Relationships between training load demands measured by surface EMG wearable technology and the military drag

Lockie, Robert G.; Moreno, Matthew R. ; Ducheny, Spencer; Orr, Rob Marc; Jay Dawes, J.; Balfany, Katherine

Relationships between Training Load Demands measured by Surface EMG Wearable Technology and the Military Casualty Drag

CALIFORNIA STATE UNIVERSITY FULLERTON

BOND UNIVERSITY TACTICAL RESEARCH UNIT

OKLAHOMA STATE UNIVERSITY

Robert G. Lockie[1] ◆ Matthew R. Moreno[1] ◆ Spencer C. Ducheny[1] ◆ Robin M. Orr[2] ◆ J. Jay Dawes[3] ◆ Katherine Balfany[4,5]

[1]Center for Sport Performance, Department of Kinesiology, California State University, Fullerton, Fullerton, CA, USA. [2]Tactical Research Unit, Bond University, Robina, Qld, Australia. [3]School of Kinesiology, Applied Health and Recreation, Oklahoma State University, Stillwater, OK, USA. [4]Athos, DBA. Mad Apparel, Redwood City, CA, USA. [5]Department of Physical Medicine and Rehabilitation, University of Colorado, Anschutz Medical Campus, Aurora, CO, USA.

CSUF CENTER FOR SPORT PERFORMANCE TACTICAL RESEARCH

ATHOS

University of Colorado Anschutz Medical Campus

ABSTRACT

INTRODUCTION: An essential job task for military personnel is a casualty drag, where a fellow soldier must be dragged from a hazardous environment. A simulation that measures the capacity to perform this task involves dragging a 123-kg dummy (equivalent weight to a soldier wearing a combat load) backwards over a 15-m distance. 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). Surface electromyography (sEMG), a wearable technology that can measure tactical tasks in a practical environment, was used to measure the training load (TL) demands associated with the casualty drag. PURPOSE: To determine the relationships between muscle TL measured by sEMG wearable technology and casualty drag velocity. METHODS: A convenience sample of 36 college-aged participants (males = 25; females = 11) performed two trials of a 123-kg casualty drag over 15-m. A 91-kg dummy with 32-kg of additional load via a weighted vest was positioned on the ground. Participants grabbed the vest handles and dragged the dummy backwards over the required distance. Time was recorded to calculate drag velocity, with the fastest trial analyzed. Prior to testing, participants were fitted with compression shorts or leggings embedded with sEMG sensors to measure the vastus lateralis and medialis (quadriceps; QUAD), biceps femoris (BF), and gluteus maximus (GM) of both legs. The sEMG signal for each muscle was measured as a percentage of maximal voluntary contraction to calculate TL. The variables included the TL of each muscle and overall TL (sum of all muscles). Pearson's correlations ($p < 0.05$) calculated relationships between drag velocity and the sEMG variables; the sexes were analyzed separately. RESULTS: A slower drag velocity correlated with a greater overall TL for both sexes (males: $p < 0.01$, $r = -0.65$; females: $p = 0.03$, $r = -0.66$). Greater QUAD TL related to a slower drag velocity for both males ($p < 0.01$, $r = -0.68$) and females ($p = 0.01$, $r = -0.73$). No significant relationships were found for BF or GM. CONCLUSIONS: Performing a casualty drag slower will increase the TL demands, predominantly via greater QUAD stress. This could impact other activities where QUAD activity is also required, such as moving to cover. Training staff should ensure efficient performance of tasks such as the casualty drag to limit impact on other demanding tasks.

INTRODUCTION

- An essential job task for military personnel is a casualty drag. A casualty drag is where 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 as quickly as possible (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).
- Military populations have started using technology more associated with elite sport (3). This has been done in an attempt to ensure cadets experience the appropriate load to attain the desired adaptations during training, and to reduce the occurrence of injuries (4). One example of emerging technology that could have practical application in military training is surface electromyography (sEMG) wearable technology.
- sEMG wearable technology evaluates activation and recruitment patterns of muscles during physical activity, and uses these to measure training load (TL) (1,6). The measurement of TL via wearable technology provides an indication of the resultant stress placed on the body by the performed activity (5), and this system could be used to measure tactical tasks in a more practical environment.
- The purpose of this study was to determine the relationships between muscle TL measured by sEMG wearable technology and casualty drag velocity.

METHODS

- A convenience sample of 36 college-aged participants (25 males: age = 25.16 ± 3.87 years; height = 1.78 ± 0.09 m; body mass = 88.93 ± 21.59 kg; 11 females: age = 24.73 ± 3.13 years; height = 1.66 ± 0.08 m; body mass = 67.86 ± 8.58 kg) volunteered to participate in this study.
- 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 (BF), 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 corresponding to 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 32-kg of additional load via a 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 the TL of each muscle (legs were summed together) and overall TL (sum of all muscles). Pearson's correlations ($p < 0.05$) calculated relationships between drag velocity and the sEMG variables. Males and females were analyzed separately.

RESULTS

- Descriptive data is shown in Table 1. The correlation data is shown in Table 2.
- A slower drag velocity correlated with a greater overall TL for both sexes, in addition to a greater QUAD TL. No significant relationships were found between casualty drag velocity and BF or GM.

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)
Casualty Drag Velocity (m/s)	1.49 ± 0.26	0.83 ± 0.16
QUAD TL (AU)	27.23 ± 9.65	44.37 ± 14.82
BF 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

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

		Casualty Drag Velocity Males (n = 25)	Casualty Drag Velocity Females (n = 11)
QUAD TL	*r*	-0.68*	-0.67*
	p	<0.01	0.03
BF TL	*r*	-0.28	-0.35
	p	0.18	0.30
GM TL	*r*	-0.26	-0.52
	p	0.21	0.10
Total TL	*r*	-0.65*	-0.73*
	p	<0.01	0.01

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

CONCLUSIONS

- Performing a backwards casualty drag more slowly increased the TL demands, predominantly via greater QUAD stress. This could impact other activities where QUAD activity is also required, such as moving to cover, where soldiers will need to sprint and move into different positions (e.g. kneeling or prone positions) (2).
- This data suggests that training staff should ensure efficient performance of tasks such as the casualty drag to reduce the experienced TL and limit impact on other physically demanding tasks.
- Additionally, this study provided an initial investigation into how 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 information could be used with the objectives of enhancing performance and decreasing injury risk via workload monitoring and manipulation.
- Further research is required as the use of sEMG wearable technology to acutely and longitudinally measure specific military tasks and training.

References

1. Balfany K, Chan MS, Lockie RG, Lynn SK. Sports performance wearable technology, sEMG and manual muscle testing: Practical methods for measuring maximal voluntary contractions. In: *Proceedings of the American Colllege of Sports Medicine Annual Meeting*. 2019: Orlando, FL.
2. Foulis SA, Redmond JE, Frykman PN, Warr BJ, Zambraski EJ, Sharp MA. U.S. Army physical demands study: Reliability of simulations of physically demanding tasks performed by combat arms soldiers. *J Strength Cond Res*. 2017;31(12):3245-52.
3. Friedl KE. Military applications of soldier physiological monitoring. *J Sci Med Sport*. 2018;21(11):1147-53.
4. Jones BH, Hauschild VD, Canham-Chervak M. Musculoskeletal training injury prevention in the U.S. Army: Evolution of the science and the public health approach. *J Sci Med Sport* 2018; 21:1139-1146.
5. Jones CM, Griffiths PC, Mellalieu SD. Training load and fatigue marker associations with injury and illness: A systematic review of longitudinal studies. *Sports Med* 2017; 47:943-974.
6. Lynn SK, Watkins CM, Wong MA, Balfany K, Feeney DF. Validity and reliability of surface electromyography measurements from a wearable athlete performance system. *J Sports Sci Med*. 2018;17(2):205-15.