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ORIGINAL RESEARCH

Soccer players have a better standing balance in nondominant one-legged stance

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Rosario Barone[1]
Filippo Macaluso[2]
Marcello Traina[3,4]
Vincenza Leonardi[4,5]
Felicia Farina[1]
Valentina Di Felice[1]

[1]Human Anatomy Section 'E. Luna', BioNeC, University of Palermo, Palermo, Italy; [2]Department of Physiological Science, Stellenbosch University, Stellenbosch, South Africa; [3]Department of Internal Medicine, Cardiovascular and Renal Diseases, [4]Methods and Didactics of Motory Activities, DISMOT, [5]Department of General Surgery, Emergency and Organ Transplants (GENURTO), University of Palermo, Palermo, Italy

Rosario Barone and Filippo Macaluso contributed equally to the work

Correspondence: Rosario Barone
Human Anatomy Section 'E. Luna', BioNeC, University of Palermo, Via del Vespro 129, 90127 Palermo, Italy
Tel +39 091 6553575
Fax +39 091 6553575
Email rusbarone@hotmail.it

Abstract: The purpose of this study was to analyze the differences in standing balance during dominant and nondominant one-legged stance among athletes of different sports and sedentary subjects. The right-footed subjects of four groups (sedentary, n = 20; soccer, n = 20; basketball, n = 20; windsurfer n = 20) underwent 5-sec unipedal (left and right foot) stabilometric analysis with open eyes and closed eyes to measure center of pressure (COP) sway path and COP velocity (mean value, anteroposterior, and laterolateral in millimeters per second). The soccer group showed better standing balance on the left leg than the sedentary group ($P < 0.05$). No other significant differences were observed within and amongst groups. The soccer players have a better standing balance on the nondominant leg because of soccer activity.

Keywords: body sway, bipedal stance, center of pressure, sport practice

Introduction

Balance is an indispensable motor skill, mainly based on muscular synergies, which minimize the displacement of the center of pressure (COP) while maintaining upright stance, proper orientation, and adequate locomotion.[1] It is actively controlled by the central nervous system, which processes the afferent visual, otolithic, and somatosensorial information.[2]

The maintenance of balance, static or dynamic, is an essential requirement for excelling in sports like soccer, basketball, and gymnastics.[3] Davlin[4] showed that each sport discipline induces specific postural adaptations, which are associated with the muscles involved and loads required to execute the specific movement. It has been demonstrated that sport training improves postural capacities, enhancing the ability to use proprioceptive information (somatosensory and otolithic).[5] Golomer et al[6] showed that professional dancers, when deprived of vision, were more able than sedentary subjects to use proprioception information to compensate for body sway. Perrin et al[7] demonstrated that dancers and judoists had better balance control than the sedentary subjects without deprivation of vision. No differences were observed by Vuillerme et al[8] between gymnast athletes and a group of subjects practising various noncompetitive sport activities.

Two different studies[9,10] demonstrated that, in soccer, the higher the level of competition, the more stable the posture and the less the visual information required for postural maintenance. Matsuda et al,[11] examining COP sway characteristics of both legs during 60-sec static one-legged stance in athletes from different sports, showed that soccer players have a better one-legged stance than swimmers, basketball players, and sedentary subjects. Moreover, none of the four groups presented laterality in their COP sway during the one-legged stance.[12]

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Most soccer players prefer to use the dominant leg for kicking the ball to be more accurate and the nondominant leg to support body weight. In fact, many drills performed (shooting, passing, and stopping) are executed in a few seconds whilst standing on one leg that normally is not the dominant leg. Although the main cause for the high accident rate in soccer is physical contact with the opponent, another factor may depend on the difference that soccer activity creates between the dominant and nondominant leg; in fact, analyses of risk factors in elite soccer players showed that soccer has a high injury rate and that contact and overuse injuries predominantly occurred to the dominant leg.[13,14]

Therefore, we hypothesize that soccer players may have a better standing balance in nondominant unipedal stance during a 5-sec unipedal stance test. Moreover, we investigated the one-legged standing balance in windsurfers and basketball players, who make strong use of their antigravity muscles during training, hypothesizing that they should have a better standing balance than sedentary subjects.

The purpose of this study was to examine standing balance of both dominant and nondominant legs during 5-sec one-legged stance in sedentary subjects, windsurfers, soccer players, and basketball players.

Methods

Experimental approach to the problem

To evaluate the standing balance during dominant and nondominant unipedal stance, we analyzed the COP measures of subjects standing on the right or left leg, respectively. Moreover, the tests were conducted to measure the contribution of vision for maintaining the standing balance.

Subjects

In this study, 80 healthy male subjects were enrolled: 20 sedentary (SED), 20 soccer players (SOC), 20 basketball players (BSK), and 20 windsurfers (WDS) (see Table 1). The SED group never practised any kind of physical activity. The SOC, BKS, and WDS groups played in the Italian league. The exclusion/inclusion criteria were: performance level (at least third division of the Italian leagues), years of training (minimum 5 years), training sessions per week (minimum 5), and dominant leg (only the right-footed subjects were included). The subjects were asked their leg preference for kicking a ball.[15] During the 6 months before the study, none of the subjects was injured (foot, ankle, knee, hip, or other known injuries). The mean height and body weight of BSK group were significantly higher than in SOC, WDS, and SED groups ($P < 0.05$) (see Table 1). There were no other differences in the anthropometric characteristics among the groups.

All the subjects gave their written informed consent prior to participation in the study, as required by the Declaration of Helsinki. The experimental procedures were approved by the Ethics Commission of the University of Palermo.

Stabilometric analysis

To evaluate standing balance, the subjects underwent stabilometric analysis. It was conducted on a modular Elettronic Baropodometr® platform (Diagnostic Support Postural Biomedicine s.r.l., Roma, Italy) with 4800 platinum electronic sensors covered by an alveolar rubber captor that gave pressure information from each foot to an electronic amplifier. The data were sampled at a frequency of 25 Hz, analyzed, and visualized using the Physical Gait® Software v. 2.66 (Diagnostic Support Postural Biomedicine s.r.l., Roma).

The stabilometric analysis was composed of four different tests in which two experimental conditions were examined: visual (open eyes [OE] and closed eyes [CE]) and leg (right and left). The stabilometric parameters were recorded with OE or CE standing on one leg for 5 sec. We

Table 1 Subject characteristics

	SOC	WDS	BSK	SED	*P*
Age (years)	23.7 ± 3.2	22.3 ± 5.3	22.9 ± 2.6	25.5 ± 3.2	–
Height (cm)	173.6 ± 5.9	175.7 ± 5.3	186.0 ± 9.5	172.3 ± 5.1	BSK versus SOC < 0.05 BSK versus WDS < 0.05 BSK versus SED < 0.05
Body weight (kg)	72.6 ± 8.5	68.4 ± 6.2	82.2 ± 11.1	71.7 ± 6.5	BSK versus SOC < 0.05 BSK versus WDS < 0.05 BSK versus SED < 0.05

Notes: The values are expressed as means ± SD.
Abbreviations: SOC, soccer group; WDS, windsurf group; BSK, basketball group; SED, sedentary group.

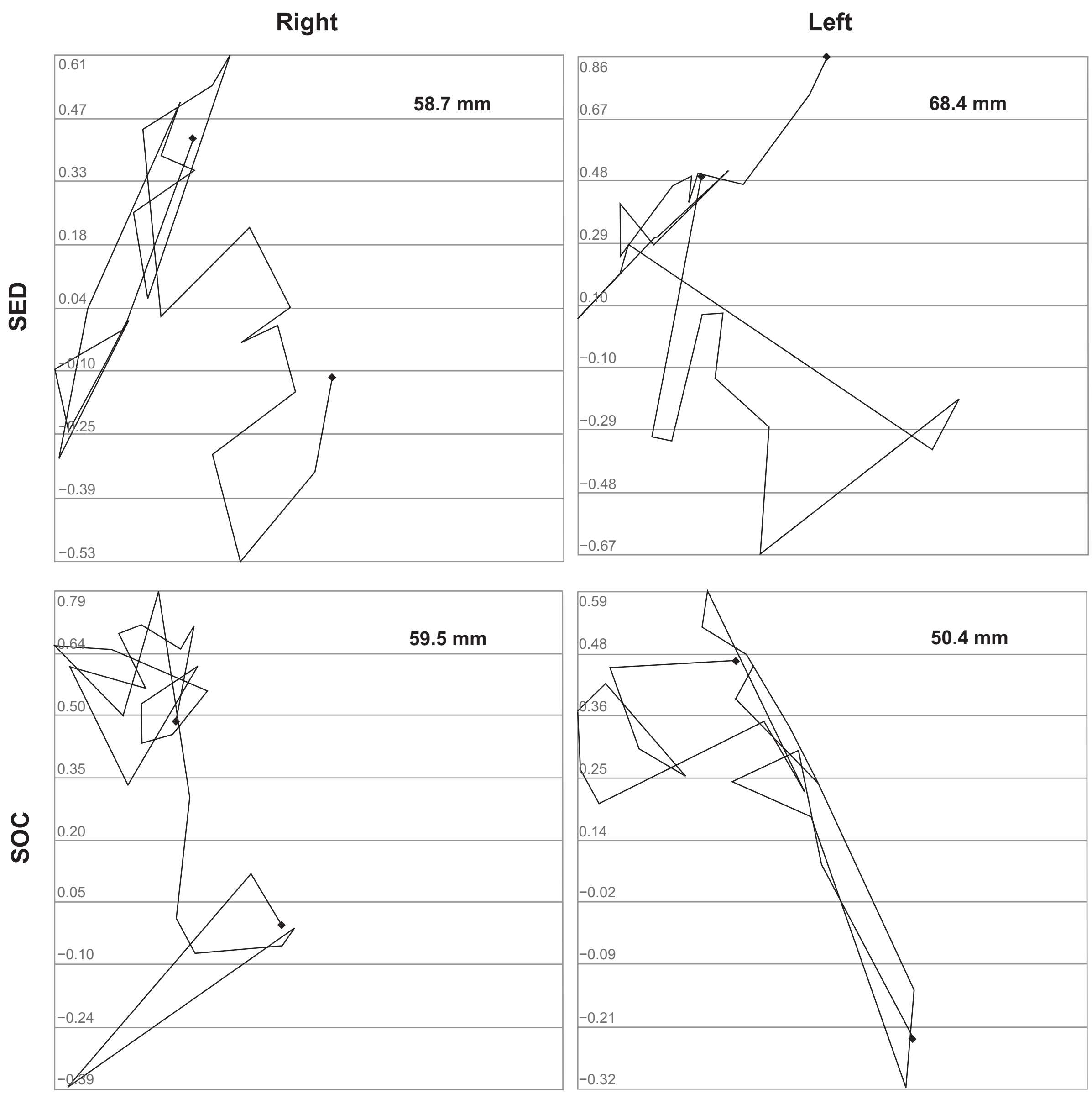

Figure 1 Example of COP sway path of sedentary (SED) and soccer (SOC) groups during the dominant (right) and nondominant (left) one-legged stance tests.

decided to use the time of 5 sec for the unipedal stance test because the 20 and 60 sec used by Asseman et al[16] and Matsuda et al,[11] respectively, were not appropriate, because these two time lapses are too long to evaluate the balance of sport game players, such as soccer players, who usually perform fast drills. During each analysis, the displacement of the projection to the platform of the COP was recorded, and COP measures were calculated: COP sway path (mm) and COP velocity (mean value, anteroposterior, and laterolateral – mm/s). From the moments (M) and forces (F) acquired, the x component of the COP was computed as $x = M_y/F_z$ and the y component as $y = M_x/F_z$. The COP sway path, an indicator of the participant's postural performance,[17] was calculated as the product of the maximum range in the x direction and in the y direction of the COP. The mean COP velocity, an indicator of the net muscular force variation,[18,19] was calculated as the COP sway path divided by the total period. The anteroposterior COP velocity, an indicator of the tone of the posterior of leg,[10] was calculated as the COP displacement in y direction divided by the total period. The laterolateral COP velocity was calculated as the COP displacement in x direction divided by the total period. The intrasubjects variability in COP measures dur-

Table 2 COP measures in unipedal stabilometric analysis of left and right foot, with OE and CE

	SOC			WDS			BSK			SED		
	OE	CE	P	OE	CE	P	OE	CE	P	OE	CE	P
Left foot												
χ vel (mm/sec)	10.74* ± 2.92	32.03 ± 12.9	0.00	11.08 ± 3.45	26.07 ± 8.61	0.00	12.15 ± 3.09	34.21 ± 12.56	0.00	13.27 ± 4.75	29.25 ± 4.75	0.00
L/L vel (mm/sec)	6.28 ± 2.29	21.53 ± 8.79	0.00	6.46 ± 2.21	16.82 ± 6.40	0.00	7.06 ± 2.99	21.75 ± 8.78	0.00	7.78 ± 3.75	19.09 ± 5.65	0.00
A/P vel (mm/sec)	7.56* ± 2.01	19.59 ± 9.98	0.00	7.78 ± 2.90	16.76 ± 5.45	0.00	8.45 ± 1.66	22.47 ± 8.32	0.00	9.29 ± 3.13	18.51 ± 5.59	0.00
Sway path (mm)	53.81* ± 14.63	160.1 ± 64.9	0.00	55.40 ± 17.29	130.3 ± 43.05	0.00	60.77 ± 15.48	171.1 ± 62.84	0.00	66.52 ± 23.71	146.2 ± 38.74	0.00
Right foot												
χ vel (mm/sec)	12.01 ± 3.83	30.71 ± 9.08	0.00	12.28 ± 4.68	23.85 ± 9.67	0.00	11.72 ± 3.88	22.73 ± 8.54	0.00	11.72 ± 4.29	30.09 ± 10.15	0.00
L/L vel (mm/sec)	6.86 ± 2.45	19.78 ± 5.81	0.00	7.75 ± 3.19	15.29 ± 7.13	0.00	6.94 ± 2.72	14.59 ± 6.94	0.00	6.43 ± 2.96	19.69 ± 7.66	0.00
A/P vel (mm/sec)	8.58 ± 3.15	19.02 ± 7.36	0.00	8.08 ± 3.29	15.14 ± 5.57	0.00	8.04 ± 2.20	14.62 ± 4.83	0.00	8.60 ± 2.90	19.01 ± 6.19	0.00
Sway path (mm)	61.00 ± 19.09	153.5 ± 45.4	0.00	61.43 ± 23.4	119.2 ± 48.39	0.00	58.61 ± 19.42	113.6 ± 42.74	0.00	58.13 ± 21.19	150.4 ± 50.78	0.00

Notes: The values are expressed as means ± SD. Significant different data between SOC and SED groups; $^*P < 0.034$.
Abbreviations: SOC, soccer group; WDS, windsurf group; BSK, basketball group; SED, sedentary group; OE, open eyes; CE, closed eyes; *P*, significant difference between OE and CE of group; left foot, nondominant leg; right foot, dominant leg; χ vel, mean velocity; L/L vel, laterolateral velocity; A/P vel, anteroposterior velocity.

ing the 5-sec test was lower than 10%. During the tests, subjects were asked to stand on the platform barefoot with arms along the body and to stand motionless while focusing on an eye-level marker on the wall (ie, to ensure minimal movement of the head).[20] Total excursion length of the COP and COP velocity were calculated and used as indicators of the magnitude of postural sway.[21,22]

Statistical analysis

To evaluate differences among groups and within group, dependent variables between groups (COP sway path, COP velocity data) were analyzed by general linear model analysis of variance (ANOVA) considering vision and/or foot or leg. If a significant difference was detected during ANOVA analysis, this was further evaluated by Bonferroni post hoc analysis. The level of significance was set at $P < 0.05$. Values were expressed as mean ± SD.

All statistical analyses were performed with the SPSS 15.0 evaluation software (SPSS Inc., 1989–2006, Chicago, USA).

Results

To evaluate the standing balance during dominant and nondominant unipedal stance, we analyzed the COP measures of subjects standing on the right or left leg, respectively. Moreover, the tests were conducted to measure the contribution of vision for maintaining the standing balance.

All groups, standing on the right or left leg, had lower COP measures with OE than with CE ($P < 0.001$). Standing on the left leg, during the OE test, the COP sway path, mean, and anteroposterior COP velocity were lower in the SOC than in the SED group ($P < 0.034$). No significant differences were observed in COP measures within groups between left and right foot (see Table 2) with OE and CE, although during the OE tests, the SOC and WDS groups showed lower COP results standing on the left leg than on the right one. The SED group had lower COP results standing on the right leg than on the left one, while the BKS group showed similar results on both legs.

Figure 1 shows the COP sway path of typical SED and SOC subjects during dominant and nondominant unipedal stance tests.

Discussion

We observed that all groups, during dominant or nondominant one-legged stance, had lower COP measures with OE than with CE. Standing on the nondominant leg during the OE test, the COP sway path, mean, and anteroposterior

COP velocity were lower in the SOC than in the SED group. Moreover, no significant differences were observed in COP measures within groups between the left and right foot. These results suggest that all groups in one-legged stance are equally dependent on visual information during a 5-sec one-legged standing balance test and that soccer players have a better standing balance on the nondominant leg. Paillard et al[10] conducted a study to evaluate the postural performance and strategy in the unipedal stance of soccer players and observed that the balance of subjects standing on the nondominant leg for 25 sec was better in the subjects who trained daily than in subjects who trained biweekly. Matsuda et al[11] did not observe any laterality difference in soccer players during 60-sec one-legged standing balance, because, in our opinion, the acquisition time is longer than the duration time of a soccer drill. Our results obtained from a 5-sec one-legged standing balance test show that soccer players have a better standing balance on the nondominant leg, probably as a consequence of many hours of soccer practice during which they maintain standing balance for a few seconds on the nondominant leg for kicking the ball with the dominant foot to have more precision,[23] although we acknowledge that the duration time and the sampled frequency may have some limitations.

Our results showing the difference in standing balance between the dominant and the nondominant leg of soccer players during a short time test opens new points of reflection for researchers and trainers. The soccer players prefer to kick with the dominant leg because they have better control or because they have better standing balance on the nondominant leg; the higher incidence injury rate in the dominant leg[13] may be influenced by the different ability to maintain standing balance between the dominant and the nondominant leg. We speculate that proprioceptive training of both legs, increasing the one-leg standing balance, may maximize kicking performance.

We did not observe a significant difference among and within SED, WDS, and BKS groups, probably because of the small number of subjects per group ($n = 20$), and the stabilometric system was not sensitive enough to pick up these differences. Although the SED group showed lower COP results standing on the dominant leg than on the nondominant leg, the WDS group showed lower COP results standing on the nondominant leg than on the dominant one, while the BKS group had similar results on both legs. Basketball players should have many opportunities to use both legs during sport practices, which may have minimized any difference in balance ability between the legs; these results confirm the Matsuda et al[11] data. Because windsurfers make strong use of their antigravity muscles during training, we hypothesized that they should have similar balance standing on both legs. However, such a tendency was not observed, and the data suggest that the drills performed on a windsurf board should improve the nondominant one-legged standing balance.

Our results provide evidence that soccer players have better standing balance than sedentary subjects during unipedal stance (nondominant leg). The repeated soccer drills, executed by soccer players in unipedal stance with the left leg used as the pivot, should modify proprioceptive factors and/or neuromuscular control and/or strength and stiffness generated around the joints and tendons of the nondominant leg. Further research is necessary to investigate which of these factors positively affect the one-legged standing balance on the nondominant leg of soccer players.

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Disclosure

No authors from the University of Palermo or Stellenbosch University have any conflict of interest.

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