Apunts Med Esport. 2016;xxx(xx):xxx–xxx

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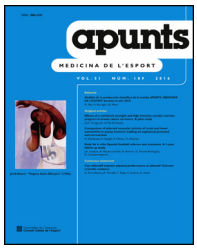

ORIGINAL ARTICLE

Acute effects of barefoot running and running requirement on lower-limb kinematics in habitually shod endurance runners

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Received 18 April 2016; accepted 11 July 2016

KEYWORDS
Long-distance runners;
Lower-limb joint angles;
Running speed;
Spatial–temporal parameters;
Unshod

Abstract The aim of this study was to analyse kinematic variables when running barefoot and when wearing conventional running shoes at comfortable and demanding running speeds. Sixty healthy recreational male runners (age = 35.6 ± 11.7 years old, body mass index = 22.9 ± 2.4 kg/m^2) performed trials in shod/barefoot running conditions on a treadmill at self-selected comfortable and demanding speeds. Photogrammetric techniques (2D) were employed. In barefoot conditions, contact time was shorter ($p < 0.001$) at demanding speed, flight time was shorter at comfortable ($p < 0.05$) and demanding ($p < 0.05$) speeds, and there was greater stride frequency at both speeds ($p < 0.001$). In addition, in barefoot conditions, runners landed with significantly greater knee flexion ($p < 0.05$); lower ankle dorsiflexion ($p < 0.001$); and lower knee flexion in take-off at demanding speed ($p = 0.002$) compared with shod conditions. In conclusion, the current study has provided evidence to suggest that acute changes occur in the temporal variables and kinematics between shod/barefoot conditions at low and high speeds in habitually shod runners. Significant differences were found in spatial–temporal events between shod/barefoot conditions, with shorter times in barefoot conditions with greater knee flexion and ankle dorsiflexion. When speed was increased in barefoot conditions, duration of timing variables decreased significantly both comfortable and demanding speed ($p < 0.001$). Because of this, stride and gait cycle was significantly faster and thus there was a higher stride frequency.

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http://dx.doi.org/10.1016/j.apunts.2016.07.006

Please cite this article in press as: Muñoz Jimenez M, et al. Acute effects of barefoot running and running requirement on lower-limb kinematics in habitually shod endurance runners. Apunts Med Esport. 2016. http://dx.doi.org/10.1016/j.apunts.2016.07.006

PALABRAS CLAVE
Corredores de larga distancia;
Ángulos de articulación de las extremidades inferiores;
Velocidad de carrera;
Parámetros espaciotemporales;
Descalzo

Efectos agudos de la carrera sin zapatillas y sus requisitos en la cinemática de las extremidades inferiores en corredores resistentes habitualmente calzados

Resumen El objetivo de este estudio fue analizar las variables cinemáticas en la carrera sin zapatillas y utilizando zapatillas convencionales específicas para carrera, a nivel de velocidad confortable y exigente. Los participantes fueron 60 corredores recreativos sanos (edad, 35,6 ± 11,7 años, índice de masa corporal, 22,9 ± 2,4 kg/m^2), quienes realizaron las pruebas descalzos sobre una cinta a velocidades confortable y exigente, seleccionadas por ellos mismos. Se utilizaron técnicas fotogramétricas (2D). En la carrera sin zapatillas, el tiempo de contacto fue menor ($p < 0,001$) a velocidad exigente, el tiempo de vuelo fue más corto a velocidades confortable ($p < 0,05$) y exigente ($p < 0,05$), y la frecuencia de la zancada fue superior en ambas velocidades ($p < 0,001$). Además, en la carrera sin zapatillas los corredores aterrizaron con una flexión de rodillas considerablemente superior ($p < 0,05$), menor dorsiflexión de tobillos ($p < 0,001$) y menor flexión de rodillas en el despegue, a velocidad exigente ($p = 0,002$) en la carrera con zapatillas. En conclusión, el presente estudio ha aportado una evidencia que sugiere que se producen cambios agudos en las variables temporales y cinemáticas en la carrera con/sin zapatillas a baja y alta velocidad, en los corredores que utilizan normalmente zapatillas. Se hallaron diferencias significativas en cuanto a sucesos espaciotemporales en carrera sin zapatillas, con una mayor flexión de rodillas y dorsiflexión de tobillos. Al aumentar la velocidad al correr descalzos, la duración de las variables de tiempo disminuyó considerablemente tanto en velocidad confortable como en exigente ($p < 0,001$). Debido a ello, el ciclo de zancada y de marcha fue considerablemente más rápido y, por tanto, se produjo una mayor frecuencia de zancada.

Introduction

Barefoot running has become very popular in recent years and remains a hotly debated topic by runners, coaches and researchers. The effect of barefoot foot-strike patterns and its relationship with footwear on the economy, performance and injury rates in endurance runners has been discussed in the literature.[1–3] It has been suggested that the model of running shoes could be a key risk factor leading to injury.[4] Possible causes of injury may include abrupt collision force[5,6] limited proprioception[7] and excessive foot pronation at heel strike.[8,9] Some authors suggest that habitual barefoot running could prevent impact-related injuries.[6,10]

Several studies have focused on the foot-strike patterns of runners and on how changes in running speed and performance can change the way that athletes strike the floor when running.[2,11] Larson et al.[2] concluded that between 87.8% and 93.0% of marathon runners were rearfoot strikers, yet among the fastest runners, midfoot strikes were the most common strike pattern. Hasegawa et al.[11] reported that the percentage of rearfoot strikes increases with decreasing speed, and midfoot strike increases as the speed increases. Thus, it seems that running speed is related to strike pattern.

In order to reduce the risk of injury, the runner's body produces changes in lower-limb kinematics. Reducing stride length is an example of an alteration in running to reduce tibial stress fracture or bone strain.[12] Other previous studies about barefoot running[1,3,13,14] obtained kinematic data, such as shorter step length or increased stride frequency. In addition, barefoot running reduces flight time and causes a lower peak force and higher pre-activation of the sural triceps than shod running.[15] In addition, Squadrone and Gallozzi[3] found differences in contact time between shod and barefoot conditions.

Bosco and Rusko[16] observed a significant change in time parameters when using soft shoes compared to normal running shoes. Previous studies of barefoot running[1,3,13,14] obtained kinematic data of shorter step length or stride frequency.

Some authors, such as Lohman et al.[17] have described kinematic changes that occur in the lower extremities on the barefoot condition. The relationship of the kinematics variables was also studied in a treadmill at 8.0 mph in barefoot condition[13] but does not offer the level of demand involved for the participants because competitive level of each was huge different. Other authors, such as Youngren,[18] have tested the kinematic differences in shod runners' self-selected speed. However, this has not produced a detailed study that combines all joint conditions of the studies described above, the comparison of the spatiotemporal variables in shod/barefoot conditions studied at different self-selected comfortable or demanding speed paces.

Some studies about barefoot running consistently show increased flexion of the knee at initial contact with the ground[1,3,19] and the knee extension starts relatively earlier.[20,21] Edwards et al.[12] used a computer model to indicate that the risk of stress fracture might decrease with decreased stride length and so might reduce the risk of

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