Efficacy of Instability Resistance Training

Introduction

A recent trend in strength and conditioning regimens is the use of the stability ball as a platform for upper-body resistance training. The incorporation of the stability ball as a base for upper-body resistance training may add variety to the training regimen. However, the effectiveness of such training regimens remains largely un-studied. The purpose of this study was to evaluate the influence of platform (unstable vs. stable, stability ball vs. flat bench) on strength and work capacity during barbell chest-press exercise. Fourteen young women (20–23 yr) performed a 1 repetition maximum (1RM) barbell chest-press and the YMCA bench press test (YBT) on a stability ball and flat bench, as well as two field tests measuring abdominal power. The women were then assigned to perform 3 weeks of barbell chest-press training on a stability ball or flat bench on strength, work capacity, and abdominal power. The 1RM barbell chest-press training included 3 sets of 3–5 repetitions at loads greater or equal to 85% of 1RM. The 1RM barbell chest-press, YBT, front abdominal power test (FAPT), and side abdominal power test (SAPT) were used to evaluate changes in strength, work capacity, and abdominal power, respectively. The chest-press tests were completed on both platforms following the training program. The increase in 1RM strength was 15% and 16% on the stability ball and flat bench for the SB group, and 16% and 19% for the FB group, respectively. The increase in work capacity was 32% and 13% on the stability ball and flat bench for the SB group, and 27% and 26% for the FB group, respectively. Both groups significantly improved on the FAPT, and there were no group differences. Performance on the FAPT improved by 5% for the SB group, and 22% for the FB group. Performance on the SAPT did not change. Barbell chest-press training performed on either the stability ball or flat bench increased strength and work capacity, and these changes were transferable across platforms. Thus, the stability ball is an effective platform for barbell chest-press training in untrained women over a short duration.

Abstract

The use of the stability ball as a platform for upper-body resistance training has gained much attention in recent years. However, the efficacy of such training regimens remains largely un-studied. The purpose of this study was to evaluate the influence of platform (unstable vs. stable, stability ball vs. flat bench) on strength and work capacity during barbell chest-press exercise. We also sought to determine the effects of a barbell chest-press training program performed on a stability ball or flat bench on strength, work capacity, and abdominal power. Fourteen young women (20–23 yr) performed a 1 repetition maximum (1RM) barbell chest-press and the YMCA bench press test (YBT) on a stability ball and flat bench, as well as two field tests measuring abdominal power. The women were then assigned to perform 3 weeks of barbell chest-press training on a stability ball (SB group) or flat bench (FB group); assignment was balanced based on 1RM strength. Barbell chest-press training included 3 sets of 3–5 repetitions at loads greater or equal to 85% of 1RM. The 1RM barbell chest-press, YBT, front abdominal power test (FAPT), and side abdominal power test (SAPT) were used to evaluate changes in strength, work capacity, and abdominal power, respectively. The chest-press tests were completed on both platforms following the training program. Platform (stability ball vs. flat bench) had no influence on strength, but work capacity was initially 12% lower on the stability ball compared to the flat bench. In response to training, both groups significantly increased strength and work capacity, and there were no group differences. The increase in 1RM strength was 15% and 16% on the stability ball and flat bench for the SB group, and 16% and 19% for the FB group, respectively. The increase in work capacity was 32% and 13% on the stability ball and flat bench for the SB group, and 27% and 26% for the FB group, respectively. Both groups significantly improved on the FAPT, and there were no group differences. Performance on the FAPT improved by 5% for the SB group, and 22% for the FB group. Performance on the SAPT did not change. Barbell chest-press training performed on either the stability ball or flat bench increased strength and work capacity, and these changes were transferable across platforms. Thus, the stability ball is an effective platform for barbell chest-press training in untrained women over a short duration.
Aside from adding variety to an upper-body resistance training regimen, performing exercises on an unstable platform may improve core function, which refers to the endurance, strength, power, stability, and coordination of the abdominal, hip, and spine musculature. The interplay among these muscle groups stabilizes the spine, facilitating daily activities and sports performance [3]. The incorporation of the stability ball as a platform during core exercises (e.g., curl-up) induces greater core muscle activity than using traditional stable platforms [34], and the incorporation of the stability ball into core training programs has been shown to improve core function [16,19,31,32]. However, the effect of resistance training on a stability ball on core function has not been studied. Given that the stability ball is an unstable platform, resistance training on it may induce greater core muscle activity, which could improve core function. The acute response of core muscle activity to resistance exercise performed on a stability ball is equivocal as some data show an increase in core muscle activity [13], whereas other data do not [7, 25].

The complex interaction of the core musculature has made it difficult to fully evaluate core function with a single test. The common clinical tests of core function include isometric tests of endurance, isokinetic tests of strength and work capacity, as well as isoinertial tests, such as the field test of trunk flexor endurance recommended by the ACSM [22] and National Strength and Conditioning Association (NSCA) [9]. As discussed elsewhere, isometric and isokinetic tests have limitations [36]. The isometric tests, for example, only assess core function at one muscle length, whereas isokinetic tests require expensive and immovable machines. Consequently, the development of new tests to evaluate core function is of great interest; however, such tests still require expensive equipment (e.g., balance platform) [26]. Thus, an easily administered field test is important in evaluating core function. Most field tests are designed to evaluate core endurance (e.g., trunk flexor and extensor endurance tests and lateral bridge test), rather than the strength or power of the core musculature. Measures of strength, rather than field tests of endurance are better predictors of back and lower extremity injury in a healthy and active population [24]. These findings suggest tests of strength, or even power, may be good indicators of core function in a healthy population. Therefore, in the present study we chose to assess core function with a test of abdominal power. Our purpose was to determine the influence of platform (unstable vs. stable, stability ball vs. flat bench) on strength and work capacity during barbell chest-press exercise. We also sought to determine the effects of a 3 week barbell chest-press training program performed on a stability ball or flat bench on strength, work capacity, and abdominal power.

Methods

Overview of the experimental design

Fourteen young women performed a 1RM barbell chest-press and the YMCA bench press test (YBT) on a stability ball and flat bench, as well as two field tests measuring abdominal power. The women were then assigned (balanced based on 1RM strength) to perform a 3 week barbell chest-press training program on a stability ball (SB group) (n = 7) or flat bench (FB group) (n = 7). The 1RM strength (mean ± SEM) for the SB group was 34.4 ± 2.2 kg on the stability ball platform and 33.1 ± 1.9 kg on the flat bench platform; the corresponding values for the FB group were 32.8 ± 2.4 kg on the stability ball platform and 32.5 ± 2.3 kg on the flat bench platform. There were no significant differences initially in 1RM strength between the groups (p > 0.05). Following the training period the 1RM barbell chest-press, YBT, front abdominal power test (FAPT), and side abdominal power test (SAPT) were used to evaluate changes in strength, work capacity, and abdominal power, respectively. The chest-press tests were completed on both platforms following the training program.

Subjects

Fourteen untrained young women volunteered to participate in this study. The mean ± SD for age, height, and weight for the SB group was 21.0 ± 0.4 yr, 164.6 ± 6.4 cm, and 63.6 ± 10.1 kg; the corresponding values for the FB group were 21.0 ± 0.8 yr, 163.6 ± 7.9 cm, and 58.5 ± 2.6 kg. There were no significant differences in age, height, or weight between the groups (p > 0.05). The subjects had no resistance trained in the six months prior to the study. The Human Subjects Committee at Ithaca College approved procedures used in this study, and all subjects provided informed consent.

Measurements

The tests were completed in the order shown, and 5 minutes of rest separated each test. The chest-press tests were completed on both platforms, with half the subjects testing initially on the stability ball and half on the flat bench; one day of rest separated platform testing sessions before and after training.

1RM barbell chest-press

The 1RM chest-press procedures of The American Society of Exercise Physiologists were used [15]. Briefly, after the subject was lying supine on the platform, she grasped the barbell with a pronated grip, hands slightly wider than shoulder width apart; feet were also shoulder width apart and firmly on the ground. The subject then slowly lowered the bar until the elbows were flexed at 90°, whereupon she pressed the bar back to the starting position. The initial load was estimated and was increased by approximately 2 kg each lift; 3 to 5 min of rest separated lifts. Each subject was given 3 attempts at the heaviest load ensuring an accurate 1RM was obtained. The 1RM was obtained in 4 to 6 lifts for all subjects.

Front and side abdominal power test

We chose to use two easily administered field tests of abdominal power to assess core function. The FAPT and SAPT were adapted from plyometric exercises used to improve abdominal power [18]. The reliability of these measures was examined in 24 untrained women. Both relative (i.e., the reproducibility of measurement to a sample of repeated measurements) and absolute (i.e., the degree to which the repeated measures vary) measures of reliability were calculated [11]. The intraclass correlation coefficient (ICC) is a relative measure of reliability. The ICC (2, k) (two-way random effects model with average measure reliability) indicated both measures have high test-retest reliability. The ICC for the FAPT was 0.95 (95% confidence interval: 0.89–0.98), and 0.93 (95% confidence interval: 0.85–0.97) for the SAPT. Absolute reliability for FAPT was calculated with a standard error of measurement, as a Bland-Altman plot for these data indicated the absence of heterocedasticity [8,14]. Absolute reliability for SAPT was calculated by determining a coefficient of variation (CV), as these data were heteroscedastic [8]. The standard error of measurement for the FAPT was 24 cm, and the
CV for the SAPT was 9.8%. Given the FAPT and SAPT showed high relative reliability and moderately high absolute reliability we feel these tests were adequate to assess abdominal power. For the FAPT, the subject lay on an exercise mat, dorsal surface down, with knees bent, back flat, and arms held in a flexed position with the palms up (Fig. 1a). A 2 kg medicine ball was placed in the subject’s hands. b Release was over the knees. Each subject reached over the knees, while keeping the arms flexed and straight (to prevent throwing by the arms) (Fig. 1b). The position of the arms (i.e., flexed and straight) during the explosive movement phase varied. That is, some subjects were unable to keep the arms flexed and straight (i.e., slight shoulder extension). Thus, the amount of shoulder extension may have caused variation in their performance. However, the release of the medicine ball was always over the knees with the arms flexed and straight. If the subject failed to release the medicine ball over the knees the trial was repeated. The high reproducibility of this measure indicated a consistent level of performance was achieved.

For the SAPT, the subject was seated on an exercise mat with knees bent, feet shoulder width apart, back at a 45° angle to the floor, and arms extended forward (Fig. 2a). A 2 kg medicine ball was placed in the subject’s hands. b Release was over the left leg. Each subject maximally rotated her trunk to the right and then projected the medicine ball by explosively rotating the trunk to the left, while keeping the arms extended and straight to prevent throwing by the arms; ball release was over the left leg (Fig. 2b). Each subject completed a total of 6 trials of each test (3 trials on each testing day). The distance the ball traveled was recorded, and the average of the 6 trials was taken. To familiarize the subjects with procedures they were given 3 practice trials on each testing day. The rest period between each trial was 2 minutes.

YMCA bench press test
The YBT was used to determine work capacity [23]. Briefly, subjects performed chest-press repetitions to failure with a 35 lb (15.9 kg) barbell to a cadence of 1 repetition every 2 seconds. The number of repetitions was counted.

Training
Each subject completed 7 training sessions over 3 weeks, with at least 1 day of rest between sessions. The size of the stability ball used by each subject was based on the manufacturer’s (Power Systems Inc., Knoxville, TN, USA) size chart. Subjects 161–166 cm tall used a 55 cm stability ball and subjects 167–171 cm tall used a 65 cm stability ball for testing, and where applicable, training.

Subjects performed the barbell chest-press exercise on the flat bench according to the procedures of the NSCA [9]. The barbell chest-press exercise on the stability ball was performed in the same fashion, but with the shoulders and thoracic spine sup-
ported by the stability ball (Fig. 3). Each training session included 2 sets of 5 repetitions at 85% of 1RM and 1 set of 3–5 repetitions at 90% of 1RM, and 3 minutes of rest separated each set.

Statistics
To examine the influence of platform and effect of training on strength and work capacity a three-way repeated measure analysis of variance (ANOVA) was performed with between factor training group (SB group vs. FB group), within factors platform (stability ball platform vs. flat bench platform), and time (pre-training vs. post-training). To examine the effect of training on the FAPT and SAPT a two-way repeated measure ANOVA was performed with between factor training group (SB group vs. FB group), and within factor time (pre-training vs. post-training).

Due to the possibility that improved upper body strength influenced the performance of the FAPT and SAPT, this analysis was repeated with a covariate analysis; the overall percent increase in 1RM strength was used as the covariate. When a significant interaction was observed, t-tests were used to determine where the interaction occurred. Data are presented as means ± SEM, unless otherwise stated. The alpha was set at p ≤ 0.05. The SPSS for Mac OS X statistical package (version 11.0, Chicago, IL, USA) was used for data analysis. Due to the small sample size in the present study, large differences may not reach statistical significance and result in Type II error. To aid in the interpretation of the findings, effect sizes (ES) are reported as an additional statistical parameter. The ES statistic reported is partial Eta squared. Partial Eta squared reflects the proportion of the effect and error variance that is attributable to the effect.

Results

Impact of platform and effect of training on strength
Platform (stability ball platform vs. flat bench platform) had no influence (p = 0.16, ES = 0.17) on strength before or after training (Table 1). Both groups increased strength across time (p = 0.00, ES = 0.85) (SB group: 34.4 ± 2.2 vs. 39.6 ± 2.7 kg on the stability ball platform and 33.1 ± 1.9 vs. 38.3 ± 2.3 kg on the flat bench platform; FB group: 32.8 ± 2.4 vs. 38.0 ± 2.6 kg on the stability ball platform and 32.5 ± 2.3 vs. 38.6 ± 2.3 kg on the flat bench platform), and there were no group differences. The percent increase in strength for the SB group was 15% on the stability ball platform and 16% on the flat bench platform (Fig. 4). The percent increase in strength for the FB group was 16% on the stability ball platform and 19% on the flat bench platform (Fig. 4).

Impact of platform and effect of training on work capacity
Platform (stability ball platform vs. flat bench platform) did affect work capacity (p = 0.00, ES = 0.50). Further analysis of this main effect using a paired t-test revealed work capacity was 12% lower on the stability ball platform before (p = 0.00) but not after training (p = 0.23) (Table 1). Both groups increased work capacity, as measured by the YBT, across time (p = 0.00, ES = 0.51) (SB group: 28.3 ± 3.3 vs. 37.3 ± 2.5 repetitions on the stability ball platform, and 33.0 ± 3.0 vs. 37.3 ± 3.2 repetitions on the flat bench platform; FB group: 28.8 ± 3.2 vs. 36.6 ± 3.2 repetitions on the stability ball platform, and 31.1 ± 4.1 vs. 39.3 ± 4.9 repetitions on the flat bench platform), and there were no group differences. There was no time x platform x group interaction (p = 0.12), although a modest ES (0.19) was observed. The percent increase in work capacity for the SB group was 32% on the stability ball platform and 13% on the flat bench platform (Fig. 5). The percent increase in work capacity for the FB group was 27% on the stability ball platform and 26% on the flat bench platform (Fig. 5).

Effect of training on abdominal power
Both groups increased performance on the FAPT (p = 0.03, ES = 0.35) (SB group: 220.1 ± 35.5 vs. 230.3 ± 27.4 cm; FB group: 179.0 ± 23.2 vs. 219.2 ± 26.4 cm). Controlling for the increase in strength (i.e., using the overall percent increase in 1RM strength as a covariate) did not alter this relationship drastically (p = 0.08, ES = 0.26). There were no group differences (p = 0.16), although a modest ES (0.16) was observed. The percent increase on the FAPT for the SB group was 5%, and 22% for the FB group (Fig. 6). There was no change in performance on the SAPT for the SB and FB groups across time (p = 0.43, ES = 0.05) (SB group: 248.0 ± 33.0 vs. 234.0 ± 26.3 cm; FB group: 222.5 ± 27.9 vs. 216.0 ± 22.6 cm), and there were no group differences. Controlling for the increase in 1RM strength had no effect (p = 0.75, ES = 0.01).

Discussion
Our purpose was to determine the influence of platform (unstable vs. stable, stability ball vs. flat bench) on strength and work capacity during barbell chest-press exercise. We also sought to determine the effects of a barbell chest-press training program...
performed on a stability ball or flat bench on strength, work capacity, and abdominal power, which has not been studied.

**Impact of platform**

We found that platform did not affect 1RM strength in previously untrained young women. These data are contradictory to the literature, which shows force production is lower on the stability ball compared to a stable platform in resistance trained men [7,12]. In these aforementioned studies, however, isometric force rather than dynamic force was assessed. The relationship between isometric and dynamic tests of strength, moreover, is not direct, which makes it difficult to fully compare studies [10, 28]. Nevertheless, understanding the influence of the stability ball on dynamic strength may have broader applicability, as individuals who resistance train typically do so dynamically. Another possible explanation for the difference between our study and Anderson and Behm [7] was the type of chest-press exercise used to assess strength. We used a barbell chest-press exercise, whereas Anderson and Behm [7] used a modified dumbbell chest-press exercise. It is possible that individuals exert greater effort to stabilize themselves during a dumbbell chest-press exercise than a barbell chest-press, thereby lowering force production [6].

In contrast to its influence on strength, platform did initially affect work capacity. We found work capacity, as measured with the YBT, was 12% lower on the stability ball platform than flat bench platform before but not after training. To the best of our knowledge, the influence of platform on work capacity has not been examined, so we cannot compare our data to the literature. A possible explanation for the difference in pre-training work capacity between the platforms may be gleaned from the study of Anderson and Behm [7], who showed that maximal force but not muscle activation of the prime movers was lower during dumbbell chest-press exercise performed on a stability ball in resistance trained men. These authors suggested that the maintenance of muscle activation in the face of lower force production during resistance training on an unstable platform probably reflected the fact that the limb musculature played a greater role in joint stability. Whether increased joint stability would result in a decrease in work capacity is unknown, and there is no evidence to suggest scapular stabilizing synergists are more active when performing the chest-press exercise on a stability ball than on a flat bench. Thus, this remains a point of emphasis for future study.

In contrast to its influence on work capacity before training, platform did not affect work capacity after training. Perhaps resistance training on a stability ball enhances synergist function, as suggested by Anderson and Behm [6]. It has been shown that during the initial weeks of a resistance training program the enhanced ability to coordinate and activate muscle groups is an important factor for increased performance [4,29]. If this were the case, then the training stimulus would increase work capacity on the stability ball platform as the post-training data reflected. However, our reasoning is only speculative, and remains a point of emphasis for future study.

**Effects of instability resistance training**

Our secondary purpose was to determine the effects of a barbell chest-press training program performed on a stability ball or flat bench on strength, work capacity, and abdominal power, which has not been studied. We found 3 weeks of barbell chest-press...
training performed on a stability ball or flat bench improved strength similarly in untrained young women. We also found that strength changes were transferable across platforms. This finding has practical significance, as individuals who choose to resistance train on the stability ball or flat bench can use either platform interchangeably as a means to add variety into their training regimen. In all, our data suggests using the stability ball as a platform for the barbell chest-press exercise can induce gains in strength, but they are only directly applicable to untrained young women, the barbell chest-press exercise, and a 3 week training program.

The increase in strength in our subject cohort is consistent with the literature, which shows barbell chest-press training increases strength by 14% over a similar time course in untrained young women [2,17]. It should be noted that changes in 1RM barbell chest-press strength using a Smith machine have been shown to occur in untrained men following weekly assessments of 1RM strength over a 4 week period, without any formal resistance training program [20]. It is unclear, however, if weekly assessments of 1RM strength represent a training response. Hence, some of the increase in 1RM strength in this study may have resulted from the 1RM tests, although these were administered 4 weeks apart. Nevertheless, the training related changes in the present study should be interpreted with caution due the short duration of our training program. The strength changes we measured likely resulted from neural adaptations [1,29,30]. It is not certain if a longer training program would have promoted similar increases in strength in the two groups, as muscle hypertrophy plays an increasingly larger role in strength gains in long-term training programs [2,17,21,27,30].

We also found that barbell chest-press training on either platform improved work capacity similarly in untrained young women; these changes, moreover, were transferable across platforms. To the best of our knowledge, the effect of platform on work capacity with training has not been examined, so we cannot compare our data to the literature. As with strength changes, the aforementioned putative neural adaptations may have also contributed to the change in work capacity we measured across time in our subjects. Small changes in the histochemical profile of the myofibers may have played a role as well [33]. In contrast to the readily apparent effects of the training program on strength and work capacity, it was difficult to discern the effects of the training program on abdominal power. Whereas the FAPT improved over time, the SAPT did not. As this is the first study to evaluate the effects of upper-body resistance training performed on a stability ball on abdominal power, we cannot compare our data to the literature. Nevertheless, we expected the training program to enhance abdominal power, as it was generally thought that the stability ball platform has a greater impact on core (i.e., abdominal, hip, and back musculature) rather than limb strength [12]. Subsequent to data collection, however, three studies were published that reported on the effects of upper-body resistance exercise performed on a stability ball on core muscle activation. One study showed that unstable platform training increases core muscle activity [13], whereas the other two did not [7,25].

In the only study to show increased core muscle activity, the greatest change was in the upper and lower erector spinae [13]. These data would suggest that the back extensors are the core muscles that may best benefit from chest-press training performed on a stability ball. If this were the case, then our measures of core function, assessing the abdominals and hip flexors, may have been inconsistent with the muscles most affected by chest-press training on a stability ball. In this light, the changes in the FAPT may have reflected increased upper-body strength rather than improved abdominal power. However, this seems unlikely as controlling for the influence of increased 1RM strength (using the overall percent increase in 1RM strength as a covariate) in our analysis did not alter this relationship drastically (p = 0.03 vs. p = 0.08). We are also unaware of any studies evaluating the effect of upper body training programs on core function. Given the only moderately high absolute reliability of the test, it is also possible that the significant increase in the FAPT partially reflects the measurement error of the test. Indeed, the SEM for the FAPT was 24 cm, whereas the mean increases in this variable were 10 and 40 cm for the SB and FB groups, respectively. To this end, the effect of barbell chest-press training performed on a stability ball on core function warrants additional study using other measures of core function, a longer training period and larger sample size.

Conclusions

We found that strength was unaffected by platform (stability ball vs. flat bench), whereas work capacity was initially 12% lower on the stability ball before, but not after training. In addition, barbell chest-press training performed on either the stability ball or flat bench increased strength and work capacity, and these changes were transferable across platforms. We conclude that the stability ball is an effective platform for barbell chest-press training in untrained young women over a short duration.

References

18 Chu D. Plyometric Exercises with the Medicine Ball. Livermore, CA, USA: Bittersweet Publishing Company, 1989
27 Morttitan T, DeVries HA. Neural factors versus hypertrophy in the time course of muscle strength gain. Am J Phys Med 1979; 58: 115–130
34 Vera-Garcia EJ, Grenier SG, McGill SM. Abdominal muscle response during curl-ups on both stable and labile surfaces. Phys Ther 2000; 80: 564–569
35 Willardson JM. The effectiveness of resistance exercises performed on unstable equipment. Strength Cond J 2005; 26: 70–74