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THE CONSTRUCT VALIDITY AND RELIABILITY OF THE OMNI-RPE SCALE IN A MILITARY POPULATION

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14. ABSTRACT

The construct validity and reliability of the OMNI-Walk/Run RPE scale (OMNI scale) in a military population has not currently been established. Nine active-duty military men (21 ± 5 years; 77 ± 6 cm; 79 ± 13 kg; VO2peak: 52 ± 4 mL• kg-1• min-1; HRmax: 192 ± 12 bpm) completed three stages of incremental work rates (walk, jog, run) across four identical study trials conducted over two study days. Physiological status was assessed using indirect calorimetry and a commercial heart rate monitoring system. Rating of perceived exertion (RPE) values were collected at the mid point of steady state for each work rate. RPE values were significant and correlated to % HRmax ($r = 0.82$; $p < 0.00$) and % VO2peak ($r = 0.84$; $p < 0.00$) throughout incremental work rates and across study days and trials. RPE and RER was not associated ($r=0.40$). The OMNI RPE scale showed significant test-retest reliability across testing days (ICC = 0.90) and trials (ICC = 0.90). The OMNI scale possesses construct validity with respect to an assessment of work strain and is a reliable work rate measurement tool for use in a military population in a controlled laboratory setting.

15. SUBJECT TERMS

Rating of Perceived Exertion (RPE); OMNI-walk/run rating of perceived exertion scale; performance monitoring

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EXECUTIVE SUMMARY

Introduction: Military leaders are in need of minimally invasive, cost and resource effective monitoring tools to help optimize training and maintain mission readiness. Rating of perceived exertion (RPE) measurements have been validated to subjectively quantify physical strain to enable the monitoring of training status and are inexpensive and minimally invasive. The OMNI-Walk/Run RPE scale (OMNI scale) is a RPE measurement tool for military consideration. The OMNI scale has been adapted for use across several environments, exercises and populations. Validity and reliability of the OMNI scale for use in an active military population has not been established. The purpose of the current study was to determine the construct validity of the OMNI scale as compared to physiological measurements and reliability across days and trials in a laboratory setting.

Methods: Nine active-duty military men (mean ± SD; age: 21 ± 5 years; height: 177 ± 6 cm; body mass: 79 ± 13 kg; body fat: 22 ± 5%; VO_{2peak}: 52 ± 4 $mL \bullet kg^{-1} \bullet min^{-1}$; HR_{max}: 192 ± 12 bpm) completed three stages of incremental work rates (walk, jog, and run) repeated during four trials over two days. Data was averaged over the 3-4 min steady-state periods at each work rate. Rating of perceived exertion (RPE) measurements with the OMNI scale were collected at the mid-point of steady state for each work rate. Physiological variables measured by indirect calorimetry (TrueOne 2400®, ParvoMedics; Sandy, UT) and a commercial heart rate monitoring system (Polar T31® Heart Rate Sensor; Kempele, Finland) were used to assess the OMNI scale's construct validity. Physiological measurements of percent of maximum heart rate (%HR_{max}), percent of peak oxygen consumption (%VO_{2peak}), and respiratory exchange ratio (RER) were compared to RPE values using Pearson's correlation coefficient across test days and trials. Intraclass correlation coefficients (ICC) were used to determine test-retest reliability across days and trials of the OMNI scale in military personnel.

Results: Rating of perceived exertion had a significant and strong correlation with % HR_{max} ($r = 0.82$; $p < 0.00$) and % VO_{2peak} ($r = 0.84$; $p < 0.00$) throughout incremental work rates and across days and trials. Respiratory exchange ratio was weakly associated with OMNI RPE scores ($r=0.40$) across days and trials. The OMNI RPE values showed significant test-retest reliability across testing days (ICC = 0.90) and trials (ICC = 0.90).

Conclusions: The OMNI scale possesses construct validity with respect to an assessment of work strain and is a reliable work rate measurement tool for use in a military population in a controlled laboratory setting. Further investigations of the OMNI

scale are need across a variety of training modalities and environments, to include those specific to the military, for widespread use and acceptance by the warfighter.

INTRODUCTION

Military leaders prioritize optimum performance of their warfighters, looking to utilize minimally invasive monitoring tools and techniques to minimize training interruptions while maintaining mission goals. Current efforts are focused on simple and reliable tools and techniques to efficiently and effectively monitor warfighter training intensity (1). Several techniques and tools available to monitor physiological status include metabolic carts, heart rate monitors, and body temperature sensors. Output variables measured with such methods are directly related to increased workload or intensity of exercise, specifically measurements of oxygen consumption (VO_2), heart rate (HR), and body temperature. These physiological variables can be correlated to increased perceptions of workload (2). Unfortunately, many of these physiological monitoring techniques and tools may not be practical for use in military settings due to the cost and/or skill required to operate and maintain the tool or sensor, as well as usability in the field environment.

Rating of perceived exertion (RPE) is a subjective, quantitative measurement of physical effort and strain that has been used to monitor athlete training load with the goal of optimizing performance and preventing undue strain to help mitigate injury risk (3-5).These quantitative measurements were developed to incorporate personalized feelings of physical stress, discomfort, and fatigue in response to the current physical activity state (6). Rating of perceived exertion scales may be a practical option for use in military training scenarios since they are inexpensive, minimally invasive, require little training for use, and add minimal physical load on the warfighter.

Currently, several RPE scales are commonly used to include the commonly used Borg RPE scale. The Borg RPE scale uses numbers from 6 to 20 with intermittent descriptive terms to capture overall exertion perceptions at each level of rating from rest through vigorous exercise (2). The scale range (from 6 at rest/no exertion to 20 a full sprint/maximum exertion) was developed to correlate with HR increments in an active, healthy adult population (7). Borg RPE ratings were developed to be multiplied by a factor of 10 to allow easy association with the equivalent HR estimated at that effort level. Specifically, a score of 6 on the Borg RPE scale corresponds to 60 bpm HR, which is an approximate resting HR in healthy average adults (2), a 7 corresponds to 70 bpm, and so forth.

Since its inception, there have been many modifications to the Borg scale. Chen et al. (8) identified four variations of Borg RPE scales. One such variation is the Borg category-ratio 10, or CR10 scale, which utilizes a range from 0 to 10 accompanied by descriptive terms (2, 7). The Borg CR10 scale was developed, not based on

physiological variables, but rather on psychophysical or sensory principles so that perceived intensity from RPE measurements could be compared during different activities or conditions (2). For example, RPE measurements of breathlessness could be compared with RPE measurements of aches in the extremities.

The Borg RPE scales have been studied across activities (2-5, 7) and populations, including warfighters (2, 9). Arney et al. (10) compared the Borg RPE scale to the Borg CR10 scale in recreationally athletes in a variety of athletic disciplines and found that the RPE measurements were similar across scales. Most commonly, the Borg RPE scales have been compared to HR in endurance-type activities (3-5, 9). During soccer (3), swimming (4), Canadian football (5), and military training (9), higher RPE measurements have corresponded to higher HR measurements. However, a meta-analysis showed varying correlations between RPE and some physiological variables to include VO_2, HR, and percent of peak oxygen consumption (% VO_{2peak}), based upon differing genders, activities, and the specific Borg RPE scale used (8).

The OMNI-Walk/Run RPE scale (OMNI scale) is a more modern scale developed in the early 2000s by RJ Robertson (11) for use with youth and adolescent populations. The OMNI scale was developed in response to observed difficulty relating to and using terminology in then available RPE scales. The OMNI scale is simple; it utilizes a range of 0 to 10 with descriptive terms in combination with images to measure RPE during strenuous exercise. “OMNI” is an abbreviation for omnibus, which in the context of an RPE scale means the scale properties can be generalized (12). Several versions of the OMNI scale have been developed with varying images specific to the age of the user (e.g. adult or child) and the activity being assessed (e.g. resistance exercise, cycling, and bench stepping) (12-17), therefore making it more relatable across users and activities.

Previous studies have demonstrated the validity of the OMNI scale compared to physiological variables including HR, respiratory exchange ratio (RER), and/or VO_2, across general adult and youth populations (13-15) and activities including resistance exercise (16), cycle ergometer exercise (12), and bench stepping (17). Research outcomes have shown strong relationships between RPE and HR and between RPE and VO_2 (12-15, 17). In general, relationships observed between RPE and HR and RPE and VO_2 have been linear (12-15).

Similar to other RPE scales, the OMNI scale is minimally invasive and cost effective for use in military populations and elsewhere. The OMNI scale’s versatility and ease of use are attractive for use in the military. The 0-10 scale makes the OMNI scale simple to use with little investment in training required. Additionally, the use of scale

images aid in streamlining the interpretation with associated numerical RPE values. Ideally, the OMNI scale images can be designed to replicate the multiple modes of military activities during a training scenario to specify the scale, thus making it an efficient technique for monitoring training status.

Regardless of the type or style of method used, any tool utilized to monitor military training intensity must be valid and reliable. Specific to validity, construct validity measures the ability of a tool or technique to accurately measure what it intends to measure and allows inferences to be made about measurements and possible correlations (18). Test-retest reliability confirms the consistency of a measurement tool or technique over repeated uses (18). There are several attributes to reliability including stability, which includes the reliability of measurements over number of different testing bouts within the same day and/or over different days of use (18).

Current literature lacks evidence for the construct validity and reliability of the OMNI scale for use in an active military population, environment, and training activities. Previous work has shown the validity of the OMNI scale in a general young adult population for walking and running under laboratory conditions (13). Building upon these findings, it is crucial to first determine the validity of the OMNI scale in a military population under similar controlled laboratory conditions, before assessment in a more military relevant field scenario. Therefore, the purpose of the current study was to determine the OMNI scale's construct validity as compared to physiological measurements of percent of maximum heart rate (% HR_{max}), % VO_{2peak}, and RER, and to determine the OMNI scale's across-day and across-trial reliability in military personnel in a laboratory setting.

METHODS

The construct validity and test-retest reliability of the OMNI scale was assessed using a within-subjects design. Participants completed three test days over the course of study with at least one recovery day separating each test day. Initially, participants completed baseline testing (Day 0) to become familiarized with study procedures. During the subsequent two test days (Day 1 and 2), participants completed two study trials per day during which systematic RPE and physiological measurements were collected.

Recruitment Methods and Participants

Nine active-duty military men were recruited from the US Army Natick Soldier Systems Center (NSSC; Natick, MA) and participated in this study. Potential study

participants were formally briefed on the protocol requirements and provided written informed consent. Data collection began after informed consent was obtained. This study was approved by the US Army Medical Research and Materiel Command's (USAMRMC) Institutional Review Board (IRB) and all data collection occurred at the US Army Research Institute of Environmental Medicine (USARIEM; Natick, MA).

Test Sessions

During the three days of study testing, individuals were instructed to refrain from exercise, and caffeine and nicotine intake for at least 24 hours prior to testing. Participants reported to the laboratory for all test days fasted (>10 hours) at a consistent time between 0630 and 0800 and were instructed to wear standard physical training attire (shorts, t-shirt, and sneakers). Environmental conditions within the laboratory were monitored by an indoor weather station (510 WeatherHawk, WeatherHawk, Logan, UT; CR-1000) and were controlled to maintain temperature between 18-22 ºC and relative humidity between 40-70 ± 5% across all test days.

Baseline. Baseline data collection was initiated to characterize the study population and familiarize the participant with the prescribed work rates. Anthropometric measurements included: a semi-nude body weight using a remote indicator scale (Doran DS1650; St. Charles, IL), height using a stadiometer (Seca 213; Hamburg, Germany), and body composition using a dual energy x-ray absorptiometry device (DEXA, DPX-IQ, Lunar Corporation; Madison, WI). Fitness was assessed through VO_{2peak} using indirect calorimetry measured with a commercially available metabolic cart (TrueOne 2400®, ParvoMedics; Sandy, UT). In preparation for the VO_{2peak} testing, participants were fitted with a mouthpiece and headgear connected to the metabolic cart and a commercial HR monitoring system (Polar T31® Heart Rate Sensor; Kempele, Finland).

Peak oxygen consumption was assessed using a continuous uphill treadmill running protocol (19), which began with a 5 minute warm-up period. Participants walked on the treadmill at a 0% grade for 2 minutes at 1.3 m/s, and then for 3 minutes at the running speed of 2.2-2.9 $m \cdot s^{-1}$ (dependent upon the participant's average self-reported 2-mile run time). Following the warm-up, the speed of the treadmill remained the same but the grade increased to 5%. The grade was then increased by 2.5% every two minutes until voluntary exhaustion. It was determined that VO_{2peak} was achieved if there was a plateau in the participant's oxygen consumption (< 2 $mL \cdot kg^{-1} \cdot min^{-1}$) following an increased workload, heart rate in excess of age-predicted maximum, and/or a respiratory exchange ratio exceeding 1.0.

The VO_{2peak} values were used to determine standardized work rates (walk: 20-40% VO_{2peak}; jog: 45-55% VO_{2peak}; run 60-75% VO_{2peak}) based upon the American College of Sports Medicine Guidelines for aerobic training (19) for Days 1 and 2. Participants were familiarized with the calculated work rates (~5 min at each work rate stage) to complete baseline testing.

Test Trials. Data collection was initialized on Day 1 with fasted weight recorded upon arrival then the participant was fitted with the metabolic cart mouthpiece and headgear and HR monitoring chest belt. Participants then completed a 3-min warm-up at a predetermined work rate of 3 mph walk on the treadmill.

Days 1 and 2 consisted of two trials each separated by a 15-minute seated rest (total of 4 test trials/participant). Exercise order and work rates were identical across test days and trials. Each test trial consisted of the three stages of incremental work rates (light to moderate): walk (20-40% VO_{2peak}), jog (45-55% VO_{2peak}), and run (60-75% VO_{2peak}) on a treadmill. Participants performed at the prescribed work level for a total of ~15 min, to include a warm-up to reach steady-state period (~5-7 min). Data was averaged over 3-4 min steady-state periods at each work rate.

Once the participant completed a designated work rate, the treadmill speed was increased to the predetermined speed to elicit the VO_2 corresponding to the next work rate stage. Similarly, data collection was initiated at steady-state for 7 continuous minutes. Data was collected across all three work rate stages (i.e. walk, jog, run) in a similar manner to complete Trial 1. At completion, mouthpiece and headgear equipment was removed and the participant was allowed to rest, rehydrate, and use the bathroom for 15 min before the start of Trial 2. Participants began Trial 2 within 15 bpm of their resting heart rate. Trial 2 directly replicated Trial 1, to include the same incremental increase in work rate (i.e. walk →jog→run) and identical timing. Upon finishing Trial 2, participants completed testing for Day 1.

Participants returned on a non-consecutive day (e.g. Day 1 = Thursday; Day 2 = Tuesday) to complete Day 2 data collection. Participants replicated physical activities, work intensities (speed and grade), and timing completed on Day 1 (two incremental test trials with a 15 min rest break between). Testing participation was complete at the conclusion of data collection Trial 2 on Day 2.

Rating of Perceived Exertion Scale. Rating of perceived exertion assessments were collected at minute 4 of steady-state data collection (mid-point) for each work rate stage (walk, jog, run). Measurements were collected by study team members using a colored OMNI scale (Figure 1) affixed to a clipboard for ease of viewing by participants

during exercise. During baseline familiarization and prior to testing each day, the use of RPE was explained to participants and their understanding was assessed and verified. Participants were instructed to use their hands/fingers to relay their RPE score at the time of visual scale prompt. Scores were then verbally repeated to the participant by a study team member for confirmation prior to recording the RPE score for that work rate stage.

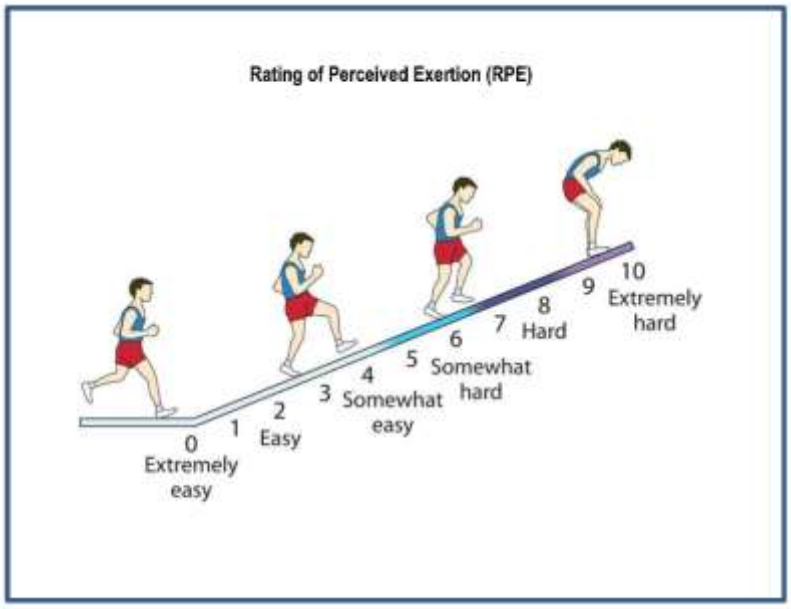

Figure 1. OMNI-Walk/Run rating of perceived exertion (RPE) scale (13). The OMNI-Walk/Run RPE scale features a numerical scale accompanied by descriptive terms and images to allow users to assess their RPE. The scale used in this study pictured an adult runner, however, modifications to the OMNI scales vary dependent upon use in different populations and activities (12-17).

Statistical Analysis

Baseline participant characteristics were compared using *t* tests. Metabolic data was averaged over 15 s intervals and the first and last 90 s of data collected were removed from the analysis. The remaining 3-4 min of data was averaged to represent variables for that designated work rate stage.

Missing RPE data (1.62%) were determined at random using Little's MCAR test (20) (MCAR, p = 0.948) and added to the data set using expectation-maximization (21). Variable outliers were determined using median absolute deviation (MAD) (22). Values greater than 3*MAD (4.66%) were removed as outliers. Pearson's correlation coefficients were calculated for the RPE measures between each physiological variable across each trial. Intraclass correlation coefficients (ICC) were calculated for the RPE measures across each test day and trial (23).

Statistical analyses were conducted using SPSS® (SPSS® Version 24, IBM®; Armonk, NY) and Excel® (Microsoft® Excel® 2013, Microsoft Corporation; Redmond, WA). Data are presented as mean ± SD unless otherwise noted. Values are deemed statistically significant at $p \leq 0.05$.

RESULTS

Nine active-duty military men (mean ± SD; age: 21 ± 5 years; height: 177 ± 6 cm; body mass: 79 ± 13 kg; body fat: 22 ± 5%; VO_{2peak}: 52 ± 4 mL• kg^{-1}• min^{-1}; HR_{max}: 192 ± 12 bpm) completed testing across four trials at three incremental work rates, over two testing days. Participant characteristics were normally distributed with no outliers observed.

Physiological variables and RPE values are presented across the three incremental work rates measured. Mean (± SD) for RPE, HR, VO_2, and RER for each test trial and day are shown in Table 1.

		Trial	***RPE***	***HR*** ***(bpm)***	***VO_2*** ***($mL \cdot kg^{-1} \cdot min^{-1}$)***	***RER***
Walk	Day 1					
		T_1	1.4 ± 0.5	101 ± 6	15.42 ± 1.80	0.83 ± 0.04
		T_2	1.6 ± 0.5	114 ± 10	15.92 ± 1.45	0.80 ± 0.03
	Day 2	T_1	1.3 ± 0.5	103 ± 6	14.96 ± 1.48	0.85 ± 0.04
		T_2	1.7 ± 0.5	114 ± 9	15.08 ± 1.51	0.80 ± 0.03
Jog	Day 1					
		T_1	3.0 ± 0.7	146 ± 12	29.15 ± 3.10	0.88 ± 0.04
		T_2	3.3 ± 0.8	154 ± 14	29.31 ± 3.12	0.84 ± 0.03
	Day 2	T_1	2.8 ± 0.9	144 ± 10	28.36 ± 2.47	0.88 ± 0.04
		T_2	3.3 ± 1.1	154 ± 15	28.98 ± 2.88	0.85 ± 0.03
Run	Day 1					
		T_1	5.6 ± 1.3	170 ± 14	35.52 ± 3.94	0.91 ± 0.03
		T_2	5.9 ± 1.5	174 ± 16	35.92 ± 4.11	0.89 ± 0.03
	Day 2	T_1	5.6 ± 1.6	171 ± 14	35.40 ± 3.54	0.91 ± 0.04
		T_2	6.2 ± 1.9	177 ± 13	35.68 ± 3.90	0.89 ± 0.04

Table 1. Physiological status measurements and Ratings of Perceived Exertion (RPE) across test day and trial. RPE, rating of perceived exertion; HR, heart rate; VO_2, oxygen consumption; RER, respiratory exchange ratio.

The reported OMNI scale RPE measurements were found to significantly correlate with % HR_{max} and % VO_{2peak} (both $p < 0.00$) across all four test trials (Figure 2 A and B). A correlation was identified between RPE and RER on Day 1 Trial 1 ($p = 0.05$), Day 1 Trial 2 ($p < 0.00$), and Day 2 Trial 2 ($p < 0.00$), but not for Day 2 Trial 1 ($p = 0.20$) (Figure 2C). Correlation values across trial and days for RPE and physiological variables are shown in Table 2.

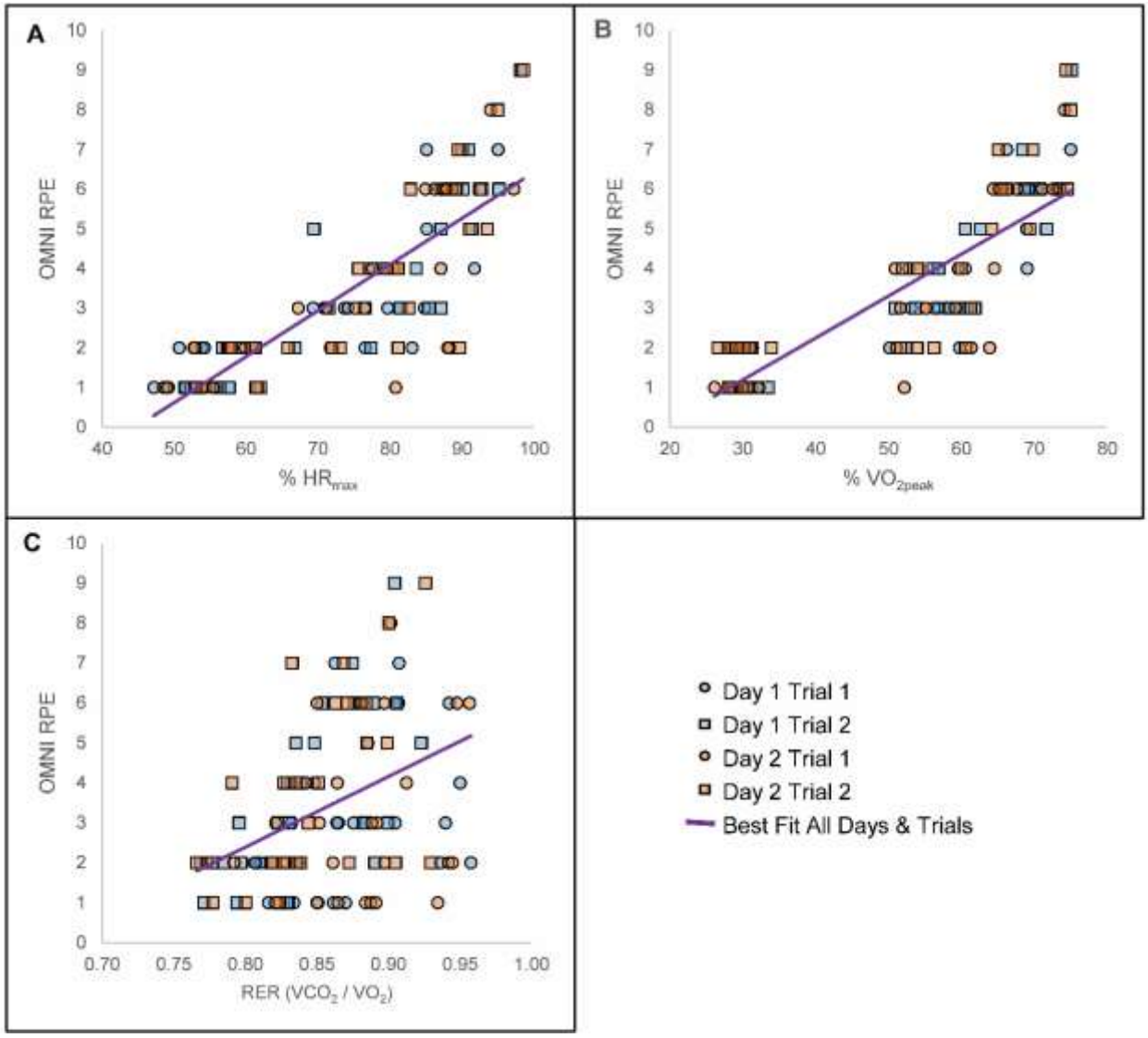

Figure 2. Relationship of the OMNI scale rating of perceived exertion (RPE) to physiological status variables. Data represents all test days and trials with a best fit line. Relationship between OMNI RPE and (**A**) % HR_{max}, (r=0.82) (**B**) % $VO_{2max,}$ (r=0.84) and (**C**) RER (r= 0.40) across test day and trial. OMNI RPE, OMNI rating of perceived exertion scale; % $HR_{max,}$ percent of maximum heart rate; % VO_{2peak}, percent of peak oxygen consumption; RER, respiratory exchange ratio.

	Trial	*% HR_{max}*	*% VO_{2peak}*	*RER*
Day 1	T_1	0.84*	0.85*	0.38*
	T_2	0.85*	0.87*	0.65*
Day 2	T_1	0.78*	0.83*	0.26
	T_2	0.83*	0.83*	0.55*

Table 2. Correlation of rate of perceived exertion (RPE) to physiological variables across test days and trials. % $HR_{max,}$ percent of maximum heart rate; % VO_{2peak}, percent of peak oxygen consumption; RER, respiratory exchange ratio, * indicates correlation of $p \leq 0.05$.

Intraclass correlation coefficient calculations showed high reliability across days (ICC = 0.90) and trials (ICC = 0.90). The ICC values depict consistency across trials and days for the OMNI scale for this study population and setting.

DISCUSSION

Use of the OMNI scale proved to exhibit construct validity and was reliable across test-trials and days in a military population under controlled laboratory conditions. Associations between RPE and % $HR_{max,}$ and % VO_{2peak} are consistent with relationship strength observed by others (8). These findings support the validity of using perceived exertion scales as an index of exercise intensity. Data correlated across multiple study days and trials show scale reliability under a controlled laboratory setting. These findings support the use of the OMNI scale as an accurate measurement tool to monitor work effort in a young military population performing endurance-type activities (e.g., walking and running) under controlled conditions.

Although several available RPE scales exist (8), the OMNI scale was investigated herein for ease of use, simplicity and efficiency of execution in a military population. The validity and reliability of the OMNI scale has been reported across various populations and activities (12-17), but not specifically for military populations. The OMNI scale validity outcomes have featured positive linear correlations between RPE and HR and VO_2 (12-15, 17). Of these studies, two (13, 14) specifically report strong positive linear relationships between RPE and % VO_{2peak} (r= 0.41- 0.86) similar to current findings reported herein. Findings from this study report positive linear associations between OMNI RPE and % VO_{2peak} (r=0.84) as well as between RPE and % HR_{max} (r=0.82), both within the published validation literature for the OMNI scale across diverse populations. The third physiological value examined, RER, showed significance across three of the four trials assessed, however overall it was not found to be closely correlated to RPE values throughout incremental work intensities of testing (r=0.40). Reported outcomes are similar to others reporting incongruent findings across various work rates and populations when comparing OMNI RPE values to RER (13, 14).

Outcomes from this study compared RPE values to % VO_{2peak} and % HR_{max} versus of standard measurement of VO_2 and HR values as a more modern approach to compare and the interpret OMNI scale values. Current guidelines from the American

College of Sports Medicine suggest monitoring and prescribing aerobic training intensity through use of a percent of VO_{2max} (19). In addition, use of % HR_{max} and % VO_{2peak} allows for systemic comparisons across individual participants with variations in fitness levels and thereby HR_{max} and VO_{2peak} measurements. The OMNI RPE values aligned with increased exercise intensity as assessed by standard physiological status markers (e.g., % VO_{2peak} and % HR_{max}) measured by indirect calorimetry during exercise. The OMNI scale proved to be a valid and accurate tool to monitor the intensity of work effort in a military population under a controlled laboratory setting.

While the positive linear correlations between OMNI scale values and % HR_{max} and % VO_{2peak} support the use of the OMNI scale for estimating exercise intensity, there was considerable intra-subject variability in OMNI scores as reported in the literature (8). As illustrated in Figure 2A, OMNI values of 2 were reported despite the exercise producing heart rates ranging from 50 to 90% HR_{max}. Likewise, the same OMNI values stratified to a group exercising at 30% VO_{2peak} and another exercising at 50-60% VO_{2peak} (Figure 2B). This is an inherent limitation of using a perceived exertion scale due in part to natural between-subject variability and perhaps the study design.

Use of RPE values to infer the estimated metabolic cost of the activity appears to be related to familiarity with the activity intensity performed and scale use (17, 24). Findings reported herein may be explained by such influences on RPE ratings, specifically at lower intensity activities in early study trials. Participants were not trained endurance athletes and therefore were naïve to rating exercise exertion prior to the study. Although the current study incorporated a participant familiarization period with work load and use of the OMNI scale at baseline, the length of time may not have been sufficient to overcome the anticipation bias experienced with progressive increases in exercise intensity (17). Although the OMNI scale overall proved to be a valid and accurate tool to monitor the intensity of work load across activities in a military population participating in a laboratory study. Future work may benefit from a more involved participant familiarization period to include sufficient time spent in work load study activities and utilizing RPE scales to provide accuracy at all intensity levels.

Providing evidence of the OMNI scale's construct validity, or how accurately the RPE scale measures work rate, builds confidence the data collected is providing the intended output. However, proving a research tool or technique is reliable is vital to ensure day-to-day, or subject-to-subject differences are real and not a factor of tool inconsistency over time. This study was designed to build in a measure of reliability utilizing a within-subject design and repeated test trials per study day and across study days. Intra-tool reliability was shown to be consistent across test days (ICC = 0.90) and trials (ICC = 0.90). The use of the OMNI RPE scale to monitor work rate was consistent thereby proving reliability as a work rate assessment tool in the military population under controlled conditions.

Although attempts were made to optimize study design, there are some limitations to consider. Ideally, work rates could have been randomized to avoid bias. However, progressive work rates were chosen as they are more time-efficient for use in

staged laboratory testing, and more relatable to training protocols. Aerobic exercise typically involves progressively increased intensity including the use of a warm-up period to optimize acute muscular and cardiovascular benefits (25). Incremental work rate is a common strategy to progress from moderate to high intensity when approaching the end of a training session, competition, or testing period (26). Finally, it is important to note the nature of the study population, overall the sample size was small and all male of a similar age group. Future studies should investigate a larger sample of the military population, over a wider age range, to include females.

To the best of our knowledge, this is the first study to investigate the construct validity and reliability of the OMNI scale as tool to monitor work rate effort for the modern warfighter. Use of a monitoring tool, like the OMNI scale, could help cadre better monitor and adapt training and recovery of their soldiers. Laboratory findings reported herein may be built upon through future research efforts to explore the use of the OMNI scale across a variety military-type activities and environments. Although further work is needed, there is a potential that regular use of the OMNI scale as tool to monitor work effort in warfighters during training may aid in optimizing performance to ultimately support mission readiness.

Conclusions

The findings of the current study support the construct validity and reliability of the OMNI scale for quantifying perceived work intensity in activities relevant to the military population in a laboratory setting. The OMNI scale is a practical, cost-effective measurement tool for quantifying training effort and intensity. Further work will aid in a better understanding of the usability across training modalities and populations within the military.

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