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LOAD AND SEX IMPACT ACTIVE LOWER LIMB MUSCLE VOLUME DURING RUNNING

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INTRODUCTION

During tasks, such as running, military personnel are often required to carry body borne loads that exceed 30 kg. Running with heavy load increases ground reaction forces, which elevates the risk of musculoskeletal injury [1]. To avert injury, military personnel may need to increase muscle volume and muscle force to safely dissipate large ground reaction forces.

Female soldiers are reportedly twice as likely to sustain a musculoskeletal injury as their male counterparts [2]. This may be due to a sex dimorphism that requires greater muscle volume for females to safely run with load. Yet, it is currently unknown if active lower limb muscle volume increases when running with load, and whether muscle volume differs between sexes.

PURPOSE

To determine whether active lower limb muscle volume increases while running with body borne load, and whether it differs between male and female participants.

METHODS

Thirty-six (20 Male, 16 Female) participants had lower limb muscle volume quantified when running 4.0 m/s with four body borne loads (20, 25, 30, 35 kg) (Fig. 1).

Figure 1. For each load condition, participants were outfitted with a helmet, mock weapon, and weighted vest systematically adjusted to provide the necessary load for each condition (**A**). Each participant was fit with 34 retroreflective markers to create the kinematic model for lower limb biomechanical analysis of each running trial (**B**).

METHODS CONT'D

Each participant performed three run trials with each load condition. During each trial, lower limb (hip, knee and ankle) joint moments (M_{joint}) were calculated using Visual 3D (C-Motion, Rockville, MD), and then muscle force (F_m) and volume (V_m) calculated with custom Matlab code.

We calculated muscle force (Eq. 1) using moment arm (r) data published by Biewener et al. [3].

Eq. 1: $$F_m = M_{joint}/r$$

We calculated hip, knee, and ankle muscle volume (Eq. 2), according to Kipp et al. [4].

Eq. 2: $$V_m = L \times Fm / \sigma$$

We used published fascicle length (L) data and assumed isometric muscle force per unit of cross-sectional area (σ=20N/cm^2) [5].

Hip, knee, and ankle muscle volume were submitted to an RM ANOVA to test the main effect and interaction between sex (*male, female*) and load (*20, 25, 30, 35 kg*). Significant interactions were submitted to a simple effects analysis, and a Bonferroni correction was used for pairwise comparisons. Alpha was $p < 0.05$.

RESULTS

There was a significant load by sex interaction for knee muscle volume (p=0.028). Females used greater knee muscle volume than males to run with the 20 (p=0.019) and 35 kg (p=0.017), but not 25 (p=0.280) or 30 kg (p=0.534) loads (Fig. 2).

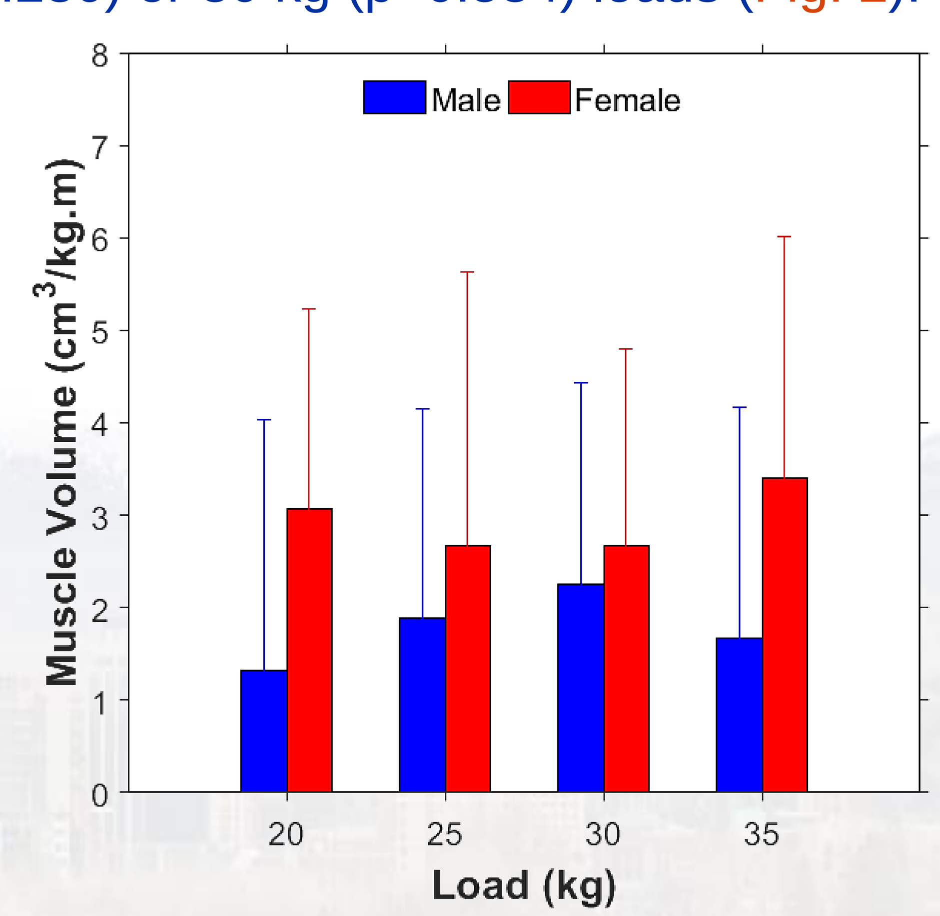

Figure 2. Mean (SD) knee muscle volume for males (blue) and females (red) for each load condition during the run task.

RESULTS CONT'D

Load increased active muscle volume increased at the ankle (p=0.012), but not hip (p=0.112) or knee (p=0.887) (Fig. 3). But, after correcting for a Type 1 error, there was no significant difference in ankle muscle volume between body borne load.

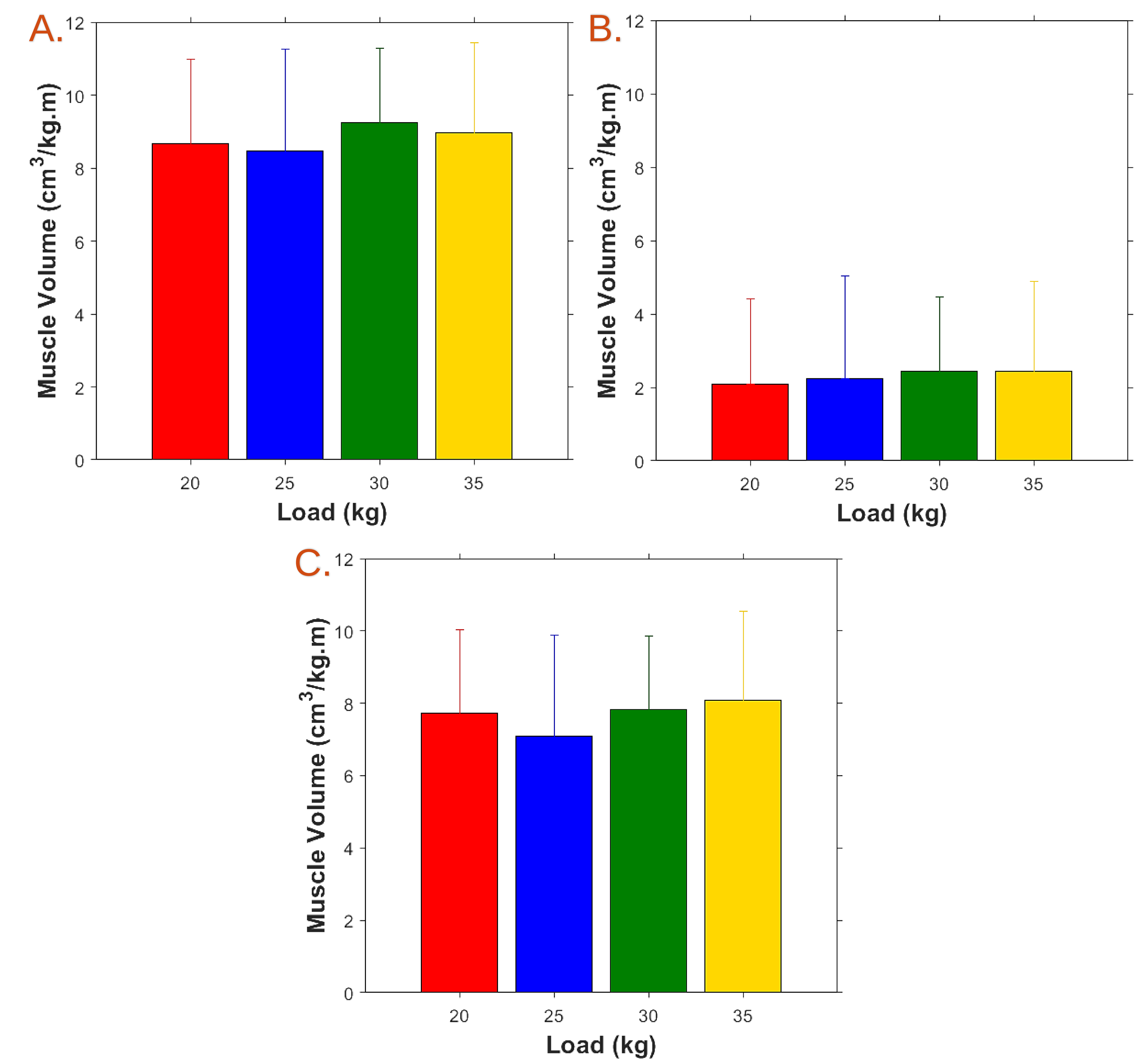

Figure 3. Mean (SD) active hip (**A**), knee (**B**), and ankle (**C**) muscle volume during the run task.

Sex had no effect on hip, knee or ankle muscle volume (p>0.05).

CONCLUSION

Load increased ankle musculature needed to run and avert musculoskeletal injury. Females activated more knee musculature to run with load than males, but work is needed to determine if this increases quadriceps force and knee loads.

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