Original Article

Predicting military specific performance from common fitness tests

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Abstract

Purpose: Good health status and adequate physical performance are required for serving as conscripts. Therefore, the purpose of the study was to assess the impact of common fitness tests on military specific skills. **Methods:** 24 conscripts (N=24, age 19.4 ± 0.9 years, height 179.0 ± 5.1 , weight 80.6 ± 16.8) of an infantry platoon completed a medical check, anthropometric assessment and isometric power tests of upper and lower extremities within a pre selection phase 10 to 16 months before military mandatory. During military mandatory a motoric test battery, a military specific test (MST), a 2400m run and a military march were conducted. **Results:** All strength parameters except leg press (LP) correlated significantly with the MST and military march ($p > 0.005$). Isometric strength tests showed the lowest relationship to MST. The strongest predictors for MST ($R^2 = 0.58$) were seated bench pull (sbPull, $p = 0.007$) and push up ($p = 0.038$). Push up ($p \leq 0.001$) and core strength ($p = 0.034$) were the best predictors ($R^2 = 0.60$) for the military march. Derived VO_{2max} was found to be a stronger predictor than 2400m running time alone for MST ($p \leq 0.001$, $R^2 = 0.38$) and march ($p \leq 0.001$, $R^2 = 0.49$). In a second step all significant predictors of MST and military march were included in a multiple linear regression. For MST the best predictors ($R^2 = 0.63$) were VO_{2max} ($p = 0.008$) and seated bench pull ($p \leq 0.001$). For military march VO_{2max} ($p \leq 0.001$) and core strength ($p = 0.006$) were the strongest predictors ($R^2 = 0.64$). **Conclusion:** VO_{2max} derived from the 2400m running test was the strongest predictor for MST and military march. Core stability and seated bench press significantly influenced military march and MST outcomes respectively. Isometric strength tests from pre-service selection revealed no significant relationship of military specific skills, which questions their predictive validity and purpose.

Keywords: physical activity, conscripts, compulsory service, army tasks,

Introduction

Throughout history, various criteria have been established for the selection process of military personnel. The focus has shifted from a simple health check to a detailed medical, psychological and physical assessment. Due to the detrimental effect of life style diseases the health and physical fitness of future soldiers also is endangered. Recent health guidelines, alterations in the motor and physiological abilities of infants and adolescents (Ruiz et al, 2016, Batista et al. 2017, Hansen et al. 2018) have had an influence on the recruitment process. For countries with compulsory service, the initial selection draws attention to personnel who best suited for the demands and requirement of a professional soldiers.

As a result, there is less toleration for underperformance in terms of strength, coordination and endurance (Nindl et al. 2017, Robinson et al. 2016), which could have a detrimental effect on a subsequent military careers. Low levels of physical fitness associated with obesity and inactivity contribute to sickness absence (Anderson et al. 2015, Teyhen, et al. 2016) and overload-related injuries (Kyröläinen et al. 2008, Taanila et al. 2015) during physical activity. Physical fitness in general can be related to safe and efficient execution of many military skills. In Austria, there is a delay of around 12 to 18 months between recruitment call up and start of service in the armed forces. Therefore, it is necessary to evaluate the efficiency of the selection process in order to compare results of the assessment and the fitness status at the beginning of military service. At the beginning of military mandatory common fitness tests were used to investigate the requirements for military specific tasks. In previous researches (Rohde et al, 2017, Hauschild et al, 2017) several military specific tasks were defined which should be representative for soldier's military specific skills. According to NATO research published in 2009 military specific skills are defined as:

- manual movement of equipment along a surface
- repeated lifting equipment on/ off ground or vehicle
- carry various equipment items over distances
- move fast- with or without change of direction for short distances
- crawl in high and low techniques
- march with load

The evaluation and assessment of longitudinal anthropometric and physiological characteristics in army recruits is of great interest in order to display general civil population's health and physical tendencies. Earlier research studies have focused on the underlying physiological factors that determine the military test performance. In addition, the standardization of a testing procedure that underpins the practicability of testing large cohorts is of elementary importance in order to ensure good data quality and ecological validity. Therefore, the aim of this study was to assess the anthropometric and physiological characteristics of army recruits from assessment centre to the beginning of military mandatory in order to evaluate the relationship of the testing results with the military specific skills.

Methods and Material

Following institutional ethical approval from Research Ethics Committee of University of Applied Science "Military Leadership Program" 24 conscripts ($N=24$, age 19.4 ± 0.9 years, height 179.0 ± 5.1 , weight 80.6 ± 16.8) of a common infantry platoon were assigned for this study. Each of them passed a pre-selection in the regional recruiting centre 10 to 16 months before military mandatory. In this assessment medical status, anthropometrics and isometric power of upper and lower extremities were recorded.

During the third week of military mandatory, a motoric test battery was conducted.

The testing procedures consisted of:

- A one repetition maximum test (1RM)
- Core stability test
- Maximum push-up test
- 2400m running test
- Military specific test
- Loaded military march (3.2 km)

The strength tests were completed within one day, with an extra day of recovery between the 2400 m running test and the loaded military march. was included to ensure rested and motivated state.

Isolated Strength Test - Regarding the isolated strength tests, upper and lower extremities isometric strength was tested using a commercially available device (DIERS myoline, Schlungenbad, Germany).

One Repetition Maximum Test - 1RM was evaluated on a machine-supported multi-rowing device (Concept2 DYNO Strength Trainer, Concept2 Deutschland GmbH, Hamburg, Germany). LP, seated bench press (sbPress) and sbPull were the preselected exercises.

Core Stability Test - Participants were instructed to hold plank position with their upperarmsvertical and forearmsparell to the ground. A further criteria was to place the posterior upperiliac spine underneath a transverse bar. From the initial position both legs are alternately moved 2-5 cm off the ground guided by a metronome with a 1 Hz acoustic signal. Exclusion criteria were losing contact with the transverse bar after three warnings by the supervisor. Overall time was recorded in seconds with a stopwatch (Hanhart Modul 3, Hanhart 1882 GmbH, Güttenbach, Germany).

Maximal Push Up Test - Movement execution: the upper body is lowered from the starting position by bending the arms in the elbow joints to the end position. The body tension must be maintained in the up-down movement. The movement needs to be executed dynamically without interruption. Total repetitions without time limit were counted.

2400m Running Test - This selected distance has been applied to the Cooper test approach. Testing was carried out on a 400 m running track with a 15-minute standardised warm-up programme. The warm up consisted of 10min steady jogging at a self-selected pace of 3-4 RPE (1-10 RPE scale). In the second half of the warm up the participants were asked to include 3x80m strides interspersed by 1.5min of recovery. The participants were registered with a bib number in order to ensure accurate lap count and timing. They were sent off with an acoustic signal.

Military Specific Test - The military specific test (MST) included 4 stations. The overall time was recorded.

Station A included moving in selective terrain with changes of direction, speed and position over a total distance of 130 m within 10 m after creep.

Station B involved a 50 kg load carrying over a total distance of 40 m

Station C contained a load of 2x18kg across a distance of 100m

Station D involved lifting/releasing a load of 5x24kg on a 125cm high wooden box

Military Loaded March - This military march consisted of a distance of 3,200 m in full military equipment (KAZ 03/3 with weapon AUG77 with 25 kg extra load. The objective was to cover the 3,200m on selective terrain in the fastest time possible for each individual. All participants were registered with a start number to assure accurate lap counting and timing. They were set off with an acoustic signal.

Data Analysis and Statistics

Split times of MST, 2400m Running Test and Loaded Military March were recorded with a manual timing system (Hanhart Modul 3, Hanhart 1882 GmbH, Güttenbach, Germany). One repetition maximum (1RM) for LB, sbPress and sbPull were performed on a machine based multi rowing machine (Concept 2 Dyno, Concept 2 Ltd, UK). Relative maximum oxygen consumption (VO_{2max}) values were derived from the 2400m Running Test using following equation according to the Cooper test (Cooper, 1968).

$$\text{VO}_{2\max} (\text{ml.kg}^{-1}.\text{min}^{-1}) = 3.5 + \frac{483}{2400\text{m time [min]}}$$

All descriptive data are presented as mean $\pm$ standard deviation (SD). Normal distribution of the data was tested using Shapiro Wilk ($p > 0.05$). Paired samples t-test compared the anthropometric measures of the assessment centre (pre) and during military mandatory (post). Linear correlation according to Pearson compared the influence of physical performance parameters including isometric strength, push ups, core stability, 2400m running test, LP, sbPress and sbPull, 2400m running test on the military specific skills including the MST and military march. Multiple regression analyses were conducted to compare the relationship between strength and endurance parameters on the soldier's military specific skills. In a second step all significant predictors of military march and MST respectively were included in a linear regression analysis. All statistical analyses were generated using the SPSS statistics 20 software package (IBM Corporation, Armonk, New York). All graphs and figures were created using GraphPad Prism 8 (GraphPad Prism version 8.0.0 for Windows, GraphPad Software, San Diego, USA).

Results

Anthropometrics

The participant's anthropometric characteristics recorded during the assessment (pre) and at the beginning of military mandatory (post) are demonstrated in Figure 1. During the military mandatory (post) participants revealed significantly higher height ($p \leq 0.001$), body mass ($p \leq 0.001$), BMI ($p = 0.002$) and waist circumference ($p = 0.010$) compared to the assessment centre (pre).

Figure 1: Conscript's anthropometric data pre (2018) and post (2019)

Influence of physical performance on military specific skills

The conscript's physical performance characteristics recorded at the beginning of military service 2019 are listed in the table 1.

Table 1: Descriptive statistics of the physical performance tests

	Mean	SD $\pm$	95% CI
Upper extremities [Nm]	404.79	76.44	372.5-437.07
Lower extremities [Nm]	243.75	67.53	215.2-272.3
Push Ups [reps]	26.79	11	21.1-31.4
Core stability [s]	97	32	87-114
LP [kg]	190.50	75.33	158.7-222.3
sbPress [kg]	73.58	29.43	61.16-86.01
sbPull [kg]	77.25	31.52	63.94-90.56
Run 2400m [s]	779.4	120.5	728.5-830.8
Military Specific Test [s]	184.9	34.7	170.2-199.6
March [s]	1683.3	189.1	1603-1763

LP (Leg Press), sbPress (seated Bench Press), sbPull (seated Bench Press)

All Strength parameters except LP significantly correlated with the MST and military march ($p > 0.005$). Furthermore, VO_{2max} derived from the 2400m running test showed a significant relationship with total time in the MST ($r = -0.617$, $p = 0.001$) and the military march ($r = -0.701$, $p = 0.000$).

Table 2: Pearson's linear correlation of physical performance tests on military specific skills

	MST	p	March	p
Upper extremities	-.591**	.002	-.449*	.028
Lower extremities	-.536**	.007	-.481*	.017
Push ups	-.639**	.001	-.711**	.001
Core stability	-.293	.164	-.435*	.034
LPmax	-.620**	.001	-.396	.055
sbPressmax	-.665**	.000	-.489*	.037
sbPullmax	-.700**	.000	-.461*	.024
Run 2400m [s]	.580**	.003	.679**	.000
VO_{2max}	-.617**	.001	-.701**	.000

LP (Leg Press), sbPress (seated Bench Press), sbPull (seated Bench Press)

For MST the strongest predictors with an R^2 of 0.58 were seated bench pull ($p = 0.007$) and push ups ($p = 0.038$). Moreover, push ups ($p \leq 0.001$) and core strength ($p = 0.034$) with an R^2 of 0.60 were considered as best predictors for the military march. Lower extremities strength could significantly predict military march performance ($p = 0.002$, $R^2 = 0.19$) while isolated upper extremities strength better predicted MST performance ($p = 0.002$, $R^2 = 0.32$). Derived VO_{2max} was found to be a stronger predictor than 2400m running time alone for MST ($p \leq 0.001$, $R^2 = 0.38$) and military march ($p \leq 0.001$, $R^2 = 0.49$). For the military march the overall strongest predictors of physical performance were VO_{2max} ($p \leq 0.001$) and core strength ($p = 0.006$) resulting in a R^2 of 0.64. Regarding MST the best predictors were VO_{2max} ($p = 0.008$) and sbPull ($p \leq 0.001$) resulting in a R^2 of 0.63.

Discussion

The findings of this study reveal that anthropometric characteristics were lower in the assessment centre (pre) compared to the beginning of military service (post). Change of body mass and body mass index (BMI) has different impact on strength and endurance parameters (Pierce et al, 2017, Pihlainen, 2018). In this study, only body height showed a significant influence on isometric strength testing. In contrast several others (Drinkard et al, 2001, Reilly et al, 2016, Vaara et al, 2012) show a relationship between anthropometric data and endurance as well as strength parameters. Differences of development of BMI and waist circumference between age groups of conscripts were shown in other investigations (Lehman et al, 2017, Floris et al, 2015, Stocker 2019). These findings suggest that the period between assessment and start of military mandatory should be within a limited time frame in order to ensure valid data for physical fitness. SbPull and core strength were the strongest predictors for military specific skills in this study. An adequate level of maximum power is required for the military specific skills (Colmenero et al, 2014, Friedl et al, 2015). Other research demonstrated that isometric strength tests of isolated muscle groups are not linked to dynamic maximum strength. The type of muscle work i.e. dynamic in the soldier's daily activities vs. static in the isometric test can lead to misinterpretation (Wilson and Murphy, 1996). In 2011 Wirth demonstrated that even an increase in cross-sectional area of the knee extensors does not necessarily lead to an increase in the measured force values if non-specific testing is carried out. The isometric muscle strength measured in an open kinetic chain was not movement-specific enough to predict performance during a more complex situation (Requena et al, 2009, Baker et al, 1994). The literature has shown that muscle strength is related to military specific capabilities (Huang et al., 2018, Harman et al., 2008, East et al., 2017). In particular, muscular endurance ability, such as a maximum number of impacts or nuclear power, has often been cited in previous research as a better predictor of military specific capabilities than 1RM (Pierce et al., 2017). VO_{2max} showed the strongest relationship to military specific capabilities for both military marching and MST. It is known that cardiorespiratory fitness in the general population and the military is an important factor for health and physical performance. Therefore, many military fitness test batteries include at least one cardiorespiratory fitness assessment. The most commonly used methods are capacity tests of fixed distance or duration between 1.5-3km or 8-12 minutes to estimate the VO_{2max} (Hauschild et al, 2017). These running tests show a high correlation ($r = 0.92 - 0.86$) to treadmill tests in the laboratory (Grant et al, 1995). Our results indicate that the modified Queens College Step test at the assessment centre was a weak predictor for VO_{2max} and therefore endurance capacity (Werner, 2012). To ensure a high level of agreement the test design should meet the requirements of the soldier's daily activities i.e. running and lifting. Other studies showed that the use of anthropometric characteristics to predict VO_{2max} also revealed low level of accuracy similar to the Queen's College step test (Aires et al, 2010, Nikolaidis, 2013, Fogelholm, 2006). One limitation of this study was that VO_{2max} was not measured due to the sample size. However, derived VO_{2max} values from running time is a commonly used method in the military to deal with large groups at a short time period (Grant et al, 1995).

Conclusion:

The findings of the present study reveal that VO_{2max} derived from the 2400m running test was a strong predictor for both MST and the military march. In addition, core stability significantly contributed to

military march performance, while sbPress clearly influenced MST outcomes. Isometric tests from the assessment center failed to predict military specific skills, which questions their predictive validity and purpose at the assessment center. In conclusion, our findings underpin the importance of endurance tests in the pre-selection for military personnel. Future research should investigate the interaction of physiological and psychological factors on military specific skills.

Disclosures

The authors report no conflict of interest.

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