



# TECHNICAL REPORT

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## UNDERSTANDING THE DEMANDS OF THE PATROL PATHFINDER COURSE: THE DEVELOPMENT OF A PERFORMANCE READINESS PROGRAM

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CANADIAN ARMED FORCES

DIRECTOR GENERAL MORALE AND WELFARE SERVICES

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HUMAN PERFORMANCE RESEARCH AND DEVELOPMENT

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## List of Acronyms

ACSM	American College of Sports Medicine
BF	Body fat
BMI	Body Max Index
BMSS	Basic Military Swim Standard
BP	Blood pressure
CAAWC	Canadian Army Advanced Warfare Centre
CADTC	Canadian Army Doctrine and Training Centre
CAF	Canadian Armed Forces
CF	Canadian Forces
CFB	Canadian Forces Base
CFMWS	Canadian Forces Morale and Welfare Services
cm	Centimetre
CO	Commanding Officer
CO <sub>2</sub>	Carbon Dioxide
CoC	Chain of Command
DRDC	Defence Research and Development Canada
ECW	Extracellular Water Ratio
FFO	Full Fighting Order
FORCE	Fitness for Operational Requirements of CF Employment
Ft	Feet
FTX	Final Training Exercise
GXT	Graded exercise test
Ht	Height
HP	Human Performance
HR	Heart Rate
hrs	Hours
ICF	Individual Combat Fitness
lbs	Pounds
LBM	Lean Body Mass
kcal	Kilocalorie
kg	Kilogram
km	kilometre
M	Male
m	Metre
min	Minute
mL	Millilitre
N	Number
O <sub>2</sub>	Oxygen
PPF	Patrol Pathfinder



PSP	Personnel Support Programs
PT	Physical Training
RER	Respiratory exchange ratio
RPE	Rate of perceived exertion
RTU	Returned to Unit
s	Second
SD	Standard Deviation
SOP	Standard Operating Procedures
TBW	Total Body Weight
VO <sub>2</sub> peak	Peak aerobic capacity
VO <sub>2</sub> max	Maximal aerobic capacity
%	Percent

## Executive Summary

Canadian Armed Forces Patrol Pathfinders (PPF) are specialized members of the Army trained for Adaptive Dispersed Operations. The 11 week PPF course is known to be gruelling and historically struggles from high attrition rates (even with screening at the unit level). In 2017, Canadian Army Advanced Warfare Centre (CAAWC) PPF course leadership requested the support of Personnel Support Programs (PSP) Human Performance (HP) with the purpose of developing evidenced-based performance readiness training to better prepare candidates and help reduce course attrition rates.

All measurements and observations of the physical demands throughout the course took place from August 14 to October 24, 2017, at or near CFB Trenton and CFB Petawawa; there were 23 candidates in the 2017 PPF course. As part of the research process, candidates filled out a pre-course questionnaire to better understand their physical fitness preparation six months prior to the course. By systematically reviewing the course curriculum with the directing staff prior to and during the course, the most physically demanding days for each section were selected for observation and measurement: (1) Individual Combat Fitness (ICF) march-day 1, (2) standard operating procedures (SOP) – week 1, (3) navigation- week 2-3, (4) water insert/extract – week 3, (5) rappel tower – week 6, and (6) final training exercise (FTX)- week 9.

### Physical Demands summary

The following summary of the demands of the course were carried forward in the development of the Performance Readiness Program that will be available to all future potential PPF applicants.

Throughout the entirety of the course, at least 38 days required wearing and handling of a rucksack for an average of 6 hours/day and up to 10 hours in one day. The weight of the rucksack throughout the course weighed between 39-45 kg. Table 0-1 summarizes the primary movements and tasks performed throughout the course.

Primary movement	Task description
Locomotion with external load carriage (wearing 45 kg rucksack)	Standing, walking and running on uneven ground on varying terrain (sand, woods, gravel) up to 10 hrs; short breaks with rucksacks off
	Climbing stairs (unbalanced stance) with high repetition
	Quickly changing direction and running in opposite direction for 5-25 s, up to 180 s with multiple repetitions
	Rucking with 13 kg parachute for 250 m
	Stepping over logs (i.e. uneven terrain)
Finning-swim	Tactical swimming (finning while controlling rucksack and weapon for 1-3 km)
Lunging and squatting (wearing up to 45 kg rucksack)	Lunging up from and down to one knee
	1 and 2-foot landing from rappel or fast rope
	Squatting up and down with load (as far down as into sitting)
Lifting (and lowering) up to 45	2-handed lift and lower the rucksack from ground (to put on or take off back of truck)

Pulling 45 kg+ (sometimes while wearing 45 kg rucksack)	Quickly pulling (1 and 2 handed) from stooping over edge of assault boat with wet rucksack and others out of water
	Quickly pulling self out of water into assault boat, from overhead (kicking legs for help)
	Lateral pull from prone and quickly pulling rucksack into water from assault boat; stooping position
	1 and 2 handed pull of rucksack from stooping posture and of others to standing from sitting with 45 kg rucksack
Gripping 45 kg + body weight	Gripping rope and fast rope (squeezing leg adductors)
Carrying (55-60 kg) (sometimes while wearing 45 kg rucksack)	Carrying extra rucksack with a sense of urgency (200+ m)
	1 handed carry of assault boat by handle (wearing rucksack) on beach and through brush; slight lean to side
	1 and 2 handed carry of boat motor (no rucksack); lowering into boat in awkward position through sand & pebbles
	Carrying a weapon (while rucking) 2 hands at chest
	2-handed, 2 person casualty carry wearing rucksack
Dragging (55-60 kg) (wearing 45 kg rucksack)	1-handed casualty drag (2 person drag) over brush and obstacles
Getting up and down from sitting (wearing 45 kg rucksack)	Rolling over to and from hands and knees, to and from laying on back, to lunge to standing (i.e. awkward positions)
	Sitting to standing and rocking forward to feet (deep squat)
Moving to and from prone (sometimes wearing 45 kg rucksack)	Stabilizing in prone position on side of assault boat; squeezing with legs while controlling weapon
	Quickly pushing self-up (2 hands) to roll into water while on unstable surface
	Moving to and from prone position to standing with rucksack and holding weapon

Table 0-1: Summary of movement analysis for all six physically demanding exercises of the PPF course.

Metabolic demands, captured from over five to 40 hour samples, were calculated throughout the six training activities. Table 0-2 provides a summary of the most metabolically demanding hour for all activities to provide a point of reference for the performance readiness physical fitness training programming; most sessions are designed to be completed in an hour to fit into common CAF training programming.

		Workload category % VO <sub>2</sub> max range					
		Sedentary	Light	Moderate	Heavy	Very Heavy	Extremely Heavy
Training Activity		0 - 20%	21 - 40%	41 - 55%	56 - 70%	71 - 85%	86 - 100%
ICF March	VO <sub>2</sub>	9.22	16.76	24.52	33.46	39.40	44.42
	Duration	0:01	0:12	0:17	6:13	41:32	11:45
SOP	VO <sub>2</sub>	7.21	15.39	24.74	32.36	39.09	44.67
	Duration	8:49	11:37	11:33	14:21	12:54	0:46

Navigation	VO <sub>2</sub>	8.22	15.84	25.63	34.01	39.61	46.90
	Duration	4:36	7:42	9:38	18:27	17:36	2:02
Insert/Extract	VO <sub>2</sub>	7.96	15.12	24.35	32.20	39.93	-
	Duration	15:12	25:29	10:27	6:33	2:20	-
Rappel	VO <sub>2</sub>	8.35	15.30	24.52	32.35	39.49	45.57
	Duration	8:27	13:52	9:04	10:55	16:06	1:35
FTX	VO <sub>2</sub>	6.88	15.07	23.85	31.48	34.98	-
	Duration	15:53	19:16	10:05	8:22	6:23	-

Table 0-2: Most metabolically demanding hour for each training activity: average VO<sub>2</sub> (mL/kg/min) and duration (min:ss) at each workload.

### Key Indicators of Success

Based on the responses to the pre-course questionnaire, shown in Figure 0-1, it is highly recommended that prior to the course, candidates participate in the Pre-PPF course (PPF relevant skills refresher) and in regular fitness training, and seek physical fitness training support (e.g., PSP fitness professional, qualified PPF) to increase the chance of course completion. Nine out of eleven (82%) successful candidates participated in at least two out of the three recommended preparation criteria as compared to only two out of the nine (22%) candidates who RTU.

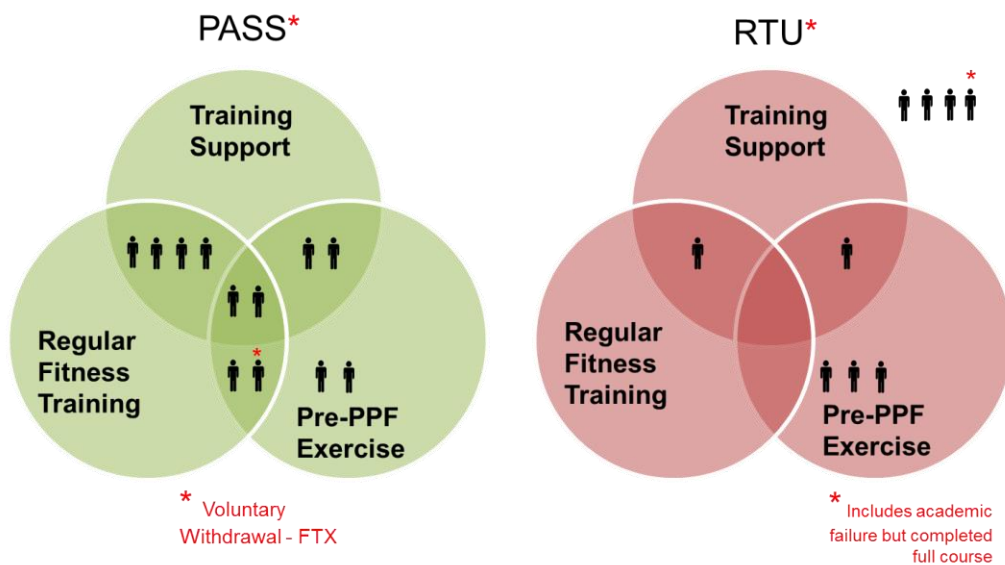


Figure 0-1: Regular fitness training, physical fitness training support, and pre-PPF participation obtained by candidates in the 6 months prior to PPF course for PASS group and RTU (injured and academic failure). One candidate from each of the PASS or RTU did not answer the pre-questionnaire. The Voluntary withdraw –FTX did not have any difficulties with the physical demands of the course.

## Performance Readiness Program

The development of the PPF physical fitness programming followed a progression from the evidence-based programming designed in *dfit.ca* for the Army which was validated in a 12-week training study (Laframboise, 2017). The intent is to host this program on a web based platform, and possibly be available as an App through *dfit.ca*. The PPF physical fitness preparation program is broken down into 2 phases:

- 1) The Foundation phase (10 weeks): Builds on the basic physical fitness which the candidate should have acquired by April: 18 weeks prior to course; this basic fitness could effectively be obtained by following *dfit.ca* FORCE Combat fitness training program for 5 days per week for 3 – 6 months or with a similar approach. The Foundation phase targets PPF-specific elements while still working on acquiring broad physical capacities. This phase has been shown to be crucial for success in the specific stages of physically and psychologically demanding tasks (Corcoran & Bird, 2009; Deweese et al., 2015).
- 2) The Specific phase (6 weeks): Builds on the foundation section, focuses on the most relevant aspects of the course, and ensures that once completed, the candidate is both physically and mentally optimally prepared to face the challenges of the course (Corcoran & Bird, 2009; Deweese et al., 2015).

As part of this study a **Performance Readiness Poster** (Appendix D) was prepared to create early awareness of the requirements and demands of the PPF course, thus providing the opportunity for the ideal performance preparation situation. This poster includes:

1. An infographic highlighting the physical fitness, military training prerequisites, personal readiness recommendations, guidance/support links and the physical demands of the course all within a timeline;
2. Guidance for the physical fitness training program through 3 phases; foundation, specific and taper (including time allocated for pre-PPF); and
3. An assessment of performance and personal readiness (not ready - ready PPF).

## Key Recommendations:

1. Create a network including PSP and PPF to support the Performance Readiness Program.
2. Program evaluation of this recommended approach/project in order to assess effectiveness. By tracking:
  - a. Physical fitness preparation;
  - b. Participation in PPF pre-course or similar;
  - c. Use of PPF and PSP support for PPF candidates;
  - d. Attrition/success on course;
  - e. Injuries.

## Background

Canadian Armed Forces Patrol Pathfinders (PPF) are specialized members of the army trained for Adaptive Dispersed Operations; they must be able to work under extreme stress, in severe conditions and in hostile environments with minimal support. The PPF course candidates are trained to be experts at insertion and extraction techniques by air, land, and sea, and to be proficient in the establishment of drop, landing, beach and cast zones and austere airstrips for follow-on forces. Alongside the intellectual capacity, situational awareness, and advanced skill set required to do the job, candidates must be prepared to advise commanders on the PPF phase in joint operations. PPF candidates must be in top physical and mental condition to withstand the rigours of long range patrolling, and remain operationally effective during long periods under the stress and pressure associated with missions in isolated situations (Downey & Deshpande, 2013).

The 11 week PPF course is known to be gruelling, and historically struggles from high attrition rates (even with screening at the unit level). In 2017, Canadian Army Advanced Warfare Centre (CAAWC) PPF course leadership requested the support of Personnel Support Programs (PSP) Human Performance (HP) with the purpose of providing evidenced-based performance readiness training to better prepare candidates and help reduce course attrition rates. Due to the demands of certain exercises on course, physical fitness in itself may not be enough to succeed. However, when physical training is programed appropriately and addresses the specificity of the target environment, injury prevention, recovery, and mental toughness, there is intuitively a greater chance of success. This approach to performance is common in elite athlete preparation (Mujika, Halson, Burke, Balague, & Farrow, 2018), and has been shown to be effective within CANSOFCOM preparation for JTF-2 assaulters, and through the Specialty physical fitness training programs delivered by PSP at Canadian Forces Base Valcartier.

## Purpose

The purpose of this work was to develop a Performance Readiness Program for future PPF applicants based on information gathered from the 2017 PPF course. To develop this program the following actions were taken:

- (1) Measurement of relevant physiological capacities prior to the course;
- (2) Observation and measurement of the most physically demanding days of the PPF course;
- (3) Via questionnaire method, collection of each candidates physical fitness preparation prior to course; and
- (4) Via questionnaire method, collection of candidates perceptions regarding physical demands and their self-perceived preparation.

## Methods

### Research Design

This study took place concurrently with Defence Research and Development Canada (DRDC) Toronto (*High Attrition rates in Patrol Pathfinders course – Phase II: Understanding the mental and physical*

*attributes related to success in more detail*). Ethics for this research was approved by DRDC Human Ethics Committee as protocol 2015-019 Amendment. This research (physical demands and questionnaires) was added as an amendment to the 2015-019 protocol, and thus was conducted on the same group.

The 2017 PPF course had 23 male candidates. Support for DRDC protocol 2015-09 was requested by Major-General J.M. Lanthier, Commander of Canadian Army Doctrine and Training Centre (CADTC). Direct access to the PPF course and candidates was granted by both Lieutenant-Colonel JF Caron - Commanding Officer of the CAAWC and Major JF Desmeules - Officer Commanding (OC) of the Advanced Mobility Company.

Physical fitness and anthropometric pre-course measurements were taken at CFB Trenton on pre-day 1 of the course following a project brief, and consent to participate. Twenty-two of the 23 candidates participated in a battery of physical fitness and anthropometric tests, as well, candidates filled out a questionnaire to better understand their physical fitness preparation six months prior to the course.

All measurements and observations of the physical demands throughout the course took place from August 14 to October 24, 2017, at or near CFB Trenton and CFB Petawawa. Six separate events were observed and measured: (1) Individual Combat Fitness (ICF) march- day 1, (2) standard operating procedures (SOP) – week 1, (3) navigation - week 2-3, (4) water insert/extract – week 3, (5) rappel tower - week 6, and (6) final training exercise (FTX) – week 9. Those candidates who made it to the FTX also filled out a questionnaire which focused on the candidates' overall impressions of the course and their own preparation.

Two candidates did not perform the Graded Exercise Test (GXT) due to elevated blood pressure.

## Measures:

### Physiological and Anthropometric Measurements:

The following physical fitness and anthropometric tests, described in detail in DRDC Ethics protocol 2015-019 Amendment 3 (Appendix A), were performed following resting blood pressure measurements:

1. **Anthropometrics:** height, body weight (BW)\*, % body fat (%BF)\*, lean body mass (LBM)\*; \*measured using Bioelectrical impedance - InBody 520.
2. **VO<sub>2</sub>peak:** obtained by performing a maximal graded exercise test (GTX) on a treadmill; using Parvo Medics True one 2400 metabolic measurement system. Maximal heart rate was also measured.
3. **The Standard Load Squat Test:** Candidates squat (to a 90° angle at the rotational axis of the knee and return to full extension) with a weight of 158lbs (72 kg) at a cadence of 42 beats per minute (b·min<sup>-1</sup>) as set by a metronome. Standing position with feet shoulder width apart, toes pointed slightly outward, back erect, and with the barbell on the shoulders.
4. **The Bench Press Beep Test:** 150lbs (68 kg) bench press at rate set using a metronome to 25 (b·min<sup>-1</sup>).

5. **The Curl-Up Beep Test:** lying on a mat (90° angle at the rotational axis of the knee), arms crossed at chest- hands on opposite shoulders, elbows must make contact with thighs with each repetition, metronome set to 25 (b·min<sup>-1</sup>).

### Questionnaires:

A PPF course questionnaire was administered on pre-day 1 of the course to understand the candidates' preparation over the 6 months prior to the course (Appendix B). A post PPF course questionnaire was administered to any candidates that completed at least a portion of the FTX to determine their perceptions of both the course and their perceived readiness (Appendix C).

### Physical Demands of PPF Course:

By systematically reviewing the course curriculum with the directing staff prior to and during the course, the most physically demanding days for each section were selected for observation. The premise was that if the candidates were capable of successfully completing the most difficult day, then the other days would be physically achievable. In addition, because it was recognized that the requirement to regularly work under load was a significant challenge throughout the course, weights/loads and time under load/wearing a rucksack, was tracked. Observations and measurements taken included weights of equipment carried, duration and/or distances under load, type of activities performed, postures and how equipment was manipulated. Heart rate (HR) measurements were also taken using a chest strap and watch, HR monitoring devices (Polar V800 and RS800 Technologies Inc., Jyväskylä, Finland); R to R intervals were used to estimate metabolic demand and caloric cost.

### Analysis

The demographic, anthropometric, and performance measurements were characterized using descriptive statistics. Data was analyzed using IBM SPSS 24 and Microsoft Excel. Graphical representations were created with Microsoft Excel 2013. VO<sub>2</sub>peak and HR responses were used to estimate the metabolic demands, using First Beat™ software analysis. Movements and tasks were described and categorized. Questionnaires were analyzed for themes, trends, and frequencies.

## Results

### Success – Attrition:

Of the 23 candidates that started the course, 12 candidates passed the course and 11 returned to unit (RTU). In terms of the RTU candidates, 1 failed for academic reasons (with no difficulty regarding the physical demands of the course), 1 voluntarily withdrew from the course during the FTX (with no physical difficulties regarding the course), and 9 were injured (3 new injuries, 6 aggravated existing injuries).

### Physical and Demographic Characteristics of PPF Candidates

In Table 1, the course candidates are separated by completed the physical demands of the course and removal due to injury (RTU injury). The rationale for this grouping reflects the type of variables presented



as they are physical fitness related in nature. The one candidate, who voluntarily withdrew from the course in the FTX is not included, although he had the highest VO<sub>2</sub>peak, while all other variables fell within the range of both groups. There were significant differences ( $p \leq 0.05$ ) between group mean (SD) for number of squats performed and age; # squats: RTU injury ( $41.9 \pm 15$ ) compared to completed physical demands ( $28.3 \pm 9.7$ ), age: RTU injury ( $29.3 \pm 2.7$ ) compared to completed physical demands ( $26.3 \pm 2.4$ ); Cohen's effect size value ( $d = 0.9$ ) for age, and ( $d = 1.0$ ) for #squats suggested a high practical significance (Cohen, 1988).

		*Age	Height (cm)	VO <sub>2</sub> peak** (ml/kg/min)	*Squats (reps)	Bench Press (reps)	Curl-ups (reps)	BW (kg)	LBM (kg)	BF (%)
Completed physical demands of the course N=13	mean	26.7	179.3	51.1	28.3	11.6	27.7	86.5	72.7	13.8
	SD	2.4	8.2	4.8	9.7	6.8	18.0	14.7	11.5	5.0
	min	23.0	168.0	41.1	15.0	1.	5.0	72.7	59.7	6.6
	max	31.0	197.5	57.9	52.0	23.0	74.0	124.3	103.7	20.6
RTU injury N= 9	mean	29.3	179.6	50.7	41.9	11.0	27.4	84.0	72.2	11.8
	SD	2.7	4.6	4.6	15.0	6.1	13.7	5.7	6.5	3.3
	min	26.0	172.5	41.2	22.0	0.0	13.0	77.4	62.5	6.2
	max	34.0	184.5	54.1	64.0	20.0	58.0	93.6	80.2	15.6

Table 1: Candidates' descriptions for demographics, anthropometrics and physical fitness performance separated by RTU and completed physical demands of the course; \*significant difference between groups,  $p \leq 0.05$ ); \*\*2 candidates did not perform the GTX due to elevated blood pressure.

### Physical and Physiological Demands of Course

The following section describes the physical and physiological demands of the 2017 Patrol Pathfinder course. Six different training activities were observed and measured that capture the most physically demanding days: (1) ICF march, (2) SOP, (3) insert/extract by boat and tactical swimming, (4) rappel tower, (5) navigation and, (6) FTX. Metabolic demands are presented for candidates where there are full records for the activity. All figures represent metabolic demands at the following workload categories adapted from Astrand et al's Textbook of Work Physiology (Astrand, Rodahl, Dahl, & Stromme, 2003).

Workload category	Sedentary	Light	Moderate	Heavy	Very heavy	Extremely Heavy
%VO <sub>2</sub> max	0-20	21-40	41-55	56-70	71-85	86-100

#### Day 1: ICF March

The first major physical objective was the completion of the 20 km ICF march over mostly flat terrain of crushed gravel, mud, and rutted cow paths. A specific time objective of 4hrs 30min was indicated, carrying a C8 weapon and a rucksack. As a result of going off course, the 23 candidates completed a total of 22 km. Table 2 below describes the average weights carried, completion times and speed. No

candidates were removed from course based on their completion time and two candidates were RTU within the next few days due to aggravation of pre-existing injuries from the ICF march.

The speed of the 22 km ICF March did not predict course success as demonstrated in Table 3. In fact, the four slowest candidates to finish the march successfully completed the course and the three fastest did not, with no obvious pattern for the remaining candidates. Based on the performances from this course, it is recommended that this component be retained as a requirement, with consideration for a modification to the completion time or speed allowed. Performance times should be monitored over the next few courses to determine if a slower time (than 6hrs 22 min) is associated with course failure.

Table 2: Average and range of performances and rucksack weights for 22 km march (ICF)

	Total Weight (kg)	Time (hours)	Speed (km/hr)
Average	37.8	4hrs 52min	4.6
Range	35.5 - 40	4hrs 12min - 6hrs 22min	3.5 - 5.3

### Metabolic demands:

Figure 1 illustrates the average metabolic demands of the 22 km ICF march presented as time and average VO<sub>2</sub> (mL/kg/min) in each metabolic category.

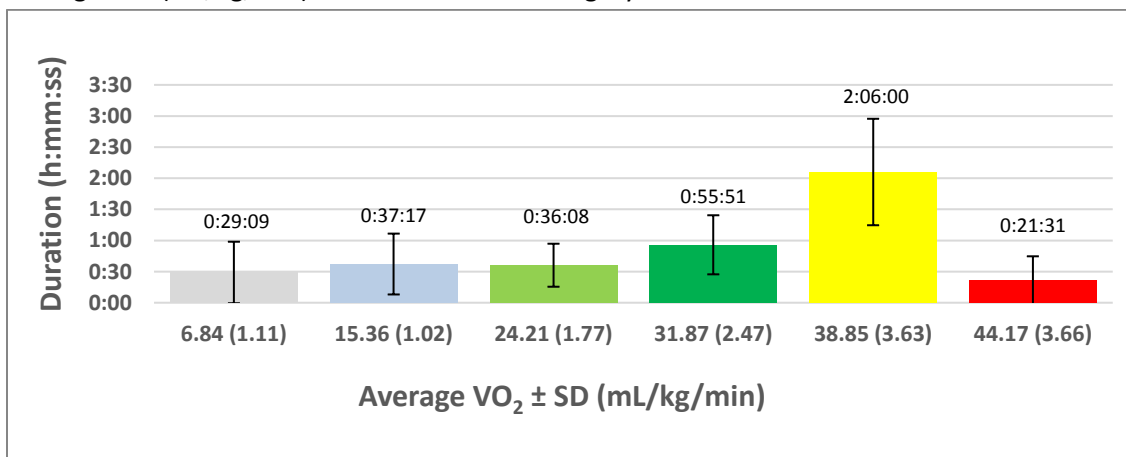


Figure 1: ICF march metabolic demands: duration and average VO<sub>2</sub> at each workload (average total time = 5hrs 5min, N=16).

### Week 1: SOP

For the 7 hours of observations made during the standard operating procedures (SOP) section, candidates carried a C9/C8 with a rucksack weighing approximately 41 kg over 7 km. In small teams, candidates coordinated tactical movement; observations in one group of seven candidates included very slow purposeful walking, approximately 25 repetitions of quick changes in direction followed by running for 5 to 25s were. In addition, to meet a rendezvous time objective, candidates had to run/shuffle for 2min 20s including up a gravel hill and then another 3min (approximately 600m) later in the day to retreat from an attack. Candidates covered uneven terrain (ruts in dry mud) with small changes in

elevation, walked over logs in the woods and through very tall grass/weeds. This training exercise also included casualty evacuations, where 2 candidates would have to quickly drag or carry the injured, and a third (and sometimes a fourth) would carry the injured candidate's rucksack and weapon. Common repeated movements while wearing a rucksack also included taking a knee, awkwardly sitting down, from sitting - rolling to hands and knees to standing from one knee or rocking forward from sitting to standing (from deep squat). Decision making and cognitive ability were essential as this training was the foundational review and coordination of SOP drills required for the next phase of the course. Thus, it was essential that physical fitness not be a limiting factor. Two candidates RTU the next day due to injuries (one new injury and one aggravated a pre-existing injury).

**Metabolic demands:**

Figure 2 illustrates the metabolic demands of the SOP exercise presented as time and average VO<sub>2</sub> (mL/kg/min) in each metabolic category.

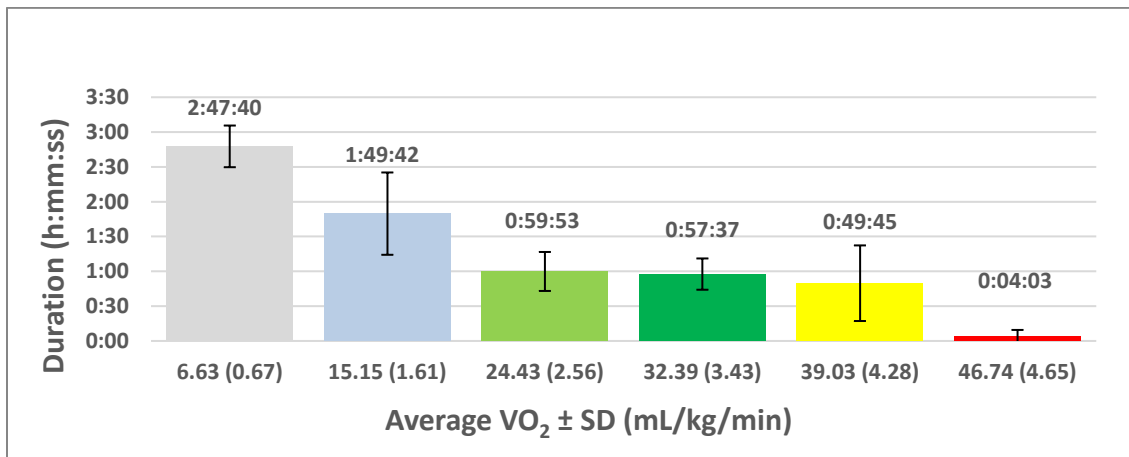


Figure 2: Metabolic demands of SOP exercise; Duration and average VO<sub>2</sub> at each workload (average total time = 7hrs 33min, N=15).

*Week 2-3: Navigation*

Independent navigation, through complex terrain to an objective during the day and night was observed for up to a 13 hour period in the training area in CFB Petawawa. The task was to navigate from an unknown to a known location (RV) and then navigate at night to a Patrol-Base of known location. The distance 'as the crow flies' was approximately 10 km across uneven and undulating terrain, through sand, dense forest, and swamp, although distances as high as 14.55 km were covered for up to 12 hr and 40 min. Nineteen candidates wore their rucksacks and carried a C8. However, because the candidates crossed water, some more than once, the rucksack weight increased by retaining water. Table 3 shows the average and range of performances and weights carried.

Table 3: Navigation performance descriptors (time, distance, average speed and starting rucksack weight) for August 27-28<sup>th</sup>, 2017.

	Time	Distance (km)	Average Speed (km/h)	Starting rucksack Weight (kg)
Average	10hrs 26min	12.7	1.2	28.0
Range	8hrs 41min - 12hrs 40min	10.91 - 14.55	0.96 - 1.67	25 - 30

One candidate did not complete the navigation objective due to an aggravated pre-existing injury. One candidate had to repeat the exercise due to academic failure the following day/night and thus was exposed to the physical demands twice.

**Metabolic demands:**

Figure 3 illustrates the average metabolic demands of the navigation exercise presented as time and average VO<sub>2</sub> (mL/kg/min) in each metabolic category.

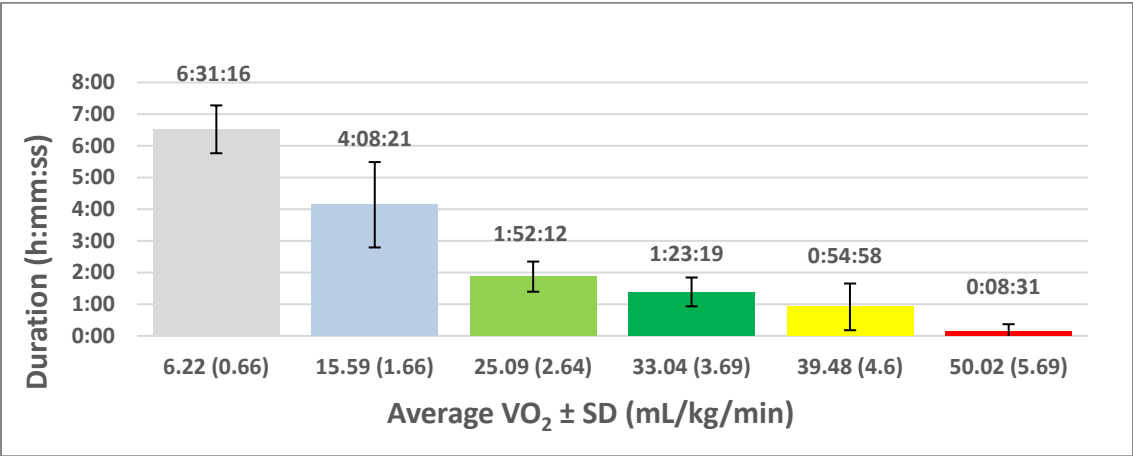


Figure 3: Metabolic demands of Navigation exercise; Duration and average VO<sub>2</sub> at each workload (average total time = 14hrs 58min, N=12).

*Week 3: Insert/Extract by Boat and Tactical Swimming*

Eighteen candidates were followed through a combination of water and land-based activities with either a C8 or C9 in hand. Activities and movements included: wearing a 41 kg rucksack while, walking to the beach to load the boats, walking out of the water (wet rucksack) in their wetsuits, walking and carrying the 195 kg six person assault boat, rib (using side handles) up through the sand and pebbled beach, moving in and out of the dense brush for about 50m, and back into the water, taking a knee and back to standing, and prone position to standing. Candidates were also required to carry the 25hp motor (71 kg) to the boat and attach it to the back of the boat (no rucksack). Water based movements included: maintaining a prone ready position while lying on the sides of the rib, squeezing legs to control being thrown off boat, rolling off the rib, pulling rucksacks up into and out of boat very quickly, pulling each other into boat, tactical swimming with fins while controlling weapon and rucksack for up to 1 km.

### Metabolic demands:

Figure 4 illustrates the average metabolic demands of the insert/extract by boat and tactical swimming exercise presented as time and average VO<sub>2</sub> (mL/kg/min) in each metabolic category.

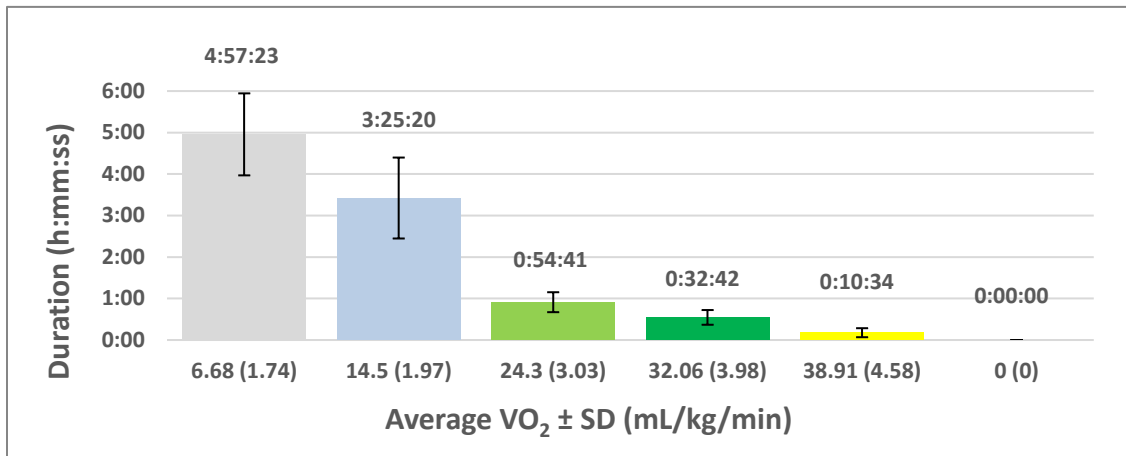


Figure 4: Metabolic demands of insert/extract by boat and tactical swimming exercise; Duration and average VO<sub>2</sub> at each workload (average total time = 10 hrs, N=10).

### *Week 6: Rappel Tower and Helocast (low hover stand) Insertion*

This phase of training required repeated bouts of stair climbing, walking up 24, 48 or 96 (20 cm riser) steps, or 4.9, 9.8, and 19.5 vertical metres respectively, while wearing up to 38.6 kg with any combination of 9 - 13.6 kg of full fighting order (FFO; helmet, rope bag, tactical vest, weapon) and rucksack as shown in Table 4. Each repetition required candidates to lift and handle their rucksacks while putting them on and taking them off for each ascent. In general, each skill sequence would begin with less equipment at a lower elevation, then progress in elevation. Finally, candidates would be assessed with FFO and rucksack from the top of the rappel tower. Following each climb, the candidates performed a rappel from the tower or helocast from low hover stand (mock helicopter) where they would land on the ground in any variation of a two feet soft deep squat or plyometric landing (depending on their skill level). Due to the nature of the task, safety and concentration was critical, thus it was critical that cognitive ability was maintained and not compromised by low physical fitness / fatigue. Cognitive tasks included acting as the brakeman to ensure safety of the candidate on rappel, being aware of others while inserting as a group, controlling decent, tying off rope mid-descent, packing rope bag and listening to instructions.

Table 4: Elevation and repetitions of tower climbs under various loads for day and evening training on September 18<sup>th</sup>, 2017.

Height (m)/steps	FFO (9-13.6 kg)	FFO + patrol pack (18-23 kg)	FFO + rucksack (34-37 kg)	Total stair climbs @ given height
4.9 / 24	3	0	4	7
9.8 / 48	3	4	2	9
19.5 / 96	7	10	2	19

### Metabolic demands:

Figure 5 illustrates the average metabolic demands of the daytime rappel tower and helocast insertion exercise presented as time and average VO<sub>2</sub> (mL/kg/min) in each metabolic category.

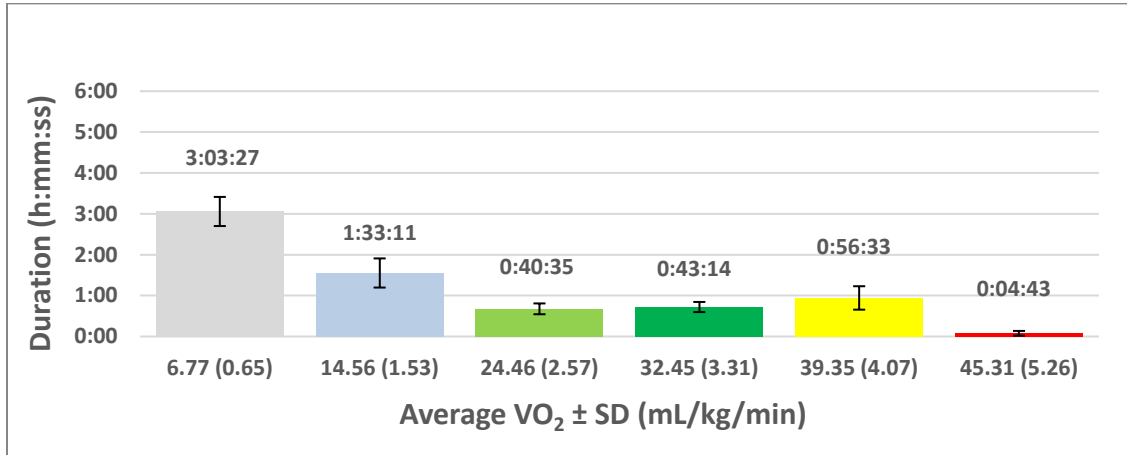


Figure 5: Metabolic demands of rappel tower exercise; Duration and average VO<sub>2</sub> at each workload (average total time = 7 hrs 1min, N=18).

### Week 9: Final Training Exercise

The final exercise was a 10-day phase requiring the remaining 18 candidates to demonstrate the knowledge and skills they had been taught throughout the previous 8 weeks. During this exercise the activities were prolonged and included land, air and water environments. Candidates worked in small teams, and were pushed to their physical limits, mostly outdoors in the cold and damp fall weather with very little sleep or recovery, and with the awareness that even under these conditions they were expected to maintain operational capacity for final evaluations. The physical environment, lack of rest and physical demands made the cognitive load of the exercise that much more challenging, stressing the importance of physical fitness required above the demand of just completing the physical tasks. (Chang Y.-K. , Labban, Gapin, Jennifer, & Etnier, 2012) The rucksack weights were the highest for the course, weighing approximately 45 kg.

During the FTX, four candidates were RTU injury (1 new injury and 3 aggravated previous injuries), while 1 candidate voluntarily withdrew from the course (no physical limitations). One candidate opted out of a 12 and 8 hour period, but decided to return and complete the course. Thirteen candidates completed the 10 days of the FTX.

### Metabolic demands:

Figure 6 illustrates the average metabolic demands of the FTX exercise presented as time and average VO<sub>2</sub> (mL/kg/min) in each metabolic category.

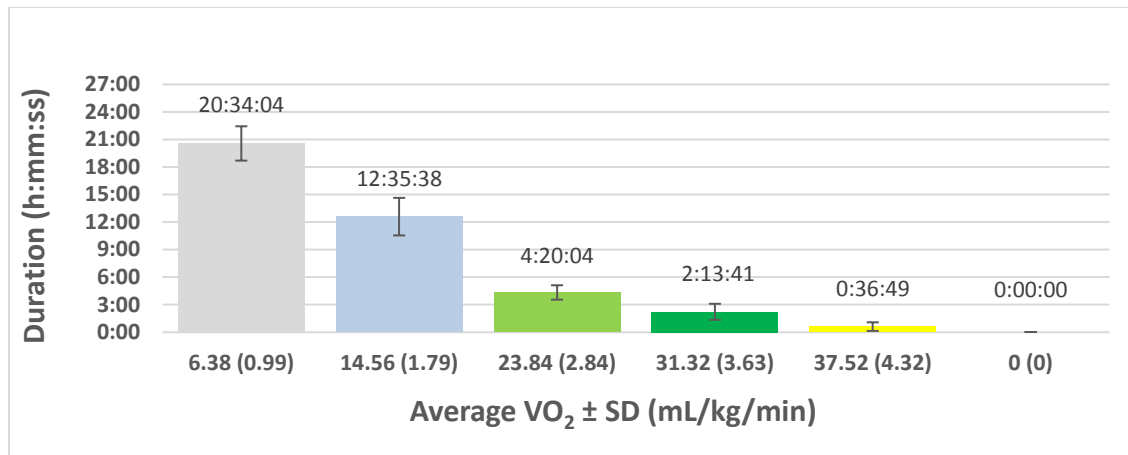


Figure 6: Metabolic demands of FTX; Duration and average  $VO_2$  at each workload (average total time = 40 hrs 20 min, N=7).

### Summary of Physical Demands of the PPF Course

The following summary of the demands of the course have been carried forward in the development of the Performance Readiness Program that will be made available to all future potential applicants.

#### *Loads Carried over PPF Course*

Figure 7 illustrates the heavy loads imposed on the candidates over 10 weeks of an 11 week course (11<sup>th</sup> week was administrative). Throughout the entirety of the course, at least 38 days required wearing and handling of a rucksack for an average of 6 hours/day and up to 10 hours in one day. The weight of the rucksack throughout the course weighed between 39-45 kg. On these days, candidates had to perform movements which involved handling/wearing the rucksack and included repeated lifting from the ground, taking a knee, lying prone, and getting up with the pack from the ground, from sitting or lying. All of these days also included walking on uneven ground and varying terrain (hills or stairs) and standing with the rucksack. Some of the exercises included changing directions quickly and running/shuffling. In addition, 8 of the 38 days included up to 4 hours (distance of 1-3 km) of tactical swimming where the candidates were repeatedly required to pull themselves and their soaked rucksacks into and out of the water from a watercraft, and carry a watercraft as a team. On the 4 days where rappel/low hover insertion skills were trained, candidates were required to wear loads from 23-39 kg. Although not observed or measured, the landing forces that candidates would be required to tolerate (under load) would also impose a demand to lower body stability and muscular strength/power capacity and represent a potential source of injury (Aerts, Cumps, Verhagen, Verschueren & Meeusen, 2013).

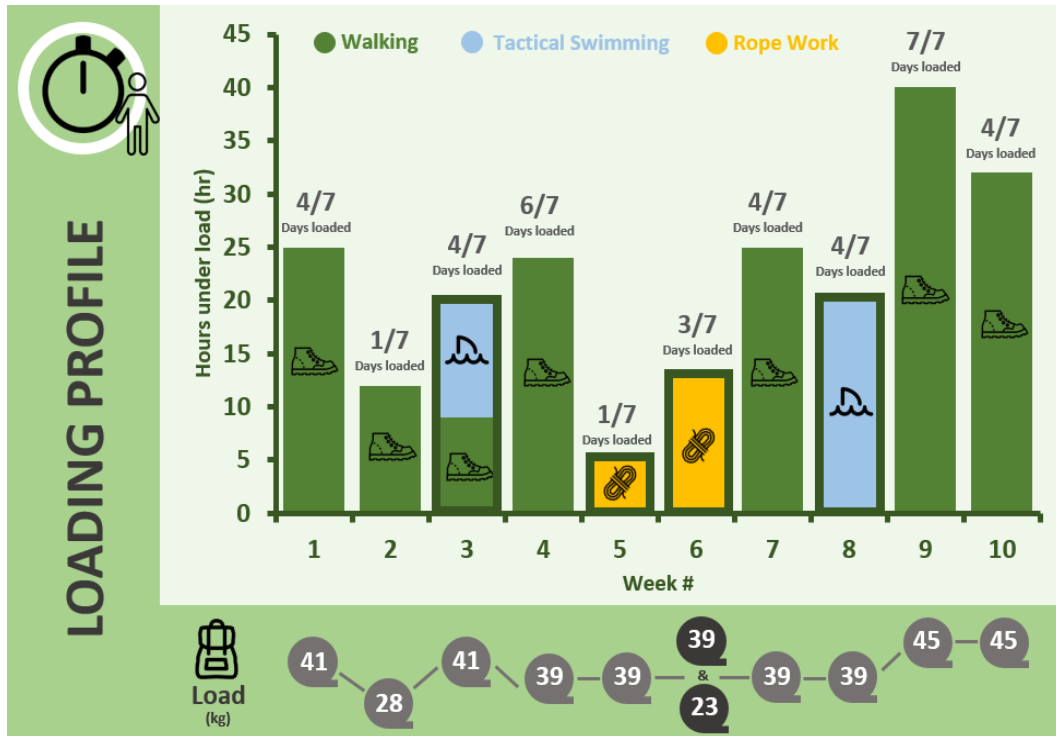


Figure 7: Loads in kg, worn by 2017 PPF candidates over the 10 week period. Each bar represents the hours load was carried for that week, with the number of days per week under load indicated above (e.g. week 1: 4/7 days carrying 41 kg).

### *Movement Analysis Summary for PPF Course*

Table 5 summarizes the primary movements and tasks performed throughout the course. An additional observation was that as the duration of time increased under load, upper body posture degraded and there was obvious struggling with the rucksack such that candidates began leaning forward during the training. This challenge emphasizes the high demand for stamina and strength in the upper body and core. It is important to note that the weight of the rucksack was identified by all candidates as being the most physically demanding part of the course.



Table 5: Summary of movement analysis for all six physically demanding exercises of the PPF course.

Primary movement	Task description
Locomotion with external load carriage (wearing 45 kg rucksack)	Standing, walking and running on uneven ground on varying terrain (sand, woods, gravel) up to 10 hrs; short breaks with rucksacks off
	Climbing stairs (unbalanced stance) with high repetition
	Quickly changing direction and running in opposite direction for 5-25 s, up to 180 s with multiple repetitions
	Rucking with 13 kg parachute for 250 m
	Stepping over logs (i.e. uneven terrain)
Finning-swim	Tactical swimming (finning while controlling rucksack and weapon for 1-3 km)
Lunging and squatting (wearing up to 45 kg rucksack)	Lunging up from and down to one knee
	1 and 2-foot landing from rappel or fast rope
	Squatting up and down with load (as far down as into sitting)
Lifting (and lowering) up to 45 kg	2-handed lift and lower the rucksack from ground (to put on or take off back of truck)
Pulling 45 kg+ (sometimes while wearing 45 kg rucksack)	Quickly pulling (1 and 2 handed) from stooping over edge of assault boat with wet rucksack and others out of water
	Quickly pulling self out of water into assault boat, from overhead (kicking legs for help)
	Lateral pull from prone and quickly pulling rucksack into water from assault boat; stooping position
	1 and 2 handed pull of rucksack from stooping posture and of others to standing from sitting with 45 kg rucksack
Gripping 45 kg + body weight	Gripping rope and fast rope (squeezing leg adductors)
Carrying (55-60 kg) (sometimes while wearing 45 kg rucksack)	Carrying extra rucksack with a sense of urgency (200+ m)
	1 handed carry of assault boat by handle (wearing rucksack) on beach and through brush; slight lean to side
	1 and 2 handed carry of boat motor (no rucksack); lowering into boat in awkward position through sand and pebbles
	Carrying a weapon (while rucking) 2 hands at chest
	2-handed, 2 person casualty carry wearing rucksack
Dragging (55-60kg) (wearing 45kg rucksack)	1-handed casualty drag (2 person drag) over brush and obstacles
Getting up and down from sitting (wearing 45kg rucksack)	Rolling over to and from hands and knees, to and from laying on back, to lunge to standing (i.e. awkward positions)
	Sitting to standing and rocking forward to feet (deep squat)
Moving to and from prone (sometimes wearing 45kg rucksack)	Stabilizing in prone position on side of assault boat; squeezing with legs while controlling weapon
	Quickly pushing self-up (2 hands) to roll into water while on unstable surface
	Moving to and from prone position to standing with rucksack and holding weapon

### Metabolic demands – Most Metabolically Demanding Hour

For each of the six physically demanding training activities that were measured, the most metabolically demanding hour is presented in the following figures and table to provide a point of reference for the performance readiness physical fitness training programming. The intent is to ensure that the physical training sessions prepare the candidates for the demands of the course, and most sessions are designed to be completed in an hour to fit into common CAF training programming.

Each graph represents a 1-hour record sample of the most metabolically demanding hour and the duration at each VO<sub>2</sub> workload (N = 1).

#### ICF March:

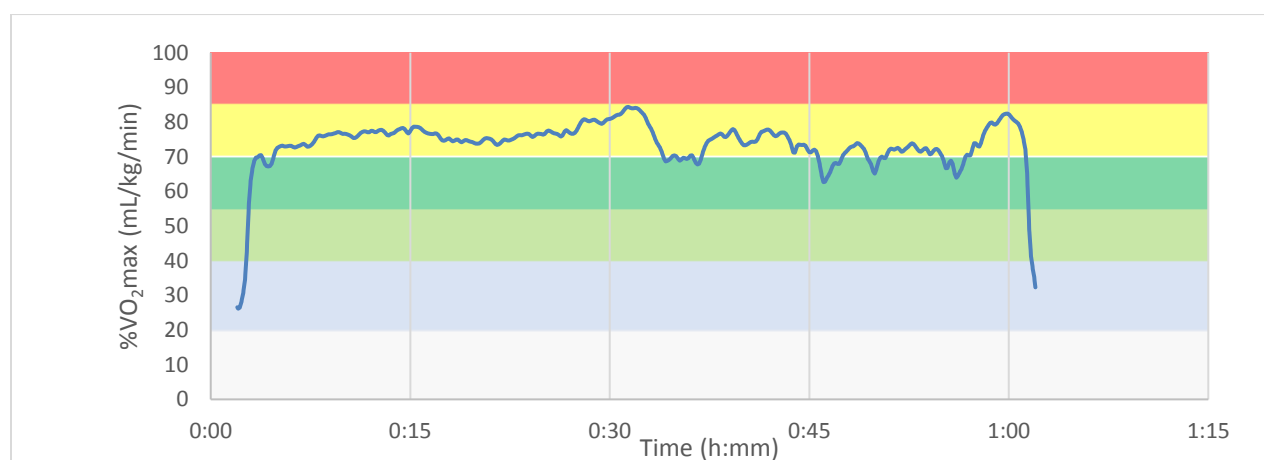


Figure 8: Sample record of the most metabolically demanding hour of the ICF march, N = 1.

#### SOP:

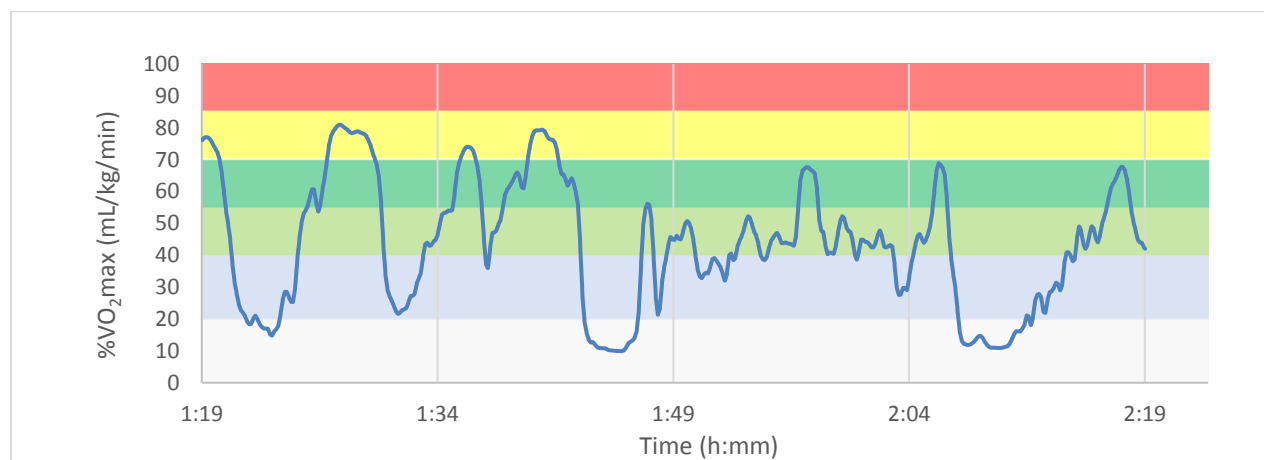


Figure 9: Sample record of the most metabolically demanding hour of the SOP, N = 1.

**Navigation:**

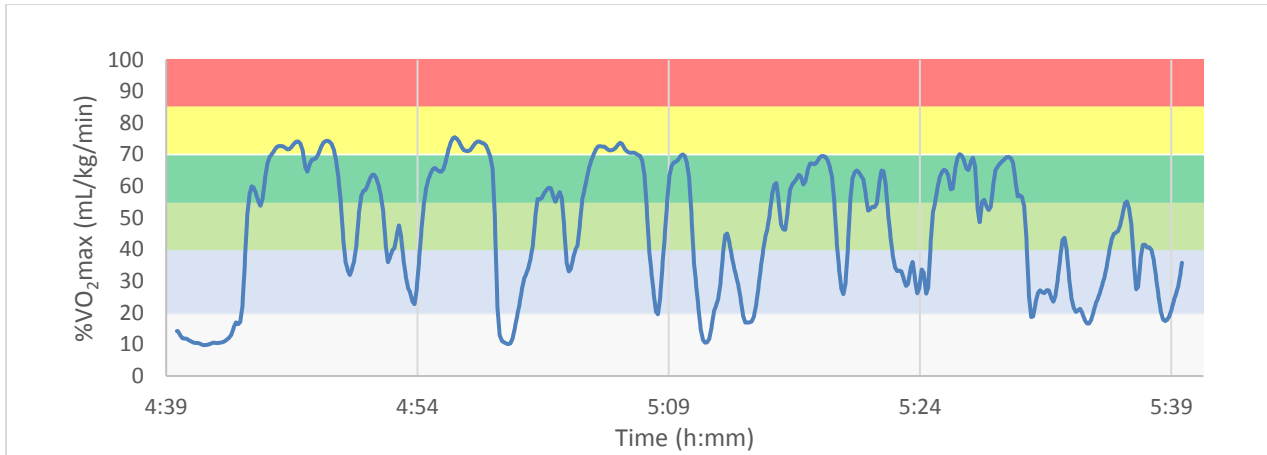


Figure 10: Sample record of the most metabolically demanding hour of the Navigation, N=1.

**Insert/Extract**

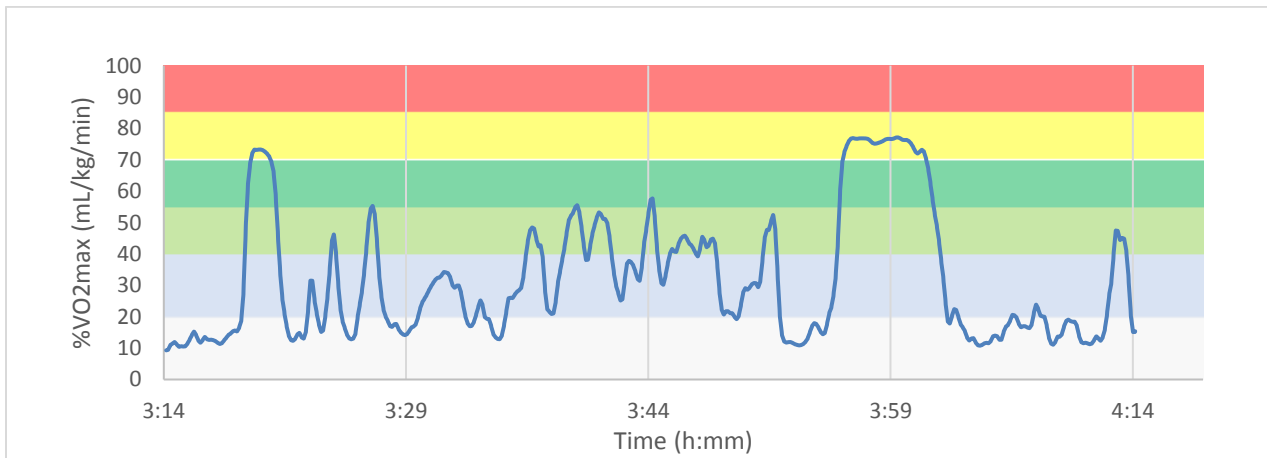


Figure 11: Sample record of the most metabolically demanding hour of the Insert/Extract exercise, N = 1.

### Rappel Tower:

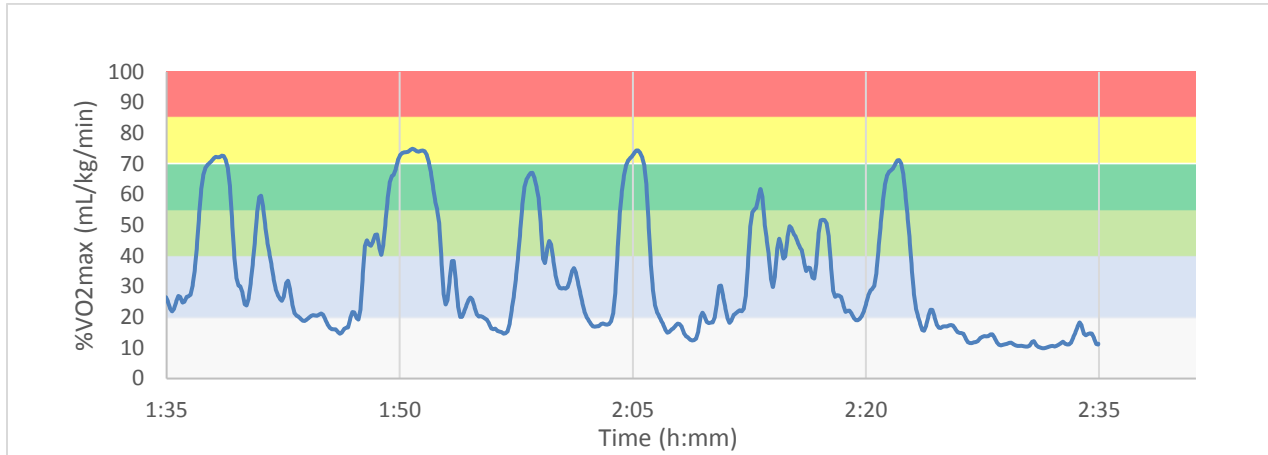


Figure 12: Sample record of the most metabolically demanding hour of the Rappel Tower exercise, N = 1

### FTX:

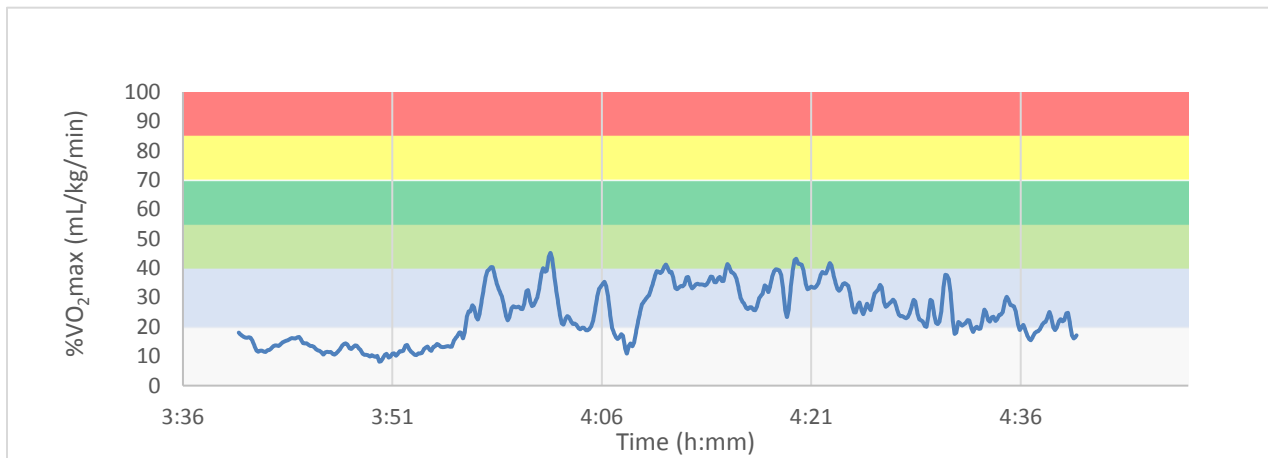


Figure 13: Sample record of the most metabolically demanding hour of the FTX, N = 1.

Table 6 provides a summary of the most metabolically demanding hour for all candidates where there are full records for each activity, as shown in Figures 1-6.

		Workload category % VO <sub>2</sub> max range					
		Sedentary	Light	Moderate	Heavy	Very Heavy	Extremely Heavy
Training Activity		0 - 20%	21 - 40%	41 - 55%	56 - 70%	71 - 85%	86 - 100%
ICF March	VO <sub>2</sub>	9.22	16.76	24.52	33.46	39.40	44.42
	Duration	0:01	0:12	0:17	6:13	41:32	11:45
SOP	VO <sub>2</sub>	7.21	15.39	24.74	32.36	39.09	44.67
	Duration	8:49	11:37	11:33	14:21	12:54	0:46
Navigation	VO <sub>2</sub>	8.22	15.84	25.63	34.01	39.61	46.90
	Duration	4:36	7:42	9:38	18:27	17:36	2:02
Insert/Extract	VO <sub>2</sub>	7.96	15.12	24.35	32.20	39.93	-
	Duration	15:12	25:29	10:27	6:33	2:20	-
Rappel	VO <sub>2</sub>	8.35	15.30	24.52	32.35	39.49	45.57
	Duration	8:27	13:52	9:04	10:55	16:06	1:35
FTX	VO <sub>2</sub>	6.88	15.07	23.85	31.48	34.98	-
	Duration	15:53	19:16	10:05	8:22	6:23	-

Table 6: Most metabolically demanding hour for each training activity: average VO<sub>2</sub> (mL/kg/min) and duration (min:ss) at each workload.

*Caloric Demands of Most Physically Demanding Training Days:*

To appreciate the energy cost that is required for each of the events that were measured, Table 7 provides the average caloric cost per hour. Based on this table and Figures 1-6, candidates are required to sustain overall, high energy demands for prolonged periods, with bouts of high cardiovascular demands, while also being able to learn. The variations in the min - max are mostly due to different body sizes.

Table 7: Average caloric demands of 6 training activities and comparable physical activity.

Training Activity Average Duration (hr:min)	Average (kcal)	SD	Min	Max	Average rate (kcal/hr)	*Comparable Physical activity (kcal/hr)
ICF (5:03)	3790	697	2744	5131	750	Running 8 km/hr Singles tennis Basketball
SOP (7:27)	3349	152	2397	4156	449	Downhill skiing Low impact aerobics Tennis doubles
Navigation (14:59)	5505	1042	3725	7463	383	Bicycling 16 km/hr Volleyball
Insert /extract (9:59)	3051	435	2197	3905	305	Walking 3.5 km/hr
Rappel Tower (7:00)	2994	461	2238	3811	426	Weight training
FTX (40:19)	12 569	2464	9328	15949	311	Yoga

\* Adapted from [www.mayoclinic.com/health/exercise/SM00109](http://www.mayoclinic.com/health/exercise/SM00109) for comparable body weight.

As a comparison, also shown in Table 7, the training activity energy demands are matched with common physical activities to provide perspective of the effort required over the 5-40 hour durations, although it does not reflect the discomfort of the heavy loads carried. This gives us perspective of the importance of the overall stamina required for extended periods of time while being able to maintain cognitive capacity, the ability for the musculoskeletal system to tolerate sustained load, and the recovery required to repeat this type of work.

### *Pre-Questionnaire:*

Prior to beginning the PPF course, 21 out of 23 candidates completed a questionnaire which investigated physical training habits 6 months prior to the course; asking questions about their training frequency, duration, intensity and type (i.e., muscular strength, power, endurance, cardiovascular, external load carriage, flexibility/mobility), support in preparing for the PPF, military courses taken prior to PPF, tapering, and recovery (see Appendix B).

Based on the responses shown in Figure 14 from the pre-questionnaire, it is highly recommended that prior to the course, candidates participate in the Pre-PPF course (refresher of PPF relevant military skills) and in regular fitness training, and seek physical fitness training support (e.g., PSP fitness professional, qualified PPF) to increase the chance of course completion. The more support/training opportunities that candidates had the greater the likelihood of success. Nine out of eleven (82%) successful candidates participated in at least two out of the three recommended preparation criteria, as compared to only two out of the nine (22%) candidates who RTU. The one candidate that voluntarily withdrew during the FTX

also participated in at least two out of the three preparation criteria suggesting a RTU reason beyond physical ability (e.g., lack of motivation). One candidate did not PASS due to academic failure but completed the physical demands of the course (RTU group); he had not participated in the PPF pre-course, did not have training support, nor had consistent physical fitness training prior to course.

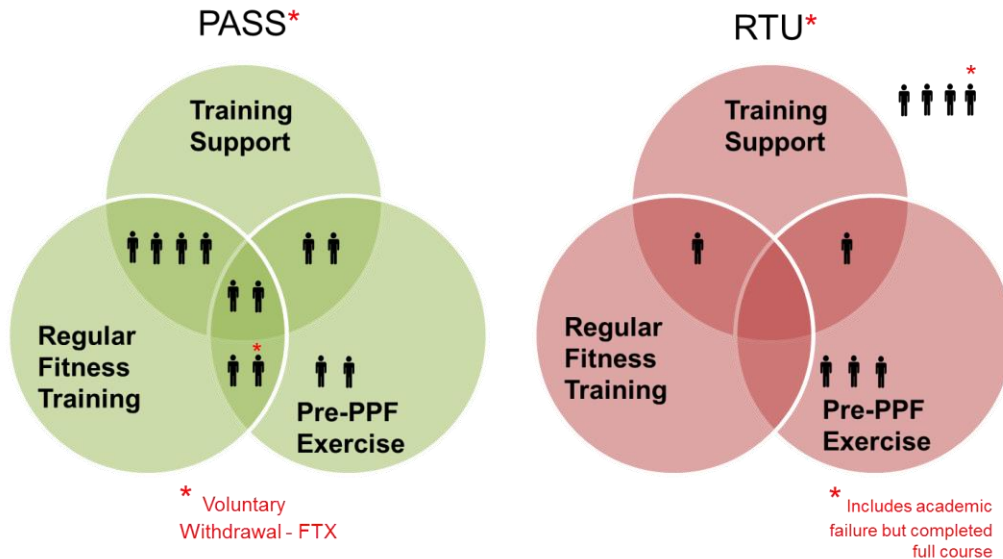


Figure 14: Regular fitness training, physical fitness training support, and pre-PPF participation obtained by candidates in the 6 months prior to PPF course for PASS group and RTU (injured and academic failure). One candidate from each of the PASS or RTU did not answer the pre-questionnaire.

### Physical Preparation

Overall, the 21 candidates that responded to the questionnaire had a wide variation in physical training preparation with no obvious differences between the RTU and PASS groups. During the 6 months prior to the course:

- Most candidates either participated in rucking at least 1x/month and up to 4x/week, carrying between 22.5-45kg; although two of the PASS group did not ruck at all except during the pre-PPF (but still felt prepared as indicated on the post-questionnaire).
- Most candidates had a good level of fitness and participated in a broad range of training activities on 4-7 days/week including moderate to hard training intensity. While the right types of training activities were included in most of the candidates training routines, twelve of the candidates (8 RTU; 4 PASS) were unable to maintain a consistent training schedule in the six months prior to the course.
  - Upon further investigation it was discovered that candidates had inconsistent training for a period between 2 - 6 months before the PPF, and were only able to complete the occasional training session and/or rucking once a week or month. This discrepancy was due to the requirement for those candidates to take prerequisite courses, other developmental course and military taskings. Although, some of these requirements

included some physically demanding activities, more often, it was mentioned that they did not. Training behaviours for the 3-6 month period were mentioned as being difficult to maintain.

- Most candidates tapered their training, which ranged from three days to four weeks to allow injuries to heal and to recover for PPF. However, there were a few candidates that did not taper due to lower volume of training, and one candidate decided to keep training with no taper (RTU injured).
- The fact that most candidates trained regularly or had a fitness training history prior to the 6 months of PPF course is not surprising considering that they were screened with the prerequisite and most physically demanding component of the course, the 39kg 20 km ICF march, assessed as part of the pre-PPF selection process.

### *Post Course Questionnaire*

Of the 18 candidates who started the FTX, 17 completed a post course questionnaire (see Appendix C). All 17 completed at least 24 hours of the FTX. The one candidate who did not, withdrew for personal reasons, however he did not demonstrate any physical fitness limitations throughout the course. Although no one was removed due to not being able to keep up, the post questionnaire indicated that those who completed the PPF course felt more prepared than those who were RTU injured during the FTX.

### *Level of Physical Preparedness*

Candidates reported their level of physical preparedness using the Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree) as shown in Table 8.

Table 8: Level of physical preparedness rating and course success, N=17.

Agreement of “Did you feel physically prepared for this course?”	count (n=17)	Status at end of course
1 (strongly disagree)	1	Injured – RTU
2 (disagree)	1	Injured - RTU
3 (somewhat disagree)	1	Completed physical demands
4 (neither agree or disagree)	1	Injured -RTU
5 (somewhat agree)	6	Completed physical demands*
6 (agree)	5	completed physical demands
	1	RTU
7 (strongly agree)	1	Completed physical demands

\* includes 1 academic failure

### *RTU Candidates:*

The candidate (RTU- pre-existing injury) who felt the least prepared (1: strongly disagreed) did not fill out the entire pre-questionnaire so it is difficult to infer where he may have been lacking in his training preparation.



One candidate (RTU- injury) who disagreed (rating of 2) with the statement *did you feel physically prepared for this course* was told 5-weeks prior to the course that there was a spot open for him (i.e., little preparation time) and reported that he only purposefully started training 5 weeks prior to the course. He had also just spent 3 months on a tasking (April-June). This candidate reported rucking 3-4 times per week with 39kg, for 1 hr and 40-50min, running 2x/ week for 30 min, and 1 set of pull-ups and push-ups (3-4x/week) as his training for the 5 weeks. He did not complete pre-PPF, nor received training support.

The candidate that somewhat disagreed (rating of 3) with the statement *did you feel physically prepared for this course*, did not complete the pre-questionnaire so it is difficult to infer what parts of his training may have contributed to his perceptions that he was somewhat unprepared for the course.

The candidate (RTU-pre-existing injury) who neither agreed nor disagreed with the statement started purposefully training 3 weeks before the course (i.e. little preparation time). This candidate participated in the pre-PPF but did not receive training support. He was also on course or operation tasking for 6 months (Jan-June) and found it difficult to fit in much training. During this time, the candidate reported completing 5 rucksack marches at distances estimating 10-20 km (weight not reported). Prior to the 6 months he had participated in a well-rounded fitness program.

The candidate who agreed (rating of 5) with the statement but was RTU for an ankle sprain, reported purposeful training for 2 months prior to the PPF course. He did not participate in the Pre-PPF, nor did he receive training support. In the 4 months prior to PPF he was on a military tasking for 2 months. In the past 6 months, the candidate reported rucking 1 time per week with 52kg pack for an estimated 15-20 km, and a strong well rounded physical training program. He took 3 days off as a taper.

*The following sections will serve as a check to ensure that these elements are addressed in the Performance Readiness Program.*

### *Physically demanding components of course*

Candidates were asked to rank the 3 most physically demanding components of the course (see Appendix C). It is important to note that the weight of the kit to be carried was the greatest underlying challenge for all candidates. The physical demands identified 'order of the most mentioned' were: Prolonged ruck: ICF March /Nav / FTX (17), lack of sleep/recovery: FTX (13), moving very quickly with rucksack (SOP; 11), climbing tower (9), tactical swimming (6), heat (ICF, SOP, rappel tower, 4). Other stressors mentioned by one candidate were: carrying the boat, getting in and out of the assault boats from the water, kneeling with rucksack, managing hydration, sore feet, pushing through the dense woods at night.

### *Most Beneficial Physical Preparation*

When asked: '*What physical preparation helped you the most to tolerate the physical demands of the PPF course?*', candidates identified the following: regular heavy rucksack (feet, body, mental toughness),

leg endurance/running, solid overall fitness, Pre-PPF course, PSP support, rest, swimming, uphill farmer's walk (trapezius strength for rucksack).

### *Reflection on the importance of PT*

Candidates were asked, what physical fitness training/preparation they should have added to be better prepared. Rucking was a top response as it was also mentioned as the most demanding, suggesting that candidates felt their training was lacking in the ruck preparation components. As previously indicated several, candidates had inconsistent opportunity for physical fitness training due to work tempo, or had been informed of course participation with little PPF specific training. Thus 'more time' was also identified an opportunity that would have helped them better prepare. Other responses included: swimming, mental prep, PSP help and more strength (core, legs, back).

## Discussion

### Fitness Test results

Although, the physical fitness results (squat, bench press, curl ups, VO<sub>2</sub>max), were not indicators of success, it does not necessarily mean that fitness did not play a role in success. It is worth noting that those candidates who did not complete the course had an average of 13 more squat repetitions than the PASS group. These indicators may not be the right tests, as they are discreet tests and do not measure the capacity for recovery over repeated days. However, the screening on base (pre-PPF selection: 20 km ICF march 39kglbs, Basic Parachutist PT test, and BMSS) may have already selected candidates to a minimal level, which may include the capacity to perform at the levels identified of these simple tests.

### Age

Although the PASS group was 2.6 years younger than those that did not complete the course, there is probably not a real physiological difference as the mean age of the candidates was in the mid to late 20s.

### Injuries

The observations from this study do not provide enough detail as to why so many candidates became injured, except that 6 of 9 had pre-existing injuries. It is possible that some of the successful candidates also had injuries, but these were not enough to prevent course completion; successful candidates were not surveyed. Possible reasons may be due to inconsistent physical fitness training followed by too much volume (catch-up training), resulting in weakness of the musculoskeletal system, thus making the body more susceptible to injury (Hulin, Gabbett, Caputi, Lawson, & Sampson, 2016) (Gabbett, 2016). Because of the combination of almost daily heavy loads, with little recovery, the benefit of beginning the course injury free, or at least with an injury that will not be aggravated by this type of load is highly recommended.

### Prior to PPF course recovery state

As almost 55% of the course can be described as heavily loaded work days balanced with 45% rest or light physical days, it is recommended that a taper period of 2 weeks be prescribed prior to beginning the course. During this period training volume is reduced by 50%-75% over the 2 weeks or completely removed for the second week, while light, fun activities and mobility are retained. This taper period is commonly prescribed for events of long duration and will allow for physical and mental recharging, and healing (Nunes, et al., 2014).

### Mental Toughness

Some of the candidates indicated the value of the ruck training for building mental fitness. Alongside the physical requirements, candidates must also demonstrate a certain degree of *mental toughness*—“...the ability to achieve personal goals in the face of pressure from a wide range of different stressors” (Hardy, Bell, & Beattie, 2014). Within the military context, research has demonstrated the importance of this construct to success and performance in the company of extreme stress, harsh conditions and physically demanding training regimes (Arthur, Fitzwater, Hardy, Beattie, & Bell, 2015). Given the high physical demands of the PPF course, mental toughness is critical to a candidate’s ability to meet required objectives while faced with the challenges of various demanding tasks (e.g., heavy load carriage over long periods in austere environments, little sleep, cold, dampness, lack of recovery, etc.). Similar to other specialized military training settings, the physical and mental demands of the PPF course requires candidates to have a degree of mental toughness and/or various mental coping strategies to help them push through repeated exposure to stress and fatigue.

### Cognitive Work Capacity

Candidates always carried and controlled either a C8 or C9, were required to maintain safety and have situational awareness throughout the course, thus should never be working at a maximum level for any period of time that would affect their decision making ability (Chang Y.-K. , Labban, Gapin, Jennifer, & Etnier, 2012). This underlying necessity highlights the importance of the candidates’ requirement to have a high enough physical capacity for performance and recovery, to always maintain cognitive effectiveness; this is an essential element of the training that is required to prepare PPF applicants.

### Post study observation – Early preparation

While there was not any real differences in physical fitness (as measured by the discrete tests: squats, sit-ups etc.) between the PASS and RTU groups during the 2017 PPF, a real difference may exist a step prior to the pre-PPF, in the early preparation phase. In the initial stages of establishing links between base PSP and PPF platoon leaders in May 2018 (with the intent of trialling/socializing the Performance Readiness Program), it became apparent that some of the candidates on the pre-PPF were unsuccessful due to fitness, in particular the ICF march, basic para PT test and the BMSS. Not all bases run the Pre-PPF but all candidates must complete the 20 km 39kg ICF march and basic military swim standards (BMSS) prior to arriving on course. Therefore, if applicants are prepared prior to the pre-PPF

time frame there may be a larger (and more competent) pool to select from making the overall process more competitive.

## Important elements which increase likelihood of success on PPF course

### *Regular purposeful fitness training (4+x/week, 6 + months)*

Candidates that follow a regular fitness training program in the months leading up to the course are more likely to have a solid base of physical fitness. This is true even if training is not as consistent immediately prior to course. Additionally, the long period increases the likelihood that the training follows progressive overload principles and thus reduces risk of injury in the buildup phase. Candidates with a solid base of physical fitness will be able to rely on it in the context of the course where high physical demand is coupled with low rest.

### *Training support*

Support from an exercise specialist and/or a veteran PPF will help guide the candidate and optimize time spent on preparing. Targeted training is more effective and time-efficient and thus is essential in the context of less than ideal training periods. Having support also means that the candidate's program can be tailored to his specific context and thus help target both his/her strong points and work on elements that need improvement to increase likelihood of success on course. In the case of setbacks or obstacles, good support can help candidates navigate through and not lose sight of the training objectives.

### *Pre-PPF course*

The aim of the 2-week course is twofold. (1) Screen candidates and (2) Expose candidates to the type of tasks and environments they will encounter during the PPF course. Candidates that go through this process ensure that they understand what is required of a PPF and see if this qualification is appropriate for them. For those candidates with less experience, the pre-PPF course may be even more important for success on the PPF course. This realistic job preview (physically and mentally) also acts as an important reality check for the candidates to see whether they are on the right path in terms of preparation and where they need to adjust their training to increase likelihood of success if recommended for the PPF course.

## Recommendations

The following recommendations are derived from the observations and measurements obtained from this study.

### *Approach for Improving PPF Course Candidates' Success*

After analysis of the demands of the PPF course a team of PSP fitness professionals was assembled to help design a physical fitness training program that would ensure that all elements present on the course are addressed and optimally prepared for. The development of the programming followed a progression from the evidence based programming designed in *dfit.ca* for the Army which was validated in a 12-week training study (Laframboise, 2017). The PPF physical fitness program is broken down into 2 phases, (1) Foundation and (2) Specific. The intent is to host this program on the web based platform, and possibly be available as an App through *dfit.ca*.

- (1) The Foundation phase (10 weeks): Builds on the basic physical fitness which the candidate should have acquired by April: 18 weeks prior to course; this basic fitness could effectively be obtained by following dfit.ca FORCE Combat fitness training program for 5 days per week for 3 – 6 months or with a similar approach. The Foundation phase targets PPF-specific elements while still working on acquiring broad physical capacities. This phase has been shown to be crucial for success in the specific stages of physically and psychologically demanding tasks (Corcoran & Bird, 2009; Deweese et al., 2015).
- (2) The Specific phase (6 weeks): Builds on the foundation section, focuses on the most relevant aspects of the course and ensures that once completed, the candidate is both physically and mentally optimally prepared to face the challenges of the course (Corcoran & Bird, 2009; Deweese et al., 2015).

### Recommendations to PPF Leadership

1. Create a network including PSP and PPF to support the Performance Readiness Program.
2. PPF units begin to socialize interested candidates one year in advance to maximize the amount of time that candidates have to prepare:
  - a. Soldiers will have sufficient time to build a solid fitness base, and
  - b. Soldiers begin taking the courses that are prerequisites; advanced capability (requires certain experience and maturity). Mandatory and optional pre-requisites increase PPF course success.
3. The interested soldier should communicate with their CoC to inform them of their intent and potentially limit the interference in the months prior to course (operational tasking and professional development) with preparation and training.
  - a. Candidate needs to prepare to maximize chance for success.
4. Soldiers connect with base PSP fitness and reconditioning professional, and PPF unit for support and increase likelihood of staying on target.
  - a. Support will build confidence which is an important component of mental toughness (Clough, Earle, & Sewell, 2002)
  - b. SME support will reduce trying to improve physical fitness too quickly or just survive pre-PPF or PPF, reducing the chance for injuries often associated with too quick of a progression.
5. If a candidate is tasked during the 6 months prior to course, being connected with a fitness professional who is knowledgeable regarding the demands of the course and the Performance Readiness Track will help that soldier focus on what is the most important, and ensure they return to training progressively.
6. Once selected for PPF, the candidates should continue to ensure they are progressing their performance training to be able to meet the demands of the course, ideally by working PSP professional and the pre-PPF team.

7. Finally, a taper period (1-2 weeks) should be built into the final stage of the preparatory phase for the PPF course period to optimize physical and mental, rest and recovery. A leave period is recommended during this phase.
8. Program evaluation of this recommended approach/project in order to assess effectiveness. By tracking:
  - a. Interaction of applicants with base PPF platoon and PSP for the purpose of guidance preparation.
  - b. Physical fitness preparation;
  - c. Participation in PPF pre-course or similar;
  - d. Use of PPF and PSP support for PPF candidates;
  - e. Attrition/success on course;
  - f. Injuries.

As part of this study a **Performance Readiness Poster** (Appendix D) was prepared to create early awareness of the requirements and demand of the PPF course thus creating the opportunity for the ideal performance preparation situation. This poster includes:

1. An infographic highlighting the physical fitness, military training prerequisites, personal readiness recommendations for PPF, and the physical demands of the course all within a timeline;
2. Guidance for the physical fitness training program through 3 phases; foundation, specific and taper (including time allocated for pre-PPF course); and
3. An assessment of performance and personal readiness (not ready / ready PPF).

Finally, for the pre-PPF course 20 km 39kg performance check, it is recommended that the distance of the ICF be matched with the PPF readiness training program (according to the time period during which pre-PPF is run). This approach will help reduce injury and allow for progressive work ups in order to be ready for the PPF course.

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## Appendix A – Physiological and Anthropometric Testing Protocol

1) **Physical Fitness** – Participants will be asked to wear their physical training gear (t-shirt, shorts and running shoes) for this portion.

Prior to commencing the Physical fitness test portion, a baseline Body Composition (weight (kg), lean body mass (kg), fat mass (kg), intercellular water, extracellular water ratio (ECW/TBW), body mass index (BMI, kg/m<sup>2</sup>), percentage of body fat (% PBF), segmental lean analysis (right arm, left arm, trunk, right leg and left leg) will be obtained—using the Lunar Inbody520.

Following this, participants will be asked to begin with a *cardiovascular endurance test or VO<sub>2</sub> max*. Once the VO<sub>2</sub> max test is completed, the participants will move onto to completing a series of *muscular strength endurance tests*.

**Cardiovascular Endurance or VO<sub>2</sub> max test:** A Graded Exercise Test (GXT) will be conducted to determine participants' peak aerobic capacity (VO<sub>2peak</sub>) and maximum heart rate (HR). Expired gases will be collected using the Parvo Medics True One 2400 (Parvo Medics Inc, Utah, USA) metabolic measurement system. Oxygen (O<sub>2</sub>) and carbon dioxide (CO<sub>2</sub>) will be analyzed using paramagnetic O<sub>2</sub> and infrared CO<sub>2</sub> sensors. A Hans Rudolph two way non-re-breathing valve (Hans Rudolph Inc, Kansas, USA) mouthpiece, nose clip and head support will be fitted on the participant. As well, a Polar Wear Link and coded transmitter (Polar Electro Canada Inc, Lachine, QC) to monitor HR will be fitted and secured around the chest beneath the participants' nipple line, next to the skin. Prior to the start of the test, participants will be permitted to familiarize themselves with treadmill running by warming up for a period of 5 minutes. For the warm-up, participants will not be hooked up to the breathing apparatus (i.e. mouthpiece, nose clip and head support), but will wear the Polar HR monitor. Participants will commence running on the treadmill at a speed of 4.0 miles per hour (mph) and will be informed to gradually increase the speed until they reach a comfortable warm-up speed between 5.0 – 7.0 mph.

After 5 minutes of running, the participant will be permitted to recover until their HR is equal to or less than 120 beats per minute (b·min<sup>-1</sup>). During the recovery period, the participant will be hooked up to the breathing apparatus (i.e. mouthpiece, nose clip and head support). The treadmill speed for the test will be based on the HR the participant attains during the warm-up period and in consultation with the tester. If the participant attains a HR greater than 160 b·min<sup>-1</sup> during the warm-up, the treadmill speed for the test will be 7.5 mph for males and 6.5 mph for females. If the participant attains a HR between 140 – 160 b·min<sup>-1</sup> during the warm-up, the treadmill speed for the test will be 8.0 mph for males and 7.0 mph for females. If the participant attains a HR less than 140 b·min<sup>-1</sup> during the warm-up, the treadmill speed for the test will be 8.5 mph for males and 7.5 mph for females. Dependent upon the participants' previous running experience, the treadmill speed for the test may be modified by the tester in consultation with the participant.

The first 2 minutes of the treadmill test will consist of running at an initial grade of 0 percent (%). Thereafter, the treadmill incline will be increased by 2% every 2 minutes until a respiratory exchange ratio (RER) of 1.00 is achieved. When a RER value of 1.00 is achieved, the treadmill incline will be increased

by 1% every minute until volitional fatigue, at which time the test will be terminated. At the end of each 2 minute test increment, up to when a RER value of 1.00 is achieved, the participants will be requested to provide a rating of perceived exertion (RPE) using the Borg scale (ACSM, 2010) as RPE has been found to be a valuable and reliable indicator in monitoring a participants' exercise tolerance. Perceived exertion ratings correlate highly with measured exercise HR and was developed to allow the exerciser to subjectively rate his/her feelings during exercise (ACSM, 2010). A copy of the Borg scale is attached as Annex F. Various objective and subjective indicators are useful to confirm that maximal effort has been elicited during the GXT. The following indicators will be used to confirm VO<sub>2</sub>peak (ACSM, 2006):

- i. failure of HR to increase with further increases in exercise intensity;
- ii. a plateau in oxygen uptake (or failure to increase oxygen uptake by 150 ml/min) with increased workload;
- iii. A RER greater than 1.15; and
- iv. A RPE of more than 17 (6 to 20 scale).

After GXT completion, the participant will be required to perform an active cool-down for 5 minutes, or longer if abnormal HR recovery is observed. If the participant is unable to perform an active cool-down, then a passive recovery will occur with the participant in a sitting or supine position. HR and blood pressure will be monitored in this case, and onsite medical staff will be advised of the situation. This fitness test has previously been approved in protocols #L-815, #L-733, #L-755 and #L-682.

***Muscular Strength Endurance Tests:*** The following fitness tests will be used to measure muscular strength endurance, that is, the ability to repeat a series of muscle contractions without fatiguing. Each strength test is specific to the action and muscle groups being tested.

- ***Upper Body:*** The Bench Press Beep Test will be used to measure maximum strength endurance of the chest muscle groups. Equipped with a standard padded bench with safety catch, a standard weight bar with 150 lb total weight (including bar), and a metronome set at a rate of 25 per minute (set at 50 to include up and down movement), each participant will be instructed to perform as many repetitions as possible. Following an appropriate warm-up, the maximum number of complete repetitions successfully performed will be recorded (Annex G).
- ***Core Strength:*** The Curl-Up Beep Test will be used to measure abdominal strength and endurance, which is important in back support and core stability. Participants will be instructed to lie in a supine position on a mat with the knees bent at 90°, heels in contact with the ground and arms crossed over their chest with each hand on opposite shoulder. The participant will be permitted a warm-up to ensure a proper curl-up is performed – with the heels in constant contact with the floor and feet are not held, a curl-up far enough so that the elbows make contact with the thighs and return so the shoulder blades touch the mat. Without pausing, participants will be asked to perform the maximum number of curl-up repetitions possible at a cadence set to 25 curl-ups per

minute (metronome set to 50 to signal up and down movement). The total number of curl-ups will be recorded. (Annex G)

- *Lower Body:* The Standard Load Squat will be used to assess lower body strength . For safety, this test this will be performed using a squat rack with a safety bar and stoppers. The safety bar and stoppers will be set just below the end position for each participant (90° angle at the rotational axis of the knee). Participants can therefore let go of the bar and step forward partway through any repetition if they judge that they cannot complete a repetition or control the bar. Prior to the commencement of the test, participants will be permitted to perform 8 – 10 repetitions with a weight bar to warm-up. For the test, participants will be required to take a standing position with feet shoulder width apart, toes pointed slightly outward, back erect, and with the barbell on the shoulders. They will then be required to squat (to a 90° angle at the rotational axis of the knee and return to full extension) with a weight of 72 kg at a cadence of 42 beats per minute (b·min<sup>-1</sup>) as set by a metronome. Each click of the metronome signals a movement either up or down with the weighted bar. The maximum number of repetitions that a participant completes before falling behind the required cadence will be recorded. (Annex G). This test has previously been approved for use in protocols L-815, L-833 and L-726.

## Appendix B – Pre-course Physical Fitness Preparation Questionnaire

How long prior to the course start date did you decide to participate in the Pathfinders course?

In the 6 month period before your course please describe your training:

Please indicate on average your volume per day overall/for each intensity. Include types of activities.

Intensity	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
<b>Very easy:</b> walking dog, stretching yoga, on feet at work includes some lifting carrying light loads							
<b>Easy:</b> fast walk unloaded, easy bike ride, physically active at work includes lifting carrying moderate loads							
<b>Moderate:</b>							
<b>Hard:</b> e.g. Circuit training with body weight							
<b>Very hard:</b> power, intervals, strength training							

Activity	Frequency (times/week/ biweekly/ monthly)	Duration (min)	Intensity: effort scale; 1:very easy, 3:moderate, 5:very hard (weight, repetition range)	Type (parts of body)
Load carriage: provide details about progression in load, distance, intensity etc.				
<i>Other details:</i>				
Loaded fitness training outside of load carriage:  e.g. weighted vest during functional circuits, tactical vest/other vest or weight # hours of day for work				
<i>Other details</i>				
Strength /power: reps/ sets, type of exercises  e.g. squats, deadlift, cleans, push-press				
<i>Other details:</i>				
Cardiovascular: include steady paced and intervals				
<i>Other details:</i>				
Functional movement training outside of strength training:  e.g. burpees, toe touches, battle ropes, agility runs from prone, types of circuits, CrossFit				
<i>Other details:</i>				
Flexibility/ mobility;  stretching, yoga, mobility exercises (Spiderman, caterpillar walk out)				

Other details:				
Competitive events or fitness checks				
Recovery; easy days, reduction in training volume				
Other details:				
Other training that is not addressed:				
Tapering before course; did you reduce your volume/intensity before course? Provide details of approach.	Decrease volume? Decrease intensity? How many days? What was your Focus?			
Overall what was the type of program followed? Progressive, maintenance?				
<b>Guidance/training support? ex: PSP, web site, unit leadership, other</b>				

## Appendix C—Post training Perceived Readiness Questionnaire

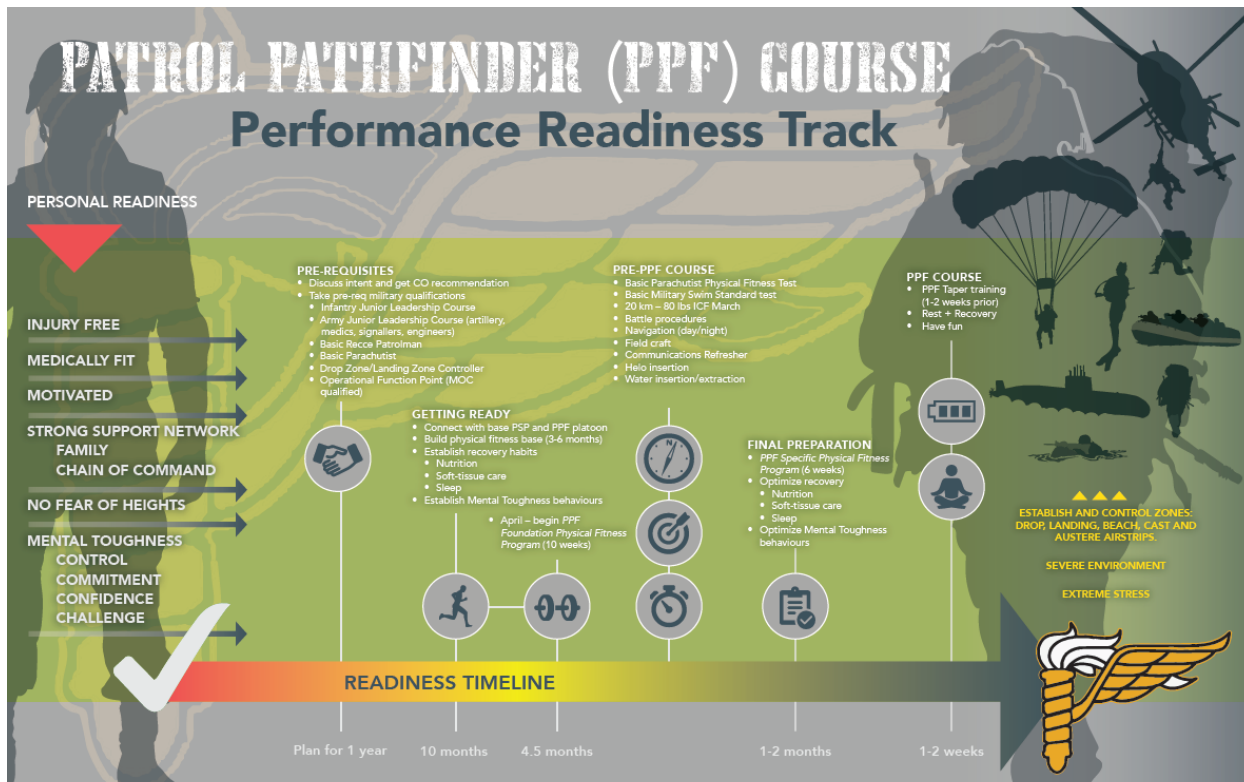
1. Did you feel physically prepared for this course?

Strongly Agree	Agree	Somewhat Agree	Neither Agree nor Disagree	Somewhat Disagree	Disagree	Strongly Disagree
7	6	5	4	3	2	1

2. Is there any physical fitness training that you feel you could have added to be better prepared? Please explain why.

3. What physical preparation do you feel helped you the most for the PPF course? Please explain why.

# Appendix D –Performance Readiness Poster



## ASSESS YOUR PERFORMANCE READINESS

	READINESS OBJECTIVE	NOT READY	BUILDING A FOUNDATION: PROGRESSING	READY FOR PPF
UNRESTRICTED MOVEMENT	Safe and controlled movements under PPF load (45kg): squat, deadlift, lunge, prone to push up	Obvious limitations in maintaining posture and body control; sagging twisting, joint instability and lack of mobility while unloaded	No limitations unloaded Safe postures and body control under moderate load (25-35kg: FORCE Combat)	Safe and effective body control and postures under PPF load
FUNCTIONAL CAPACITY	Effectively manage PPF load requirements for prolonged periods: carry, drag, lift, pull and ruck (45kg)	FORCE Combat loads are beyond ability PPF loads are well beyond current fitness	Can manage moderate loads with repetition: can complete FORCE Combat (25-35kg)	Can manage PPF loads for prolonged periods. Perform FORCE Combat circuit in less than 10min
METABOLIC CAPACITY AND ENDURANCE	Sustain and recover from long periods of heavy and intense work	Minimal or no participation in cardiovascular/metabolic fitness training. Difficulty recovering from low-moderate intensity PT	Achieve minimum VO <sub>2</sub> max of 42 mL/kg/min: run 2.4 km in at least 12:30. Capacity to recover from moderate to high intensity physical activities and training	Can endure long duration of PPF load carriage with bouts of high intensity. Capacity to recover from frequent high intensity training

## ASSESS YOUR PERSONAL READINESS

	READINESS OBJECTIVE	NOT READY	PREPARING/CONTEMPLATING	READY FOR PPF
INJURIES	No injuries that will be aggravated by rigors of course; pain free	Have pre-existing injury that will likely impact ability to complete physical preparation and the course. Currently receiving medical treatment and/or have limited movement	No injuries limiting leisure activities or moderate physical training. Practice injury reduction strategies	No limitations in high intensity PT or any activity. Confident that old injuries will not be aggravated by rigors of course
MOTIVATION	Involvement in training and PPF course for the inherent satisfaction and enjoyment of activity	Not really motivated to participate in PPF	Participating in course to satisfy others, personal challenge or gain recognition	Motivated to gain new skills and be a better soldier; doing it for myself and/or unit
MENTAL TOUGHNESS	Ability to remain calm and maintain a positive approach. Ability to set goals and work hard to obtain them. Ability to push boundaries, embrace change and accept risk. Self-belief and inner strength (ability to "dig deep")	Low	Moderate	High
SOCIAL SUPPORT	Degree of unit, family and community support	Minimally supported	Somewhat supported	Very supported



CONTACT YOUR BASE PATROL PATHFINDER PLATOON, AND PSP FITNESS AND RECONDITIONING PROFESSIONALS FOR TRAINING AND PREPARATION SUPPORT TO ENSURE OPTIMAL READINESS

