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Original empirical article

EIGHT WEEKS OF INSTABILITY RESISTANCE TRAINING EFFECTS ON MUSCULAR OUTPUTS

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Abstract. *The objective of this pilot study was to determine the differences in muscular outputs, such as power, force, and velocity, after 8 weeks of instability resistance training. It was hypothesized that instability resistance training would provide significant training gains in muscular outputs. For the purpose of this study, the dynamic bench press and squats were used, since they are some of the most widely performed exercises by athletes. The experimental group consisted of 10 male students, and none of them was a professional athlete, and had not taken part in organized and programmed resistance training in the past year. The participants trained two days per week under unstable conditions for 8 weeks. The unstable conditions were provided by a Swiss ball for the bench press, while barbell squats under unstable conditions were performed on a BOSU ball.*
Both exercises (the bench press and squat) were performed with a previously established 50% of one-repetition maximum (1RM). An analysis of the obtained results indicated that instability resistance training with 50% of 1RM provides sufficient stimuli to improve muscular outputs, and can significantly increase muscular power in previously untrained young individuals.

Key words: *instability, resistance training, muscle power.*

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INTRODUCTION

Previous studies have suggested that muscle power and strength gains can be attributed to both increases in the muscle cross-sectional area and improvements in neuromuscular coordination (Anderson & Behm, 2005; Behm et al., 2010). Based on these assumptions, an instability resistance training program could provide greater training adaptations through predominant neural adaptations in the early period of a training program. The use of unstable training environments has been purported to enhance movement specific effects through increased activation of stabilizers and core muscles (Kornecki & Zschorlich, 1994; Behm & Anderson, 2006) and thus has been advocated as more beneficial than machines (Anderson & Behm, 2005). According to the concept of training specificity, training under unstable or unbalanced conditions may provide the instability that can occur with activities of daily living, work, and athletic environments, providing a more effective transfer of training adaptations (Behm & Anderson, 2006).

The objective of this study was to determine the differences in muscular outputs, such as power, force, and velocity, after unstable resistance training. It was hypothesized that instability resistance training would provide significant training gains in muscular outputs. This pilot experiment was also used to test the design of a full-scale experiment which could then be adjusted in order to improve the chances of a clear outcome.

METHODS

For the purpose of this study, the dynamic bench press and squats were used, since they are some of the most widely performed exercises by athletes. The experimental group consisted of 10 male students of the Faculty of Sport and Physical Education in Nis (age 21.2±0.5 years, height 179.5±6.3 cm, weight 73.1±5.7 kg). None of the students was a professional athlete, nor had they taken part in organized and programmed resistance training in the past year. The level of their physical fitness reflected the program's curriculum, which included various types of practice, as well as their individual recreational practices (this included additional daily physical activities of at least one hour).

The participants trained two days per week under unstable conditions for 8 weeks. Both exercises (the bench press and squat) were performed with a previously established 50% 1RM. The use of more than 50% of 1RM under unstable conditions in this resistance training involving inexperienced subjects' may be very dangerous and may lead to anxiety about falling. The unstable conditions were created by a Swiss ball with a diameter of 65 cm placed to support only the upper back, not the cervical area or head and with the participants' feet placed on the floor. Complete inflation of the ball was confirmed before each training session. Barbell squats under unstable conditions were performed from full extension to a knee angle of 90° while the participant held the barbell on his back on the BOSU ball (BOSU; Fitness Quest, Canton, OH, USA). For safety reasons, two assistants spotted the participants by standing on each side during the lift, and one assistant stood behind the participants to impede a possible fall.

All of the participants had volunteered to take part in the study, and were informed regarding the main purpose of the study, procedures, and the experimental risks prior to the study. The procedures presented were in accordance with the ethical standards on human experimentation. Standard medical screening was performed before the study.

None of the participants showed any evidence of recent injury in their anamnesis or clinical report.

Familiarization. Prior to the study, the participants were exposed to two familiarization sessions. Before data collection, the participants were given an orientation session where they were instructed on the proper technique of both exercises. Emphasis was placed on achieving a knee angle of 90° during the squats. The participants had another familiarization session specifically designed for the testing procedures. They were instructed not to engage in exhausting exercise for a period of 48 hours prior to testing, and were warned to refrain from eating or drinking energy or caffeine drinks for two hours prior to the testing. The participants were allowed to drink non-caffeinated liquids ad libitum before testing.

Testing procedures. All of the testing sessions took place in a gymnasium. Prior to testing, the participants warmed up for approximately 10-15 minutes of submaximal intensity aerobic activity on stationary bikes and/or step machines and short bouts of dynamic muscle stretching.

1RM Testing. The participants underwent a one-repetition maximum (1RM) test on a stable surface. Prior to each 1RM test, two warm-up sets were performed: first with 8 repetitions at approximately 50% of the estimated 1RM, and then with 4 repetitions at approximately 70% 1RM. Next, single attempts with increasingly heavier resistance of at least 2.5 kg were performed until each participant reached the greatest weight that he could lift once with correct technique. A 3-minute rest period was given between each lift. The 1RM was achieved within 3-6 attempts. For safety, three assistants were present at all times. The correct bench press technique involved lowering the bar in a controlled manner until it lightly touched the chest, after which the bar was lifted back to the start position with elbows fully extended. Careful attention was paid to ensure the bar did not bounce off the chest. No compensatory motion was allowed during the bench press movement. Barbell squats were performed from full extension to a knee angle of 90° while the participant held the barbell on his back. The participants were monitored in order to ensure that they lifted the barbell without significant deviation from a line perpendicular to the floor. The tempo of each 1RM attempt was not controlled so that as long as good technique was maintained, the participants could take as long as required to complete the lift.

Muscular outputs testing. Power, force and velocity of movement for each repetition were measured by means of the Fitrodyne dynamometer (Fitronic, Bratislava, Slovakia) according to the suggested protocol. The validity and reliability of the device was confirmed by Jennings et al. (2005), and the device was also used in similar studies (Jones et al., 2008; Ignjatovic et al., 2011). During each of the sessions, the participants were instructed to accelerate the barbell as fast as possible during the entire range of motion, during which the peak power and velocity of movement were measured by means of a computer-interfaced Fitrodyne attached to the barbell via a tether. All of the data were computed, based on Newton's second law, by using the appropriate software (Fitronic, Bratislava, Slovakia) in addition to the dynamometer.

Statistical analyses. The Kolmogorov-Smirnov test of normality was performed on all the variables. All of the data were normally distributed, and a paired t-test was used to compare muscular outputs (power, force and velocity of movement) and 1RM during the bench press and squats before and after 8 weeks of instability resistance training. The data were described as means ± standard deviation (SD). Statistical significance was set at $p<0.05$ for all of the statistical analyses.

RESULTS

An analysis of the obtained data using a parametric t-test for paired samples showed a statistically significant increase of muscular power and velocity of movement during the bench press after 8 weeks of resistance training under unstable conditions (the Swiss ball). There was no statistically significant changes in muscle force (p=0.61) and 1 RM (p=0.11) during the bench press in comparison to the initial measurements (table 1).

Table 1. Mean (SD) values of muscular outputs during the bench press before and after 8 weeks of instability resistance training (n=10).

Variables (unit)	Initial	Final	p value
Power (W)	452.5±57.1	503.4±65.9	p<0.001
Force (N)	613.6±179.1	593.8±181.4	ns
Velocity ($cm \cdot s^{-1}$)	113.2±16.9	121.9±17.1	p<0.01
1 RM (kg)	69.5±14.2	72.5±11.1	ns

The statistical analysis of the obtained data showed a statistically significant increase of muscular power during the squat after 8-week resistance training under unstable conditions (the BOSU ball). In addition, 1 RM for squats increased significantly (p<0.05) compared to the corresponding pre-training value. There was no statistically significant changes of muscle force (p=0.58) and velocity of movement (p=0.06) during the squat in comparison to initial measurements (table 2).

Table 2. Mean (SD) values of muscular outputs during the squat before and after 8 weeks of instability resistance training (n=10).

Variables (unit)	Initial	Final	p value
Power (W)	574.8±88.8	667.9±78.2	p<0.001
Force (N)	598.4±128.2	614.1±100.6	ns
Velocity ($cm \cdot s^{-1}$)	121.9±17.8	130±11.1	ns
1 RM (kg)	80±16.3	83.5±15.6	p<0.05

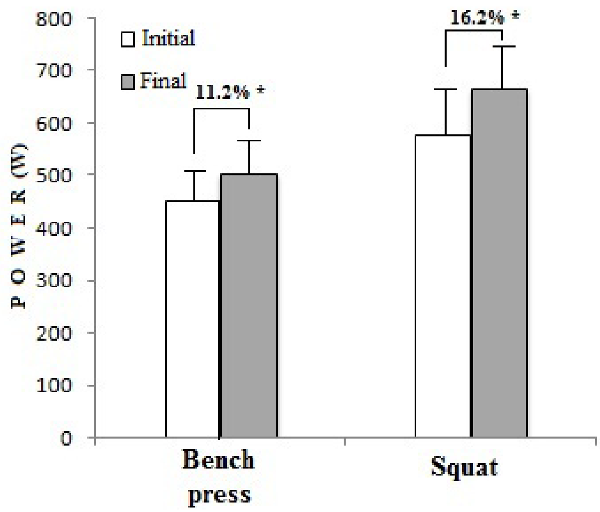

Fig. 1. Percentage of muscle power increase after 8 weeks of instability resistance training.

* A significant difference ($p<0.001$) compared to the corresponding pre-training value

DISCUSSION

Resistance training exercises under unstable conditions, such as during the use of a Swiss ball and BOSU ball have gained popularity in recent years. Intervention studies have also indicated that a short-term training program using a Swiss ball is more effective than floor exercises for improving trunk stability (Cosio-Lima et al., 2003; Stanton, Reaburn, & Humphries, 2004). Previous findings have shown that producing high-power output with a light to moderate load would be more effective in developing peak muscle power than using a heavy load (Häkkinen, 1989; Wilson et al., 1993). Therefore, it seems that such a low reduction rate may still allow muscular power gain with resistance exercise under unstable conditions. All these reports suggest that unstable resistance training may facilitate the neural adaptation of core-stabilizing muscles, resulting in improved core stability.

For the students of the Faculty of Sport and Physical Education, who had no experience with unstable exercises, resistance training load with 50% of 1RM performed on the Swiss ball and BOSU ball provided sufficient challenges to the neuromuscular system. The possibility of a reduced training load under unstable conditions may be compensated by high muscle activation and internal muscle tension providing similar training stresses. The significant increase in muscular power (11.25% for the bench press and 16,2% for squats) after 8 weeks of unstable resistance training (Figure 1) occurred because training load with 50% of 1RM for both exercises was an adequate stimulus to initiate muscle adaptations.

The study of Sparkes and Behm (2010) based on an 8-week training study indicated that instability resistance training, which inherently uses lower resistive forces (Behm et al., 2010), can increase strength and balance in previously untrained young individuals as can training with more stable machines employing heavier loads on the body (Sparkes & Behm, 2010). The findings also suggest that instability resistance training may have a tendency to be more efficient at increasing force under unstable conditions. Thus, stable and unstable resistance training provide similar training outcomes with untrained and recreationally active individuals. Similar short-term training programs of 8 weeks tend to emphasize neural more than hypertrophic adaptations (Anderson & Behm, 2005; Behm et al., 2010), and thus, the motor learning component may have played a larger role than tension in providing power and strength gains.

Although 80% of 1RM is usually required to improve muscle power and strength in trained individuals (Kraemer et al., 2002), and the force output during unstable resistance exercises would not meet this requirement (McBride, Cormie & Deane, 2006), our results indicated that instability resistance training with 50% of 1RM can increase muscular power outputs in previously untrained young individuals similar to traditional resistance training with heavier loads. Considering the small number of participants who were involved in the study, more research is needed to establish the effectiveness of resistance training exercises under unstable conditions before giving precise training recommendations.

CONCLUSION

This pilot study has demonstrated that instability resistance training may be considered effective for previously untrained young individuals. Therefore, the bench press as a resistance exercise performed on a Swiss ball with a reduced training load (50% of 1RM) and squats with a reduced training load (50% of 1RM) performed on a BOSU ball provide a sufficient stimuli to improve muscle power and could be incorporated into the training programs for inexperienced resistance trainers. However, the results of this pilot study can provide only limited information on the sources and magnitude of the variation of response measures, but allow the design of a full-scale experiment on this topic.

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EFEKAT OSMONEDELJNOG TRENINGA SNAGE U NESTABILNIM USLOVIMA NA MIŠIĆNI POTENCIJAL

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Cilj sprovedenog pilot istraživanja bio je utvrđivanje razlika u mišićnoj sili, snazi i brzini nakon osmonedeljnog treninga sa opterećenjem pri nestabilnim uslovima. Pretpostavljeno je da će trening sa opterećenjem pri nestabilnim uslovima dovesti do značajnih poboljšanja ispitivanih parametara. Za potrebe istraživanja korišćene su vežbe koje sportisti najčešće izvode u treningu sa opterećenjem: potisak sa grudi i čučanj. Eksperimentalna grupa se sastojala od 10 studenata i niko od njih nije bio profesionalni sportista, niti je učestvovao u organizovanom i programiranom treningu sa opterećenjem tokom poslednjih godinu dana. Ispitanici su trenirali dva puta nedeljno, tokom 8 nedelja, pri nestabilnim uslovima. Vežba potisak sa grudi izvođena je na „švajcarskoj" lopti, dok je vežba čučanj izvođena na BOSU lopti, čime su obezbeđeni nestabilni uslovi pri treningu sa opterećenjem. Obe vežbe su izvođene sa prethodno utvrđenim opterećenjem od 50% vrednosti jednog maksimalnog ponavljanja (1RM). Analiza dobijenih rezultata je pokazala da vežbe potisak sa grudi i čučanj, izvođene pri nestabilnim uslovima sa opterećenjem 50% 1RM, pružaju dovoljni stimulus za poboljšanje parametara funkcije mišića, te da mogu značajno da povećaju mišićnu snagu kod prethodno netreniranih mladih ljudi.

Ključne reči: *nestabilnost, trening sa opterećenjem, mišićna snaga.*