Energy Cost, Number of Maximum Repetitions, and Rating of Perceived Exertion in Resistance Exercise with Stable and Unstable Platforms

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¹University of Trás-os-Montes and Alto Douro, Research Center for Sport, Health, and Human Development, Vila Real, Portugal, ²Rio de Janeiro Federal University, School of Physical Education and Sports, Rio de Janeiro, Brazil, ³Juiz de Fora Federal University, Motor Evaluation Laboratory, Minas Gerais, Brazil, ⁴Minas Gerais State University, Paediatric Departament, Minas Gerais, Brazil, ⁵School of Human Kinetics and Recreation, Memorial University of Newfoundland, St. John’s, Newfoundland, Canada, ⁶Pernambuco Federal University, Physical Education Department, Pernambuco, Recife

ABSTRACT

Panza P, Aranda LC, Damasceno VO, Bentes CM, Novaes JS, Behm DG, Vianna JM. Energy Cost, Number of Maximum Repetitions, and Rating of Perceived Exertion in Resistance Exercise with Stable and Unstable Platforms. JEPonline 2014; 17(3):77-87. The purpose of this study was to compare the energy cost, the rating of perceived exertion, and the maximum number of repetitions with 80% of 1RM bench press exercise on stable and unstable surfaces. Ten trained men (age 23 ± 2.16 yrs) performed a 1RM bench press test that was followed 48 hrs later with 80% of 1RM until failure of the concentric muscles. There were no significant differences between the rating of perceived exertion (P=0.352) or the number of repetitions (P=1.00) with the unstable and stable trials. However, the unstable platform led to significantly higher energy costs than the stable platform (P=0.02). In conclusion, the bench press exercise performed on an unstable surface resulted in higher energy expenditure.

Key Words: Energy Metabolism, Resistance Training, Stable Conditions, Unstable Conditions
INTRODUCTION

The American College of Sports Medicine (ACSM) Position Stand (7) regarding physical fitness and health is that adults should be engaged in a regular exercise training program to develop the different components of physical fitness (i.e., cardiorespiratory fitness, muscular strength, muscular endurance, body composition, flexibility, and neuromotor fitness). The collective body of scientific evidence demonstrates that regular exercise outweigh the risks of not exercising in most adults. In fact, it is clear that regular exercise improves and maintains physical fitness and health.

While it is important that adults engage in regular exercise, it is equally important to avoid injury that is likely to interfere with a training program. Yet, some training centers encourage adults to use unstable conditions during their exercise training to develop the core and limb musculature. Interestingly, the Canadian Society for Exercise Physiology (CSEP) does not fully endorse unstable resistance training (4). The CSEP position stand supports the use of traditional ground-based free-weights (e.g. squats, dead lifts, Olympic lifts) since the addition of an unstable platform during resistance exercises often decrease the subject’s force, power, movement velocity, and range of motion. On the other hand, it is likely that the use of lower loads associated with instability resistance training may play an important role in rehabilitation programs.

Behm and Colado (2) reported a ~30% decrease in strength or power with unstable versus stable exercise conditions. In agreement, Koshida et al. (11) reported minor but significant deficits in strength, power, and velocity (6 to 10%) with a dynamic bench press performed on a physioball. But, they also concluded that the deficits may not compromise the training response. That is, since most resistance exercise programs are dynamic, the instability-induced strength deficits may not be as important as construed by the literature. After all, it is common knowledge that athletic performances are often performed when exerting a force when in an unstable condition.

Regarding the use of an unstable platform and instability resistance training, it is believed that the neuromuscular system experiences an increase in demand that is greater than when engaged in a traditional stable platform. Unstable platforms increase the activation of the stabilizer muscles of the trunk (8) and limbs (1) while executing a resistance exercise. This activation represents an additional stress on the neuromuscular system (1,3). This increased role of stabilizing the body during resistance exercise training may alter the maximum repetitions for each overload as well the subject’s rating of perceived exertion (RPE) and energy cost. If the stabilizing signals increase during an unstable platform exercise compared to a stable platform exercise, it is likely that the resistance exercise using an unstable platform could result in an increase in the caloric cost of the exercise.

While there is a large number of studies that have reported on the measurement of energy cost of resistance exercises with stable platforms (20-22,24,25), there remains a lack of knowledge on the assessment of the energy cost during resistance exercises with an unstable platform. Thus, the purpose of this study was to compare the energy cost, maximum number of repetitions, and RPE during a stable and an unstable bench press exercise.

METHODS

Subjects

Ten recreationally trained men volunteered to participate in this study (Table 1). The subjects had previous resistance training (RT) experience with a mean frequency of ≥3 sessions·wk⁻¹. Each
subject answered the Physical Activity Readiness Questionnaire and, then, signed an informed consent form before participation in the study in accordance with the Declaration of Helsinki. The research project was approved through Opinion No. 101/2010 of the Ethics Committee for Human Research of the Federal University of Juiz de Fora.

Table 1. Descriptive Data of the Subjects.

<table>
<thead>
<tr>
<th>Conditions</th>
<th>Mean ± Standard Deviation</th>
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</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>23 ± 2.16</td>
</tr>
<tr>
<td>Body Mass (Kg)</td>
<td>81.13 ± 9.86</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.80 ± 7.57</td>
</tr>
<tr>
<td>Body Mass Index (BMI, kg·m⁻²)</td>
<td>25.08 ± 2.54</td>
</tr>
<tr>
<td>Fat Percentage (%F)</td>
<td>12.30 ± 2.62</td>
</tr>
</tbody>
</table>

Procedures
To obtain reliable 1RM loads, data were assessed during a bench press exercise on two non-consecutive days on a stable platform using Righetto Fitness Equipment (São Paulo, Brazil). The following steps were carried out: (a) general activation with 5 to 10 repetitions with a load of between 40% and 60% of the subject’s perceived maximum; (b) after a 1-min rest period with stretching, 3 to 5 repetitions with a load between 60% and 80% of the subject’s perceived maximum; (c) after a 2-min rest period, the subject attempts to perform one maximum repetition with a load close to the perceived maximum; and (d) after this load was successfully lifted or not, a rest of 5 min was allowed, after which the load was increased or decreased. Standard exercise techniques were followed for each exercise. All the subjects were asked not to exercise any of the muscle groups involved in the testing 48 hrs prior to the strength assessments. The heaviest load achieved between both days was considered the 1RM (12).

The OMNI Resistance Exercise Scale was used to obtain RPE. All subjects performed two familiarization sessions over 1 wk, during which the instructions were explained using the OMNI Scale. Then, the subjects were asked to choose a number on a scale based on their perceived exertion or subjective intensity of effort, strain, discomfort, and/or fatigue experienced during the exercise session. The familiarization sessions consisted of two exercises, bench press on the stable platform and bench press on an unstable platform, performed for 1 set of 15 repetitions in each exercise. Immediately following each exercise of the sequence, the subjects were asked to identify their RPE (14).

The measurement of the energy cost was performed through indirect calorimetry with the use of a Medical Graphics VO2000 metabolic analyzer. This device analyzed micro-samples of expiration (VO₂, volume of consumed oxygen; VCO₂, volume of carbon dioxide produced; and Vₑ, volume of expired air; all in L·min⁻¹) through the method of time selection, and it was adjusted to perform the
analysis of the expired gases every three ventilatory incursions. Before the tests, the metabolic analyzer was calibrated according to the recommendations of the manufacturer.

The calculation of the excess postexercise oxygen consumption (EPOC) was performed by the sum of the total energy cost used until the values returned to values found before the exercise. The EPOC was converted into the energy cost of 1 L of O₂ (19.6 kJ) to eliminate any glycolytic component based on the measurement of O₂ absorption (22).

The subjects underwent a familiarization program on the unstable platform, which was represented by a bench press on a Swiss ball. The following body position was required of each subject: Using a Thera-Band® 75 cm Professional Exercise Ball, position the posterior part of the shoulders, neck, and head in contact with the ball with the feet supported against the floor at shoulder and thigh length apart as the hips and torso remained parallel to the ground. Then, the subject grasped the bar, which was fixed atop a support structure, with the hands in pronation and a distance wider than shoulder width. Upon inhaling, the bar was lowered by controlling its movement until it touched the chest from which the bar was lifted while exhaling at the end of movement.

Seventy-two hours after the last familiarization, energy cost was measured with the bench press in machine. Before performing the exercise, each subject performed a specific warm-up with a load of 40% 1RM on a stable surface. The gas analyzer was then connected to the subject. The subject remained seated on the bench for 5 min to identify the pre-exercise resting values. The proposed exercise began with an intensity of 80% 1RM, which was performed until voluntary fatigue. At the end of the exercise, the subject remained seated until the energy cost values returned to the pre-exercise values. The expired gas was measured continuously beginning at 5 min before the exercise, during the exercise, and after the exercise. Figure 1 illustrates the experimental design of the study that was used over the course of seven sessions.

Seventy-two hours after the first series of data collection, the energy cost was determined for the maximum repetitions with a flat bench press on the Swiss ball with an intensity of 80% 1RM (using the load obtained with the 1RM on the stable platform). The procedures just described were followed except for one difference: during the rest periods before and after the exercises, the subject remained seated on a mat located next to the Swiss ball (refer to Figure 1).

Immediately at the end of the both sessions, the number of repetitions performed on the two platforms was recorded, and after the exercise was performed the subjects were asked to select a number on the OMNI-RES scale that represented their perceived exertion (13).

To monitor the rhythm of the exercises, an electronic metronome (Qwick Time™, China) was used. It produced flashes of light and sound that dictated the rhythm at which the exercises were performed (e.g., 2 sec for the eccentric phase and 1 sec for the concentric phase; 40 beats·min⁻¹ = 20 repetitions). The metronome helped to ensure that all of the subjects took the same amount of time for each repetition (10).
Statistical Analyses

The statistical analysis of the data was initially performed using the Shapiro–Wilk normality test and the homoscedasticity test (Bartlett criterion). The intraclass correlation coefficient (ICC) was applied to determine the reproducibility of the loads for 1RM. To compare the energy cost, the RPE (OMNI-RES), and the number of repetitions during the stable platform bench press exercise and the unstable platform bench press exercise, a Student’s t-test for paired samples was used.

In all of the statistical analyses, a level of significance of $P \leq 0.05$ was used. Additionally, to determine the magnitude of the findings, effect sizes (ES = mean change / standard deviation of the sample scores) were calculated and reported (5). The data were analyzed using the treatment and statistical analysis software in the Statistical Package for the Social Sciences (SPSS Science, Chicago, USA), version 20.0.

RESULTS

The findings indicate that the ICC for the stable platform bench press was 0.989. A paired-samples t-test was performed. It did not demonstrate any significant difference ($P<0.05$) between the 1RM tests on separate testing occasions. The energy cost results showed significant difference between the stable platform and the unstable platform (stable: $20.74 \pm 4.28$ kJ and unstable: $26.60 \pm 5.92$ kJ, $P=0.02$). The ES results showed a large magnitude between protocols (ES = 0.97, Figure 2). The maximum repetition results showed no significant differences ($10 \pm 2.10$ on the stable platform and $10 \pm 2.02$ RM on the unstable platform; $P=1.00$). The ES results showed a trivial magnitude between protocols (ES = 0, Figure 3). The RPE results showed no significant differences between protocol for stable platform vs. the unstable platform ($6.6 \pm 1.84$ and $7.3 \pm 1.42$, $P=0.35$; ES = 0.46, respectively). The ES results showed a moderate magnitude between protocols (ES = 0.46; Figure 4).
Figure 2. Absolute Values of the Energy Cost (kJ) for the Stable (Flat) Bench Press on a Bench and the Unstable (Flat) Bench Press on the Swiss Ball. *Significant difference between the energy cost of the stable flat bench press (bench) and unstable flat bench press (Swiss ball).

Figure 3. Absolute Values for the Number of Repetitions of the Stable (Flat) Bench Press on a Bench and the Unstable (Flat) Bench Press on the Swiss Ball.
The major findings in the present study were the higher energy costs associated with an unstable platform versus the stable bench press even though the maximum number of repetitions and RPE were similar between the two exercises. With regard to increased energy cost during the unstable bench press, this finding is similar to Scott et al. (22) who compared the absolute and relative aerobic and anaerobic energy costs for a single set with a bench press at different intensities. At an intensity of 80% 1RM, an energy cost of 20.7 ± 6.5 kg was found. This is almost identical to the value of 20.74 ± 4.28 kJ reported for the stable platform in the present study. In contrast, Vianna et al. (24) had their 14 male subjects perform a single set of stable flat bench press at 80% 1RM. They reported an energy cost of 28.88 ± 5.12 kJ, which contrasts with the present study. This difference may be explained by the fact that Vianna and colleges (24) used the Accumulated Oxygen Deficit (AOD) methodology to identify energy cost.

The greater energy cost with an unstable bench press may be related to the previously reported instability-induced high limb and trunk muscle activation that may be attributed to the increase in muscle activity to stabilize the exercise (3). The increased muscle stabilization around the joints and trunk area would include not only the agonist (i.e., prime movers) but the synergists and antagonists working together as well (3,15).

The performance of resistance training on the unstable platform may not only increase trunk muscle activation but can also increase the muscle activation of the limbs (15,16). Marshall and Murphy (16) demonstrated that a bench press at 60% of 1RM performed on a Swiss ball caused
greater EMG activity in the anterior deltoids, transverse abdominis, internal oblique, and the rectus abdominis muscles in comparison with a stable surface. Similarly, Norwood et al. (18) reported greater activation of the latissimus dorsi, rectus abdominis, internal oblique, soleus, biceps femoris, and erector spinae muscles during the unstable flat bench press exercise versus the stable flat bench press exercise. Anderson and Behm (1) also found greater activation of the soleus muscles when performing the unstable squat exercise versus the stable squat exercise.

In regards to the number of repetitions, there were no significant differences between the exercises performed on the bench and on the ball at 80% 1RM. Shimano et al. (23) and Scott et al. (22) reported means of 9 and 8 RM, respectively, for trained individuals with the flat bench press, respectively, which is similar to the results in the present study. Although a number of studies report instability-induced strength deficits (2,4), there are contradictory studies that do not report deficits. Dynamic maximum isokinetic bench press strength on a physioball compared to a stable bench press has been reported to be maintained (6,9). Koshida et al. (11) suggested that the statistically significant yet minor deficits in strength, power, and velocity (6 to 10%) with a dynamic bench press performed on a physioball may not compromise the training response.

Somewhat similar to the present study, Koshida et al. (11) used a submaximal load of 50% of 1 RM. Most athletes use a training load that is less than maximal with dynamic rather than isometric contractions, the CSEP’s statement against instability resistance training for athletes may be misguided since it appears that it is influenced by maximal isometric testing. Alternatively, all the aforementioned studies that reported similar stable to unstable strength or repetitions used a bench or chest press on a ball. It could be argued that the additional load compresses (flattens) the exercise ball making it more stable.

Furthermore, a chest or bench press action involves a relatively large surface area of the trunk in contact with a large compressed ball that is no longer circular. The findings of comparable results between stable and unstable bench press actions may not be completely transferable to other unstable exercises (e.g., squats performed on inflatable discs). Thus, the present study demonstrates that similar bench press workloads can be accomplished when using a moderately intense load equal to 80% of 1 RM for approximately 10 repetitions.

Although, there was no statistically significant difference in RPE between the stable and the unstable bench press exercises, Pincivero et al. (19) reported that the RPE increased with an increase in the number of repetitions (19), and Lagally and colleagues (14) reported that the increase in RPE is linear in relation to the increase in repetitions (14). This behavior of the RPE regarding the number of repetitions is normally explained by the fact that a greater amount of work (repetitions and/or loads) indicates a greater RPE.

Using the Borg Scale, Marshall and Murphy (15) reported a significantly higher RPE for the unstable platform compared with the stable platform. Fourteen subjects participated in their study (9 men and 5 women), each with at least 6 mth of weight training experience. The RPE was analyzed for the flat bench press with a machine and with free weights (dumbbells) on the Swiss ball at 60% 1RM. With 11 students who practiced resistance exercise recreationally, Naclerio et al. (17) showed that the RPE (OMNI-RES) of a load of between 70 to 80% 1RM for various exercises including the flat bench press on a bench was between 6.4 and 6.8 RM. Given the variation in the platforms, these values are close to those found in the present study. The fact that our sample of experienced physical education students had three familiarization sessions using the Swiss ball may have contributed to the lack of significant RPE differences.
CONCLUSIONS

Although the number of repetitions and RPE for the same load percentages was not different between stable and unstable bench press exercises, the energy cost was higher during the unstable bench press exercise on the ball. Based on the values found in the present study, we suggest that resistance exercises performed on an unstable platform at the same load percentage used on a stable platform result in a greater expenditure of energy. This increase in expenditure may contribute to a greater metabolic impact during the training session, which is important in weight loss programs.

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