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Predicting stretcher carriage: Investigating variations in bilateral carry tests

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ABSTRACT

Carrying a casualty on a stretcher is a critical task within military and emergency service occupations. This study evaluated the impact of manipulating carry speed and the object type in bilateral carries on the ability to predict performance and reflect the physical and physiological requirements of a unilateral stretcher carry. We demonstrated that three task-related predictive tests; a jerry can carry performed at 4.5 km h^{-1}or 5.0 km h^{-1} and a kettle-bell carry performed at 5.0 km h^{-1} were strongly predictive of the physical and physiological demands of an individual participating as part of a four-person stretcher carry team. Therefore, bilateral predictive assessments have the utility for predicting the suitability of employees to effectively and safely conduct a four-person unilateral stretcher carry.

1. Introduction

Physical employment standards are developed with the aim of ensuring that an employee's physical and physiological capacities are commensurate with the demands of their occupation. The implementation of scientifically-rigorous physical employment standards can lead to a workforce with increased capability and productivity (Taylor and Groeller, 2003) and have been shown to significantly reduce injuries across a range of occupations (Harbin, 2005; Larsson and Harms-Ringdahl, 2006; Rosenblum and Shankar, 2006). In occupations where tasks may be time-critical, such as military, fire, ambulance and emergency rescue, physically capable employees are paramount in ensuring that such tasks are performed effectively and efficiently. One such time-critical task is a stretcher carry, whereby the efficiency of extricating a casualty may impact on medical-related outcomes. This is exemplified in the Australian Army whereby personnel are expected to be able to extract a wounded soldier using a four person stretcher carry over a distance of 100 m.

A range of generic physical assessments have previously been used to predict stretcher carriage, such as grip strength, upright pull, dead lift, isokinetic leg strength, standing broad jump and predictive assessments of peak oxygen consumption (Knapik et al., 1999; Rice and Sharp, 1994). While generic predictive assessments are generally easy to administer, they lack specific job-related characteristics, are susceptible to body mass bias and commonly only test one specific physical construct of a task that may have multiple physical constructs (Payne and Harvey, 2010; Vanderburgh, 2008). Task simulations are considered to be the 'gold standard' of assessments as they replicate the actual job task (Payne and Harvey, 2010). However, team assessments introduce poor reliability, lack of standard operation, and remove the ability to accurately assess individual maximal performance. For example, a four person stretcher carry is challenging to assess during large-scale testing and individual performance is dependent on the ability of the other team members. Subsequently, task-related predictive tests provide the opportunity to assess individual performance while still assessing relevant physiological constructs.

Task-related predictive tests also provide the opportunity to manipulate test parameters to maximise the predictive ability and the physical and physiological link to the criterion task. A number of studies have reported the impact of test parameters on the physiological demands of carry tasks. Such parameters include the use of a harness (Knapik et al., 2000; Rice et al., 1996) and number

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of personnel (Rice et al., 1996) in stretcher carriage, as well as the carried mass (Kilbom et al., 1992; McGill et al., 2013). While these studies provide insight into the change in physiological response according to variation of task parameters, they are not conducted with the aim of developing physical employment standards. As such, they do not provide insight into how task manipulation may impact the ability of a test to reflect the physical and physiological demands of a critical task.

Our group has previously investigated the impact of carry mass and showed that, at matched carry speeds, a bilateral carry of two 22 kg jerry cans better predicted four-person stretcher carry performance when compared to a bilateral carry of two 15 kg jerry cans (Beck et al., 2015). However, the manipulation of other test parameters, such as carry speed and the object type, may enhance the predictive ability of a task-related predictive test and the physical and physiological link to the criterion task. This study aims to address this gap in knowledge.

Given that the stretcher carry involves a deeper squat relative to the jerry can carriage task, it is suspected that even when the carry speed is matched over a set distance, carry speed may be greater in the stretcher carry as a result of the time delay associated with lifting the stretcher from ground level. Similarly, an object that more closely replicates the squat depth required in picking up the stretcher and the handle dimensions of a stretcher may improve prediction of stretcher carriage. Subsequently, we established two hypotheses. The first hypothesis is that a faster carry speed in the bilateral carries will better predict performance and replicate the physical and physiological demands of stretcher carriage at 4.5 km h^{-1} when compared with the bilateral carries at the same carry speed (4.5 km h^{-1}). The second hypothesis is that an object with a handle that more closely replicates that of a stretcher and requires a squat depth that more closely aligns with picking up a stretcher, such as a kettle bell, will better replicate the physical and physiological demands stretcher carriage compared with the jerry cans.

Subsequently, the aim of this study is to understand the impact of manipulating two parameters (object carried and carry speed) in bilateral carries (task-related predictive tests) on the ability to predict performance and reflect the physical and physiological requirements of a stretcher carry.

2. Methods

2.1. Participants

Seventy-three (49 males and 24 females) Australian Army soldiers, age 40.9 ± 10.2 yrs, stature 1.72 ± 0.09 m and mass 82.5 ± 15.7 kg participated in this investigation (Table 1). Participants freely provided written informed consent prior to the commencement of the experimental protocol, with ethical approval for the investigation provided by the Australian Defence Human Research Ethics Committee (Protocol 491-07).

2.2. Experimental design

Participants attended six assessment sessions that consisted of five carry tasks and a test of cardiorespiratory fitness. Each assessment session was conducted to volitional fatigue and separated by at least 48 h rest. Assessment order was balanced to reduce the influence of systematic bias and any learning effects. Prior to, and immediately upon the completion of each assessment participants performed to two isometric tests to measure hand grip and back-leg isometric strength.

2.3. Cardiorespiratory fitness

A multi-stage shuttle run test to volitional termination was used to estimate peak oxygen consumption (Léger and Lambert, 1982). Eight participants were unable to engage in running activities due to lower limb injury; for these subjects a sub-maximal cycle ergometer assessment was used to predict peak oxygen consumption from changes in cardiac frequency (Astrand, 1960; Åstrand and Ryhming, 1954). Their result was then used to compare the measured maximal oxygen consumption of each carry task to that predicted from the multi-stage shuttle run or maximal cycling test (%). Estimations of peak oxygen consumption using either Leger and Thivierge (1988) or Astrand (1960) are known to be well correlated.

2.4. Carry tasks

Participants conducted each of five carry tasks: a stretcher carry as part of a four-member team, two jerry can carries and two kettle bell carries. All tests were conducted until volitional fatigue, with performance for each of the carries capped at a maximum carry distance of 2000 m. The performance score was the distance carried to the nearest 5 m. Participants were provided with audio guidance for pacing, with a beep provided at the 10 m and 15 m marks to guide the carry speed. Audio guides were also provided in preparing to lift and lower the carried object. Participants wore disruptive pattern combat uniform (DPCU), boots and a 22-kg weighted vest (MiR Vest Inc., San Jose, CA, USA) to simulate a typical torso borne load worn by Australian Army soldiers in the conduct of training and operational duties. A standardised warm-up was conducted prior to each session.

In the Australian Army, personnel are expected to be able to extract a wounded soldier using a four person stretcher carry over a distance of 100 m. Through detailed job task analysis and subject matter expert guidance, 4.5 km h^{-1} was deemed to be an appropriate carry speed, ensuring safety of the casualty and an expedited extraction. The task was observed to be conducted in a team of four whereby participants regularly swapped carry hands to reduce fatigue. This task is termed a ‘criterion task’ as it is necessary to ensure that all personnel have the requisite physical capacity to complete this task. Subsequently, we established a simulation of this unilateral task (described below) from which we sought to

Table 1
Descriptive and physical characteristics of participants, stratified by sex.

	Group (n = 73)	Male (n = 49)	Female (n = 24)
Age (years)	40.9 (10.2)	43.4 (9.7)	35.9 (9.5)*
Stature (m)	1.72 (0.09)	1.77 (0.07)	1.63 (0.07)*
Body mass (kg)	82.5 (15.7)	90.3 (12.4)	67.2 (9.6)*
Beep test (level, shuttle)	8.05	8.11	7.02*
Predicted oxygen consumption (mL kg^{-1} min^{-1})	41.73 (7.21)	43.33 (7.07)	37.35 (6.51)*
Maximum heart rate (bpm)	180.9 (15.2)	181.4 (16.2)	180.5 (14.6)

Data are mean (standard deviation). * Denotes a significant difference between males and females.