INTRODUCTION

Recent research has shown that early weightbearing and range of motion exercise after surgically treated rupture of the Achilles tendon improves prognosis without increasing the frequency of ruptures. The postoperative use of ankle foot orthoses (AFO), which permit gradually increasing motion as opposed to immobilisation in rigid casts, has therefore increased and an improved long-term prognosis with more aggressive rehabilitation has been reported. When walking with the ankle immobilised in an AFO with heel lifts, triceps surae activity gradually decreases with increasing wedge height. There are, however, difficulties involved in correlating EMG activity to tendon load as stress on the Achilles tendon is influenced by both passive stretch and triceps surae muscular contraction resulting in either isometric tendon loading or ankle motion.

There is no empirical data describing directly measured Achilles tendon loading during walking in AFO’s. Our aim was therefore, to measure the load on the Achilles tendon using an optic fibre technique in subjects walking in an AFO set at positions used in standard rehabilitation protocols and to relate this loading to plantarflexor and dorsiflexor muscle activity.

METHODS

Eight healthy subjects (five male, three female) were included in the study. An optic fibre (diameter 0.5 mm) was inserted in the Achilles tendon following a previously described procedure. An AFO with adjustable ankle angle (DeRoyal Europe Inc., Ireland) was used in this experiment. The following orthosis settings were chosen in accordance with the standard rehabilitation protocol of the Department of Physiotherapy, Karolinska University Hospital / Huddinge: 1. locked at 10° plantarflexion with further plantarflexion possible (10PF), 2. locked at 10° dorsiflexion with further plantarflexion possible (10DF), 3. locked in both directions at 20° plantarflexion (20PF). No crutches were used, so as to eliminate the variability introduced with partial weightbearing.

EMG was recorded from the medial gastrocnemius, soleus and tibialis anterior muscles. Two walking trials were conducted at self-selected speed. The optic fibre and EMG signals were synchronised and sampled at 1003.1 Hz. A 200-point adjacent average linear envelope was calculated for the EMG data, which was normalised to the maximum signal found for each subject during all walking trials. The optic fibre signal was not filtered. The Achilles tendon force (ATF) was normalised to body weight and walking speed to eliminate variability in walking velocity between experimental conditions. A repeated measures ANOVA was applied to identify differences dependent upon AFO setting.

RESULTS

No clear pattern relative to the AFO setting was found in the ATF calculated across all subjects (Fig. 1). The lowest ATF was recorded for the 10PF setting, although no significant differences were found. An analysis of the EMG – ATF relationship for one subject is presented. A trend showing higher ATF with greater muscle activity was seen in the plantarflexed settings. In the 10PF setting (Fig. 2) the correlation coefficient was significant for soleus (p ≤ 0.05), while at 20PF tibialis anterior activity was significantly, positively correlated to ATF. No significant correlations were found in the 10DF setting with very weak positive correlations for all three muscles. Gastrocnemius activity did not correlate with ATF in any condition.

DISCUSSION

The ATF did not follow the intuitively expected pattern of greatest loading at the most dorsiflexed position. This result indicated that other mechanisms apart from the external, mechanical constraints placed by the AFO influenced the tendon load. The results of tibialis anterior activity indicated an influence of passive stretching on the ATF, possibly in combination with co-contraction of plantarflexors. No significant correlation of gastrocnemius activity to ATF was found for the presented subject, indicating that EMG can not be directly equated with Achilles tendon loading, and this appears especially true of the gastrocnemius. By combining the EMG data with in vivo Achilles tendon force recordings, the complexity of tendon loading could be explored. Although it appears that the AFO used in this study does not diminish tendon loading as much as expected, other AFO principles, e.g. heel wedges, may function differently. The data presented provide important information for developing more efficient, perhaps more aggressive rehabilitation protocols for patients following surgery of the Achilles tendon.

REFERENCES


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