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Sex Differences in Heel Pad Stiffness During a Standing Heel-rise Task

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Summary

The mechanical properties of the calcaneal fat pad have been determined during plantarflexion using synchronised motion analysis and force plate systems. This study showed no significant differences in stiffness measurements between genders with respect to the left and right heels. The application of this combined technology has potential to be used within the clinics to support foot disease diagnosis such as plantar fasciitis and heel pain.

Introduction

The heel region of the foot (or heel fat pad) is designed to bear stress and dissipate shock associated with impact activities. Females may be more susceptible to softer heels than males due to higher levels of oestrogen; this may account for the differences in heel pad stiffness [1]. The aim of this study was to compare the heel pad stiffness using kinematic and kinetic techniques in both males and females during a standing heel-rise task, which consisted of dynamic loading and unloading phrases. We hypothesize that the heel pad stiffness would be higher in males than in females.

Methods

Ten male (age 26.3yrs, height 180.2cm, mass 78.7kg) and ten female participants (age 22.3yrs, height 164.3cm, mass 57.3kg) performed two-footed heel-rise at a controlled speed. A total of 13 retroreflective 3-mm markers were placed on the left and right heel pads of the participants (Figure 1) using a customised template to allow for consistent marker placement across participants. A 2-second static capture was obtained with the participant standing on the force plates, with one leg on each plate. This was followed by three standing heel-rise trials that involved three continuous phases: Foot flat (baseline), bilateral heel raise (unloading), and foot flat (loading) with each lasting two seconds. The stiffness of the heel was evaluated based on the shift in marker position/deformation of the heel pad during dynamic activity with respect to each phase. Independent *t*-tests were performed to determine the difference between genders and between left and right sides, respectively. Significance levels was set to P=0.05.

Results

Regarding foot morphology, male participants had wider ankle width (left 76.3mm, right 77.0mm) than female participants (left 68.7mm, right 71.0mm). There was a significant difference in heel stiffness between the left and right sides in the female group (P<0.05). There were no significant differences in stiffness measurements between the left and right heels of the male participants (P>0.05). Both males and females showed no significant differences at the loading phase between the left (P=0.95) and right (P=0.74) heels. Males produced higher bilateral heel pad stiffness values when compared to the female group (Table 1).

Figure 1: A picture of the marker placement on the heel.

Table 1. Heel pad central marker representative stiffness data

Phase	Male (L)	Male (R)	Female (L)	Female (R)
Baseline	6.89 ± 1.20	6.63 ± 1.50	4.95 ± 1.00	4.91 ± 1.10
Unloading	2.35 ± 0.30	2.30 ± 0.40	1.71 ± 0.30	1.86 ± 0.50
Loading	6.93 ± 1.10	6.53 ± 1.40	5.07 ± 1.10	4.83 ± 0.90

Discussions and Conclusion

Apart from *in situ / in vitro* heel pad analysis (i.e. ultrasound and indention test), combined kinematic and kinetic measures can yield dynamic reliable measurements of heel pad stiffness. The present results did not determine differences in the heel pad stiffness between males and females. This contradicts with a previous study, which showed lower heel pad elasticity in females may mean more susceptibility to musculoskeletal injury [1,2]. Interestingly, a slight variation in stiffness occurred between the dominant (right) and non-dominant (left) heels among female participants. Thus, different variations of stiffness between the left and the right heel may increase the likelihood of injury or disease occurring inside the heel. Furthermore, other factors such as aging and high body mass index may have significant impact on increased heel stiffness [3]. The outcome of this result may benefit healthcare research and have a positive impact on practitioners and patients in clinical settings.

References

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