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Effect of expertise and visual contribution on postural control in soccer

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This work analyzes the postural performance and the use of visual information in soccer players according to their level of competition. Two groups of healthy soccer players were investigated at the mid-competition season: an amateur (AM) ($n = 15$) group composed of regional-level players and a professional group at a national level (PRO) ($n = 15$). Posture was assessed by measuring the center of foot pressure (COP) with a force platform during a test (51.2 s) of bipedal quiet standing posture. The test was completed with eyes open (the subjects looked at a fixed-level target at a distance of 2 m) and closed (they kept their gaze in a straight-ahead direction). The statistical analysis showed that PRO soccer players were more stable than AM soccer players. Moreover, the contribution of vision in postural maintenance was less important in the PRO players than in the AM players. The present study suggests that intense training allows PRO soccer players to become less dependent on vision to control their posture such that vision can be dedicated to treating the information, that emanates from the game.

The repetition of specific movements in sport training improved postural regulation (Aalto et al., 1990; Cremieux & Mesure, 1992; Era et al., 1996; Perrin et al., 1998; Golomer et al., 1999; Vuillerme et al., 2001a, b; Davlin, 2004). Nevertheless, the specific modalities of postural regulation developed with sport training are not always transferable to upright stance situations (Asseman et al., 2004). Indeed, Paillard et al. (2002) did not observe any significant difference between the postural performance of two group of judoists at different levels of competition when testing subjects with a classical bipedal standing task. Thus, these authors showed that judoists of the highest level of competition were more dependent on visual information to control their posture. Expert sportsmen use predominantly certain sensorial information to regulate their posture according to the requirement of their discipline (Perrin et al., 1998; Vuillerme et al., 2001a). For example, somatosensory cues are more informative than otholitic cues for the perception of body orientation in expert gymnasts (Bringoux et al., 2000), whereas vision is strongly involved in the regulation of posture in expert dancers (Golomer et al., 1999). Hence, the relation between the contribution of vision and the expertise level on postural control appears to depend on the sport practised. Even if the role of visual cues on postural control has been widely investigated in ballet dancers or gymnasts (Golomer et al., 1999; Vuillerme et al., 2001a, b; Perrin et al., 2002), few studies have been conducted with team sports players. It is known that team sport experts display improved perceptual abilities thanks to a relevant use of the visual information (Kioumourtzoglou et al., 1998). Indeed, in a sport like soccer, players must necessarily perform motor skills and control their posture during the game, while using visual information to collaborate with other team members or to oppose the opponents. Nevertheless, no study investigated the contribution of vision in postural control according to the level of competition in healthy soccer players. We therefore compared the postural abilities of soccer players at different levels of competition. This was done in two different sensorial conditions: with eyes open (EO) and with eyes closed (EC).

Methods

Subjects

Two groups of healthy male soccer players aged 18 to 30 years old participated in the experiment. The first group was composed of 15 amateur players at a regional level (AM group). The second group was composed of 15 professional soccer players at a national level (PRO group). The subjects' morphological characteristics (Table 1) showed no difference between the two groups (one-factor analysis of variance (ANOVA)). All the subjects had practiced soccer for at least 6 years. None had stopped practicing for more than 3 weeks during the 6 months before the study because of injury or any

other reason. The experiment was conducted at the mid-competition season. The subjects participated voluntarily in the experiment and signed an informed consent according to the procedures approved by the local Ethics Commission.

Material

The subjects were asked to stand as still as possible for 51.2 s on a force platform (PostureWin©, Techno Concept®, Cereste, France), the arms hanging along the body. The displacements of the center of foot pressure (COP) were recorded at a 40 Hz frequency (12 bit A/D conversion). The task was performed first with EO and then, EC. In the EO condition, the subjects looked at a fixed-level target (1 cm^2) at a distance of 2 m. In the EC condition, they were asked to maintain their gaze in a straight-ahead direction. The legs were straight and the feet formed an angle of 30° (inter-malleolar distance of 5 cm). The subjects were similarly placed according to precise marks.

The following parameters were calculated to describe the subjects' postural behavior: the COP surface area (estimated by fitting an ellipse to the COP data that encompasse 90% of the data), the COP velocity (the total COP displacement divided by the total period), the average position of the COP on the medio-lateral axis (X_{COP}) and antero-posterior axis (Y_{COP}) and the COP velocity variance on the Y-axis (VVY). The COP surface area is an indicator of the subject's postural performance (Caron et al., 2000; Asseman et al., 2004), whereas the COP velocity and the VVY can be viewed as parameters evaluating the postural control. Indeed, the COP velocity is an indicator of the net muscular force variations (Caron et al., 2000; Asseman et al., 2004) and the VVY parameter assesses the tone of the muscles of the posterior lodge of leg (Gagey & Weber, 1999).

Statistics

Statistical analyse of the results was carried out with a two-factor ANOVA [one unrepeated inter-factor: the two-level of competition (PRO and AM) group factor and one repeated intra-factor: the two-level (EO and EC) vision factor]. This ANOVA reports possible interactions between these two factors. In the results, the F-value corresponds to Fisher's F. The level of significance chosen was $P<0.05$.

Table 1. Comparison of the subjects' morphological characteristics between the two groups (one-factor analysis of variance)

	AM group ($n=15$)	PRO group ($n=15$)	Statistics
Age (years)	23 ± 3	24 ± 3	NS
Height (cm)	174 ± 4	179 ± 5	NS
Weight (kg)	68 ± 5	72 ± 3	NS

None of the inter-group differences were significant.
Values are means ± SD.
NS, non-significant; AM, amateur; PRO, professional.

Results

The COP surface area, the COP velocity and the VVY were significantly greater in the AM group than in the PRO group with EO and EC (group factor, Table 2). The X_{COP} and Y_{COP} did not significantly differ between the two groups. The vision factor engendered significant differences in both the AM and PRO groups. Indeed, the COP surface area ($F=5.80$; $P<0.02$), the COP velocity ($F=104.19$; $P<10^{-9}$) and the VVY ($F=38.97$, $P<10^{-6}$) were greater in the EC condition than in the EO condition. In addition, a significant vision × group interaction was observed for the COP velocity ($F=5.48$, $P<0.03$). For this parameter, the difference between the EC condition and the EO condition was greater for the AM group than for the PRO group.

Discussion

The present work compared the postural behavior and the contribution of vision in postural control in two groups of soccer players at different levels of competition.

Whatever the visual condition (EO or EC), the COP surface area was greater in the AM soccer players than in the PRO soccer players, which showed that the PRO soccer players demonstrated better postural performances than the AM players. This result is in accordance with previous findings about the close relationship between the level of sport training and the postural abilities (Aalto et al., 1990; Cremieux & Mesure, 1992; Era et al., 1996; Golomer et al., 1999; Vuillerme et al., 2001a, b; Perrin et al., 2002; Davlin, 2004). It thus corroborates the conclusion of Perrin et al. (1998), who postulated that training could develop sensorimotor adaptabilities transferable to postural control in non-specific conditions of the practice. Indeed, the

Table 2. Comparison of postural parameters between amateur (AM) and professional (PRO) soccer players with eyes open or closed

Parameters of the posture	Eyes open (EO)		Eyes closed (EC)		Statistics (group factor)	
	AM group	PRO group	AM group	PRO group	F	P
Surface area (mm^2)	139 ± 95	86 ± 35	180 ± 126	96 ± 38	5.8	0.02
COP velocity ($mm\,s^{-1}$)	19.0 ± 14.0	7.7 ± 3.4	41.4 ± 20.4	18.0 ± 9.5	15.4	0.0005
VVY	−2.4 ± 2.4	−4.2 ± 2.1	0.2 ± 1.8	−1.3 ± 1.0	9.7	0.004
X_{COP} (mm)	4.3 ± 6.7	6.5 ± 7.5	4.0 ± 8.8	4.9 ± 7.7	0.3	0.57
Y_{COP} (mm)	7.1 ± 15.6	16.0 ± 14.0	9.5 ± 12.1	17.9 ± 12.6	3.2	0.08

Values are means ± SD.
NS, non-significant; COP, centre of foot pressure; VVY, velocity variance on y-axis.

improvement of the postural performance induced by the practice of soccer was transferable to a simple evaluation test of bipedal standing task that corresponded to a usual daily life situation. Moreover, the COP velocity was greater in the AM soccer players than in the PRO soccer players, suggesting that postural control was more efficient in the PRO soccer players than in the AM players. Likewise, the VVY was greater in the AM players than in the PRO players. According to Gagey and Weber (1999), such a result shows that the PRO soccer players would have a greater tone of the posterior leg muscles compared with the AM soccer players.

The suppression of vision significantly disturbed both the postural performance and control in the two groups of soccer players, as observed previously with many other sports – e.g., shooting, judo, ballet dancing, gymnastics – (Aalto et al., 1990; Cremieux & Mesure, 1992; Golomer et al., 1999; Viuillerme et al., 2001a, b; Paillard et al., 2002; Perrin et al., 2002). Soccer players were less stable in the EC condition than in the EO condition. Nevertheless, the presence of a significant vision × group interaction for the COP velocity showed that the eye closure led to different alterations of postural control between the AM and PRO soccer players. This result illustrates a stronger dependence of vision for postural maintenance in the AM soccer players than in the PRO soccer players. Hence, with soccer players, the participation of visual cues in postural regulation decreases as the level of competition increases. This result is not in accordance with the findings reported by Paillard et al. (2002) in judoists, who showed that the more expert the subjects are, the higher the visual contribution to postural maintenance appears. The present study thus reinforces the idea previously developed by Perrin et al. (2002) about the specificities of a sports discipline according to the importance of visual inputs for the regulation of postural control. It confirms that high-level sportsmen display improved balance control in relation with the requirement of each discipline (Perrin et al., 2002). Indeed, the practice of soccer brings about a strong visual dependence in relation to the ball, opponents and team partners. The necessity to control the ball with the feet requires the players to bring their gaze down, which is conflicting with the necessity to watch the displacement of the other players. Expert soccer players have developed the capability to turn their gaze away from the ball to augment the time of observation of the match. The lower dependence on vision for postural control in PRO players may be an illustration of the acquisition of this ability to control the ball without watching it. Expert soccer players may have improved their proprioceptive capacities to control the ball while maintaining balance. As Golomer et al. (1999) initially suggested with ballet dancers, soccer training could shift the sensorimotor dominance from vision to proprioception for postural maintenance.

Perspectives

The current study showed that in soccer, the higher the level of competition, the more stable the posture. Furthermore, a high level of competition is linked to a reduction of the contribution of visual inputs for postural maintenance. Therefore, it seems interesting to introduce balance exercises with the EC (e.g., on seesaw platform, soft ground, slipping ground) in soccer training to improve postural abilities and proprioception. This type of training could allow soccer players to become less visually dependent such that the gaze can be dedicated to treating the information, that emanates from the game. Moreover, a training based on the improvement of proprioception on a seesaw platform can reduce the frequency of ankle sprains in soccer players (Tropp et al., 1985). Hence, the measurement of the postural abilities in soccer players can be useful in a preventive or a therapeutic frame. Indeed, the analysis of postural control can be relevant to prevent the risks of traumatic injuries of the lower extremities in soccer players (Soderman et al., 2000) and to evaluate the effects of a rehabilitative training of the ankle joint (Gauffin et al., 1988; Pintsaar et al., 1996). As the postural abilities are being linked to the competition level, one could suggest that an involution of the postural capabilities would allow to anticipate a risk of traumatic injuries of the lower extremities or to evaluate the effects of a rehabilitation training program of the ankle joint following an injury.

Key words: postural control, soccer, vision, expertise.

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