Comparison of a Standard Abdominal Curl and Six Different Exercises Using a Portable Abdominal Machine

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ABSTRACT

Twenty subjects were evaluated to test the effectiveness of a portable abdominal device (6 second Abs Machine (Savvier, LP, Carlsbad,CA). The relationship between work and peak surface EMG (sEMG) of a traditional crunch was compared to six different exercises using the 6 Second Abs Machine (SAM). sEMG was used to evaluate the bilateral rectus and oblique muscles. The work accomplished (EMG amplitude x time of contraction) in a crunch was 9 times greater using the SAM device for the Rectus and 11 times greater for the Oblique muscles ($p<0.02$). The sitting reverse exercise was 40 times greater at the oblique muscle and 23 times greater for the rectus musculature. ($p<0.02$).

Average peak sEMG of a SAM crunch compared to a traditional crunch was 39% greater at the Rectus and 37% at the Oblique ($p<0.02$). The sitting reverse crunches increased to 78% at the Rectus and 113% at the Oblique ($p<0.001$) on the SAM compared to the traditional crunch. The SAM provided much greater exercise for the rectus and oblique muscles when performed in a seated and supine position than traditional crunches.

INTRODUCTION

Americans spend millions of dollars each year in the quest for fitness, weight loss and a "flat" stomach (French, Story et al. 2001). There are about 200 or more abdominal exercise devices all claiming to provide a "flat" stomach. Although toned abdominal muscles may look attractive, these core muscles actually serve a very important role in helping to "stabilize" the back. The abdominal muscles and back muscles are key components of the muscular network providing the strength and stability to keep the body upright and for movement (Hodges 1999). When these muscles are in poor condition, additional stress is applied to the spine as it supports the body. Therefore, good abdominal muscle strength is important for trunk stability. Without strong abdominal muscles, posture is poor and the risk for back pain may be greatly increased (O'Sullivan, Twomey et al. 1998; Moseley and Hodges 2005).

The most common exercise used is the partial crunch or variations of the partial crunch (Urquhart, Hodges et al. 2005). Most abdominal exercises are performed without resistance, except in gyms or health clubs where exercise machines are available. To complete a crunch, a person lies supine with the knees bent at about 45 degrees. The head and shoulders are then raised to clear the surface. The position of the upper extremities can be placed next to the sides of the trunk, crossed on the chest, or with the upper extremities in full flexion over the head. By varying the position of the upper extremities different degrees of difficulty or resistance is obtained for the abdominal muscles.

If abdominal exercise is not performed correctly and consistently, the desired strengthening will occur slowly or not have the desired effect (Kisner and Colby 2007). For example, if the feet are held down during a crunch, there is a great likelihood that the hip flexors will be used causing muscle substitution (Kisner and Colby 2007) With substitution of the hip flexors, there will be less strengthening of the abdominal muscles (Kendall and Kendall 1983).

To achieve consistent positions for an optimal abdominal crunch, a portable abdominal device ("6 Second Abs Machine") has been developed (Helewa, Goldsmith et al. 1993; Petrofsky, Bonacci et al. 2003). The device has been used in a supine, sitting or in a sitting position in a swimming pool (Petrofsky, Bonacci et al. 2003). Benefits of this device are consistency of the abdominal exercise and comfortable or pain free movement performed during the different positions of exercise (Petrofsky, Bonacci et al. 2003). The 6 second Abs machine has been studied in different abdominal exercise positions using sEMG analysis (Helewa, Goldsmith et al. 1993; Petrofsky, Bonacci et al. 2003; Petrofsky, Morris et al. 2003; Petrofsky, Cuneo et al. 2005). Past studies have also used sEMG to test the abdominal muscles of the rectus abdominus and the internal oblique's (Allison, Godfrey et al. 1998; Bayramoglu, Akman et al. 2001; McMeeken, Beith et al. 2004; Koumantakis, Watson et al. 2005).

sEMG is a painless and non-invasive way of recording muscle activity (Morrish 1999). sEMG is able to document muscle function by its ability to show electrical activity from muscles contracting during movement and can show muscle imbalance between muscles during movement (Souza, Baker et al. 2001). It has been shown that sEMG can show abnormal muscle substitution during abdominal movement (O'Sullivan, Twomey et al. 1998; Hungerford, Gilleard et al. 2003; Teyhen, Miltenberger et al. 2005)

The purpose of this study was to investigate whether this portable abdominal device was more effective at producing work and peak sEMG with 6 different exercises with the rectus and oblique abdominal muscles when compared to a standard abdominal crunch.

METHODS

Subjects

Subjects were recruited from a flyer posted on the campus of University of Nevada, Reno. Twenty subjects participated in the experiment. Ten were male and ten were female with ages ranging from 20 to 57 with a mean age of 37.5 +/- 12.4 years. Demographics are listed in Table 1. Inclusion criteria were 20-60 years of age and the ability to read and write in English. Exclusion criteria were any low back pain in the past

Table 1. Subjects baseline characteristics.

Sex (male/female)	10/10
Age	37.5 +/- 12.4 years
Height	171.2 +/- 8.7 cm
Weight	70.4 +/- 14.4 Kg

6-months, cardiac or neurological problems. Subjects were also excluded if they were pregnant. All experimental protocols and procedures were approved by the Human Review Committee at the University of Nevada, Reno. The subjects were asked to read and sign the informed consent before agreeing to participate in the study.

Exercise Device:

The 6 Second Abs machine

The "6 Second Abs machine" is a commercial exercise device that is produced by Savvier LP of Carlsbad, California. The device consists of a rectangular plastic frame with elastic bands on the inside to adjust the resistance. To compress the device, the upper part of rectangle is placed under the axilla of the arm and held with a supinated hand grip against the chest and the base of the rectangle is based on the proximal to mid quadriceps muscle. This described previously (Petrofsky, Bonacci et al. 2003).

EMG

Surface electromyogram (Biopac Systems Inc, Santa Barbara, CA) was used to quantify rectus oblique and external oblique activity during exercise. The sEMG was recorded through two bipolar vinyl adhesive 1.75 inch electrodes (silver silver- chloride) with an active circumference of 0.5 cm2. An interelectrode distance of 1cm was used as suggested elsewhere (Basmajian and DeLuca 1985). The sEMG data was amplified using a 4-channel EMG amplifier whose frequency response was flat from DC to 1,000 Hz. The data was normalized to a maximum effort for 3 seconds from the raw EMG as required when comparing muscle groups (Winter 1991; Soderberg 1992; Soderberg and Knutson 2000). The EMG was then digitized at 2,000 samples per second by a Biopac 16-bit analog to an additional converter and displayed and stored in an IBM computer for later analysis. The amplitude of EMG was assessed by half-wave rectifying the raw data and calculating the mean voltage of rectified EMG (Petrofsky, Cuneo et al. 2005).

Statistical Analysis

Statistical analysis involved the calculations of mean, standard deviations, t-tests and repeated analysis of variance (ANOVA). The level of significance was $P<0.05$.

Procedures

The procedures were explained to the subjects and the informed consent was signed. The subjects then picked a single random number that correlated with the sequence of six abdominal exercises preformed using the 6-second abdominal device (counter balance design). The traditional crunch was administered first before the sequence of abdominal exercise.

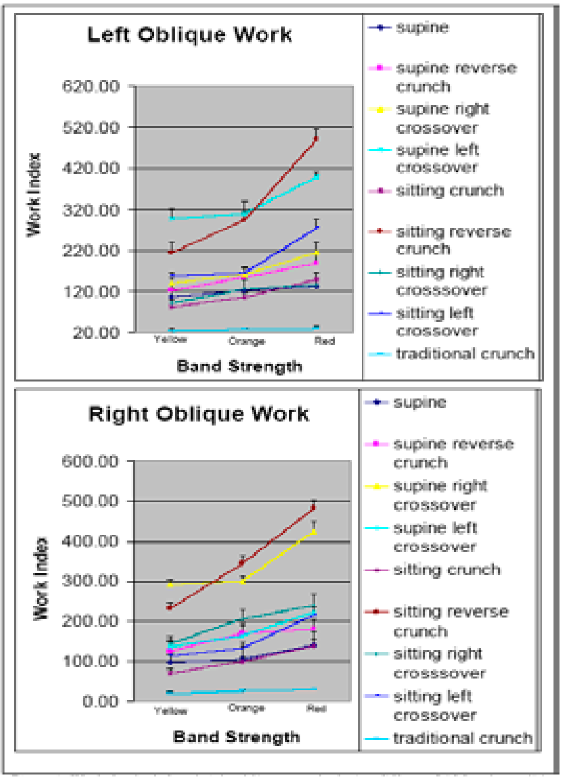
Measurement of Traditional Crunch

The subjects were in the supine position with their hips at 45 degrees. The knees were bent to avoid any subjects that may have short hip flexors creating an anterior tilt of the pelvis and hyperextension of the lumbar spine (Kendall and Kendall 1983). The subjects were asked to perform a sit up while attempting to clear the scapula with their hands behind their head from the table (Kendall and Kendall 1983). Subjects were asked to hold this position for six seconds. sEMGs was used to obtain data from the rectus and oblique muscles.

Testing at different positions using the 6-second abdominal machine

Six different exercises were used with the portable abdominal device along with three different resistance bands. Placement of the sEMG electrodes were the same as the traditional crunch. The six different positions are shown in Figure 1. The subject's resistance was adjusted so they were able to obtain the "third click" in each position before sEMG measurements were taken. If the subject could not achieve the third "click", that level of resistance was not recorded. sEMG was

***Figure 1**. Work for the left and right oblique muscle during different SAM and a traditional crunch. All SAM exercises demonstrated more work than the traditional crunch (p<.001)*



used to collect the data and an average was taken from the three tests in each position.

RESULTS

Figure 1, 2 show the comparison of work (EMG amplitude x time of contraction) with the traditional crunch versus the portable exercise device in 6 different positions. Each point represents the mean for 20 subjects (10 female and 10 male) +/- the SD. Each graph demonstrates the specific muscle, type of exercise performed, and differences using the yellow(low band- 20lbs), orange(medium band- 35lbs), or red band(high band- 50 lbs) with the portable exercise device. All exercises using the portable abdominal device demonstrated increased work vs. the traditional crunch. ($p<0.01$). Work of the traditional crunch, which is the product of a given force acting through a given distance or time, was compared to the average of the left and right rectus and oblique muscles during various excises by the portable abdominal machine. The sitting crunch was 9 times greater using the portable abdominal at the Rectus and 11 times greater at the Oblique muscles vs. a traditional crunch.($p<0.02$). The sitting reverse exercise was 40 times greater at the oblique and 23 times that of the rectus musculature vs. a traditional crunch. ($p<0.02$).

Average peak sEMG of sitting crunch compared to a traditional crunch was 39% greater at the Rectus and 37% at the Oblique ($p<0.02$).. The sitting reverse crunch increased to 78% at the Rectus and 113% at the Oblique ($p<0.001$).

DISCUSSION

There are greater benefits to having stronger abdominal musculature than appearance alone. Low back pain is considered to be one of the most common physical complaints occurring in adults (Moseley and Hodges 2005) and cited with corresponding weak abdominal musculature (Addison and Schultz 1980; Helewa, Goldsmith et al. 1999).

Injury, deconditioning from inactivity and obesity all contribute to low back pain. Muscles controlling the trunk become weaker due to muscle inhibition brought on by chronic pain or acute injury (Helewa, Goldsmith et al. 1993; O'Sullivan, Twomey et al. 1998).

With chronic low back pain there has been some discussion as to whether increased intra abdominal pressure lends support to the lumbar spine or if there is improved motor control of the trunk from increase in abdominal strength (Moseley and Hodges 2005).

Core stability is described as the product of motor control and muscular capacity of the lumbo-pelvic-hip complex (Leetun, Ireland et al. 2004). The spine is dependent upon active muscles for stability (Cholewicki and McGill 1996). It has been demonstrated that submaximal levels of muscle activation are adequate in the healthy population for effective spine stabilization (Cholewicki and McGill 1996). The abdominal muscles play a key role in this complex with external loads and support during dynamic movements (Juker, McGill et al. 1998; Barr, Griggs et al. 2005).

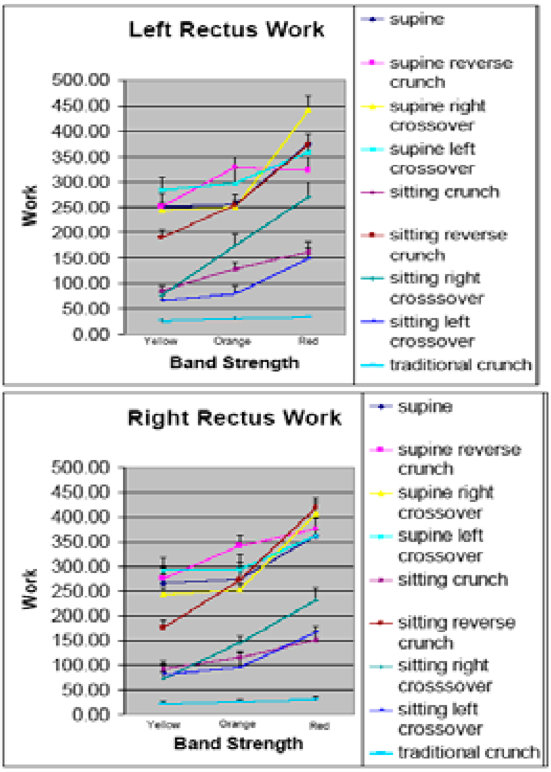
One study concluded that not all physical therapists are testing the abdominal strength in patients with low back pain (Rone-Adams, Shamus et al. 2004). This is of concern considering that stability of the spine is essential during daily forces that challenge to our bodies with everyday activities of daily living (Hubley-Kozey 2005).

The literature has various conclusions when using portable abdominal strengthening machines compared to a standard crunch. Abdominal sEMG recordings indicated that the standard abdominal crunch, sit-up, and specific abdominal strengthening devices (AbFlex, AbRoller, AbWorks, and the Nautilus crunch machine) all had similar results in respect to muscle activation (Avedisian, Kowalsky et al. 2005). There have been other studies conducted analyzing the effectiveness of other abdominal strengthening devices such as the Abvice, AbRocker, Sissel ball, Ab Trainer, Abslide, and the Fitball (Clark, Holt et al. 2003; Hildenbrand and Noble 2004; Avedisian, Kowalsky et al. 2005).

For instance, comparison of sEMG study of a standard crunch vs. the Abworks device concluded that both exercises had similar recruitment of abdominal muscles. However, the Abworks provided a more stable neck and back support, while the conventional curl-up required more hip-flexor involvement (Leung 2005). Conversely, other studies using the same portable exercise device saw an increase in abdominal strength (Petrofsky, Bonacci et al. 2003; Petrofsky, Morris et al. 2003; Petrofsky, Cuneo et al. 2005) along with better balance and functional reach in the geriatric population (Petrofsky, Cuneo et al. 2005).

Our study found a significant increase in peak sEMG and work when comparing the traditional crunch to the six different positions using the six-second abdominal machine. Our average sEMG results also took into account the three different resistances used with the six-second abdominal machine. A prior study compared a traditional crunch using the six-second abdominal device and found a 15% increase in work targeting the same abdominal muscles using sEMG (Petrofsky, Bonacci et al. 2003). Our results were similar at 9 times greater using the portable abdominal at the Rectus and 11 times greater at the Oblique muscles

Figure 2. Work for the left and right rectus muscle during different SAM exercises and a traditional crunch. All SAM exercises demonstrated more work than the traditional crunch (p<.001).



($p<0.02$). The sitting reverse exercise was 40 times greater at the oblique and 23 at the rectus musculature. ($p<0.02$). This work increase may be higher in some areas secondary to using more exercises in the gravity dependent position i.e., sitting reverse crunch.

Our data did not include subjects that could not obtain a "3rd click" during the exercise. Because of the progressive resistance of this device, the work at the abdominal area continued to increase as the subjects attempted a higher band and a 3rd click. Abdominal muscle fatigue can be achieved quicker with a progressive resistance vs. having to attempt increase repetitions with a traditional crunch to gain comparable muscle fatigue. Increase repetitions could stress joints at the low back, especially people who have low back pathology.

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