

# ASSESSMENT OF A COMMERCIAL ABDOMINAL EXERCISE DEVICE AND A CONVENTIONAL CURL-UP EXERCISE: A COMPARATIVE ELECTROMYOGRAPHIC ANALYSIS

Raymond Leung

*University of Southern Indiana, Evansville, Indiana, USA*

Recently, some commercial abdominal exercise devices have come to the market and have become popular with the public. The objective of the present study was to examine whether differences in the electromyographic (EMG) activity existed between abdominal exercises, as performed using a selected commercial device, the AbWorks, and a conventional curl-up exercise. Using surface electromyography, the relative peak and mean EMG activities of the sternocleidomastoid, sacrospinalis, rectus abdominis, external oblique and rectus femoris were assessed during the two modes of abdominal exercises. Thirty-three subjects aged  $22.4 \pm 4.9$  years (body mass index =  $25.6 - 5.1 \text{ kgm}^{-2}$ ; waist circumference =  $0.8 \pm 0.1 \text{ m}$ ) performed four repetitions of crunch start curls, and four repetitions of oblique start curls on both the AbWorks and the conventional curl-up. To assess the differences in the relative peak and mean EMG activities between the two exercise modes, repeated measures ANOVA ( $\alpha = 0.05$ ) were conducted. For both the sternocleidomastoid and sacrospinalis muscles, the AbWorks-performed abdominal exercise resulted in significantly ( $p < 0.05$ ) lower relative peak and mean EMG activities than those of the conventional curl-up. For both the rectus abdominis and external oblique muscles, no significant ( $p > 0.05$ ) differences in the relative peak and mean EMG activities were found between the two exercise modes. For the rectus femoris muscle, the AbWorks exercise generated significantly ( $p < 0.05$ ) higher relative peak and mean EMG activities than those of the conventional curl-up. To conclude, the AbWorks and the conventional curl-up are similarly effective in recruiting the abdominal muscles. The use of the AbWorks provides better neck and back support but the conventional curl-up exercise appeared to be safer, with less hip flexor involvement.

**Keywords:** abdominal exercise, curl-up, electromyographic activity

## Introduction

The sit-up/curl-up has long been identified and used as an exercise for conditioning abdominal muscular endurance, which is the ability of the abdominal muscle

to perform repeated contractions over time, sufficient to cause muscular fatigue (American College of Sports Medicine, ACSM 2000). However, the procedures for the correct execution of the sit-up/curl-up have always been a controversial issue. During the 1950s and 1960s, the sit-up tests with legs straight, ankles anchored and the trunk being raised to approximately vertical from a supine starting position were typically used in most health-related fitness assessment batteries (Juker et al. 1998; Axler & McGill 1997; Sparling et al. 1997; Diener et al. 1995; Alaranta et al. 1994; Hall et al. 1992; Faulkner et

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### Corresponding Author

Raymond Leung, University of Southern Indiana, 8600 University Blvd., Pac 314, Evansville IN 47712 USA  
Fax: 812-465-7094  
rleung@usi.edu

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al. 1989; Robertson & Magnusdottir 1987). Research nevertheless has revealed that the sit-up with such execution causes anterior pelvic tilt, which could potentially lead to low back pain as a result of recruiting the unwanted hip flexor muscles.

The objective of performing abdominal exercise is to condition the abdominal muscles. However, the traditional leg-straightened ankle-stabilized sit-up exercise was found to recruit not only the abdominal muscles but also the hip flexor muscles (Hall et al. 1990; Alexander 1985; Vincent & Britten 1980; Nachemson 1976; Girardin 1973). The abdominal muscles consist of four major muscles (Moore & Agur 2002; Guyton & Hall 2000). From the most superior to the most inferior, the abdominal muscles are the rectus abdominis, the external obliques, the internal obliques and the transversus abdominis. The hip flexor group is composed of the iliopsoas and the rectus femoris (Moore & Agur 2002; Guyton & Hall 2000). When the abdominal muscles contract, they pull the pelvis into a posterior tilt position, which causes the back to flatten. The contraction of the hip flexor group has the opposite effect, which increases anterior pelvic tilt by hyperextending the lower back. If the abdominal muscles are not strong enough to counteract the force generated by the hip flexors, there is an increased risk of the development of lumbar lordosis. Anterior pelvic tilt is undesirable during the execution of abdominal exercise, as the hyperextension of the back and compression on the intervertebral discs is increased markedly. So too is the stress applied to the posterior vertebral structures such as ligaments, neural arch and facet joints (Hall et al. 1990; Alexander 1985; Vincent & Britten 1980; Nachemson 1976; Girardin 1973).

As a result of the potentially negative consequences of performing the traditional sit-up exercise, the curl-up exercise was introduced during the 1970s and 1980s. The main variation in which the curl-up differed from the sit-up was that the curl-up exercise requires a trunk elevation of 30° to 45° from a supine position, instead of a 90° trunk raise. This difference in trunk elevation angle is critically imperative in determining the relative muscular recruitment between abdominal muscles and hip flexor muscles. Research has identified that abdominal muscles accounted for only the first portion of the sit-up during the initial 30° to 45° of trunk flexion, while the remaining movement until the body becomes verti-

cal was accomplished by the hip flexor muscles (Macfarlane 1993; Robertson & Magnusdottir 1987; Mutoh et al. 1983; Ricci et al. 1981; Vincent & Britten 1980; Flint 1965). As a result, a substitute exercise was sought, which would recruit the abdominal muscles but not the hip flexors during the entire range of motion. Subsequently, the curl-up was developed, in which the body was raised from a supine position to approximately 30° to 45° during the exercise. Researchers indicated that performing the curl-up resulted in a greater demand on the abdominal muscles and a smaller demand on the hip flexors during the entire range of motion. In addition, the knee-bent ankle-unanchored curl-up exercise was found to reduce hip flexor activity, as opposed to the leg-straightened ankle-stabilized form (Macfarlane 1993; Robertson & Magnusdottir 1987; Mutoh et al. 1983; Ricci et al. 1981; Vincent & Britten 1980; Flint 1965).

In recent years, many abdominal exercise device manufacturers have been marketing their machines as the better equipment for training the abdominals. Exercise science and fitness professionals were often asked if those abdominal exercise machines were more effective in recruiting the abdominal muscles and whether those devices were safer than conventional abdominal exercises without using the equipment. Therefore, the present study served as an independent scientific trial to examine this matter by comparing a selected commercial abdominal exercise device, the AbWorks, and a conventional curl-up exercise. The specific objective of this study was to examine whether differences existed in the peak and mean electromyographic (EMG) activities of the neck flexor muscle (sternocleidomastoid), the back muscle (sacrospinalis), the prime longitudinal abdominal muscle (rectus abdominis), the obliquely-arranged abdominal muscle (external oblique) and the surface hip flexor muscle (rectus femoris) during the AbWorks-performed abdominal exercise, compared with the conventionally-performed curl-up.

## Methods

### Subjects

A total of 33 subjects (17 males and 16 females) volunteered to participate in the study. All subjects were university students, ranging in age from 18 to 32 years. The

physical characteristics of the subjects are presented in the Table. All subjects were required to complete an informed consent form and a medical history form prior to testing. Subjects reporting any history of acute and chronic low back pain or other contraindication to exercise, as suggested by the ACSM guidelines (ACSM 2000), were excluded from the study. The subjects were instructed to refrain from abdominal exercise for 48 hours before testing. Any subject not completing all testing sessions was excluded from data analysis. In an attempt to control for body composition, which would affect the range of motion of trunk curl during testing, each subject was required to have a body mass index (BMI) of less than  $30.0 \text{ kgm}^{-2}$ , a BMI of more than  $18.5 \text{ kgm}^{-2}$ , and a waist circumference smaller than 1.02 m and 0.88 m for male and female, respectively. These values were considered to be normal and non-obese as suggested by the ACSM guidelines (ACSM, 2000).

### **Treatment designs and procedures**

Subjects were instructed to perform abdominal exercises using the AbWorks and the conventional curl-up, with a variation of two different starting positions. As a result, each subject performed a total of four forms of abdominal exercises for testing. For variation one (crunch start position), the subjects started from a supine position with the face directing along the saggital plane. The subjects then curled-up the upper body along the saggital plane with the hip as the axis of rotation. For variation two

(oblique start position), the upper body of the subjects started from an obliquely-rotated supine position. The subjects rotated the upper body so that the right hand was placed against the left forearm.

### **Practice sessions**

Prior to any testing, the subjects were taught to perform the four forms of abdominal exercises correctly. Each subject was instructed to perform each particular abdominal exercise in a five-second cycle. This cycle consisted of a one-second concentric upward phase, then a one-second isometric hold, followed by a one-second eccentric downward phase. A two-second rest interval was introduced between consecutive repetitions to allow muscular relaxation between adjacent cycles. A metronome (Country Technology, Model DM-20, Gays Mills, WI) set at 60 beats per minute was used to ensure a uniform angular velocity of each repetition. The subjects were given 10 minutes to practice as many repetitions as they needed until they demonstrated the correct movement in cadence with the metronome. For the AbWorks exercise, the subjects were instructed to lie on the AbWorks with both feet on the floor and position the body so that the head was on the support pad. The subjects then grasped the overhead handles and kept the head in contact with the pad at all times. The subjects used the abdominals to raise the shoulders and back off the floor and curled up to a crunch position so that the head, hands, and entire upper body worked in unison (AbWorks: Owner's Guide, 1996). For the conventional curl-up exercise, the subjects were instructed to assume a supine position on a mat with the knees bent at  $90^\circ$  and the feet flat on the floor with hands placed on the thighs. The subjects then curled up and slid the hands up the thighs until the finger tips reached the knee caps. Afterwards, the subjects curled down and returned slowly to the starting position. A 1.5 cm thick exercise mat was provided during the conventional curl-up exercise.

### **Testing sessions**

Each subject performed four repetitions of each of the four forms of abdominal exercises as described in the practice sessions. The four forms of abdominal exercises were conducted using a Latin-square design to randomize the testing order. An interval of a three-minute

**Table 1.** Physical characteristics of the subjects

	Total (n = 33)	Males (n = 17)	Females (n = 16)
Age (year)			
M	22.4	21.0	23.8
SD	4.9	3.8	4.6
Mass (kg)			
M	63.5	71.9	53.5
SD	7.8	6.8	5.7
Height (cm)			
M	169.7	175.5	158.2
SD	10.1	9.1	7.8
Body Mass Index ( $\text{kgm}^{-2}$ )			
M	25.6	26.7	22.8
SD	5.1	5.5	4.9
Waist Circumference (cm)			
M	81.5	88.2	74.1
SD	12.1	6.5	5.7

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rest was given between consecutive four repetition exercises to minimize abdominal fatigue. All abdominal exercises were performed with knees bent at a 90° angular displacement measured by a double-armed goniometer (Preston, Lafayette Ins., Lafayette, IN). The feet or ankles of the subjects were left unanchored. The subjects were asked to maintain a constant angular velocity during the entire range of motion of each repetition and to stay in the supine position until the next repetition was initiated by the metronome. The subjects were instructed to maintain a slow, constant and rhythmic movement with no jerking throughout the exercise. In addition, the trunk elevation angle was regulated by an inclinometer (Baseline, Fabrication Ent., Irvington, NY). For all exercise testing, the trunk elevation angle was limited to be no greater than 45°. A test administrator monitored and instructed the subjects to stop the continual trunk elevation when the initial 45° angle was completed during the one-second concentric upward phase.

#### ***EMG recording and data acquisition***

A multichannel EMG recording system (Therapeutics Unlimited, Model 544, Iowa City, IA) was employed for EMG data acquisition and recording. Silver/silver chloride disk surface electrodes (Medical-Surgical, Model 2258, St. Paul, MN), with a diameter of eight mm were placed in parallel to the muscle fibers being tested in a bipolar configuration for EMG recording. The raw EMG data acquired at a rate of 1,000 Hz were amplified, filtered, rectified and smoothed. Cross talk was minimized by placing the electrodes as close to each other as possible, provided that no overlapping of electrode components occurred. To ensure minimal electrode positional movement and better skin-electrode contact, all electrodes and their connections were secured with adhesive tape. For electrode positioning, the subjects were prepared with palpation to establish electrode placement landmarks. The hairs around the electrode locations were shaved, and the skin was wiped with alcohol and abraded with cotton gauze to lower cutaneous electrical impedance. The surface electrodes were then applied to the muscles to be tested. For the sternocleidomastoid, the electrodes were placed midway between the mastoid process of the occipital bone and the sternoclavicular joint (Moore & Agur 2002; Guyton & Hall 2000). For the sacrospinalis, the electrodes were

positioned three cm lateral to the spine, at the level of the third lumbar vertebra. For the rectus abdominis, the electrodes were located to the right of the midline and three cm lateral to the umbilicus. For the external oblique, the electrodes were placed in the coronal plane, mid-distance between the iliac crest and the costal margin. For the rectus femoris, the electrodes were positioned along the muscle belly, converging on the quadriceps tendon, which extended to the patella and continued as the patellar ligament and inserted on the tibial tuberosity (Moore & Agur 2002; Guyton & Hall 2000). All electrode sites were positioned on the right side of the body midline to ensure consistent measurements. A ground electrode for all measurement channels was located on the right acromion. The EMG measurements were guided by the reference by Soderberg (1992).

#### ***Data analysis***

For the EMG data acquired, only the data of the second and third repetitions were utilized and averaged for analysis. For each subject, the peak and mean EMG data during the testing on the AbWorks and the conventional curl-up in each variation of abdominal exercise were collected. To examine the differences in the peak and mean EMG data for each muscle, repeated measures two-way ANOVA (mode × variation) were utilized. *Post hoc* examination of significant ANOVA consisted of paired t-tests to examine the differences between exercise modes using the AbWorks and the conventional curl-up; and between exercise variations on the crunch and oblique positions. An alpha level of  $p < 0.05$  was set to indicate significance.

## **Results**

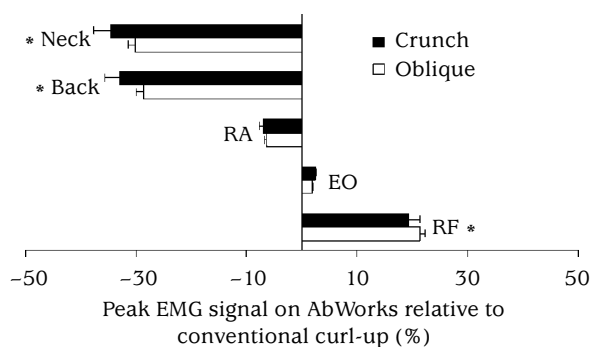
The EMG data measured during the conventional curl-up were employed as a representation of 100% muscle activation. The EMG activity measured on the AbWorks was expressed relative to that of the conventional curl-up. Specifically, the averaged relative peak and mean EMG activity measured on the AbWorks were calculated as the respective percentage of that of the corresponding conventional curl-up. For the relative EMG activity of each muscle, several differences were found between abdominal exercises as performed using the AbWorks

and the conventional curl-up for the two exercise variations (Figures 1 and 2).

For the sternocleidomastoid muscle, abdominal exercises as performed using the AbWorks resulted in significantly lower relative EMG activity than that of the conventional curl-up in both variations of exercise ( $p < 0.05$ ). For the crunch position type, the use of the AbWorks resulted in 34.5% ( $p < 0.01$ ) lower peak EMG activity and 39.3% ( $p < 0.01$ ) lower mean EMG activity relative to the conventional curl-up. Similarly, for the oblique position form, the peak and mean EMG activities detected during the AbWorks-performed exercise were 30.1% ( $p < 0.01$ ) and 38.8% ( $p < 0.01$ ), respectively, lower than those detected on the conventional curl-up.

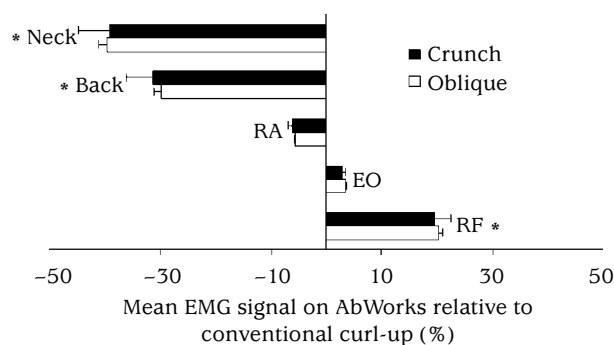
For the sacrospinalis muscle, the AbWorks exercise resulted in significantly lower relative EMG activity than that of the conventional curl-up in both exercise variations ( $p < 0.05$ ). Regarding the crunch form, the AbWorks exercise resulted in 32.6% ( $p < 0.01$ ) lower peak EMG activity and 29.7% ( $p < 0.01$ ) lower mean EMG activity, compared with the conventional curl-up. Similarly, with respect to the oblique type, the peak and mean EMG activities measured during the AbWorks exercise were 28.5% ( $p < 0.01$ ) and 31.2% ( $p < 0.01$ ), respectively, lower than those measured on the conventional curl-up.

For the rectus abdominis muscle, no significant ( $p > 0.05$ ) differences in both the relative peak and mean EMG



**Fig. 1** Comparisons of peak electromyographic (EMG) signal (%) of AbWorks exercise, relative to conventional curl-up (100% activation) between two exercise variations of crunch and oblique start positions for the following muscles: sternocleidomastoid (neck), sacrospinalis (back), rectus abdominis (RA), external oblique (EO) and rectus femoris (RF). Crunch: crunch start position. Oblique: oblique start position.

\* Significant difference between AbWorks and conventional curl-up exercise ( $p < 0.05$ ).



**Fig. 2** Comparisons of mean electromyographic (EMG) signal (%) of AbWorks exercise relative to conventional curl-up (100% activation) between two exercise variations of crunch and oblique start positions for the following muscles: sternocleidomastoid (neck), sacrospinalis (back), rectus abdominis (RA), external oblique (EO), and rectus femoris (RF). Crunch: crunch start position. Oblique: oblique start position.

\* Significant difference between AbWorks and conventional curl-up exercise ( $p < 0.05$ ).

activities were observed between abdominal exercises, as performed using the AbWorks and the conventional curl-up for both exercise variations. For the external oblique muscle, no significant ( $p > 0.05$ ) differences were detected in the relative peak and mean EMG activities between AbWorks-performed and conventionally-performed abdominal exercises. No significant ( $p > 0.05$ ) differences were found between the two variations of exercise (crunch and oblique start position) for either the sternocleidomastoid, sacrospinalis, rectus abdominis or rectus femoris. Significantly higher peak (45.4%,  $p < 0.01$ ) and mean (48.2%,  $p < 0.01$ ) external oblique EMG activities in oblique form than those in crunch position were evident.

For the rectus femoris muscle, significantly ( $p < 0.05$ ) higher relative EMG activity was found in abdominal exercises as performed using the AbWorks than that of the conventional curl-up in both variations of exercise. For the crunch position form, the AbWorks-performed abdominal exercise resulted in 19.6% ( $p = 0.022$ ) higher peak EMG activity, and 20.2% ( $p = 0.019$ ) higher mean EMG activity when compared with those performed conventionally. For the oblique position type, the AbWorks exercise resulted in 21.5% ( $p = 0.012$ ) and 19.5% ( $p = 0.022$ ) higher peak and mean EMG activities, respectively, than those of the conventional curl-up.

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## Discussion

The present study was designed to compare abdominal exercises as performed with a commercial device (AbWorks) versus without device (conventional curl-up), in terms of neck, back, abdominal and hip flexor muscle activation assessed by surface electromyography. Major findings indicated that the use of the AbWorks resulted in lower neck and back muscle involvement, similar abdominal muscle recruitment and greater hip flexor muscle participation, as compared with the conventionally-performed curl-up. Specific findings and their implications are discussed as follows.

With respect to neck and back muscle activity, abdominal exercises performed using the AbWorks generated less sternocleidomastoid and sacrospinalis muscle activation compared with activity performed with the conventional curl-up. The lower neck and back muscle involvement during the AbWorks-performed exercise might be attributed to the head and back support pad that provided improved support for the head, neck and back. This finding in the present independent scientific trial supported the claim by the AbWorks for better neck and head support while using the device.

With regard to abdominal muscle activity, no statistical difference in the rectus abdominis muscle activation was observed between abdominal exercises as performed using the AbWorks and the conventional curl-up. Despite this finding, the AbWorks-performed abdominal exercise tended to generate lower rectus abdominis muscular activity than that of the conventional curl-up. Although the differences were slight (approximately 5 – 7%), a speculative reason may be worth explaining. The slightly lower rectus abdominis involvement using the AbWorks might be explained by the enhanced upper-body stability provided by the device. Owing to the fixation of the hands onto the overhead handles and the support of the back pad while using the AbWorks, an increased tendency for the subjects to use the shoulders and arms to initiate the movement may have occurred. As a consequence, relatively less may have been required from the rectus abdominis to function as the prime muscle for trunk elevation; or possibly a delayed onset of abdominal activation may have occurred. In comparison, during the conventional curl-up exercise, owing to the hand placement on the thighs without hand fixation, the

abdominals may be required to a greater extent during the entire range of motion. For the external oblique muscle activity, no difference was found in the EMG activity between the AbWorks and curl-up exercises, whereas a significant EMG difference was evident between the two variations of exercise (crunch and oblique start positions). This finding was as anticipated, and the higher external oblique muscle activation during the oblique start exercise was due to the direct involvement of external oblique for side curls.

In terms of hip flexor muscle activity, abdominal exercises performed with the AbWorks resulted in higher EMG activity in the rectus femoris than exercises performed on the conventional curl-up. The difference in muscle activation in this regard did not appear to be intuitively logical, as the lower body of the subjects has already been standardized to perform all exercises with knees bent at 90° and ankles unsupported. From the observation of the investigator during testing, a possible biomechanical explanation for this difference might relate to the structural design of the AbWorks. Although the legs of the subjects were instructed to position on the ground with knees bent at a standardized 90° angle during all exercises, the support pad of the AbWorks elevated the upper body to a higher plane relative to the feet. Therefore, the hip of the subjects may have been placed into an anterior pelvic tilt position prior to the start of the exercise, thus pre-exposing the hip flexors for increased activity. In contrast, the subjects performing the conventional curl-up on an exercise mat with the body and the feet positioned on the same elevation, thus placed the hip in a posterior pelvic tilt position. In addition, during the use of the AbWorks, the body tended to curl from proximal to distal. With concentration of the feet on ground and hands on overhead handles for stabilization, spinal flexion progressed from the proximal end of the trunk, which was approximately the location of the hip flexor. On the other hand, during the conventional curl-up exercise, the body tended to curl from distal to proximal. The subjects initially concentrated on the shoulder movement and progressed from the thoracic spine to the lumbar spine. These speculative observations deserve further investigation.

Unique to the present study was the use of an inclinometer to regulate and control the range of motion of the trunk elevation angle during all abdominal exercise

tests. Numerous research has revealed that the initial 30° to 45° of the trunk curl from a supine position was generated primarily by the contraction of the abdominal muscles. The further 45° to 90° of the trunk elevation increased the involvement of the hip flexors (Macfarlane 1993; Robertson & Magnusdottir 1987; Mutoh et al. 1983; Ricci et al. 1981; Vincent & Britten 1980; Flint 1965). Therefore, the trunk elevation angle of all abdominal exercises under investigation in the current study was standardized to be no larger than 45° by an inclinometer. From the observation of the investigator, the use of an inclinometer was feasible and crucial in standardizing the angle of trunk elevation during abdominal exercise tests. Secondly, the EMG measurement on the conventional curl-up was used as the representation of 100% muscle activation. Because the primary objective of the study was to assess the effectiveness of the AbWorks in comparison to the conventional curl-up, the EMG measurement on the AbWorks was expressed relative to that measured on the conventional curl-up. The use of relative measure, instead of absolute measure, to compare the magnitude of muscle activation between the use of the AbWorks and the conventional curl-up was imperative because different muscles had varying degrees of absolute EMG measures. Hence, the relative expression of the EMG results allowed comparable examinations across muscles. Thirdly, a metronome was employed to regulate the uniform curling velocity of the execution of each repetition of abdominal exercise. The use of a metronome for this purpose has been found to be important to standardize the speed of trunk curl in the study by Gutin and Lipetz (1971).

Several considerations impacted the design of the study. Firstly, attempts have been made to select the type of conventional curl-up exercise in the present study as control. Although many different versions of curl-ups were available (Juker et al. 1998; Axler & McGill 1997; Sparling et al. 1997; Diener et al. 1995; Alaranta et al. 1994; Norris 1993; Hall et al. 1992; Faulkner et al. 1989; Robertson & Magnusdottir 1987; Robertson 1987), they might be far from the purpose of practical everyday-life use. Therefore, the selection of the layman-type curl-up fulfilled the practical aspect of the study with procedural considerations of exercise testing adhered to the ACSM guidelines (ACSM, 2000). Secondly, with regard to the design of exercise variation (crunch and oblique start

position), the selection of this variation was based on the instructions accompanying the AbWorks manual (AbWorks: Owner's Guide, 1996). Therefore, the AbWorks was used according to the manufacturer's specifications. Thirdly, as a consequence that the main aim of this study was to evaluate the use of equipment during abdominal exercise, no attempts were made to compare the present findings with the previous literature investigating different movement forms of sit-up/curl-up (Andersson et al. 1995; Piering et al. 1993; Jette et al. 1984; Griffin 1983; Kelley 1982; Gilliam & Roy 1980; Halpern & Bleck 1979; Godfrey et al. 1977; Lipetz & Gutin 1970; Walters & Partridge 1957). Previous sit-up/curl-up related research built solid foundations upon different performance forms of abdominal exercise, such as leg-straightened versus knee-bent and ankle-stabilized versus ankle-unanchored, in recruiting abdominal musculature. The current study elaborated on previous foundations to investigate the effectiveness of commercially-available abdominal exercise equipment.

The findings of the present study indicate that the use of the AbWorks offers better neck and back support but causes undesirable hip flexor involvement, while abdominal muscular recruitment is similar to the curl-up conventionally performed without equipment. Particular attention should be paid to the validity and safety of performing abdominal exercise. The underlying principle of practicing valid and safe abdominal exercise is to maximize the involvement of the abdominal muscles and to eliminate the participation of the hip flexor muscles. Abdominal exercise merely providing neck and back support does not necessarily reduce the risk of back pain. With respect to muscle involvement, the activation of the hip flexor muscles during abdominal exercise causes the pelvis to tilt anteriorly and the lower back to hyperextend excessively, thus potentially leading to back pain.

In a nutshell, the use of equipment may assist in encouraging and motivating users to exercise, but individuals should bear in mind that the key to condition the abdominal musculature validly and safely is to follow the principles that the trunk elevation angle should be less than 45° (not 90° or body vertical), the knees should be flexed (not straightened), and the ankles should be unanchored (not held by a partner or an obstacle).

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