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Development of a Valid Simulation Assessment for a Military Dismounted Assault Task

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ABSTRACT The Australian Defence Force is currently developing physical standards commensurate with job demands. Vital to this development process has been the accurate profiling of common military tasks. One such task required of all dismounted combat soldiers, an offensive assault on an enemy force, was the subject of in-depth profiling. In addition to overall assault performance, potential differences among patrol roles (scout, gunner, and flank) were investigated. Three different mock assaults of 100 to 150 m were performed by three patrols comprising qualified experienced infantry soldiers. Each soldier was fitted with a heart rate monitor and wore a global positioning device. Average assault duration was 6.5 minutes and required nineteen 7-m bounds performed on a 22-seconds duty cycle at 75% heart rate reserve and a work to rest ratio 1:4. Assaults conducted in more densely vegetated terrain resulted in significantly reduced ($p < 0.05$) bound distance, bound duration, and movement velocity. Results indicated significant performance differences ($p < 0.05$) among patrol roles for external load carried, heart rate response, bound duration, and distance covered while movement velocity was not different ($p > 0.05$). As a result of profiling the assault task, a valid simulation capable of assessing soldiers' physical capacity to perform this task was developed.

INTRODUCTION

Recently within the Australian military, there has been a large focus on the development of valid job-related employment standards. It is envisaged that the application of these standards will ensure personnel have the physical capacity commensurate with the performance of critical duties and tasks required of soldiers in their unique and often demanding working environment. Failure to perform such tasks to a minimum acceptable standard could put the individuals, their colleagues, and ultimately the full complement of personnel involved in an activity at increased hazard. These physical employment standards have also been aimed at providing a safer workplace by ensuring each soldier is physically capable of performing all necessary duties without risk of injury as a result of inadequate and/or non-job-related physical conditioning. Profiling the physical demands of common and essential military tasks is therefore an essential and logical part of establishing bona fide operational requirements.

A review of the training processes within the Australian Army and consultation with military staff indicated that the key tactical movement tasks required of the dismounted combatant included a defensive withdrawal under fire and an offensive assault. The withdrawal under fire is achieved using a break contact drill, a maneuver that is employed for withdrawing from an enemy when engagement is not desired. Breaking contact requires soldiers to alternate between providing covering fire and sprinting down a corridor of section members, with this rotation continuing until a safe separation distance has been achieved. The characterization of this task has previously been reported along with the development of a valid task simulation test.[1] However, the characterization of an offensive assault has not previously been reported in the literature. In its most basic sense, this task requires a group of soldiers to advance on, and assault an enemy position, while being engaged in a firefight, with the objective being the neutralization of the enemy threat. An offensive assault is achieved using coordinated fire and movement, which is characterized by repeated short sprints known as "bounds" where a soldier advances from one point of cover to the next, with subsequent bounds being separated by periods of relative rest where they apply fire onto the enemy position.

To accurately replicate the physiological demands of an activity such as fire and movement, it is imperative that one first understands and quantifies performance parameters and characteristics. In a team-sport environment, performance analysis may include such variables as distance covered during a match, the number of sprints above a given velocity, time spent within differing modes of movement, and rest durations. The information generated from these investigations can then be used to guide the physical conditioning programs and the development of activity-specific fitness testing procedures.[2–4] The technique and technology used to analyze performance are varied and have recently moved away from the traditional video-based player tracking and subsequent replay analysis to athlete-worn global positioning system (GPS) units as a more convenient and equally valid method to categorize movement during field-based sports.[5–7] The latter technique forms the basis of the current research.

Global positioning technology and equipment have evolved significantly over recent years, progressing from units capable of sampling at 1 Hz (one sample per second) to those claiming 15 Hz sampling. Although player-worn GPS devices have

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displayed valid and reliable results when tracking longer duration, continuous and low-intensity movements,[6,8,9] their validity when analyzing high-intensity, short-duration activities and repeated sprint situations has been questioned.[6,9] Validity of GPS-derived measures appears to be dependent on the speed of movement, the distance traveled during that movement, and the sampling rate of the device used.[9,10] Certainly, it appears that although GPS devices sampling at 1 Hz possess acceptable validity during continuous movement, they have very limited applicability within short-duration, high-intensity or repeat sprint activities. In previous work characterizing a break contact maneuver, video data were relied on to determine work to rest ratios and thus calculate time spent sprinting and resting, because of limitations in sampling rate (1 Hz) of the GPS equipment used.[1] The use of GPS devices with more frequent sampling rates has been shown to vastly improve measurement precision during activities consisting of high movement speeds and short durations.[10–12] This evolution in technology has provided greater confidence in captured data and given rise to a much more detailed understanding as to the nature of intermittent, short-duration, high-intensity sprint activities.

The purpose of this investigation was to establish the movement characteristics, activity parameters, and physiological demands of an offensive assault task (comprising fire and movement) performed by the dismounted combatant using a soldier-worn 10 Hz GPS technology. The outcomes of this task characterization will be used to guide the development of a suitable assessment capable of simulating the demands of the assault task. A test based on the movement characteristics and physiological demands of fire and movement within an assault would provide confidence that the minimum capacity commensurate with the performance of this common and critical dismounted combat task is assessed.

METHOD

Experimental procedures were approved by the Australian Defence Human Research Ethics Committee. All participants were fully briefed and provided written and informed consent. Twenty-three active service infantry soldiers (male) participated in the study (age [years] 22.8 [SD 3.1]; body mass [kg] 83.9 [SD 12.2]; height [m] 1.81 [SD 0.10]; estimated aerobic power from 20-m multistage shuttle test [$mL \cdot kg^{-1} \cdot min^{-1}$] 49.6 [SD 3.8]).

Offensive Assault: Task Description

The process applied to characterize the assault task occurred over two stages. First, subject matter experts of various ranks were consulted to determine the tactical requirements of the task according to standard operating procedures to define a realistic operational scenario under which the task would be performed. Second, a series of staged, in-field observations of fire and movement were conducted.

In evaluating the tactical requirements of the task, it was determined that a dismounted patrol will adopt a formation that is appropriate for the given terrain, vegetation, and enemy threat. Patrol members are positioned within these formations in accordance with their responsibilities, and this role-specific positioning necessitates differing requirements in the event that the patrol comes into contact with an enemy force. Scouts are positioned at the front of the patrol and are responsible for relaying information. Centrally located within the patrol are gunners, responsible for carrying the automatic machine guns. Positioned at the back of the patrol are flank soldiers tasked with providing rear security. If the patrol contacts or is contacted by an enemy force, they will shift formation to one known as extended line. Typically, scouts will hold position while the other patrol members move to realize this shift. The end result sees the patrol is seen in a single line perpendicular to the enemy position.

To advance in this extended line formation, movement is performed in a staggered manner, with only a portion of the group (approximately 40%) moving at any one time while the remainder waits in place and engages the enemy. Movement consists of getting up from a prone firing position, sprinting forward a short distance, and then readopting a prone firing position. For the purposes of this article, this will be referred to as a "bound." Closing on the enemy position is controlled so that alternate subgroups move to maintain a relatively straight assault line. Once the enemy position has been captured, a further distance of typically 20 m (depending on the terrain and vegetation) will be cleared to ensure no more enemy soldiers remain. This final piece of the assault is commonly referred to as the "fight through" and is conducted using a low crawl movement.

Procedures

Three patrols each consisting of seven to eight soldiers conducted three staged, mock assaults (herein referred to as "assault") on an enemy force under the instruction of their respective patrol commanders. The three assaults were performed within a 3-hour session with 30- to 40-minutes rest in between. Assault distances were advised by subject matter experts, were determined to accurately reflect typical engagement distances, and were presented to the patrols in a varied order and included the following: (1) 100-m flat terrain with sparse vegetation (100S), (2) 100-m flat terrain with medium-density vegetation (100M), and (3) 150-m flat terrain with sparse vegetation (150S). Patrol members wore fighting order, which was comprised of webbing, weapon, body armor, and helmet. Mean fighting order load was 24.4 (SD 4.9) kg, which approximated 28.9 (SD 4.9) % of body mass. External loads for scout and flank were not different to one another ($p > 0.05$). Gunners carried a significantly heavier ($p < 0.05$) absolute external load (31.9 [SD 4.5] kg) when compared to both scout (22.2 [SD 1.3] kg) and flank (21.9 [SD 2.1] kg). This significant difference ($p < 0.05$) remained when external load was expressed as percentage of body mass (gunner, 35.3 [SD 5.1] %; scout, 27.0 [SD 3.2] %; flank, 26.9 [SD 1.8] %).

To achieve a more valid representation of the task, patrol commanders were not constrained during the performance of the assault (i.e., allowing them to dictate the response they deemed appropriate) and each assault was conducted against a two-man enemy party and blank ammunition was used. The behavior of the enemy party was controlled to ensure parity between patrols regarding engagement distance, aggression shown, and enemy activity cessation. Although all care was taken to ensure consistent engagement distances, it was noted that contact was not initiated with each patrol at exactly the same point on the ground as each patrol was in a slightly different formation when it was engaged by the enemy, adding to the variability of assault parameters. However, although these variations affected reproducibility, they did add the element of realism to the assault.

Assault duration was defined from when the first weapon discharged through to the completion of the fight through. Variables of interest during the assaults included the following: (1) duration of assault, (2) distance covered during assault, (3) number of bounds performed, (4) distance covered during each bound, (5) duration of each bound, (6) rest interval between bounds, and (7) heart rate response.

Measurements

Before the conduct of the assaults, each participant was fitted with a GPS device (minimax S4, Catapult Sports, Melbourne, Australia) and a heart rate monitor (Polar Team^2 Pro, Polar Electro Oy, Kempele, Finland). The GPS device is a small, lightweight unit worn on the upper back, between the shoulder blades, in a custom garment. The unit captures and records data from numerous sensors, including a 10-Hz GPS and a triaxial accelerometer.

An automated bound recognition feature was developed and incorporated into the proprietary software program (LoganPlus, Catapult Sports). The identification of a bound occurred if the following conditions were met: (1) bound entry velocity threshold ≥ 1 m·s^{-1}, (2) bound exit velocity ≤ 0.2 m·s^{-1}, (3) duration within that velocity band ≥ 2 seconds, and (4) minimum interbound rest duration ≥ 2 seconds.

Analysis

Comparisons between variables of interest were performed using one-way analysis of variance and corrected for multiple comparisons (Bonferroni correction). These comparisons were conducted between assault types (100S, 100M, and 150S) and patrol roles (scout, gunner, and flank). Level of significance was set at 0.05. Data are presented as means and SDs of the means, unless otherwise stated.

RESULTS

Mean assault durations were 6.6 (0.6) minutes (range 6.0–7.2 minutes), 4.6 (1.3) minutes (range 3.8–6.2 minutes), and 8.7 (2.4) minutes (range 6.2–11.0 minutes) for the 100S, 100M, and 150S, respectively. When all assaults were combined, the mean duration was 6.6 (2.3) minutes, performed at a mean movement rate of 23 (5) m·min^{-1}. Mean bound cycle duration (inclusive of bound duration and interbound rest) was between 20 and 25 seconds for each of the assault types and the patrol roles. Although bound duration was observed to increase from scout to gunner to flank, only the comparison between scout and flank was found to be significantly different ($p < 0.05$). Although no significant difference was observed, the interbound rest interval was observed to decrease across the patrol roles from scout to gunner to flank. Bound velocity was found to be significantly greater in sparse vegetation compared to medium ($p < 0.05$) but not different between patrol roles ($p > 0.05$). Assault data are presented in Table I.

There was no difference observed in heart rate response among the assault types ($p > 0.05$). However, significant differences between patrol roles were present. For instance, the scout role was found to elicit a significantly lesser response than both gunner and flank ($p < 0.05$) while heart rate responses of gunner and flank were not different ($p > 0.05$). Heart rate data for the three patrol roles are shown in Figure 1.

To elucidate the nature and magnitude of inter-role performance differences observed during this study, total bound time, total interbound rest, and heart rate response were analyzed further. Total bound time was considered to be the product of the number of bounds and the mean bound duration, whereas total interbound rest was equal to the number of bounds minus one multiplied by mean interbound rest duration. Resulting from this analysis was the finding that while the flank soldier spent 50% more time than the scout and 26%

TABLE I. Descriptive Results for Performance Measures During Dismounted Military Assault Tasks

			Intrabound Characteristics			
Assault Type or Patrol Role	Distance (m)	Total Bounds	Distance (m)	Duration (second)	Peak Velocity (m s^{-1})	Interbound Rest (second)
100S	151.0 (6.5)*	18.3 (1.0)*	7.5 (0.3)*	4.4 (0.1)*	2.6 (0.1)*	19.3 (1.5)
100M	84.3 (3.9)*	13.3 (0.6)*	5.3 (0.3)*#	3.8 (0.2)*#	2.0 (0.1)*#	17.3 (1.0)
150S	224.5 (8.4)*	25.4 (1.0)*	8.1 (0.3)#	4.7 (0.2)#	2.6 (0.1)#	16.2 (1.0)
Scout	126.3 (11.8)§	16.9 (1.3)	6.4 (0.4)	3.9 (0.1)§	2.4 (0.1)	20.3 (1.7)
Gunner	149.5 (16.1)	18.7 (1.7)	6.9 (0.5)	4.2 (0.2)	2.4 (0.1)	18.1 (1.2)
Flank	181.8 (17.3)§	20.6 (1.9)	7.8 (0.5)	4.8 (0.2)§	2.4 (0.1)	15.6 (1.1)

Results for individual assault types and each patrol role investigated are shown. Data presented as mean values with the SEs in parentheses. Data in the same column sharing the same symbol are significantly different from one another ($p < 0.05$).

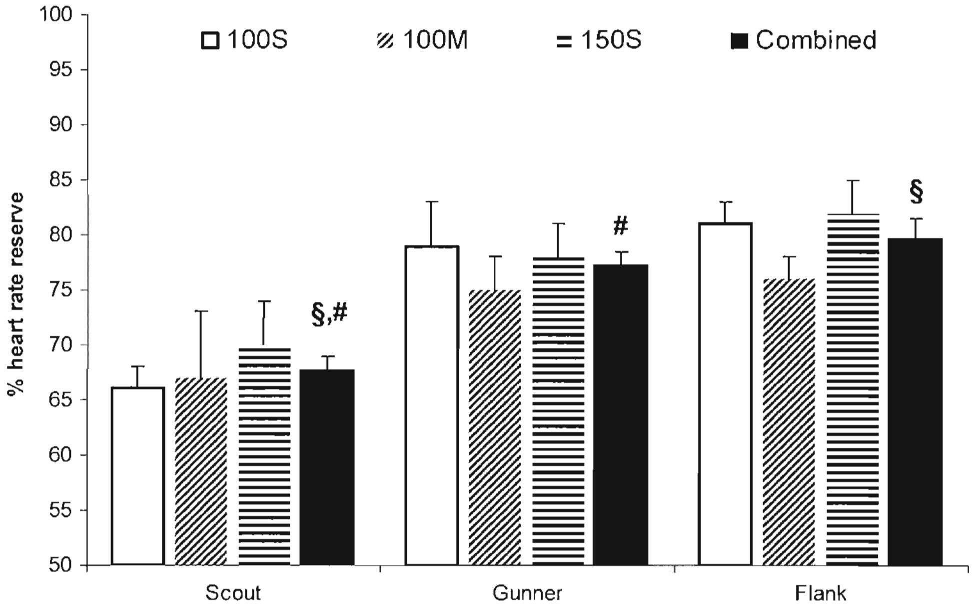

FIGURE 1. Heart rate responses of each patrol role during three dismounted military assault types (100S, 100-m sparse vegetation; 100M, 100-m medium-density vegetation; 150S, 150-m sparse vegetation) and the three assaults combined. Results are presented as mean percentages of heart rate reserve with error bars indicating the SE of the means. Statistical analysis was only conducted on the "combined" assaults. Columns sharing the same symbol are significantly different from one another ($p < 0.05$).

more time than the gunner engaged in bounding, the inter-bound rest remained relatively similar, with only a 5% between-role variation observed. This between-role difference is also reflected in the resulting work to rest ratios, which were 1:5, 1:4, and 1:3 for scout, gunner, and flank, respectively. Even though soldiers in the role of flank had a higher work to rest ratio and spent more time bounding than the gunner, the heart rate response was observed not to be different. This can be explained with the fact that gunners carried a significantly heavier external load. Given the flank role was found to carry an equivalent external load relative to the scout, but have a higher work to rest ratio and greater total bound duration, there was a significantly greater heart rate response observed for this role ($p < 0.05$).

As the scout was the first into enemy contact, this role was investigated further. Assault performance data are shown in Table II. Recalling that a typical fight through covers approximately 20 m, results support the validity of the engagement distance within the 100S and 150S assaults but highlights a shorter than expected distance for the 100M. This shortfall within the 100M assault is proposed to result from a difficulty in visual recognition by the enemy party (because of vegetation) and the abbreviated fight through observed. The positioning of the scout role also provided further insight into the assault movement rate because of the fact that on initial enemy contact, this role remains relatively fixed while other patrol members maneuver to form the extended line. Subsequent to extended line formation, the movement rate of an assault averaged approximately 20 $m \cdot min^{-1}$ during the fire and movement advance.

TABLE II. Descriptive Results for Performance Measures During Dismounted Military Assault Tasks for the Scout Role

Assault Type	Distance (m)	Total Bounds	Duration (Minute)	Movement Rate ($m \cdot min^{-1}$)
100S	119 (8)	16 (5)	6.6 (0.6)	18 (4)
100M	74 (11)	12 (3)	4.6 (1.4)	16 (4)
150S	187 (16)	23 (3)	8.7 (2.4)	21 (5)
Combined	126 (50)	17 (6)	6.6 (2.2)	19 (5)

Results for individual assault types and the three assaults combined are shown. Data are presented as mean values with the SD in parenthesis.

DISCUSSION

All military forces are trained to perform a dismounted assault of some variety, and there is much training literature and doctrine regarding the conduct of these assaults accessible to personnel. However, until the availability of suitable technology to analyze and describe task performance, this information has been based on the opinions and experiences of subject matter experts. To the best of our knowledge, this is the first time the movement characteristics and physiological demand of a dismounted assault on an enemy force have been explored using high-fidelity GPS technology. It was found that a typical 100-m dismounted assault took approximately 6 minutes to conduct and required the performance of a 6- to 7-m bound every 20 to 25 seconds at a work to rest ratio of approximately 1:4 and was completed using a low crawl over a short distance. This resulted in the task being performed at an average intensity of 75% heart rate reserve with efforts at over 85% observed. Differences regarding task performance between patrol roles have also been highlighted with a strong indication that the roles of flank and gunner are more physically demanding than scout.

A current U.S. Army Field Manual detailing soldier combat skills[13] describes an individual movement technique that is performed during enemy contact which is the fastest method of movement from one point of cover to the next. The Field Manual terms this movement "rushing," and it is essentially the same as the "bounding" movement described in this study. Although there is no definitive distance or number of steps prescribed, it states that a "rush" should be limited to 3 to 5 seconds in duration to prevent enemy machine gunners or riflemen from tracking a moving soldier. The findings of this study support this.

The majority of military physical fitness assessment batteries used to establish employment/deployment suitability test only aerobic power and local muscle endurance, with assessments such as distance runs with no external load and body mass resisted exercises (e.g., push-ups and sit-ups) commonly being used for this purpose. Noticeably missing from these testing batteries is an assessment of short-duration, high-intensity repeat sprint performance. In addition to this, the majority of fitness assessments are conducted in lightweight clothing (shorts, t-shirt, and running shoes), which is not reflective of the considerable external load typically carried during the performance of dismounted soldiering tasks. Given that the successful performance of the assault task characterized in this study is fundamental to the role of dismounted soldiers, physical conditioning and assessments should emphasize this attribute. Therefore, the failure to include a repeated, short-duration, high-intensity component to physical fitness testing regimes and replicate external load carriage requirements is of concern particularly if establishing a soldier's fitness for duty is deemed paramount.

Using task characterization results identified in this study and advice received from subject matter experts, a fire and movement simulation was developed. The development process took into consideration a number of factors, including assault duration, engagement distance and assault movement rate, and the role(s) on which to model the simulation. It was critical that the simulation possessed a high degree of validity, was safe for soldiers to perform, and could be easily implemented.

To realize service-wide acceptability and satisfy scientific integrity and defensibility, it was critical that the simulation appear logical and accurately predict task performance. Thus, during the formulation of the simulation, four forms of validity were considered: content validity, the degree to which the simulation represents the physiological characteristics of the task; criterion validity, a demonstrated relationship between the simulation and a direct measure of task performance; construct validity, the simulation measures attributes necessary for successful task performance; and face validity, the appearance that the simulation reflects the task.

Subject matter experts advised an engagement distance of 100 m as a minimum standard, and this was used as a base on which to develop the simulation. From the six 100-m assaults conducted, the average duration was 5.6 minutes and comprised 16 bounds of approximately 6.5 m at a movement rate 20 $m \cdot min^{-1}$. As dismounted combatants may be required to perform each of the roles within a patrol, it was decided to use gunner and flank as the performance standard because of their higher overall demand.

The resulting simulation comprises sixteen 6-m bounds (for a total of 96 m) followed by an 18-m leopard crawl (to simulate the fight through). Considering the observed movement rate and work to rest ratio, bounds were to be performed on a 20-s cycle, with each bound to be completed within 5 s, with the leopard crawl to be completed within 35 s. The simulation has a total duration of 5.9 minutes. Although each bound is commenced from a prone firing position, as is the case during task performance, the finish position has been altered for reasons of safety. During task performance, each bound normally ends with soldiers diving to the ground to assume their new fire position. However, within the simulation, each bound will finish in a kneeling firing position before adopting the prone position ready for the next bound. For ease of implementation and standardization, the assessment should be performed on a level grassed area, use a 24-m layout (constituting 4 × 6-m bounds), be controlled by a custom-made digital cadence, and require an external load equivalent to fighting order to be worn. The result is a task simulation possessing high degrees of content, criterion, construct, and face validity and is safe for participants.

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