IMMEDIATE EFFECTS OF MAXIMAL STRENGTH TRAINING ON STATIC BALANCE

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Abstract

The aim of this study was to determine effect maximal strength training on static balance. Eleven Croatian championship rugby players (mean±SD: age, height and weight 22.5 ± 2.7 years, 182.5 ± 6.2 cm, and 92.9 ± 9.5 kg, respectively) volunteered in this study. Players were tested for Transversal both feet standing on balance board with open eyes, Parallel one leg stand on board with open eyes, Perpendicular one leg standing on board with open eyes. Results of this study generally showed that there were no statistical significant differences in results of static balance before and after Maximal Strength Training (MST) (p = 0.32). But, we found that there was statistical significant difference on Transversal both feet standing on balance board (p=0.03). Other two tests showed increasing results on their dominant leg in contrast to the results of non-dominant leg but not statistically significant (p > 0.05). In majority of sports most of the training time is spend on strength and power development, coaches should know that with developing strength and power they affect other abilities in this case balance. This is important practical information for sport coaches because of a lack of time, especially in in-season period.

Key words: *maximal strength training, rugby, balance, ability*

Introduction

Static balance is defined as ability to maintain a base of support with minimal movement (Hrysomallis, 2011). From physical aspect static balance means a sum of inner and outer forces that affect body, which equals zero. From neuromuscular aspect static balance refers to maintaining specific stance in which antagonist muscles are contracted, so there is minimum of body swinging or sophisticated muscle acts (Jurinec and Vunić, 2006). Static balance is seen in numerous situations in rugby, like holding a player in lineouts, keeping a balance of the scrum or driving a strong and balanced maul. Thus, static balance plays an important role in rugby game which makes it an important role of rugby training as well. It is also known that static balance is important component of each competitive sport (Hrysomallis, 2011). Maximal strength training (MST) is one of the most used types of training in competitive sport. The primary aim of it is to improve athlete's performance. The term ''maximal strength training'' has been used to describe strength training using high loads, few repetitions, and emphasis on neural adaptations to strength enhancement rather than muscular hypertrophy (Hoff et al., 2007). There are some studies (Bellew et al., 2003; Hess and Woollacott, 2005; Orr et al., 2008) about correlation between strength training and their effects on balance, but to our knowledge, primary in the old people. It has been documented that resistance/strength training which increases muscular strength also increases stability and coordination (Carroll et al., 2001). Few studies have closely examined whether the dose of resistance training determinants a positive balance outcome, and aspect critical to the design of optimal exercise programs to enhance balance (Orr et al., 2008). Narici et al. (1996) demonstrated in their 6 month study of resistance training that muscle growth and strength have a parallel increase after first two months. Which suggested that in the first two months strength´s increase was, exclusively, result of a neurological adaptation to resistance/strength training? Evidence suggests that resistance training, in the absent of balance training, also have positive effects on balance. It was also found that gait stability improves significantly more by resistance training (Anderson & Behm, 2005). So, our presumption is that increase of balance which comes as a result of MST is because of neurological adaptations that appear in the first period of strength, and of course, maximal training program.

Some authors (Marković et al., 2008; Kahumi et al., 2011) have been examining acute effects of heavy preloading (maximal or near maximal voluntary isometric or dynamic contraction) on ballistic movements. The exact mechanisam of Post activation potentiating (PAP) is unclear but it has been attributed to either increased motoneuron excitability or phosporylation of myosin regulatory light chains. PAP was described as increased excretion of force during 8 does 12 minutes, which means that the effects should be measured right after one or more sets of exercise. However, we measured effects after maximal strength training that lasted 45 minutes. Thus, we cannot call this effects PAP. These phenomena can be described as a sum of effects of the whole maximal strength training. Bompa (2005) called this type of effects immediate effects (IE). IE is defined as an effect that occurs immediately after a set of exercises or after individual training (Bompa, 2005).

IE reflects the size and character of biochemical changes in the body, as a consequence of consumption of energy supplies, decrease activity of nervous system, disorders in regulatory of motor functions (Zeljaskov, 2004). To our knowledge there are no studies about immediate effect of maximal strength training on static balance Therefore, the aim of this study was to determine immediate effect of maximal strength training on static balance.

Methods

Experimental Approach to the Problem
Most of the previous studies which examined effects of strength training on static balance were made on older adults (Bellew et al., 2003; Hess and Woollacott, 2005; Orr et al., 2008). To our knowledge there are no studies about immediate effect of maximal strength training on static balance. It is known that in the first part of strength training program, increase in the strength is a consequence of neurological adaptations. So we hypothesized that maximal strength training will produce an immediate effect on static balance. After the initial balance testing subjects were performing maximal strength training. Before training subjects were tested for 1RM (back squat, lunge and unilateral leg press) to define individual load for every participant. Training was consisted of back squat, lunge and unilateral leg press. Each exercise was performed in 4 series with 4-2-2-1 repetition. After that subjects performing final testing.

Subjects
Eleven Croatian championship rugby players (mean±SD age, height, weight 22.5 ± 2.7 years, 182. 5 ± 6.2 cm, and 92.9 ± 9.5 kg, respectively) volunteered in this study. Each player had at least 4 years of training experience, corresponding to 2 hour training sessions, and at least 1 competition per week. Self–reported medical histories were received from all subjects, and any subject reported any orthopaedic problem and/or taking any medicamentations on regular basis in the last year was not accepted into the study. Before testing subjects signed informed consent. All procedures were approved by the Ethics Committee of the Faculty of Kinesiology University of Zagreb. Each athlete performed a standardized 15 minute warm-up consisting of general movements and dynamic and static stretching. After the general warm-up, players performed assessments of balance ability. After the training, subjects were instructed to perform the tests in the same order as they did before training.

Procedures
Subjects were measured indoor in The Croatian Academic Rugby Club Mladost Zagreb. Before each testing the subjects performed a standard 15 minute warm-up. During the test air temperature ranged from 22°C to 25°C. It began at 10 am and finished by 1 pm. Players were instructed not to be involved in strenuous exercise for at least 48 hours before the training and consume their normal pre-training diet before the testing session. None of the subjects were injured 6 months before the initial testing. There was no supplement addition regarding the nutrition of players. In addition, subjects were not taking exogenous anabolic-androgenic steroids and other drugs that might be expected to affect physical performance or hormonal balance during this study. Measurements were taken on Monday morning because the athletes had rested during the weekend. Before testing subjects were introduced to testing protocol, but not with the aim of the study. The testing session began with anthropometric measurements. Players were then instructed to assess the static balance ability measurements. Two days before training subjects were tested for one repetition maximum (1RM) (back squat, lunge and unilateral leg press) to define individual training load for every participant.

Table 1. Maximal strength training session

	Squat	Lunge	Leg press
1st set	60% 1RM 4 repetitions 4 min rest between sets	60% 1RM 4 repetitions 4 min rest between sets	60% 1RM 4 repetitions 4 min rest between sets
2nd set	80% 1RM 2 repetitions 4 min rest between sets	80% 1RM 2 repetitions 4 min rest between sets	80% 1RM 2 repetitions 4 min rest between sets
3rd set	80% 1RM 2 repetitions 4 min rest between sets	80% 1RM 2 repetitions 4 min rest between sets	80% 1RM 2 repetitions 4 min rest between sets
4th set	100% 1RM 1 repetition 4 min rest between sets	100% 1RM 1 repetition 4 min rest between sets	100% 1RM 1 repetition 4 min rest between sets

Transversal both feet standing on balance board with open eyes (BAL1)
Holding with his right hand on the wall, barefoot subjects stands transversally on the balance board with his forefoot and his feet together. Palm of his left hand is by his thigh. Board is located from the wall by the average length of subject's hand, and the board is perpendicular to the wall. When subject feels that he can maintain the balance takes his hand of the wall and puts it by his thigh (during the test both hands are by his thigh). The aim of the test is to maintain the balance as long as it is possible. The result is measured in seconds.

Parallel one leg stand on board with open eyes (BAL2R and BAL2L)
Barefoot subject stands parallel with his one foot on the balance board and other one on the ground, arms by thigh. The aim of the test is to transfer the whole weight on the foot on the balance board, and to take his other foot off his other foot of the ground and maintain the balance without removing his hands from the thigh as long as he can. Test is measured for his left and right leg. The results are measured in seconds.

Perpendicular one leg standing on board with open eyes (BAL3D and BAL3L)
Barefoot subject stands parallel with his one foot on the balance board and other one on the ground, arms by thigh. The aim of the test is to transfer the whole weight on the foot on the balance board, and to take his other foot off the ground and maintain the balance without removing his hands from the thigh as long as he can. Test is measured for his left and right leg. The result is measured in seconds. After their initial balance testing they were performing maximal strength training. Training was consisted of 3 exercises: back squat, lunge and unilateral leg press. Training loads were individually defined according to 1RM and present in Table 1. Rest interval was 4 minutes between every sets. Each exercise was performed in 4 series with 4-2-2-1 repetition.

Statistical analysis
The statistical Package for Social Sciences SPSS (v18.0, SPSS Inc., Chicago, IL) was used for the statistical analysis. Descriptive statistics were calculated for all experimental data. Kolmogorov-Smirnov test was used to test if data were normally distributed. Changes in the balance of players over the training were compared using multivariate analysis of variance (MANOVA). One-way univariate analysis of variance (ANOVA) was used to compare results from initial and final testing for each variable separately. Significance level was set at $p<0.05$.

Results

This study evaluated IE of MST on static balance, measured with 3 different tests, one bilateral (Transversal both feet standing on balance board with open eyes) and two unilateral (Parallel one leg stand on board with open eyes and Perpendicular one leg standing on board with open eyes) tests. Results of this study generally showed (Multivariate level for all variables) that there were no statistical significant differences ($p = 0.32$) in results of static balance before and after Maximal Strength Training (MST), which is not in accordance with our hypothesis. But, we found that there was statistical significant difference on Transversal both feet standing on balance board test ($p = 0.03$). Other two tests showed increasing results but not statistically significant ($p < 0.05$) on their dominant leg (Parallel one leg stand on board $p=0.09$; Perpendicular one leg standing on board with $p = 0.13$) in contrast to the results of non-dominant leg (Parallel one leg stand on board $p = 0.98$; Perpendicular one leg standing on board with $p = 0.8$). No significances of the results of dominant leg we can prescribe to the lack of subjects.

Table 2. Differences between initial and final testing

	Initial		Final	
	Mean ± SD	min - max	Mean ± SD	min-max
Transversal both feet standing on balance board	3.03±0.73*	1.79 - 4.16	5.04±3.10*	2.16 -11.83
Parallel one leg stand on board-right foot	3.57±1.11	2.15 - 6.23	4.59±2.14	2.59 -8.16
Parallel one leg stand on board-left foot	4.56±2.22	1.83 - 8.63	4.58±1.64	2.20 -7.98
Perpendicular one leg standing on board-right foot	2.35±0.90	1.17 - 4.05	2.74±0.79	1.43 -4.04
Perpendicular one leg standing on board-left foot	2.68±1.26	1.14 - 4.83	2.60±0.88	1.33 -4.43

*-statistically significant differences $p<0.05$

Discussion

Progressive resistance training and power training have been reported to improve balance performance (Orr et al., 2008). So we started this research with the assumption that the increase of strength first comes from the neurological adaptations.

Neurological adaptations appear in the first 3 to 4 weeks of strength training (Folland & Williams, 2007). According to that fact we suggested that there will be immediate improvement in balance results after maximal strength training. It is very *interesting that we didn't find any increase in the results of static balance on non-dominant leg. This we can prescribe to differences in developing right and left brain hemisphere, which results with dominant and non-dominant side of the body. Dominant hemisphere processing information better, and has better communication between the different brain areas. In consequence, dominant side of the body has better inter and intra muscular coordination (Judas & Kostović, 1997). Previous studies that researched effects of strength training showed that neurological adaptations to high-resistance training/MST are of importance because of a specific nature of the adaptations of strength to the training. Considerable debate consists of the nature of the neurological changes that accompany strength training. The disproportionately larger increase in muscle strength than size, particularly in the early stages of strength training, has been taken to indicate the neurological adaptations, and also increase in specific tension, that is often largely ascribed to neurogenic factors. Definitive evidence of an increase in motor-unit recruitment with training would require demonstration of population of previously uninvolved motor units that can be recruited after training. Unfortunately, this is beyond the capacity of current techniques (Folland & Williams, 2007).

They also found that efficient coordination of agonist and antagonist muscles is one of the most important early adaptations in resistance training responsible for large increases in strength or torque (Baker and Newton, 2005). Some authors even showed that in some muscles; imagine contractions appear to increase strength by inducing purely central nervous system adaptations (Folland & Williams, 2007). When we talk about neurological adaptation to strength training that many authors proved with cross-education and effects on balance there are two levels of adaptations, intramuscular and intramuscular coordination.

Intramuscular coordination means increase the number of activated motoric units, frequency of activation motor units and better synchronization of motor unit's activity. Intramuscular coordination implies better coordination of agonists, synergists and antagonistics muscle activity. The first intramuscular adaptation, increase the number of activated units, is doubtful, namely some studies showed that nonathlethes who are not include in strength training program can activate motor units maximally or almost maximally (Marković et al., 2008). Experts consider that the main neurological adaptation to strength training is increasing the frequency of motor units activation, especially at the beginning of contraction, and increase the number of double activations of the same motor unit in a short time interval (≤ 5 ms) (Van Cutsen et al., 1998). Although generally IE reflects the size and character of biochemical changes in the body, as a consequence of consumption of energy supplies, decrease activity of nervous system, disorders in regulatory of motor functions (Željaskov, 2004). Because of MST does not have consequence of high energy supplies consumption our training did not decrease activity of nervous system. From neuromuscular aspect balance is defined as maintaining specific position with minimum aberration of movement. Which leads us to a conclusion that intramuscular and intramuscular coordination play important role in maintaining static balance?

Conclusion

In this research we measured some of immediate effects of maximal strength training that had influence on static balance. Results showed us in which part maximal strength training influences on balance. Power is the basic ability for successful performance in any sport, and strength is prerequisite for power development. In majority of sports most of the training time is spend on strength and power development, coaches should know that with developing strength and power they affect other abilities in this case balance. This is important practical information for sport coaches because of a lack of time, especially in in-season period. There are still issues about is it better to develop balance training on its own or as a finishing part of strength training because of proven neural adaptation of strength training. In a future there is need for further study of this problem.

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TRENUTNI UČINCI MAKSIMALNOG TRENINGA SNAGE NA RAVNOTEŽU

Sažetak

Cilj ovog rada bio je utvrđivanje efekata treninga maksimalne snage na statičku ravnotežu. Jedanaest hrvatskih prvaka u ragbiju (prosjek±SD: uzrasta, visine, težine 22.5 ± 2.7 years, 182.5 ± 6.2 cm, i 92.9 ± 9.5 kg, respektivno) dragovoljno je sudjeovalo u istraživanju. Igrači su testirani u položajima: Transverzalno stajanje na obje noge na "balans ploči" otvorenih očiju, Paralelno stajanje na ploči otvorenih očiju i Okomito stajanje na jednoj nozi na ploči otvorenih očiju. Rezultati istraživanja općenito pokazuju da nema statistički značajnih razlika u rezultatima statičke ravnoteže prije i poslije Maksimalnog treninga snage (p = 0.32). Ali, pronađene su statistički značajne razlike kod transverzalnog stajanja (p = 0.03). Ostala dva testa pokazala su poboljšanje rezultata kod dominantne noge u odnosu na nedominantnu, ali rezultat niej bio statistički značajan (p > 0.05). U većini sportova većina trenažnog vremena iskoristi se za razvoj snage i sile, treneri bi trebali znati da razvojem snage zadiru i u druge sposobnsoti, u ovom slučaju u ravnotežu. To je važna informacija za praksu i sportske trenere zbog optimizacije vremena, posebno u natjecateljskoj sezoni.

Ključne riječi: *trening maksimalne snage, rugby, ravnoteža, sposobnosti*

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