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Aspects regarding the investigation of single-leg balance in athletes

Aspecte privind investigarea echilibrului pe un picior la sportivi

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Abstract

Background. Body balance is an important factor for a good motricity in static and dynamic activities.

Aims. The aim of the study was to analyze one-leg balance on the preferred leg in athletes with eyes open and closed.

Methods. The study was carried out on 20 subjects aged between 10-13 years old. Ten of them practiced gymnastics and the other 10, fencing. With the digital program GPS 5.0, the computer registered and assessed the following variables of balance: mediolateral displacement of the center of mass, anterior posterior displacement of the center of mass, frequency of oscillations in frontal and sagittal plane. Statistical analyses were conducted using SPSS 20.0 software for Windows and were expressed as mean and standard deviation, and the parametric t test was used for the differences of the means. The independent samples t test was used to find out whether there were any balance differences in the dominant leg between gymnasts and fencers.

Results. The results revealed a value of $p<0.05$ for mediolateral displacement and the frequency of oscillations in frontal plane. In addition, the paired t test was used to compare the scores obtained in two different conditions (with eyes open and closed) in each group. In the group of gymnasts no significant differences were obtained for the variables of balance and the fencers' group showed statistical differences for two variables: mediolateral displacement of the center of mass and frequency of oscillations in frontal plane.

Conclusions. The differences found in mediolateral displacement may be related to lower limb and hip strength depending on the sport practiced.

Keywords: balance, oscillations, center of mass, gymnastics, fencing.

Rezumat

Premize. Capacitatea de echilibru a corpului este o condiţie indispensabilă motricităţii, atât pentru activităţile statice, cât şi pentru cele dinamice.

Obiective. Studiul îşi propune să analizeze echilibrul pe piciorul preferat la sportivi, atât cu ochii deschişi, cât şi cu ochii închişi.

Metode. Cercetarea s-a realizat pe un număr de 20 de subiecţi, cu vârsta cuprinsă între 10-13 ani. Dintre aceştia 10 subiecţi practică gimnastică, iar 10 scrimă. Cu ajutorul programului digital GPS 5.0 s-au înregistrat şi evaluat următoarele variabile: deplasarea mediolaterală şi anteroposterioară a centrului de presiune, precum şi frecvenţa oscilaţiilor în plan frontal şi sagital. Pentru calculul statistic am utilizat programul SPSS 20.0 pentru Windows, iar datele au fost reprezentate ca medie şi deviaţie standard, pe baza cărora s-au aplicat testele t parametrice de comparare a mediilor. Testul t pentru eşantioane independente a fost aplicat pentru a verifica dacă există diferenţe semnificative în ceea ce priveşte echilibrul pe piciorul dominant între gimnaşti şi scrimeri.

Rezultate. Rezultatele au relevat valori ale lui $p<0,05$ pentru variabilele: deplasarea mediolaterală a centrului de presiune şi frecvenţa oscilaţiilor în plan frontal. De asemenea, am comparat scorurile obţinute în condiţii diferite (cu ochii închişi şi cu ochii deschişi) la fiecare grupă de subiecţi, utilizând testul t pentru eşantioane perechi. La grupa gimnaştilor nu s-au constatat diferenţe semnificative la nici una dintre variabilele echilibrului, iar la grupa scrimerilor diferenţele au fost semnificative pentru 2 variabile: deplasarea mediolaterală a centrului de presiune şi frecvenţa oscilaţiilor în plan frontal.

Concluzii. Diferenţele obţinute la deplasarea centrului de presiune în plan frontal pot fi rezultatul dezvoltării diferite a musculaturii membrului inferior şi a bazinului, în concordanţă cu specificul sportului practicat.

Cuvinte cheie: echilibru, oscilaţii, centru de presiune, gimnastică, scrimă.

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Introduction

The diversity of approaches to defining balance comes from the field of expertise and the domain of the person who debates this issue; each specialist tries to explain as clearly as possible the aspects describing this capability. Hence, in the opinion of certain authors, balance is defined as the state of a body submitted to forces that cancel each other without changing its state – moving or quiet; others present it as an availability response, a specific feeling for the right movement, a motor skill (Marcu, 2000; Hotz, 2003). The notion of postural balance – analyzed from a physiological perspective – is defined as the dynamic of mechanical tensions in the agonist and antagonist muscles, commanded voluntarily or automatically and controlled by at least five feedback loops (Creţu et al., 2007). From the perspective of biomechanics, balance refers to internal forces generated by muscle contraction, while, in kinesiotherapy, balance is defined as the maintenance of the body's gravitation line within the support polygon (Gagea, 2006; Sbenghe, 1999). From the perspective of physical education and sport, the concept of balance is presented as the capacity of maintaining the body in a balanced position and of restoring its balance following displacements or wide-range strain (Manno, 1992).

The fundamental elements that interfere with the capacity of controlling body balance are as follows: stability of support surface, localization of the center of gravity, limit of stability, size of support surface, capacity of visualizing the environment, motor activities approached by the individual, integrity and interaction between mechanisms of postural control. Hence, body balance can be impaired or even lost in situations when the limit values of any of the aforementioned elements are exceeded (Marcu & Chiriac, 2009).

Balance is one of the basic physical qualities in the athlete's movements, irrespective of the sport; if the player is to lose his/her balance abilities, he/she consequently loses his accuracy of performing the skill (El-Maaty, 2010). Postural changes are distinct depending on the activity, and each sport has its own postural adjustments. For instance, in combat sports practices, the focus is on somatosensory information, while gymnastics is based on visual information (Filingeri et al., 2012).

The development of elegance and beauty in gymnastics movements depends on the level of certain motor skills such as flexibility, which plays an important role in this sport, considering that it is necessary for the execution of wide range movements (Karloch et al., 2012). The manner of executing these elements depends very much on postural balance, necessary for the accuracy of movements (Poliszczuk & Broda, 2012). Because rhythmic gymnastics comprises numerous elements associated with launching and catching apparatus, athletes must find original perceptive and motor solutions (Geoffroy et al., 2008).

Speed has developed very much and it has become what is known today as "conversation through the blade" (Sowerby, 2012). Fencing is a rapid sport from all perspectives: speed of perception, speed of reaction, speed of motion, rapid action change, rapid change of rhythm, rebalancing speed. Fencing develops many coordinative capacities, which can be divided intro three groups, as follows: motor educability, motor control and motor adaptability. From this standpoint, fencing is very different from other sports that involve similar motor skills, such as gymnastics, acrobatic gymnastics, etc. (Czajkowski, 2005). Fencing is characterized by dynamism, which involves both analyzing the trajectory of the weapon and managing the dynamic balance based on continual movements within speed attacks, which force the athletes to adapt constantly from a spatial, temporal and situational perspective. The fencer faces a double constraint: he/she must react to the opponent and regain balance during attacks and counterattacks (Herpin et al., 2010).

Hypothesis

If the athlete practices one particular sport, during sports training, the specificity of the sport influences balance on the preferred leg. Hence, this paper aims at analyzing body balance on the preferred leg in beginners aged between 10 and 13 years – practitioners of gymnastics and fencing – and to pinpoint the differences arising in two different conditions: eyes open and eyes closed.

Material and methods

Research protocol

a) *Period and place of the research*

The investigation was conducted in September-November 2013 and it comprised two stages, at the Medical Recovery Center within the Arcadia Hospital Iaşi. We mention that, in agreement with the Declaration of Helsinki, the Amsterdam Protocol and Directive 86/609/EEC, all study procedures were approved by an ethics commission within the Faculty of Physical Education and Sport concerning investigation on human subjects, and that we obtained the written consent of the subjects and of their parents.

Subjects and groups

The research sample comprised 20 subjects, aged between 10 and 13 years. Of these, 10 subjects were gymnasts, while 10 were fencers and they had been practicing this sport for 1-3 years.

b) *Tests applied*

Balance on the preferred leg with the help of the GPS 400 Stabilometric Platform, which shows the situation in real time and can detect minor changes in the subjects' ability to maintain balance.

Each subject was asked to maintain position on the preferred leg, arms close to the body, palms facing the body and the other leg knee flexed for 30 seconds or as much as he/she could without exceeding this time duration. If a subject maintained position for less than 30 seconds, then he/she was allowed to try again (but no more than three attempts), and the computer registered the best result. The tests took place in two different conditions: eyes open and eyes closed.

By using the GPS 5.0 software, we registered and assessed the following variables: mediolateral and anterior posterior displacement of the center of mass (units) and frequency of oscillations in frontal and sagittal plane (Hz).

c) *Statistical processing*

For statistical calculations, we used SPSS 20.0 for Windows, and results were expressed as mean and standard

deviation, and the parametric t test for the differences of the means. The independent samples t test was used to find out whether there were any balance differences in the dominant leg between gymnasts and fencers.

Results

For the test of balance on the preferred leg (Table I), gymnasts featured a lower frontal deviation of the General Center of Mass (GCM) compared to fencers (3.86±4.23 units vs. 28.20±11.60 units), while sagittal deviation was lower among fencers compared to gymnasts (3.26±15.37 units vs. 14.50±9.14 units). Concerning the frequency of oscillations in the two planes, gymnasts had a higher deviation compared to fencers.

Table I

Balance on the preferred leg with eyes open.

Parameters	Eyes open			
	Gymnastics (N=10)		Fencing (N=10)	
	Mean	SD	Mean	SD
GCM projection in frontal plane	3.68	±4.23	28.20	±11.60
GCM projection in sagittal plane	14.50	±9.14	3.26	±15.37
Frequency of GCM oscillations in frontal plane	0.41	±0.32	0.28	±0.21
Frequency of GCM oscillations in sagittal plane	0.29	±0.21	0.17	±0.38

Table II

Balance on the preferred leg with eyes closed .

Parameters	Eyes closed			
	Gymnastics (N=10)		Fencing (N=10)	
	Mean	SD	Mean	SD
GCM projection in frontal plane	4.23	±3.37	10.94	±16.48
GCM projection in sagittal plane	16.15	±13,32	7.43	±22.17
Frequency of GCM oscillations in frontal plane	0.63	±0.36	0.25	±0.14
Frequency of GCM oscillations in sagittal plane	0.23	±0.12	0.25	±0.09

As for balance on the preferred leg with eyes closed (Table II), we recorded the same deviations of the GCM: lower in frontal plane in gymnasts, while lower in sagittal plane in fencers. In regard to the frequency of oscillations, in frontal plane they were higher by 0.63±0.36 Hz in gymnasts compared to fencers, who scored a mean of 0.25±0.09 Hz, while in sagittal plane, the frequency of oscillations had a mean of 0.23±0.12 Hz in gymnasts, lower than the one of the fencing group (0.25±0.09 Hz).

After analyzing the balance on the preferred leg in gymnasts (Table III), we found no significant differences between the two tested situations (eyes open and eyes closed), while fencers had significant differences for GCM in frontal plane and for the frequency of oscillations in sagittal plane (Table IV).

Table III

Statistical differences between balance with eyes open and eyes closed in gymnasts.

Parameters	Mean diff.	t	p
GCM projection in frontal plane	0.55	-0/481	>0.05
GCM projection in sagittal plane	1.65	-0.611	>0.05
Frequency of GCM oscillations in frontal plane	0.21	-1.284	>0.05
Frequency of GCM oscillations in sagittal plane	0.06	0.731	>0.05

Table IV

Statistical differences between balance with eyes open and eyes closed in fencers.

Parameters	Mean diff.	t	p
GCM projection in frontal plane	17.26	2.708	00.05
GCM projection in sagittal plane	4.17	-0.489	>0.05
Frequency of GCM oscillations in frontal plane	0.02	0.297	>0.05
Frequency of GCM oscillations in sagittal plane	0.06	-2.280	<0.05

Discussions

Previous research has shown the existence of complex factors, where perception and action play a crucial role in the control of body posture (Smart et al., 2004; Gautier et al., 2008). Maintaining balance and spatial orientation are necessary in performance sports and they refer to the body's ability of maintaining the center of gravity within the support base (Cordun, 2009; Duarte & Freitas, 2010). Maintaining balance through the mechanism of postural control leads to small, but constant oscillations of the body while standing, which plays a very important role in distributing the weight on the soles (Viera & Oliveira, 2006; Shigaki et al., 2013). However, other studies support the idea that superior balance is the result of training the ability to respond to relevant proprioceptive and visual signals (Ashton-Miller et al. 2001).

The originality and novelty of our investigation reside in the fact that we focused on investigating balance on the preferred leg in two different individual sports. Findings evidenced similarities between balance on the preferred leg with eyes open and closed in gymnasts, and no statistically significant differences were found. Our findings are similar to others, which showed no significant differences on the level of frequency of oscillations in the two planes (Tookuni et al, 2005).

In fencers, significant differences were found in GCM projection in frontal plane with eyes open/closed, and in the frequency of oscillations in sagittal plane. It is worth noting that for balance with eyes closed, subjects had much better balance than with eyes open (28.20 units – eyes open vs. 10.94 units – eyes closed). In fencers, the significantly better results in balance with eyes closed can be explained by the fact that visual information is not very much used for balance control, but rather for reading the opponent's intentions (Gautier et al., 2008). Fencing is a unique sport, which reflects an asymmetrical development of muscles. Maintaining one-leg balance requires force and increased focusing capacity, in direct connection with other receptors at the level of auditory and visual analyzers and at the level of muscles and joints (Tzolakis & Tziganos, 2008).

One-leg support is one of the most unstable balance stances, due both to the support (very small compared to the body weight) and to the external and internal forces that manifest their vectors in different directions.

By eliminating the visual analyzer (closing the eyes), instability increases and it cannot be controlled for long; the final result is the loss of balance. Furthermore, reducing the body's points of contact with the support surface in the one-leg stance not only limits the support surface, but also

increases segment force, as an effect of the increase in muscle and ligament tension and in pressure on the sole. The consequence is the increase in the floor's reaction forces, which disturbs the state of balance (Alexe, 2009).

Certain limitations can be considered for this study: we had a too small number of subjects to provide for a characteristic of the population studied; considering the age of the subjects, sport did not have the time to put a mark on early specialization, mostly in fencing; the technique of the two sports is different; the groups comprised both boys and girls; the tests were conducted only on the preferred leg. Starting from these limitations, our future intention is to conduct similar investigations, in order for these findings to help the specialists in practice.

Conclusions

The investigation demonstrated that at this age, gymnasts have better balance on the preferred leg compared to fencers, while fencers have better balance in frontal plane with eyes closed than with eyes open.

Concerning the frequency of oscillations, it is higher in frontal plane compared to the sagittal plane, and this goes for both groups of subjects.

Conflicts of interests

There were no conflicts of interests.

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