DRDC-RDDC-2017-P010

Determination of Orientation and Practice Requirements When Using an Obstacle Course for Mobility Performance Assessment

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Objective: Determine effect of orientation (introduction and familiarization) and practice (repeated performance) on human performance under various load conditions as assessed by an obstacle course.

Background: Obstacle courses are commonly used as screening tools by military, police, and firefighters or to assess human capabilities and the effect of wearing personal protective equipment (PPE) and other occupationally necessary equipment on mobility task performance. Unfortunately, little is formally documented about the effect of orientation and practice on performance outcomes of obstacle or mobility courses being used.

Method: Forty-eight participants were recruited from the Canadian Army Infantry and Combat Engineer population. Participants either received regular or extensive orientation of the course before completing it. Following orientation, participants completed the course five consecutive times while wearing their PPE with full fighting order (FFO) and five consecutive times while wearing no PPE and non-FFO across a five-day period (maximum two runs per day), with ensemble presentation order counterbalanced. Total course completion time and individual obstacle completion times were measured for each run of the course.

Results: While wearing FFO, participants continued to decrease the time required for completing the course; however, while wearing non-FFO, time to course completion did not significantly change over the five runs. There were no differences in course completion times for the regular and extensive course orientation groups.

Conclusions: Considerations required to mitigate orientation and practicing effects can differ depending on type or complexity of load condition. While wearing FFO, practicing effects can introduce undesired confounding factors into data collection.

Application: Any practice runs on an obstacle course prior to its use as an assessment tool should focus on the loaded (e.g., FFO) condition because improvement on loaded runs is likely transferred to unloaded, but this does not apply in the reverse.

Keywords: personal protective equipment, mobility, performance, occupational tasks, military, Army

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HUMAN FACTORS
Vol. XX, No. X, Month XXXX, pp. 1–11
DOI: 10.1177/0018720816686611

INTRODUCTION

Obstacle or mobility courses are used in athletic training, the military, and other occupations to train and evaluate individuals. For example, obstacle courses are used as physical screening tests for firefighters (Mamen, Oseland, & Medbo, 2013; Sheaff et al., 2010) and police officers (Anderson, Plecas, & Segger, 2001; Jackson & Wilson, 2013). In the military, obstacle courses are commonly used in basic training as a means of improving physical fitness, confidence, and coordination. In addition to using obstacle courses for physical training and evaluation of individual performance, obstacle courses are also commonly used to assess the influence of tactics and equipment on the performance of job-related tasks. Occupationally relevant obstacle courses have previously been used to test the effect of wearing personal protective equipment (PPE) in the military (Dorman & Havenith, 2009) and in firefighting (Taylor, Lewis, Notley, & Peoples, 2012).

Specific to military applications, LaFiandra et al. (2003) examined the effect of various load carrying equipment on obstacle course performance, and Hasselquist, Bensel, Corner, Gregorczyk, and Schiffman (2008) examined the effects of various body armor configurations on obstacle course completion times. These studies suggest that carrying heavy loads results in decrements in cognitive function, compensatory alterations in task performance, decreased levels of comfort, and increased reports of injury. However, none of the aforementioned studies examined the potential effects of course orientation prior to completion or the possible effects of practice that may result from repeatedly running the same obstacle course in different load configurations, both of which may influence improvement in performance and may also influence how the obstacle course may be used in future testing.

The Canadian Load Effects Assessment Program (CanLEAP) was developed in order to determine the implications of "Soldier Burden" on mobility and combat tasks and to determine the threshold at which the degradation of operationally relevant performance occurs. Burden may be loosely defined as external loads imposed on the soldier by their ensemble (e.g., PPE and full fighting order [FFO]) and may be influenced by such factors as absolute weight, weight distribution, and mass properties, such as bulk or stiffness of the soldier ensemble.

The CanLEAP course consists of a series of operationally relevant tasks or obstacles performed in fixed sequence; performance is most generally measured as the time to complete the entire course. The obstacles range in complexity in terms of the task being performed and the physical exertion required to complete the task. Until the present study, there have been no attempts made to determine the effect of orientation or practice on course performance, where orientation is defined as an introduction to guide one in adjusting to a new activity and practice is defined as the repeated performance of an activity to acquire or maintain proficiency in it.

Objective

The purpose of this study was to determine the orientation and practice effects in order to develop training requirements when using the CanLEAP obstacle course to assess human performance. The importance of this study lies in the research question: Are participants continually improving their performance over the repeated completion of obstacle course, potentially confounding results due to an order effect? Using an obstacle course as part of a selection, screening, or equipment design process will benefit from the best possible control of confounding factors. The specific hypotheses tested in this study were:

Hypothesis 1: After repeatedly completing the course, a steady-state performance will be achieved—regardless of the clothing ensemble.

Hypothesis 2: Providing participants with extensive course orientation and the ability to repeatedly complete each obstacle in isolation will decrease the number of full course runs required to reach a steady-state performance level on the course. This hypothesis is based on participants having the opportunity to be guided and adjusting to the new obstacles.

Hypothesis 3: The FFO condition will require more practice on the course before reaching a steady-state performance level as compared to wearing the most basic clothing ensemble (non-FFO).

METHODS

The study was designed to determine the effect of course orientation and practicing the CanLEAP course through repeated runs on the performance of the entire obstacle course as well as each individual obstacle. Participants were provided either regular or extensive course orientation (independent variable) and performed the course five successive times (independent variable) for each the FFO and non-FFO clothing ensembles (independent variable). Assignment to clothing ensemble presentation order was randomized, with half the participants presented FFO first and half presented non-FFO first (independent variable). Time to completion was the performance measure recorded for the entire course and each individual obstacle (dependent variables).

The study methods were approved by the research center's institutional ethics review board.

Participants

Forty-eight male participants were recruited from the Canadian Army Infantry and Combat Engineer regular force population. Participants were randomly assigned to either regular course orientation or an extensive course orientation group (n = 24 each). One participant from the regular orientation group did not complete the study, and three participants from the extensive orientation group did not complete the study. Of the participants that did not complete the study, three did not complete the study because they became ill during the week of data collection, and one sustained an injury during the study. Data from participants that did not complete the study were not included in the analysis. The average participant age was 28 ± 5 years (*SD*).

The average participant height and weight was 177.54 ± 5.73 cm and 89.0 ± 16.3 kg, respectively. The average participant-predicted VO2 max and BMI was 44.7 ± 4.9 mL/kg/min and 28.2 ± 4.5 kgm^2, respectively. There was no statistical difference in age, height, weight, predicted VO2 max, or BMI between the regular and extensive orientation groups. As members of the Canadian Armed Forces, each participant was required to complete the Minimum Physical Fitness Standards (MPFS) test within the past 12 months. The MPFS consists of three timed tasks and one completion task. Task 1 is the sandbag lift: 30 consecutive lifts of a 20 kg sandbag above a height of 1 m in under 3 minutes 30 seconds. Task 2 is the intermittent loaded shuttles: complete ten 20 m shuttles alternating between a loaded shuttle with a 20 kg sandbag and unloaded shuttles in under 5 minutes 21 seconds. Task 3 is 20 m rushes: complete two 20 m shuttle sprints dropping to prone position every 10 m for a total of 80 m in 51 seconds. Task 4 is the sandbag drag: carry one 20 kg sandbag and pull four on the floor over 20 m without stopping. Participants likely had some experience with other types of obstacle courses used in training throughout their careers as CAF members. Prior obstacle course training experience was not characterized for the participant pool. Four participants had minimal prior experience on LEAP (7-8 runs). All other participants had no prior LEAP experience. All participants with prior LEAP experience were placed in the extensive orientation group. All prior experience on LEAP was approximately one year prior to the current study and is not believed to have affected the results of the current study.

CAN-LEAP Course Description

The CanLEAP obstacle course (see Figure 1) is a replica of the U.S. Marine Corps LEAP course (MC-LEAP). MC-LEAP was developed in consultation with subject matter experts in combat maneuvers for the program manager of the Marine Expeditionary Rifle Squad of the U.S. Marine Corps. Unlike many military obstacle or confidence courses, LEAP is a mobility obstacle course with individual tasks representative of the most common and challenging soldier-specific combat mobility tasks. There are 14 sequential test segments, 10 of which represent an obstacle course or mobility challenge. While all 14 test segments were completed during this experiment, the focus will be solely on the timed obstacle portion of CanLEAP (first 10 segments). The other 4 test segments include two weight transfer tasks, a horizontal long jump, and a marksmanship test.

Hatch and tunnel. This obstacle consisted of a four-step riser with a hatch located in the platform at the top of the stairs. A tunnel was connected to the structure on the side opposite the stairs. The tunnel had five segments with varying diameter and four 90° bends. The participants climbed the stairs, entered the hatch, and then traversed through the tunnel in a crawl position.

Sprint. The participants completed a straight 18.3 m sprint as fast as possible.

Stairs and ladder. This obstacle consisted of two sets of stairs, one with a short run and high rise and the other with a long run and low rise and a platform on top with a straight ladder on one side and an angled ladder on the other. The participants ascended and descended the stairs in one direction, turned and completed the stairs again in the other direction. Then the participants climbed the ladder on one side of the platform and descended the opposite side ladder, turned, and completed the ladders again in the other direction.

Agility run. The participants sprinted around five poles set in a weaving pattern, with .32 m high step-over obstacles placed between each pole.

Casualty drag. The participants dragged an 81.8 kg × 1.83 m tall mannequin out to a turn-around point 9.1 m away. The participants then dragged the mannequin back around a second turn-around flag next to the starting location until the mannequin was returned to the start location.

Windows. This obstacle consisted of two walls, 1.5 m wide × 3 m tall × 0.2 m deep, spaced approximately 3 m apart. Wall 1 had a window cutout that was .9 m × .9 m and a bottom ledge 1.5 m from the ground. Wall 2 had the same size window cutout and a bottom ledge 1.2 m from the ground. Wall 1 had three toe holds on the approach side to aid in mounting the obstacle.

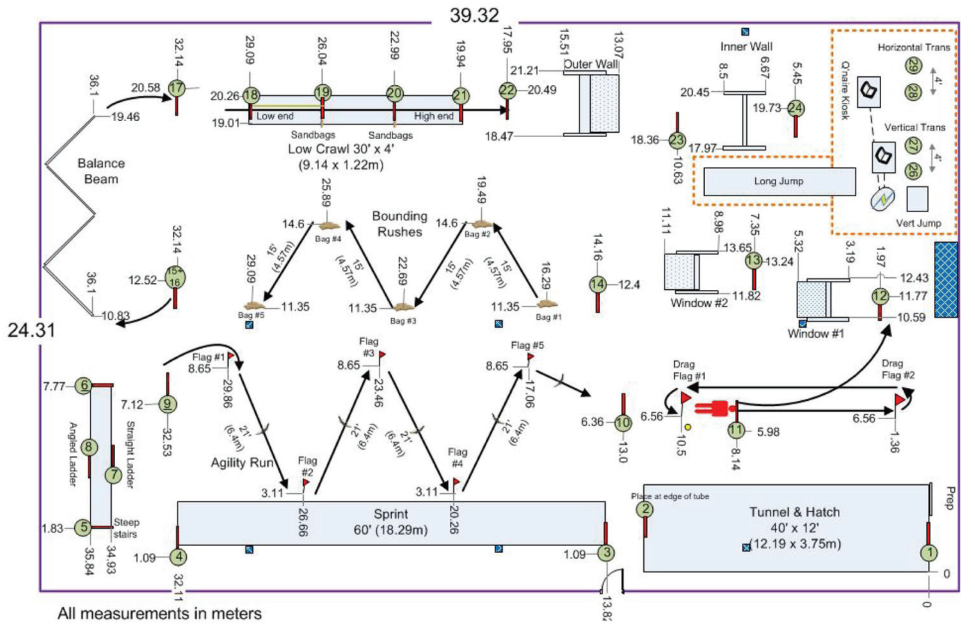

Figure 1. Schematic representation of the Canadian Load Effects Assessment Program (CanLEAP) course configuration.

Wall 2 had no toe holds. The participants passed through both windows to complete the obstacle.

Bounding rushes. This obstacle consisted of five staggered prone firing positions. Each firing position was marked with a sandbag. The first firing position was 2.1 m from the starting position and at an angle of 45° to the right. The second firing position was 4.6 m from the first at an angle of 45° to the left. All subsequent firing positions were 4.6 m from the previous at angles of 45° (alternating left and right). The participants moved to each firing position, assumed a prone position, and acquired a sight picture before moving to the next position. This was the only obstacle that required a weapon or simulated weapon in order to complete the obstacle.

Balance beam. This obstacle consisted of four sloped segments, 3 m long × .2 m wide, connected together at right angles. The start and the end of the beam was .15 m above the ground. The connection between beams 1 and 2 and the connection between beams 3 and 4 were raised .79 m. This gave the obstacle the appearance of an inverted "W" shape, and the entire obstacle had a slope of approximately 15°. At the midpoint of each beam, there was a box .2 m high and .2 m long. The participants traveled across the balance beam, avoiding the boxes.

Crawls. The participants completed a 3 m low crawl beneath a surface .5 m from the ground, followed by a 3 m back crawl beneath a .5 m surface, followed by a 3 m high crawl beneath a .66 m surface.

Courtyard walls. The participants traversed a simulated outer and inner courtyard wall. The outer courtyard wall was 1.6 m high × 2.4 m wide × .45 m deep. The inner wall was 1.2 m high × 2.4 m wide × .15 m deep. The higher outer wall had a series of toe holds the participant could use to traverse the wall. The lower inner wall had no toe holds.

Procedure

Participants were randomly assigned to either the regular or extensive orientation group. Orientation was conducted by two contracted professionals highly experienced with set-up and data collection using the LEAP course. The regular orientation group was provided brief verbal description of an obstacle, followed immediately by a demonstration of the obstacle being successfully completed. This was done for each obstacle on the course. For some of the obstacles, one or two alternate strategies were also verbally described to the participants (e.g., for the casualty drag, the demonstrator always performed a one-armed drag; however, the suggestion was made that participants could perform a two-arm casualty drag if they chose to). The extensive orientation group was provided the same orientation as the regular group; however, after the demonstrator completed the obstacle, each participant was required to complete the obstacle three times in the clothing ensemble they were to complete their first full course run in. The goal was to allow each participant sufficient opportunity to acquire proficiency in each obstacle individually before they were required to complete the entire course. Once a participant completed the entire course for their first full run, they were instructed to maintain a consistent strategy for completing each obstacle on subsequent runs.

Each participant completed five successive runs for each of two different clothing ensembles. The non-FFO clothing ensemble consisted of: combat trousers, t-shirt, combat shirt, and combat boots (mean load mass = 4.8 kg ± 0.86 *SD*). The FFO clothing ensemble consisted of the same articles as non-FFO plus: in-service helmet, C7A2 assault rifle with C79 sight and sling, tactical vest with standard combat load (four loaded dummy magazines, two dummy frag grenades, two dummy smoke grenades, 1 L of water, personal role radio, and two field dressings; mean load mass = 18.3 kg ± 0.78 *SD*). The order of presentation of the clothing ensembles was randomized with the constraint that half the participants did non-FFO first and half did FFO first. Prior to each run attempt, participants completed a 3-minute warmup protocol. The warmup protocol consisted of six activities: jumping jacks, arm circles, high knee hold, lunge walk and trunk rotation, leg swings, and self-selected warmup. For the bounding rushes obstacle, participants were provided with a C7A2 assault rifle even when completing it while wearing non-FFO. This was the only obstacle for which the rifle was provided while wearing the non-FFO ensemble.

Participants were at the testing center for 5 consecutive days. Participants did two runs per day with hour-long breaks implemented between test runs to ensure cardiovascular recovery. With respect to clothing ensemble, participants completed all their runs in their first clothing ensemble (either FFO or non-FFO) followed by all their runs in their second clothing ensemble; on Days 1 and 2, they did two runs in the same clothing ensemble, then on Day 3, they did their first run in their first clothing ensemble, then their second run in their second clothing ensemble. On Days 4 and 5, participants did their remaining four runs in their second clothing ensemble.

The entire course was instrumented with a Fitlight timing system (Fitlight Sports Corp., Aurora, Canada) that measured the time taken to complete each individual obstacle and the time taken to complete the entire course. Research staff were employed as "walkers" to accompany each participant as they traversed the course. The role of the walkers was to monitor participants' health and safety, ensure they traversed obstacles according to protocol, and capture back-up manual timing measures. Steady-state performance on the course was defined as the state in which the average time for course completion was not statistically different for three consecutive runs of the course.

Statistical Analyses

A mixed model four-way ANOVA was used for statistical analysis. The independent measures were: course orientation type (regular vs. extensive; between), run sequence number (1–5; within), clothing ensemble (non-FFO vs. FFO; within), and clothing ensemble order (non-FFO First or FFO First; between). The outcome variables were total course time (alpha = .05) and time to complete each obstacle (alpha = .001 to avoid family-wise error). A Tukey correction was used for all post hoc comparisons.

RESULTS

This section is divided into two subsections. Each subsection focuses on one of the two types of dependent variables from this study: total course completion time and individual obstacle completion times.

Total Course Completion Time

The type of course orientation participants received (regular vs. extensive) had no statistically significant effect on the overall course completion times, $F(1, 42) = 0.03$; $p = .8639$. Clothing ensemble and run sequence number were found to be statistically significant factors, $F(1, 42) = 1{,}879.83$, $F(4, 167) = 12.16$; both $p < .05$. Overall, runs completed when in FFO took an average of 305.98 ± 6.96 seconds (standard error), whereas runs completed when in non-FFO took an average of 208.50 ± 6.95 seconds. This average difference in time to course completion was significant ($p < .05$). Clothing ensemble order was also found to be significant, $F(1, 40) = 16.26$; $p < .05$. There were no interactions found between course orientation type or clothing ensemble order and any of the other independent variables. Therefore, pairwise comparisons for clothing conditions, collapsed across course orientation type and clothing ensemble order, are presented at Figure 2. An interaction between clothing ensemble and run number was found, $F(4, 141) = 3.87$; $p < .05$ (Figure 2), where course completion times remained constant over the five runs when completed in non-FFO (Figure 2) but significantly decreased over the five runs when completed in FFO (Figure 2). In FFO, runs one and two showed no significant difference, $t(141) = 2.65$; $p = .2456$, but runs one and three did, $t(141) = 4.62$; $p < .05$. Runs two and three showed no statistical difference, but runs two and four did, $t(141) = 2.01$; $p = .6373$, and $t(141) = 4.00$; $p < .05$, respectively. Runs three and four showed no significant difference, but runs three and five did, $t(141) = 1.98$; $p = .7048$ and $t(141) = 3.58$; $p < .05$, respectively. Finally, runs four and five showed no statistical difference, $t(141) = 0.95$; $p = .8412$. No other interactions were observed between independent variables (Table 1).

Individual Obstacle Completion Time

The type of course orientation received by the participants was not a significant factor for any of the obstacles. Run sequence number was a significant factor for 5 of the 10 obstacles (stairs and ladder, $F[4, 167] = 6.27$, $p < .001$; bounding rushes, $F[4, 167] = 4.75$, $p < .001$; balance beam, $F[4, 167] = 9.01$, $p < .001$; crawl, $F[4, 167] = 7.12$, $p < 0.001$; and courtyard walls, $F[4, 167] = 8.67$, $p < 0.001$); however, the trend did not always follow the same consistent decrease in completion time with subsequent runs, as was seen in total course time, for all individual obstacles. The clothing ensemble worn while completing the course was a significant factor for all the obstacles, with the heavy clothing ensemble consistently causing slower obstacle completion times. Clothing ensemble order was a significant factor for 2 of the 10 obstacles (stairs and ladder, balance beam). There were no other interactions.

DISCUSSION

Total time to complete the course and each individual obstacle was greater for the FFO ensemble when compared to the non-FFO ensemble. This is an expected result because participants were wearing, on average, 13.5 kg of additional equipment while completing the obstacle course in FFO. There is a significant body of literature that shows wearing additional mass slows movement and reduces human performance (Attwells, Birrell, Hooper, & Mansfield, 2006; Beekley, Alt, Buckley, Duffey, & Crower, 2007; Bhambhani, Buckley, & Maikala, 1997; Bigard, 2000; Birrell, Hooper, & Haslam, 2007; Devroey et al., 2007; Dorman & Havenith, 2009; Goh, Thambyah, & Bose, 1998; Harman, Hoon, Frykman, & Pandorf, 2000; Holewijn & Meeuwsen, 2000; Johnson, Knapik, & Merullo, 1995; Patton, Kaszuba, Mello, & Reynolds, 1991; Taylor et al., 2012).

The effect of practicing or repeatedly completing the same obstacle course while wearing additional load has not been reported to date. Based on the results of this study, personnel in good physical condition showed no significant improvement while wearing minimal or no additional mass (non-FFO) (Figure 2B). In contrast, while wearing a considerable load (FFO), there are significant decreases in total time to complete the CanLEAP obstacle course between runs one to five. This holds true for the majority of the individual obstacle times as well. These results support the third hypothesis of this study. Perhaps there may be subtle changes in strategy or skill to be learned while completing the course in a loaded ensemble as compared to an unloaded ensemble. Future studies should employ motion capture to examine strategies and how these might be affected by ensemble parameters.

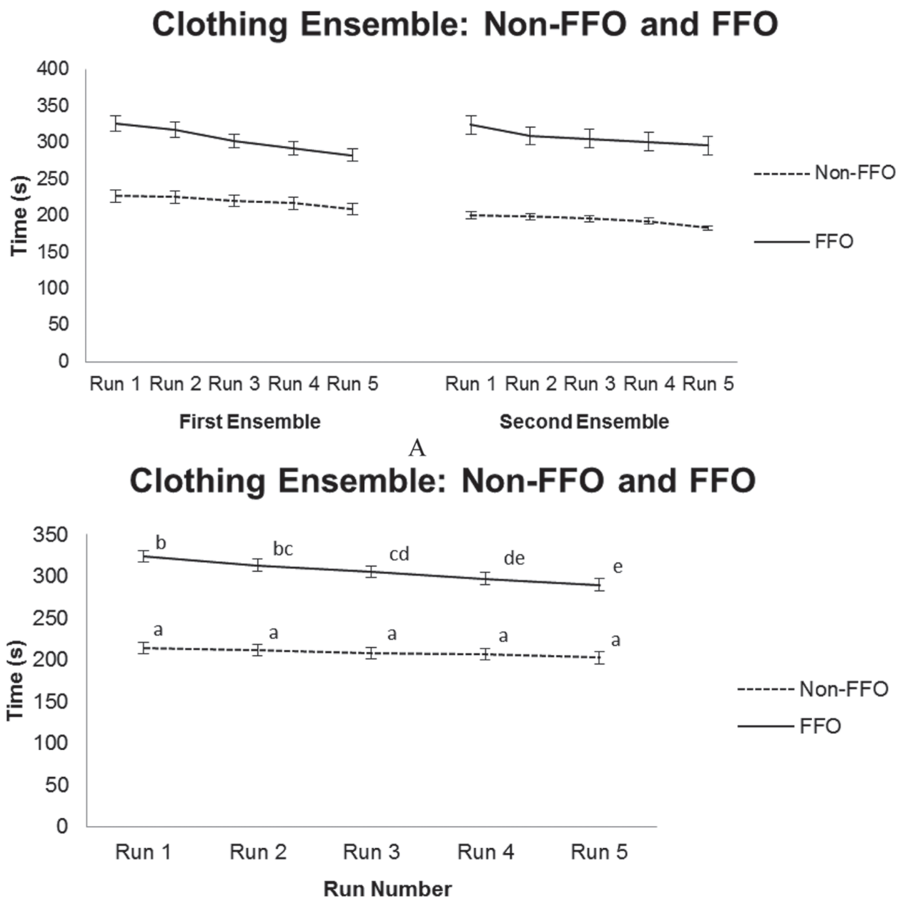

Figure 2. (A) Average time to complete Canadian Load Effects Assessment Program (CanLEAP) course for each run while wearing Clothing Condition A (no personal protective equipment [PPE]) or Clothing Condition B (PPE). Error bars represent standard error. (B) Average time to complete CanLEAP collapsed across clothing ensemble order. Superscript letters indicate results of post hoc analysis. Groups with the same lowercase letter indicate no significant differences in course times.

When examining the total course completion times by clothing ensemble order (Figure 2A), there appears to be a benefit to starting out in the FFO condition before running the course without FFO (non-FFO). On the contrary, the same benefit did not apply when the non-FFO condition was presented first. From a practitioner's perspective, this may indicate that if practice runs are limited, practice runs should be concentrated on loaded conditions rather than the non-loaded. This recommendation may only be applicable to a sequence of obstacles, not necessarily individual obstacles.

This result does not support the first hypothesis of this study since it does not appear that performance while wearing FFO reached a steady-state after five runs. Since the design of the present study effectively only tested one clothing ensemble (FFO) against a control ensemble (non-FFO), the relative contribution of different load characteristics (weight, bulk, stiffness, mass distribution, surface complexity, etc.) to training and practicing requirements to achieve a steady-state performance on the CanLEAP obstacle course cannot be commented on in this discussion. Future studies can be designed

TABLE 1: Main Effects and Interactions Results of Four-Way ANOVA for Total Course Completion Time

ANOVA	Num DF	Den DF	*F* Value	*p*	Cohen's f^2
Course orientation type	1	42	0.03	.8639	
Run sequence number	**4**	**167**	**12.16**	**<.05**	**0.2362**
Course Orientation Type × Run Sequence Number	4	167	1.17	.3280	
Clothing ensemble	**1**	**42**	**1879.83**	**<.05**	**7.9911**
Course Orientation Type × Clothing Ensemble	1	42	0.54	.4686	
Run Sequence Number × Clothing Ensemble	**4**	**141**	**3.87**	**<.05**	
Course Orientation Type × Run Sequence Number × Clothing Ensemble	4	141	0.12	.9761	
Clothing ensemble order	**1**	**40**	**16.26**	**<.05**	**0.0826**
Course Orientation Type × Clothing Ensemble Order	1	40	2.21	.1450	
Run Sequence Number × Clothing Ensemble Order	4	133	1.51	.2017	
Course Orientation Type × Run Sequence Number × Clothing Ensemble Order	4	133	0.80	.5259	
Clothing Ensemble × Clothing Ensemble Order	1	40	0.82	.3719	
Course Orientation Type × Clothing Ensemble × Clothing Ensemble Order	1	40	0.51	.4773	
Run Sequence Number × Clothing Ensemble × Clothing Ensemble Order	4	133	0.27	.8954	
Course Orientation Type × Run Sequence Number × Clothing Ensemble × Clothing Ensemble Order	4	133	0.11	.9784	

Note. Statistically significant results ($p < 0.05$) are highlighted with bold text. Num DF = degrees of freedom in the numerator; Den DF = degrees of freedom in the denominator.

with multiple clothing ensembles, varying in complexity and other load characteristics, to assess the isolated effect of each type of load characteristic on orientation and practicing of the course.

The results of this study indicate that course orientation type had no main effect on number of full course runs required to reach a steady-state performance level, as measured by total time to complete the course. This is contrary to the second hypothesis of this study. Course orientation type also did not interact with any of the other independent variables in this study. There are a number of possible reasons why the extensive course orientation did not appear to be effective. Perhaps on aggregate, the course obstacles were not complex enough to require extensive course orientation for the participants to master the entire course. When each individual obstacle was independently evaluated, there were two obstacles that did show an interaction between course orientation and run number. Both the stairs and ladder and balance beam obstacles had a significant decrease in time across runs. For both obstacles, the difference in average time to completion between runs one and five was lower for the extensive course orientation group. This indicates that some of the more complex or difficult obstacles may have benefited from extensive orientation; however, the benefit may not have been dramatic enough to cause a significant difference in overall time to course completion.

Anecdotally, there were a number of participants who commented that the biggest difference in strategy they adopted between earlier runs and later runs was the pace at which they completed each obstacle. In their first run of the course, participants felt they generally exerted too much energy on the early obstacles and did not save enough energy for the later ones. This may suggest that extensive orientation on a per obstacle basis is no better than regular orientation for helping participants develop their pacing strategy. This may also confound results related to performance in individual course segments/obstacles as orientation on individual obstacles diminishes the time per obstacle, but practicing the course as a whole (repeated runs) may increase the time per obstacle for some obstacles as the participants learn to pace themselves. Ensemble order affected two obstacles, stairs and ladder and balance beam. Both obstacles have an element of balance required; however, no definitive conclusion can be drawn. Future studies would need to vary the order of the obstacles to determine whether or not they contribute to the change in total course and individual obstacle completion times.

With respect to changes in total time to completion between all independent variables, the authors cannot comment on the operational/practical relevance of the magnitude of time changes. There still exists a paucity of literature in this domain, and further research is still needed to determine the association between changes in course completion time and operational implications on soldiers in theatre and during training. Furthermore, time to completion may not be the only relevant outcome measure from both an operational and scientific perspective. Other metrics (e.g., motion capture) that examine specific strategies chosen by the participants to complete each obstacle and the course as a whole should also be examined. These metrics may be relevant to orientation and practice as well as for gross performance measurement.

It must also be noted that the participants completing the present study were all members of the Canadian Armed Forces. As CAF members, they are required to complete the CAF Minimum Physical Fitness Standards test every 12 months. In many ways, the MPFS can be considered a human performance test. Although none of the tasks in the MPFS are the same as any of the tasks in the mobility course described in the study, all participants did have some experience with human performance testing as well as wearing body armor. This should also be considered when interpreting the results of the present study.

CONCLUSION

In practice, when using the CanLEAP or similar obstacle course in the future to determine the effect of different load ensembles on performance, it may be resource prohibitive to require participants to achieve steady-state performance by completing the course more than five times in each load condition. Experiments should continue to manage the effect of practice by randomizing and properly balancing condition presentation order. Other strategies to consider include: use of an experienced participant pool for assessing performance implications of alternative ensembles, a practice that may or may not introduce other issues (nonrepresentative of the user population, unwanted motivational effects); collection of data from multiple runs per load condition; or scheduling test runs in different ensembles consecutively. The latter may help minimize the effect of practice since course completion time for two consecutive runs was consistently shown in this study to be not statistically different. Although the present study was conducted specifically for the CanLEAP course, the results are certainly applicable to LEAP courses being used by other nations and also may be applicable in a more general sense to other obstacle courses that are used to assess human performance across multiple application domains (not limited to the military). Further research is required in this area to determine the generalizability of these findings.

Finally, both the total course completion time and individual obstacle time data demonstrated variability. The variability in time can likely be attributed to a number of different factors, including participant motivation, coordination, anthropometrics, and fitness. In the past, Bishop, Crowder, Fielitz, Lindsay, and Woods (2008) reported that body mass only has a small impact on obstacle course performance, so normalizing course and obstacle times to participant body mass would likely not have reduced the variability in the data. This does not exclude the future possibility of trying to include metrics for motivation, coordination, or a range of fitness measures to reduce or explain data variability.

ACKNOWLEDGMENTS

The authors wish to acknowledge the invaluable contributions of Dorothy Wojtarowicz, Ken Ueno, Eric Kramkowski, Jordan Bray-Miners, and all the soldiers who participated in or provided support to this study. This work was entirely funded by Defence Research and Development Canada.

KEY POINTS

- This study demonstrates that participants improve their performance on an obstacle course with repeated runs to a greater extent while wearing additional clothing and equipment.
- Any potential performance improvement associated with practice depends on the load worn by the participant and may also be associated with improved pacing in addition to improved skill.
- It is important to consider this when a timed obstacle course is used to assess an individual's ability to perform an occupationally relevant task or the impact of alternative loads or personal protective equipment designs.
- Any practice runs on the obstacle course prior to an assessment should focus on the loaded (e.g., full fighting order) condition because improvement on loaded runs is likely transferred to unloaded, but this does not apply in the reverse.

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Date received: September 10, 2015
Date accepted: November 18, 2016