Validation of a new task-specific treadmill protocol for special operation forces

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by

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Abstract

Special operation forces (SOF) are required to withstand great psychological and physiological stress (Farina et al., 2019). Therefore, it is important that only those get selected for a position in a SOF-unit that fit the required profile. This study treats the aerobic capacity of SOF. Examined parameters include the maximal uptake in oxygen (VO_2max, Friedrich, 2022), the ventilatory thresholds 1 and 2 (VT1 & VT2, Westhoff et al., 2013) and the power (P) at those respective parameters. The goal of this study is to validate a newly developed cardiopulmonary exercise test (CPET) called "POTS", in which the subjects perform a run on a treadmill at 8 km/h with gradually increasing inclination (1°/min) and a weight vest of 13 kg. For that goal, the results of POTS are compared to the results obtained from a valid CPET protocol, "Swiss Olympic". If the validation is successful, POTS will be used in the future to assess the aerobic capacity and trainability of SOF-applicants and members.

Participants were 19 male (30.53 ± 8.46 years; VO_2max 56.42 ± 7.51 ml/min/kg) and 4 female (25.25 ± 2.16 years; VO_2max 47.25 ± 5.36 ml/min/kg) subjects. All subjects performed two CPET tests within seven days, once with the protocol POTS and once with Swiss Olympic. Their heartrate (HR) and their pulmonary gas exchange was measured.

The data obtained using POTS and Swiss Olympic (VO_2max, HR at VT1 (HR@VT1), HR at VT2 (HR@VT2), P at VT1 (P@VT1), P at VT2 (P@VT2) and maximum of P (Pmax)) were first compared using a Student's t-test, then a correlation using Pearson's *r* was done and the data was displayed in a Bland-Altman plot using a confidence interval of 95 %.

For VO_2max, no significant difference was found between POTS and Swiss Olympic ($p = .55$) with a systematic error from POTS of -0.32 ml/min/kg. For the parameter HR@VT1 and HR@VT2, a significant difference was found for HR@VT2 ($p = .04$) with respective systematic errors of 1.41 and 3.44 bpm, which were within the predetermined limits of agreement of 95 %. For the values of P, significant differences between P@VT1 and Pmax between POTS and Swiss Olympic were found ($p < .001$).

These data suggest that POTS yields accurate results and can be used to evaluate the aerobic capacity and the trainability of SOF-candidates and members. There is need for a new formula for calculating P in uphill running with added load. POTS also needs to be validated further by comparing it to other CPET protocol and looking at the test-retest reliability.

Contents

1 Introduction

Special operating forces (SOF) are a part of every military and police force. Their main missions are to act when conventional units do not fulfil the requirements, such as in situations where flexibility, speed, complete confidentiality, or special training is needed to complete the mission. They are required to be consisting of highly physically performant individuals (operators), which is why physical performance is one of the main criteria for selecting candidates for SOF (Farina et al., 2019).

The more demanding the task area of the respective specialisation, the higher are the physical and/or psychological demands on the operators (Margolis et al., 2014). As a result, candidates for SOF around the world undergo selections to determine who fulfils the performance requirements. It has been shown, that well developed endurance performance (Marées, 2003) can be considered an important predictor for a successful selection as well as success in operational situations (Harman et al., 2008; Knapik et al., 1990; Nindl et al., 2015; Teplitzky, 1991).

When measuring endurance performance, it is important that it is measured task-specific to obtain the most valid results and interpretations possible (Clénin, 2019; Larsson, 2003). Since SOF-tasks are most of the times carried out wearing body armour and additional gear, task specific measuring would mean to measure the endurance performance of operators while carrying additional load. To further support the task specific measuring in this case, Bugala et al. (2023) have shown, that performance with and without load differ significantly. However, it is not clear which are the most practicable and reliable methods for determining the task-specific endurance performance of an operator.

Following this, the goal of this study is to validate a SOF task-specific protocol for measuring the endurance performance.

1.1 Endurance performance

Endurance is generally understood as the capability of a human to resist psychological and physiological fatigue over a duration of time (Friedrich, 2022). The human body needs energy to sustain locomotion over extended periods of time, which is mainly supplied by breaking down adenosine triphosphate (ATP; Dunn & Grider, 2024). The human skeletal muscle at rest only stocks enough ATP to support a short period of muscular activity (Barclay, 2017). This fact highlights the importance of the capacity of the human body to regenerate ATP during muscular activity. There are mainly three different biochemical energy supply systems in which

ATP can be (re-)generated: (i) anaerobic alactacid, (ii) anaerobic lactacid and (iii) aerobic (Friedrich, 2022). The anaerobic alactacid system regenerates ATP by resynthesizing ADP with creatine phosphate (CP/PCr) to ATP, the aerobic alactacid system does so by glycolysis and the aerobic system by oxidative phosphorylation (Barclay, 2017; Friedrich, 2022). All these systems are always active when the human body is moving but to different degrees depending on the intensity and duration of the activity, whereas the anaerobic alactacid system can produce the highest amount of energy in a short duration and the aerobic system provides less energy at a time but for longer duration. The anaerobic lactacid system falls in the middle of the two systems regarding its energy production and sustainability (Friedrich, 2022). The functioning of those three supply systems is the basis for the endurance performance of a human, whereas the importance of a well-developed aerobic system is greater than the degree of development of the other two systems since it will provide most of the energy during middle to long endurance events. Performance limiting factors include the capacity of the mitochondrial metabolism, the size of the carbohydrate storage, percentage of slow-twitch muscle-fibres, the coordination and technique, maximum oxygen uptake, age and gender as well as psychological factors such as motivation or mental resilience (Friedrich, 2022; Taylor & Bachman, 1999).

1.1.1 Aerobic capacity

When trying to measure and determine an individual's endurance performance, one will quickly hear about the notion VO_2max, or maximal oxygen consumption (Lundby et al., 2017). This notion is widely used to compare athletes' aerobic capacities and measure progress regarding their cardiorespiratory fitness. It describes the maximum volume of oxygen that the body can use in a specific amount of time, indicated either in l/min for the maximal oxygen uptake or ml/kg/min for the relative uptake. This value is used to develop exercise prescriptions and measure progress in aerobic endurance capacity, since this value can be increased by training (Bassett, 2000) and correlates strongly with distance running performance (Houmard et al., 1991). The limiter of oxygen uptake is mainly cardiac output complemented by peripheral diffusion in the muscles (Beltz et al., 2016). First, there must be a lot of oxygenized blood getting to the muscles, then they must efficiently take up this Oxygen. Oxygen uptake efficiency in the muscle can be interpreted by looking at the difference in oxygenation of arterial and venous blood. Both parameters (cardiac output and peripheral diffusion) can be increased by endurance training (Bassett, 2000; Friedrich, 2022). Yet, it was found that there are better indicators than the VO_2max when looking specifically at predicting distance running

performance, such as the time spent running at or just below the ventilatory threshold 1 (VT1, called anaerobic threshold in Bassett, 2000).

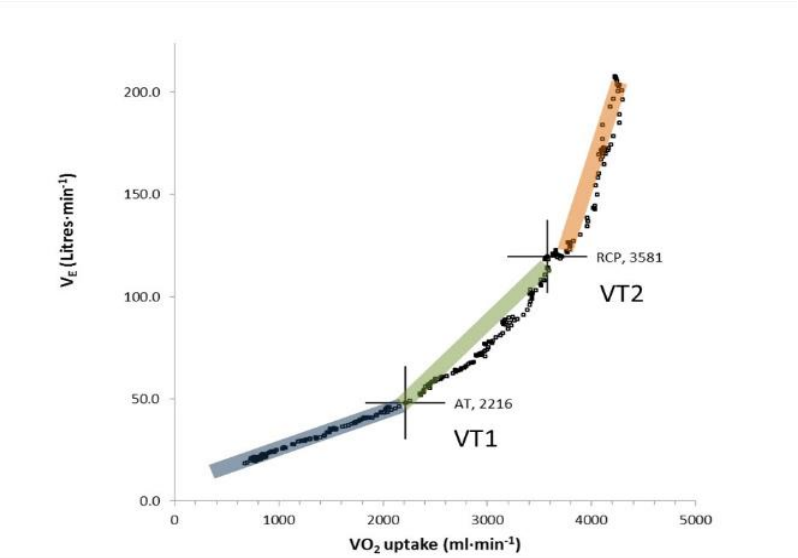
1.1.2 Threshold zones

The notion of VO_2max is a good indicator for cardiorespiratory fitness and it provides information about the maximum aerobic capacity of an individual. But the VO_2max can be upheld during a duration of maximally 10' (Friedrich, 2022; Morton & Billat, 2000), which falls short of most aerobic endurance performances in the field. It is much more important, especially for athletes, to know their ventilatory thresholds 1 and 2 (VT1 & VT2; Westhoff et al., 2013) as to properly structure their training.

These two thresholds mark the beginning and the end of the transition zone from aerobic to anaerobic energy supply and are determined by the ventilatory responses of the human body in reaction to metabolic load on the system. It is important to note, that energy supply is never either aerobic or anaerobic, but always a mix of both (Friedrich, 2022). The transition aerobic-anaerobic merely refers to which system is predominant. At VT1, there is a clear increase in ventilation (VE) and expiration of CO_2 (VCO_2) in relation to inspired O_2 (VO_2). This is caused by an increase in blood lactate with subsequent lactate buffering, causing the CO_2 production to rise (Binder et al., 2008). The VT2 marks the point at which the muscular lactate production rate exceeds the lactate elimination rate. This is when metabolic acidosis happens and the relation VE/VCO_2 increases disproportionately. Wasserman et al. (1973) called this the respiratory compensation point (see Figure 1).

Figure 1

Relation VE to VO_2



Note. This illustration shows the VT1 and 2 on the panel 1 of the nine-panel plot used for cardiopulmonary exercise testing. RCP = respiratory compensation point, AT = anaerobic threshold, VT1 = ventilatory threshold 1, VT2 = ventilatory threshold 2 (Patrick Jamieson, 2018).

Endurance athletes are usually structuring their training around their aerobic and anaerobic zones depending on which zone of speed they want to improve. Therefore, they must know their VT1 and VT2 as well as a point of reference (most practically heartrate) as to when those are reached, since knowing these zones can greatly increase training effectiveness (Astorino et al., 2018). For that reason, it is important for athletes and coaches to know where their VT1 and VT2 is regarding their heartrate/breath-rate as to accurately and practically model and monitor their training (Friedrich, 2022).

1.2 Testing procedures

It is important to note, that testing maximally (until voluntary exhaustion) is yielding more accurate estimations compared to testing submaximal and is therefore always preferred (Sartor et al., 2013). Given the positive effect of well-informed training on endurance performance, the importance of exactly measuring an individual's relevant physiological parameters becomes evident (Friedrich, 2022). There are a multitude of methods to estimate the most relevant

physiological parameters. Some of the most accurate ones are direct calorimetry (Kenny et al., 2017), blood lactate measurements during exercise (Goodwin et al., 2007) or cardiopulmonary exercise testing (CPET; Albouaini et al., 2007; Glaab & Taube, 2022) via gas exchange analysis. The CPET thereby uses multiple cardiorespiratory parameters to determine the VT1 & 2 (Beaver et al., 1985), which has been shown to correlate with the "anaerobic threshold" described by other papers (Loat & Rhodes, 1993; Londeree, 1997; Yamamoto et al., 1991). CPET is also the method used in this study to assess the participants.

Regarding the protocol used for testing, there is a discussion about which protocol is most efficient to determine VT1 & 2 and VO_2max when using CPET. It is generally found, that incremental treadmill protocols estimate the highest values of VO_2max for an average individual, but same values for the VT1 & 2 as other protocols and that the duration of protocol should be in the range of 8 - 12' to achieve maximal metabolic responses (Beltz et al., 2016). Nevertheless, when testing athletes, they should be tested using task-specific protocols as to acquire the most accurate estimations of VT1 & 2, VO_2max and subsequently their peak endurance performance (Beasley et al., 1989; Clénin, 2019). Regarding task-specific testing, in sports like distance running, graded treadmill protocols are used (Daniels & Daniels, 1992), for rowers, a graded rowing ergometer protocol is used (Senanayake et al., 2023) and for cyclists, graded cycle ergometer protocols are used (Lucía et al., 1998).

1.3 Aim of the study

The aim of this study is to check the concurrent validity of a newly created graded incremental endurance performance test protocol with additional weight (POTS; see Appendix 1) specifically designed for the requirements of SOF in deployment with an established incremental endurance test protocol (Swiss Olympic; see Appendix 2). If the validation is successful, this test protocol could be used for the future diagnosis of the endurance performance and trainability of SOF-members and candidates. The parameters that were compared were chosen based on their usefulness when giving training advice and monitoring progress. The measurements of VO_2max and power output at different stages can be used to monitor progress, the heartrates at different ventilatory thresholds can be used to give well informed training advice (Reis et al., 2011).

Research question: To what extent does CPET using the "POTS" protocol lead to the same indicators of endurance performance (VO_2max, heartrate at VT1 [HR@VT1], VT2 [HR@VT2] and power output at maximum, VT1 and VT2 [Pmax, P@VT1, P@VT2]), as when testing with the "Swiss Olympic" protocol proposed by Maier et al. (2016)?

H1: The two test protocols POTS and Swiss Olympic do not show significantly different results for the estimated values VO_2max, HR@VT1, HR@VT2, Pmax, P@VT1 and P@VT2.

H0(1): The two test protocols POTS and Swiss Olympic show significantly different results for the estimated values VO_2max, HR@VT1, HR@VT2, Pmax, P@VT1 and P@VT2.

If there are significant differences in the measured values:

H2: The higher the subject's body weight, the smaller the difference in the estimated values (VO_2max, HR@VT1, HR@VT2, Pmax, P@VT1 and P@VT2) from POTS to Swiss Olympic.

H0(2): The subject's body weight has no influence on the differences in the estimated values (VO_2max, HR@VT1, HR@VT2, Pmax, P@VT1 and P@VT2).

The second hypothesis H2 was put forward since the POTS protocol adds additional weight to the subject, which is not relative to bodyweight, hence it should have different levels of impact on performance in general on subjects of greatly differing bodyweight. It is expected that lighter subjects might be prone to achieve muscle fatigue before achieving their maximal aerobic performance, hence influencing the estimated values especially for lighter subjects.

2 Methods

The presented study is part of a bigger study. The following chapter gives a description of the methods used to test the POTS protocol for its concurrent validity regarding the comparison with the CPET-protocol Swiss Olympic.

2.1 Participants

The participants were 23 adult subjects, of those 19 male (n = 19; 30.53 ± 8.46 years; 179.32 ± 6.67 cm; 77.38 ± 10.30 kg; 23.95 ± 2.28 BMI) and 4 female (n = 4; 25.25 ± 2.17 years; 167 ± 6.04 cm; 57.80 ± 3.96 kg; 20.75 ± 2.59 BMI). Their fitness levels were allowed to vary greatly to the extent that the test subjects had to be mentally and physically able to perform a graded maximal exercise test.

2.2 Instruments

The form "Informed consent" (see Appendix 3) was used to inform the subjects. Body weight and height were taken using a calibrated digital balance (Model 877; Seca GmbH, Hamburg, Germany) and a stadiometer (Model 214; Seca GmbH, Hamburg, Germany). The equipment used for the CPET was a treadmill (h/p Cosmos Pulsar, Nussdorf-Traunstein, Germany), a breath-by-breath spiroergometric system (MetaMax 3B-R2, Cortex Biophysics, Leipzig, Germany) with high precision calibration gas (15.8 % O_2, 5 % CO_2 in N; Cortex Biophysik GmbH, Germany) and a 3-L syringe for volume flow calibration (Cortex, Leipzig, Germany). The data measured were processed by the software MetaSoft® Studio (V5.16.0SR1, Cortex Biophysik GmbH, Leipzig, Germany). A chest belt worn heart rate sensor (Polar H10, Polar Oy, Kempele, Finland), shown to yield accurate measurements of heartrate (error of -0.14 bpm, Schaffarczyk et al., 2022), were used. A weight vest (12.6 kg) adapted in the chest area for better transmission of HR was used for POTS.

2.3 Data collection

All participants were informed in detail about the examination procedures, techniques, and risks before signing the institutionally approved informed consent document using the form in Appendix 3. All procedures were approved by the Ethics Committee of the Canton of Bern under the number 2022-00767 and were in accordance with the Declaration of Helsinki. The tests were all carried out in a testing facility of the SFISM (Swiss Federal Institute of Sport Magglingen) in Biel (CH) in the period from 02/23 – 07/23. Each subject completed two CPET,

once using the POTS protocol and once using the Swiss Olympic protocol. The main differences of these two protocols were that Swiss Olympic increased gradually in speed (0.5km/h / 30s), but stagnated at 4° inclination, whereas POTS stayed at a stagnant 8 km/h, but increased inclination by 1° every minute (see Appendix 1 & 2). Additionally, subjects wore a weight vest (12.6 kg) during the POTS-trial. Both protocols were completed until voluntary exhaustion. The two tests were completed minimally 24 hours, maximally 7 days apart. It was randomised for each subject which protocol was performed first. Before the subjects arrived, the spiroergometric device was prepared and calibrated by using a 3-L syringe for volume flow calibration, the high precision gas to calibrate the gas analysers and by verifying the calibration against ambient air.

Upon arrival of each subject at the testing facility, the form mentioned in 2.2 was filled in and controlled, the subjects were informed about the procedure of the trial. Their weight without clothes and height using the Frankfurt horizontal (Deutsche Horizontale, 2020) was measured, a mask was fitted to their face and the heartrate sensor was installed around the chest of the subject. Then, they were given time to individually warm themselves up for 10'. After the warm-up, the subjects were equipped with the mask with the spiroergometric device as well as the weight vest, if POTS was used. After the control of the correct recording of data of the involved devices, the subjects were reminded to apply their full effort and to communicate drastic changes in well-being by using hand signs. Then, the respective CPET protocol was started. When the subjects could not continue the effort, they stepped on the non-moving part of the treadmill by holding on to the side handlebars. The treadmill was stopped. The subject was then asked to think of and indicate the reason he stopped (e.g. fatigue in calves, cardiorespiratory exhaustion, general exhaustion) and his rating of perceived exertion (RPE) using a visually presented BORG-Scale (Williams, 2017). All the measuring devices stayed active and on until 2' after abortion of the protocol. After that, the subject was done for the day and returned within the following 7 days to complete the second protocol of CPET which hasn't yet been completed.

The data directly measured during the two protocols are Heartrate (HR), volume of inspired O_2 (VO_2) and expired CO_2 (VCO_2) breath-by-breath. These data are used by MetaSoft® Studio to calculate and estimate the VT1, VT2 and VO_2max. Values for P were calculated using the weight of the subject, the speed and inclination using the formula "Woodway" (see 2.4). The VT1 & 2 and VO_2max were determined by a sport scientist specialised in CPET using the procedure of the German working group "cardiopulmonary exercise testing" (Dumitrescu et al.,

2015; Westhoff et al., 2013). The criterium for VO_2max was thereby the attainment of a VO_2 plateau. VT1, VT2 and VO_2max were visually determined by making use of the method of the German working group "cardiopulmonary exercise testing" (Westhoff et al., 2013) using the nine-panel-plot (Chambers & Wisely, 2019) developed originally by Wasserman et al. (1973).

2.4 Data analysis

Results are presented as mean ± standard deviation (SD). The relevant values obtained by using CPET with the POTS protocol (HR@VT1, HR@VT2, VO_2max, Pmax, P@VT1 and P@VT2) were checked for their concurrent validity by comparing them to the results obtained from the Swiss Olympic protocol. Several data couldn't be used in the final evaluation due to measurement errors. This concerned six datapoints for the values HR@VT1, five for HR@VT2, one for VO_2max and one for Pmax, P@VT1 and P@VT2. The data were checked for normality using the Shapiro-Wilk test. Student's T-test was used to test parametric data, Wilcoxon rank to test non-parametric data, both at a threshold of significance of $p < .05$. Both tests were done to check for significant differences in distribution between the data of POTS and Swiss Olympic. The correlation of the data was then calculated using Pearson r for parametric and Spearman ρ for non-parametric data, using the framework for interpreting correlation strength for medical research given by Mukaka, 2012. The correlation for HR@VT1, HR@VT2 and VO_2max was then graphically displayed using Microsoft Excel to visualise the distribution. A Bland-Altman Plot with a 95 % confidence interval was used to further visualise the data to check for potential outliers as well as the general trend of deviation between the two protocols. The results for Pmax, P@VT1 and P@VT2, obtained by using the formula Woodway, were visualised using boxplots, the values for Pmax, P@VT1 and P@VT2 were reported in text. The results of the formula were compared "intra-formula", POTS vs. Swiss Olympic, using a t-test.

The formula Woodway is the formula used by the program MetaSoft® Studio, which utilises the following formula supplied on demand by Woodway GmbH:

$$W = (1.065 + 0.0511 * G + 9.322 * 0.0001 * G^2) * v * \frac{BW}{4}$$

W is watts, *v* is speed in km/h, *G* is inclination in percentage (%) and *BW* is bodyweight in kg. For POTS, the weight of the vest worn was added to *BW*.

The Data shown in the results section will be used in the discussion to determine if the concurrent validity of the newly developed POTS testing procedure could be confirmed or not. This covers the analysis of H1, which was conducted using Jamovi (Jamovi, 2024) and Microsoft Excel.

3 Results

The results of both CPET protocols POTS and Swiss Olympic are presented in this chapter. For POTS, subjects voluntarily stopped their effort after an average duration of 590.09 ± 110.11 s, at an average inclination of 8.90° ± 1.88°. For Swiss Olympic, the subjects stopped after an average duration of 576.52 ± 131.00 s at an average speed of 14.39 ± 2.10 km/h.

Displays of data in the Appendix which is referenced in text will be used in the discussion. All values obtained using Student's t-test regarding the comparison of the parameter POTS versus Swiss Olympic are indicated in Table 1. For a general overview of all the data obtained, see Table 1. More detailed data is supplied in the respective chapter of the parameter.

Table 1

Overview of data at different stages of CPET

	HR@VT1	***P@VT1****	***HR@VT2****	***P@VT2***	***VO_2max***	***Pmax****
POTS	154.74	224.93	180.28	321.73	55.00	365.67
Swiss Olympic	156.12	275.33	183.72	321.89	54.68	399.95
Student's t *p* - value	0.64	< .001	0.04	0.981	0.55	< .001
Pearson's *r*	0.64	0.94	0.82	0.92	0.95	0.94
Systematic error	1.41	-	3.44	-	-0.32	-

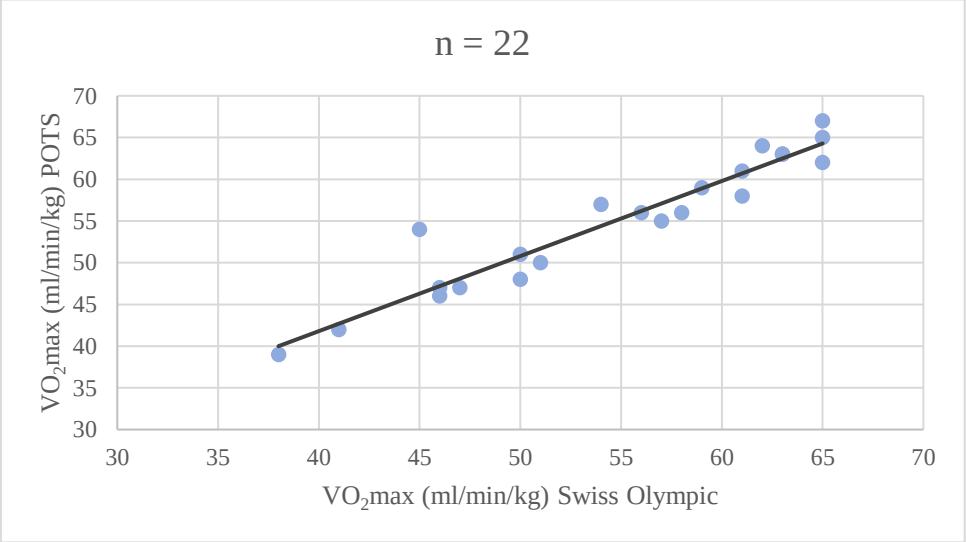
Note. The lower part of the table indicates the values for the columns in the upper part. The values in the columns marked with *, ** or *** are significantly different at $p < 0.05$, $p < 0.01$ and $p < .001$ respectively. P is indicated in Watts, HR@VT1 and HR@VT2 in bpm and VO_2max in ml/min/kg. For more detailed values, see Chapter 3.1, 3.2 and 3.3. HR@VT1 = heart rate at ventilatory threshold (VT), HR@VT2 = heart rate at VT 2, P@VT1 = Power at VT 1, P@VT2 = Power at VT 2, VO_2max = maximal uptake in oxygen, Pmax = maximum Power.

3.1 VO_2max

The measured values for VO_2max for both protocols POTS and Swiss Olympic were normally distributed (POTS p = .515; Swiss Olympic p = .117). The average VO_2max measured with POTS was 55.00 ± 7.85 ml/min/kg, with Swiss Olympic 54.68 ± 8.32 ml/min/kg with a respective minimum and maximum value of 39 and 67 for POTS and 38 and 65 for Swiss Olympic. Pearsons r resulted in very strong correlation with values of r = 0.95 and p < .001 (see Figure 2). The Bland-Altman-Plot in Figure 3 visualises the general trend of the data.

Figure 2

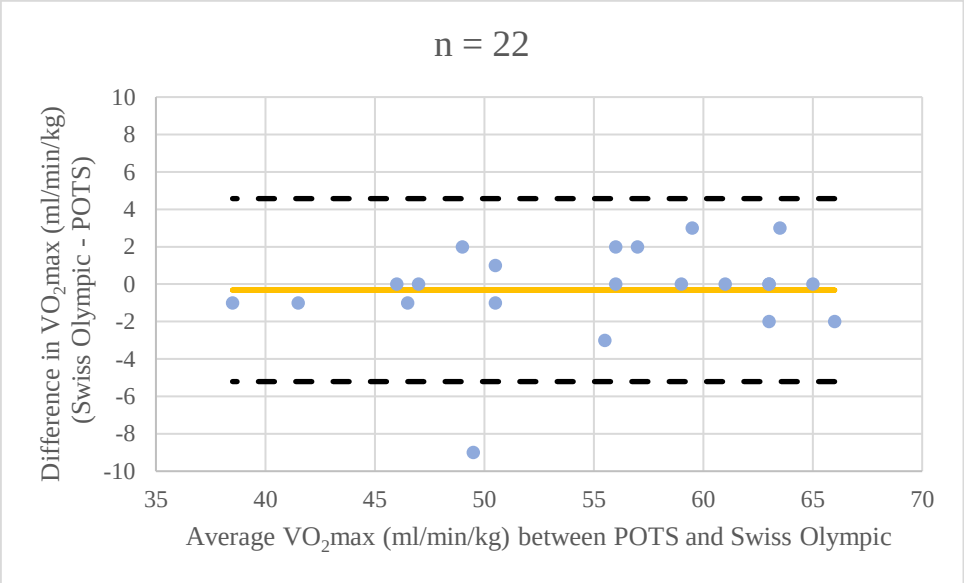
Correlation between VO_2max of POTS and Swiss Olympic



Note. The black line shows the line of regression for the correlation (r = 0.95, p < .001). VO_2max = maximal uptake in oxygen.

Figure 3

Bland-Altman-Plot VO_2max of POTS and Swiss Olympic



Note. Lower level of agreement (LoA) was calculated at -5.21 ml/min/kg, upper LoA was calculated at 4.57 ml/min/kg (see dashed lines). The systematic error (orange line) was -0.32 ml/min/kg. Negative datapoints represent an overestimation of VO_2max, positive represent an underestimation of VO_2max by POTS when compared to Swiss Olympic. VO_2max = maximal uptake in oxygen.

3.2 HR@VT1 and HR@VT2

The measured values for HR@VT1 for both protocols POTS and Swiss Olympic were normally distributed (POTS p = .95; Swiss Olympic p = .42). The average HR@VT1 measured with POTS was 154.74 ± 13.30 bpm, with Swiss Olympic 156.12 ± 14.97 bpm with a respective minimum and maximum value of 132 and 184 for POTS and 121 and 184 for Swiss Olympic. Pearsons r resulted in a moderate correlation with values of r = 0.64 and p = .003 (see Appendix 4). See Appendix 5 for a Bland-Altman plot.

The measured values for HR@VT2 for both protocols *POTS* and Swiss Olympic were normally distributed (POTS p = .16; Swiss Olympic p = .22). The average HR@VT2 measured with POTS was 180.28 ± 11.79 bpm, with Swiss Olympic 183.72 ± 11.17 bpm with a respective minimum and maximum value of 157 and 197 for POTS and 162 and 199 for Swiss Olympic. Pearsons r resulted in a very strong correlation with values of r = 0.82 and p < .001 (see Appendix 6). See Appendix 7 for a Bland-Altman plot.

3.3 Pmax, P@VT1 and P@VT2

The calculated values for Pmax Woodway for both protocols POTS and Swiss Olympic were normally distributed (POTS $p = .46$; Swiss Olympic $p = .07$). The average Pmax Woodway calculated using the POTS protocol was 365.67 ± 73.18 W, with Swiss Olympic 399.95 ± 82.42 W with a respective minimum and maximum value of 207.06 and 483.82 for POTS and 223.00 and 501.00 for Swiss Olympic. Pearsons *r* resulted in a very strong correlation with values of $r = 0.94$ and $p < .001$.

The calculated values for P@VT1 Woodway for both protocols POTS and Swiss Olympic were normally distributed (POTS $p = .76$; Swiss Olympic $p = .79$). The average P@VT1 Woodway calculated using the POTS protocol was 224.93 ± 39.35 W, with Swiss Olympic 275.33 ± 41.9 W. Pearsons *r* resulted in a very strong correlation with values of $r = 0.93$ and $p < .001$.

The calculated values for P@VT2 Woodway for both protocols POTS and Swiss Olympic were normally distributed (POTS $p = .87$; Swiss Olympic $p = .66$). The average P@VT2 Woodway calculated using the POTS protocol was 321.73 ± 70.86 W, with Swiss Olympic 321.89 ± 54.32 W. Pearsons *r* resulted in a very strong correlation with values of $r = 0.92$ and $p < .001$.
For POTS and Swiss Olympic respectively, VT1 and VT2 were reached at 61.4 % and 68.8 % of Pmax for VT1, as well as 87.95 % and 77.50 % of Pmax for VT2.

A visual representation of the values of P can be seen in Appendix 8 and 9 and in Table 1.

4 Discussion

The goal of this study was to check for the concurrent validity of the results obtained by performing two different graded exercise testing protocols, POTS and Swiss Olympic, whereas POTS was a newly developed, task-specific protocol tailored for SOF. If a concurrent validity can be detected, POTS could be used in the future to assess the candidate's aerobic performance, their ventilatory thresholds regarding their heartrate and their power output at different stages as well as to compare the results with other studies. These data can then be used to give well informed training recommendations to improve and monitor the performance and progression (Friedrich, 2022; Herdy et al., 2016) of operators.

The measurement errors mentioned in Chapter 2.4 were excluded from the analysis due to several factors: difficulties in transmitting heart rate data via Bluetooth through the weighted vest worn during POTS (6 cases), failure to achieve VO_2max (1 case), and software malfunctions (1 case). The issue with Bluetooth transmission was resolved by cutting a hole in the chest area of the metal plates in the weighted vest.

The results obtained for the VO_2max of the subjects showed a very strong correlation between POTS and Swiss Olympic (r = 0.95). The data displayed in Table 1 and Figure 3 showed a systematic error of -0.32 ml/min/kg, meaning that the POTS protocol measured on average a VO_2max 0.32 ml/min/kg higher than Swiss Olympic, which is within the pre-set LoA of 95 %. The data is distributed equally to both sides of the systematic error except for one outlier to be observed in Figure 3, where POTS indicated significantly higher VO_2max than Swiss Olympic. Regarding the intrapersonal variability of ± 5.6 % VO_2max (Katch et al., 1982) and excellent percentage errors of 1.95 ± 1.90 for respiratory gas exchange variables of the Meta-Max 3B-R2 (Van Hooren et al., 2024), the data suggests that measuring VO_2max with POTS leads to the same values as when measuring with Swiss Olympic and can therefore be regarded as equivalent when determining VO_2max.

The results obtained for HR@VT1 showed a moderate correlation between POTS and Swiss Olympic (r = 0.64). The data displayed in Appendix 5 showed a systematic error of 1.41 bpm, meaning that measuring with POTS led to a HR@VT1 1.41 bpm lower than with Swiss Olympic. There were more measurements (9 total) of HR@VT1 that indicated higher bpm for Swiss Olympic than for POTS, but in those cases (4 total) where POTS reported higher HR@VT1, the difference was bigger. In Appendix 5, a trend can be seen that the lower the

HR@VT1, the bigger the differences in bpm tend to be between POTS and Swiss Olympic. This implies that if the HR@VT1 of a suspect is relatively low, that there could be a greater difference in the relation of heartrate to VT1 than for suspects with relatively higher HR@VT1. This effect can only be observed for heartrates > 160 bpm. In general, there is only one outlier to be observed in Appendix 5, which suggests that measuring HR@VT1 with POTS and Swiss Olympic lead to the same values and can be regarded as equivalent.

The results obtained for HR@VT2 showed a very strong correlation (r = 0.82) between POTS and Swiss Olympic. The data displayed in Table 1 and Appendix 7 showed a systematic error of 3.44 bpm, meaning that measuring with POTS leads to a HR@VT2 3.44 bpm lower than with Swiss Olympic. There's no clear trend to be observed in Appendix 7 apart from Swiss Olympic measuring on average higher heartrates by a small margin. There is one outlier to be observed, showing a difference in heartrate of the two protocols outside of the predetermined LoA. Even though the t-test showed a significant difference with p = .04, the Bland-Altman plot (Appendix 7) showed no data outside of the LoA. These data suggest, that measuring HR@VT2 with POTS leads to the same values as when measuring with Swiss Olympic.

The results for HR@VT1 and HR@VT2 are contrary to the findings of Belli et al. (2019) and De Lucas et al. (2022), which both concluded that testing with a treadmill protocol that gradually increases incline leads to different HR at VT1 and VT2 as when testing with a protocol that doesn't increase incline, but only speed. Even though POTS indicates lower HR at both VT1 and VT2, it is not significantly lower than Swiss Olympic for HR@VT1, and the data is within the pre-set LoA of 95 % for the HR at both VT1 and 2. This could be explained by the additional load in POTS (which was not present for Belli et al. [2019] and De Lucas et al. [2022]), which would increase the metabolic demand on the body therefore also increasing the heartrate at a certain inclination. Considering Polar H10's negligible error of -0.14 bpm (see Chapter 2.2), the HR at both VT1 and VT2 obtained from POTS can be used as reference point when training or giving training advice, since it is the same values as when measuring with Swiss Olympic. Still, values obtained by POTS of < 160 bpm at VT1 are to be treated with caution, as this study cannot make a definite statement about the relation of HR to VT1 below the range of 160 bpm.

The results obtained for P@VT1, P@VT2 and Pmax were significantly different for P@VT1 and Pmax (see Table 1) when comparing POTS to Swiss Olympic. In both cases, Swiss Olympic indicates significantly higher values for P than POTS.

When looking at the percentages of Pmax at which VT1 and VT2 were reached (see Appendix 9 for exact values), VT1 is reached at 61 and 69 % for POTS and Swiss Olympic, VT2 is reached at 88 and 78 %. This is within the range of percentage of Pmax for VT1 and nearly for VT2 indicated by Hug et al. (VT1 at 60 - 70 %, VT2 at 80 - 90 % of Pmax; 2003).

It has already been shown, that running with additional load and running at an inclination results in higher energy cost (Hoogkamer et al., 2014; Keren et al., 1981) compared to level running. Even though the speed is lower for the protocol POTS, the added load and the steeper inclination should therefore in theory result in higher or at least the same P values when using POTS over the different parameter for which P was measured. This is not represented by the values of P obtained by using the formula used by Metasoft® Studio. Therefore, we suggest that a new formula should be developed, which describes the output of power more accurately when running uphill with added load.

As there were no relevant significant differences in VO_2max, HR@VT1 and HR@VT2, H2 was not examined.

4.1 Limitations and considerations

One of the limitations of this study is the technical knowledge required to operate the spirometry hard- and software. Without proper handling of the equipment and proper knowledge considering the interpretation and correction of data collected, the data becomes inaccurate. There must always be an expert present when handling the devices and data as to reduce inaccuracies and mistakes. Another limiting factor is the high cost of the equipment and the laboratory environment needed to guarantee the most accurate results.

The on average very high aerobic capacity of the subjects of this study (VO_2max of 55.00 ± 7.85 ml/min/kg) means that the findings of this study can only be applied to people with a high aerobic capacity. Since the protocol POTS is aimed at SOF, this should not pose a problem as SOF are usually expected to have a high aerobic capacity. But when applying POTS for testing normal police or military forces, people with average or even low aerobic capacity, the results could differ from the ones measured in this study. The sample size also contained few women (4 female, 19 male), which makes the conclusions of this study only valid and reliable for men with a high aerobic capacity. Therefore, to determine the accuracy and practicability of POTS for all levels of cardiorespiratory fitness, further studies should be done investigating POTS utility for people of average and low cardiorespiratory fitness.

Another consideration which wasn't checked for in this study would be the influence of low bodyweight. Since POTS uses a fixed weight, the additional load will have different effects on

subjects with greatly differing bodyweight. For lighter subjects, the fixed weight represents a higher metabolic demand, which could lead to premature fatigue and submaximal effort during testing. Hence, further studies should be conducted testing the limits of POTS regarding bodyweight in relation to additional load.

In this study, there was one outlier to be observed for every parameter tested which always originated from the same subject. It could have been, that this specific subject was in some sort impaired on one of the two test days, but since he did not report any concerns or impairments, it was decided to leave the data in the examined sample. Anthropological data did not suggest any concerns that could have influenced the results to differ to such an extent as measured.

The test-retest reliability of POTS hasn't been tested yet and POTS should also be compared to other protocols than Swiss Olympic to further establish its position as a valid and reliable CPET protocol.

5 Conclusion

It is of great importance to test SOF as specific as possible as to predict their trainability and performance accurately. Therefore, the new CPET protocol POTS was developed and validated. The concurrent validation of POTS with Swiss Olympic was successful regarding the endurance performance parameters VO_2max, HR@VT1 and HR@VT2. For VO_2max, POTS has a systematic error of -0.32 ml/min/kg and a very high correlation of r = 0.95 with Swiss Olympic. For the parameter of HR@VT1 and HR@VT2, a systematic error of 1.41 bpm at VT1 and 3.44 bpm at VT2 was found with a strong correlation for HR@VT1 and a very strong correlation for HR@VT2 with the values obtained from using Swiss Olympic. All systematic errors were within the pre-set limits of agreement as well as were all data points, with one exception.

In conclusion, this means that for the protocol POTS, the VO_2max is reached by subjects to the same extent as with Swiss Olympic. The ventilatory thresholds (VT1 & VT2) in relation to the heartrate occur at the same values of bpm. POTS can thereby be used to assess the endurance performance of men with high cardiorespiratory fitness and the obtained HR at VT1 & 2 can be used as a basis for training and training prescription. POTS needs further evaluation to assess its utility and precision when testing women and people of lesser aerobic capacity (VO_2max > 40 ml/min/kg). It should be noted that when using POTS, it is important to have a CPET specialist with the required knowledge about the instruments and the interpretation of the data. Otherwise, there can occur inaccuracies and faulty interpretation of the data collected.

The formula Woodway used by Metasoft® Studio seems to be unfit for calculating values of P in uphill running with added load, as it indicates significantly lower values of P for P@VT1 and Pmax, even though higher or at least same values of P are expected for POTS when compared to Swiss Olympic (Hoogkamer et al., 2014; Keren et al., 1981). We advise that a new formula specialised in calculating values of P in uphill running with added load is developed and tested, as to more accurately calculate the values of P for POTS.

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Appendix

1 POTS protocol

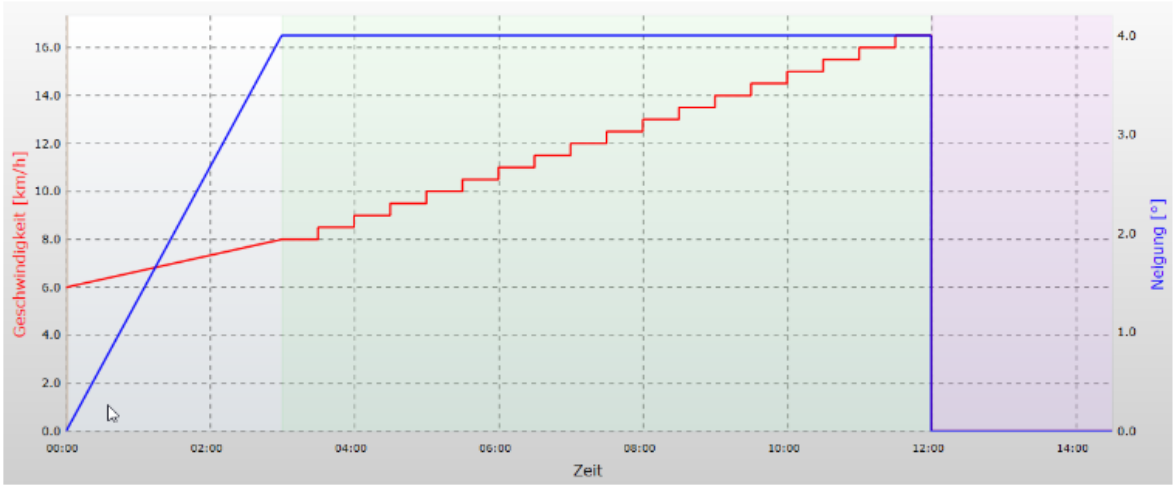
POTS:

- 1 min. 5.5 km/h flach;
- Ramp: 8km/h, 1° inclination per min (ad infinitum)
- Recover: 2 min 0 km/h

2 Swiss Olympic protocol

Swiss Olympic:

- 2 min. 6 - 8 km/h, flach – 4° (7%)
- Start 8 km/h, 4°
- Geschwindigkeit steigt alle 30 Sekunden um 0.5 km/h
- 2 min. 30 Recover



3 Informed consent

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Eidgenössisches Departement für Verteidigung,
Bevölkerungsschutz und Sport VBS
Bundesamt für Sport BASPO
Eidgenössische Hochschule für Sport Magglingen EHSM

Anfrage zur Teilnahme an medizinischer Forschung:

Entwicklung und Validierung von Ausdauer/VO_2max- und KraftFeldtest-Alternativen und Benchmarking

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Sehr geehrte Dame, sehr geehrter Herr

Wir fragen Sie hier an, ob Sie bereit wären, an unserem Forschungsvorhaben mitzuwirken.

Ihre Teilnahme ist freiwillig. Alle Daten, die in diesem Forschungsprojekt erhoben werden, unterliegen strengen Datenschutzvorschriften.

Das Forschungsvorhaben wird durchgeführt vom Projektleiter und Prüfperson der Eidgenössischen Hochschule für Sport Magglingen (EHSM), bzw. dem Bundesamt für Sport (BASPO). Ihre Daten werden ausschliesslich von der EHSM ausgewertet. Bei Interesse informieren wir Sie gerne über die Ergebnisse aus diesem Forschungsprojekt.

Mit dieser kurzen Information erklären wir Ihnen die wichtigsten Punkte. Im Anschluss folgen dann weitere, detaillierte Informationen. Sehr gerne erläutern wir ihnen das Forschungsprojekt mündlich im Detail und beantworten allfällige Fragen. Damit Sie sich bereits jetzt ein Bild machen können, hier das Wichtigste vorweg.

Die Armee und die Polizei verwenden für die Rekrutierung von geeignetem Personal Feldtests, um die Ausdauerleistungsfähigkeit zu bestimmen. Mit dieser Studie soll nun untersucht werden, wie genau die aktuellen Methoden sind und ob alternative Methoden besser geeignet sind und genauer messen als die aktuellen Messmethoden.
Zudem wird untersucht, wie genau die aktuellen Methoden zur Messung der Explosivkraft messen (also wie valide die Messmethode ist).

Form der Teilnahme: Wenn Sie sich entscheiden mitzumachen, nehmen Sie an vier verschiedenen maximalen und einem submaximalen Ausdauertest sowie zwei Methoden zur Messung der Kraft teil. Bei allen Tests werden sie mit einem Herzfrequenzmessgerät ausgerüstet. Sie werden zudem einen Fragebogen zu ihrem Trainingsverhalten und zu Ihrem Befinden am Testtag ausfüllen.
Ablauf der Teilnahme: Wenn Sie teilnehmen, werden sie alle zuvor genannten Tests an zwei Testtagen absolvieren. Der lange Testtag ist aufgeteilt in Teil I vormittags (ca. 90 Minuten) und Teil II nachmittags (ca. 60 Minuten). Zwischen den Vormittags- und Nachmittagstests haben sie eine Pause von 4 Stunden. Der kurze Testtag dauert insgesamt ca. 90 Minuten.

Nutzen

Sie haben keinen direkten Nutzen, wenn Sie bei diesem Forschungsvorhaben mitmachen. Sie erhalten jedoch eine persönliche Auswertung ihrer Ausdauerleistungsfähigkeit und der Kraftwerte.
Sie helfen mit Ihrer Teilnahme bei der Validierung und Entwicklung bestehender und neuer Feldtests für die Rekrutierung zukünftiger Armee- und Polizeiangehörigen.

Risiko und Belastung

Die Fitnesstests sind anstrengend, es handelt sich um Test der maximalen Ausdauer- und Kraftfähigkeiten.

Mit Ihrer Unterschrift am Ende des Dokuments bezeugen Sie, dass Sie freiwillig teilnehmen und dass Sie die Inhalte des gesamten Dokuments verstanden haben.

Detaillierte Information

1. Ziel und Auswahl

Unser Forschungsvorhaben bezeichnen wir in dieser Informationsschrift als *Forschungsprojekt.* Wenn Sie an diesem Forschungsprojekt teilnehmen, sind Sie eine *Teilnehmerin* bzw. ein *Teilnehmer*.

In diesem Forschungsprojekt wollen wir verschiedene Ausdauerfeldtests und ihre VO2max-Abschätzung validieren. Zudem möchten wir die Messung der Explosivkraft durch den Countermovement Jump (CMJ) und den Standweitsprung (SLJ) validieren. Wir fragen Sie an, da alle Personen teilnehmen können, die folgende Einschlusskriterien erfüllen:

gesund

mindestens 18 Jahre alt

keine Herzkreislaufprobleme oder andere bekannte Krankheiten, die es nicht zulassen, sich maximal auszubelasten.

2. Allgemeine Informationen

Diese Studie ist Teil des übergreifenden Projekt P(O|TS). Das Projekt will die Selektion von Personal für körperlich anspruchsvolle Jobs bei der Armee und bei der Polizei optimieren. Wir möchten daher herausfinden, ob spezifisch auf den zukünftigen Job ausgerichtete Leistungsdiagnostiktests zusammen mit Informationen zum Genotyp das noch vorhandene Entwicklungspotenzial und den späteren Erfolg vorhersagen können.

Mit dieser Studie wollen wir einen Teil der in der Studie P(O|TS) angewendeten Leistungsdiagnostiktests (Goldstandardtests) und alternative/neue Messmethoden validieren. Für die zukünftige Auswahl von geeignetem Personal ist es von grosser Bedeutung, dass die gewählten Tests genau messen, und trotzdem nicht in einem speziellen Labor durchgeführt werden müssen.

Insgesamt werden wir etwa 36 Teilnehmende untersuchen. Diese werden in Biel und Magglingen an zwei Testtagen (insgesamt drei Halbtage) durch unser geschultes Studienteam der EHSM getestet. Die Messungen dauern pro Teilnehmerin oder Teilnehmer und pro Messzeitpunkt maximal 60 bis 90 Minuten.

Wir machen dieses Forschungsprojekt so, wie es die Gesetze in der Schweiz vorschreiben. Ausserdem beachten wir alle international anerkannten Richtlinien. Die zuständige Ethikkommission hat das Forschungsprojekt geprüft und bewilligt.

3. Ablauf Testtag I

Wenn die Teilnehmenden eintreffen, findet zunächst eine Vorbereitungsphase statt: Mündliche Informationen zur Studie werden gegeben, der PAR-Q und die Einverständniserklärungen werden kontrolliert, der Fragebogen "Bewegungs- und Sportverhalten" und die "Checkliste für Testpersonen" werden ausgefüllt. Dann werden Körpergewicht und Körpergrösse gemessen (Teilnehmer in leichter Sportkleidung, ohne Schuhe).

Nach einem 10-minütigen Aufwärmen absolvieren Sie den Standweitsprung (SLJ; 3 Maximalversuche) und den CMJ (3 Maximalversuche). Der CMJ und der SLJ werden in zufälliger Reihenfolge (randomisiert) durchgeführt.

Anschliessend werden Sie mit einem Brustgurt (H10, Polar) ausgerüstet und es wird der erste Feldtest zur Bestimmung des berechneten VO2max durchgeführt.

Testtag II

Sie füllen erneut die "Checkliste für Testpersonen" aus. Nach dem Aufwärmen, welches gleichzeitig der Walking-Test ist, absolvieren Sie den zweiten Feldtest (ebenfalls mit Brustgurt Polar H10 ausgerüstet).

Die Messung der maximalen Sauerstoffaufnahme (VO_2max) im Labor findet ebenfalls zufällig (randomisiert) entweder am ersten oder zweiten Testtag statt. Dabei wird nach dem Feldtest eine Pause von 240 Minuten gemacht. In dieser Zeit können Sie eine Mahlzeit zu sich zu nehmen. Nach der Pause folgt das Rampenprotokoll auf dem Laufband zur Messung des VO_2max.

Testtag 1 und Testtag 2 finden im Abstand vom mindestens 72h und maximal 7 Tagen statt. Sie werden gebeten, 48h vor beiden Testtagen keinen Wettkampf oder belastende Trainings zu absolvieren, um die Leistungsfähigkeit nicht zu beeinflussen. Zudem werden Sie angewiesen, genügend Flüssigkeit zu sich zu nehmen und am Vorabend der Tests auf Alkohol zu verzichten.

Kaffee und andere koffeinhaltige Getränke können wie gewohnt konsumiert werden. Die gewohnte
Ernährung sollte ebenfalls beibehalten werden. Zudem wird darauf geachtet, dass der Tageszeitpunkt der Durchführung des zweiten Testtages gleich ist wie bei der ersten Durchführung.

Es kann sein, dass wir Sie vom Forschungsprojekt vorzeitig ausschliessen müssen. Das kann z. B.
geschehen, wenn Sie innerhalb von 7 Tagen nicht alle Tests absolvieren können oder es aus einem Grund nicht mehr möglich ist, sich maximal auszubelasten.

4. Nutzen

Sie haben keinen direkten Nutzen, wenn Sie bei diesem Forschungsvorhaben mitmachen. Sie erhalten jedoch eine persönliche Auswertung ihrer Ausdauerleistungsfähigkeit und der Kraftwerte. Zudem helfen Sie mit Ihrer Teilnahme an der Studie bei der Validierung und Entwicklung bestehender und neuer Feldtests für die Rekrutierung zukünftiger Armee- und Polizeiangehörigen in der Schweiz.

5. Freiwilligkeit und Pflichten

Sie nehmen freiwillig teil. Wenn Sie nicht an diesem Forschungsprojekt teilnehmen oder später Ihre Teilnahme zurückziehen wollen, müssen Sie dies nicht begründen.

Wenn Sie an diesem Forschungsprojekt teilnehmen, werden Sie gebeten:

- sich an die Vorgaben und Anforderungen des Forschungsprojekts durch den Prüfplan zu halten und an allen geforderten Leistungsdiagnostiktests mitzumachen und dabei ihre maximale Leistungsfähigkeit abzurufen

6. Risiken und Belastungen

Durch das Forschungsprojekt sind Sie nur geringfügigen Risiken ausgesetzt. Es handelt sich bei den durchgeführten Leistungstests um Maximaltests, wobei eine maximale Ausbelastung gefordert wird. Sie werden jedoch jederzeit vom Studienteam beaufsichtigt.

Für Frauen, die schwanger werden können

Sollten Sie während des Forschungsprojekts schwanger werden, müssen Sie die Projektleitung informieren. Die Projektleitung wird zusammen mit dem Prüfarzt und mit Ihnen das weitere Vorgehen besprechen.

7. Alternativen

Es gibt keine Alternativen zu diesem Projekt.

8. Ergebnisse

Ihre individuellen Messwerte werden nach Beendigung des Projektes vom BASPO zusammengestellt und Ihnen elektronisch zugestellt.

Objektive End-Ergebnisse des gesamten Forschungsprojekts werden in wissenschaftlichen Zeitschriften publiziert. Falls gewünscht, kann Ihnen die Projektleitung am Ende des Forschungsprojekts eine Zusammenfassung der Gesamtergebnisse zukommen lassen.

9. Vertraulichkeit von Daten

9.1. Datenverarbeitung und Verschlüsselung

Für dieses Forschungsprojekt werden Daten zu Ihrer Person und Gesundheit erfasst und bearbeitet, teilweise in automatisierter Form. Bei der Datenerhebung werden Ihre Daten verschlüsselt. Verschlüsselung bedeutet, dass alle Bezugsdaten, die Sie identifizieren könnten (Name, Geburtsdatum etc.), durch einen Code ersetzt werden.

Eine Liste mit Ihrem Code und den identifizierenden Bezugsdaten (Schlüssel-Liste) ist ausschliesslich beim Leiter des Forschungsprojektes. Personen, die keinen Zugang zu dieser Schlüssel-Liste haben, können keine Rückschlüsse auf Ihre Person ziehen. Die Schlüssel-Liste bleibt immer bei der Eidgenössischen Hochschule für Sport Magglingen (EHSM), BASPO. Nur sehr wenige Fachpersonen werden Ihre unverschlüsselten Daten sehen und zwar nur, um Aufgaben im Rahmen des Forschungsprojekts zu erfüllen. Diese Personen unterliegen der Schweigepflicht. Sie als teilnehmende Person haben das Recht auf Einsicht in Ihre Daten.

9.2. Datenschutz

Alle Vorgaben des Datenschutzes werden streng eingehalten. Es ist möglich, dass Ihre Daten in verschlüsselter Form, zum Beispiel für eine Publikation, übermittelt werden müssen und anderen Forschern zur Verfügung gestellt werden können.

9.3. Einsichtsrechte bei Kontrollen

Dieses Forschungsprojekt kann durch die zuständige Ethikkommission überprüft werden. Die Projektleitung muss dann Ihre Daten für solche Kontrollen offenlegen. Alle müssen absolute Vertraulichkeit wahren.

10. Rücktritt

Sie können jederzeit von dem Forschungsprojekt zurücktreten. Die bis dahin erhobenen Daten werden in diesem Fall allerdings noch in verschlüsselter Form ausgewertet.

11. Entschädigung

Wenn Sie an diesem Forschungsprojekt teilnehmen, bekommen Sie dafür keine Entschädigung. Es entstehen Ihnen oder Ihrer Krankenkasse keine Kosten durch die Teilnahme.

Die Ergebnisse dieses Forschungsprojekts können unter Umständen dazu beitragen, kommerzielle Produkte zu entwickeln. Durch Ihre Teilnahme haben Sie kein Anrecht auf Anspruch an kommerziellen Entwicklungen (z. B. Patente).

12. Haftung

Falls Sie durch das Forschungsprojekt einen Schaden erleiden sollten, haftet das Bundesamt für Sport BASPO, welches das Forschungsprojekt veranlasst hat und für die Durchführung verantwortlich ist. Die Voraussetzungen und das Vorgehen sind gesetzlich geregelt. Wenn Sie einen Schaden erlitten haben, so wenden Sie sich bitte an die Projektleitung.

13. Finanzierung

Das Forschungsprojekt wird vom Bundesamt für Sport (BASPO) und dem Innovationsboard der Schweizer Armee bezahlt.

14. Kontaktpersonen

Sie dürfen jederzeit Fragen zur Projektteilnahme stellen. Auch bei Unsicherheiten, die während des Forschungsprojekts oder danach auftreten, wenden Sie sich bitte an:

Alain Dössegger
Eidgenössische Hochschule für Sport Magglingen EHSM
Bundesamt für Sport BASPO Hauptstrasse 243, 2532 Magglingen
Telefon (Erreichbarkeit: zu Bürozeiten): [redacted]

Mitarbeiterin
[redacted]
Telefon (Erreichbarkeit: zu Bürozeiten): [redacted]

Einwilligungserklärung

Schriftliche Einwilligungserklärung zur Teilnahme an einem Forschungsprojekt

Bitte lesen Sie dieses Formular sorgfältig durch. Bitte fragen Sie eine Kontaktperson (siehe Punkt 14 oben), wenn Sie etwas nicht verstehen oder wissen möchten. Für die Teilnahme ist Ihre schriftliche Einwilligung notwendig.

BASEC-Nummer:	2022-00767
Titel des Forschungsprojekts:	P(O|TS); Vorhersage von potenziell hoch leistungsfähigen Operatoren und Feuerwehrpersonen
Verantwortliche Institution (Projektleitung mit Adresse):	Bundesamt für Sport BASPO, Eidgenössische Hochschule für Sport Magglingen, Hauptstrasse 273, 2532 Magglingen
Ort der Durchführung:	[redacted]
Leiterin/Leiter des Forschungsprojekts am Studienort: Name und Vorname in Druckbuchstaben:	[redacted]
Teilnehmerin/Teilnehmer: Name und Vorname in Druckbuchstaben: Geburtsdatum (TT.MM.JJJJ):	_____ __.__.

Ich wurde von der unterzeichnenden Projektleitung mündlich oder schriftlich über den Zweck, den Ablauf des Forschungsprojekts, über mögliche Vor- und Nachteile sowie über eventuelle Risiken informiert.

Ich nehme an diesem Forschungsprojekt freiwillig teil und akzeptiere den Inhalt der zum oben genannten Forschungsprojekt abgegebenen schriftlichen Information. Ich hatte genügend Zeit, meine Entscheidung zu treffen.

Meine Fragen im Zusammenhang mit der Teilnahme an diesem Forschungsprojekt sind mir beantwortet worden. Ich behalte die schriftliche Information und erhalte eine Kopie meiner schriftlichen Einwilligungserklärung.

Ich bin einverstanden, dass die zuständigen Fachleute der Projektleitung und der für dieses Forschungsprojekt zuständigen Ethikkommission zu Prüf- und Kontrollzwecken in meine unverschlüsselten Daten Einsicht nehmen dürfen, jedoch unter strikter Einhaltung der Vertraulichkeit.

Bei Ergebnissen und Zufallsbefunden, die direkt meine Gesundheit betreffen, werde ich informiert. Wenn ich das nicht wünsche, informiere ich die Projektleitung.

Ich weiss, dass meine gesundheitsbezogenen und persönlichen Daten nur in verschlüsselter Form zu Forschungszwecken für dieses Forschungsprojekt weitergegeben werden können.

Der Sponsor gewährleistet, dass der Datenschutz nach Schweizer Standard eingehalten wird.

Ich kann jederzeit und ohne Angabe von Gründen von der Teilnahme zurücktreten. Die bis dahin erhobenen Daten und Proben werden für die Auswertung des Forschungsprojekts noch verwendet.

Das Bundesamt für Sport BASPO haftet für allfällige Schäden.

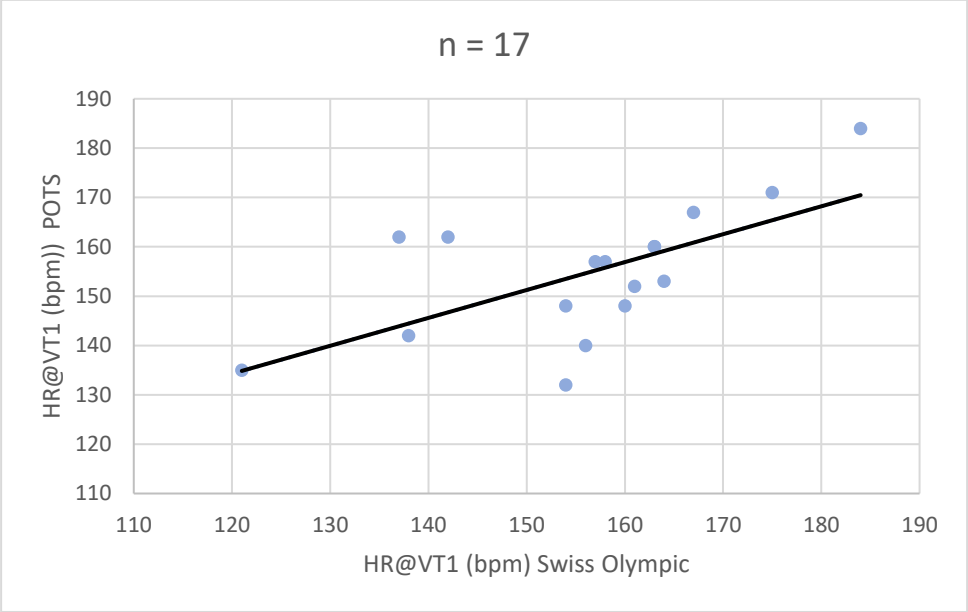
Ich bin mir bewusst, dass die in der Informationsschrift genannten Pflichten einzuhalten sind. Im Interesse meiner Gesundheit kann mich die Projektleitung jederzeit ausschliessen.

Ort, Datum _____	Unterschrift Teilnehmerin/Teilnehmer

Bestätigung der Prüfperson: Hiermit bestätige ich, dass ich dieser Teilnehmerin/diesem Teilnehmer Wesen, Bedeutung und Tragweite des Forschungsprojekts erläutert habe. Ich versichere, alle im Zusammenhang mit diesem Forschungsprojekt stehenden Verpflichtungen gemäss in der Schweiz geltenden Rechts zu erfüllen. Sollte ich im Verlauf des Forschungsprojekts von Aspekten erfahren, welche die Bereitschaft der Teilnehmerin/des Teilnehmers an dem Forschungsprojekt beeinflussen könnten, werde ich sie/ihn umgehend darüber informieren.

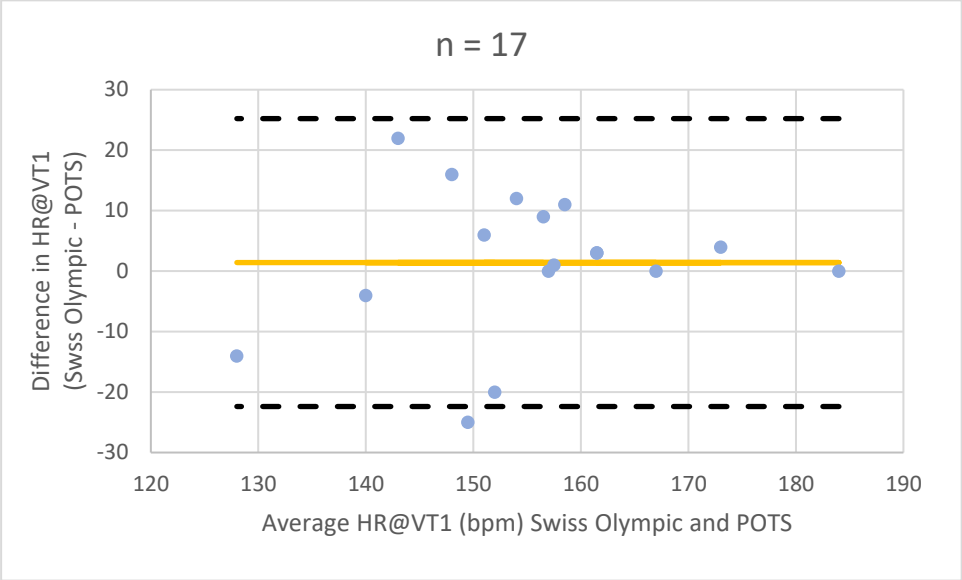
Ort, Datum	Alain Dössegger

4 Correlation between HR@VT1 of POTS and Swiss Olympic



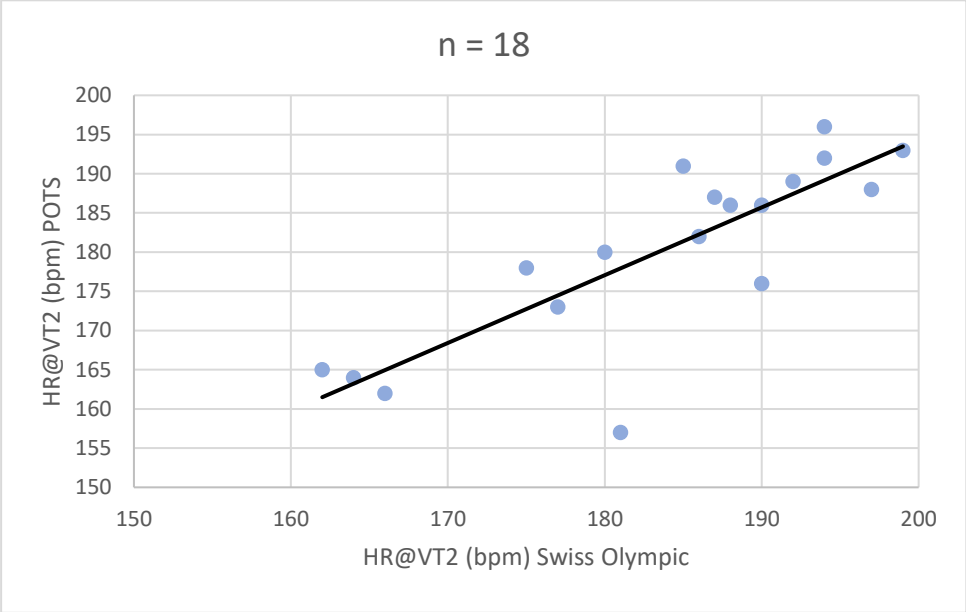
Note. The black line shows the line of regression for the correlation (r = 0.64, p = .003).

5 Bland-Altman-Plot HR@VT1 of POTS and Swiss Olympic



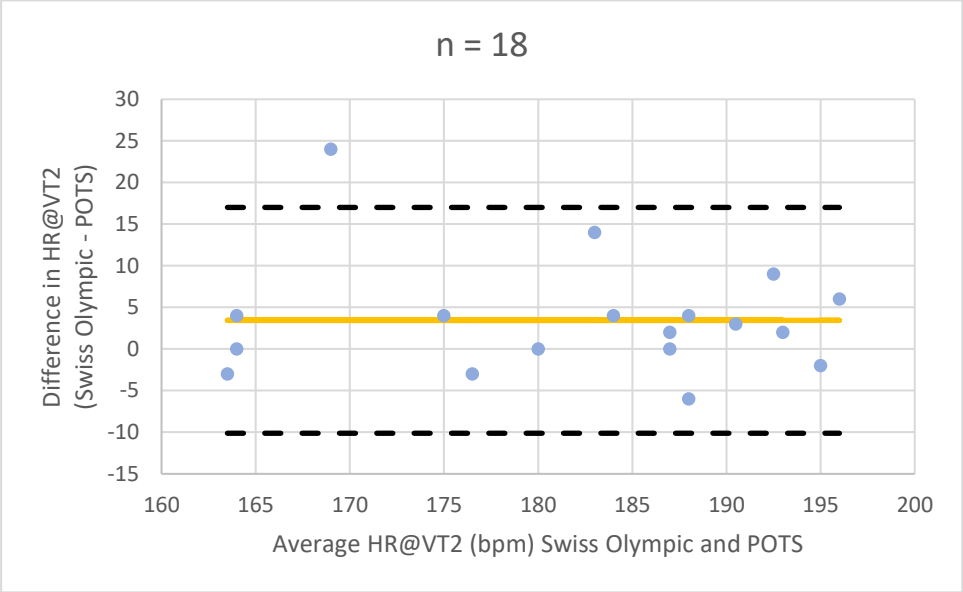
Note. Lower LoA was calculated at -22.39 bpm, upper LoA was calculated at 25.22 bpm (see dashed lines). The systematic error (orange line) was 1.41 bpm. Negative datapoints represent an overestimation of HR@VT1, positive represent an underestimation of HR@VT1 by POTS when compared to Swiss Olympic.

6 Correlation between HR@VT2 of POTS and Swiss Olympic



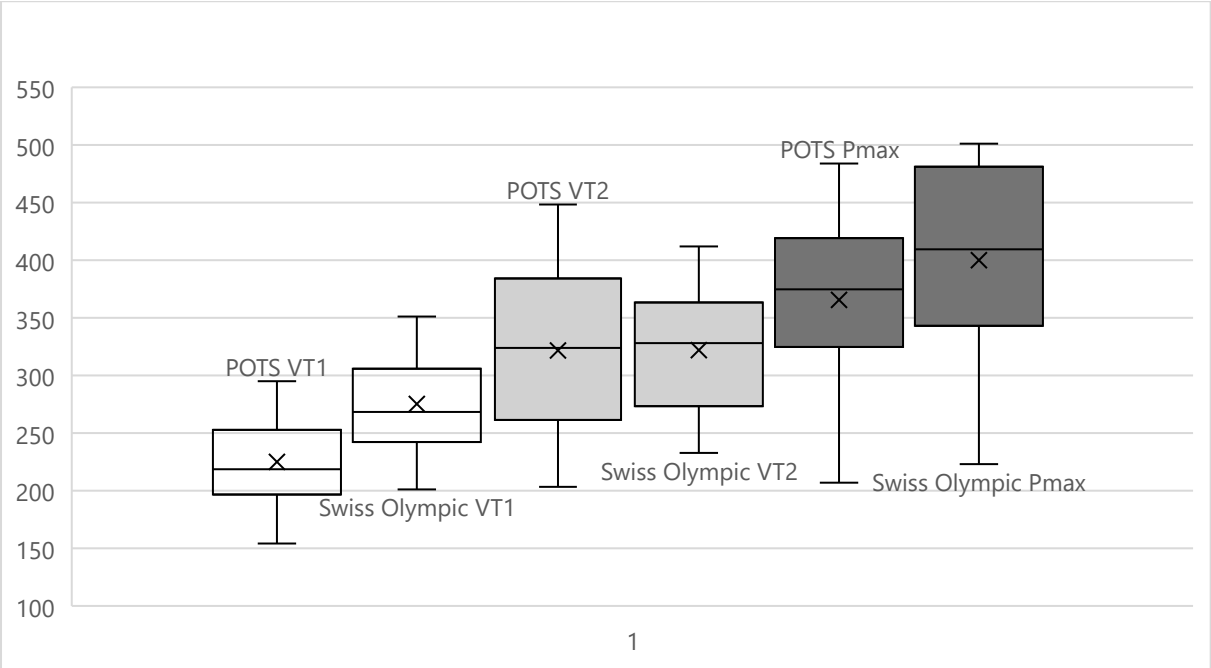
Note. The black line shows the line of regression for the correlation (r = 0.82, p < .001).

7 Bland-Altman-Plot HR@VT2 of POTS and Swiss Olympic



Note. Lower LoA was calculated at -10.12 bpm, upper LoA was calculated at 17.01 bpm (see dashed lines). The systematic error (orange line) was 3.44 bpm. Negative datapoints represent an overestimation of HR@VT2, positive represent an underestimation of HR@VT2 by POTS when compared to Swiss Olympic.

8 Boxplots of P value at different stages



Note. The x in each Boxplot represents the mean of the respective protocol and Pmax formula. For the detailed means and SD, see Chapter 3.

9 P@VT1 and P@VT2 as percentage of Pmax

Protocol	P@VT1 as % of Pmax	P@VT2 as % of Pmax
POTS	61.37%	87.95%
Swiss Olympic	68.75%	77.50%

Note. For the values of Pmax, see Chapter 3 and Table 1.