ISB 2013 BRAZIL
24th CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS

THE EFFECT OF PROLONGED RUNNING ON LOWER EXTERMITY JOINT COUPLING

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SUMMARY

Repetitive movements in a disturbed joint coupling situation might lead to overuse injuries of the lower extremity. The purpose of the current study was to examine the effect of prolonged running on the joint coupling between the subtalar joint and the knee joint. 17 healthy males participated in the study. They were asked to run for 45 minutes at a constant speed on a treadmill. A 3D kinematic analysis of the lower limbs was conducted in order to calculate joint coupling. There was no significant trend in the mean difference between time to maximum foot pronation and maximum knee flexion throughout the prolonged run.

Prolonged running at 45 min duration does not affect joint coupling however some of the subjects did show deviations which may be significant over much longer running periods.

INTRODUCTION

Foot pronation and knee flexion are both associated with internal tibial rotation whereas foot supination and knee extension are associated with external tibial rotation (Inman 1981; Nordin 1989). This mechanism is of particular importance in close kinematic movements such as running. Asynchrony between the subtalar joint and the knee joint may cause counter forces that will act on the proximal and distal tibia and lead to increased loads on soft tissue and bone (McClay I 1997; Pohl et al. 2006). This phenomenon is known as joint coupling. Studies have shown that repetitive movements in a disturbed joint coupling situation might lead to overuse injuries of that lower extremity (Pohl et.al. 2006; Stergiou et al. 1999; Stergiou 1997). It is also recognized that prolonged running is associated with overuse injuries of the lower extremities, and that altered subtalar kinematics may contribute to such injuries (Hetsroni et al. 2008). It is unknown however, whether prolonged running is associated with alterations in subtalar and knee joint coupling. The purpose of the current study was therefore to examine the effect of prolonged running on the joint coupling between the subtalar joint and the knee joint. We hypothesized that prolonged running may be associated with alterations in subtalar and knee joint coupling, thereby providing rationale for the development of overuse injuries in individuals subjected to such activity.

METHODS

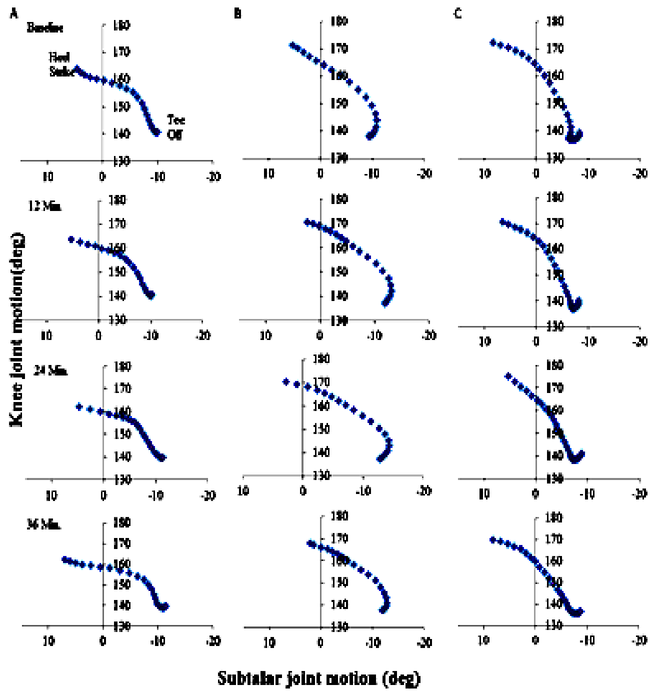
17 healthy males, participated in the study. Subjects' characteristics were [mean (SD)]: age (years), 24.6 (2.7), height (cm), 176.1 (5.2), weight (kg), 73.06 (6.8), running speed (km*h^{-1}), 11.0 (1.8). Inclusion criteria were: regular aerobic activity of 30 minutes at least twice a week and no previous injury to the lower extremity musculoskeletal system within the 6 months period prior to the study. Exclusion criteria were: excessive foot pronation, non-heel strike runners and abnormal lower limbs alignment. Movement capture was conducted using four digital cameras at 200 HZ. 3D kinematic were calculated with the APAS system Eleven markers were placed on the subject's right leg: greater trochanter, lateral tibial epicondyle, head of fibula, tibial tuberosity, lateral malleolus, medial malleolus, 5th metatarsal head, center of the width of the sole 1 cm form the ground, upper part of the heel cap at the heel tab, Achilles tendon 2 cm above the heel tab of the define shoe and 6 cm proximal to the previous marker. Subjects were instructed to start running on a treadmill and gradually increase their running speed until they reached the 65 % of maximal heart rate, after which they were instructed to continue running for another 42 minutes, maintaining the running speed. Every 6 minutes data were collected. At every data collection point, running cycles were analyzed. Kinematic analysis was conducted from heel strike to heel off. The data was smoothed using a low pass digital filter at a cutoff frequency of 10HZ. The calculated kinematic variables were: maximum foot pronation angle (deg), maximum knee flexion angle (deg), time to maximum foot pronation (% stance time), time to maximum knee flexion angle (% stance time), average foot pronation velocity (deg/sec), time difference between the time to maximum foot pronation and maximum knee flexion (% stance time), foot pronation range of motion (deg), knee flexion range of motion (deg). Joint coupling was calculated using two different procedures: (a) Pearson product-moment correlation coefficient between two different kinematic curves. High correlation indicates good joint coupling (Bates et al. 1996; Derrick et al. 1994). Calculation of this correlation was conducted from heel strike to maximum foot pronation/knee flexion (the latest of the two). (b) Vector coding (Pohl, et.al 2006). Descriptive statistics were calculated for all measured variables. For each kinematic variable the mean of the three running cycles was calculated. One way repeated measures analysis of variance

(ANOVA) was used to compare between the different sampling periods of the prolonged running. Significance level was set to $P<0.05$ and Tukey HSD procedure was selected for post hoc analysis.

RESULTS AND DISCUSSION

No significant differences throughout the prolonged running were found in the mean temporal differences between time to maximum foot pronation and time to maximum knee flexion. Neither the Pearson product-moment correlation coefficient nor the vector coding used for calculation of the joint coupling changed significantly during the running period.

Figure 1. Three characteristic graphs of the subtalar joint and knee joint dynamics.



One of the recommended measures for the evaluation of joint coupling is the Pearson product-moment correlation coefficient. Stergiou et al. examined joint coupling at different running speeds and found a high correlation between the subtalar joint and the knee joint (Stergiou, Bates 1999). In the present study, subjects ran at the same speed but for a prolonged time. Statistically, a high correlation was found between the subtalar joint and the knee joint throughout the prolonged run (mean value 0.93, range: 0.87-0.98), suggesting high level of coupling. However, when generating individual graphs of the changes in the angular displacement of the subtalar joint and knee joint, three different patterns were noted (figure 1). In the first graph (A), the subject reaches maximum foot pronation and maximum knee flexion at about the same time (7 of 17 subjects). In the second graph (B), the subject reaches maximum foot pronation and starts foot supination before maximum knee flexion (6 of 17 subjects). In the third graph (C), the subject reaches maximum knee flexion and starts knee extension before maximum foot pronation (4 of 17 subjects). The prolonged running did not influence the individual coupling behavior showing minor and non-significant variability, regardless of the particular pattern group. Even though 59% of the subjects present some deviation from a perfect joint coupling, it cannot be determined whether these patterns have a clinical significance. It may just be, that those subjects who showed a somewhat disturbed coupling, may be more prone to overuse injuries in the long run. In order to asses this assumption answer an extensive epidemiological study is necessary in which the incidence of injuries and their relationship to joint coupling, as well as injuries developing over a longer period of running will be examined.

CONCLUSIONS

Prolonged running over a test run of 45 min does not affect joint coupling. However, longer running periods may be needed to test the clinical significance of joint coupling deviations which were observed in the majority of the cases..

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