A TARGETED LOAD-CARRIAGE TRAINING PROGRAM ELICITS POSITIVE ADAPTATIONS AFTER 10-WEEKS

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The purpose of this study was to identify and characterise physical performance responses to a targeted 10-week load-carriage physical training intervention in males. Performance measures of maximal strength, heart rate, rating of perceived exertion, and basic fitness from nine male civilians before and after the 10-week training intervention are presented. There were significant increases in maximal force (~200 N) and aerobic performance (Level. Shuttle 8.9 vs 9,4 variables). Small-to-large effect sizes were shown for basic fitness and perceptual responses. The 10-week load-carriage physical training intervention elicited physical performance improvements and may facilitate load-carriage task performance.

KEYWORDS: Strength, fitness, military

INTRODUCTION: Load-carriage is a requirement of many military occupational roles and is commonly used as an assessment standard of recruits. However, the type and volume of the physical load experienced by recruits is often greater than the individual's capacity (Friedl et al., 2015). Failure to adapt to increases in musculoskeletal demands and physiological stresses result in decreased soldiering performance (Groeller et al., 2015).
Progressive resistance training is known to improve occupational performance, and reduce cumulative demands of physical training (Kraemer et al., 2001). Repeated task exposure (i.e., simulated loaded walking tasks) decrease physical stress responses that result in improved occupational task performance. (Szivak & Kraemer, 2015). Lenton et al. (2017) identified specific demands of load-carriage and found the hip to be the critical lower-limb joint, contributing ~60% power, followed by the ankle (~25%), and then the knee (~15%). A physical training program targeting the hip joint musculature may improve Australian soldier's load-carriage capacity through performance and neuromuscular adaptations. The purpose of this study was to identify and characterise physical performance responses to a targeted 10-week load-carriage training program.

METHODS: Sixteen male civilians have been recruited; nine of these have completed all testing (Mean ± SD: age 22.1±1.3 years, 1.80±0.06 m, 83.7±7.3 kg); the remainder are currently completing the training. At the time of testing, no participants had acute or chronic injuries. No former experience with load-carriage was required. Participants gave their written informed consent and the Macquarie University Human Research Ethics Committee approved the study (protocol number: 5201700406). Participants were required to meet or exceed the Army Basic Fitness Assessment (BFA) standards for male soldiers ≤25 years old (Mullins et al., 2015) (70 sit-ups and 40 push ups in 2 minutes each), body mass ≥73 kg, and have a maximal aerobic capacity ≥45 $mL \cdot kg^{-1} \cdot min^{-1}$ (Flouris, Metsios, & Koutedakis, 2005; Ramsbottom, Brewer, & Williams, 1988).
Participants completed maximal strength tests (isometric mid-thigh pull (IMTP), countermovement (CMJ), and squat jumps (SJ) using a portable force plate (Fitness Technology, Adelaide, Australia), and Ballistic Measurement Software (Innervations, Perth, Australia). These and BFA tests were repeated upon completion of the 10-week training program. Eccentric utilisation ratio (EUR) was calculated using results from the CMJ and SJ (McGuigan et al., 2006).
In two separate laboratory sessions, a single load-carriage task representative of the minimum physical employment requirement for Australian Army All Corps Standard (5 km at 5.5 $km \cdot h^{-1}$, wearing a 23 kg vest) was completed before and after the 10-week training program. Heart rate (HR) and rating of perceived exertion (RPE) were measured every 5-minutes during the load-carriage task.

The 10-week physical training program consisted of resistance training three times per week and walking with a weighted vest twice per week. Sessions were delivered to participants by an accredited strength and conditioning coach, with resistance tailored to individual abilities. Loaded walking sessions were self-directed on a separate day to weight training sessions, with load incrementally increasing over the 10-week program ranging from 0 kg to 25 kg.
Paired t-tests were conducted on IMTP, CMJ, SJ, EUR, BFA measures, RPE, and cardiovascular response (HR). Effect sizes were calculated using difference in means (*d*) and were interpreted as trivial, small, moderate, and large effects for values of *d* equal to 0.0, 0.2, 0.6, and 1.2, respectively (Hopkins, 2016).

RESULTS: Results are presented for nine participants; the remaining seven participants are currently completing the 10-week training program.
Significant main effects were found for maximal force output for SJ (t(8) = -5.014, p = 0.001, d = 0.52), but not for CMJ (t(8) = 0.018, p = 0.986, d = -0.005). There was a small-to-moderate effect size for squat jump, and a trivial effect size for countermovement jump. No significant main effects were shown for the IMTP maximal force values with small to moderate effect sizes ranged from (t(8) = -1.548, p = 0.160, d = 0.36). EUR calculations for maximal force demonstrated significant effects (t(8) = 2.409, p = 0.043, d = -0.78) with a moderate to large effect size.
BFA results demonstrated significant effects for beep test scores only (t(8) = -2.63, p = 0.030, d = 0.32). A small to moderate effect size was shown for push up (d = 0.54) and sit-up scores (d = 0.49) (Table 1).

Table 1: Physical performance measures pre and post the targeted physical training intervention. Values are means (±SD) *Indicates significant difference pre-post training (p < 0.05).

Performance Measure	Variable	Pre	Post	Significance	Effect Size
SJ	Maximal Force (N)	1920 (358)	2103 (347)	0.001*	Small-Moderate
CMJ		1888 (213)	1887 (245)	0.986	Trivial
IMTP		2982 (450)	3033 (509)	0.160	Small-Moderate
CMJ/SJ	Eccentric Utilization Ratio (AU)	1.00 (0.14)	0.91 (0.10)	0.043*	Moderate-large
Basic Fitness Assessment	Push-Ups (#)	49 (8)	55 (15)	0.055	Small-Moderate
	Sit-Ups (#)	76 (5)	79 (9)	0.196	Small-Moderate
	Beep Test (Level.Shuttle)	8.9 (1.4)	9.4 (1.6)	0.030*	Small-Moderate

SJ, squat jump; CMJ, countermovement jump; IMTP, isometric mid-thigh pull. * Indicates significantly different at p < 0.05. N = Newtons, AU = Arbitrary Units.

HR decreased on average by 6 beats as a result of the training program. Similarly, RPE values decreased on average by two points after the training program compared to pre-values (Figure 1). Although differences were not significant they demonstrated up to large effect sizes (d = -0.19 to -0.75).

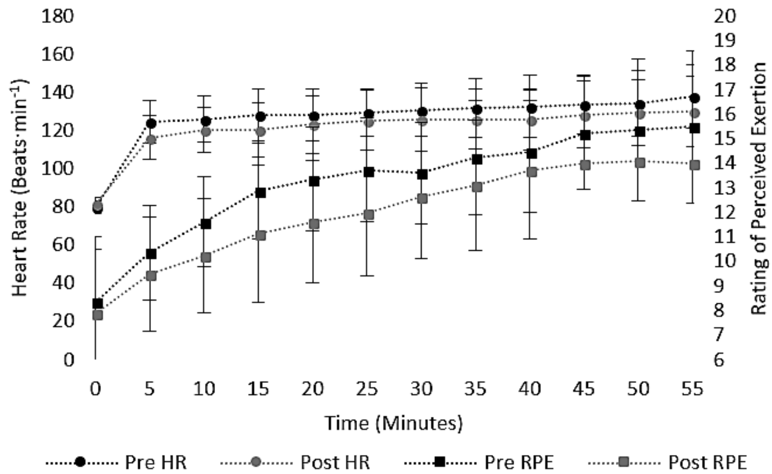

Figure 1: Heart rate and perceptual responses during the 5 km load-carriage walking task. Values are means (±SD).

DISCUSSION: The purpose of this study to identify and characterise physical performance responses to a periodised progressive 10-week resistance training program. Significant main effects for pre-post physical performance measure values were observed. Some measures were not statistical significant, however, effect size values indicated differences in pre-post means.

The SJ performance improved following the training program, but CMJ did not. This indicates enhanced capacity of the lower limb to produce concentric strength (McGuigan et al., 2006), which was a goal of the current training program. An increased capacity of the hip extensors to produce force during a predominantly concentric only contraction may account for the increase in force production during the SJ. The EUR supports this speculation, as there was a decrease between pre- and post-intervention (pre: 1.00(0.14), post: 0.91(0.10)).

Statistically significant differences for beep test scores indicate an improvement in maximal aerobic capacity of 5.6% as a result of the training program. This is an interesting finding given the aerobic capacity per se was not a goal of the program. Results however, are supported by previous findings where strength training increased aerobic capacity 13% after a 12-week program (Kraemer et al., 2004). These responses may be due to specific loaded walking tasks within our 10-week training program (Häkkinen et al., 2003) or possibly an improvement in lower body strength and therefore economy of movement (Beattie, Kenny, Lyons, & Carson, 2014). The push-ups and sit-ups performance did not achieve statistical significance, though improvements were observed pre-post (PU, 13%; SU, 5%, respectively), similarly to previous research (PU, 32%; SU, 8%, respectively) (Harman et al., 2008).

Reductions in HR suggest participants experienced less physiological strain during testing as a result of the training program (Mullins et al., 2015). RPE was similar to previous reports (Birrell, Hooper, & Haslam, 2007; Mullins et al., 2015), and increased throughout the duration of the loaded walking task. Pre-post values revealed no significant differences, however, post training RPE decreased by at least 2 points per time interval, indicating reductions in overall perceived exertion.

CONCLUSION: The current study was the first to investigate physical performance responses to a 10-week targeted load-carriage training program. Results demonstrate that an evidence-based resistance training program can induce physical performance improvements and physiological adaptations in males. Military organisations could utilise such a program to effectively train soldiers over a decreased duration to facilitate improvements in overall task capacity. Further insight into training responses will follow upon completion of the 10-week program by remaining participants. Additionally, sex-specific responses should be investigated to understand any training adaptations that are specific to males and females.

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