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Estimation of aerobic fitness among young men without exercise test

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Summary

Study aim: to develop and estimate the validity of non-exercise methods to predict VO_2max among young male conscripts entering military service in order to divide them into the different physical training groups.
Material and methods: fifty males (age 19.7 ± 0.3 years) reported their physical activity before military service by IPAQ and SIVAQ questionnaires. Furthermore, Jackson's non-exercise method was used to estimate VO_2max. Body mass and height were measured, body mass index calculated and VO_2max measured directly in a maximal treadmill test. Subjects were randomly divided into two groups. The results of the Group 1 (N = 25) were used to develop a regression equation to estimate VO_2max. The results of the Group 2 (N = 25) were used to evaluate the validity of the developed non-exercise methods and Jackson's non-exercise methods to estimate VO_2max by Bland and Altman plot. The validity was further evaluated by comparing the results to 12-minute running test performed by 877 male conscripts (age 19.6 ± 0.2 years).
Results: the developed models explained 68–74% of the variation in VO_2max. Mean difference between directly measured and estimated VO_2max was not significant, while Jackson's method overestimated VO_2max ($p < 0.001$). Both developed models were equally valid to divide conscripts into tertile group of fitness. However, 5% of the conscripts were classified into the highest fitness group based on both methods, but they were actually in the lowest fitness group based on a running test.
Conclusion: in practice, these findings suggest that developed methods can be used as a tool to divide conscripts into different fitness groups in the very beginning of their military service.

Keywords: Military – Regression analysis – Aerobic capacity – Exercise test – Men

Introduction

The fitness level of young men entering compulsory military service in Finland has declined, with a concomitant increase in body mass during the last 25 years [25]. This fact has made it more challenging for the Finnish Defence Forces to accomplish their task of training capable soldiers with an adequate performance capacity for military units. Finnish military training has been observed to improve aerobic [21, 26] and muscular fitness [6, 27] and to induce beneficial changes in body composition [20, 27]. However, one third of the conscripts were classified as overreached at the end of an 8-week military basic training period (BT) [31]. In the second half of BT, increased somatic symptoms of overreaching and several physiological and biochemical markers indicated that the training load was not well tolerated by all the conscripts, 33% of whom were classified as overreached [31].

Aerobic fitness, as measured by maximal oxygen uptake (VO_2max), is an important component of the physical fitness profile [1]. In addition, aerobic fitness has been found to be an important component of soldiers' performance as it can influence an ability to sustain the training load during BT [13, 30], while poor physical fitness and overweight increases the risk of injury and illness leading to limited duty days during BT [13, 15, 31]. In addition, while the risk of injuries and premature discharge from the military seems to be highest during the first weeks of military training [13, 17, 19, 23], the physical load of training at this stage has to be relatively low and optimal in relation to prior physical activity of the conscripts.

In order to enhance physical fitness and to avoid overreaching and overtraining syndrome, it has been suggested that conscripts could be divided into different training groups according to their aerobic fitness level [31] or simply based on BMI, rather than aerobic fitness level or a combination of these parameters [30]. However, measuring VO_2max by fitness testing is time consuming and not

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practical for a large group of subjects, for example during the call-up of new recruits. In addition, dividing to training groups should be able to do before entering to military service and the timing of traditionally used 12-minute running test in the militaries is too late in the practical point of view. Thus, more alternative methods are needed to estimate aerobic fitness of young male conscripts before they enter compulsory military service. Previous studies have suggested that self-reported exercise habits may be useful in developing non-exercise prediction models to estimate maximal oxygen consumption among adult population [12]. Thus, the purpose of the present study was to develop and estimate the validity of non-exercise methods to predict VO_2max among young men.

Material and methods

The study was performed in two phases (Study I and Study II) among conscripts who entered military service. In the first phase, Study I, the purpose was to develop a non-exercise method to predict VO_2max. In the second phase, Study II, the validity of developed non-exercise methods was evaluated. In both studies, all subjects were carefully informed of the experimental protocol and they gave written consent to participate in the study. They were also advised of their right to withdraw from the investigation at any time. The study protocol was approved by the Finnish Defence Forces, and the Ethics Committees of the University of Jyväskylä and the Kainuu region.

Study I – development and estimation of non-exercise methods

Fifty males (age 19.7 ± 0.3 years) reported their physical activity before military service. During the first week of military service, their body mass and height were measured, body mass index (BMI) calculated and VO_2max measured by a treadmill test. They also run a 12-minute running test.

Physical activity (PA) questionnaires. One month before military service subjects reported their physical activity by a) a self-administered short version of international physical activity questionnaire (IPAQ) covering the previous seven days [8] and b) Single-Item Question on Leisure-Time Vigorous Physical Activity (SIVAQ) [9, 28]. In addition, Jackson's non-exercise questionnaire [12, 24] was used to estimate their VO_2max.

IPAQ. IPAQ outcome was reported as MET minutes per week calculated in five different ways [8]: 1) Light PA: daily minutes x days per week with walking × 3.3 MET. 2) Moderate PA: daily minutes × days per week with moderate-intensity physical activity × 4.0 MET. 3) Vigorous PA: daily minutes × days per week with physical vigorous activity × 8.0 MET. 4) Moderate to vigorous PA (ModVig PA): Moderate PA + Vigorous PA. 5) Total PA: Light PA + Moderate PA + Vigorous PA.

SIVAQ. Single-Item Question on Leisure-Time Vigorous Physical Activity (SIVAQ) [9, 28] consisted of the following question: "Think of the previous 3 months and consider all leisure-time physical activity with duration of at least 20 minutes. How frequently were you physically active?" The response alternatives were 1) less than once a week; 2) no vigorous activities, but light or moderate physical activity at least once a week; 3) vigorous activity once a week; 4) vigorous activity twice a week; 5) vigorous activity three times a week; 6) vigorous activity at least four times a week. For further analyses, PA by SIVAQ was categorised as follows: 1 = no PA or light or moderate PA at least once a week, 2 = vigorous PA once a week, 3 = vigorous PA twice a week, 4 = vigorous PA three times a week and 5 = vigorous PA at least four times a week.

Jackson's non-exercise questionnaire. Jackson's non-exercise questionnaire [12, 24] consisted of a question: "Use the appropriate number (0–7) which best describes your general activity level for the previous month". Do not participate regularly in programmed recreation sport or heavy physical activity: 0) avoid walking or exertion, e.g. always use elevator, drive whenever possible instead of walking; 1) walk for pleasure, routinely use stairs, occasionally exercise sufficiently to cause heavy breathing or perspiration. Participate regularly in recreation or work requiring modest physical activity, such as golf, horseback, riding, gymnastic, table tennis, bowling, weight lifting, yard work: 2) 10 to 60 min per week; 3) over one hour (h) per week. Participate regularly in heavy physical exercise such as running or jogging, skipping rope, running in place or engaging in vigorous aerobic activity type exercise such as tennis, basketball or handball: 4) run less than 2 km per week or spend about 30 min per week in comparable physical activity; 5) run 2 to 10 km per week or spend 30 to 60 min per week in comparable physical activity; 6) run 10 to 15 km per week or spend in 1 to 3 h per week in comparable physical activity; 7) run 15 km per week or spend over 3 h per week in comparable physical activity. VO_2max was estimated according to the following equation: (56.363 + 1.921 * physical activity level (0–7) – 0.381 * age – 0.754 * BMI + 10.987 * 1).

Maximal oxygen uptake (VO_2max) and anthropometry. During the first week of military service, VO_2max ($mL \cdot kg^{-1} \cdot min^{-1}$) was directly measured by a maximal treadmill test. The start of the test involved walking for 3-min at 4.6 $km \cdot h^{-1}$ and walking/jogging at 6.3 $km \cdot h^{-1}$ (1% slope) as a warm-up. Thereafter, exercise intensity was increased every 3-min to induce an increase of 6 $mL \cdot kg^{-1} \cdot min^{-1}$ in the theoretical VO_2max demand of running [1]. This was achieved by increasing the initial running speed of 4.6 km · h^{-1} by a mean of 1.2 km · h^{-1} (range 0.6–1.4 km · h^{-1}), and by increasing the initial grade of 1 deg by a mean grade of 0.5 deg (range 0.0–1.0 deg) up to the point of exhaustion [1]. Pulmonary ventilation and respiratory gas exchange data were measured by breath-by-breath method (Jaeger Oxygen Pro, VIASYS Healthcare GmbH, Hoechberg, Germany), and mean values were calculated at 1-min intervals for statistical analysis. The analyzer was calibrated before each test according to manufacturer's specifications. Heart rate was continuously recorded at 5-s intervals using a telemetric system (Polar810i, Polar Electro Oy, Kempele, Finland). Blood lactate was determined 1 min after completion of the exercise from a fingertip blood sample using a lactate analyser (LactatePro®, Arkray, Japan). The criteria used for determining VO_2max were: VO_2max and heart rate did not increase despite an increase in grade and/or speed of the treadmill, a respiratory exchange ratio (RER) higher than 1.1, and a post-exercise blood lactate higher than 8 mmol · l^{-1} [1]. All subjects fulfilled all criteria.

Body mass was measured with an accuracy of 0.1 kg (Inbody720 body composition analyser, Biospace Co Ltd, Seoul, Korea). The measurements were performed between 6:00 and 7:00 a.m. after an overnight fast and after voiding, with no exercise for 12 hours before the test. The subjects were barefoot and wore T-shirts and shorts. Body height was measured to the nearest 0.5 cm using a wall-mounted stadiometer. Body mass index (BMI) was calculated as body mass (kg) divided by body height (m) squared.

Development of the ECAF (Estimate of Conscripts Aerobic Fitness) non-exercise method. Subjects were randomly divided into two groups. The results of the Group 1 (N = 25) were used to develop a regression equation to estimate conscripts aerobic fitness (ECAF) in terms of VO_2max based on two different physical activity questions, IPAQ (ECAF1) and SIVAQ (ECAF2), and anthropometric measures. The results of the Group 2 (N = 25) were used to evaluate the validity of ECAF1, ECAF2 and Jackson's non-exercise methods to estimate VO_2max by Bland and Altman plot [4].

Statistical analysis. Pearson correlation coefficients were computed between VO_2max and 12-min running test. For the Group 1, Pearson correlation coefficients were computed to determine the linear relationship between VO_2max (mL · kg^{-1} · min^{-1}) and body mass, height, BMI, Light PA, Moderate PA, Vigorous PA, ModVig PA, Total PA and SIVAQ PA. To identify the best prediction model to estimate VO_2max from the optimal combination of independent variables, multivariable linear regression analysis was used. The independent variables tested for ECAF1 were body mass and height or BMI and Light PA, Moderate PA and Vigorous PA or VigMod PA or Total PA. For ECAF2, the tested independent variables were body mass and height or BMI and SIVAQ PA. The final model was computed after the multicollinearity diagnostic and the assumptions for regression analysis were fulfilled. The validity of ECAF1, ECAF2 and Jackson's non-exercise method was evaluated by comparing the results to directly measured VO_2max by Bland and Altman plot [4] by the subjects of Group 2 (N = 25).

Study II – agreement between estimated and measured aerobic fitness categories

Subjects were 887 male conscripts of Kainuu Brigade (Group 3) (age 19.6 ± 0.2 years). On the first day of military service, the subjects filled out a questionnaire for ECAF1 and ECAF2 to estimate their VO_2max. In addition, body mass and height were measured and the question "To which physical training group you would like to participate, low, moderate or high" was asked. During the first two weeks of service, the subjects run a 12-minute running test [7].

Statistical analysis. The validity of ECAF1 and ECAF2 was further evaluated by comparing the estimated VO_2max to 12-minute running test of Group 3 (N = 887). Group 3 was divided into tertile groups with equal numbers of subjects according to their aerobic fitness measured by 12-minute running test (low < 2235 m, middle 2236–2499 m, high > 2500 m) and estimated VO_2max by ECAF1 and ECAF2 (low ≤ 43.0 mL · kg^{-1} · min^{-1}, middle 43.1–46.0 mL · kg^{-1} · min^{-1}, high ≥ 46.1 mL · kg^{-1} · min^{-1}). Crosstabs and Pearson's correlation coefficients were evaluated between these results. All statistical analyses were performed using SPSS (16.0.1. 2005; SPSS Inc., Chicago, IL). The level of statistical significance was set at $p < 0.05$.

Results

Characteristics of the subjects are presented in Table 1. There were no significant differences between three study groups in body composition, physical activity level and aerobic fitness. A strong positive correlation between measured VO_2max and 12-min running test was observed ($r = 0.79$, $p = 0.000$).

Developed non-exercise methods. The associations between VO_2max and physical activity variables are presented in Table 2, showing that Light PA was not associated with VO_2max. Table 3 demonstrates the multivariate regression equations for explaining variation in VO_2max. For ECAF1, the best fitting model included BMI and the IPAQ's question of Vigorous PA. The model explained 74% of conscripts' VO_2max with a standard error of estimate (SEE) of 4.0 mL · kg^{-1} · min^{-1}. For ECAF2, the best fitting model included BMI and SIVAQ PA explaining 68% of the variation in VO_2max (SEE 4.2 mL · kg^{-1} · min^{-1}).

Table 1. Anthropometry, physical activity and aerobic fitness (mean ± SD) of study groups

	Study I		Study II
	Group 1 (N = 25)	Group 2 (N = 25)	Group 3 (N = 877)
Body mass (kg)	77.1 ± 19.8	80.9 ± 14.2	76.1 ± 13.2
Height (cm)	176.6 ± 7.4	179.4 ± 5.3	178.0 ± 6.3
BMI ($kg \cdot m^{-2}$)	24.7 ± 5.9	25.0 ± 3.5	24.0 ± 3.7
IPAQ			
Light PA ($MET \cdot min \cdot wk^{-1}$)	982 ± 1071	1225 ± 1926	
Moderate PA ($MET \cdot min \cdot wk^{-1}$)	1064 ± 1159	949 ± 2011	
Vigorous PA ($MET \cdot min \cdot wk^{-1}$)	2179 ± 1831	2000 ± 3199	1998 ± 2219
ModVig PA ($MET \cdot min \cdot wk^{-1}$)	3243 ± 2692	2949 ± 5023	
Total PA ($MET \cdot min \cdot wk^{-1}$)	4225 ± 3141	4174 ± 6633	
SIVAQ PA	2.6 ± 1.6	2.4 ± 1.3	2.3 ± 1.3
VO_2max ($mL^{-1} \cdot kg^{-1} \cdot min^{-1}$)	43.8 ± 7.4	42.4 ± 7.8	
12-minute running test (m)	2319 ± 308	2271 ± 392	2361 ± 312

Table 2. Pearson's correlation coefficients between VO_2max and BMI, Light, Moderate, Vigorous, ModVig, Total PA and SIVAQ PA

	VO_2max ($mL \cdot kg^{-1} \cdot min^{-1}$)	
	r	p
BMI ($kg \cdot m^{-2}$)	–0.71	<0.001
Light PA ($MET \cdot min \cdot wk^{-1}$)	0.09	0.520
Moderate PA ($MET \cdot min \cdot wk^{-1}$)	0.31	0.029
Vigorous PA ($MET \cdot min \cdot wk^{-1}$)	0.34	0.014
ModVig PA ($MET \cdot min \cdot wk^{-1}$)	0.35	0.013
Total PA ($MET \cdot min \cdot wk^{-1}$)	0.30	0.035
SIVAQ PA (scale 1–5)	0.36	0.009

Table 3. Multivariate regression models for explaining the variation in maximal aerobic fitness ($mL^{-1} \cdot kg^{-1} \cdot min^{-1}$).

Independent	Coefficients	SE	p	Adjusted R^2	SEE
ECAF1			<0.001	0.74	4.0
Constant	65.751				
BMI ($kg \cdot m^{-2}$)	–1.0003	0.14	<0.001	0.62	4.5
Vigorous PA ($MET \cdot min \cdot wk^{-1}$)	0.001	0.00	<0.001	0.74	4.0
ECAF2			<0.001	0.68	4.1
Constant	64.915				
BMI ($kg \cdot m^{-2}$)	–0.986	0.14	<0.001	0.62	4,5
SIVAQ PA (scale 1-5)	1.214	0.52	<0.001	0.68	4.1

Validity of non-exercise methods. Mean difference between directly measured VO_2max and VO_2max estimated by ECAF1 method was not significant (–1.8 ± 5.7 $mL \cdot kg^{-1} \cdot min^{-1}$, $p = 0.13$; the 95% limits of agreement – 12.9 – 9.3 $mL \cdot kg^{-1} \cdot min^{-1}$). There were no significant correlation ($r = 0.22$, $p = 0.28$) between the

Table 4. The association of measured VO_2max and estimated by non-exercise methods of Jackson's index, ECAF and ECAF2

	ECAF1	ECAF2	Jacksons' index
Mean difference between measured and estimated VO_2max ($mL^{-1} \cdot kg^{-1} \cdot min^{-1}$)	–1.8 ± 5.7	–1.7 ± 5.4	–5.3 ± 4.6***
The 95% limits of agreement ($mL^{-1} \cdot kg^{-1} \cdot min^{-1}$)	–12.9 – 9.3	–12.4 – 8.9	–14.2 – 3.7
Correlation between mean and differences of measured and estimated VO_2max	0.22	0.54**	0.64***

** $p < 0.01$, *** $p < 0.001$

mean values and the difference of the ECAF1 and measured VO_2max (Table 4). Similarly, the mean between directly measured VO_2max and VO_2max estimated by ECAF2 was not significant (–1.7 ± 5.4 $mL \cdot kg^{-1} \cdot min^{-1}$, $p = 0.12$; the 95% limits of agreement – 12.4 – 8.9 $mL \cdot kg^{-1} \cdot min^{-1}$). However, there was a significant correlation ($r = 0.54$, $p = 0.005$) between the mean values and the difference of ECAF2 and measured VO_2max (Table 4).

Jackson's non-exercise method overestimated VO_2max compared to measured VO_2max. The mean difference between directly measured (42.0 ± 7.9 $mL \cdot kg^{-1} \cdot min^{-1}$) and estimated (47.3 ± 5.1 $mL \cdot kg^{-1} \cdot min^{-1}$) VO_2max was – 5.3 ± 4.6 $mL \cdot kg^{-1} \cdot min^{-1}$ ($p < 0.001$) (95% limits of agreement – 14.2 – 3.7 $mL \cdot kg^{-1} \cdot min^{-1}$). Furthermore, there was a significant correlation ($r = 0.64$, $p < 0.001$) between the mean values and the difference of the measured VO_2max and Jackson's method indicating that Jackson's method overestimated VO_2max to a higher degree among males with low aerobic fitness. (Table 4).

Evaluation of developed ECAF1 and ECAF2 estimations of VO_2max in different fitness groups. Both ECAF1 and ECAF2 estimates of VO_2max correlated positively with 12-min running test time ($r = 0.49$, $p < 0.001$; $r = 0.53$, $p < 0.001$, respectively). ECAF1 (Fig. 1) and ECAF2 (Fig. 2) demonstrated to be equally valid to divide conscripts into tertile group of fitness; among 887 subjects, 461 (52%)

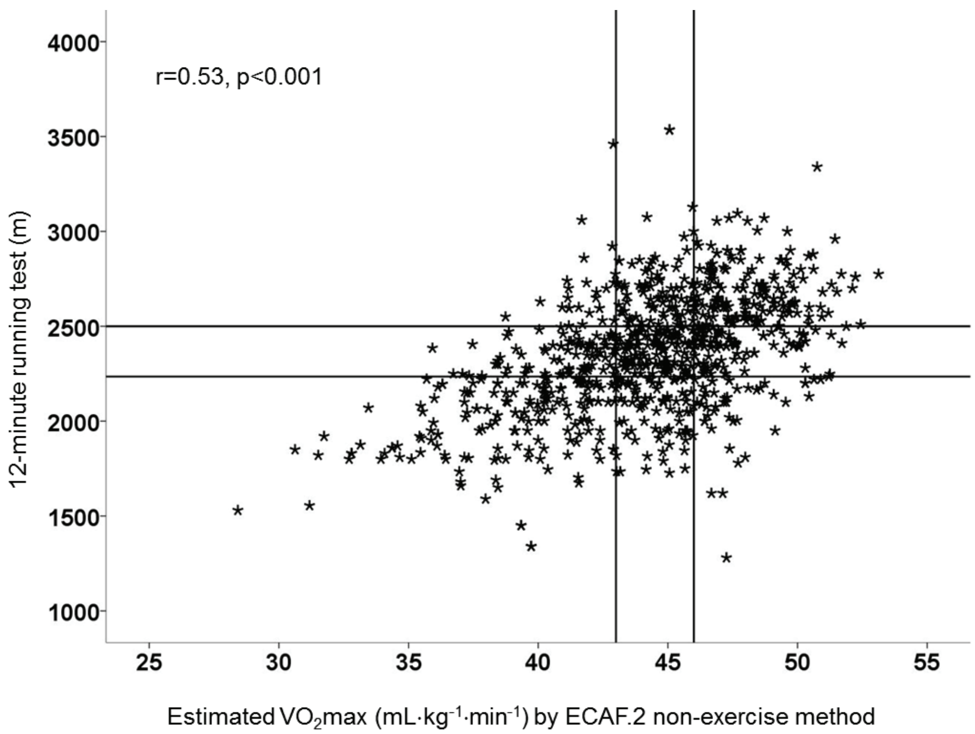

Fig. 1. Pearson correlation coefficient between VO_2max estimated by ECAF1 non-excercise method and 12-minute running test. Vertical and horizontal lines indicate the tertiles of 12-minute running test (lower < 2235 m, middle 2236–2500 m, upper > 2500 m) and estimated VO_2max by ECAF1 (lower ≤ 43.0 $mL \cdot kg^{-1} \cdot min^{-1}$, middle 43.1 – 46.0 $mL \cdot kg^{-1} \cdot min^{-1}$, upper ≥ 46.1 $mL \cdot kg^{-1} \cdot min^{-1}$)

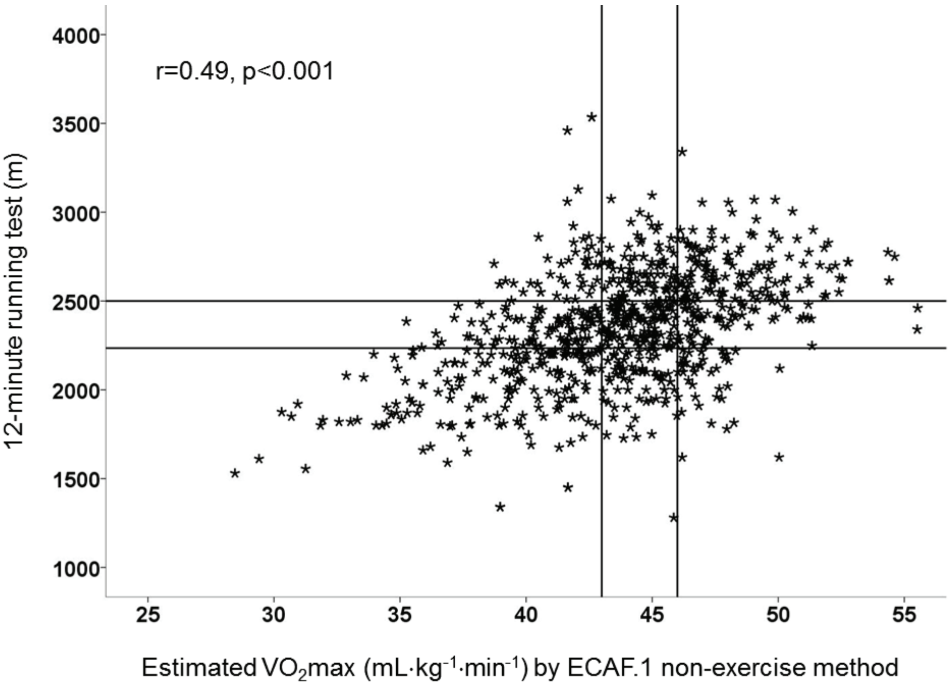

Fig. 2. Pearson's correlation coefficient between VO_2max estimated by ECAF2 non-exercise method and 12-minute running test. Vertical and horizontal lines indicate the tertiles of 12-minute running test (lower < 2235 m, middle 2236–2500 m, upper > 2500 m) and estimated VO_2max by ECAF2 (lower ≤ 43.0 mL · kg^{-1} · min^{-1}, middle 43.1 – 46.0 mL · kg^{-1} · min^{-1}, upper ≥ 46.1 mL · kg^{-1} · min^{-1})

and 466 (53%) were correctly classified into the appropriate fitness tertile based on ECAF1 and ECAF1, respectively. Crosstabs analysis (Table 5) revealed that of the participant who were estimated to be in the lowest fitness tertile based on ECAF1, 58% were in the lowest tertile, 29% in middle tertile and 13% in the highest tertile based on 12-minute running test. Of the participants who were estimated to be in the highest fitness tertile based on ECAF1, 57% were in the highest tertile, 27% in middle tertile and 16% in the lowest tertile based on 12-minute running test. The crosstabs analyses were very similar for ECAF1 and ECAF2.

A total of 5% of the conscripts were classified into the highest fitness group based on both ECAF1 and ECAF2, but they actually were in the lowest fitness group based on 12-min running test. Compared to the others in the beginning of BT, these conscripts had lower body mass (62.3 ± 5.5 vs. 76.3 ± 12.5 kg, $p < 0.001$) and lower BMI (19.9 ± 1.3 vs. 24.0 ± 3.5 kg · m^{-2}, $p < 0.001$). They also had less vigorous PA (1347 ±1693 vs. 2002 ± 2132 MET · min · wk^{-1}, $p < 0.001$), but there were no differences in SIVAQ PA (2.1 ± 1.3 vs. 2.4 ± 1.3). Furthermore, 75% of these subjects expressed their willingness to take a part

Table 5. The Crosstabs between aerobic fitness tertile groups measured by 12-minute running test and estimated by non-exercise methods ECAF1 and ECAF2

			12-min running test		
			Lower	Middle	Upper
Estimated VO_2max by ECAF1*	Lower	% within ECAF1 tertile	58%	29%	13%
	Middle	% within ECAF1 tertile	26%	42%	32%
	Upper	% within ECAF1 tertile	16%	27%	57%
Estimated VO_2max by ECAF2*	Lower	% within ECAF2 tertile	60%	31%	9%
	Middle	% within ECAF2 tertile	25%	41%	34%
	Upper	% within ECAF2 tertile	16%	27%	58%

* Pearson ChiSquare $p < 0.001$. 12-minute running test tertiles: lower < 2235 m, middle 2236–2500 m, upper > 2500 m. Estimated VO_2max by ECAF1 and ECAF2 tertiles: lower ≤ 43.0 mL · kg^{-1} · min^{-1}, middle 43.1 – 46.0 mL · kg^{-1} · min^{-1}, upper ≥ 46.1 mL · kg^{-1} · min^{-1}

to the lowest and the rest 25% to the moderate physical training group. From the all conscripts, only 9% wanted to participate in the highest physical training group, 37% in the moderate and the most 54% in the lowest physical training group.

Discussion

The present study indicates that among large groups of young male conscripts, VO_2max can be estimated with reasonable accuracy by body weight, height and self-reported participation in physical activity at the vigorous intensity. In practice, these findings suggest that developed ECAF1 and ECAF2 methods can be used as a tool to divide conscripts into different fitness groups either in the call-up or in the very beginning of the military service. ECAF1 and ECAF2 predicted 74% and 68% of the variations in VO_2max, respectively, being very close to earlier findings.

Several previous studies have also evaluated a prediction of maximal aerobic fitness by using physical activity questionnaire data [2, 5, 10–12, 18, 32]. In these studies, subjects have been men and women between 18 to 79 yr. of age. The variables affecting VO_2max have been gender, age, BMI as well as volume and intensity of physical activity during a certain time period. Four of these studies had also evaluated the validity of non-exercise models to predict maximal aerobic fitness [11, 12, 18, 32]. In a study of Whaley et al. (1995) [32], the average age of participating men and women was 40 years, of whose age, gender, BMI and physical activity status explained 70% of the variation in VO_2max. However, this regression model was unable to categorise subjects into the fitness groups. Also in a study by Ainsworth et al. (1992) [2] age, gender, BMI and frequency of vigorous exercise per week explain 75% of the variations in VO_2max for men. Recently, Nes et al (2011) [22] have further demonstrated that age, waist circumference, leisure time physical activity and resting heart rate together explained 61% of variance in VO_2max for men.

The strength of the present study was that the study population represents well the physical fitness characteristics of young Finnish men [25]. Secondly, the study included both validation and evaluation of the developed non-exercise method for predicting maximal aerobic fitness both in the laboratory and field. Earlier studies have suggested that non-exercise models can be valid predictors of VO_2peak for heterogeneous samples [11] and can give relatively accurate results conveniently [5]. Recently, Aspenes et al. (2011) [3] have further suggested that "valid and reliable physical activity questionnaires that predict cardiorespiratory fitness may be valuable instruments for monitoring physical fitness in a population, when more costly and time-consuming techniques are not feasible".

The non-exercise prediction model developed by Jackson et al. [12] has also been shown to be an accurate method for measuring VO_2max in all except the most fit subjects (VO_2max > 55 mL · kg^{-1} · min^{-1}). The present study indicates that Jackson's method overestimated VO_2max to a higher degree among young males with low aerobic fitness and underestimated among young males with good aerobic fitness. One explanation for this could be rather complicated nature of PA questionnaire. The participant might have had difficulties to find an appropriate PA category from the questionnaire [24] used in Jackson's method. The present simple SIVAQ and IPAQ vigorous PA questionnaires have been shown to have positive associations with aerobic and muscular fitness [9].

Classification into fitness groups is, however, challenging while only 52% of the conscripts are matched to the right class, but this is still higher when compared to the accuracy of 36% reported in a previous study [18]. On the other hand, only 5% of the conscripts were classified into the highest fitness group based on both ECAF1 and ECAF2, but they were actually in the lowest fitness group based on their running test result. Nevertheless, caution should be taken especially among those conscripts who report low physical activity and low body mass. Thus, willingness of the physical fitness group can be used as additional criteria.

Each year almost 25 000 20-year old males enter Finnish compulsory military service. The present developed non-exercise fitness test method can be used as a part of an integrated internet based data system during the call-up phase of the conscripts, when it is not possible to have practical fitness tests due to the limited time resources. The rate of premature discharge from the military service in Finland has increased during the last decade mainly due to mental disorders or muscular skeletal diseases [19]. Several studies have demonstrated that a high level of physical fitness including adequate muscle strength and muscle endurance is essential for soldiers, not only in order to perform their daily duties, but also for the prevention of injuries [14–16, 19, 29]. Therefore, it is important that conscripts have participated in physical training before military service. One way to increase conscripts' physical activity before the military service might be the promotion of physical training during the call-up.

In summary, non-exercise fitness tests can be useful tools for dividing conscripts into different physical training groups. However, willingness of the physical fitness group can be used as additional criteria. Optimal physical training load in the beginning of the military service could contribute to decrease the rate of discharge from the military service as well as injuries during service

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