Comparison of the Postural Control Performance of Collegiate Basketball Players and Nonathletes

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ABSTRACT

Athletes who play basketball are at risk for ankle injuries. Whether athletes demonstrate different postural stability and limb asymmetry during a quiet standing task compared with nonathletes is unknown. Fifteen collegiate basketball players and 15 nonathletes performed 3 trials of bipedal quiet standing for 30 s with 60 s of rest. Postural stability measures were obtained for each limb: integration of the resultant of the center of pressure (COP) speed (anteroposterior [AP] and mediolateral [ML] directions); COP area; and frequency (AP and ML). An asymmetry index between lower limbs was calculated for COP speed (AP and ML), COP area, and weight distribution. Basketball players demonstrated less COP speed (ML) ($P = .039$), decreased levels of asymmetry for COP speed ($P = .033$), and reduced COP area ($P = .005$) and COP speed in the ML direction, compared with nonathletes. Whether this reduction influences incidence of ankle sprains requires further investigation.

Different sports require different postural control strategies and predispose athletes to certain types of injuries. Postural control seems to be affected by an athlete's level of activity and the type of sport played.[1,2] It has been reported that ankle sprain injuries are more prevalent in basketball players.[3-6] The incidence of ankle sprains is high among athletes who play basketball,[7] and ankle sprains are the most common injury in collegiate men's basketball.[8] However, controversy exists as to whether experienced players demonstrate different postural control strategies (eyes open or closed and single- or double-leg stance) compared with inexperienced players or healthy individuals. Previous studies have demonstrated that athletes control their balance during standing better than inexperienced athletes,[1,9-14] whereas other studies did not reveal differences in balance between experienced and inexperienced athletes.[15,16]

Athletic tasks performed during basketball place a high demand on stability. For example, maintaining an in-bound possession, passing, shooting, and dribbling on flat and stiff surfaces without traveling require versatile control of balance. Therefore, it is natural to think that basketball players present with better postural control than nonathletes. However, athletic training may result in the development of aberrant neuromuscular control patterns according to the postural challenges imposed during repetitive athletic maneuvers. These repetitive neuromuscular patterns may initiate an imbalance of the forces acting to stabilize the joints during standing and may lead to alterations of athletes' postural strategies. Favored postural tendencies that result in potential imbalances, such as asymmetries between the lower limbs and postural sway deficits, may predispose athletes to injury and cause a decrease in performance.[5,17-22]

Whether increased postural stability is developed with experience and time playing the sport or whether experience leads to asymmetrical control patterns that might prejudice postural control, particularly for bas-

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ketball players, is still an open question. Therefore, the aim of the current study was to investigate whether differences exist in postural control and leg asymmetries between athletes and nonathletes during standing. We hypothesized that postural control and lower limb asymmetry will be different between athletes and nonathletes due to the intense athletic training and asymmetric demands in basketball.

METHOD

Participants

Fifteen male collegiate basketball players on the same team (age, 18±1 years; height, 193±10 cm; weight, 80±12 kg; experience with basketball, 6±1 years) and 15 male collegiate nonathletic individuals (age, 23±5 years; height, 176±5 cm; weight, 73±9 kg) participated in this study. No basketball players had stopped playing for more than 3 weeks during 1 year before the study and no nonathlete had any level of basketball training. All participants in the nonathlete group were recreationally active but did not participate in a sport modality more than 2 days per week. They practice 1 occasional physical activity, such as running or playing soccer, volleyball, or basketball, but at a recreational level. Individuals who participated in this study had no previous surgery on the lower extremities, no history of injury with residual symptoms (pain, giving-way sensations, endurance loss) in their lower extremities within the past year, and no evidence of a leg-length discrepancy (difference of distance from the anterior superior iliac spine to the superior surface of the most prominent aspect of the medial malleolus) of more than 1 cm. We conducted the experiment in the beginning of the competitive basketball season. The University of São Paulo's ethics committee approved this study, and all volunteers provided written informed consent before participation.

Procedures

Prior to data collection, the participants were asked which leg was preferred for kicking a ball. The preferred kicking leg was considered the dominant leg.[23] For the standing task, the participants were asked to select a comfortable standing position with the feet approximately hip-width apart, with their arms crossed on the chest. Participants stood with each foot on a different force plate (OR6; AMTI, Watertown, Massachusetts). Participants were instructed to stand as still as possible, with their eyes open, while concentrating on a point approximately 2 m away at eye level. Each participant performed 3 trials of quiet standing for 30 s, followed by 60 s of rest. We recorded the ground reaction forces and moments from each force plate at a 300-Hz sampling frequency and used these to calculate the center of pressure (COP) displacement for each force plate (limb) and the resultant COP displacement for the whole body in the anteroposterior[24] (AP) and mediolateral (ML) directions as follows:

$$COP = (COP_1 \cdot Fz_1 + COP_2 \cdot Fz_2/(Fz_1 + Fz_2)$$

where Fz is the ground reaction force in the vertical direction and the indexes 1 and 2 refer to the different force plates.

Data Analysis

All data were analyzed with a customized program written in MATLAB (MathWorks Inc, Natick, Massachusetts). The COP data were filtered with a fourth-order, 10-Hz, low-pass, zero-lag Butterworth filter.

Balance was assessed by measuring the following variables for the COP data from the dominant and nondominant limbs separately and for the resultant COP data: COP area, COP speed in the AP and ML directions, frequency in the AP and ML directions, and weight distribution. The COP area was estimated by fitting an ellipse that encompasses 95% of the total COP data for each limb.[25] The COP area variable represents a measure of spatial variability of the COP data on the base of the support during standing. The COP speed was calculated by dividing the COP total displacement by the total 30-s period of the trial. The COP speed variable represents a measure of how fast the COP data moved on the base of the support during standing. The frequency of the COP displacement was calculated by determining the frequency at which less than 80% of the COP spectral power occurred. The 80% cut-off value was chosen based on previous work[26] that suggested this value is a superior discriminator for the COP data than other spectral measurements. The power spectral density was estimated by the Welch periodogram of the data, with a resolution of 0.039 Hz.[26] The COP frequency variable represents a measure of the range of the most common frequencies in the COP data during standing. The weight distribution was defined as the mean value of Fz for each force plate, normalized by the total weight (sum of the Fz from each force plate) during the whole quiet standing trial. The weight distribution variable represents how much weight is supported by each limb during standing.

In addition, we computed the level of asymmetry using an asymmetry index (AI) between limbs for the following variables of each limb (force plate): COP speed (AP and ML directions), COP area, and weight distribution. The AI between limbs was calculated using the absolute values for all variables as follows:

$$AI = 100 \cdot \left| \frac{(V_d - V_{nd})}{(V_d + V_{nd})/2} \right|$$

where V_d is the dominant leg variable and V_{nd} is the nondominant leg variable.

Normality and homogeneity of variances of the data were confirmed by the Kolmogorov–Smirnov and the Levene tests, respectively. Differences in height were found between groups; therefore, height was used as a covariate when using an analysis of covariance (ANCOVA) to compare mean differences between groups (COP speed, COP area, and frequency). A one-way analysis of variance was used to compare differences in lower limb asymmetry between groups (AI of the COP speed, COP area, and weight distribution). An alpha of 0.05 was used for all statistical tests, which were performed using SPSS version 18.0 (SPSS Inc, Chicago, Illinois).

RESULTS

No differences were found between the athlete and nonathlete groups for COP area (5.3±3.0 cm^2 and 4.9±3.0 cm^2, respectively; $F_{1,27} = 0.21$, $P = .64$), COP speed AP (8.4±1.4 cm/s and 10.2±4.7 cm/s, respectively; $F_{1,27} = 2.70$, $P = .11$), COP frequency AP (0.38±0.01 Hz and 0.39±0.01 Hz, respectively; $F_{1,27} = 0.79$, $P = .38$), COP frequency ML (0.38±0.01 Hz and 0.38±0.02 Hz, respectively; $F_{1,27} = 0.004$, $P = .84$), and weight distribution ($F_{1,27} = 0.002$, $P = .96$). Differences were revealed between groups for COP speed ML ($F_{1,27} = 4.71$, $P = .039$), with the athlete group demonstrating less speed than the nonathlete group (4.9±0.9 cm/s and 7.8±2.7 cm/s, respectively) (Figure 1).

The asymmetry index variable was significantly different between groups for COP speed AP ($F_{1,25} = 5.07$, $P = .033$) and COP area ($F_{1,25} = 9.26$, $P = .005$). The athlete group demonstrated less asymmetry for these 2 variables, compared with the nonathlete group (Figure 2).

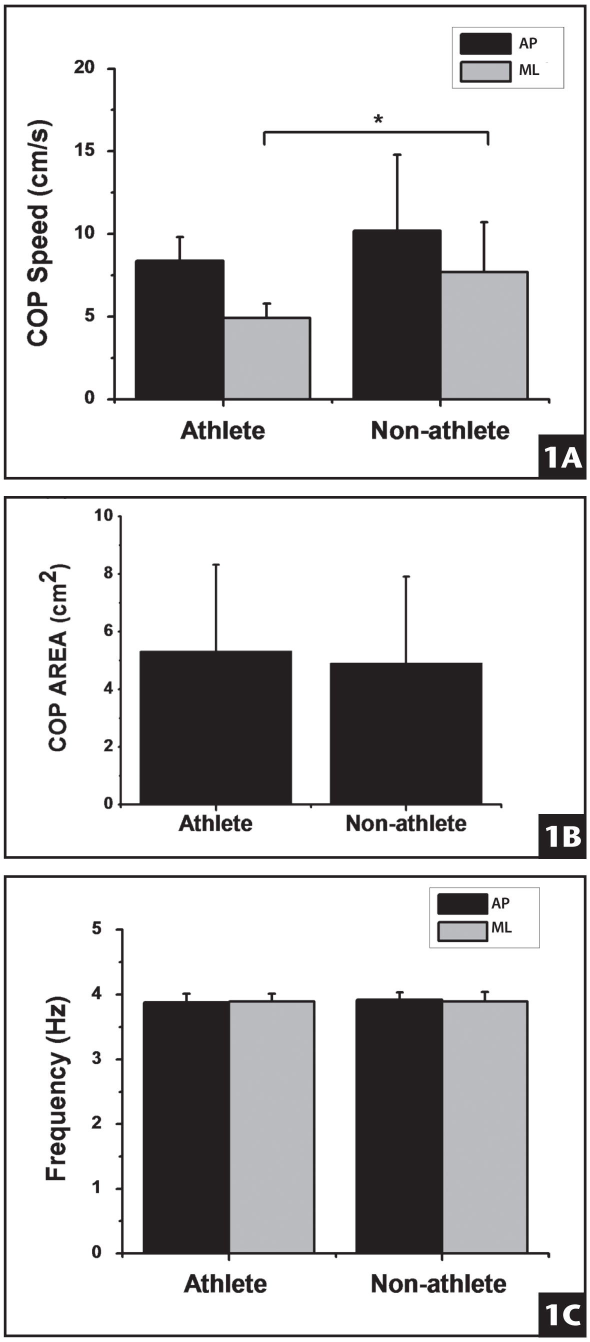

Figure 1. Mean ± standard deviation values for the athletic and nonathletic groups for the following analyzed variables: (A) Center of pressure (COP) speed (anteroposterior [AP] and mediolateral [ML] directions); (B) COP area and (C) frequency (AP and ML directions). $^*P < .05$.

DISCUSSION

The aim of the current study was to investigate differences regarding postural stability (balance) and lower limb asymmetry between an athletic group of collegiate basketball players and a nonathletic group. Our

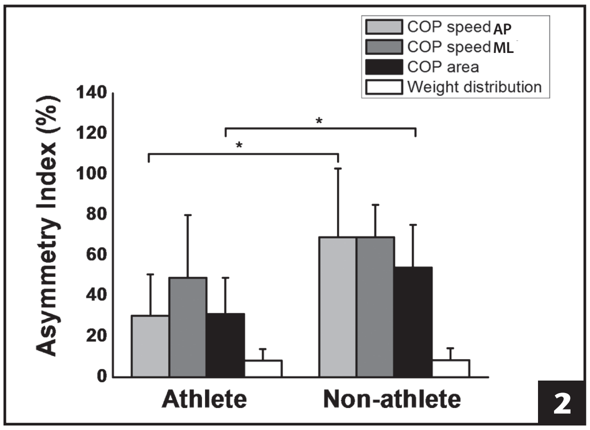

Figure 2. Mean ± standard deviation of the asymmetry index values for the nonathletic and athletic groups for center of pressure (COP) speed (anteroposterior [AP] and mediolateral [ML] directions), COP area, and weight distribution. $*P < .05$.

hypotheses that athletes would demonstrate different postural stability and leg asymmetry compared with a nonathletic group during a bipedal quiet standing task were partly supported by this work. The basketball players demonstrated significantly less COP speed in the ML direction (frontal plane) and significantly decreased levels of asymmetry for COP speed in the AP direction (sagittal plane) and COP area; however, both groups demonstrated similar COP area, COP speed in the AP direction, and COP frequencies in both directions. Regarding the asymmetry index, although both groups did not present with weight distribution asymmetry between limbs, the basketball players were more symmetrical for the COP area and COP speed variables. Therefore, overall, our results suggest that the athlete group exhibits a similar balance (postural stability) compared with the nonathlete group but that the athletes demonstrated less asymmetry between limbs.

The only variable that was different between groups—the slower COP speed in the ML direction by the athlete group—can be interpreted as a slightly improved balance in the athletes' frontal plane. The rationale that smaller values of the COP speed variable would reflect a better balance is borrowed from clinical studies in which higher COP speed is typically associated with pathologies or a higher risk of falling in the elderly population.[27,28] The slower COP speed demonstrated by the athletes during quiet standing suggests that athletic training and basketball practice may develop a better postural control strategy to stabilize the body against self-perturbations during quiet standing. However, both groups were composed of individuals with no identifiable postural control problems, and the athletes and nonathletes did not present with any difference on spatial variability (measured by the COP area variable). The amount of postural sway, either measured by the COP area or COP speed variables, did not seem to threaten the equilibrium of any of the participants. In fact, in the context of control of movement, it is well recognized that a certain amount of variability may play a positive role and should not be viewed as deleterious noise or a failure of the central nervous system.[29] The exact nature of the postural sway and its meaning for differentiating athletes from nonathletes is still under debate and beyond the goal of this study. Our observed difference in postural stability between the athletes and nonathletes was small and limited to only 1 variable (ie, COP speed differences in the ML direction; effect size, 6.7). If athletes have different postural stability during bipedal stance than nonathletes, the current results show only very small differences.

Our results are in contrast to previously reported postural control findings in basketball players, which is likely due to different tasks and conditions being investigated as well as the inclusion of only female basketball players in one of the studies. Matsuda et al[15] investigated postural control during single-leg standing of soccer players, basketball players, swimmers, and nonathletes and found that only the soccer players presented with different characteristics (higher frequency of sway and lower sway amplitude) compared with the other groups. Bressel et al[2] also studied female basketball players and compared their postural control with female soccer players and gymnasts. They investigated postural control during single- and double-leg standing in static and dynamic tasks and calculated an overall score for each condition. They found that the female gymnastic group presented 55% lower errors in balance compared with the basketball players and that Star Excursion Balance Test scores were 7% higher for soccer players than for basketball players.

We hypothesized that the asymmetry during standing would be different between athletes and nonathletes, with an implicit idea that the basketball players would present with lower asymmetries due to the intense athletic training and demands of basketball. This hypothesis was confirmed.

A possible explanation for reduced limb asymmetry is a more coordinated pattern of postural stability and a better force management between lower limbs by the athlete group due to higher physical demands of the sport[15,16,30] and specific sensorimotor challenges.[1] The nature of basketball requires athletes to have unilateral and bilateral stability, move skillfully on both legs, and control their center of mass while swaying in all directions.

Limb dominance, or laterality, plays a role in creating limb asymmetry.[31-33] Unilateral athletic maneuvers, such as one-legged rebounds and lay-ups, require both limbs to perform well during these tasks. Furthermore, basketball players often perform advanced bipedal postural strategies to maintain larger shifts in their center of mass during athletic offensive and defensive maneuvers and to avoid penalties, such as traveling and out-of-bounds calls. This challenge to the right and left limbs during unilateral and bilateral sport maneuvers may decrease the opportunity for collegiate basketball players to exhibit limb dominance or laterality.

Athletic tasks required of basketball players may necessitate improved dynamic postural control strategies in both legs during a lower level, less challenging static postural task. In addition, the higher level of conditioning of the athlete group may provide a challenge to postural stability, such as quiet standing.[15,16,34] It is possible that these athletes developed some specific balance skills that are partly transferable to static posture control; however, other investigations involving dancers and gymnasts have reported no such transfer.[15,16] For example, basketball players' postural strategies are perturbed by an opponent as one player remains "set" in bipedal stance while waiting for a rebound, setting a pick, and setting up a pass to avoid a referee's travel call while the other player is jostling for the ball and contacting or moving the set player. These bipedal dynamic skills used by basketball players may be more similar to the bipedal stance evaluated in this study, whereas dancers and gymnasts may use fewer bipedal positions during their sports activities and are not trained to react against unexpected external perturbations from another athlete. Therefore, the lack of an opponent and differing skill acquisition in dancers and gymnasts, compared with basketball players, may account for the lack of the transfer during a bipedal static postural control task.

LIMITATIONS

We recognize that this study has some limitations. We did not exclude basketball players with a previous history of lower extremity ankle sprains. We assumed that players who had injuries without any residual symptoms for more than 1 year did not differ significantly from players who had no history of injuries[5,22] or different kinds of injury. Our groups also were not matched for height. We were unable to recruit nonathletic individuals without basketball training who were as tall as the basketball players. However, we did account for height differences by using height as a covariate when making group comparisons.

IMPLICATIONS FOR CLINICAL PRACTICE

Our findings that collegiate basketball players move their COP slower in the frontal plane and have a more symmetrical balance profile compared with nonathletes is of clinical interest. The shorter path of the COP in the medial and lateral directions may be a successful or unsuccessful strategy when the ankle rolls into a mechanism of an inversion or eversion sprain. Whether asymmetry scores and COP speed in the frontal plane are correlated with functional outcomes of athletes with ankle sprains is unknown. Our balance measures may correlate with subjective questionnaires used to rate function in a population with ankle instability (eg, the Foot and Ankle Disability Index and the Functional Ankle Ability Measure).[35,36] Future studies investigating the possible changes in postural control strategies across different age and competitive levels and during different times in the season are also necessary.

CONCLUSION

Nonathletes and athletes are similar in terms of postural control. Looking at the health and well-being of the individuals, the fact that young collegiate basketball players with several years of intense athletic training do not show any sign of deterioration of their postural control suggests that no adverse effect of training and competition was observed. However, the athletes showed less overall limb asymmetry than nonathletes, suggesting that athletes use a more coordinated pattern for postural control and force management between lower limbs. ■

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