Effects on gait of thermoformed plantar orthotics

The objective of this study, in which 14 healthy adult volunteers (10 men and 4 women) took part, was to determine the effect of wearing thermoformed orthotics with lateral reinforcements on the spatial, temporal and kinematic parameters of the lower limb during walking. The effects of lateral reinforcements are thought to include limiting pronosupination movements of the rear foot. These results may be due to the increase in tactile inputs caused by wearing thermoformed orthotics.

Plantar orthotics are used to ensure that the static and dynamic functioning of a subject's feet are as close as possible to the ideal. They have a major influence on the movements of the rear foot (pronation and supination) during running and walking.

Inserting lateral reinforcements appears to reduce pronation of the rear foot (Nester et al., 2003). There also appears to be a direct relationship between overpronation and running injuries (McKenzie et al., 1985). In addition, wearing orthotics is thought to increase shock absorption on initial contact (Redmond et al., 2000).

Moreover, inserting thermoformed orthotics changes plantar pressure and consequently the foot's proprioceptive and tactile inputs. It has previously been shown, in quasi-static conditions, that thermoformed orthotics enable better distribution of plantar pressure (Berger et al., 2005).

Lastly, Mündermann et al. (2003) demonstrated the positive influence of moulded orthotics on the running pattern. Moulded orthotics reduce the maximum overpronation of the rear foot, the maximum external rotation of the tibia, and modification of the axis of the knee. For this reason, it would seem a good idea to evaluate research on the combined effects of these two types of orthotics.

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Materials and methods

Ten healthy adult volunteers took part in this study: 8 men and 2 women, aged 26.4 ± 4.7 years.

Their anthropometric characteristics were: 171.5 ± 7.8 cm, 68.9 ± 10.8 kg and a foot length of 26.1 ± 2 cm, the approximate equivalent of the French shoe size 41 (41 ± 2).

Plantar orthotics

Two pairs of insoles were used for this study:

– one pair of hygiene insoles (reference condition, REF);

– one pair of thermoformed orthotics with lateral reinforcements (experimental condition, OR) (figure 1).

The method chosen to make the orthotics was thermopressure in position with correction by thermoshaping. To make the insoles, in the first instance it was necessary to obtain an accurate mould of the foot using a vacuum bag. The orthotics were made malleable by heating them and then positioned underneath the subject's feet in order to assume the foot shape. Using the windlass technique when moulding the thermoformed orthotics ensured that the rear foot and midfoot were naturally realigned.

Protocol

A kinematic, spatial and temporal analysis of the subject's gait on a treadmill (at a constant speed of 3.7 km/h) was carried out under the two experimental conditions with the REF and OR insoles inserted, in a random order. All subjects used the same model of footwear (figure 2). After a 5-minute warm-up in bare feet, followed by one minute of walking for each condition, a 20-second sequence was recorded. This duration enabled an analysis of a minimum of 10 complete walking cycles to be made.

Anatomical markers were placed on the right lower limb in the following positions: hip joint, knee, ankle (on the great trochanter, lateral femoral condyle and fibular malleolus). Two other markers were used: one on the shoe, on the lateral face of the forefoot and the other on the lateral face of the heel. The first reference point on the posterior face of the leg was placed in the middle of the calcaneal tendon between the malleoli, and the second was placed 15 to 20 cm higher up, on the myotendinous junction of the triceps surae on the longitudinal axis of the leg in line with the popliteal fold. The reference points on the shoe were aligned in such a way as to represent the axis bisecting the calcaneum.

Two cameras were used to film the movement of the lower limb. One was placed in the sagittal plane for analysis of the spatial, temporal and kinematic parameters of the gait, and the other was placed in the longitudinal plane in order to focus on the kinematic analysis of the rear foot. The cameras filmed at a sampling rate of 25 Hz.

The video data were processed using the Dartfish™ software, which produces reconstituted interlaced images at 50 Hz.

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Figure 1. The thermoformed plantar orthotics with lateral reinforcements (OR) comprised a base of Transflux® resin (1 mm), identical lateral reinforcements, an Evamic® top layer (2.5 mm), Orthomic® at the rear foot (3 mm) and Viscotène® at the forefoot (2.5 mm).

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Figure 2. The subjects walked on a treadmill at a constant speed of 3.7 km/h and wore the same model of footwear.

Statistical analysis

The temporal, spatial and kinematic data from the two conditions (control and experimental) were compared using a non-parametric statistical test, the Wilcoxon test, with the first level of significance being set at $p < 0.05$.

Results

No significant difference between the two conditions was observed in the spatial parameters. As figure 3 shows, wearing orthotics had no effect on pace length, cycle length or cycle time during the walking cycle.

The insertion of OR insoles resulted in statistically significant reductions in contact time ($p < 0.05$) and double-contact time ($p < 0.01$) in comparison with the REF condition (figure 4).

However, OR insole insertion had no statistically significant effect on walking speed, pace length or walking-cycle length.

Discussion

These orthotics therefore appear to reduce contact and double-contact time. They are therefore likely to affect the performance of the subjects when used. It would be a good idea to test this in the field because walking on a treadmill is not exactly the same as walking on the ground. Several studies in humans have shown a difference between kinematic models when walking on the ground and walking on a treadmill (Strathy et al., 1983; Murray et al., 1985), suggesting that less information, particularly proprioceptive information, is provided when walking on a treadmill than when walking on the ground. The reduction in contact and double-contact time may be explained by the stiffness of the insoles, which limits deformation. The reinforcements may also contribute to this limiting of deformation.

In addition, the lateral reinforcements may reduce the pronosupination movements of the rear foot. Indeed, studies involving a kinematic analysis of the rear foot during walking such as the study carried out by Nester et al. (2002) show that orthotics positioned medially appear to reduce pronation of the rear foot by a few degrees.

These results may be due to the increase in tactile inputs caused by wearing thermoformed orthotics, which results in better distribution of plantar pressure (Berger et al., 2005). Furthermore, a change to the muscle pattern like that shown in previous studies by Nurse and Nigg (2001, 2005) cannot be ruled out.

It would be a good idea to investigate the effectiveness of these orthotics on performance during running and their effects in terms of risk of falling and/or sprains. Furthermore, no studies have yet been carried out to investigate any continuing effects during regular wearing of these orthotics or to evaluate the risk of sprain-type traumas. ■

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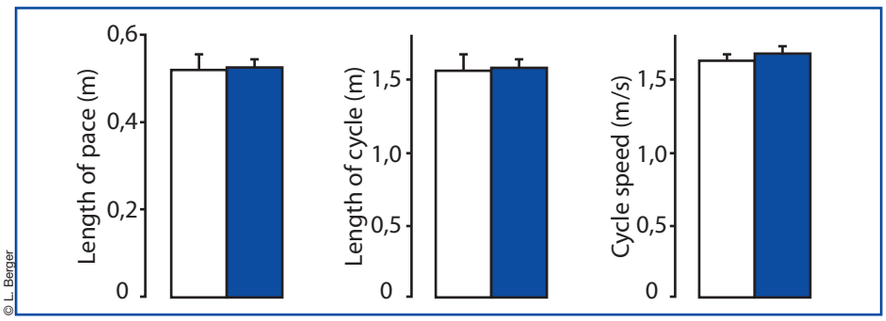

Figure 3. Bar charts showing the spatial parameters and speed of the gait for each condition, REF (white) and with orthotics with lateral reinforcements (OR, blue).

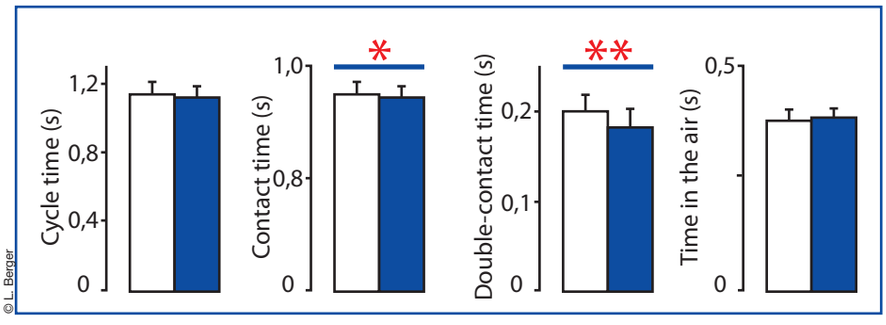

Figure 4. Bar charts showing the temporal parameters of the gait for each condition, REF (white) and with thermoformed orthotics with lateral reinforcements (OR, blue). Note the statistically significant differences *p<0.05 and **p<0.01.

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