INFLUENCE OF FOOTWEAR AND RUNNING TECHNIQUE ON THE DYNAMICS OF FOOT-GROUND CONTACT IN JOGGING

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Reduction of running injuries through the use of better shoes and running techniques has been a major concern (Bates, 1980; Therrien et al., 1981; Therrien, 1981) in recent research on human locomotion. Better attenuation of the ground reaction forces (Cavanagh and Lafortune, 1982; Bourassa and Therrien, 1981) has become an important proccupation for biomechanists, runners and shoe manufacturers.

Problem

Former studies (Dupuis et al., 1976; Paul et al., 1978; Prince, 1980; Radin and Paul, 1970) have indicated that foot-ground impact forces were more or less attenuated within the human body through a variety of energy absorption mechanisms; these mechanisms vary according to the region of the foot that makes the original contact with the running surface (Prince, 1980): rearfoot impacts are attenuated mainly through bony-or hard-tissues, while ground reaction forces produced in forefoot impacts are absorbed mainly through the soft tissues which contol or resist the motion of the foot around the ankle joint. Outside of the body, impact attenuation is achieved through the use of footwear with soles made of energy absorbant materials, as well as through the deformation of the running surface.

The present study was undertaken in order to shed more light on the means - and their relative value - a jogger can use or develop to assure his body a better protection against the short term as well as the long term negative repercussions of the periodic shocks and lower limbs loadings experienced in activities such as jogging.

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Method

In order to study the influence of the shoe as well as the jogging technique (rearfoot vs forefoot contact) in the attenuation of the longitudinal shock transmitted to the body at each impact, ten male subjects, ranging from 20 to 40 years of age, were evaluated while jogging over a force platform at a velocity of 3.5 ms^{-1}.

The subjects were allowed preparatory trials in order to develop the desired speed and to adapt themselves to the laboratory environment.

Then, two successive trials for each experimental condition at the proper speed, with the right foot contacting the platform, were recorded with the use of a microprocessor based data acquisition system.

The loading rate of the vertical component of the ground reactive forces during the initial phase of ground contact was used as shock absorption criteria (Bourassa and Therrien, 1981) and was measured in each of the following experimental conditions:

1) Forefoot contact with high absorption shoe.
2) Rearfoot contact with high absorption shoe.
3) Forefoot contact with low absorption shoe.
4) Rearfoot contact with low absorption shoe.
5) Barefoot with forefoot contact.
6) Barefoot with rearfoot contact.

Data from the vertical force-time curves were then calculated in terms of body weight per unit of time and the slopes of the maximal loading rates were computed.

Results

The slopes corresponding to the average loading rates for each experimental condition have been illustrated in Figures 1 and 2. These Figures also included the general shapes of the force-time curves for both the rearfoot and the forefoot impacts.

The means of all subjects and all trials for each experimental conditions were in the following order of decreasing loading rates:

1) Barefoot with rearfoot contact: 380 B.W. s^{-1}
2) Rearfoot contact with low absorption shoe: 98 B.W. s^{-1}
3) Rearfoot contact with high absorption shoe: 83 B.W. s^{-1}
4) Forefoot contact with low absorption shoe: 54 B.W. s^{-1}
5) Forefoot contact with high absorption shoe: 49 B.W. s^{-1}
6) Barefoot with forefoot contact: 46 B.W. s^{-1}

Statistical analysis of these results, using a multivariate analysis of variance and Newman-Keuls post hoc procedure test of significance disclosed significant differences between the means at $P < .05$ between the following conditions:

1) Rearfoot vs forefoot
2) Barefoot vs all shoe conditions
3) Barefoot with rearfoot contact vs all other conditions

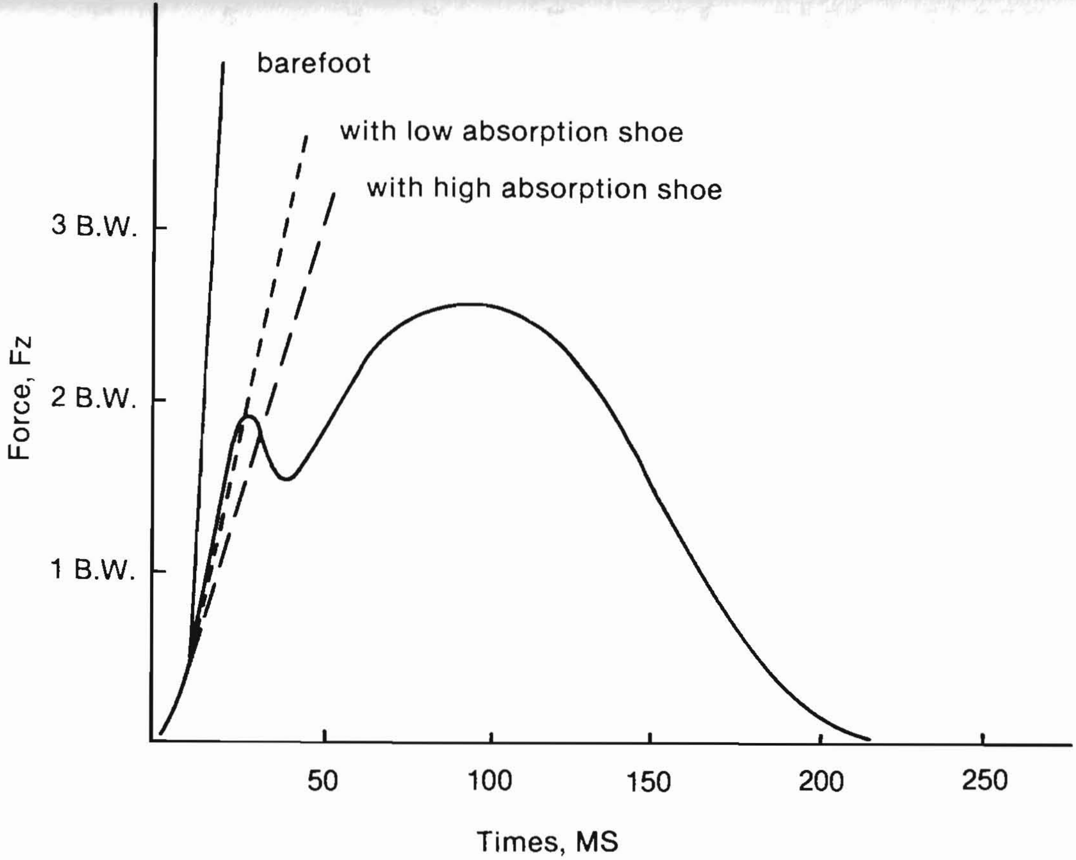

Figure 1. Different loading rates for rearfoot contacts.

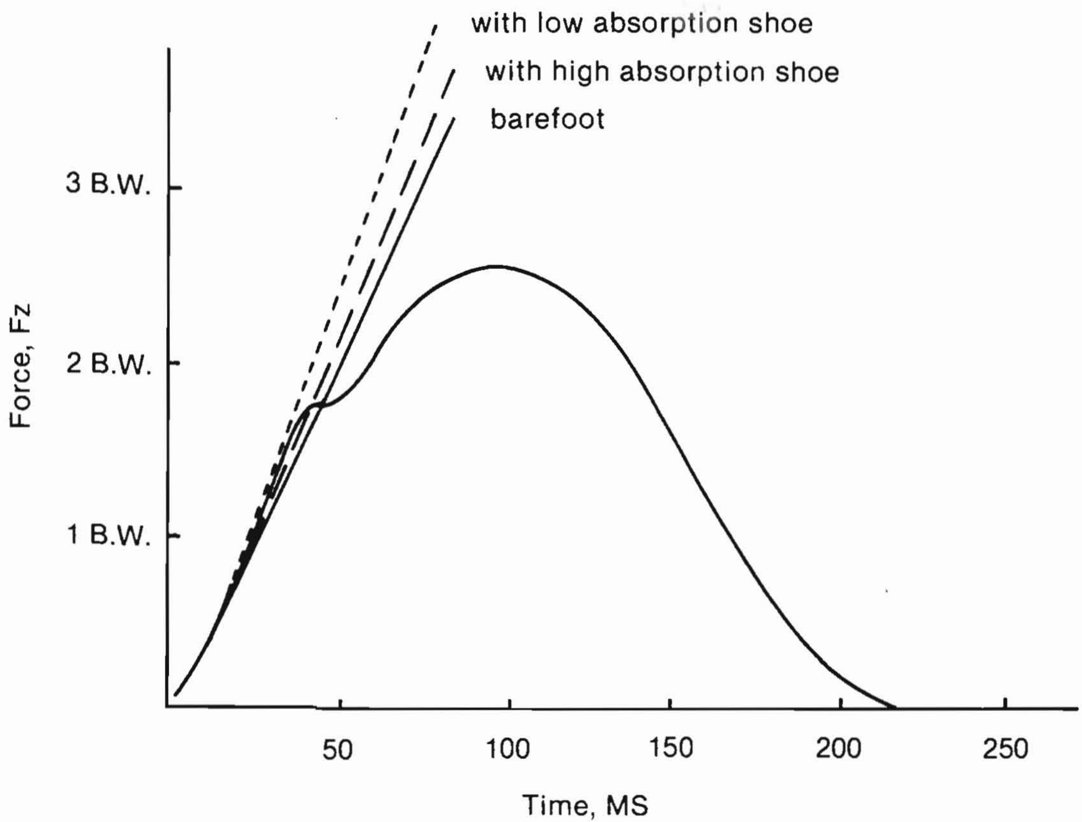

Figure 2. Different loading rates for forefoot contacts.

4) Rearfoot contact with low absorption shoe vs all forefoot contact conditions
5) Rearfoot contact with high absorption shoe vs all forefoot contact conditions.

However no significant difference was found between the three forefoot contact conditions.

Conclusions

The analysis of the results indicated that the use of a shoe, even if it is made of high absorbant, material, did not produce a lower loading rate than jogging barefoot when the forefoot contact technique is used. However, in rearfoot contacts, the wearing of a shoe, or of a shoe with better cushioning characteristics is indeed associated with much lower loading rates than when jogging barefoot, or with a lower absorption shoe.

Such results suggest that the forefoot contact technique may permit a greater adaptation of the body to the hardness of the foot-ground impacts. Thus, it may become a more efficient shock absorbing mechanism in or to attenuate the rapid rising ground reaction forces experienced at foot strike in jogging.

However a question is raised concerning the exact nature of the mechanisms which allowed the joggers who volunteered for the present study to experience loading rates in the forefoot contact conditions which were as low when jogging barefoot as when wearing shoes.

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