Physical Therapy in Sport 22 (2016) 11–15

Contents lists available at ScienceDirect

Physical Therapy in Sport

journal homepage: www.elsevier.com/ptsp

Original research

Dynamic balance is impaired after a match in young elite soccer players

Massimiliano Pau [a, *], Federico Mereu [a], Marco Melis [a], Bruno Leban [a], Federica Corona [a], Gianfranco Ibba [b, c]

[a] Department of Mechanical, Chemical and Materials Engineering, University of Cagliari, Cagliari, Italy
[b] Cagliari Calcio, S.p.A., Italy
[c] Department of Medical Sciences, Sports Physiology Lab, University of Cagliari, Cagliari, Italy

ARTICLE INFO

Article history:
Received 1 August 2015
Received in revised form
29 April 2016
Accepted 12 May 2016

Keywords:
Soccer
Postural sway
Time-to-stabilization (TTS)

ABSTRACT

Purpose: The aim of this study is to assess the effect of actual match effort on dynamic balance abilities in young elite soccer players.
Methods: Seventeen Under 15 male players who compete at national level participated in the study. Their dynamic balance was assessed by having them jump starting with both feet on the ground in a standing position and land on one foot only. Their vertical time to stabilization (vTTS) and postural sway were calculated before and after 35 min of an unofficial match. Postural sway was assessed on the basis of center-of-pressure (COP) trajectories. Parameters considered were sway area, COP displacements in the antero-posterior (AP) and medio-lateral (ML) directions and COP path length.
Results: After the match, a significant increase in vTTS ($p = 0.007$) COP path length ($p = 0.001$) and COP displacements in ML ($p < 0.001$) was observed. Such effects involve both non-dominant (vTTS, path length) and dominant limb (COP displacements).
Conclusions: The physical effort associated with the match induces significant impairments of players' dynamic balance abilities. On the basis of such findings, coaches might consider integrating training sessions with specific balance exercises as well as performing injury-prevention routines even when players are fatigued, to better adapt them to match conditions.

1. Introduction

Balance represents a key factor in ensuring optimal performance in soccer. Most technical skills such as dribbling, kicking and ball handling require one of the lower limbs (often the non-dominant one) to provide body support and balance while the other is in control of the ball (Teixeira, de Oliveira, Romano, & Correa, 2011). Moreover, it would be desirable for players to have good capabilities for recuperating appropriate body posture after dynamic tasks such as sharp decelerations, cutting maneuvers or when landing from a jump (Schreiner, 2000) to effectively conclude an action and reduce the risk of inappropriate movements that may result in injuries.

Similar to what occurs in physical performance (Mohr, Krustrup, & Bangsbo, 2005) and technical skills (Russell, Benton, & Kingsley, 2011; Stone & Oliver, 2009), postural control is affected by fatigue, where the quality and effectiveness of sensory inputs (i.e. visual, vestibular and proprioceptive) tend to deteriorate and impair the associated motor outputs (Paillard, 2012). This represents a critical issue because a reduction in balance abilities may act as a co-factor in lower limb injuries, considering that players appear more exposed to injuries in the final stages in each half of a match (Paul, Nassis, & Brito, 2015; Rahnama, Reilly, & Lees, 2002). In particular, fatigue appears to affect neuromuscular function at the ankle joint level, thus increasing the risk of ankle sprains (Gutierrez, Jackson, Dorr, Margiotta, & Kaminski, 2007). In young players, such aspects are exacerbated by the ongoing maturation of the postural control system, which is incomplete until the age of 17–18 (Wolff, Rose, Jones, Bloch, Oehlert, & Gamble, 1998) and thus it is important to monitor their balance abilities in terms of injury prevention, but also as a potential performance marker, In fact, it has been

* Corresponding author. Department of Mechanical, Chemical and Materials Engineering, University of Cagliari, Piazza d'Armi, 09123 Cagliari, Italy. Tel.: +39 070 6753264; fax: +39 070 6755717.
E-mail address: massimiliano.pau@dimcm.unica.it (M. Pau).

http://dx.doi.org/10.1016/j.ptsp.2016.05.008
1466-853X/

demonstrated that players' technical abilities are related to postural performance (Paillard & Noé, 2006; Paillard, Noé, Rivière, Marion, Montoya, & Dupui, 2006).

Surprisingly however, few studies have to date attempted to assess the effects of fatigue on balance performance in soccer players by following quantitative approaches based on instrumental analysis. Experimental tests on tilting platforms (Biodex® Balance System) were performed by Greig and Walker-Johnson (2007) and Greig and McNaughton (2014) who analyzed balance in 10 semi-professional adult players before and after 90 min of intermittent soccer-specific treadmill protocol (divided into two 45-min periods with a passive 15-min half-time interval). Their results revealed a change in balance strategy due to fatigue that was hypothesized as indicative of impaired functional joint stability and thus possibly involved in an increased risk of injury. The same device was used by Yamada et al. (2012) who found a decrease in the overall stability index following the Hop Test protocol in U18 players. Furthermore, acute fatigue subsequent to the Repeated Sprint Ability test (6 repetitions of 2 × 15-m shuttle maximal sprint interspersed with 20 s of passive recovery) demonstrated significant increases in postural sway in U14 elite players, as assessed by means of center-of-pressure (COP) time-series analyses for both two- and single-leg stance tests (Pau, Ibba, & Attene, 2014).

While the aforementioned studies were carried out in a laboratory setting, to the authors' knowledge, only in two cases were adult (Zemková & Hamar, 2009) and young (Brito, Fontes, Ribeiro, Raposo, Krustrup, & Rebelo, 2012) players tested “in-the-field” to reveal possible changes in postural control following actual soccer match fatigue. In both studies, the authors observed significant increases in COP velocity after the match for two- and single-leg stance in presence of visual input (i.e. eyes open).

A limitation of most previous tests performed to elucidate the relationship between fatigue and balance abilities is that they adopted the static (either unipedal or bipedal) stance as the motor task to investigate this, even though in some cases balance was dynamically challenged through movements of the base of support. Although this is perfectly reasonable, even considering the large amount of data available in the literature for comparison, such a condition is not fully representative of soccer demands.

In a recent study on young soccer players (Pau et al., 2015), an attempt was made to compare static and dynamic balance assessed respectively by means of postural sway and vertical Time to Stabilization (vTTS) plus postural sway measured at the end of the stabilization phase. As it was found that postural sway acquired during static standing is not correlated with either vTTS or postural sway after stabilization, it appears to be impossible to extrapolate the results thus far obtained to characterize balance in dynamic situations, which are more common and realistic in soccer. Therefore, on the basis of the aforementioned considerations, this study intends to investigate dynamic balance abilities (assessed by means of the analysis of stabilization and postural sway after execution of a single-leg jump) of young soccer players before and after the first half of an actual match. The hypothesis to test is whether the muscular effort associated with the performance increases the amount of time needed to recover stability after landing, as well as postural sway during the stabilization phase.

2. Methods

2.1. Participants

Seventeen male U15 players affiliated with the professional soccer team Cagliari Calcio (Cagliari, Italy) participated in the study on a voluntary basis. During the playing season (mid-September to June) they trained 4 times per week, 90 min per session, plus 1 match per week. The players were included in the study only if they were free from lower limb injuries in the six weeks prior to the test. We also decided to exclude goalkeepers from the study, owing to the completely different physical and technical demands imposed by their position during games. The dominant limb of each player was assessed by asking him his preferred limb used for kicking the ball.

The purposes of the research, as well as the details of the experimental test procedure, were carefully explained to participants and their guardians, and written informed consent was obtained from both. The study, supervised by the team's medical and technical staff, was carried out in compliance with the ethical principles for research involving human subjects expressed in the Declaration of Helsinki, and was approved by the Departmental Review Board. The main anthropometric features of the players enrolled are reported in Table 1.

2.2. Data acquisition and post-processing

All the experimental tests were performed in February 2015 using two pressure platforms (FDM-S, Zebris Medical GmbH, Germany, 120 Hz acquisition frequency, measuring range 1–120 N/cm^2, accuracy ±5%) composed of 2560 capacitive sensing elements arranged in a 64 × 40 matrix (1.4 sensors/cm^2), and connected via USB interface to a Personal Computer.

As previously mentioned, dynamic balance was assessed by means of vTTS and postural sway analysis. The vTTS, first defined in 1992 by McKinley and Pedotti, describes the body's ability to minimize postural sway when transitioning from a dynamic to a static state and represents the time needed by the vertical component of the ground reaction force (GRF) to reach and stay within ±5% of the body weight after impact subsequent to the landing phase of either bipedal or single leg jumps. This concept was subsequently extended by including antero-posterior (AP) and medio-lateral (ML) components of the GRF to separately calculate the TTS values for each of the three mutually orthogonal directions. The TTS was then employed in a number of studies to characterize dynamic balance in both healthy and injured subjects (Brazen, Todd, Ambegaonkar, Wunderlich, & Peterson, 2010; Colby, Hintermeister, Torry, & Steadman, 1999; Flanagan, Ebben, & Jensen, 2008; Pau et al., 2015; Wikstrom, Powers, & Tillman, 2004) as it encompasses several aspects related to postural control, mechanical stability and proprioception (Brown, 2010).

After a brief familiarization phase the players, who wore the same soccer shoes used for playing, were required to perform a submaximal jump (as if they were heading the ball to pass it during the game) onto the pressure platform using both legs from a 90 cm distance and landing on a single limb with the aim of stabilizing the body as quickly as possible (Pau et al., 2015). They were left free to use their arms as they wanted both in jumping and in stabilization phases and to stand as still as possible after landing until they received a verbal signal marking the end of the trial. The overall time of the trial, which started as the pressure plate was triggered by the landing force, was set to 10 s. The vertical Ground Reaction

Table 1
Anthropometric features of the participants. Values are expressed as means ± SD.

Players (#)	17
Age (years)	14.6 ± 0.3
Height (cm)	172.9 ± 7.5
Body Mass (kg)	57.5 ± 6.8
Body Mass Index (kg m^{-2})	19.2 ± 1.6
Dominant limb	11 R, 6 L
R = right, L = left	