RBCDH Revista Brasileira de CINEANTROPOMETRIA e Desempenho Humano

DOI: http://dx.doi.org/10.5007/1980-0037.2014v16n5p563

original article

Influence of running distance on plantar pressure

Influência da distância de corrida na pressão plantar

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Abstract – Running is a popular sport performed at different places and involving different distances and modalities. Long distance running promotes cumulative loading on joints and soft tissues that could determine important biomechanical alterations. A tool for assessing such loads is the measurement of plantar pressure. Here we compared static plantar pressure before and after 10 km and 21 km running competitions. Twenty trained runners participated in this study. They were assigned to 10 km (n=10) or 21 km (n=10) group according to their competition distance. Static plantar pressure was assessed in the day before competition and quickly after competition finished. Mean plantar pressure was compared between pre and post competition, between groups, legs and foot regions. Static plantar pressure did not differ between feet in either groups. In 10 km runners, higher plantar pressure post competition was observed in the forefoot, while any changes were observed in the 21 km group. Differences in plantar pressure between foot regions were similar between groups. In summary, static assessment of plantar pressure seemed more sensitive to changes in plantar pressure after a 10 km running, but not after 21 km. After 10 km running, forefoot experiences higher plantar pressure.

Key words: Foot; Injury; Kinetics; Running; Plantar sensitivity.

Resumo – *A corrida é um esporte popular praticado em vários locais e em diversas modalidades e distâncias. Corridas de longa distância promovem cargas cumulativas e repetidas sobre articulações e tecidos moles que podem refletir alterações biomecânicas importantes. Uma ferramenta para avaliar essas cargas é a medida de pressão plantar. Aqui comparamos a pressão plantar estática antes e após uma competição, entre corredores de 10 km e 21 km. Vinte corredores treinados participaram deste estudo. Eles formaram dois grupos, chamados de 10 km (n=10) e 21 km (n=10), conforme a modalidade da sua competição. Todos tiveram a pressão plantar estática avaliada no dia anterior e logo após o término da competição. A pressão plantar média foi comparada entre as condições pré e pós-corrida, entre os grupos, entre os pés e entre as regiões dos pés, pré e após a competição. A pressão plantar estática foi simétrica entre os pés em ambos os grupos. Para corredores de 10 km, maior pressão plantar foi observada no antepé após competição, enquanto nenhuma mudança ocorreu após 21 km. Diferenças entre as regiões do pé foram similares em ambos os grupos. Em conclusão, a avaliação estática parece mais sensível a mudanças após 10 km de corrida, mas não após 21 km. Após 10 km de corrida, o antepé apresenta aumento na pressão plantar.*

Palavras-chave: *Cinética; Corrida; Lesões; Pé; Sensibilidade plantar.*

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Received: 19 February 2014
Accepted: 25 May 2014

INTRODUCTION

Running is a popular sport that can be performed at any place and covering different distances and modalities[1,2]. The involvement in regular running training is known to improve several aspects of cardiovascular health[3,4] as well as to minimize the risk of non-transmissible chronic diseases[5]. Such benefits motivate a continuous increase in the number of runners in competitive or recreational levels[6]. Nevertheless, it is important to recognize that prolonged running can increases stress on joints and other soft tissues, especially in the lower body[7].

Prolonged running increases loads on the lower body, especially at knee, ankle and foot[2,8,9]. Considering the foot, cumulative loads experienced by long distance runners may alter plantar pressure. Plantar pressure is a biomechanical measure that provides coaches and athletes with important information for treatment or prevention of foot injuries[10] like skin injuries and stress fractures[10,11]. Therefore, learning about the effects of running distance on plantar pressure permits to help prevents foot injuries such as stress fractures.

It was previously suggested that a 10 km running did not alter foot sensitivity or plantar pressure distribution in runners[12]. However, considering a protocol of 30 minutes running to fatigue, increases in the peak pressure and relative impulse for the forefoot region were observed[11]. Indeed, after a marathon, peak pressure and impulse magnitudes were higher in the forefoot region[3]. Dynamic assessment of plantar pressure suggests contradictory results when 10 km and longer distances are compared. While dynamic assessment of plantar pressure permits to identify the roll-off characteristics, static assessments may provide a better understanding of load distribution during weight support. The purpose of our study was to compare the static plantar pressure before and after 10 km (rustic racing) and 21 km (half marathon racing) performed by trained runners.

METHODOLOGICAL PROCEDURES

Participants

All participants included in this research signed an informed consent form approved by the local ethics committee (protocol number 0062011) before starting participation in the protocols. Participants were trained runners and have registered at the *18ª International Half-Marathon of Uruguaiana* 2013 or at the ACORU 2013 Rustic Competition. These running events were organized together by the ACORU (*Associação dos Corredores de Rua de Uruguaiana*). Both races were performed in asphaltic surface, with low variation (lower than 90 m) in the terrain level. During the races, temperature was around 20º C. Both the races started at 8:00 AM in a cloudy morning.

Participants had plantar pressure assessed pre and post competition. The evaluation pre competition was performed in the day before the racing, while athletes were taking their competitor kits. The post evaluation was

completed right after the participant finished the course. Twenty athletes were evaluated before and after competition. Ten runners (5 male) were assigned to the 10 km group and 10 runners (8 male) were assigned to the 21 km group (Table 1). After the post competition assessment, each runner received an individual report with the results of plantar pressure assessment.

Plantar pressure assessment

Plantar pressure was measured during a quiet standing barefoot trial. During data acquisition participants were requested to keep eyes open and look at a reference mark positioned 3 m far away at the eyes level. Arms were resting along the trunk. Data were sampled at 400 Hz during 30 s using a pressure mapping system (Matscan Versatek, Tekscan Inc., Boston, USA) calibrated according to the manufacturer recommendations. We tried to ensure that all athletes included in the experimental groups worn similar shoes.

Table 1. Characteristics of the groups at the time of evaluation. Data are expressed for mean ± standard-deviation.

Groups	Age (years)	Body mass (kg)	Height (m)	Training experience (years)	Training volume (km/session)	Training frequency (days/week)
10 km (n=10)	37 ±8	74 ±14	1.72 ±0.08	6.67 ±7.26	7.30 ± 2.86	3.20 ±1.13
21 km (n=10)	43 ±9	65 ±13	1.67 ±0.09	12.45 ±7.02	15.40 ±6.18	5.80 ±1.61

Data analysis

Plantar pressure was analyzed considering the mean values found for each foot, divided into forefoot, midfoot and rearfoot, as described elsewhere [13]. Normality of data distribution was assessed using Shapiro-Wilk tests. Plantar pressure was compared between *pre* and *post* competition, for each group and foot region using paired samples t test for parametric or Wilcoxon test for non-parametric data sets. Bilateral asymmetries were analyzed using paired samples t test for parametric or Wilcoxon test for non-parametric data sets. Groups were compared using independent samples t test for parametric data sets or Mann-Whitney test for non-parametric data sets. Foot regions were compared within groups using one-way Anova with Bonferroni *post-hoc*. Statistics procedures were performed using a commercial statistics package (SPSS Inc 17.0, Chicago, USA) with statistical significance level set at 0.05.

RESULTS

Asymmetries in plantar pressure were not found in any condition (Figure 1). Therefore, all subsequent analyses were performed considering data from the right foot of each participant.

Plantar pressure in the different foot regions was similar between pre and post competition when data were compared within groups. When foot region was compared between the groups, pre competition plantar pressure was similar between groups. However, post competition assessment revealed great plantar pressure in the forefoot of 10 km group than in 21 km (Figure 2) (t=-3.121; p=0.006).

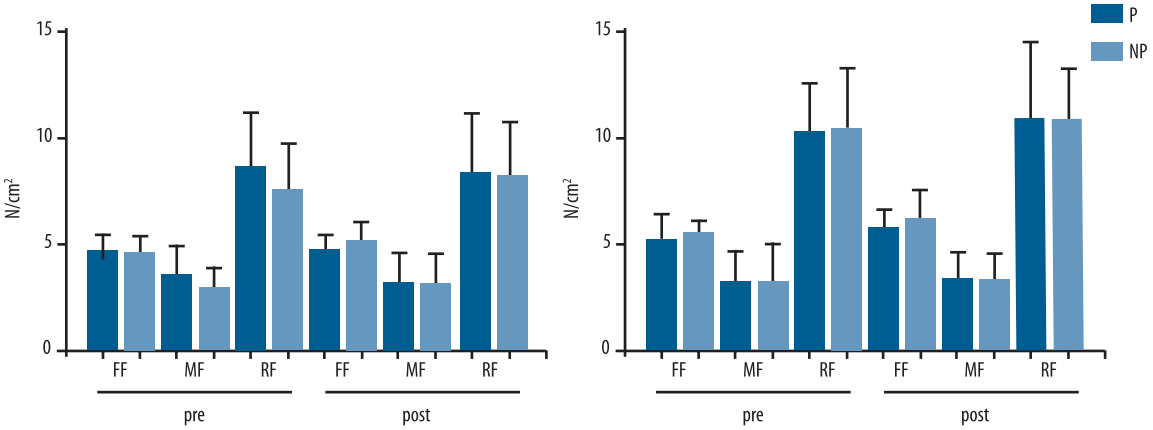

Figure 1. Mean plantar pressure (vertical bars) and standard-deviation (vertical lines) measured in the preferred (P) and non-preferred (NP) foot, pre and post competition in the group 21 km (left) and 10 km (right). FF: forefoot; MF: midfoot; RF: rearfoot. No differences between right and left feet were observed.

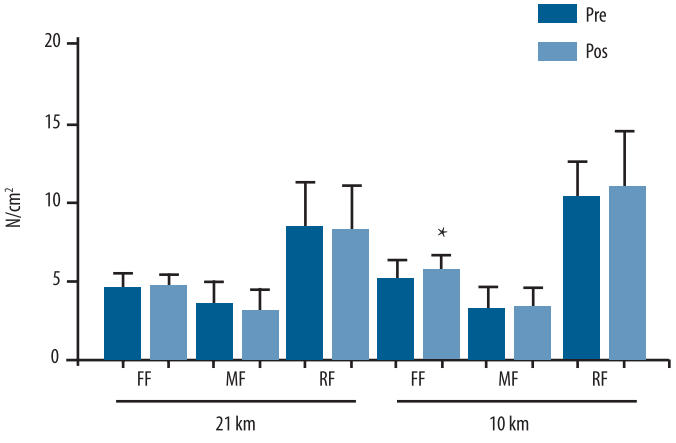

Figure 2. Mean plantar pressure (vertical bars) and standard-deviation (vertical lines) for each foot region when groups were compared pre and post competition. * indicates statistical significant difference between groups for post competition measures (p<0.05). FF: forefoot; MF: midfoot; RF: rearfoot.

Figure 3 presents comparison between the foot regions pre and post competition. When pressure in the forefoot, midfoot and rearfoot were compared within groups, results suggested that 21 km runners present the same pattern of pressure distribution pre and post competition. In the 10 km group, plantar pressure pre competition elicited difference between forefoot and midfoot (p=0.04), while in the post competition assessment these regions presented similar pressure (p=0.06) suggesting a change in the pattern of pressure distribution towards the forefoot among 10 km runners.

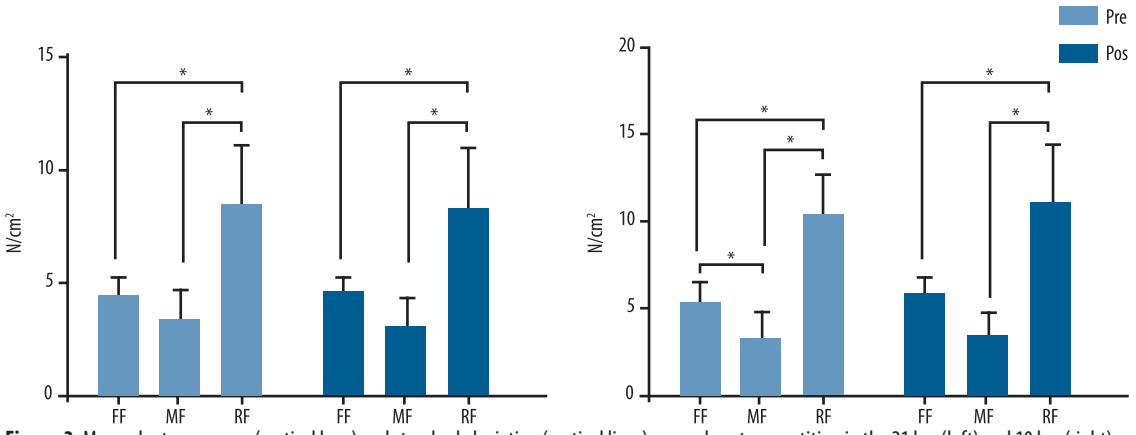

Figure 3. Mean plantar pressure (vertical bars) and standard-deviation (vertical lines) pre and post competition in the 21 km (left) and 10 km (right) groups. FF: forefoot; MF: midfoot; RF: rearfoot. * indicates statistical significant difference ($p<0.05$) between the regions identified by the lines.

DISCUSSION

In this study we investigated if running distance could have influence in static plantar pressure in runners. Comparisons were performed considering half-marathon (21 km) and rustic (10 km) runners. Our main result was an increase in the static plantar pressure in the forefoot of 10 km runners post competition, while no changes were observed among 21 km runners. Such result differ from those observed for dynamic assessments of plantar pressure, when shorter distances (e.g., 10 km) did not alter plantar pressure, while longer distances (e.g., >20 km) significantly changed dynamic plantar pressure. Symmetry in the plantar pressure was observed between preferred and non-preferred foot for both the groups.

Our results for static plantar pressure bring important points for applied discussion. The one we highlight is the fact that static assessment of plantar pressure seemed sensitive to changes in plantar pressure of runners after they ran 10 km, which was not observed in previously research using dynamic assessments[12]. Furthermore, changes in plantar pressure after running 20 km demonstrated using dynamic assessment[10] where not detected here using static measurement.

Considering dynamic assessment of plantar pressure, it was previously suggested that foot sensitivity and plantar pressure were not influence after running 10 km[12], but 30 min of intense running increased the plantar pressure and impulse in the forefoot region[11]. Increased plantar pressure was also observed after running a marathon[3]. Analyzing data from static assessment, we observed no changes in the static plantar pressure after 21 km, but significant changes were found after a 10 km running. In light of these results, we suggest static assessment of plantar pressure may not be more sensitive to identify changes in plantar pressure in response to a half-marathon event. However, changes in plantar pressure after a 10 km race, which previously were not observed when dynamic trials were performed, can be observed using static assessments.

Despite of the protocols of evaluation, changes in plantar pressure after running are consistent with a shift in plantar pressure towards the

forefoot[3,10,11], which we observed to happen after 10 km running. Among the reasons for this result we can highlight a fatigue effect, which was previously suggested as determinant for center of pressure shifts toward the forefoot[14] most likely due to fatigue in intrinsic muscles of the foot and ankle[15]. In addition, an association between running fatigue and magnitude of plantar pressure was suggested after short races with 400 m distance[9]. The increased loading in forefoot of 10 km runners may also suggest attention for training, as this pattern of loading can influence the development of patellofemoral pain syndrome[16], which depends on the running technique[17], and is a risk factor for ankle injuries such as ankle sprains[18]. Considering a regular involvement in running training, the persistence of changes after competition (up to 24 h after a prolonged running[19]) suggest further attention to the foot health among athletes and coaches.

The lack of control of the running shoe used during competition may be a limitation in our study, although we tried to ensure that all athletes included in the experimental groups worn similar shoes. In addition, the information about foot sensitivity before and after competition could provide further evidences for our discussion. However, assessing foot sensitivity may take a long time, which would negatively affect our proposal of evaluating runners after the competition finished. The measure of foot arch, suggested as a determinant for changes in plantar pressure was not measure in our participants, which can have some effect on our conclusions. These improvements in the methods should be considered for further researches in this topic.

CONCLUSION

After ran 10 km trained runners experience higher static plantar pressure in the forefoot than observed among half-marathon athletes. Compared to dynamic assessment, the static plantar pressure permitted to identify changes in plantar pressure after a 10 km race, but not after 21 km.

Acknowledgments

ACORU Uruguaiana for help contacting the athletes; and Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul (FAPERGS) for partial financial support (grant nº 1013100). We thank Dr Rodrigo Bini for his comments in the manuscript.

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