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Analysis of Knee Motion to Prevent and Treat the Increasing Incidence of Premature Knee OA

Tyler Brown , *Boise State University*
Micah Drew , *Boise State University*
Samantha Krammer , *Boise State University*

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Abstract

Purpose/Background: Osteoarthritis (OA) is a costly, debilitating musculoskeletal disease. A disparity in OA incidence in young individuals who don body borne load while physically active, such as service members, reportedly exists. Incidence of premature OA in service members is greater than twice the general population and steadily increasing at the knee. Moreover, there is disparity in knee OA incidence for female and African-American service members, who are 15%-25% more likely to develop the disease. A service member's physical activity directly contributes to premature knee OA development. Specific knee locomotion biomechanics indicative of joint instability, including large and/or abrupt knee adduction motions, may increase their likelihood of OA development. Yet, no objective measure of knee instability currently exists; nor is it understood how body borne load leads to altered, and potentially hazardous knee locomotion biomechanics that increase incidence of premature knee OA among service members. This study sought to determine whether knee motions posited to be indicative of joint instability progressively increase with body-borne load and duration of load carriage.

Materials & Methods: To date, six recreationally active adults had knee biomechanics quantified while walking 1.3 m/s for 60 minutes with a different, randomly ordered body borne load: (unloaded: 0 kg, 15 kg and 30 kg). During the load carriage task, dominant limb knee biomechanics were quantified from three walk trials (1.3 m/s ± 5%) recorded at minute 0, and every 15 minutes thereafter (i.e., 5, 15, 30, etc.). For each trial, the peak, range, and jerk cost of knee adduction angle was quantified using data from the video-based motion capture system and accelerometer-based IMU sensors. To determine whether body-borne load or the duration of load carriage increases knee joint instability, each dependent knee adduction measure was submitted to a RM ANOVA to test the main effect and interaction between time (minutes 0, 15, 30…60) and load (0,15 and 30 kg). To compare the video-based and accelerometer-based data, each dependent knee adduction measure was submitted to equivalence testing, or two one-sided t-tests of the difference between these measures, in the same participant. Alpha was $p < 0.05$.

Results: Preliminary analysis found neither body borne load, nor time had a significant effect on peak, range, or jerk cost of knee adduction ($p>0.05$) (Table 1 and Figure 1). No significant difference was evident between the video-based and accelerometer-based derived knee adduction measures ($p>0.05$).

Discussion/Conclusion: Walking with body borne load may increase knee OA risk for service members. During locomotion, current participants exhibited a non-significant increased in range and jerk cost of knee adduction, and OA risk with each addition of body borne load. Specifically, participants exhibited a 11% and 22% increase in range and jerk cost of knee adduction with the 30 kg load. In contradiction to our hypothesis, participants did not further increase knee adduction throughout the duration of locomotion, despite the 33% increase in jerk cost after 45 minutes of load carriage. With additional testing, we expect a statistically significant increase range and jerk cost of knee adduction with body borne load, but only an increase in jerk cost throughout the duration of load carriage.

Keywords

Knee Motion; Knee. Knee OA

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School of Public Health
University of Nevada, Las Vegas

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Tyler Brown, Boise State University
Micah Drew, Boise State University
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Corresponding Author: Tyler Brown, tynbrown@boisestate.edu

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Table 1. Mean peak, range, and jerk cost of knee adduction exhibited during stance during locomotion with each body borne load.

Time	Peak (deg)			Range (deg)			Jerk Cost (deg^2/sec^5)		
	0 kg	15 kg	30 kg	0 kg	15 kg	30 kg	0 kg	15 kg	30 kg
0	3.62	3.21	3.21	4.57	3.32	4.54	36.35	38.59	44.38
15	3.55	4.00	3.16	3.67	3.48	4.35	36.38	42.14	46.04
30	3.73	4.10	3.31	3.69	3.84	4.64	29.24	39.70	63.52
45	4.20	3.95	3.11	4.00	3.69	4.25	79.63	41.29	39.46
60	3.73	3.75	3.19	4.12	3.48	4.59	52.38	39.46	66.89

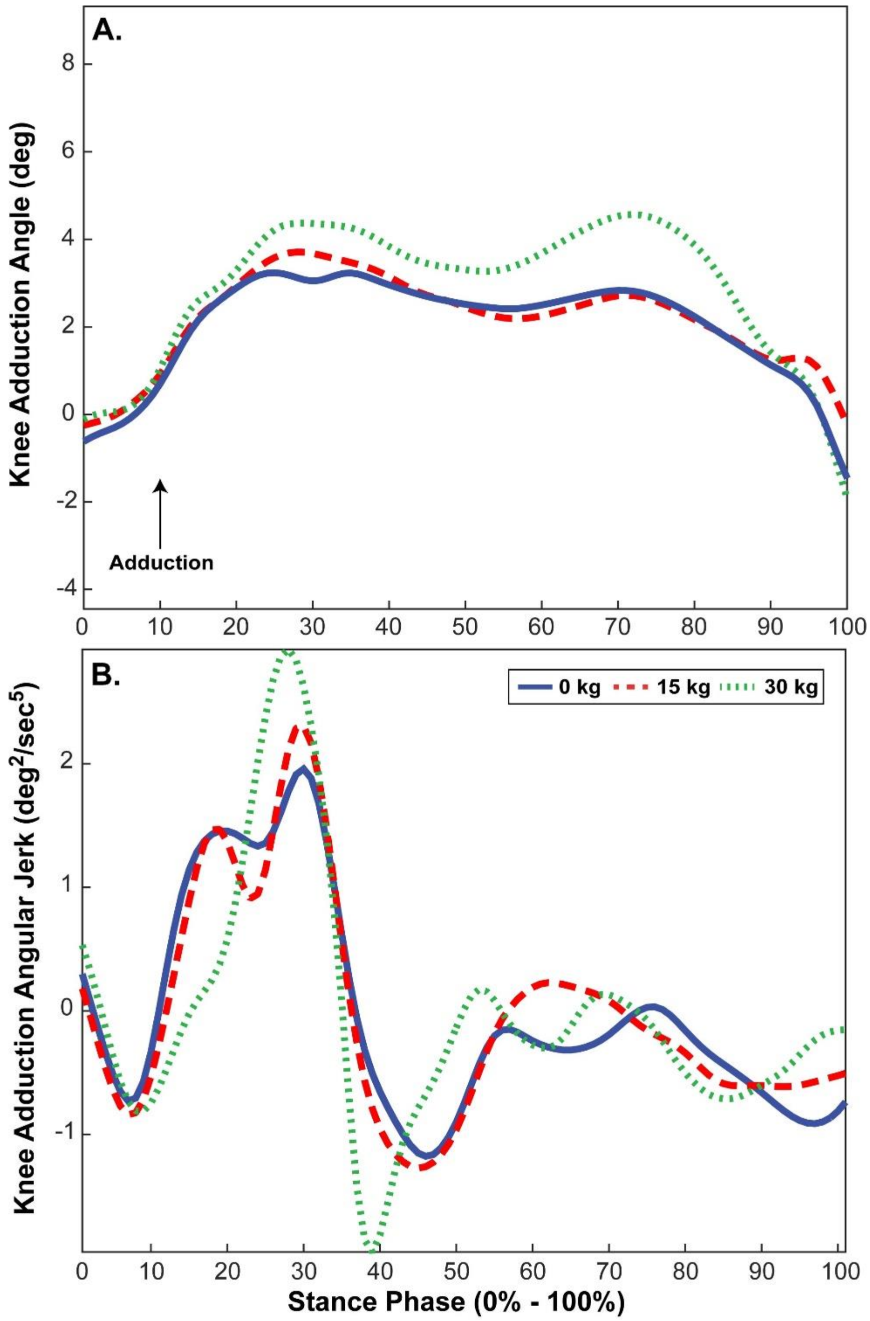

Figure 1. Depicts knee adduction joint angle (A) and angular jerk cost (B) during the stance phase (heel strike to toe off) of locomotion with each body-borne loads (0, 15 and 30 kg).