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The effect of rocker soles on bending and torsional load acting on the forefoot during walking and slow jogging

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Introduction

Usually, plantar pressure distribution measurements are used to analyze the effects of rocker soles. However, the results obtained in these studies are discussed controversially. Brown et al. (2004) reported a reduced peak pressure at the forefoot using the rocker sole whereas Hutchins et al. (2009) emphasized that the effect of the rocker sole is not clearly understood. In this discussion it has to be considered that there are several pressure distribution systems available using different kind of sensors (e. g. capacitive, piezoelectric, resistive), which hinder the comparison of different studies. Furthermore, the question arises whether or not other parameters beside pressure might be useful to evaluate the effect of orthopedic devices like rocker soles. Therefore, the purpose of this study is to analyze the influence of a rocker sole on bending and torsional moments acting in the shoe during walking and jogging.

Methods

14 subjects performed both walking (3.5±0.5 km/h) and jogging (7.2±1.4 km/h) at self-selected speed on a treadmill. Three different shoe conditions were considered all using adidas Samba: (i) neutral shoe without rocker (woR); (ii) modified with a rocker sole (wR). The thickness of the rocker sole was 1 cm from the heel up to 1 cm posterior of the first metatarsal head (MTP I). From this location the sole's thickness is constantly reduced to 0 until the anterior end of the shoe; (iii) modified with a control rocker (wCR). The thickness of the control rocker sole was again 1 cm, but here the thickness remains constant. Conditions (ii) and (iii) were considered to analyze (2-factor [movement-condition and shoe-condition] repeated ANOVA) whether a change in bending and torsional moments at MTP I (measured with betois [bending torsion insole system]) was related purely to the additional stiffness of the shoe (condition (iii)) or also to the geometry of the rocker sole (condition (ii)).

Results

Normal distribution was proved with Kolmogorv-Smirnov-test for all obtained data.

<u>Bending moments (Fig. 1), positive values indicate a dorsal extension moment</u>

The dorsal extension moment does not differ significantly between walking (walk) and jogging (jog) but the plantar flexion moment is significantly ($p < .001$) greater during jogging (-91±35 N*mm) compared to walking (-54±27 N*mm). Using rocker (wR) dorsal extension moment (167±39 N*mm) is significantly ($p = .016$) lower compared to the control condition wCR (186±38 N*mm). The plantar flexion moment differs significantly ($p < .001$) between the shoe conditions (wR: -49±25 N*mm / wCR: -79±38 N*mm / -91±31 N*mm). While the control condition wCR produces the highest plantar flexion moment during walking peak moment for jogging is obtained when using no rocker (woR). This interaction is significant ($p = .006$), too.

<u>Torsional moments, positive values indicate an external rotation moment</u>

The internal rotation moment is significantly ($p = .042$) higher during jogging (2±1 N*mm) compared to walking (1±1 N*mm) whereas the external rotation moment is significantly ($p = .032$) reduced during jogging (-12±3 N*mm) compared to walking (-14±4 N*mm). There are no significant differences in the internal rotation moments between the three shoe conditions, but external rotation moments differ significantly ($p < .001$) (wR: -12±3 N*mm / wCR: -11±3 N*mm / -17±2 N*mm).

Discussion

Based on the significantly lower bending moments using the rocker sole compared to the control condition it can be suggested that the effect of the rocker sole is not based on additional stiffness only but also on the sole's geometry. However, reduced torsional moments for the control-condition compared to the rocker-sole do not correspond to the results for bending moments. So the fabrication (geometry) of the rocker sole counteracts the effect of the sole's stiffness.

Increased plantar flexion moments during jogging can be caused by the higher momentum acting on the foot compared to walking which might lead to a higher deformation of the foot. Reduced external rotation moments during jogging indicate more a modified foot contact phase compared to walking rather than an effect of the rocker sole. The presents study shows the necessity to obtain additional parameters beside pressure during in-shoe measurements to achieve a deeper understanding of the interaction between shoe and user.

Literature

Brown, D., Wertsch, J. J., Harris, F. G., Klein, J., Janisse, D. (2004) Effect of Rocker Sole on Plantar Pressures. Arch Phys Med Rehabil, 85, 81-86.

Hutchins, S., Bowker, P., Geary, N., Richards, J. (2009) The Biomechanics and Clinical Efficacy of Footwear Adapted with Rocker Profiles – Evidence in the Literature. Foot 2009, 19 (Suppl 3), 165-170.

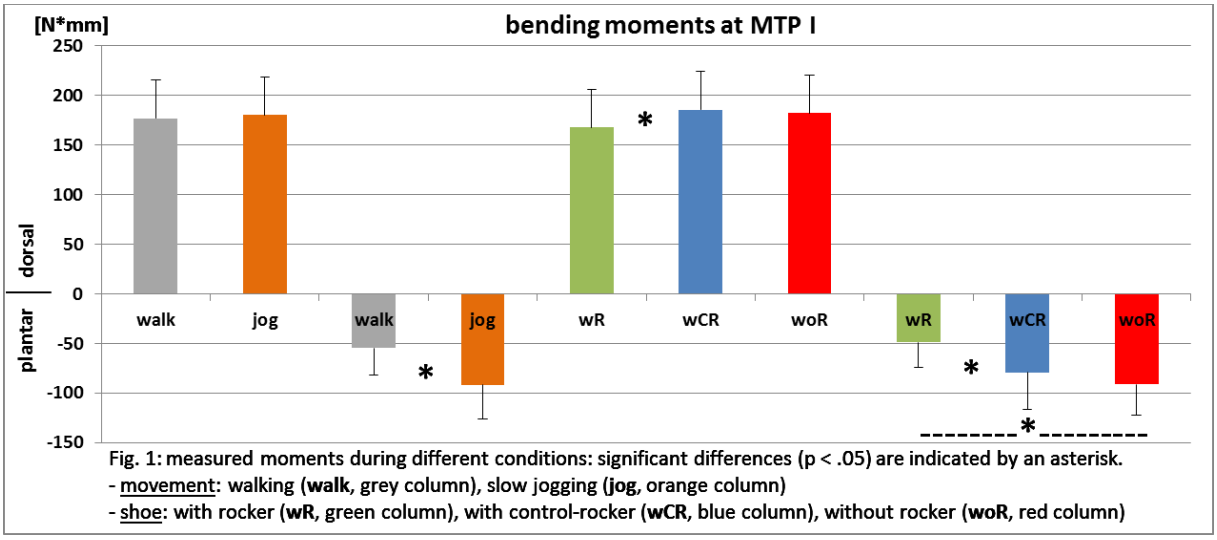

Fig. 1: measured moments during different conditions: significant differences ($p < .05$) are indicated by an asterisk.
- movement: walking (**walk**, grey column), slow jogging (**jog**, orange column)
- shoe: with rocker (**wR**, green column), with control-rocker (**wCR**, blue column), without rocker (**woR**, red column)