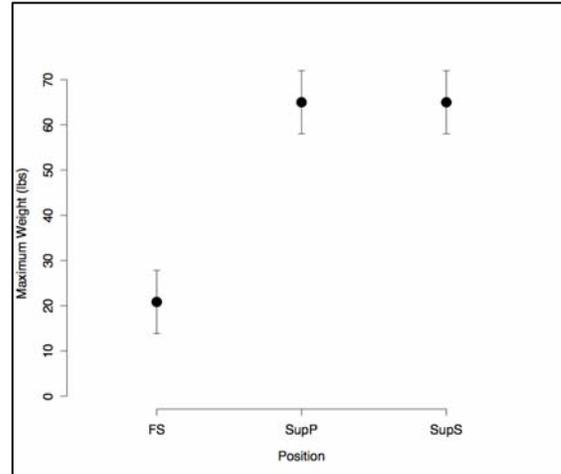


Figure 5. 10 RM workloads for free standing (FS), partial support (Sup P), and full support (Sup S) conditions

EMG data, in microvolts, for the three testing conditions are presented in Table 2, and shown graphically in Figure 6. As indicated in the table, mean square EMG data were 275 mV and 277 mV, for the free-standing (FS) and fully supported (Sup S) positions, respectively. These values were not significantly different.

Table 2. EMG Amplitude for Free Standing (FS), Partial Support (Sup P), and Full Support (Sup S)

	Mean Square of EMG	Difference vs. FS
FS	275	
Sup P	780	184%
Sup S	277	0%

Average EMG amplitude for the partially supported (Sup P) condition was 780 mV. This value was nearly three times, or 184% greater than both the free-standing and fully supported positions, and was significant at the .01 confidence level.

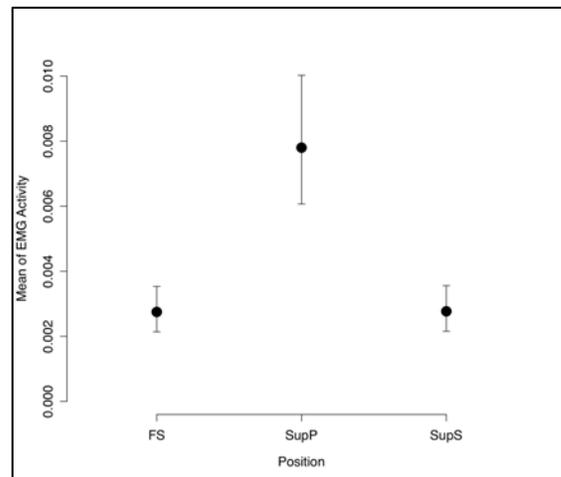


Figure 6. Mean EMG data for free standing (FS), partial support (Sup P), and full support (Sup S) conditions

Discussion

The results of this study support the findings of Santana et al (2007) that performing a cable chest press in a free-standing position limits the amount of weight that can be lifted. In this case, subjects were capable of lifting only 32% as much weight as they could if they were provided some degree of postural support.

Interestingly, there was no difference in workload capacity between the fully and partially supported conditions. One might have expected a difference here, since the support pad, in the partial stability condition, was placed at the sacrum. This would have left the trunk without support, potentially resulting in reduced workloads. The results suggest, however, that despite the absence of trunk support, there was enough torso stability to accommodate the same high workloads associated with a fully stable postural set. This finding is consistent with the EMG data, and the level of muscle activation arising during this task.

As revealed in this study, abdominal muscle activity during the partially stabilized condition was 184% greater than the fully stabilized condition. This is not altogether unexpected. With the support pad placed at the sacrum and the line of force located at the shoulders, a significant torque was applied to the trunk. This torque loading would evoke higher levels of muscle activity in order to provide stability for the trunk, thus also providing support for increased workloads.

A finding that was surprising, on the other hand, was the similarity in muscle activity between the free-standing and fully supported positions. It is a common belief that free-standing cable activities are advantageous because they evoke higher levels of core muscle activity than traditionally stabilized exercises, such as the supine bench press. These findings contradict that theory.

A possible explanation for these results is that subjects, in order to perform the free-standing cable press, have to displace their weight forward, while simultaneously pushing down and back into the ground through their legs. The combination of forward lean and backward push creates a balanced condition around the lumbar spine, with little net torque. Consequently, with little load applied to the spine, there is a reduced need for abdominal muscle activity.

One could argue, therefore, that in the context of overall strength development, there is little advantage to exercising in a free-standing posture, since there seems to be no additional core muscle activity, and workloads are substantially lower. Stable conditions, on the other hand, involve the same degree of core muscle activity, but at much higher workloads.

In conclusion, the data herein reveal that the position which best combines workload capacity with core muscle activity is a standing cable press with partial postural support.

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