Comparison of the subtalar joint angle during submaximal running speeds

LEONARDO ALEXANDRE PEYRÉ TARTARUGA[1], MARCUS PEIKRISZWILI TARTARUGA[2], GABRIELA LOVIS BLACK[3],
MARCELO COERTJENS[4], LEONARDO ROSSATO RIBAS[5], LUIZ FERNANDO MARTINS KRUEL[6]

SUMMARY

The objective was to describe the behavior of the maximum pronation (MP), of the maximum pronation speed (PS) and of the linear crossover (LC) of the right and left feet of 23 distance runners during treadmill running, at speeds ranging from 11 to 13 $km \cdot h^{-1}$ for female athletes and from 14 to 16 $km \cdot h^{-1}$ for male athletes, related to an average of 70% - 75% of the maximum aerobic power (VO_{2max}). The statistical analysis (Student's T-Test for dependent and independent samples, $p<0.05$) showed that, by increasing submaximal running power, there was a significant increase on MP, and by increasing running linear speed, the PS was significantly higher. Regarding LC, we believe that this is biased by the running technique used by each runner.

Keywords: Subtalar joint; Pronation; Foot.

INTRODUCTION

During the last few decades, the study of human pace has been widely spread among the various sport research centers(1). Many researches have been developed aiming to study the relationship between physical activity and lesion(2), especially those involved in running activities(3,4).

Studies establishing a relationship between subtalar joint angle and the kind of shoe used for running activities have obtained a significant importance on pursuing a better understanding of lesions involving the hip, knee, ankle, and foot(2,5).

Potential causes for excessive-use lesions in athletes, particularly in runners, can be attributed to extrinsic and intrinsic (anatomic) factors(2). Among the extrinsic factors, mistakes in drills have been associated at a great percentage (60%) with lesions in runners(2). The most common mistake in drills was the excess of volume, followed by drills in inappropriate sites (hard floors and slopes).

On the other hand, many anatomical or intrinsic factors have been related to excessive-use lesions in runners, however, there is a lack of data establishing structural or functional specific variations of the mechanisms of excessive-use lesions(3).

Currently, it is stated that the etiology of such lesions is multifactorial and diverse(6). Little abnormalities, imposing no consequences in other sports, can become a significant factor on lesions development in distance runners due to the existent impact force, especially at the moment in which the foot makes contact with the floor, corresponding to twice or three times of the body weight, at an average pace frequency of 70 – 100 steps/ minute. A portion of the impact force is reduced by the use of sportive shoes, while the remainder is transferred to the anatomical structures. Thus, the combination of impact cumulative loads and deviations on anatomical structures can contribute to the incidence of excessive-use lesions in professional runners. A very common case is that of the excessive foot pronation (Figure 1), known as foot eversion, dorsoflexion and abduction, occurring at the frontal, sagittal and transversal planes, respectively(7). It is believed that there is a cause relationship between hyperpronation and excessive-use lesions, but the mechanism of the correlation between hyperpronation and lesions is not very clear(8). The maximal pronation value is usually achieved around 45% of the support phase period. This value is particularly influenced by the running linear speed(9), as well as by muscular unbalances and/ or ligament lassitude, causing changes on malleolum heights (valgus or varus)(7), and by the running technique imposed by the runner, seen through the linear crossover of both feet comparing to the lumbar spine(10). At around 75% of the support period, there is a significant increase on re-supination rate. According to some authors(8), a certain amount of pronation is required to attenuate impact forces.

Study conducted at the Gymnastics School – ESEF / UFRGS, Exercises Research Laboratory – LAPEX, Jardim Botânico, Porto Alegre, RS, Brazil.

Correspondences to: Gymnastics School – ESEF / UFRGS, Exercises Research Laboratory - LAPEX/ CENESP. Rua Felizardo, 750, Jardim Botânico, Porto Alegre/ RS, Brazil. ZIP code: 90690-200. E-mail: peyre@brturbo.com, mtartaruga@bol.com.br, lfkruel@adufrgs.ufrgs.br

1. Professor at Esef/ UFRGS, Professor at FACOS, Professor at FSG
2. Academic in Gymnastics at Esef/ UFRGS, holder of a scholarship on Scientific Initiation by BIBIC/ CNPq.
3. Master (in course) in Human Motion Sciences at Esef/ UFRGS, Physical Therapist by IPA.
4. Master (in course) in Human Motion Sciences at Esef/ UFRGS.
5. Licensed in Gymnastics by IPA, Track and Field Coach at the Porto-Alegrense Society of Gymnastics.
6. Professor on graduation and post-graduation courses at Esef/ UFRGS, Coordinator of GPAA/ UFRGS.

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Nonetheless, hyperpronation is not the only variant related to excessive-use lesions(4). The maximal pronation speed has a relevant importance due to the fact that there already were studies proving the relationship between maximal pronation speed and excessive-use lesions, especially in exhaustive situations. Some studies describe the importance of foot deceleration degree (damping), particularly on the first contact of the foot with the floor in order to try to explain the mechanisms of lesions related to running activities(10,11). However, the lack of further studies describing the influence of the running speed and the effort intensity with the maximal pronation speed along the running support phase for preventing lesions, does not allow clearer explanations regarding the subject. Other potentially intervenient factor on maximal pronation behavior and on maximal pronation speed is the gender, because there are evidences showing changes in running techniques between male and female runners(12).

Thus, the study's purpose was to describe maximal pronation behavior, maximal pronation speed behavior and the linear crossover behavior of both feet regarding the lumbar spine in different submaximal intensities of running and the running linear speeds, for males and females.

METHODOLOGY

Twenty-three distance runners were assessed. They were members of the Porto-Alegrense Society of Gymnastics – SOGIPA, divided into two groups: 16 males (ages: 29 ± 9 years old; VO2max: 50,9 ± 6,0 ml.kg-1.min-1) and 7 females (ages: 26 ± 14 years old; VO2max: 42,5 ± 5,7 ml.kg-1.min-1). For each group and from a VO2max(2) test, the submaximal running speeds were established (11 and 13 km.h-1 for women, and 14 and 16 km.h-1 for men), related to an average of 70% and 75% of the VO2max. Individuals were selected as volunteers, which characterized the research as being almost experimental, due to the lack of randomization on sample selection, and all individuals signed a consent form, which is in compliance with the ACSM (American College of Sports Medicine, 1994).

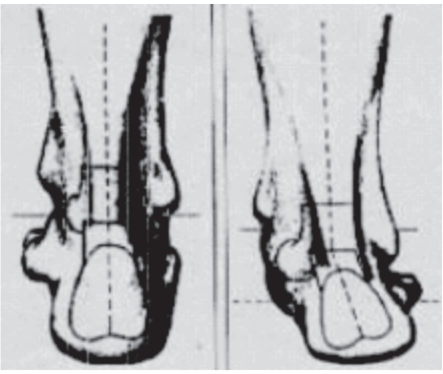

Figure 1- *Excessive pronation of the subtalar joint.*

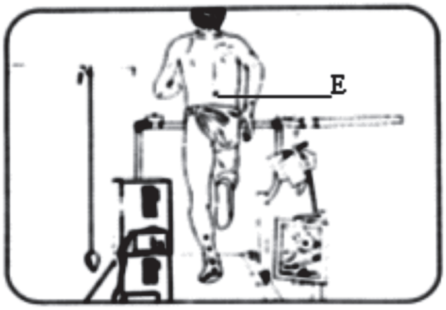

Figure 2 – *Posterior frontal plane*

Figure 3 - *Detailed image of the legs*

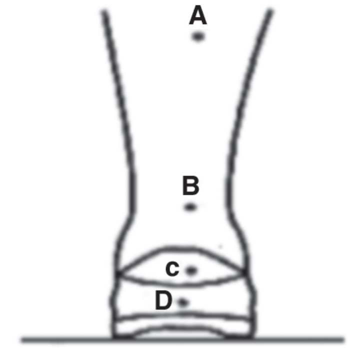

Figure 4 - *Anatomical points:*
(a) Gastrocnemuis ascending point
(b) Gastrocnemius descending point
(c) Ankle point
(d) Heel point.

On the subsequent week, after determining submaximal running speeds, a running-saving test was prepared, in which sample participants had to run during five(5) minutes within their respective gender speeds (11 and 13 km.h-1 for women, and 14 and 16 km.h-1 for men), bringing up to a total of 10 minutes of running for each individual. During the running-saving test, a tape was recorded at 120 Hz, in a frontal plane, behind the runner (Figures 2 and 3). The camera used was a Punix F4, positioned at a distance of three(3) meters from the assessed individual and at one(1) meter from the floor. Thus, movements of the posterior part of both feet were recorded during one(1) minute, as well as the point of lumbar spine (Figures 2 and 3) at the correspondent speeds. Then, the computer system Peak Performance version 5.3.3 was employed for automatic digitalization of anatomical points. For data decodification, the residual analysis proposed by Winter(13) was performed, in which it was decided to use a Butterworth filter with a 9Hz cut-off.

In this study, we chose to adopt the running-saving concept proposed by Daniels and Daniels(14) in which running saving is described as being the relationship between the aerobic power (VO2) and the running speed (v), which means the energy spent on the execution of the effort.

The nomenclature of the anatomic markers used in this study (7 markers on posterior frontal plane) was taken, among others, from recommendations proposed in 2002 by the Standardization and Terminology Committee (STC) from the International Society of Biomechanics (ISB). The anatomical points selection was based on studies conducted by Edington, Frederick and Cavanagh(3). The anatomical markers were distributed as follows (Figures 2, 3, and 4): two (2) points on the posterior portion of both feet (named, respectively, as heel (D) and ankle (C)), one (1) point placed at 1/3 from the distal portion of the gastrocnemius muscle of the left leg (B), one (1) point at the level where the gastrocnemius muscle originates at the left leg (A), and one (1) point at the lumbar spine (E), which served as a linear reference for the heel points of both feet, regarding the calculation of the linear crossover (horizontal) of those points compared to the reference point (Figure 5). The fixation of the anatomical points was made by using a reflexive strap aided by a plummet, in an attempt to limit the vertical position error of the respective points.

All individuals wore sportive shoes of the same brand and with close manufacturing dates, which provided for a higher reliability of the results achieved.

Descriptive statistics, the K-S test (Lilliefors), and the Student's T-test were performed for dependent and independent samples, all of them with $p<0.05$. The statistical pack used was the SPSS "Statistical for Social Sciences Software", version 10.0.

PRESENTATION OF RESULTS

By assessing the maximal pronation behavior formed by the subtalar joint, through the 2-point method(5), no significant differences were found between assessed individuals' right and left foot, in both genders. The same result was found by Wit, Clercq and Lenoir(9) where similar behaviors on maximal pronation values were found between assessed individuals' right and left foot. Thus, it was decided to analyze the left leg behavior of each individual.

It was seen that maximal pronation (MP) increased significantly ($p<0,05$) from 11 km.h-1 to 13 km.h-1 (5.87 ± 4.66 degrees to 9.44 ± 5.15 degrees) in women, as well as from 14 km.h-1 to 16 km.h-1 (6.79 ± 4.01 degrees to 9.69 ± 3,.14 degrees) in men (Chart 1).

The maximal pronation speed (PS) (Chart 2) has also significantly increased ($p<0,05$) at the respective speeds (202.58 ± 54.38 degrees/s to 278.42 ± 74.33 degrees/s in women and 226.48 ± 55.63 degrees/s to 303.90 ± 69.54 degrees/s in men).

Both increase of maximal pronation values and the increase of maximal pronation speed values result from the increase in the running linear speed in males and females separately.

Nevertheless, there were no statistically significant differences ($p>0,05$) in maximal pronation values between men and women, when compared within a same running submaximal intensity (70% and 75% of VO2max), which makes us believe that the increase in maximal pronation is related to the increase in effort intensity (VO2). Those results corroborate the findings by Gheluwe and Madsen(4), who demonstrated that the pronation increase, as well as the supination increase, are directly related to the effort intensity and not to the pace length increase, and, consequently, to the running linear speed increase. However, the influence of the effort intensity was not determinant of the maximal pronation speed behavior, while linear speed significantly ($p<0.05$) influenced this variant's behavior.

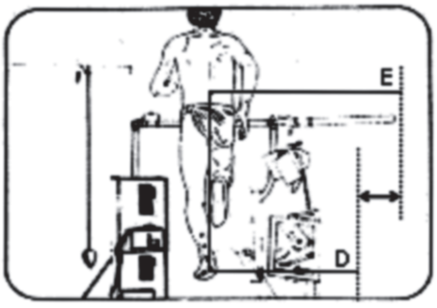

***Figure 5 -** Linear crossover of the left leg.*

As opposed to the existence of significant differences on maximal pronation and maximal pronation speed values, no significant differences were seen ($p>0.05$) on the linear crossover among running linear speeds for each gender (Charts 3 and 4). Nevertheless, significant differences were noted ($p<0.05$) between the feet (right and left) for each gender, which shows that there is a trend to cross the left leg in relation to the sagittal median plane of the individual (0.35 ± 4.20 cm (left leg) and 3.97 ± 0.81 cm (right leg) at 11 km.h-1 and – 0.27 ± 4.88 cm (left leg) and 4.52 ± 2.39 cm (right leg) at 13 km.h-1, in women (Chart 3), and – 0.29 ± 3.89 (left leg) and 5.07 ± 2.22 cm (right leg) at 14 km.h-1 and – 0.29 ± 2.20 cm (left leg) and 4.70 ± 2.49 cm (right leg) at 16 km.h-1, in men (Chart 4)). This trend may be related to a lateral bent of the trunk, which, consequently, is related to the running technique imposed by the runner, resulting from the drills in tracks having unnoticeable slopes(10). Thus, it is possible to say that the lateral oscillations of the trunk are not influenced by running linear speed within the parameters assessed in this study.

CONCLUSION

This study proved that angular variants (maximal pronation and maximal pronation speed) are directly related to running linear speed. In addition, it was proved that individuals from different genders, at a similar effort intensity (similar aerobic power rate) tend to present a similar behavior on maximal pronation, since no significant differences have been found ($p>0.05$) between the speeds of 11 km.h-1 (for females) and 14 km.h-1 (for males), corresponding to 70% of the VO2max, as well as between 13 km.h-1 (for females) and 16 km.h-1 (for males), corresponding to 75% of the VO2max. Thus, we can conclude that the increase of maximal pronation is related to the effort intensity

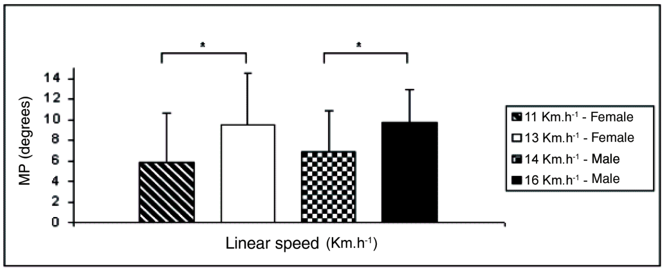

***Chart 1 -** Average and standard deviations of maximal pronation values at the speeds of 11 and 13 km.h-1 for women, and 14 and 16 km.h-1 for men. * p<0.05.*

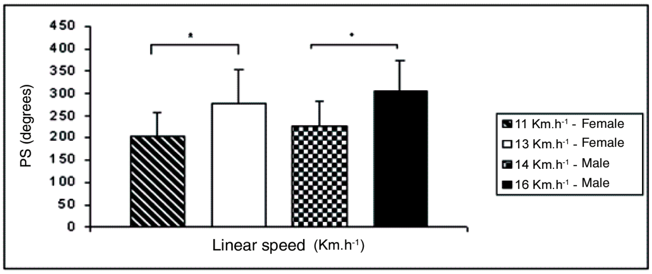

***Chart 2 -** Average and standard deviations of maximal pronation speed values at the speeds of 11 and 13 km.h-1 for women, and 14 and 16 km.h-1 for men. * p<0.05.*

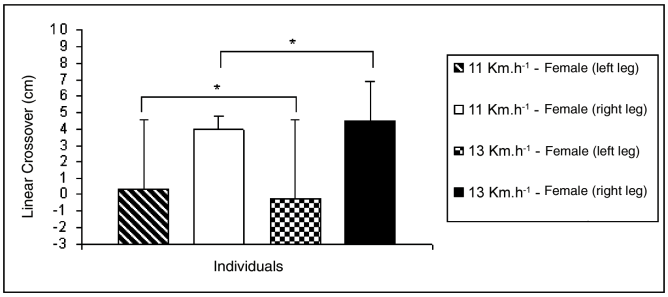

***Chart 3 -** Average and standard deviations of right and left legs' linear crossover at the speeds of 11 and 13 km.h-1 for females. * p<0.05.*

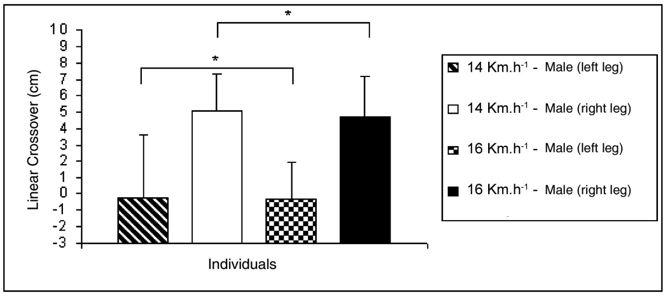

***Chart 4 -** Average and standard deviations of right and left legs' linear crossover at the speeds of 14 and 16 km.h-1 for males. * p<0.05.*

(VO2), and that the maximal pronation speed, the running linear speed, which makes us believe that the effort intensity could be a determining variant of the number of lesions resulting from running activities. On the other hand, no behavior change on both feet's linear crossover values was noticed for each gender with the increase of running linear speed, but a trend to cross the left leg in relation to individual's median sagittal plane, which allows us to say that trunk oscillation is, probably, related to the running technique and to individual's stability in effort situations, and is not dependent of the running linear speed within the parameters assessed here.

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