EFFECTS OF LAW ENFORCEMENT LOAD CARRIAGE ON INTERMUSCULAR COORDINATION DURING WALKING

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Introduction

- Law enforcement officers (LEO) experience high rates of injuries, specifically to the lower extremity and back regions. LEO commonly wear load on the body in the form of a duty belt or tactical vest while on duty.
- Prior literature has reported on the biomechanical effects of load carriage related to postural stability and gait kinematics.
- Given these reported effects, it is plausible load carriage alters muscular coordination and subsequently increases injury risk. However, the effects of LEO style load carriage on muscle activity and inter-muscular coordination is scarce in the current literature.

Purpose

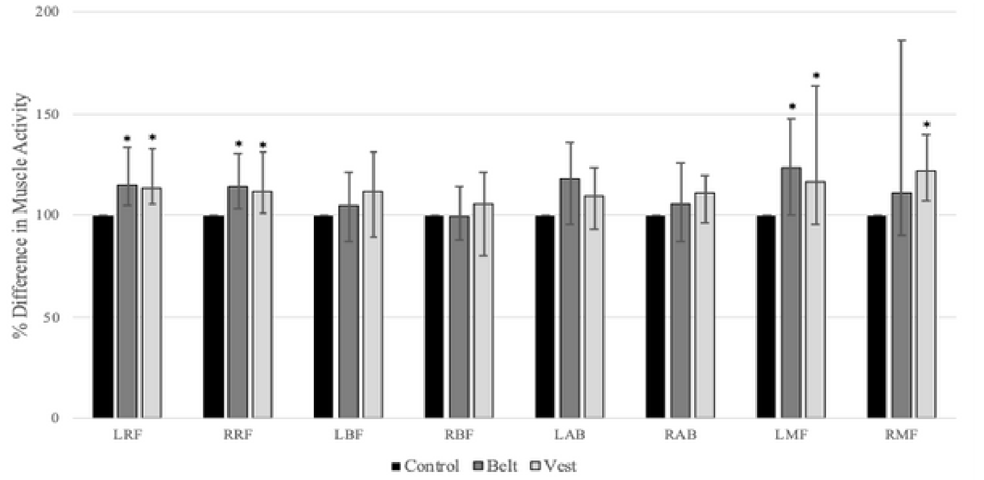
The purpose of this study was to examine the effects of law enforcement load carriage on intermuscular coordination during walking.

Methods

- Demographics: 24 non-LEO volunteers participated (male=13, age=24.50, yrs±6.01, height=1.69m±9.79, mass=72.98kg±11.08).
- Participants completed 2 load carriage conditions (leather duty BELT and tactical VEST; both 7.2kg) and a CONTROL condition in a randomized order. For each condition, participants walked on a treadmill at 3.0 mph for 30 seconds.
- Surface electromyography (sEMG)
  - sEMG electrodes were placed bilaterally on the vastus lateralis, biceps femoris, multifidus, and lower rectus abdominus.
  - sEMG data were sampled at 2000Hz, bandpass filtered (20-490Hz) then lowpass filtered (5Hz cutoff) with a 4th order Butterworth filter.
- Statistical analysis
  - Pearson correlation coefficients were computed for each muscle pair during the trials. The correlations were z-transformed prior to descriptive and inferential statistical analyses.
  - Appropriate repeated measures inferential statistical testing was conducted based on whether data had a normal (i.e. repeated measures ANOVA) or non-normal distribution (i.e. Friedman's Test).

Results

Figure 1. Comparison of muscle activity between conditions



Note: Values are medians and interquartile range in the brackets.
* denotes statistical difference compared to control.

Muscle Activity

- There was a significant main effect for condition in the left RF ($\chi^2(2)=16.3$, $p=0.001$, Wk=0.34), right RF ($\chi^2(2)=9.0$, $p=0.011$, Wk=0.19), left MF ($\chi^2(2)=8.58$, $p=0.014$, Wk=0.18), and right MF ($\chi^2(2)=13.1$, $p=0.001$, Wk=0.27).
- Belt and vest conditions were not significantly different from one another.

Table 1. Correlation coefficients of muscles between conditions during walking

Muscle Pair	Control M	Control SD	Belt M	Belt SD	Vest M	Vest SD	p-value	post-hoc
LRF-RRF	0.16	0.43	0.11	0.41	0.14	0.44	0.115	
LRF-LBF	0.50	0.52	0.51	0.55	0.47	0.52	0.755	
LRF-RBF	-0.31	0.29	-0.28	0.25	-0.29	0.32	0.214	
LRF-LAB	0.09	0.19	0.18	0.21	0.23	0.20	**0.007**	Belt<Control
LRF-RAB	0.03	0.22	0.10	0.23	0.05	0.23	0.847	
LRF-LMF	0.33	0.27	0.32	0.28	0.30	0.31	0.759	
LRF-RMF	0.46	0.30	0.46	0.30	0.46	0.34	0.970	
RRF-LBF	-0.21	0.31	-0.18	0.32	-0.22	0.31	0.883	
RRF-RBF	0.46	0.52	0.42	0.50	0.47	0.56	0.214	
RRF-LAB	0.05	0.19	0.14	0.18	0.05	0.22	0.453	
RRF-RAB	0.08	0.17	0.15	0.23	0.17	0.26	0.175	
RRF-LMF	0.54	0.30	0.50	0.35	0.52	0.35	0.610	
RRF-RMF	0.38	0.22	0.39	0.23	0.39	0.24	0.994	
LBF-RBF	-0.39	0.27	-0.32	0.21	-0.38	0.25	0.185	
LBF-LAB	0.14	0.19	0.18	0.26	0.18	0.18	0.697	
LBF-RAB	0.04	0.14	-0.03	0.15	-0.07	0.19	**0.048**	Vest<Control
LBF-LMF	0.27	0.26	0.26	0.37	0.20	0.29	0.425	
LBF-RMF	0.29	0.25	0.26	0.27	0.27	0.28	0.697	
RBF-LAB	0.02	0.21	0.01	0.16	-0.06	0.18	**0.036**	None
RBF-RAB	0.06	0.19	0.11	0.28	0.22	0.28	**0.016**	Vest>Control
RBF-LMF	0.27	0.30	0.15	0.31	0.27	0.32	**0.049**	None
RBF-RMF	0.28	0.30	0.20	0.24	0.26	0.30	0.263	
LAB-RAB	0.55	0.34	0.55	0.39	0.50	0.41	0.686	
LAB-LMF	0.17	0.21	0.24	0.20	0.19	0.16	0.268	
LAB-RMF	0.19	0.24	0.20	0.23	0.21	0.23	0.940	
RAB-LMF	0.14	0.27	0.17	0.26	0.21	0.22	0.354	
RAB-RMF	0.13	0.29	0.08	0.27	0.20	0.28	0.115	
LMF-RMF	0.68	0.33	0.63	0.42	0.60	0.38	0.072	

Abbreviations: LRF, left rectus femoris; RRF, right rectus femoris; LBF, left biceps femoris; RBF, right biceps femoris; LAB, left rectus abdominus; RAB, rectus abdominus; LMF, left multifidus; RMF, right multifidus.
Shading: White shading=trivial association, light gray shading=weak association, darker gray shading=moderate association.

Muscle Coordination

A main effect of condition on the correlation between:

- Left RF with left AB ($F(2,46)=5.487$, $p=0.007$, $h2=0.076$; post-hoc: BELT<CONTROL, $p=0.021$)
- Left BF with right RA ($\chi^2(2)=6.083$, $p=0.048$, Wk=0.13; post-hoc: CONTROL>VEST, $p=0.009$)
- Right BF with left RA ($F(2,46)=3.582$, $p=0.036$, $h2=0.038$; no significant post-hoc comparisons)
- Right BF with right RA ($\chi^2(2)=8.333$, $p=0.016$, Wk=0.17; post-hoc: VEST>CONTROL, $p=0.002$)
- Right BF with left MF ($F(2,46)=3.226$, $p=0.049$, $h2=0.031$; no significant post-hoc comparisons) was observed.

Conclusion

- The aim of the study was to investigate the effects of LEO style load carriage on core muscle activity and coordination during walking, which is a common activity performed by LEO. Our first hypothesis, both types of load carriage would result in changes in these measures as compared to unloaded walking, was supported by the findings. The second hypotheses, that there would be no differences between types of load carriage, was supported as well.
- The increased levels of muscle activity (Figure 1) in the multifidus are notable considering that higher levels of core muscle activity in patients with low back pain, as compared to healthy controls, have been reported previously. A common consequence of load carriage is for individuals to increase their forward lean and anteriorly tilt the pelvis. These changes in posture would subsequently increase the length of low back musculature and necessitate greater force production to maintain posture as the moment about the low back is increased. Although we did not record trunk lean, the increase in the multifidus muscle activity in our study is likely related to increased demands on low back musculature to maintain an upright trunk posture.
- Core stability in particular requires coordination of muscles on the anterior-posterior and lateral regions of the core region of the body to stabilize during flexion/extension, lateral bending and rotation movements. We found the strongest associations between abdominals and lower back musculature bilaterally which load carriage did not affect (Table 1). There were effects of load carriage on the coordination of several muscle pairs due to load. Interestingly, all these instances were between a muscle of the thigh segment and core.
- In conclusion, the increased muscle activity due to LEO load carriage in some, but not all muscles, indicates altered recruitment patterns and intermuscular coordination compared to unloaded walking during short duration time periods. However, there is no clear support for the use of one type of load carriage over the other.

Practical Applications

- Practitioners working with LEO should be aware that altered muscular activity and coordination between core muscles and muscles in the lower extremity occurs due to load carriage and individuals may benefit from an acclimatization period to avoid injury from altered muscular activation patterns.