FACTA UNIVERSITATIS
Series:**Physical Education and Sport** Vol. 14, N° 2, 2016, pp. 247 - 255

Original research article

THE INFLUENCE OF PROPRIOCEPTIVE TRAINING ON YOUNG RHYTHMIC GYMNASTS BALANCE

UDC 796.266.412

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Abstract. *The aim of this study is to investigate the influence proprioceptive training has on the development of the balance ability in young rhythmic gymnasts. This study was conducted on a sample of 60 healthy girls, aged 7-8, who practice rhythmic gymnastics. The whole sample was divided into two groups: an experimental (33 girls) and control (27 girls) one.The experimental group was engaged in proprioceptive training before regular rhythmic gymnastics training sessions for a period of 12 weeks (24 training sessions), while the control group was engaged in only regular rhythmic gymnastics training.Based on earlier research,it was assumed that proprioceptive training will improve the balance ability in rhythmic gymnasts. To estimate the effects of this method of training, balance ability was assessed by 6 balance tests. All of the participants were tested before the commencing of the experiment and subsequently after 12 weeks of applying experimental treatment.To determine the differences in the results from the initial measuring and the final measuring, the t-test for dependent samples was used and the t-test for independent samples was used to determine the difference between groups at the initial and also at the final measuring. It was concluded that proprioceptive training can significantly improve the ability of rhythmic gymnasts aged 7-8 to maintain balance.*

Key words: *proprioception, static balance, rhythmic gymnastics*

INTRODUCTION

Balance is one of the most important neuromotor abilities of humans, not only essential for general everyday movement but also in performing the most complex sport techniques. Gambetta and Grey (1995) consider it to be the crucial singular ability in sport. In contemporary sport, balance may indirectly influence a better demonstration of other motor abilities and easier management of techniques, while in some sports the

Received September 04, 2015 / Accepted July 05, 2016
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degree of its development directly influences the competitors' results. In rhythmic gymnastics, balance ability is decisive in performing a great variety of elements. One of the three basic structural groups of body elements are balances (FIG, Code of Points, 2013). They also form the basis of turns, a structural group of elements whose performance, for the greater part, relies on the balance ability. A higher degree of this motor ability development allows for an easier and more solid performance of apparatus handling techniques. Vestibular, kinesthetic, tactile and optic analyzers play an important part in maintaining balance while the surface size of the foothold, the height of the body center of gravity, and position of body parts that remain free in space determine the complexity and degree of difficulty of the balance position (Radisavljević, 1992).

In order to enable coordinated movement which is necessary for maintaining balance, timely activation of motor units is essential together with precise regulation of the intensity and frequency of nerve impulses. Information sent by proprioceptors is of crucial importance for the latter one. They react to changes in tension and length of muscles, speed of change in the tenseness and length of muscles, the changes in the position and movement of body parts and the body as a whole (Grbavac, 1997; Harris & Dudley, 2000; Lephart& Fu, 2000). Proprioception is a complex neuromuscular process wherein the stimulation of receptors is carried to lower or higher levels of the nervous system by afferent pathways so that timely activation of corresponding motor units can enable the maintaining of balance during static or dynamic activities (Laskowski, Newcomer-Aney, & Smith, 1997).

A special kind of training which concentrates on proprioceptor stimulation and improvement of proprioception functioning is called proprioceptive training. It is based on constantly disrupting balance positions aiming to produce adequate activation of respective motor units in order to regain balance once again. Proprioceptive training was first applied in the process of rehabilitation, primarily in cases of ankle injuries. Many findings confirm that this kind of training improves the functional stability of the ankle and helps in restoring the damaged postural status, at the same time reducing the frequency of recurring injury (Irrgang, Whitney, & Cox, 1994; Wester, Jespersen, Nielsen, & Neumann, 1996; Bernier & Perrin, 1998; Elis & Rosenbaum, 2001; Liu Ambrose, Taunton, McIntyre, McConkey, & Khan, 2003). Ankle injuries are caused by an insufficient development of proprioception which subsequently results in an inadequate activation of motor units when the foot comes into contact with the ground in dynamic conditions and there is not enough time for correcting the neuromuscular response (Robbins & Waked, 1998). Improvement of the neuromuscular response to the stimulation of kinesthetic receptors may be the key factor for an effective reduction of the risk of ankle injury, and some results of previously undertaken research work have shown that application of the proprioceptive training method is an effective means in ankle injury prevention (Gauffin, Tropp, & Odenrick Pay, 1988; Sheth, Yu, Laskowski, & An, 1997; Robbins & Waked, 1998; Eils, Schröter, Schröder, Gerss, & Rosenbaum, 2010). In the case of healthy individuals the positive effects of this kind of training are visible in the improvement of the ability to maintain balance or, in other words, in the reduction of postural oscillations (Hoffman & Payne, 1995).

Studies that have been conducted to ascertain the effects of applying proprioceptive training in active and healthy athletes with the aim to develop various motor abilities and improve sports techniques, are distinctly fewer in number (Ziegler, Gibson, & McBride, 2002; ŠimekŠalaj, Milanović, &Jukić, 2007; Ljubojević, Bijelić, Zagorc, Radisavljević, Uzunović, & Pantelić, 2012). Some studies have proved that proprioceptive training has positive effects on the development of balance in healthy adults (Yaggie & Campbell, 2006), and athletes engaged in sport dancing (Ljubojević et al., 2012).

Some authors believe that by relying on kinesthetic sense, the learning of particular movements in sports such as rhythmic gymnastics can be increased considerably (Wolf-Cvitak, Grčić-Zubčević, & Dolančić, 2002), while Šebić-Zuhrić, Rađo and Bonacin (2007) point out that proprioceptive training is an important means for enhancement of rhythmic gymnastics-specific techniques.

Yet, it remains unknown what effect proprioceptive training has on the development of balance in children of a younger school age (7-11 years), particularly if they are engaged in rhythmic gymnastics. The relevant findings of such a study would make a great contribution to other sports in which success and mastery are largely dependent on the development of this ability. Not forgetting that the period between the age of 7 and 12 is sensitive for the development of the balance ability (Gužalovskii, 1984; Drabik, 1996) and implementation of appropriate training methods to maximize the existing capacity to develop these skills, this indicates the importance that such a study could have. The aim of this research is to investigate the influence that proprioceptive training has on the development of the balance ability in young rhythmic gymnasts. As mentioned above, a recent study has shown that proprioceptive training reduces postural oscillations and improves postural status, and at the same time enhances the functional stability of the ankle. Since all these parameters play an important part in maintaining balance positions, it is hypothesized that proprioceptive training will improve the balance ability of rhythmic gymnasts of this age.

METHODS

Participants

This study was conducted on a sample of 60 healthy girls, aged 7-8, who practice rhythmic gymnastics for recreational purposes in the Sports Club “In”in Belgrade (Serbia). All the girls that participated in the experimental program trained for one or two years, practicing in sessions of 60 minutes twice a week. By applying the method of random sampling, the whole sample was divided into two groups: experimental (E) – numbering 33 girls, and control (C) – numbering 27 girls.

Measures

All of the participants were tested (initial measuring – T1) before the commencing of the experiment and subsequently after 12 weeks of applying the experimental treatment (final – T2). The sample of variables includes six variables for assessing the ability of maintaining a balance position and were all measured by standardized, valid tests whose reliability has previously and generally been accepted (Metikoš, Hofman, Prot, Pintar, &Oreb, 1989):

- standing on one foot turned breadth-wise on the balance beam, eyes open (P1O, in s),
- standing on one foot turned lengthwise on the balance beam, eyes open (U1O, in s),
- standing on both feet turned breadth-wise on the balance beam, eyes open (P2O, in s),
- standing on both feet turned breadth-wise on the balance beam, eyes closed (P2Z, in s),
- standing on both feet turned lengthwise on the balance beam, eyes open (U2O, in s),
- standing on both feet turned lengthwise on the balance beam, eyes closed (U2Z, in s).

Procedures

All of the participants were barefoot, dressed in light, sports clothes. Before the measuring commenced, all of them were given the task to kick a ball as far as they could, thus determining which foot would be considered the dominant one. They also were given a trial kick followed by three measured attempts and the best result for each participant was taken to be used in the analyses. Before each particular test, the participants were instructed to attempt to maintain a balance position on the balance beam for as long as they possibly could. Additionally, all the participants were informed of the test protocol before the beginning of the experiment. The participants performed each test three times and the best result was recorded. All of the measuring was conducted by one examiner.

Test – standing on one foot breadth-wise on the balance beam, eyes open (P1O) was performed in the following manner: the participant places one foot across, i.e., on the width of the beam while the other foot is still on the floor. The test begins when the participant lifts the supporting foot off the floor and maintains a balance position on the foot placed on the beam. Time is measured from the moment contact with the floor is discontinued until the moment when it is reassumed, in other words, when the participant loses balance.

Test – standing on one foot lengthwise on the balance beam, eyes open (U1O) was performed according to the same protocol, only the participant places his foot lengthwise on the beam.

Test – standing on both feet breadth-wise on the balance beam, eyes open (P2O) was performed in the following manner: the participant places both feet breadth-wise on the beam, supporting himself with one hand touching the wall. The measuring starts when the participant removes his hand from the wall and continues till the moment when his hand touches the wall again or one or both feet touch the floor.

Test – standing on both feet breadth-wise on the balance beam, eyes closed (P2Z) was conducted in the same way but this time the participant performs it with eyes closed. Measuring begins and ends as with the previous test, but also if the subject opens his eyes during the test.

Test – standing on both feet lengthwise on the balance beam, eyes open (U2O) and *Test -standing on both feet lengthwise on the balance beam, eyes closed* (U2Z) were performed in the same manner as the previous two (P2O and P2Z) except that both feet were placed lengthwise on the beam with the toes of one foot touching the heel of the other.

The experimental program of the proprioceptive model of training

The experimental group participated in proprioceptive training before regular rhythmic gymnastics training sessions for a period of 12 weeks (24 training sessions), while the control group only participated in regular rhythmic gymnastics training. The program of proprioceptive training was executed with the use of different boards generally used for this kind of training: T-board, half-globe board, board with a cylinder, as well as a Pilates balls, low balance beam and soft mattresses. Different tasks were performed with open or closed eyes, on one or both feet, and later on in the experiment, specific techniques of rhythmic gymnastics were also included (such as balancing a ball, spinning a hoop or rope, throwing and catching, etc.) all with the aim to add complexity to the tasks, or in other words, to increase strain. The training procedure included 5 to 7 minutes of warm-up and the training session was organized by method of stations. During one training session the participants were given three tasks which they performed in three series and they were also given equal time periods for both the training performance and recovery between each series (Jukić, Milanović, Šimek, Nakić, & Komes, 2003). The participants were organized into pairs: one performed the task while the other was recovering/resting (e.g. one participant was engaged in the task of maintaining balance for one minute on the T-board and then was given one minute to rest while his pair performed the set task). All of the elements of the experimental program were carried out at the beginning of the training session which meant that the complete duration of the active phase of proprioceptive training did not exceed 10 minutes; this prevented any nerve-muscle fatigue. Special attention was given to ensure that the participants were properly concentrated on the performance of tasks set in order to enhance the economic flow of sensory information in the central nervous system (Voight & Cook, 1996; according to Lephart, Pincivero, & Rozzi, 1998), and by that improve the effectiveness of the exercise. Proprioceptive training started 15 minutes before regular rhythmic gymnastics sessions and since time periods of active exercise and recovery rotated in equal time intervals, the workload was nearly the same as in the control group.

Statistical analysis

The mean and standard deviation were determined by criteria taken from the field of descriptive statistics. From the field of comparative statistics, we used the t-test for dependent samples in order to determine the differences in the results from the initial measuring and the final measuring. The t-test for independent samples was used to determine the differences in the results of the control group and the experimental group, first at the initial measuring and then for the final measuring. The obtained data was processed by procedures contained in the SPSS 20.0 program.

RESULTS

By using Kolmogorov Smirnov Test it was checked whether the data distribution was normal. In regard to the fact that all variables had a normal distribution, it was allowed to apply the t-test.

The results of the t-test for independent samples (Table 1) at the initial measuring show that the experimental and control group did not differ significantly in the achieved results for any of the tests.

Table 1 T-test for independent samples

	Initial measuring			Final measuring		
	E (n=33) Mean (SD)	C (n=27) Mean (SD)	p	E (n=33) Mean (SD)	C (n=27) Mean (SD)	p
P1O (s)	2.04 (1.41)	1.73 (1.04)	0.350	3.41 (1.87)	2.25 (1.27)	**0.008**
U1O (s)	8.19 (9.78)	6.48 (6.71)	0.444	15.96 (21.03)	7.35 (6.11)	**0.031**
P2O (s)	4.88 (3.53)	4.28 (6.20)	0.643	7.93 (7.48)	4.89 (4.38)	0.068
P2Z (s)	1.72 (0.97)	1.40 (0.54)	0.108	2.59 (1.17)	1.89 (0.65)	**0.005**
U2O (s)	4.60 (2.68)	5.88 (5.43)	0.290	8.47 (4.40)	6.51 (6.39)	0.166
U2Z (s)	1.95 (0.78)	2.09 (1.58)	0.663	2.62 (0.83)	2.14 (0.84)	**0.030**

Key: E – experimental group, C – control group, SD – standard deviation,
* level of significance set on p<0.05

Table 2 shows the results achieved at the initial and final measuring, as well as the significance of their differences, for both groups. According to descriptive criteria, both the experimental and control group showed better results in all of the tests at the final measuring. The results of the t-test for dependent samples showed that the experimental group enhanced its performance in all the tests for maintaining balance; as for the control group, significant improvement was noticeable in two tests (P1O and P2Z).

Table 2 T-test for dependent samples

	Experimental				Control			
	Initial Mean (SD)	Final Mean (SD)	p	% improve	Initial Mean (SD)	Final Mean (SD)	p	% improve
P1O	2.04 (1.41)	3.41 (1.87)	**0.000**	**67.06**	1.73 (1.04)	2.25 (1.27)	**0.018**	**29.79**
U1O	8.19 (9.78)	15.96 (21.03)	**0.008**	**94.86**	6.48 (6.71)	7.35 (6.11)	0.523	13.34
P2O	4.88 (3.53)	7.93 (7.48)	**0.021**	**62.58**	4.28 (6.20)	4.89 (4.38)	0.602	14.29
P2Z	1.72 (0.97)	2.59 (1.17)	**0.000**	**50.18**	1.40 (0.54)	1.89 (0.65)	**0.002**	**35.08**
U2O	4.60 (2.68)	8.47 (4.40)	**0.000**	**84.00**	5.88 (5.43)	6.55 (6.55)	0.670	11,47
U2Z	1.95 (0.78)	2.62 (0.83)	**0.001**	**34.58**	2.09 (1.58)	2.11 (0.86)	0.949	0.96

Key: SD – standard deviation; * level of significance set on $p<0.05$

By comparing the results achieved by both the experimental and control group at the final measuring (Table 1) we can state that the experimental group showed better results than the control group in all the tests and that the noticeable differences in most of the tests were statistically significant (P1O, U1O, P2Z, U2Z).

DISCUSSION

The results of the tests that were achieved at the initial measuring did not show any significant differences between the experimental and control groups; therefore, the differences obtained at the final measuring can be attributed to proprioceptive training.

After taking part in the proprioceptive training, the experimental group significantly improved its performance in all the tests for maintaining a balance position. Similar results were reached by Ljubojević et al. (2012) while researching the effects of this method of training on a sample of dancers aged 15 to 19, using the same tests for assessing balance maintenance. A significant enhancement of the ability to maintain balance through the application of proprioceptive training was registered with healthy adults (Yaggie& Campbell, 2006). The control group significantly enhanced its performance of tests P1O and P2Z, which can be attributed to rhythmic gymnastics training. While working with girls at the beginner level, much attention is given to easier forms of balancing such as standing on one foot, on tip-toe, which can account for the improvement in test P1O. Positions with both feet on tip-toe are an essential element of all movements in rhythmic gymnastics because they are most often their starting position. Training of younger categories regularly includes these elements, thus explaining the improvement of the control group results in test P2Z. A review of the percentages of achieved improvement in these two tests showed a greater enhancement in the experimental group compared with the control group. In test P1O the experimental group achieved an improvement of 67.06%, while the control group achieved 29.79%; in the test P2Z the experimental group achieved better results by 50.18%, while the control group improved by 35.08%.

Comparing the results of the experimental and control groups at the final measuring we can observe that the experimental group achieved better results in all the tests for maintaining balance, and in most of the tests statistically significant better results as well (P1O, U1O, P2Z, U2Z). Only in tests P2O and U2O is this difference not statistically significant, which can safely be attributed to the influence of rhythmic gymnastics training on the development of the ability to maintain balance. The significant improvement exhibited by the experimental group in the previously mentioned tests may be taken as evidence that proprioceptive training enhances the balance ability in several ways. Such an improvement may partly be viewed as the result of a better kinesthetic sense; this statement can be supported by better P2Z and U2Z test results as these tests are performed with closed eyes, excluding the sense of sight. For the other part, it may also be viewed as the result of improvement of all the other systems crucial to maintaining balance positions, as shown by recorded better results in tests P1O, U1O. According to previous studies, this method of training reduces postural oscillations (Hoffman & Payne, 1995), improves the functional stability of the ankle and postural status (Irrgang et al., 1994; Wester et al., 1996; Bernier & Perrin, 1998; Elis & Rosenbaum, 2001; Liu Ambrose et al., 2003), all of which are important factors in maintaining balance positions.

Since improvement in the experimental group was recorded in balance tests with the foot placed either breadth-wise (P1O, P2O, P2Z) or lengthwise on the balance beam (U1O, U2O, U2Z), we can conclude that the applied method of proprioceptive training greatly contributed to the enhancement of control in maintaining balance positions in anterior-posterior and median-lateral directions.

CONCLUSION

Based on all the above stated facts it can clearly be concluded that proprioceptive training can significantly improve the ability of rhythmic gymnasts aged 7-8 to maintain balance, whereby the proposed hypothesis of this study is proved.

One of the shortcomings of the study was the measuring instrument used, in this case a stop-watch, as it can lead to mistakes in measuring resulting from the “subjectivity” on the part of the timekeeper. In future studies more reliable measuring instruments could be used, such as the BIODEX Balance system or a power platform.

A further step in this field of research could include the investigation of the pace of development through the application of proprioceptive training, as well as the pace of preserving the achieved results.

THE IMPORTANCE OF STUDY IN PRACTICE

The importance of this study primarily lies in the fact that it can be applied in everyday practice. Proprioceptive training does not require greater organizational and financial efforts,nor does it take up too much time; on the other hand, its application can result in significant improvement of the balance ability. For these reasons it can be recommended not only as a means to enhance balance in those sports where results directly depend on how developed this ability is, but in other sports as well, where this ability can indirectly lead to better results at the competition level.

Acknowledgement:*The paper is a part of the research done within the project of the Ministry of Education, Science and Technological Development of Republic of Serbia: Effects of applied physical activity in locomotion, metabolic, psychosocial and educational status of the population of R. Serbia. No. 47015 (2011-2015).*

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UTICAJ PROPRIOCEPTIVNOG TRENINGA NA RAVNOTEŽU MLADIH RITMIČARKI

Cilj ovog istraživanja bio je da ispita uticaj proprioceptivnog treninga na sposobnost održavanja ravnoteže kod mladih ritmičarki. Studija je sprovedena u uzorku 60 zdravih devojčica, uzrasta 7 do 8 godina, koje treniraju ritmičku gimnastiku na rekreativnom nivou. Ceo uzorak je podeljen u dve grupe: eksperimentalnu (33 devojčice) i kontrolnu (27 devojčica). Eksperimentalna grupa je primenjivala trening propriocepcije pre svojih redovnih treninga u trajanju od 12 nedelja (24 treninga), dok je kontrolna grupa pohađala samo treninge ritmičke gimnastike. Na osnovu ranijih istraživanja, pretpostavljeno je da će trening propriocepcije poboljšati sposobnost ravnoteže kod mladih ritmičarki. Za procenu efekata ovog metoda treninga, sposobnost ravnoteže procenjivana je pomoću šest testova. Sve ispitanice testirane su pre primene eksperimentalnog tretmana i 12 nedelja nakon njegove primene. Za ispitivanje razlika u postignutim rezultatima između inicijalnog i finalnog merenja korišćen je t-test za zavisne uzorke, dok je za utvrđivanje razlika između grupa na inicijalnom i finalnom merenju korišćen t-test za nezavisne uzorke. Studija je pokazala da proprioceptivni trening značajno poboljšava sposobnost ravnoteže kod ritmičarki uzrasta 7 do 8 godina.

Ključne reči: *propriocepcija, statička ravnoteža, ritmička gimnastika*