A Pilot Analysis of Emerging Surface Electromyography Wearable Technology: Training Load Demands, Muscle Ratios, and Sex Differences in the Casualty Drag

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INTRODUCTION

- An essential job task for military personnel is a casualty drag. A backwards casualty drag is required when a soldier must drag a colleague from a hazardous environment. The US Army created a simulation that measures the capacity to perform this task, and involves dragging a 123-kg dummy (equivalent weight to a soldier wearing a combat load) backwards over a 15-m distance (2).
- In the field, a casualty drag can be demanding, and execution of this task could affect subsequent tasks a soldier may need to perform (e.g. moving under direct fire). As a result, the ability to perform this task should be developed during basic training.
- Military populations are now using technology more commonly associated with elite sport (3). Technology has been adopted in an attempt to ensure cadets experience the appropriate load to achieve the desired adaptations during training, and to reduce injury occurrence (4). One example of emerging technology that could have practical application in military training, especially basic training, is surface electromyography (sEMG) wearable technology.
- sEMG wearable technology evaluates muscle activation and recruitment during physical activity, and uses this input to measure training load (TL) (7). The measurement of TL via wearable technology could provide an indication of the stress placed on the body by the performed activities (5), and this system could measure tactical tasks such as a casualty drag in a practical environment.

PURPOSE

- The purpose of this study was to determine TL demands, muscle ratios, and sex differences in the tactical task of a casualty drag (CD) using sEMG wearable technology.

METHODS

- A convenience sample of 36 college-aged participants (age = 25.03 ± 3.62 years; height = 1.74 ± 0.10 m; body mass = 82.49 ± 20.92 kg), including 25 males and 11 females, volunteered to participate in this research. Physically active, healthy volunteers were used as surrogates for a tactical population, as this allowed for recruitment of males and females with divergent physical capabilities (6,8). Previous research has shown minimal learning effects with the casualty drag (2), which means that even for participants who were not soldiers, they should perform the casualty drag with consistency across trials.
- Participants were fitted with sEMG wearable technology (Athos, Redwood City, California) prior to testing. Males wore compression shorts, females wore leggings, and each were embedded with sEMG sensors that measured the vastus medialis and lateralis (quadriceps; QUAD), biceps femoris (hamstrings; HAM), and gluteus maximus (GM) of both legs.
- The sensors provided a bipolar differential sEMG measurement with an inter-electrode distance of 2.1 cm and were comprised of a conductive polymer. No skin or electrode preparation was performed at the site for each electrode as it aligned with recommended product usage.
- After a dynamic warm-up, participants completed maximum voluntary isometric contraction (MVIC) assessments via manual muscle testing for each leg which was used to normalize the sEMG data (1). Participants then performed two trials of a 123-kg casualty drag over 15-m (2). A 91-kg dummy with a 32-kg weighted vest was positioned on the ground, and participants grabbed the vest handles and dragged the dummy backwards over the required distance as quickly as possible. Time was recorded via stopwatch to calculate drag velocity (measured in meters per second; m/s), with the fastest trial analyzed.
- The sEMG signal for each muscle was measured as a percentage of MVIC to calculate TL (measured in arbitrary units; AU). The variables included: overall TL (sum of all muscles), and QUAD:HAM, GM:HAM, and QUAD:HAM+GM ratios. Independent samples t-tests calculated sex differences between CD velocity and the sEMG variables. Partial correlations controlling for sex calculated relationships between CD velocity and the sEMG variables.

RESULTS

- The descriptive data for males and females are shown in Table 1. Males were significantly taller and heavier, and completed the CD faster than the females (all $p < 0.01$). Accordingly, females experienced a greater TL for the QUAD, HAM, GM, and total (all $p < 0.01$). There were no between-sex differences in the muscle ratios (p = 0.56-0.64).
- A slower drag velocity correlated with a greater overall TL for both sexes, in addition to a greater QUAD TL (Table 2). There was a significant correlation between faster CD velocity and greater QUAD-HAM ratio

Table 1. Descriptive data (mean ± SD) for casualty drag velocity and the TL variables measured by the sEMG wearable technology.

	Males (n = 25)	Females (n = 11)
Age (years)	25.16 ± 3.87	24.73 ± 3.13
Height (m)	1.78 ± 0.09	1.66 ± 0.08*
Body Mass (kg)	88.93 ± 21.59	67.86 ± 8.58*
Casualty Drag Velocity (m/s)	1.49 ± 0.26	0.83 ± 0.16*
QUAD TL (AU)	27.23 ± 9.65	44.37 ± 14.82*
HAM TL (AU)	16.82 ± 8.03	29.54 ± 11.27*
GM TL (AU)	11.96 ± 4.32	20.82 ± 7.34*
Total TL (AU)	56.01 ± 15.30	94.73 ± 27.84*
QUAD:HAM	1.07 ± 0.80	0.92 ± 0.58
GM:HAM	0.88 ± 0.58	0.76 ± 0.32
QUAD:HAM+GM	0.97 ± 0.40	0.91 ± 0.25

* Significantly ($p < 0.05$) different from the males.

Table 2. Correlation data for casualty drag velocity with the TL variables measured by the sEMG wearable technology.

		QUAD TL	HAM TL	GM TL	Total TL	QUAD: HAM	GM:HAM	QUAD: HAM+GM
Velocity	r	-0.64*	-0.28	-0.31	-0.59*	-0.35*	-0.22	-0.26
	p	<0.01	0.10	0.07	<0.01	0.04	0.20	0.13

* Significant ($p < 0.05$) relationship between casualty drag velocity and the TL variable.

CONCLUSIONS

- The sEMG wearable technology could indicate the stress associated with soldiering tasks, in this instance a backwards casualty drag. Slower performance increased TL demands, which was notable for the females. This could impact other activities which could also result in high TL demands, such as moving to cover, where soldiers will need to sprint and move into different positions (e.g. kneeling or prone positions) (2). Greater QUAD contribution in the casualty drag, shown through the QUAD-HAM ratio, could contribute to faster performance.
- This study provided a pilot analysis into how emerging sEMG wearable technology could be used to measure military tasks, and by extension potentially integrated into basic training. The current data detailed that less-efficient performance of the dragging task was related to higher TL demands. This has implications for soldier training, where TL increases have been associated with injury risk. sEMG wearable technology could be used to measure the stress of tasks where TL metrics may be difficult to measure (e.g., lifting and carrying loads, combat simulations).
- Nonetheless, there is still a need for greater research into the validity and reliability of the sEMG wearable technology. This needs to be conducted prior to any further use in military populations.

OPERATIONAL RELEVANCE

- This study provided a pilot investigation into how sEMG wearable technology could be integrated into basic training by measuring TL of a specific task. Initial measures indicated greater TL demands with slower CD task performance.
- sEMG wearable technology could measure soldier TL during basic training, with objectives of enhancing performance and decreasing injury risk via workload monitoring and manipulation. However, more research is required to validate the sEMG wearable technology to ensure accuracy of data.

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