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BRIEF NOTE

Motor preferences in running and quiet standing

Préférences motrices en course et en position statique érigée

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KEYWORDS
Gait;
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Summary
Introduction. — Running gait is an individual coordinated whole-body movement within which different foot strike patterns are employed. Mid/forefoot and rear foot strike patterns entail distinct muscle activation, with the ankle flexors and extensors primarily involved in regulating the ankle-joint position. These muscles also play an important role in quiet standing. Our aim was to identify the nature of any relationship between foot strike patterns as well as the global running patterns of individuals and the antero-posterior position of the centre of pressure during quiet standing.
Facts and results. — The running biomechanics of thirty-five regularly-trained runners were assessed subjectively and globally using the Volodalen® method, and objectively using a high-speed video camera, while the static position of the centre of pressure was evaluated using a plantar pressure platform. Both the foot strike pattern and the global subjective score were correlated with the centre of pressure position in quiet standing.
Conclusion. — These preliminary results support the existence of an overlap in how humans regulate running and quiet standing, which is likely to involve local and global mechanisms.

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MOTS CLÉS
Pattern de course ;
Contrôle postural ;
Pose de pied ;
Coordination globale

Résumé
Introduction. — Le pattern de course est un mouvement global et coordonné dans lequel différentes poses de pied peuvent être utilisés. Les poses de pied en talon et en plante de pied induisent des activations musculaires distinctes avec les fléchisseurs et extenseurs de cheville comme principaux régulateurs. Ces muscles jouent également un rôle dans le maintien de la position statique érigée. L'objectif de cette étude était d'identifier la nature des relations entre le type de pose de pied (niveau local) et le pattern de course (niveau global) en course et la position antéro-postérieur du centre de pression en statique.
Synthèse des faits et résultats. — La biomécanique de course de trente-cinq coureurs réguliers a été évaluée objectivement grâce à une caméra vidéo haute-fréquence (niveau local) et subjectivement à partir de la méthode Volodalen®. La position statique du centre de pression de chaque participant a été mesurée à trois reprises et moyennée à partir d'une plate-forme baropodométrique. L'angle de pose de pied et le score subjectif global tous deux évalués en course étaient corrélés à la position du centre de pression observée en statique.
Conclusion. — Ces résultats préliminaires supportent l'existence d'une régulation similaire de la course et la position statique érigée qui pourrait impliquer des mécanismes locaux et globaux.

1. Introduction

In running, both rear foot and mid/forefoot strike patterns have been proposed to be the most economical. On an individual level, self-selection of foot strike patterns seems to be the most efficient. We believe that this ''self-selection is the most economical'' paradigm also applies to the entirety of the running pattern where runners can be categorized as being aerial or terrestrial runners [1]. Running gait is a coordinated movement pattern that involves the whole body within which the vertical oscillation of the head, the arms' movement, the pelvis position as well as the foot strike pattern are involved [1]. Concerning this last parameter, aerial runners are preferentially associated with a mid/fore foot strike, whereas terrestrial runners are preferentially associated with a rear foot strike [1].

The foot strike pattern is controlled by the ankle flexors and extensors muscles [2]. A mid/forefoot strike pattern leads to more activation of ankle extensors, while a rear foot strike pattern leads to more activation of ankle flexors. Muscle control at the ankle joint level is involved in other weight-bearing activities, such as quiet standing. Indeed, the regulation of the anteroom-posterior (AP) sway of the centre of pressure (Cop) is primarily due to the ankle flexors and extensors, as long as subjects use an ankle strategy [3]. The inverted pendulum model dictates that increasing ankle flexors activity moves the CoP posteriorly, and increasing ankle extensors activity moves the CoP anteriorly [3].

As the same muscles groups are used in running and postural control, we hypothesized that the way one controls AP position of the CoP in quiet stance should reflect in a particular running pattern. We expected that a more anterior mean AP position of the CoP in quiet standing would be associated with an aerial pattern and more forefoot striking during running, and reciprocally as to a more posterior AP position.

2. Method

2.1. Participants

Thirty-five regularly trained runners of different running teams (age: 31.7 ± 8.6 years, height: 176.3 ± 5.6 cm, body mass: 69.4 ± 6.9 kg, and maximal aerobic velocity, MAV: 17.4 ± 1.0 km·h^{-1}) participated in this study. Each participant completed one experimental session in our laboratory including running and quiet standing assessment. The university's Institutional Review Board approved the study protocol prior to participant recruitment (CPP: 2014-A00336-41), which was conducted in accordance with the latest amendments of the Declaration of Helsinki.

2.2. Quiet standing

A plantar pressure platform (Footwork Pro, AMCube IST, France) sampling at 200 Hz was used to measure the mean AP position of CoP in quiet standing (in % of the foot length, %AP). Participants were required to stand, in socks, quietly for 15 seconds with eyes open. They were permitted to use their preferred foot stance position during testing, with arms relaxed along their sides. The mean value from 3 consecutive trials was used for data analysis. The reliability of this procedure has been tested during a second identical session of measurement one month later by using Hopkins recommendations and did not show any significant difference (P = 0.161) with an adequate typical error of measurement (coefficient of variation, CV: 5.3 ± 12.1%) between both sessions.

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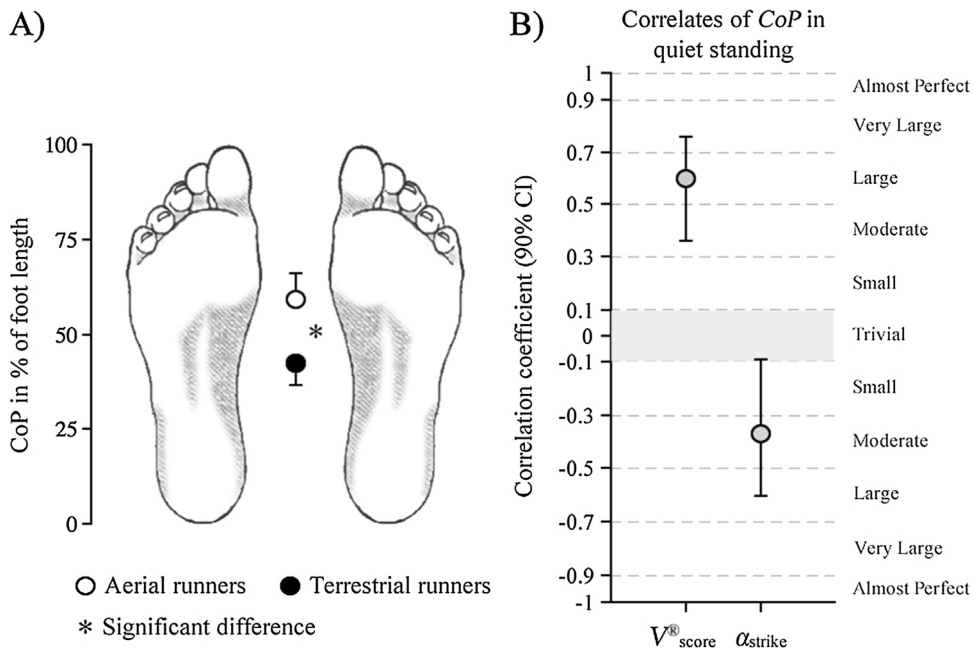

Figure 1 A. Mean antero-posterior (AP) position of the centre of pressure (CoP) in the aerial and terrestrial running patterns. B. Correlations between the AP position of CoP in quiet standing and the global subjective score (V®score) and foot strike angle (α_{strike}).

2.3. Subjective assessment of running gait

During a continuous 10-min run on a 400 athletic track (velocity between 2.5 and 3.5 m·s^{-1}), a running coach with more than 10 years of experience using the Volodalen® method focused on the global movement patterns of participants and a particular attention has been given to five key elements (Fig. 1), each rated on a 5 points scale. The sum of these 5 items formed a global subjective score (V® score), which allowed to split runners into two different categories: terrestrial (TER, V® score ≤ 15) and aerial (AER, V® score > 15). The Volodalen® method demonstrates adequate intra and inter-rater reliability (respectively, CV = 6.1 ± 7.0% and 6.6 ± 6.5%, paired t-test: *P* = 0.927 and 0.250), and is described in a previous study [1].

2.4. Objective assessment of running gait

During the same 10-min run, a high-speed video camera (Sony HDRSR7E, Sony Corporation, Tokyo, Japan) was placed 2 m ahead and perpendicular to the acquisition space on a 0.45 m support to capture sagittal plane kinematics at 200 Hz during each 400 m lap. Circular opaque markers of 9 mm diameter were positioned on the right leg over the lateral malleolus and fifth metatarsal phalangeal joint to assist in computing angles. The video sequences were analyzed off-line using Dartfish Pro Analysis software version 5.5 (Dartfish, Fribourg, Switzerland) to determine foot-ground angles (α_{strike}, °) at impact. The more positive values indicated a more rear foot strike pattern (more ankle dorsiflexion), and the more negative values indicated a more forefoot strike pattern (more ankle plantar flexion).

2.5. Data analysis

Descriptive statistics are presented using mean ± SD values and correlation statistics usingmean ± 90% confidence limits (CL). Student *t*-tests were used to compare participants' characteristics, V® score, %AP, and α_{strike} between aerial and terrestrial patterns. Correlation coefficients were used to assess whether %AP was correlated with the V® score and α_{strike}. Statistical significance was accepted when the overall *P* value was < 0.05 and performed using SigmaStat12 (Systat Software Inc., USA) and Hopkins spreadsheets (http://www.sportsci.org).

3. Results

Age, morphological features, MAV, and training volume of aerial (*n* = 19) and terrestrial (*n* = 16) runners were similar, while V® score and α_{strike} were respectively higher and lower in aerial compared to terrestrial runners (Table 1). Shoes worn characteristics were not different between the two groups (aerial vs. terrestrial, shoe mass: 310 ± 51 vs. 315 ± 53 g, heel height of 20.2 ± 4.8 vs.19.7 ± 5.0 mm, and drop of 10.5 ± 2.5 vs. 8.9 ± 3.8 mm, *P* > 0.05).

%AP was more anterior in aerial compared to terrestrial patterns (58.6 ± 7.7 vs. 43.6 ± 6.4 *P* < 0.001) (Fig. 1A). The correlation coefficients were large between %AP and V® score (r = 0.603 ± 0.195, *P* < 0.001) and moderate between %AP and α_{strike} (r = −0.363 ± 0.261, *P* = 0.037) (Fig. 1B).

4. Discussion

To our knowledge, this is the first study to establish a relationship between running parameters [evaluated subjectively and globally (V® score), and objectively (α_{strike})]

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Table 1 Age, height, body mass, maximal aerobic velocity (MAV), training volume, global subjective score (V® score), and foot strike angle (α_{strike}) in the aerial and terrestrial running patterns.

	Age (year)	Height (cm)	Body mass (kg)	MAV (km·h−1)	Training volume (h·week−1)	V® score	α_{strike} (°)
Aerial	31.8 ± 9.6	176.4 ± 6.7	67.9 ± 7.7	17.5 ± 1.0	3.9 ± 1.7	18.9 ± 2.0	10.4 ± 7.0
Terrestrial	31.7 ± 7.6	176.3 ± 4.3	71.1 ± 5.6	17.2 ± 1.0	4.3 ± 1.5	10.7 ± 2.6	17.2 ± 6.3
P values	0.486	0.465	0.091	0.228	0,279	**< 0.001**	**0.002**

Values are mean ± SD. Level of significance is $P < 0.05$. Significant difference between aerial and terrestrial patterns is indicated in bold.

and the postural control (%AP). Terrestrial runners exhibit significantly more ankle dorsiflexion at ground contact during running, and amore posterior CoP in quiet standing compared to aerial runners. These results are strengthened by the correlations between the %AP and running parameters at both global (large with V® score) and local (moderate with α_{strike}) levels.

A posterior CoP position leads to a greater activation of the ankle flexors [3]. Conversely, the ankle extensors are more active when the CoP is in a more anterior position [3]. In our study, %AP differed between aerial and terrestrial patterns, suggesting a different activity of the ankle extensor/flexor muscles. In addition, our study objectively shows less rear foot strike in aerial than terrestrial patterns. Spontaneous mid/forefoot striking during running elicits longer and quicker activation of the ankle extensors than natural rear foot striking (i.e., terrestrial pattern) [4]. Therefore, the observed differences between aerial and terrestrial runners through running foot strike pattern also suggest different activity of the ankle extensor/flexor muscles.

To summarize, aerial runners display a more anterior %AP and a less rear foot strike pattern, whereas terrestrial runners display a more posterior %AP and a more rear foot strike pattern. These findings suggest a similar muscle control between running patterns and quiet standing [2,3]. The relationship observed between %AP and the foot strike angle in running support this hypothesis. However, correlation is moderate, suggesting that other elements have to be taken into account. For instance, and in contrast to our results, a recent study has shown that a forward lean trunk during running, which suggests a more anterior %AP, was not associated with more mid/forefoot striking [2,3]. However, the present study shows a large correlation between V® score and %AP, which could indicate a rather global (i.e., muscle chains) than local (i.e., ankle muscles) regulation of these two activities.

This study shows relationships between overall running pattern as well as foot strike pattern and the mean AP position of the CoP in quiet standing. These preliminary results support the existence of a similar body organisation between running and quiet standing, possibly through preferential muscle activation pattern. Electromyographic and biomechanical investigations of the leg and trunk are required to confirm these suggestions.

Déclaration de liens d'intérêts

Les auteurs déclarent ne pas avoir de liens d'intérêts.

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