THE EFFECT OF LOAD MAGNITUDE AND DISTRIBUTION ON LUMBAR SPINE POSTURE IN ACTIVE-DUTY MARINES

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INTRODUCTION

Lower back pain in the military population has been associated with injuries that result from heavy load carriage during training and operational tasks [1]. As a result, load carriage limits and configuration recommendations have been studied and established based on energy expenditure and situational awareness [2,3]. However, the interaction between load magnitude and distribution on lumbar spine (LS) posture has not been described in detail.

METHODS

A group of 12 active-duty Marines (age 24.42±5.48 years, BMI 24.69±2.53 kg/m², time of service: 57.21±44.72 months) were scanned using a 0.6T MRI scanner (Upright MRI scanner, Fonar Corporation, Melville, NY, USA). This scanner allows for images to be acquired while subjects are standing. The lumbar spine of each Marine was scanned while standing unloaded and loaded with 6 different configurations: carrying 22, 33 and 45 kg, with the load distributed 50% anteriorly and 50% posteriorly and 20%-80%, respectively. The order of the scans was randomized. The imaging protocol consisted of a 3-plane localizer and sagittal T2 weighted images (TR = 1974msec, TE= 160sec, FOV =32cm, 224x224 acquisition matrix, 4.5-mm slice thickness, no gap, scan duration 3min) were acquired. Images were used to create a 3D representation of the endplates of each vertebra (L1-S1) by placing seed points on the four corners of each vertebra and posterior elements landmarks using Osirix (Pixmeo, Geneva, Switzerland). Custom software was then used to measure the overall angle of the LS with respect to the horizontal, overall LS lordosis, superior LS lordosis (Sup L4 to Inf S1), and intervertebral angles (L1-S1) [4].

All variables were compared using two-way (load × configuration) repeated measures ANOVA and post hoc Sidak tests to identify significant differences and interactions among these factors (α=0.05). All data in plots are reported as means ± standard deviation.

RESULTS AND DISCUSSION

A significant interaction (p<0.05) between load magnitude and distribution was found, meaning that the effect of load on LS posture is distribution dependent. Moreover, loads carried in the 20%-80% configuration induced (p<0.05) postural changes through 33kg, while those carried in the 50%-50% configuration did not have an effect on LS posture.

Increased trunk flexion (p<0.05) was found when load was carried in the 20%-80% configuration. However, no differences in lumbar flexion were measured between 33kg and 45kg (Fig. 1, solid bars).

![Figure 1: Results for angle with respect to the horizontal. Thick dashed line indicates average value when standing without external load; thin dashed lines indicate one standard deviation. Clear bars: 50-50% load distribution; solid bars: 20%-80% load distribution. Horizontal bars represent statistical significance (p<0.05).](image-url)
Significant (p<0.05) main effects of both load magnitude and configuration on whole LS lordosis were found. However, post hoc tests revealed no differences between load magnitudes (Fig. 2A). Furthermore, superior and inferior LS lordoses were measured to identify regional postural response to load magnitude and distribution. A main effect of load magnitude was found (p<0.05) on the superior LS. Overall, superior LS became more lordotic as load magnitude increased from between 22kg to 33kg, while no difference was detected 33kg and 45kg (Fig. 2B). Contrastingly, a main effect of load configuration was detected (p<0.05) on the inferior LS; furthermore, when load was carried in the 20%-80% configuration the inferior LS became straighter (~5°) regardless of load magnitude (Fig. 2C).

Figure 2: Results for A) whole, B) superior and C) inferior LS lordosis. Thick dashed line indicates average value when standing without external load; thin dashed lines indicate one standard deviation. Clear bars: 50-50% load distribution; solid bars: 20%-80% load distribution. Horizontal bars represent statistical significance (p<0.05).

CONCLUSIONS

Load carriage in the 50%-50% configuration did not induce changes in LS flexion or lordosis. These data suggest that the LS posture while carrying load equally distributed anteriorly and posteriorly is similar to that while standing without external load. Future work is needed to establish if this may have a positive or negative effect on LS health or operational efficiency.

In this study, we have shown that as load magnitude increases the LS flexes forward when load is carried in the 20%-80% configuration. Additionally, we observed opposing lordosis postures in the superior and inferior LS. The superior LS becomes progressively more lordotic as load magnitude increases, potentially to maintain an upright head position. Surprisingly, we found that the inferior LS became less lordotic regardless of load magnitude.

It has been previously hypothesized that LS postural changes during load carriage are aimed at maintaining the center of mass of the system. Interestingly, global LS postural differences were not found when Marines carried 33kg and 45 kg in the 20%-80% configuration. This may suggest a plateau effect of load induced postural changes with a posterior load-carriage bias. Importantly, lumbar spine postural changes were not observed when loads were balanced anterior to posterior.

REFERENCES


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