Protective ankle muscle activation strategies during quick cutting movement in humans

TR Jenkyn[1] and AC Nicol[2]

[1]Biomechanics Laboratory, Div. of Orthopedic Research, Mayo Clinic, Rochester, MN, USA
[2]Bioengineering Unit, University of Strathclyde, Glasgow, UK
Email: jenkyn.thomas@mayo.edu

INTRODUCTION

Sprain of the lateral ligaments is the most common ankle injury in sports and activities of daily living (Liu, 1999). This often occurs during quick medially directed cutting turns causing rapid inversion and plantar-flexion of the foot. The greatest risk factor for sprain is history of previous sprain (Thacker, 1999), but occurrence seems unrelated to subtalar positioning at touchdown or joint laxity (Wright, 2000).

This study examines the ankle muscle activation patterns, which may protect against sprain during quick cutting movements.

METHOD

12 normal subjects (6 male, 6 female, aged 20-37) performed walking and turning tasks in a motion analysis laboratory. EMG was collected from 8 ankle muscles (Ag-AgCl electrodes, sampled at 1000Hz, bandpass 30-500Hz with gain 350). The leg was modeled as two segments (thigh and shank) and the foot as four segments (hindfoot, midfoot, lateral and medial forefoot). Kinematics of both the ankle and subtalar joints and the joints of the foot were measured.

Muscle and ligament positioning and wrapping on the bones of the leg and foot was reconstructed from CT and anatomical images (Visible Human Project, NIH) and with the kinematics, instantaneous muscle lengths, velocities, lines of action and lever arms were calculated throughout the tasks. Individual muscle tensions were calculated with an EMG-based Hill-type muscle model. Ligament loading was then calculated with an optimization routine, which minimized the maximum ligament load.

RESULTS AND DISCUSSION

The medial ground reaction force (GRF) component was larger in a cutting turn than in walking. A peak of 0.68xBW occurred in early stance (Fig. 1A). Inverting subtalar joint moment was also larger during turning (Fig. 1B). Peroneal tension was greater in early stance during turning (Fig. 2A). Combined dorsi-flexor tension was also increased in early stance with turning (Fig. 2B).

Lateral ankle ligaments are more vulnerable to injury during rapid medial cutting turns than during walking due to a greater medial GRF component. When turning is anticipated and controlled, ankle muscle activation stabilizes the joints and protects lateral ligaments from injury. Peroneal tension increases to oppose the greater inverting subtalar moment during a turn. Increased dorsi-flexor tension stiffens the joints through antagonism with the plantar-flexors and peroneals. Thereby, lateral ligament loading is not enough to cause injury.

Perhaps if the turn is not fully anticipated and these protective patterns are late or absent, the kinematics and GRF conspire to overload the lateral ligaments resulting in injury.

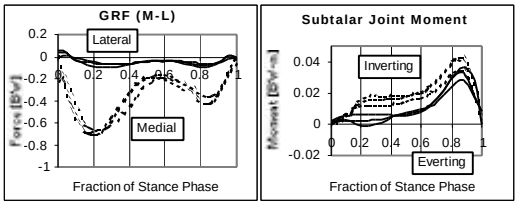

Figure 1: A) Medio-lateral GRF and **B)** subtalar joint moment during walking (solid) and turning (turning).

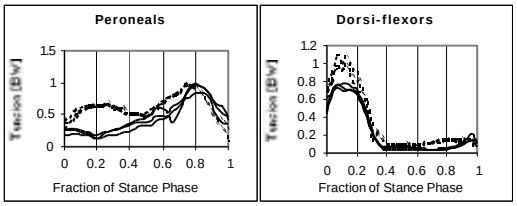

Figure 2: A) Combined tension in peroneals and **B)** dorsi-flexors during walking and turning.

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