POSTURAL PERFORMANCE IN THE BIPEDAL AND UNIPEDAL STANCE OF ELITE SOCCER PLAYERS IN DIFFERENT AGE CATEGORIES

Lucia Mala, Tomas Maly and Frantisek Zahalka

Faculty of Physical Education and Sport, Charles University in Prague, Czech Republic

Original scientific paper

Abstract

Postural stability (PS) is considered to be a highly important factor for athletes. The aim of the study was to compare differences in PS performance in the bipedal and unipedal stance of soccer players in different age categories. Elite players in three age categories (Senior team (ST): n = 24, Junior team (U21): n = 20 and Youth team (U16): n = 20) participated in three tests of PS (wide stance with and without visual control and flamingo stance on the preferred and non-preferred leg). Analysis of variance (ANOVA) and Bonferroni's post hoc tests were used for investigating the effect of visual control and leg preference on PS performance in elite soccer players. ANOVA revealed significant differences in total travelled way (TTW) among the observed groups ($F_{(2,128)} = 20.41$, $p < .01$, $\eta_p^2 = .25$) in bipedal stance tests. Visual control had a significant effect on the level of PS in the tested players ($F_{(1,128)} = 25.96$, $p < .01$, $\eta_p^2 = .18$). Additionally, in the performance of the flamingo test, ANOVA showed significant differences in TTW among the tested groups ($F_{(2,128)} = 6.25$, $p < .01$, $\eta_p^2 = .09$). Despite higher values in the non-preferred leg among all teams, limb preference had no significant effect on the level of PS in the tested players ($F_{(1,128)} = 1.64$, $p > .05$, $\eta_p^2 = .01$). The presented data can serve as a certain top standard for comparisons of PS performance in elite soccer players indifferent age categories, with the aim being to optimize and compensate for observed differences; this information can be useful in the development of strategies for injury prevention.

Key words: *postural stability, total travelled way, football, maladaptation, elite sport, balance*

Introduction

Standing posture is a complex system that involves the maintenance of the relative positions of body segments. The use of numerous muscles and the integration of different sensorial inputs (visual, vestibular, proprioceptive) are a part of the complexity of this system. Proprioception, one of the operating components, is a particular and complex system in which information from various joints, spindles and cutaneous receptors contributes to the appreciation of the immediate position of corporal segments and mechanical strains on the skin and muscles (Lephart, Pincivero, Giraldo, & Fu, 1997). Sport training and movement activity enhances the ability to use somatosensory and otolithic information, which improves postural capabilities (Massion, 1998; Zahalka, Maly & Mala, 2014). Depending on the practised sport, various postural changes develop. Judo training emphasizes somatosensory information (Mala, Maly & Zahalka, 2016), while dancing emphasizes visual information (Bringoux, Marin, Nougier, Barraud & Raphel, 2000). Furthermore, better postural stability was detected in specific situations of the particular sport discipline in comparison to the tests that follow an individual's common activities (Bringoux et al., 2000). Soccer is a dynamic and complex sport, in which many variables, such as technical, tactical, physiological, and psychological variables, determine the final result. Soccer requires a unipedal posture to perform different technical movements (e.g., kicking, shooting) (Zahalka, Maly, Mala, Hrasky, & Hank, 2014). The stability of the supporting foot is critical to shooting as accurately as possible (Paillard et al., 2006).

Postural regulation is organized in hierarchic and stereotypic patterns and requires the integration of afferent information from the visual, vestibular, and proprioceptive systems (Paillard et al., 2006). The importance of postural stability for soccer performance was the subject of several studies (Gryc et al., 2013; Paillard et al., 2006; Soderman, Werner, Pietila, Engstrom & Alfredson, 2000). Soderman et al. (2000) investigated a unipedal stance in soccer players with the aim to record and reduce the risk of traumatic injuries to the lower extremities. Pintsaar, Brynhildsen, and Tropp (1996) examined the effect of rehabilitative training of the ankle joint. Hiemstra, Lo, and Fowler (2001) emphasized the relationship between changes in lower limb neuromuscular control and joint dynamic stability because of fatigue and frequent injuries in soccer matches (Rahnama, Reilly & Lees, 2002).

The some researchers describe a soccer player's load in the match and the onset of fatigue as a factor that negatively influences postural stability (Gribble & Hertel, 2004; Ribeiro, Santos, Goncalves & Oliveira, 2008). On the other hand, Bisson, Chopra, Azzi, Morgan, and Bilodeau (2010) and (Brito et al., 2012) dealt with the importance of proprioceptive and visual control for postural control in soccer players. The available studies compare the effect of regular controlled activity, in the form of soccer training, on the level of postural stability in comparison to the general population and also within the level of sport performance and age category. The aim of this study was to compare differences in PS performance in the bipedal and unipedal stance of soccer players in different age categories.

Methods

Participants

Participants were 64 elite Czech soccer players (Senior team (ST): n = 24, age 25.7 ± 3.6 years, Junior team (U21): n = 20, age 19.8 ± 1.1 years and Youth team (U16): n = 16, age 15.3 ± 0.5 years), all of whom are members of the AC Sparta Prague soccer team, which is the most successful soccer team in the Czech Republic. All participants have had long-term training in the sport of soccer (ST = 14.2 ± 3.1 years, U21 = 11.1 ± 2.9 years and U16 = 8.0 ± 2.5 years). Concerning the sport training periodization, the research was carried out during the preparatory period at the laboratory. Basic anthropometric characteristics and differences between teams are listed in Table 1 (Result).

Anthropometric assessment

Body height was measured using a digital stadiometer (SECA 242, Hamburg, Germany), and body mass was assessed using a digital scale (SECA 769, Hamburg, Germany).

Postural stability

The multi-sensoric FOOTSCAN platform (RS scan; Belgium) (0.5 m x 0.4 m; approximately 4100 sensors; sensitivity from 0.1 of $N.cm^{-2}$; sampling frequency 500 Hz) was used for the posturographic examination. Pressure on individual sensors was measured, and the centre of pressure (COP) was calculated on the contact area. Resulting force reacting to the ground was calculated from pressure and contact area under both feet by the equation (1):

$$F = p*S$$

where "F" is reacting force (N), "p" is pressure (Pa), "S" is area (m^2), and this force is called Centre of Force (COF). Testing of stability was composed of 3 partial tests, namely: wide stance with and without visual control lasting for 30 s and flamingo stance on the preferred and non-preferred leg. Limb preference was determined by determining which foot each participant preferred to use to kick a ball (Maly, Zahalka, Mala, & Teplan, 2014). During the measurements, participants stood at a distance of 3 metres from a wall on which a visual point (a black circle with a diameter of 3 cm) was located at the level of the participant's eyes. The standard standing position with a wide base was measured according to standard practice (Kapteyn, Bles, J., Koodde, & Mol, 1983), and transparent sheeting for the tracing foot position was used during the examination. We measured (recorded, monitored) the entire course of total travelled way (TTW) of COP. The research was approved by the Ethical Committee of the Faculty of Physical Education and Sports at Charles University in Prague. Measurements were carried out in accordance with the ethical standards of the Declaration of Helsinki and the ethical standards in sport and exercise science research (Harriss & Atkinson, 2011).

Statistical analysis

The normality of the distributions was assessed using the Shapiro-Wilks test. Descriptive statistics were calculated for each team. Two-way ANOVA with two between-subject effects (age, visual control or preferred leg) was used for evaluating differences in TTW between the factors. The probability of a type I error (alpha) was set at 0.05 in all statistical analyses. The probability of a type II error (beta) was controlled using post hoc (retrospective) analysis and was set at 0.2 (conventional value). When the criterion of sphericity, which was one of the conditions of ANOVA, as assessed by Mauchly's test (χ^2), was not met, the degrees of freedom were adjusted by means of Greenhous-Geisser's (GG) sphericity correction, following which the statistical significance was assessed according to particular degrees of freedom. The effect size was evaluated using the Eta square coefficient (η^2), which explains the proportion of the variance of the monitored factor. Statistical analyses were performed using IBM® SPSS® v21 (Statistical Package for Social Science, Inc., Chicago, IL, USA).

Results

Analysis of variances revealed significant differences in somatometric characteristics among the tested teams in three age categories (Table 1). In performance of the flamingo test, ANOVA showed significant differences in TTW among the tested groups ($F_{(2,128)} = 6.25$, $p < .01$, $\eta_p^2 = .09$) (Table 3). Despite higher values in the non-preferred leg in all teams, limb preference had no significant effect on the level of PS in the tested players ($F_{(1,128)} = 1.64$, $p > .05$, $\eta_p^2 = .01$).

Bonferroni's post hoc analysis revealed a significantly higher level of PS in adult players in comparison to U16 players (Table 3). No significant difference was found between U19 and U16 players ($p > .05$).

Table 1. Basic somatometric characteristics of the screened sample

Parameters		Descriptive statistics		ANOVA			Bonferroni's post- hoc test	
		Mean	SD	*F*	*p*	η^2		
BH (cm)	ST	182.76	6.22	14.08	< .01	0.32	ST vs. U16 (p<.01)	U19 vs. U16 (p<.01)
	U21	182.21	8.84					
	U16	171.58	7.92					
BM (kg)	ST	77.75	6.34	28.01	< .01	0.48	ST vs. U16 (p<.01)	U19 vs. U16 (p<.01)
	U21	75.51	8.06					
	U16	62.11	7.61					

BH – body height, BM – body mass, ST – senior team, U21 – junior team, U21 – youth team

Table 2. Differences of body PS stability among teams with regard to visual control in bipedal stance tests

Parameters		Visual control			No visual control			ANOVA			Bonferroni's post- hoc test
		Mean	SD		Mean	SD		*F*	*p*	η^2	
TTW (mm)	ST	208.96	26.72		236.08	37.99		20.4	< .01	0.25	ST vs. U19 (p<.01) ST vs. U16 (p<.01)
	U21	238.35	26.56		272.05	34.65					
	U16	248.6	29.09		273.35	29.65					

Legend: TTW – total travelled way, ST – senior team, U21 – junior team, U21 – youth team

Table 3. Differences of body PS among teams with regard to preferred leg in unipedal stance tests

Parameters		Preferred leg			Non preferred leg			ANOVA			Bonferroni's post- hoc test
		Mean	SD		Mean	SD		F	p	η^2	
TTW (mm)	ST	1324.86	261.63		1379.08	297.19		6.23	< .01	0.09	ST vs. U16 (p<.01)
	U21	1441.7	320.62		1555.55	456.52					
	U16	1580.55	322.2		1651.85	434.72					

TTW – total travelled way, ST – senior team, U21 – junior team, U21 – youth team.

In the case of testing the preferred leg, the differences in percentage among the categories were as follows: ST vs. U19 (8.1 %), ST vs. U16 (16.2 %) and U19 vs. U16 (8.8 %). When testing the non-preferred leg, percentage differences were as follows: ST vs. U19 (11.4 %), ST vs. U16 (16.5 %) and U19 vs. U16 (5.8 %). The differences in PS using the preferred and non-preferred legs were as follows (ST = 3.9 %, U19 = 7.3 % and U16 = 4.3 %).

Discussion

Soccer is characterized as an intermittent sport with bouts of walking, running, sprinting and numerous changes of direction and jumps. Soccer training has been reported to improve one´s postural control ability. Balance is a complex task that requires intact information from the somatosensory, visual, and vestibular systems and an intact central nervous system to maintain upright stance (Horak, Nashner & Diener, 1990). The importance of postural control is emphasized especially in the onset of fatigue during a soccer match. Nevertheless, muscle fatigue modifies the peripheral proprioceptive system by increasing the threshold for muscle spindle discharge and consequently changing alpha/gamma co-activation (Ribeiro et al., 2008). Therefore, neuromuscular control, as represented through deficits in postural control, might decrease because of fatigue (Gribble & Hertel, 2004). Visual control had a significant effect on the level of PS in all tested players. One of the results, namely, better PS with visual control than without visual control has been supported in other studies (Bisson et al., 2010; Brito et al., 2012; Garcia, Barela, Viana & Barela, 2011). Studies that monitored the importance of visual control and the level of PS during a soccer match emphasized a deleterious effect of muscle fatigue on postural sway during unilateral stance tasks (Bisson et al., 2010; Gribble & Hertel, 2004; Salavati, Moghadam, Ebrahimi & Arab, 2007; Springer & Pincivero, 2009). Current research diverges in the opinions on the importance of visual control for maintaining balance. It was reported that fatigue equally affected postural control with or without vision (Brito et al., 2012; Corbeil, Blouin, Begin, Nougier & Teasdale, 2003); whereas Derave, Tombeux, Cottyn, Pannier and De Clercq (2002) observed that fatigue altered postural control only when visual input was present. When testing PS on one leg (flamingo test), ANOVA indicated significant differences in TTW among the observed groups (Table 3). According to Brito et al. (2012), activities in soccer confer better stability to the non-dominant leg, and the athletes showed better unilateral stance with the non-dominant limb than with the contralateral limb. The authors explain it by the balance requirements in kicking. Matsuda, Demura, and Uchiyama (2008) reported that soccer players are more able to maintain a stable one-legged stance than basketball players, swimmers, and non-athletes and soccer players have superior ability to maintain a stable one-legged stance. A previous study in young basketball players observed no significant differences between dominant and non-dominant lower limbs (McGuine, Greene, Best, & Leverson, 2000). In our observed players, despite higher values for the non-preferred leg in all teams, limb dominance did not have any significant effect on the level of PS (Table 3) in accordance with Matsuda et al. (2008). During the game, strength and power movements are accumulated on both lower extremities. This occurs in an asymmetrical manner and may gradually lead to higher shifts of myodynamic characteristics and strength asymmetries of the lower extremities (Maly, Zahalka, & Mala, 2016). Although soccer players frequently use their dominant leg for kicking and passing, players also have many opportunities to use both legs evenly during daily soccer training, which may have minimized any differences in balance ability between the legs arising from soccer specific training (Matsuda et al., 2008).

We recorded significant differences in TTW among the tested groups (Table 2) in bipedal stance tests when senior players showed a significantly better level of PS than the other groups. Similarly, in the flamingo test, which is the most reliable test involving specific actions in soccer, the level of PS in the adult group appeared to be significantly better than in the U16 category (Table 3).

Possible contributions to this finding are as follows: a greater volume of physical load, a better specific balance adaptation, a higher level of proprioceptive sensitivity during one-leg standing tasks, regular inclusion of balance exercises, influencing proprioceptors and accurate realization of coordinated movements or individual soccer actions. Additionally, a long-term training adaptation of the core system achieved in training sessions by a specialized fitness coach for the men's professional team may have contributed to this finding. The result of appropriate activation of the core system (through core or vibration training) is health and a rehabilitative effect that is obviously directed toward achieving optimal soccer performance. Incorporation of vibration training in warm-up exercises has been suggested as a way of preparing athletes for the subsequent performance (Cochrane, 2013).

Conclusions

The recorded parameters of PS indicated values characteristic of an elite soccer team. PS of professionals included in the senior team was significantly better in comparison to the players from the younger teams (U21 and U16). Visual control was important for maintaining PS in all groups. Lower limb dominance showed no significant effect on the level of PS; however, lower values were observed in the non-preferred leg. Regular inclusion of balance exercises in the team's training sessions should be a suitable means of improving the level of PS as a factor influencing soccer performance. The presented data can serve as a certain top standard for comparisons of PS quality in elite soccer players indifferent age categories, with the aim being to optimize and compensate for observed differences; this information can be useful in the development of strategies for injury prevention.

Along with increasing the number of studies in the field of soccer, our results could be helpful in establishing good practices for the clinical staff (e.g., athletic trainer, physiologist, physician, fitness coach, research worker, and medical doctor). Further research should focus on the relationship between PS and performance level, injury prevention management and the long-term adaptation effect of balance and core training in elite soccer players.

References

Bisson, E.J., Chopra, S., Azzi, E., Morgan, A., & Bilodeau, M. (2010). Acute effects of fatigue of the plantarflexor muscles on different postural tasks. *Gait & Posture, 32*(4), 482-486.

Bringoux, L., Marin, L., Nougier, V., Barraud, P. A., & Raphel, C. (2000). Effects of gymnastics expertise on the perception of body orientation in the pitch dimension. *Journal of Vestibular Research-Equilibrium & Orientation, 10*(6), 251-258.

Brito, J., Fontes, I., Ribeiro, F., Raposo, A., Krustrup, P., & Rebelo, A. (2012). Postural stability decreases in elite young soccer players after a competitive soccer match. *Physical Therapy in Sport, 13*(3), 175-179.

Cochrane, D. (2013). The sports performance application of vibration exercise for warm-up, flexibility and sprint speed. *European Journal of Sport Science, 13*(3), 256-271.

Corbeil, P., Blouin, J.S., Begin, F., Nougier, V., & Teasdale, N. (2003). Perturbation of the postural control system induced by muscular fatigue. *Gait & Posture, 18*(2), 92-100.

Derave, W., Tombeux, N., Cottyn, J., Pannier, J. L., & De Clercq, D. (2002). Treadmill exercise negatively affects visual contribution to static postural stability. *International Journal of Sports Medicine, 23*(1), 44-49.

Garcia, C., Barela, J.A., Viana, A.R., & Barela, A.M.F. (2011). Influence of gymnastics training on the development of postural control. *Neuroscience Letters, 492*(1), 29-32.

Gribble, P.A., & Hertel, J. (2004). Effect of lower-extremity muscle fatigue on postural control. *Archives of physical medicine and rehabilitation, 85*(4), 589-592.

Gryc, T., Zahalka, F., Maly, T., Mala, L., Vaidova, E., & Teplan, J. (2013). Morphological and Postural Asymmetry of Lower Limbs in Elite Female Soccer Players *Medicine and Science in Sports and Exercise, 45*(5), 168-168.

Harriss, D.J., & Atkinson, G. (2011). Update - Ethical Standards in Sport and Exercise Science Research. *International Journal of Sports Medicine, 32*(11), 819-821.

Hiemstra, L.A., Lo, I.K.Y., & Fowler, P.J. (2001). Effect of fatigue on knee proprioception: Implications for dynamic stabilization. *Journal of Orthopaedic & Sports Physical Therapy, 31*(10), 598-605.

Horak, F.B., Nashner, L.M., & Diener, H.C. (1990). Postural strategies associated with somatosensory and vestibular loss. *Experimental Brain Research, 82*(1), 167-177.

Kapteyn, T.S., Bles, W., Nijokiktijen, C.J., Koodde, L., Massen, C.H., & Mol, J.M. (1983). Standardization in platform stabilometry being a part of posturography. *Agressologie, 24*, 321-326.

Lephart, S.M., Pincivero, D.M., Giraldo, J.L., & Fu, F.H. (1997). The role of proprioception in the management and rehabilitation of athletic injuries. *American Journal of Sports Medicine, 25*(1), 130-137.

Mala, L., Maly, T., & Zahalka, F. (2016). Influence of maximal anaerobic performance on body posture stability in elite senior and junior male judo athletes. *Archives of Budo, 12*, 117-124.

Maly, T., Zahalka, F., & Mala, L. (2016). Unilateral and ipsilateral strength asymmetries in elite youth soccer players with respect to muscle group and limb dominance. *Int J of Morphology, 34*(4), 1339-1344.

Maly, T., Zahalka, F., Mala, L., & Teplan, J. (2014). Profile, Correlation and Structure of Speed in Youth Elite Soccer Players. *Journal of Human Kinetics, 40*(1), 149-159.

Massion, J. (1998). Postural control systems in developmental perspective. *Neuroscience and Biobehavioral Reviews, 22*(4), 465-472.
Matsuda, S., Demura, S., & Uchiyama, M. (2008). Centre of pressure sway characteristics during static one-legged stance of athletes from different sports. *Journal of Sports Sciences, 26*(7), 775-779.
McGuine, T.A., Greene, J.J., Best, T., & Leverson, G. (2000). Balance as a predictor of ankle injuries in high school basketball players. *Clinical Journal of Sport Medicine, 10*(4), 239-244.
Paillard, T., Noe, F., Riviere, T., Marion, V., Montoya, R., & Dupui, P. (2006). Postural performance and strategy in the unipedal stance of soccer players at different levels of competition. *J of Athletic Training, 41*(2), 172-176.
Pintsaar, A., Brynhildsen, J., & Tropp, H. (1996). Postural corrections after standardised perturbations of single limb stance: Effect of training and orthotic devices in patients with ankle instability. *British Journal of Sports Medicine, 30*(2), 151-155.
Rahnama, N., Reilly, T., & Lees, A. (2002). Injury risk associated with playing actions during competitive soccer. *British Journal of Sports Medicine, 36*(5), 354-359.
Ribeiro, F., Santos, F., Goncalves, P., & Oliveira, J. (2008). Effects of volleyball match-induced fatigue on knee joint position sense. *European Journal of Sport Science, 8*(6), 397-402.
Salavati, M., Moghadam, M., Ebrahimi, I., & Arab, A. M. (2007). Changes in postural stability with fatigue of lower extremity frontal and sagittal plane movers. *Gait & Posture, 26*(2), 214-218.
Soderman, K., Werner, S., Pietila, T., Engstrom, B., & Alfredson, H. (2000). Balance board training: prevention of traumatic injuries of the lower extremities in female soccer players? A prospective randomized intervention study. *Knee Surgery Sports Traumatology Arthroscopy, 8*(6), 356-363.
Springer, B.K., & Pincivero, D.M. (2009). The effects of localized muscle and whole-body fatigue on single-leg balance between healthy men and women. *Gait & Posture, 30*(1), 50-54.
Zahalka, F., Maly, T., & Mala, L. (2014). Body postural stability in ageing. *Starnuti, 2014*, 168-173.
Zahalka, F., Maly, T., Mala, L., Hrasky, P., & Hank, M. (2014). Kicking Performance Differences In Soccer Players According To Age And Lower Limb Dominance. *Medicine and Science in Sports and Exercise, 46*(5), 954-954.

POSTURALNA IZVEDBA U BIPEDALNOM I UNIPEDALNOM STANJU ELITNIH NOGOMETAŠA RAZLIČITIH UZRASNIH KATEGORIJA

Sažetak
Posturalna stabilnost (PS) smatra se vrlo važnim čimbenikom za sportaše. Cilj istraživanja bio je usporediti razlike u izvedbi PS u dvostrukom i jednostrukom stavu nogometaša u različitim dobnim kategorijama. Elitni igrači u tri dobne kategorije (seniori (ST): n = 24, juniori tim (U21): n = 20 i mladi (U16): n = 20) sudjelovali su u tri testa PS (široki stav sa i bez vizualne kontrole i flamingo stav na preferiranoj i nepreferiranoj nozi). Analiza varijance (ANOVA) i Bonferroni post hoc testovi korišteni su za ispitivanje učinka vizualne kontrole i preferiranja nogu na izvedbu PS s elitnim nogometašima. ANOVA je pokazala značajne razlike u ukupnom prijeđenom putu (TTW) među promatranim skupinama (F (2,128) = 20,41, p <.01, ηp2 = .25) u testovima dvostrukog položaja. Vizualna kontrola je imala značajan utjecaj na razinu PS u testiranim igračima (F (1.128) = 25.96, p <.01, ηp2 = .18). Dodatno, u provedbi flamingo testa, ANOVA je pokazala značajne razlike u TTW u ispitanim skupinama (F (2,128) = 6,25, p <.01, ηp2 = 0,09). Unatoč višim vrijednostima u nepreferiranoj nozi među svim momčadima, preferencija udova nije imala značajan utjecaj na razinu PS u testiranim grupama (F (1.128) = 1.64, p> .05, ηp2 = .01). Prikazani podaci mogu poslužiti kao određeni vrhunski standard za usporedbu izvedbe PS s elitnim nogometašima indiferentnih dobnih kategorija s ciljem optimizacije i nadoknade promatranih razlika. Ove informacije mogu biti korisne u razvoju strategija za prevenciju ozljeda.

Ključne riječi*: posturalna stabilnost, udaljenost, nogomet, neprilagodba, elitni sport, ravnoteža*

Received: September 11, 2015
Accepted: April 15, 2016
Correspondence to: Tomas Malý, PhD.
Faculty of physical education and sport
Charles University
16252 Prague, Jose Martiha 31, Czech Republic
Phone: +20 77 653 11 43
E-mail: tomimaly@yahoo.com

Acknowledgements:
This research was supported by GACR 16-21791S.