THE EFFECT OF ICE HOCKEY BAG LOAD CARRYING ON THE MUSCLE ACTIVITIES OF THE TRUNK OF YOUNG MALES DURING GAIT – A PROGRESS REPORT

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The purpose of this study was to explore the trunk muscle activities during unilateral load carriage in carrying a hockey bag. This paper reports on-going research with results from the first seven male subjects (23.56 ±2.19 years) who carried a hockey bag over their dominant carrying shoulder and walked for 8 m. The muscle activities of the trunk as well as temporal-spatial data were recorded. Two hockey bag sizes (small and large) and three load weights were tested. Load weights were 10%, 20%, and 30% of the subject's individual body weight. Walking without carrying a load served as a control condition. Results showed that the unloaded erector spinae and both the unloaded and loaded rectus abdominis activities increased with added weight. Stride length decreased while the stride width increased as load weight increased.

KEY WORDS: Gait, Electromyography, Unilateral load carriage.

INTRODUCTION: Load carriage can be seen in the form of backpacks, side-packs, or front-packs, and have been proven to alter the gait, posture, and muscle activities of the human body (Motmans, Tomlow, & Vissers, 2006; Smith & Ashton, 2006). Many studies indicate that the more drastic and perhaps more injury prone method of load carriage is unilateral (side-pack) carrying (Devita, Hong, & Hamill, 1991; Motmans et al., 2006). The ice hockey bag is commonly carried unilaterally especially by young-adult males. They choose this method of carrying because of its easy pick-up and drop-down style and afordability in price, when compared to a hockey bag with wheels. Of the unilateral load carriage studies available, all have studied load weights of 20% or less of the subject's bodyweight. Most of these studies examine the carriage of duffle bags or school bags carried at the side of the body. The ice hockey bag is much larger in volume than the average duffle bag and according to a recent survey, hockey bags can weigh as much as 33% of one's body weight (Corrigan, Law, & Law, 2010). Also, the way that the hockey players carry these bags, which is almost in a postero-lateral position just above the hip, is much different than the usual unilateral carriage method seen in most studies. The purpose of the present research was to examine the effects that this type of unilateral load carriage has on the muscles of the trunk under heavier loads and in a larger volume bag. It is hypothesized that peak muscle activations will result in the heavier bag along with a shorter stride length and wider stride width. Differences between the small and large hockey bags may result from the distance of the bag to the center of mass and consequently stride parameters may vary.

METHODS: Seven healthy males (23.56 ±2.19 years, 78.56 ±10.49 Kg) volunteered as subjects for the study. All subjects had at least three years of ice hockey experience and therefore three years of carrying hockey bags. Four load conditions were examined, including no load, 10%, 20%, and 30% body weight (BW) for a small Reebok hockey bag (volume = 0.11 m^3) and a large Reebok hockey bag (volume = 0.36 m^3). Styro-foam insulation was placed in the bags to bring out the bag's true volume. Designated spots were cut out in the insulation where metal weights were placed. The instruments used to capture the temporal-spatial kinematic data included ten infra-red, high speed, optical cameras used to translate collected retro-reflective markers into a three-dimensional image with the Vicon Motion Analysis System, recording at 200Hz (Vicon MX-13, Oxford Metrics, Oxford, UK). Four force plates (2 Bertec and 2 Khistler) were used in helping to define foot contact, however subjects were informed to ignore the force plates and walk as normally as possible. A 16-channel EMG system (DS-B04, Bagnoli™-16 Desktop EMG system, Delsys Inc., Boston, MA) was used to record muscle activity in 4 muscles at 1000 Hz. Each participant read and signed a consent form approved by the University of Ottawa Health Sciences and Science Research Ethics Board. The sensors were applied with double-sided tape and placed on the muscle belly of the left and right rectus abdominis (RA) just inferior to the umbilicus and the erector spinae (ES) at the L3-L4 level. The areas were shaven and cleaned using an isopropyl alcohol swab before having the muscle sensors placed. The grounding sensor was placed on the left clavicle. Maximum voluntary contractions (MVC) took place manually through two trials for each muscle group. The RA MVC was performed through an isometric crunch while the MVC for the ES was performed through lying prone and extending the arms and legs simultaneously. Retro-reflective markers were placed on the medial and lateral malleolus, the heel and the first toe of both feet.

The weight and height of the participant were then recorded and used to adjust hockey bag weight. The 7 conditions were presented to the participants using a Latin squares design. The participants were instructed to walk at their own selected pace, to carry the bag as they would normally carry their own hockey bag, and to take breaks after each trial to avoid fatigue. The participants were allowed to practice any load carriage task before testing to become familiar. Participants performed 4 trials of each condition. Each trial consisted of an 8 m walk in a straight line inside the capture area on smooth laboratory flooring. Analysis took place of one stride length at the 2-6 m section.

Data of the each participant were averaged for each condition and then averaged among all participants. The EMG data was processed with a cut off frequency of 4 Hz and filtered using a low pass Butterworth filter on SmartAnalyzer (BTS Software). One of the seven participants carried the load on their dominant left shoulder. To avoid confusion, the term 'loaded' will be used and refers to the side that the load is applied.

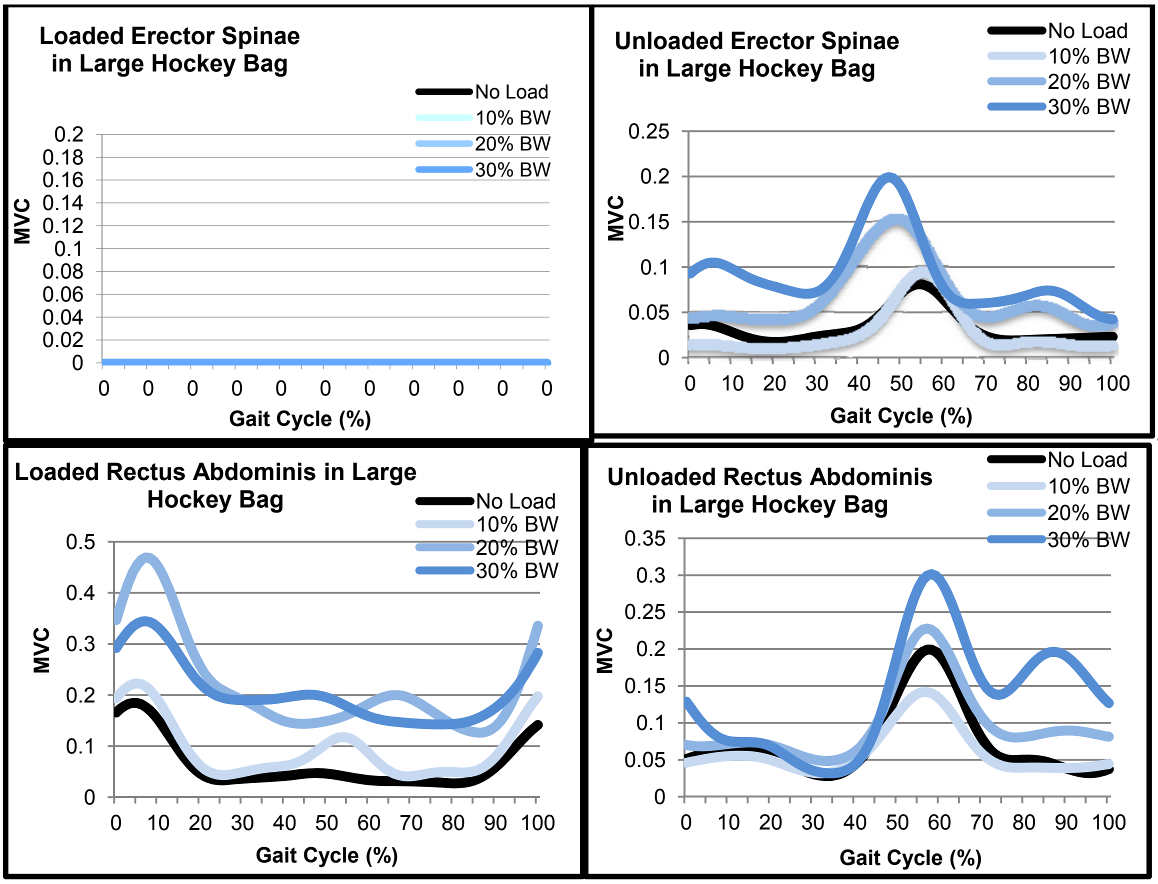

Figure 1 EMG activity patterns of erector spinae and rectus abodominis in one gait cycle (loaded gait cycle) from heel strike to heel strike at each walking condition when carrying a large hockey bag. The control condition of no load is represented in black. Values on the y-axis are shown as a ratio of the maximum voluntary contraction = 1.0. Significance is found in the means of the unloaded rectus abdominis from the 10% BW to the 30% BW (P<0.25).

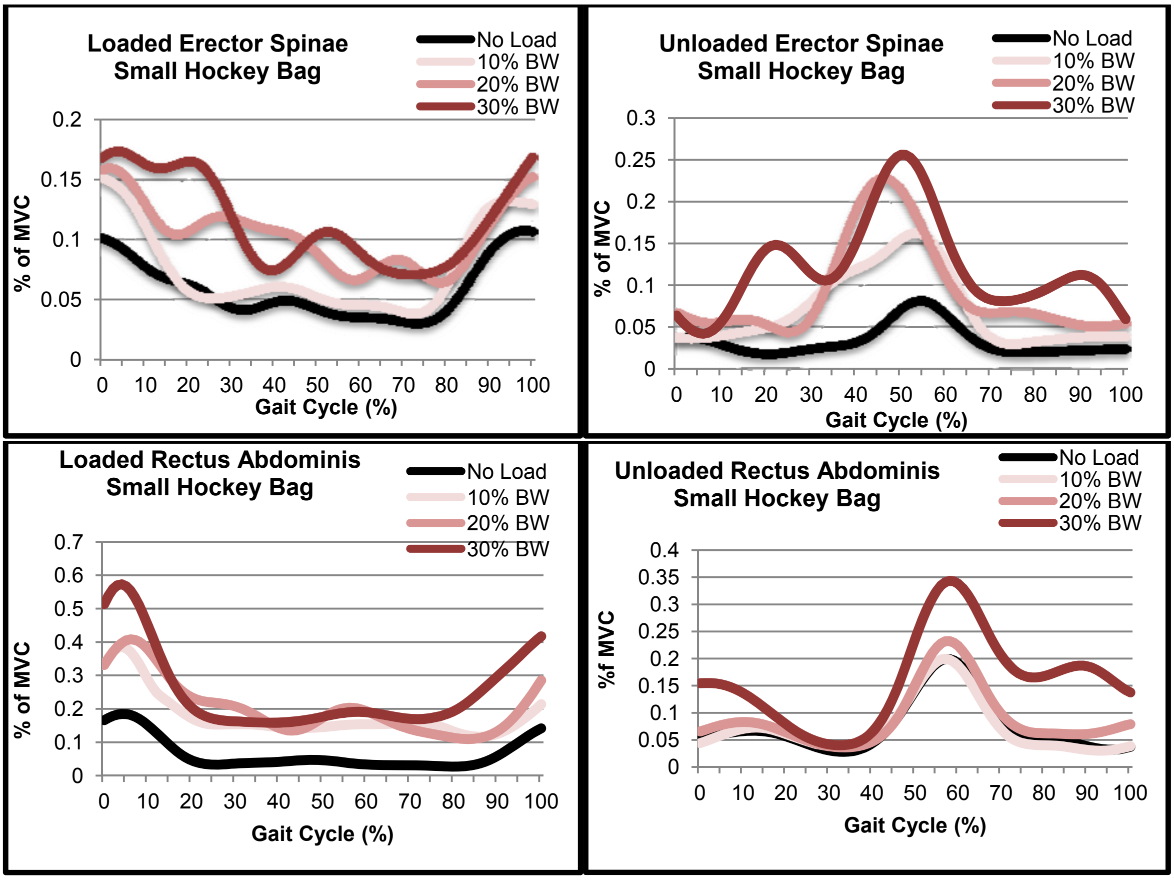

Figure 2 EMG activity patterns of erector spinae and rectus abodominis in one gait cycle (loaded gait cycle) from heel strike to heel strike at each walking condition when carrying a small hockey bag. The control condition of no load is represented in black. Values on the y-axis are shown as a ratio of the maximum voluntary contraction = 1.0. Significance is found in the means of the unloaded rectus abdominis from the 10% BW to the 30% BW (P<0.25).

Table 1: Stride length, Stride Width, and Double Support time

Load condition	Stride length (m)		Stride width (m)		Doble support (%)	
	Large bag	Small bag	Large bag	Small bag	Large bag	Small bag
No load	1.52 ±0.07[a]		0.11 ±0.01[c]		25.86 ±3.96[a]	
10% BW	1.44±0.06	1.44±0.09	0.13±0.02[d]	0.11±0.02[d]	27.64±3.27	26.47±3.80
20% BW	1.45±0.08[b]	1.46±0.10[b]	0.15±0.04	0.15±0.02	28.71±4.01	27.88±4.72
30% BW	1.40±0.11[a,b]	1.36±0.07[a,b]	0.15±0.04[c,d]	0.16±0.05[c,d]	29.14±3.78[a]	29.80±3.27[a]

a= sig. at no load-30% BW (P<0.05), b= sig. at 20% BW -30% BW (P<0.05), c= sig. at no load-30% BW (P<0.07), d=sig. at 10% BW-30%BW(P<0.07)

RESULTS: Electromyography activity: The EMG patterns of the normalized averages in the four muscles at different walking conditions are presented in figures 1 and 2.

The loaded ES shows no major change through the conditions in both the small and large ice hockey bags. It is in the unloaded ES that differences in peak EMG activity become present. The peak changes of EMG in the unloaded erector spinae range from 8.10% (no load condition) to 19.93% (30% BW load condition) in the large bag and to 25.60% (30% BW load condition) in the small bag.

Similar changes occur for the rectus abdominis, but with an increase in both the loaded and unloaded muscle. A significant increase is found in the unloaded rectus abdominis (P<0.25) from the 10% BW load condition to the 30% BW load condition in both bags. The differences thus far in the study show that the smaller bag may require greater muscle activity than the larger bag at the same load condition. However, this was not evident through a statistical analysis (P<0.25) of the first seven participants and needs to be confirmed in a larger sample size.

Temporal-spatial variables: Table 1 shows an increasing trend in the double support time during the gait cycle when a load is applied and increased. The double support time was significantly higher in the 30% BW load condition when compared to the control ($P<0.05$). It is also found that the increasing stride width and a decreasing stride length occur as the heavier load is applied.

DISCUSSION: The study by Motmans et al. (2006) on the trunk muscle activity in different modes of carrying school bags, found that during 30 second static standing the loaded erector spinae activities showed a significant decreases when compared to no load (25% lower for a 15% BW load when compared to no load) (19 participants, 9 male and 10 female, 20.12 ±2.03 years of age). Results also showed that the unloaded erector spinae significantly increased its activity (77% greater with a 15% BW load than no load). In the present study, the results for the rectus abdominis did not have significant differences when compared to the control condition of no load but differences were found between left and right RA (unloaded had an 18% increase). The results from this study and Motmans' are similar in that the unloaded erector spinae yields greater increases in peak muscle activity but the results differ in that the rectus abdominis playing a greater role when carrying hockey bags. This may be due to the position of the load. In Motmans' study, the load was placed directly lateral and over the hip. The strap of this load ran diagonally across the body. In hockey bag load carriage, the bag is in a postero-lateral position, relying more on the anterior torso muscle (rectus abodominis) to counter the posterior load.
The results from published work in a temporal-spatial kinematics study on asymmetrical load carriage, showed, although a small decrease, that no significant difference in stride length of either limbs from 0% BW, 10% BW, and 20% BW were found when a 0.0192 m^3 load was carried on the left side of 5 males (Devita et Al., 1991; avg. 25.0 years of age). The amount of single support time also did not differ significantly between loads. In comparison, the present study also reveals no significant change in stride length from no load to 20% BW, but shows a significant decrease from no load to 30% BW ($P<0.05$). In the present study, an increase of double support time (%) ($P<0.05$) and decreases in stride width ($P<0.10$) were also found when comparing no load to the 30% load. These biomechanical gait modifications are applied by the human body in an effort to maintain balance in carrying large loads of 30% BW.

CONCLUSION: The results show that both unloaded and loaded rectus abdominis' increase in peak activity as well as the unloaded erector spinae when an ice hockey bag load is applied. Also, an increase in double support time, decrease in stride length and increase in stride width may result in the body's effort to obtain balance equilibrium. It should be noted that this is an ongoing study, and thus because of the small sample, higher alpha levels were accepted in the analysis of the trunk EMG's. Statistical analyses showed no significance between the large and small hockey bags. Based on the preliminary data it can be summarized that the EMG activities of the erector spinae of the unloaded side and rectus abdominis in both sides are changed dramatically by carrying a load unilaterally.

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