DO LOWER LIMB MUSCLE ACTIVITY PATTERNS CHANGE WITH PROLONGED LOAD CARRIAGE?

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INTRODUCTION

In occupational, military and recreational activities, loads are often carried in a backpack. Modern backpacks utilise a hip belt and shoulder straps to redistribute the load from the back to the large muscle groups surrounding the hips and legs in an attempt to protect the lower back from injury. However, by redistributing these loads the lower limbs are subjected to repetitive mechanical stress during prolonged load carriage while wearing heavy backpacks, which may, in turn, lead to lower extremity overuse injuries.

Numerous studies have identified gait and posture adaptations to carrying load, including changes to stride length, stride frequency, double and single support time, knee and trunk flexion, vertical and horizontal ground reaction forces [1,2]. However, little research has investigated changes in muscle activity during load carriage. Increased EMG activity with load has been reported for the gastrocnemius, hamstring, and quadriceps muscles [4]. Other research has found load carriage prolonged the duration of EMG activity for vastus lateralis, although hamstring EMG duration remained unchanged with load [5]. However, most of this previous research has focused only on the effects of short duration load carriage on changes in muscle activity, despite the fact that loads are often carried in a backpack for extended periods of time. Therefore, this study aimed to investigate the effects of prolonged load carriage on lower limb muscle activation patterns during gait.

METHODS

Fifteen healthy female recreational hikers (age = 22.3 ± 3.9 years) participated in the study. Each trial involved the subjects walking an 8 km circuit at a self selected speed carrying 30% of their body weight in a backpack. Data were collected at the start of the course and at 2 km intervals during the load carriage trial. During each trial muscle activity was sampled using a Noraxon Telemyo System (1000 Hz; 16 - 500Hz bandwidth) for six superficial lower limb muscles while the ground reaction forces generated at foot-ground contact were collected (1000 Hz) a Kistler force platform. The vertical GRF data were used to determine initial foot-ground contact (IC) and peak braking force (IC-peak). The EMG signals were full-wave rectified, filtered using a zero phase 4th order Butterworth low pass filter to create linear envelopes. Temporal characteristics of each muscle burst (see Table 1) were then determined using a threshold detector whereas the intensity of muscle activity was calculated by integrating the muscle bursts of interest. To determine whether there were any significant ($p < 0.05$) differences in the muscle activity patterns displayed with increasing hiking distance, a one-way repeated measures ANOVA design was used.

RESULTS AND DISCUSSION

Means and standard deviations calculated for the dependent EMG variables are presented in Table 1. No significant differences were noted for the temporal characteristics of tibialis anterior (TA), medial gastrocnemius (GM), rectus femoris (RF) or biceps femoris (BF) with increasing distance during load carriage. However, a significantly shorter semitendinosus (ST) muscle burst duration was evident when comparing the values obtained at the start of the 8 km circuit and all other distances. ST also was found to turn on significantly later between the start and the 8 km distance. The intensity of the vastus lateralis (VL) muscle burst also decreased from the start of the 8 km circuit in comparison to all other distances. Irrespective of any main effects of walking distance, all subjects displayed high variability in their EMG data, as is evident via the high standard deviations in Table 1.

The findings suggest that lower limb muscle activation patterns are relatively unchanged during prolonged carriage when subjects walk at a self selected speed over an 8 km circuit. However, the significantly shorter ST duration and later ST onset at the end of the load carriage trial may indicate that this muscle group is fatiguing and, in turn, may not be able to control deceleration of the limb in preparation for initial foot-ground contact. This lack of control of the leg by the hamstring muscles may predispose the knee to increased loading. However, further investigation of the internal forces acting on the lower limb is required to confirm or refute this notion.

REFERENCES

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Table 1: Mean (±standard deviation) muscle activity variables displayed by the subjects at 2 km intervals during prolonged load carriage

Variable	Muscle	Start	2 km	4 km	6 km	8 km
Muscle burst duration (ms)	RF	341±72	355±130	355±113	322±99	334±108
	VL	324±56	295±67	301±75	304±86	299±77
	ST	271±46*	250±58*	243±55*	246±50*	252±52*
	BF	290±64	278±83	275±73	281±67	288±94
	TA	412±132	376±129	398±146	400±162	390±153
Muscle burst onset time to IC peak (ms)	RF	233±35	233±43	346±334	217±35	220±71
	VL	252±55	236±46	263±109	226±443	211±66
	ST	335±41*	313±82	351±108	326±32	311±51*
	BF	385±177	347±187	542±412	371±154	359±163
	TA	486±227	429±200	533±310	512±331	443±237