THE EFFECTS OF PROPRIOCEPTIVE TRAINING ON JUMPING AND AGILITY PERFORMANCE

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Abstract:

The purpose of this research was to identify the changes in tests assessing speed-explosiveness abilities after a completed proprioceptive training programme. The research included 75 physically active men divided into the experimental (n = 37) and the control (n = 38) group. The first group underwent the proprioceptive training programme lasting ten weeks (60 minutes three times a week). The training programme consisted of one-leg and double-leg static and dynamic balance drills. The demands and duration of those exercises increased progressively. The control group continued to carry out their daily activities during the experiment. The explosive jumping strength and agility were estimated by nine tests at the beginning and at the end of the experiment. For each variable the central and dispersion parameters were calculated as well as the basic metric features. The differences between groups and time points in certain variables were determined by the repeated measure analysis of variance and the *post-hoc* Tukey test.

The results of this research show that there were positive changes in some analysed tests due to the proprioceptive training programme. There were some significant changes in the experimental group under the influence of the proprioceptive training programme in *double-leg vertical jump explosive strength* tests and in forward agility (*20Y test*). Minor but positive changes point to the possibility of developing motor abilities by means of proprioceptive training, and not only to prevent injuries, which has already been proved in a number of research studies.

Key words: *neuromuscular training, motor development, explosive strength*

Introduction

Agility and explosive jumping strength are important motor abilities required for success in a number of sports, first and foremost in sporting games. Agility is often described as the ability of a quick and efficient transfer of a body in space conditioned by the change of direction and sudden stop (Sheppard & Young, 2006; Young, McDowell, & Scarlett, 2001; Verstegen & Marcello, 2001; Flisk, 2000; Pearson, 2001).

Explosive jumping strength represents the ability of maximum muscle activity that enables the acceleration of one's own body in the activities such as vertical and horizontal jumps (Milanović, 2005; Željaskov, 2004). The results of previous research as well as practical experience show that differently planned training procedures of speed and explosiveness can efficiently develop these abilities. Agility and explosive jumping strength are mostly developed by the training process like the quick change of direction (lateral, frontal and horizontal) and by applying the plyometric technology of training, respectively. Furthermore, weight training with a small and medium load is used for the same purpose. These loads are dealt with explosive work (Sheppard & Young, 2006; Pyke, 2001; Marković & Peruško, 2003). Proprioceptive training based on the training operators of balance and imbalance is an important part of the physical conditioning training technology. The purpose of proprioceptive training is to advance the complex activity of the neuromuscular system. Information should be transferred from the peripheral receptors – the afferent and efferent pathways of the nervous system -- which enables the stability and balance of the body during static and dynamic activities (Laskowski, Newcomer-Aney, & Smith, 1997). Apart from preventing and rehabilitating the ankle and knee joint (Parkkari, Kujala, & Kannus, 2001; Bernier & Perrin, 1998; Vad, Hong, Zazzali, Agi, & Basrai, 2002) there are certain assumptions about the effects of proprioceptive training on the central and peripheral level that can be related to the development of motor skills. Central effects include greater body awareness due to the improved sense of the position and movement of joints (Palma, 2005; Eils

& Rosenbaum, 2001; Gruber & Gollhofer, 2004). Body posture and balance are also improved.

Besides, there is an increase of rate of force development during voluntary muscular contraction (Gruber & Gollhofer, 2004). This suggests the possibility of proprioceptive training influence on the neuromuscular system due to the initiation of the generated force, i.e. an improvement of explosive strength and neuromuscular activation at the start of a voluntary muscular activity. The improvement of proprioception can have a positive impact on neural activation – excitation of the motor-neural system, especially concerning the stretch-shortening cycle (SSC) (Komi, 1984, according to Gruber & Gollhofer, 2004; Palma, 2005). Peripheral impacts of training are seen in a better reflex intermuscular coordination of agonists and antagonists, i.e. in an optimal regulation of the joints fixation by means of dynamic stabilizers. Different research studies have stated the effects of proprioceptive training on muscle strength (Heitkamp, Horstmann, Mayer, Weller, & Dickhuth 2001), agility (Yaggie & Campbell, 2006) and jumping (Ziegler, Gibson, & McBride, 2002; Kovacs, Birmingham, Forwell, & Litchfield, 2004). Malliou and associates (2004) found some significant changes in a specific skiing agility (in slalom) after additional proprioceptive training, and in the research of Yaggie and Campbell (2006) the applied proprioceptive programme improved complex agility (90° change of direction, running backwards and lateral movement). Yet, the application of this type of training with the purpose of developing motor abilities, i. e. agility and jumping strength has not been fully confirmed.

Based on the given potential effects of proprioceptive training, especially the change in muscle force generation (Gruber & Gullhofer, 2004) there is an assumption that some changes might be expected in speed and explosiveness after this kind of training. The purpose of this research was to study the changes in agility and explosive jumping strength after a proprioceptive training programme.

Methods

Experimental approach to the problem

All subjects were tested prior to the experiment (T 1) and then after the experiment (T 2). In the initial measurement no stastically significant differences were found in any variable between E and C group. After the initial testing the subjects were divided into the experimental (E) and the control (C) group. The first group was under a proprioceptive training programme, whereas the C group was instructed to carry on with their regular daily activities. The experiment lasted for 10 weeks during which 30 training sessions were conducted (3 times per week).

Subjects

The sample for this research was comprised of 75 healthy, active, male kinesiology students (aged 19±1.2 years; height: 180.5±5.6 cm; weight: 76.8±7.3 kg). Before the experiment the students spent 6.6±4 hours practising different sports. The subjects were divided into the E (n=37) and the C group (n=38). According to their motor characteristics, these subjects were similar to top-level athletes (Marković, 2004; Matavulj, Kukolj, Ugarkovic, Tihanyi, & Jaric, 2001; Gabbett, 2006; Little & Williams, 2006). At the beginning of the experimental procedure there were 102 subjects. The analysis included only those subjects who underwent the T1 and T2 testing completely with 27 or more out of 30 training units. Those included in the analysis were not been injured in the course of the experiment.

Procedures

Testing

All subjects were tested before and after the experimental procedure applying nine tests evaluating explosive jumping strength and agility. To evaluate explosive jumping strength the *double-leg vertical jumps test* (CMJ) and the *single leg - right* (CMJR) and the *single leg – left vertical jump test* (CMJL) (Bosco, 1992) were used, as well as the *double-leg horizontal jump without swinging of the arms* (HJ) (Wiklander, 1987) and the *single-leg – right - horizontal jump* (SLRHJ) and the *single-leg – left - horizontal jump* (SLLHJ). Explosive strength tests of vertical jumps were measured using the QUATTRO JUMP (Kistler, Switzerland) platform for measuring the force. The result of a vertical jump was the height of the jump measured in centimetres (cm). The horizontal jump was measured using the horizontal jump landing surface with graduated markings (Elan, Slovenia). The result was the distance in centimetres between the tiptoes before take-off and the rear heel after landing. Agility was estimated by the *20-yard tests* (Y 20) (Milanović, 2003), *side steps* – lateral agility (LAT) (Metikoš, Hofman, Prot, Pintar, & Oreb, 1989) and by the *side jumps over the bench during 10 seconds test* (HOPS) (Šimek, 2006). The *20-yard test* was conducted with a maximum forward-running speed for a distance of 20 yards (18.28 m) with one 90° turn and two 180° turns, whereas the side steps were performed by moving to the side without crossing the legs over the 6 × 4-m distance. (Figure 1). The result in both tests was the time in seconds needed to complete the task. In the *HOPS test* the task was to jump laterally, legs together, over the bench as many times as possible during a period of 10 seconds.

The subjects were instructed with the way of conducting the tests before the experiment. Prior to the testing the subjects performed a warm-up aerobic activity for 5 minutes, working out and stretching. Each test was conducted three times and the result for every attempt was noted. The tests of explosive vertical jumping strength (CMJ, CMJR, CMJL) were conducted twice. After each attempt, i.e. after the completion of the test, the rest time was 1-2 minutes so that the fatigue of the subjects would not influence the final result. The result that was taken for further data analysis was the mean of two or three attempts.

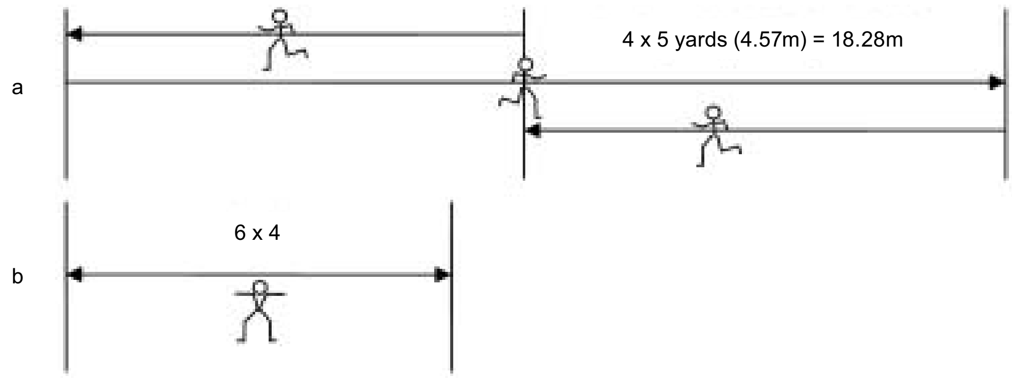

Figure 1. The scheme of agility tests - a) 20 yards (Y 20) and b) side steps (LAT).

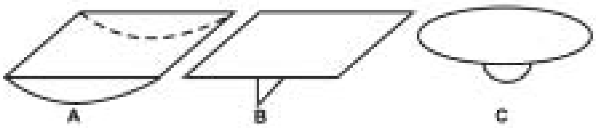

Figure 2. Balance boards applied in the conducted training programme.

Training

The proprioceptive experimental programme was conducted with three balance boards (Figure 2) which differed in the size and form of the supporting surface. On each board the progressive increase of load was done: from double-leg to single-leg tasks, with eyes open and closed, with additional disturbances of balance, by manipulating the objects, by applying strength exercises on the boards, and jumping off and on, and hopping on the board. The range-movement-tasks (the board edges touch the floor) and balancing (the board is parallel to the floor) were performed in all directions, in anterior-posterior and medio-lateral direction. The time of each stimulus on the balance board was increased by 20 to 70 seconds (according to Jukić, Milanović, Šimek, Nakić, & Komes, 2003), with a break during the performance duration. In one training unit 10 to 30 series of balance board tasks were realised. From Table 1 the content and the extensity of practice per minute in the realised experimental programme can be seen.

Statistical analysis

Statistica for Windows (Version 7.0) was used for statistical analysis. The basic statistical data were calculated for all variables: mean, standard deviation, minimum value, maximum value, range, kurtosis and skewness of distribution. This experiment called for the inclusion of between-groups and repeated measurements factors. The changes in each measure of test of motor skills between two times A and B and the differences between the groups were found by means of the 2×2 analysis of variance (ANOVA) for repeated measurements. This model includes a time-group interaction

Table 1. The overall extensity of the training process in the experimental group (in minutes)

Static and dynamic balance drills	Bilaterally		Unilaterally				Total
			Right leg		Left leg		
	Range	Balance	Range	Balance	Range	Balance	
Anterior-posterior	3.5	37.5	7	42	7	42	139
Medio-lateral	11	25.5	7.5	22	7,5	22	95,5
In all directions	7.5	43.5	16	49	16	49	181
Hops and jumps on boards	12		17.5		17.5		47
Total	140.5		161		161		

which represents the main effects (Hopkins, 2006; Statsoft, 2006). An effect of interaction occurs when a relation between (at least) two variables is modified by (at least) one variable (Hopkins, 2006). When an F-ratio of interaction was significant the *post-hoc* Tukey test was used with the purpose of locating the changes (the E and C group).The level of statistical significance was set at p<.05.

Results

Table 2. Arithmetic mean and standard deviation (AS±SD) in tests that evaluated the explosive vertical jumping strength for the experimental (E) and the control (C) group in the initial (T1) and the final testing (T2)

	E			C		
	CMJ	CMJR	CMJL	CMJ	CMJR	CMJL
T1	43.64 ± 4.01	28.78 ± 3.50	29.99 ± 3.45	42.20 ± 3.90	28.11 ± 3.52	29.23 ± 3.41
T2	45.28 ± 4.06*†	30.14 ± 3.06‡	31.23 ± 3.27†	41.70 ± 3.59	28.64 ± 3.57	29.32 ± 2.96

* significant main effects for TIME × GROUP † significant main effects for GROUP
‡ significant main effects for TIME

The changes in the results of the double-leg vertical jump are to be seen in Table 2. The analysis of variance showed a large difference between the groups in the CMJ test ($F_{1.73}$=10.27, p<.01). Also, there was statistically important interaction of group and time ($F_{1.73}$=5.79, p=.02). The *post-hoc* Tukey test showed statistically significant difference in results between the subjects of the E and the C group in the final testing (p<.0001).

In the CMJR the statistically relevant main effects for both groups ($F_{1,72}$=2.65, p=.11) were not found, but those for *time* (*before* and *after*) were ($F_{1.73}$=.95, p=.33). There was no substantial interaction of group and time ($F_{1.73}$=.95, p=.33). In the CMJL the statistically significant main effects both for the E and for the C group were identified ($F_{1.73}$=4.69, p=.03), but not the *time* ($F_{1.73}$=2.25, p=.14). There was no significant interaction of group and time.

The obtained results show that significant change occurred in the double-leg vertical jumping efficiency in the subjects from the E group due to the conducted proprioceptive programme.

In the HJ test there were no statistically relevant main effects either for *groups* (E or C) ($F_{1.73}$=3.49, p=.07) or for *time* (before/after) ($F_{1.73}$=1.34, p=.25). There was no significant interaction between the two groups in the final testing that could prove to be the result of the experimental programme. The test SLRHJ showed no statistically significant main effects either for *groups* ($F_{1.73}$=2.25, p=.14) or for *time* ($F_{1.73}$=2.25, p=.14). Yet, there was a statistically significant group-time interaction ($F_{1.73}$=4.55, p<.05). The results of the *post-hoc* Tukey test showed the differences between two tests in the experimental group that were not statistically significant – (p=.07). In the SLLHJ there were no statistically significant effects either for *groups* (E-C) ($F_{1.73}$=1.04, p=.31) or for *time* ($F_{1.73}$=3.88, p=.06). Accordingly, there was no statistically significant group-time interaction ($F_{1.73}$=1.70, p=.20), which shows that there was no statistically significant difference in the final testing between the E and the C group.

The results point to the changes in single-leg jumping efficiency (right leg) in the subjects from the E group which can be attributed to the training process applied.

In the agility test *Y20* there were no statistically significant main effects for *groups* (E/C) ($F_{1.73}$=3.4, p=.07), but a statisticaly significant difference was found for *time* (before/after). There was a statistically significant interaction between the *groups* and *times* (p<.05). The *post-hoc* Tukey test showed

Table 3. Arithmetic mean and standard deviation (AS±SD) in tests that evaluated the explosive horizontal jumping strength for the experimental (E) and the control (C) group in the initial (T1) and the final testing (T2)

	E			C		
	HJ	SLRHJ	SLLHJ	HJ	SLRHJ	SLLHJ
T1	193.72 ± 10.97	171.36 ± 11.66	175.51 ± 11.33	190.49 ± 12.98	174.59 ± 13.68	175.08 ± 13.68
T2	196.70 ± 11.47†	177.47 ± 11.77*	181.08 ± 13.34‡	191.12 ± 13.38	173.41 ± 15.50	176.21 ± 15.09

* significant main effects for TIME × GROUP † significant main effects for GROUP
‡ significant main effects for TIME

Table 4. Arithmetic mean and standard deviation (AS±SD) in tests for the assessment of agility: Y 20, LAT, HOPS for the experimental (E) and the control (C) group in the initial (T1) and the final testing (T2)

	E			C		
	Y20	LAT	HOPS	Y20	LAT	HOPS
T1	4.73 ± 0.18	7.32 ± 0.38	18.81 ± 1.23	4.75 ± 0.16	7.34 ± 0.35	18.91 ± 1.10
T2	4.72 ± 0.14*	7.35 ± 0.38	19.58 ± 1.43‡	4.82 ± 0.14	7.43 ± 0.33	19.11 ± 1.69

* significant main effects for TIME × GROUP † significant main effects for GROUP
‡ significant main effects for TIME

that there were statistically significant differences between the E and the C group in the final testing ($p<.01$). Differences were also found within the C group between the initial and the final testing ($p<.05$). The numerical values showed that the results of the E group in the final testing were similar to those in the initial testing, whereas the results of the C group were much poorer.

In the lateral agility test *LAT* there were no statistically significant effects either for *groups* ($F_{1.73}$=.54, p=.20) or for *time* ($F_{1.73}$=1.64, p=.20). Also, the interaction of *group* and *time* was not statistically significant ($F_{1.73}$=.33, p=.57). It is evident that the results of the E and the C group in the final testing did not differ significantly.

In HOPS test there were no statistically significant effects for groups ($F_{1.73}$=.53, p=.47) but this did not apply to time ($F_{1.73}$=6.78, p=.02). The interaction between groups and time was not statistically significant ($F_{1.73}$=2.38, p=.13). The numerical values showed that the subjects from the E group made one jump more than they did in the initial testing.

As for agility, the statistically significant change that can be attributed to the proprioceptive training programme was identified in the E group only in the agility test Y20.

Discussion and conclusions

Vertical jumping performance

Based on the results shown, certain changes in vertical jumping performance were evident following proprioceptive training. Although there was a certain improvement in the results for the E group between the T1 and the T2 testing (in all three jumping tests), the numerical value of those changes was relatively minor (1.2 -1.6 cm). Vertical jumping is a complex multi-joint activity which demands a great muscle strength in the hip, knees and ankle joints (Lees, Vanrenterghem, & De Clercq, 2004). Several researchers have proved the importance of the strength of muscles on the front and back side of the thigh for the performance of different jumps (Baker, 1996; Davies & Jones, 1993). Previous research showed that the proprioceptive training affects the increase in strength of the flexor and extensor muscles of the foot (Tropp & Askling, 1988). It also affects the increase in strength of the muscles on the back side of the thigh (Heitkamp et al., 2001). The increase in strength of leg extensor muscles along with the inhibition of stretch reflex (Lloyd, 2001) and the co-contraction mechanism can be the reasons for the improvement in vertical jumping performance.

Knowing that the explosive force generation in vertical jumping performance is influenced by the rapid transfer from eccentric to concentric muscle work (stretch-shortening cycle), it is possible that the proprioceptive training has had an effect on the quick generation of strength as well as on the higher rate and early inclusion of motor units (Gruber & Golhoffer, 2004), thus leading to the increase in the height of vertical jumps in the final testing in E group.

Although some numerical differences are observable, the changes were minor because the plantar flexors generated force at the very end of the take-off (it applies to 90-100% from the starting time) (Lees et al., 2004). The programme was intended to develop the strength of these muscles. Apart from that, the contribution of muscle activity in the hip joint is very important in maximum vertical jumping performance and very often determines the jump height thus differentiating between submaximal and maximal jumping performance (Lees et al., 2004). In the experimental programme the training activities were not intended to develop the strength of hip joint muscles.

Even though Ziegler (2002) noticed in his research big changes (12 %) in the height of the double-leg vertical jump (CMJ), his research was carried out with an untrained female population. Changes were also found (10.3 %) in the drop jump (DJ) (Ziegler, 2002). The sample in this research was comprised of physically active men, kinesiology students, whose characteristics in vertical jumping performance were similar to those of trained athletes (Matavulj et al., 2001). Regarding a higher level of physical fitness, the size of expected changes brought about by training was minor. In the Yaggie and Campbell (2006) research on physically active subjects there were no significant changes in the vertical jumping performance after the executed training plan of balancing on a half ball.

Bruhn, Kullmann and Gollhofer (2004) investigated the effects of proprioceptive training on the change of height in a squat jump. After four weeks of the training programme on unstable surfaces there were no significant changes in the jump height (p=.117) although a numerical difference was found. It might be that a 10-week-long training programme would produce more significant effects.

It has been shown that the changes in vertical jumping performance, i.e. slow-type (CMJ) and the fast-type (DJ) stretch-shortening cycle activities in the untrained population are achievable by applying proprioceptive training (Ziegler, 2002). However, the effects were poorer with the untrained population or not significant (Bruhn et al., 2004; Yaggie & Campbell, 2006). It can be assumed that the introduction of proprioceptive training for the improvement of explosive jumping strength is a substantial addition to the usual plyometric training.

Horizontal jumping performance

Regarding previous research (Liu-Ambrose, Taunton, MacIntyre, McConkey, & Khan, 2003) as well as the changes in vertical jumping performance proved by this research, the changes in explosive strength of horizontal jumping performance could be expected; however, they did not occur. The possible reason is the involvement of different muscle groups during vertical and horizontal jumping performance. The main contributors to the height of the vertical jump without swinging the arms were leg extensors followed by hip extensors. In horizontal jumping the impact of hip extensors was even greater. There were no significant changes in horizontal jumping performance, probably due to the fact that the experimental programme did not activate hip extensor muscles.

The training effects in the *single-leg – jump right* were identified in the E group and amounted to approximately 6 cm. There is a possibility that this was caused by cross-education. Cross-education represents the neural adaptation defined as the increase in strength of a counter-lateral extremity after a unilateral training of the other extremity (Farthing, Chilibeck, & Binsted, 2005). As stated in the research performed by Farthing and associates, by a unilateral training of the right-hand muscles right-handed people improved the strength of the untrained extremity, i.e. of the left hand (compared to those who worked out unilaterally with their left hand). Based on the results of this research it can be assumed that training the strong side (extremity) makes the other extremity stronger more than is the case of vice versa. There is a possibility that this research made severe changes in the right-leg strength due to the unilateral training with the strong (dominant) (take-off) leg (the left one), i.e. due to cross-education. On the other hand, the assumption is that the effect of cross-education of the weak extremity did not cause great changes in the strength of the left leg.

However, certain numerical changes in all horizontal jumps could be noticed. In the applied training programme one of the activities was jumping onto and off the boards which in its structure resembled jumping for distance. Since there is a tendency of improvement in the tests for assessment of horizontal jumping performance of E group, which is not the case with the C group, it is possible that with a longer training programme the results would be more significant.

Agility performance

In this research, the changes were found in some agility tests (*20Y, HOPS*), but not in the LAT test. In the *20Y* test there were minor numerical changes (.01 seconds), but the C group had much poorer results compared to the initial status (.07 seconds). It can be assumed that the proprioceptive training programme had no developmental effect on the subjects of the E group, but it had some sustaining effects. The assumption is that the speed of task execution in the subjects comprising the E group would have been lower if they had not been exposed to the training programme. Agility is a complex ability which depends on coordination, the mobility of the joint system, dynamic balance, strength, elasticity, stabilising and suppressing strength, speed, the stability of the locomotor apparatus and finally, on the optimal biomechanical structure of movement (Verstegen & Marcello, 2001). The reason for minor changes in this test could be the fact that the training programme included only dynamic balance and stabilisation exercises, not strength, speed or plyometric exercises.

Considering the applied training programme and activities both for plantar flexion and dorsal extension (anterior-posterior) of the ankle while standing on A and B boards and for movements on C boards in all directions (Table 1), it can be assumed that a certain level of the strength of the ankle joint was supplied, which led to positive changes in forward running activities. Based on the influence of proprioceptive training on the rate of force development and neural activation of individual muscles found in several studies (Bruhn and associates, 2004; Gruber & Gollhofer, 2004) we hypothesised that proprioceptive training could have positive effects an the activity with an explosive character. The analysis of body acceleration and running as well as the results of the research showed that the proprioceptive training could improve the results in the *20Y* test, and that it could considerably contribute to the acceleration of the body after a turn – the acceleration depends, before all, on the rate of force development.

The proprioceptive training programme in this research included all levels of motor control by means of exercises that are assumed to improve the activation of the central nervous system (on the level of cerebral cortex - a conscious movement, on the level of the brain stem - balance exercises, on the spinal level - practice in unstable conditions). At the same time the programme was directed towards strengthening certain groups of muscles essential for these kinds of activities.

In the *side steps test* there were neither numerical nor statistically significant changes that could be attributed to the experimental programme. There are several hypotheses regarding the possible reasons of such results. Firstly, in the research by Kaminski and associates (2003) the influence of proprioceptive training on the isokinetic strength of the ankle joint in eversion and inversion was analysed. After six weeks of training there was no significant change in strength. If we compare the results of the conducted research with previous research that confirmed the changes in ankle strength in flexion and extension (Tropp & Askling, 1988), we can assume that the proprioceptive training has a greater impact on the strength of the foot muscles in flexion and extension than in inversion and eversion. Regarding the specific nature of *side steps* it can be assumed that the strength of the foot in those movements provides a better result. Secondly, in the proprioceptive training programme in this research less time was spent on activities that were performed in medial and lateral directions, which can be the explanation for the lack of changes. For lateral movements the strength of the abductor and adductor of the foot is important. In this training programme the activation of these muscles was not significant.

In the *side jumps over the bench test* there were no significant main effects, however, certain differences in the E group in the final compared to the initial testing were found. Side jumps were structurally similar to double-leg vertical jumps where statistically significant changes were found that occurred due to the training programme. The reasons for the changes (approximately one jump more) could be the same in this test. Practising hops and jumps on boards, as well as preparatory dynamic balance exercises on the floor from this research could be the reasons for minor numerical changes. Considering that in general there were no changes that could be attributed to the training programme, not much attention was paid to them.

Although the changes in the analysed speed-explosiveness abilities were small, in practice they are important because very often the sum of minor changes in several training features can influence the overall success of an athlete. The research studies have proved that the proprioceptive training influenced a decrease of the number of injuries. However, this research has proved that the proprioceptive training influences the changes in tests for the assessment of some motor abilities. This particularly refers to the speed-explosiveness abilities, i.e. the activities where the goal is to generate great strength in a short time. The results of this research point to a possible value of this programme both for an integral system of the sports preparation and for a multi-directed preventive training programme (proprioceptive, jumping and agility performance training and weight training). Future research should be done on top-level athletes in some sports, i.e. their training programmes should be closely observed (with or without a proprioceptive programme), their sports injuries, as well as the results of several competition seasons. Such research could confirm or reject the usefulness of these training procedures in actual sporting conditions.

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UČINCI PROPRIOCEPTIVNOG TRENINGA NA SKOČNOST I AGILNOST

Sažetak

Uvod

Agilnost i eksplozivna snaga tipa skočnosti važne su motoričke sposobnosti potrebne za uspjeh u velikom broju sportova, prije svega u sportskim igrama. Dosadašnja istraživanja upućuju na mogućnost utjecaja proprioceptivnog treninga na živčanomišićni sustav prilikom inicijacije generiranja sile, odnosno poboljšanje eksplozivne snage i živčanomišićne aktivacije na samom početku voljne mišićne aktivnosti (Gruber i sur, 2004; Komi, 1984, prema Gruber i Gollhofer, 2004; Palma, 2005). U određenom broju istraživanja utvrđeni su učinci proprioceptivnog treninga na sposobnosti mišićne jakosti (Heitkamp i sur., 2001), agilnosti (Malliou i sur., 2004; Yaggie i Campbell, 2006) i skočnosti (Ziegler i sur., 2002; Kovacs i sur., 2004). Ipak, primjena ovog tipa treninga s ciljem unapređenja agilnosti i skočnosti još nije u potpunosti potvrđena. Cilj ovog istraživanja je utvrđivanje promjena u pokazateljima agilnosti i eksplozivne snage tipa skočnosti nakon provedenog proprioceptivnog trenažnog programa.

Metode

Uzorak ispitanika za ovo istraživanje činilo je 75 zdravih, tjelesno aktivnih studenata fizičke kulture (dob: 19 ± 1.2 god; visina: 180.5 ± 5.6 cm; težina: 76.8 ± 7.3 kg). Nakon inicijalnog testiranja, ispitanici su podijeljeni u eksperimentalnu (n = 37) i kontrolnu grupu (n = 38). Između njih u inicijalnom mjerenju nije utvrđena značajna statistička razlika niti u jednoj varijabli. Eksperimentalna grupa provodila je proprioceptivni trenažni program na balans daskama (slika 2), dok je kontrolna grupa nastavila sa svakodnevnim aktivnostima. Eksperimentalni postupak trajao je 10 tjedana, tijekom kojih je provedeno 30 trenažnih jedinica (3× tjedno). Svi ispitanici testirani su prije i nakon eksperimentalnog postupka primjenom 9 testova za procjenu eksplozivne snage tipa skočnosti i agilnosti. Za procjenu eksplozivne snage tipa skočnosti korišteni su testovi skok uvis s pripremom sunožno (CMJ), jednonožno desnom (CMJR) i lijevom nogom (CMJL) (Bosco, 1992) te skok udalj s mjesta bez zamaha ruku sunožno (HJ) (Wiklander, 1987) tednonožno desnom (SLRHJ) i lijevom nogom (SLLHJ). Agilnost je procijenjena testovima:20 jardi (Y20), koraci u stranu – lateralna agilnost (LAT)(Metikoš i sur., 1989) i preskoci preko švedske klupe u 10 sekundi (HOPS) (Šimek, 2006). Podaci su obrađeni programom Statistica for Windows (ver. 7.0). Promjene u svakom od mjerenih testova motoričkih sposobnosti između dvije vremenske točke te razlike između grupa utvrđene su 2x2 ANOVA-om za ponovljena mjerenja. Razina statističke značajnosti postavljena je na $p< 0.05$.

Rezultati

Analizom varijance i Tukeyevim *post-hoc* testom utvrđena je značajna razlika između rezultata ispitanika eksperimentalne i kontrolne grupe u finalnom mjerenju ($p<0.001$) u testu vertikalne skočnosti CMJ. U testovima CMJL i CMJR utvrđene su razlike između vremenskih točaka i grupa, ali nije utvrđena značajna interakcija grupe i vremena niti u jednom od njih (tablica 2). U testu horizontalne skočnosti HJ nisu utvrđene statistički značajne razlike između eksperimentalne i kontrolne grupe u finalnom mjerenju koje bi mogle biti posljedica eksperimentalnog programa. U testu skok udalj iz mjesta desnom nogom (SLRHJ) utvrđena je statistički značajna interakcija grupa×vrijeme ($F_{1,73}=4.55$, $p<0.05$). U testu skok udalj iz mjesta lijevom nogom (SLLHJ) eksperimentalna i kontrolna grupa u finalnom mjerenju nisu se značajno razlikovale (tablica 3). U testu agilnosti Y20 postoje statistički značajne razlike između eksperimentalne i kontrolne grupe u finalnom mjerenju ($p<0.01$) te razlike u kontrolnoj grupi između inicijalnog i finalnog stanja ($p<0.05$). U testovima lateralne agilnosti LAT i HOPS eksperimentalna i kontrolna grupa u finalnom mjerenju nisu se značajno razlikovale, iako je u testu HOPS zabilježena značajna promjena između inicijalnog i finalnog mjerenja.

Rasprava

Na temelju prezentiranih rezultata vidljive su određene promjene (1,2-1,6 cm) u vertikalnoj skočnosti pod utjecajem proprioceptivnog treninga. S obzirom na to da na eksplozivno generiranje sile u vertikalnom skoku s pripremom utječe i brzi prijelaz ekscentrične u koncentričnu mišićnu akciju, moguće je da je proprioceptivni trening utjecao na brzo generiranje sile te povećanu frekvenciju i ranije uključivanje motoričkih jedinica (Gruber i Gollhofer, 2004) te doveo do povećanja visine vertikalnog skoka u finalnom mjerenju kod eksperimentalne grupe. Iako je Ziegler (2002) u svom istraživanju zamijetio velike promjene (12%) u visini sunožnog vertikalnog skoka (CMJ), to istraživanje provedeno je na netreniranoj ženskoj populaciji. U istraživanju Yaggie i Campbella (2006), kao ni kod Bruhna i suradnika (2004), kod tjelesno aktivnih ispitanika nisu dobivene značajne promjene u vertikalnom skoku nakon provedenog proprioceptivnog treninga. Iz navedenog vidljivo je da su kod netrenirane populacije moguće promjene u vertikalnoj skočnosti pod utjecajem proprioceptivnog treninga, ali kod trenirane populacije efekti su manji ili nisu značajni.

Iako se u rezultatima testova horizontalne skočnosti mogu primijetiti određene numeričke razlike, u ovom istraživanju nisu dobivene statistički značajne promjene koje bi mogle biti posljedica provedenog proprioceptivnog trenažnog programa, iako je u nekim istraživanjima to bio slučaj (Liu-Ambrose i

sur., 2003). Moguće je da bi duži eksperimentalni program doveo do toga da bi efekti u svim analiziranim skokovima bili značajni. Zabilježeni su efekti treninga u eksperimentalnoj grupi u jednonožnom skoku desnom nogom i iznose ≈ 6 cm. Postoji vjerojatnost da je zbog unilateralnog treninga dominantne (odrazne) noge – lijeve, zbog kros-edukacije, došlo do značajnijih promjena u jakosti desne noge.

U nekim testovima agilnosti su zabilježene promjene (20Y, HOPS), dok u testu LAT nisu. U testu 20Y došlo je do malih numeričkih promjena (0,01s), ali je kontrolna grupa u odnosu na inicijalno stanje imala značajno slabije rezultate (0,07s). Može se pretpostaviti da provedeni proprioceptivni program nije imao razvojni učinak na ispitanike eksperimentalne skupine, ali pokazuje moguće održavajuće učinke koji bi se mogli pripisati pozitivnim promjenama u gradijentu sile i neuralnoj aktivaciji pojedinih mišića nakon primjene proprioceptivnog treninga (Gruber i Gollhofer, 2004). U testovima lateralne agilnosti moguće je da do promjena nije došlo zbog manjeg utjecaja proprioceptivnog treninga na jakost skočnog zgloba u pokretima everzije i inverzije (Kaminski i sur., 2003) koja je bitna u lateralnom kretanju. U provedenom programu manje je vremena bilo utrošeno na sadržaje u mediolateralnom smjeru, što može biti razlog izostanku promjena (tablica 1).

Promjene u analiziranim brzinsko-eksplozivnim sposobnostima bile su male te više predstavljaju održavajuće nego razvojne efekte treninga. Iduća istraživanja trebala bi biti usmjerena ka vrhunskim sportašima u pojedinim sportovima, odnosno praćenju njihovih trenažnih programa (uz proprioceptivni program ili bez njega), sportske ozljede i rezultate tijekom nekoliko sezona. Takva bi istraživanja mogla potvrditi ili odbaciti smisao primjene ovakvih trenažnih postupaka u realnim sportskim uvjetima.