HEEL LIFT INFLUENCE ON ACHILLES TENDON LOADING

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INTRODUCTION

A non-invasive method for the estimation of Achilles tendon force is described. Owing to the common use of heel lift devices in the treatment of Achilles tendon injury, the methodology is used to investigate the influence of heel lift manipulation on the peak force and stress experienced by the Achilles tendon in running.

REVIEW AND THEORY

Although it is not known what aspects of tendon loading are of most importance for injury occurrence, peak force and stress are likely to be influential. The estimation of Achilles tendon force using inverse dynamics techniques has previously been described using markers on the skin covering the Achilles tendon to represent the visually identifed line of action (Dixon and Kerwin, 1998). In the present study, the suitability of using skin markers to represent Achilles tendon orientation is examined using magnetic resonance imaging (MRI).

Heel lifts have been claimed to reduce the occurrence of Achilles tendon injury (Clement et al., 1984). However, the mechanim by which this reduction occurs is not known. The purpose of this study is to investigate the suitabilty of using skin markers to monitor Achilles tendon moment arm in running, and to use skin marker methods to assess the influence of heel lift manipulation on Achilles tendon loading. It is hypothesised that an increase in heel lift will reduce the peak force and stress experienced by the Achilles tendon.

PROCEDURES

MRI data were collected for a supine subject for distinct ankle angles ranging from peak dorsi- to peak plantar-flexion. The Achilles tendon line of action was defined as a straight line through the tendon centre in the sagittal plane, and ankle joint centre of rotation was determined using the full range of joint rotation. Achilles tendon cross-sectional area was calculated for the location 5 cm proximal to the tendon insertion using transverse MRI images. The MRI data revealed that, owing to the approximately uniform thickness of soft tissue covering the tendon, markers placed on the posterior of the lower leg followed the tendon movement. Ankle joint centre of rotation was found to be effectively represented using a marker placed on the lateral malleolus.

Running data were collected for seven well-trained subjects. Markers were placed over the Achilles tendon on the posterior of the lower leg, and on the lateral malleolus. Subjects performed 10 running trials under each of three heel lift conditions: zero heel lift; 7.5 mm heel lift and 15 mm heel lift. Synchronised force plate data at 1000 Hz (Kistler 9281B12), and kinematic data at 120 Hz (MacReflex, Qualisys AB, Sweden), were used to calculate sagittal plane ankle joint moments using inverse dynamics techniques. Achilles tendon line of action was represented by anterior translation of the straight line through the tendon markers, based on the marker radius and the distance from skin surface to Achilles tendon line of action (determined from the MRI data). A scaled translation distance was obtained for each individual subject using calliper measurements of Achilles tendon thickness. Triceps surae muscle moment values were divided by corresponding Achilles tendon moment arm lengths to provide Achilles tendon force throughout ground contact. Mean values for peak Achilles tendon force, peak stress, and occurrence time were calculated for each of the heel lifts, and were compared for the group data using an ANOVA with repeated measures ($p<0.05$).

RESULTS

Peak Achilles tendon force, peak stress and time of occurrence of peak force for the three heel lift conditions are presented in Table 1.

Table 1. Mean values for peak Achilles tendon force and stress for seven subjects (±SD)

	Zero Heel Lift	7.5 mm Heel Lift	15 mm Heel Lift
Peak Achilles Tendon Force (Bodyweights)	11.4 (3.7)	10.9 (3.1)	10.8 (3.0)
Peak Achilles Tendon Stress ($N.m^{-2} \times 10^6$)	72.0 (15.7)	69.3 (15.9)	69.0 (11.8)
Time of Peak Force (ms)	101.1 (10.6)	104.6 (8.8)	106.1 (12.0)

Compared with zero heel lift, both heel lift conditions resulted in a reduction in peak Achilles tendon force and Achilles tendon stress (non-significant). The time to peak Achilles tendon force increased with increased heel lift, with this difference being significant for both the 7.5 mm and 15 mm heel lifts compared with zero heel lift ($p<0.05$).

DISCUSSION

MRI data have supported the use of skin markers for monitoring Achilles tendon moment arm in running. The change in this length with ankle angle variation supports the findings of Rugg et al. (1990), and illustrates the importance of monitoring the moment arm throughout ground contact. Although the hypothesis that peak Achilles tendon force and stress are reduced for increased heel lift has been supported in the present study, the observed reductions were not significant. Additionally, analysis of single subject data revealed varied responses to heel lift across subjects. The significant increase in time to peak force suggests that the rate of loading may be of importance when assessing the mechanism by which heel lift influences Achilles tendon injury. This suggestion is supported by single subject analyses, showing an increase in time of occurrence of peak Achilles tendon force with heel lift for all seven subjects. It is concluded that heel lift tends to reduce the average rate of Achilles tendon loading in running, but that the influence on peak force and stress is subject-specific. Based on these findings, reductions in injury occurrence with increased heel lift may be the result of reduced loading rate. Alternatively, if peak force is of consequence, the success of heel lift interventions is likely to be subject-specific.

REFERENCES

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