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ORIGINAL SCIENTIFIC PAPER

Static- vs. Dynamic-Stretching in Development of the Dynamic Balance; Chronic Effects of Specific Training Interventions in Female Football Players

Dragan Mijatović[1], Miran Pehar[2], Šime Veršić[3], Ivan Kvesić[2], Goran Gabrilo[3]

[1]University of Mostar, Faculty of Health Sciences, [2]University of Mostar, Faculty of Science and Education, [3]University of Split, Faculty of Kinesiology

Abstract

Flexibility is an important determinant of dynamic balance, but studies rarely examined the chronic effects of flexibility training on changes in balance capacity. This study aimed to determine the influence of different forms of flexibility exercises on dynamic balance in female professional football players. Participants were 30 female professional football players (age =19.0±4.1 years), divided into three groups dynamic stretching group (DSG; N=10, age =18.9±3.3 years), static stretching group (SSG; N=10, age =19.5±4.3 years) and control group (N=10, age =18.5±3.3 years). All groups participated in equal football training, while DSG and SSG performed additional flexibility training 3-times a week (10-15 min of duration) throughout the study course (16 weeks). Dynamic balance was measured by the Y-balance test (YBT), and ANOVA for repeated measurement was applied to identify the effects. Results evidenced the significant influence of both flexibility programs on dynamic balance. Both DSG and SSG were equally effective in the first part of the study (until the 8th week), but between the 8th and 16th study week, only DSG improved their balance capacity significantly. Static stretching should be applied in the first phases of flexibility training aiming at the improvement of dynamic balance, but in later phases, usage of dynamic stretching is suggested.

Keywords: *soccer, dynamic balance, flexibility, intervention, females*

Introduction

Balance appears as a term in many professions and each defines it within its specifics (Pollock, Durward, Rowe, & Paul, 2000). Viewed from the angle of sports performance, balance can be most simply defined as "keeping the center of gravity of the body within the base of support" (Hrysomallis, 2007). It is a key component of most motor skills and performances, regardless of the degree of complexity (Davlin, 2004). Generally, it can be divided into static, in which the balance is maintained with minimal movement, and dynamic, which implies the ability to perform a task while maintaining a stable position (Winter, Patla, & Frank, 1990; Bressel, Yonker, Kras, & Heath, 2007a).

Balance is an extremely important quality in sports, not only because it can affect an athlete's efficiency but also because a balance deficit can cause injuries (Zemková, 2014; Viran & Canli, 2022). Although, in some sports, balance manifests in static conditions, dynamic balance is much more present in most team sports, including football. Dynamic balance in team sports is reflected in running, jumping, and many other specific movements (Zemková, 2014). Besides these biotic motoric abilities, during football activity, players perform passing, shooting and dribbling with lower extremities with cleated or noncleated shoes on variable turf conditions (Bressel, Yonker, Kras, & Heath, 2007b). These tasks and environmental conditions put specific demands on the sensorimotor system and affect the balance abilities of football players (Orchard, 2002). In these

Correspondence:

Miran Pehar
University of Mostar, Faculty of Science and Education
E-mail: miran.pehar@fpmoz.sum.ba

situations, maintaining balance is conditioned by: (i) sensorimotor information collected through the somatosensory, visual and vestibular system and (ii) motor responses to this information which are influenced by coordination, range of motion (ROM) and muscle strength (Grigg, 1994; Palmieri et al., 2003; Bressel et al., 2007a). Therefore, ROM should be observed as being directly related to balance.

The ROM of human joints is directly associated with muscle flexibility (Gleim & McHugh, 1997; Mohammad, Elattar, Elsais, & AlDajah, 2021). Indeed, flexibility training affects the improvement of many body functions, including movement control and increasing the elasticity of connective tissue and the manifestation of other motor skills (i.e. speed, strength, power, agility) (Alter, 2004; Fletcher, 2010; Ryan et al., 2014; Su, Chang, Wu, Guo, & Chu, 2017). There are several ways to develop flexibility, while static and dynamic stretching is most commonly used. Static stretching is described as the gradual elongation of a muscle through the static hold of an elongated position to a point of discomfort, while dynamic is defined as controlled movement through an active articular range of motion during which individual limits of flexibility are not exceeded (De Vries, 1962; Fletcher & Jones, 2004). Increased mobility of the joints and the amplitude of movement leads to more precise movement, better motor control and thus improvements in dynamic balance (Behm & Chaouachi, 2011).

The relationship between balance and flexibility so far has been investigated mainly in the elderly population, primarily because it influenced health status. In brief, a mutually positive impact between flexibility and balance has been found (Bird, Hill, Ball, & Williams, 2009; Emilio, Hita-Contreras, Jiménez-Lara, Latorre-Román, & Martínez-Amat, 2014). Moreover, studies have investigated the acute effects of different types of stretching on dynamic balance and the results are quite inconsistent (Costa, Graves, Whitehurst, & Jacobs, 2009; Behm & Chaouachi, 2011; Costa, Ruas, & Smith, 2018). However, most of these studies were short-term and/or cross-sectional and authors either cross-sectionally evaluated associations between flexibility and balance status, and/or determined acute effects of flexibility exercise on balance capacity (Curry, Chengkalath, Crouch, Romance, & Manns, 2009; Chatzopoulos, Galazoulas, Patikas, & Kotzamanidis, 2014). Meanwhile, there is a clear lack of research that has examined changes in the balance due to long-term longer-term specific flexibility treatment.

Collectively, despite the known importance of flexibility on dynamic balance, there is an evident lack of studies that directly examined the effects of flexibility training on changes in balance capacity. The knowledge of such kind would be particularly valuable knowing the importance of both capacities on sports performance and injury occurrence in sports. Although there are some studies on the male football population, studies on female athletes are particularly scarce. Additionally, studies reported different neuromuscular predictors of dynamic balance between genders, with core and hip strength and mobility being the most significant predictors in the female player (López-Valenciano, Ayala, De Ste Croix, Barbado, & Vera-Garcia, 2019). Therefore, the aim of this study was to determine the impact of different forms of flexibility exercises on dynamic balance in a sample of female football players.

Methods

Participants

Participants in this study were 36 female professional football players members of the female football club Široki Brijeg, from Bosnia and Herzegovina, all competing at the highest competitive rank in the country. Inclusion criteria for participating in the study consisted of (i) no injury to the musculoskeletal system within 3 months of the start of the study, (ii) age above 14 years and (iii) voluntary participation in the study. Participants were fully informed about the objectives and procedures of the study using video and oral presentations. All participants received written information on all procedures and gave their signed informed consent to participate. For participants younger than 18, consent was signed by a parent/guardian. Of the 36 football players initially involved, six did not meet the inclusion criteria so 30 players were randomly selected in three groups of 10 players. All three groups trained regularly throughout the study. The first experimental group (E1S; age: 19.5±4.3 years; experience in football 6 years in minimum) participated in a supplementary static stretching/flexibility program (please see later for details), the second experimental group (E2D; age: 18.9±3.3 years; experience in football 6 years in minimum) participated in a dynamic stretching/flexibility training program, while the control group (C; age: 18.5±3.3 years; experience in football 6 years in minimum) did not participate in any kind of additional training program. Study was approved by Ethical Board of Universtiy of Split, Faculty of Kinesiology (Ethical board number: 2181-205-02-05-22-0021; June 10th, 2018).

Training procedures

Experimental training programs of E1S and E2D were conducted daily for 15 minutes after training sessions during the 16 weeks. All exercises (presented in Table 1) were explained verbally, and presented in pictures and written text to all participants. The exercises were conducted under the supervision of a strength and conditioning coach, three times per week, after the warm-up, before the main training session (mostly Mon-Wed-Fri) (McGill & Montel, 2019).

Participants were tested at the study baseline (Testing 1), after 8 weeks of intervention (Testing 2), and at the end of intervention (Testing 3). All three testing sessions were done in the same closed facility, at a temperature of approximately 20 degrees, using the same testing equipment, between 16:00 and 19:00. Before testing, participants performed a standardized warm-up consisting of jogging (3 min), and dynamic warm-up exercises (lunging, skipping, jumping, squatting) incorporated in jogging (3 min).

Variables

Variables in this study included anthropometric parameters (body height, body weight, body mass index and lower limb length) and YBT protocol.

In this study, we used the Y Balance test (YBT) as a test of dynamic balance. YBT is a variation of the Star Excursion Balance Test (SEBT) and has been repeatedly confirmed as a valid and reliable diagnostic tool for assessing dynamic balance (Plisky et al., 2009; Gribble, Hertel, & Plisky, 2012; Kim et al., 2020). YBT determines the asymmetries of lower limb movements and the level of balance through single-leg balance

Table 1. Types of stretching exercises over 3 months [sets x repetitions (hold)]

Static exercise (experimental group 1, n=10) [3x5 (15 sec)]	**Dynamic exercise (experimental group 2, n=10) [3x10]**	**None (control group, n=10)**
Standing quadriceps stretch	Downward dog to runner's lunge	
Gastrocnemius stretch	Dynamic squat stretch	
Standing split	Crescent to hamstring stretch	
Adductor stretch	Half-kneeling hamstring stretch	
Half-kneeling groin stretch	Side-to-side lunge with reach	
Hamstring stretch on the bench	Standing calf and hamstring stretch	
Prayer squat	Hurdles	
Seated adductor and hamstring stretch	Side-to-side lunge with step	Without stretching exercise
Hurdle seat	IT band stretch	
Seated glute stretch	Walking quad stretch	
Lying glute stretch	Swing the leg forward and back	
Seated groin abduction	Swing the leg cross	
Soleus stretch	Knee pull	
Half-kneeling quad stretch	Standing squat stretch	
Split hamstring stretch	Standing gluteus stretch	

with movements in the anterior (ANT), posteromedial (PM) and posterolateral (PL) direction (Smith, Chimera, & Warren, 2015). It is important to note that researchers have shown that performance on YBT can be a very good indicator of lower-extremity impairments and a predictor of future injuries in various sports (Plisky, Rauh, Kaminski, & Underwood, 2006; Pollock, 2010; Endo & Sakamoto, 2014; Alnahdi, Alderaa, Aldali, & Alsobayel, 2015). YBT consists of a three-part test used to assess lower extremity dynamic balance and neuromuscular control (Coughlan, Fullam, Delahunt, Gissane, & Caulfield, 2012). A YBT kit (Perform Better, FMS) was used, consisting of three connected cylindrical tubular wooden bars marked in centimeters. Each bar has a movable indicator plate, which is pushed with the feet/toes without relying on the weight of the indicator. Before the test, participants conducted three minutes warm up and performed the test without footwear.

The participants were allowed to have six trial attempts on each leg in each of the three directions – anterior, posteromedial and posterolateral - before formal testing. Starting position included standing on one leg (which is not graded) in the center of the platform while the leg being graded needs to remain in the air. While maintaining balance with one leg, the participants were instructed to reach three attempts with the free leg in the anterior direction, followed by three attempts in the posteromedial direction, and then three attempts in the posterolateral direction, all according to the YBT protocol. The football player was instructed to move the distance indicator as far as possible in the direction being assessed. The researcher monitored testing and did not allow participants to move the indicator by hitting it or accelerating at the end of the push. The maximum reach distance was recorded at the farthest point reached by the foot at the proximal edge of the indicator and was measured at half a centimeter. The trial was rejected for one or more of the following reasons: if the participant (i) lost his balance during the exercise, (ii) raised the heel of the foot which was on the platform, (iii) if the foot did not maintain contact with the distance indicator while the indicator was in motion (e.g. the indicator was kicked), (iv) if the distance indicator was used to maintain posture body (e.g. the athlete leaned his weight on the distance indicator) or (v) there was a loss of balance during the return to the starting position after the distance was marked (Shaffer et al., 2013).

The study design and testing sequences are presented in Figure 1.

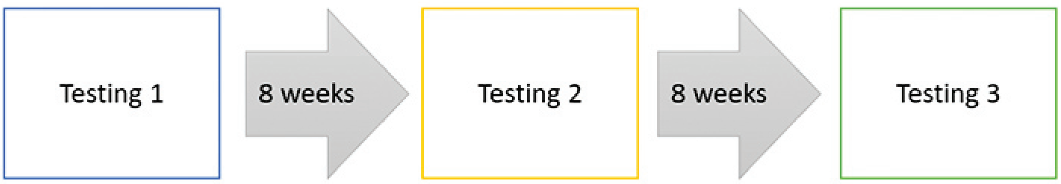

FIGURE 1. Study design with time-frames

Statistics

All data were log-transformed to reduce the non-uniformity of error, and normality was tested using the Kolmogorov–Smirnov test procedure. Homoscedasticity was checked by the Levene test. The statistical analyses were done on log-transformed data, but results in tables and figures are presented as true-value means and standard deviations.

The ANOVA for repeated measurements (Group x Measurement) was calculated to evaluate the effects of the applied programs, with consecutive, posthoc Schefee test.

Statistica ver. 13.5 (Tibco Inc. Palo Alto, CA) was used for all calculations, and a p-level of 95% was applied.

Results

Descriptive statistics for general variables are presented in Table 2.

Results of the 2-way analysis of the variance for repeated measurement with "Group" and "Measurement" as main effects and "Group x Measurement" interaction are presented in Table 3. In brief, significant main effects for "Group" were found for Left posteromedial, Right postero-lateral, and Left postero-lateral. Significant effects for "Measurement" were evidenced for Left posteromedial and Right postero-lateral results. Finally, the "Group x Measurement" effect was significant for the Right posteromedial, and Right leg composite scores.

Table 2. Descriptive statistics of the studied sample of participants for general variables

	Mean	Minimum	Maximum	Std.Dev.
Age (years)	19.13	14.00	30.00	4.52
Body mass (kg)	59.10	40.00	77.00	9.14
Body height (cm)	165.42	155.00	175.00	5.40
BMI (kg/m2)	21.58	14.30	27.20	3.07
Leg length right (cm)	86.28	76.00	97.00	4.75
Leg length left (cm)	86.28	76.00	97.00	4.75

Table 3. Descriptive statistics and results of the 2-way analysis of the variance for repeated measurements (*denotes statistical significance of p<0.05)

	Test 1	Test 2	Test 3	ANOVA		
				Group	Measurement	Interaction
	Mean±SD	Mean±SD	Mean±SD	F-test	F-test	F-test
Right leg anterior	60.2±7.01	60.83±5.86	60.84±7.07	0.31	2.68	1.34
Left leg anterior	59.71±6.27	60.88±6.94	60.95±7.01	0.11	1.72	1.06
Right leg posteromedial	107.78±12.54	108.9±10.49	108.92±12.65	2.42	2.1	2.85*
Left leg posteromedial	106.89±11.22	109±12.43	109.11±12.54	4.03*	3.54*	1.75
Right leg posterolateral	106.81±12.43	107.92±10.4	107.94±12.54	3.85*	4.01*	2.08
Left leg posterolateral	105.93±11.12	108.02±12.32	108.13±12.43	4.43*	1.53	0.8
Right leg composite score	97.1±11.3	98.11±9.45	98.13±11.4	2.08	1.67	2.91*
Left leg composite score	96.3±10.11	98.2±11.2	98.3±11.3	1.21	1.59	2.41*

A more detailed overview of the changes which occurred in composite scores is evidenced in Figure 2 and Figure 3. Specifically, both experimental programs induced positive changes in Right leg composite scores between Test 1 and Test 2 (posthoc differences within E2D and E1S were statistically significant and p<0.05). However, only E2D achieved significant improvement between Test 2 and Test 3 (at p<0.05) (Figure 2). In the left leg composite score, E2D improved results from Test 1 to Test 2 (p<0.05), with no significant posthoc differences between Test 2 and Test 3 for any of the observed groups (Figure 3).

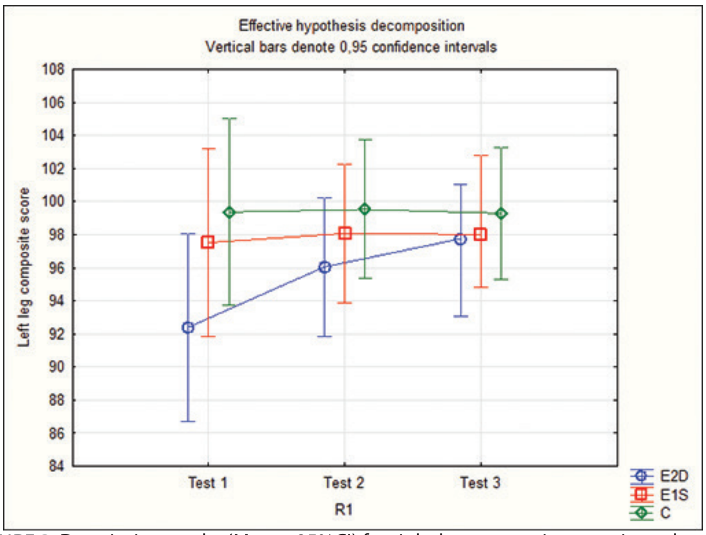

FIGURE 2. Descriptive results (Mean±95%CI) for right leg composite score in each study group – changes over the study course (Test 1, Test 2, Test 3); Legend: E2D – dynamic stretching experimental group, E1S – static stretching experimental group, C – control group

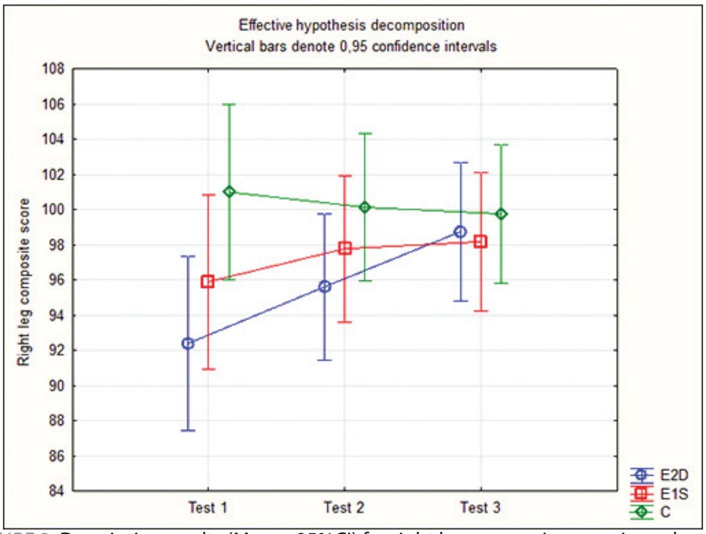

FIGURE 3. Descriptive results (Mean±95%CI) for right leg composite score in each study group – changes over the study course (Test 1, Test 2, Test 3); Legend: E2D – dynamic stretching experimental group, E1S – static stretching experimental group, C – control group

Discussion

This study aimed to evaluate the effects of different types of flexibility training on changes in dynamic balance among female football players. With regard to study aims, we can highlight two most important findings. First, our results showed that flexibility training irrespective of the type (e.g. static or dynamic stretching) has a positive impact on the development of dynamic balance. Second, while both dynamic and static stretching had a similar positive influence on dynamic flexibility in the first period, the impact of static stretching stagnates, while dynamic flexibility exercise improved the dynamic balance over the whole study course.

Flexibility training improves dynamic balance

Both static and dynamic stretching exercises improved dynamic balance significantly. As introduced, balance can be defined as the ability to maintain the center of gravity of the body within the base of support which is performed through neuromuscular actions conditioned by external stimuli (Con Hrysomallis, 2007). This is particularly important knowing the protective influence of improved balance on injury occurrence, and balance is generally considered an important factor contributing to the incidence of injuries in sports, with better balance preventing injury occurrence (Hrysomallis, 2007; Gribble, Hertel, & Plisky, 2012; Han, Anson, Waddington, Adams, & Liu, 2015; Lai et al., 2017; Sekulic, Prus, Zevrnja, Peric, & Zaletel, 2020). Increased mobility and amplitude in the joints leads to more precise movement, better control and thus improvements in dynamic balance (Weirich, Bemben, & Bemben, 2010; Líška, Švantner, & Batalík, 2021). Looking at the movement structure in YBT, it is clear that better mobility of the lower extremities will have a significant impact on the maximal reach and thus on the final result in the test.

Supportively, previous studies evidenced the positive relationship between joint kinematics and performance on the YTB test. Specifically, investigations found that dorsiflexion of the foot, ankle and hip flexion should be observed as significant predictors of YBT results (Robinson & Gribble, 2008; Kang et al., 2015). Therefore, it seems that performing flexibility exercises improves mobility which leads to easier control of the body in the maximal range on balance tests, resulting in better YBT even in our players. Generally, our results on the positive impact of static stretching on dynamic balance confirmed the results of previous studies (Behm, Bambury, Cahill, & Power, 2004; Costa, Graves, Whitehurst, & Jacobs, 2009; Lewis, Brismée, James, Sizer, & Sawyer, 2009). However, the impact of dynamic stretching is relatively unexplored, and almost exclusively evaluated the acute effects of dynamic stretching on dynamic balance (Wang, 2013; Chatzopoulos, Galazoulas, Patikas, & Kotzamanidis, 2014; Amiri-Khorasani & Gulick, 2015). In general, these studies confirmed the positive acute effect of stretching, especially dynamic, on balance performance and recommend incorporating stretching activities in the warm-up protocols (Amiri-Khorasani & Gulick, 2015). Finally, no study compared the effects of different stretching forms on dynamic balance in professional athletes.

The physiological mechanism behind these results can be explained by the extension of muscle and connective tissue (lengthening) through mechanical and neural adaptations through stretching exercises (Guissard & Duchateau, 2004; Shrier, 2004). The scientific literature has repeatedly confirmed the usefulness of static stretching on ROM development (Bandy, Irion, & Briggler, 1997, 1998; Feland, Myrer, Schulthies, Fellingham, & Measom, 2001), while maintaining the center of gravity within the base of support will certainly be facilitated if the individual can have a greater ROM in the joints. This is especially emphasized in the YBT, where the athlete because of the better hip ROM, can lower her center of gravity of the body more, and consequently is more able to maintain a balance position (Kang et al., 2015).

Differences in the duration of the effect of static and dynamic stretching

Results of our study show that in the first phase of training both stretching methods have approximately equal positive effects on the development of flexibility and consequently the ROM. However, in the second part of the experiment (for the 8th to 16th week of the program) effects of static stretching reached the plateau, and for further progress, it is necessary to move to more aggressive forms of stretching like dynamic stretching. The explanation of such results should be found in specifics of applied stretching programs.

In the flexibility training methodology, it is generally accepted that the static type of stretching should be used in the first phases as it is less intense and risky (Clark & Lucett, 2010). However, it is relatively well known that once an athlete has mastered static stretching techniques, it is necessary to continue to increase the ROM through functional dynamic movements, which preferably mimic the movement structure of a particular sport (Mann & Jones, 1999). This type of training will increase the amplitude of the movement when performing some more or less complex movements. Given that performance in YTB involves a dynamic component, of both balance and flexibility, through reaching the end position with active movement, it becomes clear why dynamic stretching provided better results in developing balance and flexibility than static stretching.

Concerning the superior effects of dynamic stretching, another issue deserves attention. Research has shown that not all muscle groups respond equally to static stretching, and therefore stretching protocols should differ between muscles (Youdas, Krause, Egan, Therneau, & Laskowski, 2003). It has also been found that through more aggressive types of stretching, such as active and neuromuscular stretching, greater improvements in ROM can be achieved (Etnyre & Lee, 1988; Fasen et al., 2009; Schuback, Hooper, & Salisbury, 2004). This is in accordance with our findings indicating that after a certain period of time (8 weeks) the effect of static stretching on balance cannot be expected.

The main limitation of this study is the fact that only one test was used to assess dynamic balance. Also, in future studies, additional anthropometric measures should be included. One of the limitations of the study was a small sub-sample of the participants, but this was mainly influenced by the number of players in the observed club. However, this was one of the first studies which investigated the chronic effects of different forms of stretching on dynamic balance. The long duration of the intervention (16 weeks), three groups of athletes and the fact that this is one of the rare intervention studies on female football players are however important strengths of the study.

Conclusion

The results of this study showed the positive effects of both static and dynamic stretching on dynamic balance improvements. This finding is very important in the context of injury prevention in football as better balance is a protective factor for injury occurrence.

Additionally, the impact of both types of stretching over time is also an important finding of this study. In detail, in the first phase of the systematic implementation of flexibility training, static and dynamic stretching achieve almost identical effects. However, while the impact of static stretching weakens over time, progress in balance is possible over a longer period as a result of practicing dynamic stretching. Considering this, we can suggest that football players should start with systematic static stretching training and after a certain time, when adaptations have occurred, move on to more advanced and demanding types of stretching. It is also very important to imitate sport-specific movements in order to have a higher transfer on sports performance.

Regular and systematic flexibility training will result in a greater range of motion, which will enable soccer players to achieve greater movement amplitudes. This will affect a better adaptation to new situations in which the balance is disturbed and will help in both, preventing injuries and in a more optimal and precise sports performance.

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Conflict of Interest
The author declares that there is no conflict of interest.

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