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Effects of Baseline Fitness and BMI Levels on Changes in Physical Fitness During Military Service

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ABSTRACT

Objectives. The purpose of the present study was to investigate how aerobic fitness, muscle fitness and body mass index (BMI) change in relation to their baseline levels during 6-12 months of military service.

Design: Retrospective longitudinal follow-up study.

Methods. The study group consisted of 249 279 healthy young male conscripts (age 19.1±0.4 yrs.) who completed their military service between the years 2005-2015. Anthropometrics (body mass, height, BMI), aerobic fitness (12-minute running test) and muscle fitness (sit-ups, push-ups, standing long jump) were measured.

Results. A 12-minute running test improved by 5% (107±292 m), standing long jump 1% (2.1±16.2 cm), 1-min sit-ups 19% (4±8 repetitions/min) and 1-min push-ups 33% (5±10 repetitions/min) ($p<0.001$ for all). Baseline fitness and baseline BMI levels were inversely associated with their changes ($r= -0.37$ - -0.47, $p<0.001$). Performance improved in conscripts in the lowest two baseline fitness quartiles in all tests, while it decreased in conscripts in the highest fitness quartiles. In addition, in conscripts who were obese at baseline, body mass decreased on average by 4.9±7.0 kg ($p<0.001$).

Conclusions. On average, the physical fitness of conscripts improved during their compulsory military service. In particular, conscripts with a lower baseline fitness level or higher BMI showed the largest improvements, which may be significant findings from both a military readiness and national health perspective. However, the decline in physical performance of high-fit conscripts

highlights the importance of individualization of physical training and military training load during military service.

Keywords: Physical performance, exercise, readiness, public health, conscript.

INTRODUCTION

It is generally recognized that successful management of military duties requires high levels of aerobic fitness and muscular strength [1]. Aerobic fitness is particularly important in prolonged military tasks consisting of physical activity at varying intensities [2]. Muscular strength and power are also essential physical performance attributes during physically demanding tasks such as sprinting short distances, jumping over obstacles, and lifting, carrying or dragging heavy loads and materials [3]. Adequate physical fitness level is also desirable since it may decrease the risk of musculoskeletal injuries and premature discharge from military service [4, 5]. From a health perspective, physical fitness and physical activity have been linked to a number of central and peripheral adaptations that decrease the risk of cardiovascular diseases [6], which are currently the leading causes of death in males globally [7]. In addition, physical activity is a significant contributor to reductions in excess body weight, which is a risk factor for all-cause mortality and disability [8].

While some studies have observed positive adaptations to a standardized military training [9, 10, 11], many of them have focused on one training phase such as basic training [4, 12, 13]. Currently, there are limited data concerning the effects of longer follow-ups, e.g. 6-12 months, which report physical performance and body composition changes with a large representative sample size and throughout the complete military service time [14, 15]. Finland is one of the very few countries where conscription is compulsory for all healthy males, which results in about 75% of young men performing their military service annually. Currently, the military service is divided into three main phases, known as basic training, special training and unit training period. The length of each period is approximately 8 weeks. In addition, roughly one third of the conscripts are trained for non-commissioned officer and reserve officer tasks for 16 to 22 weeks. During the 6–12 months of military service, conscripts perform progressive physical training that includes combat training and close-order drills, marching and sports-related training for more than 20 hours per week [9]. However, the execution of optimal military training has become more challenging because an increasing proportion of young Finnish men are overweight and have poor aerobic fitness [16]. With this in mind, the purpose of the present study was to investigate military service-induced changes in physical fitness and body mass index (BMI) of male conscripts in relation to their baseline levels.

METHODS

The present retrospective dataset consisted of individual fitness test and body anthropometry results of 249 279 healthy young male conscripts (19.1±0.4 yrs., 179.2±6.6 cm, 77.0±13.3 kg) during 2005–2015 (Table 1). The baseline fitness tests were conducted during the first two weeks of military service by educated fitness instructors, while the post-measurements were performed approximately 4–6 weeks before the end of service. The average duration of the military service was 38 (range 24-52) weeks. After the tests, fitness instructors imported the results to the central database according to the standards determined by the Training Division of the Defence Command. Results concerning temporal changes in the initial body anthropometrics and physical fitness of conscripts from the same dataset were recently published by Santtila et al. [16].

Table 1 here

The present fitness tests and anthropometric measurements were conducted as part of military service, after a physical examination by medical doctors. Safety instructions were given to conscripts before each fitness test, and they were advised of their right to voluntarily interrupt the test at any time. The test termination criteria included the following indications: onset of angina-like symptoms, shortness of breath, wheezing, leg cramps, claudication, light-headedness, confusion, or nausea [17]. All subjects were fully informed of the procedures and possible risks associated with the fitness tests. This study was approved by the Defence Command Finland and conducted according to the 1975 Declaration of Helsinki. The data were anonymized before scientific use.

The measurements of the present study have been described in detail by Santtila et al. [16]. Briefly, anthropometric measurements were conducted by a physician during a standardized medical examination as part of the military service. Body mass was measured to the nearest 100 g and stature with an accuracy of 5 mm. Thereafter, BMI was calculated by dividing body mass (kg) by the square of stature (m^2).

Physical fitness tests, protocols and techniques were standardized according to the guidelines of the Defence Command Finland [17], and the tests were supervised and demonstrated by educated fitness instructors. Aerobic fitness of the conscripts was assessed using the 12-min running test. Conscripts were instructed to perform the test with maximal effort at a progressively increasing running speed and the results were recorded with an accuracy of 10 m.

Separated from the 12-min running test by at least two days, muscle fitness was assessed using standing long jump, 1-min sit-up and 1-min push-up tests. Standing long jump (SLJ) was used to assess explosive power production of the lower extremities. The result of this test was expressed in centimeters from the longest jump of three trials. The sit-up test assessed dynamic performance of abdominal and hip flexor muscles, while the push-up test assessed arm and shoulder extensor muscle performance. The outcome measure of the sit-up and push-up tests was the number of repetitions in one minute.

Commercial software (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) was used for statistical analyses. Data are presented as means and standard deviations (± SD) where appropriate. Significance of changes between baseline and follow-up measures were analyzed using paired samples T-tests. Pearson correlation coefficients were calculated to examine associations between body composition and physical fitness variables and their changes. The data were additionally pooled into combined BMI categories and quartiles for each fitness test result, and the group differences were tested using analysis of covariance (ANCOVA). In the ANCOVA models, the contributions of categorized baseline fitness and BMI levels to changes in a given fitness variable were examined. Similarly, the contributions of categorized baseline BMI and categorized baseline fitness test results to changes in BMI were determined. Further adjustment for service duration only had a very small effect on comparative values and is therefore not presented in this article. Statistical significance was defined as $p<0.05$.

RESULTS

The average changes in stature and body mass were 0.5±1.5 cm ($p<0.001$) and 0.0±4.9 kg ($p=0.602$), respectively, during the follow-up period. The respective change in BMI was −0.1±1.5 kg/m^2 ($p<0.001$). Change in body mass explained 93% of the change in BMI ($R^2=0.93$, $p<0.001$). Despite the modest overall changes, the most marked reductions in body mass were observed in initially obese conscripts. Whereas the underweight (BMI <18.5) conscripts gained body mass on average by 4.0±4.6 kg ($p<0.001$), their overweight (BMI 25−29.9) and obese (BMI≥30) counterparts lost −2.0±5.9 ($p<0.001$) and −4.9±7.0 kg ($p<0.001$), respectively. Conscripts in the normal BMI category (18.5-24.9) gained body mass by an average of 1.1±3.8 kg ($p<0.001$).

Mean running distance in the 12-min running test improved by 107±292 m ($p<0.001$). Respective improvements in SLJ (2.1±16.2 cm), 1-min sit-ups (3.8±8.4 repetitions/min) and 1-min push-ups (5.0±10.1 repetitions/min) also reached statistical significance ($p<0.001$ for all). In general, one third (34%) of the conscripts improved their results in all fitness tests (12-min run, SLJ, 1-min push-up and sit-up), and another third (34%) improved in three out of four tests. On the other hand, 11% of conscripts performed worse in at least three out of four tests after military service. With the exception of stature, baseline anthropometrics and fitness were moderately associated with their changes ($r = -0.37$ - -0.49, $p<0.001$) during military service (table 2).

Table 2 here

When the data were pooled into combined baseline fitness quartiles and BMI categories, the largest increases in all fitness variables were observed in conscripts who were initially in the least fit quartiles, irrespective of BMI category (figure 1). Conversely, conscripts who were initially in the highest fitness quartiles showed a decline in performance in all assessed fitness variables, especially in SLJ and the 12-min run.

Figure 1 here

Positive fitness adaptations to military service were more pronounced in the lowest baseline fitness categories and the magnitude of change decreased linearly with increasing baseline fitness, independent of the baseline BMI category (supplement table 3). Baseline fitness had a stronger effect on change in physical fitness than baseline BMI category (supplement table 4). In addition, when compared to the obese BMI category, the most positive adaptations in fitness were observed in conscripts with initially normal BMI.

DISCUSSION

Compulsory military service generally induced beneficial adaptations to physical performance and body composition. A significant proportion of conscripts improved most of the assessed fitness outcomes, and 97.6% of conscripts improved in at least one of the four fitness tests. The most marked improvements were observed in conscripts with the lowest baseline fitness levels. Similarly, the greatest decreases in body mass were observed in conscripts who were obese at the beginning of military service. Hence, compulsory military service led to improvements in the fitness of young men with the greatest need for improvements, while body mass decreased in obese men by nearly 5 kg and their physical fitness improved significantly. On the other hand, conscripts initially in the highest fitness quartile exhibited decreased physical performance in every test, irrespective of baseline BMI. Therefore, military training should be optimized more individually, especially for initially high-fit individuals, to improve their performance during the service.

Although the average changes in body mass were modest overall, conscripts who were initially underweight gained weight and the initially obese conscripts lost weight during military service. While the BMI of underweight conscripts increased by 7%, it declined in obese conscripts by 5%. This is an important finding given that being underweight or overweight is associated with negative health consequences [18]. Being of a normal weight is also beneficial from an operative perspective since excess weight increases oxygen cost and may impair performance in critical military tasks [19]. These results support previous findings [14, 15, 20] which have also documented military service-induced decreases in fat mass and changes in fat distribution in obese conscripts, as well as improvements in cardiovascular risk factors in a smaller sample of the same study population. Furthermore, Santtila et al. [11] showed that among conscripts with normal BMI, military service increased fat free mass and decreased fat mass without significant changes in body mass.

The improvement of physical fitness, as well as BMI, was presumably due to an increase in total physical activity during the military service and the endurance nature of military training, compared to the habitual physical activity patterns of conscripts before entering the service. Tudor-Locke et al. [21] reported that over 10 000 steps per day can be classified as a physically active lifestyle. Typically, Finnish conscripts take 13 937±2276 steps per day during military field training [22]. Furthermore, conscripts often wear combat gear (25-35 kg) and carry other equipment, which increases the total work load of training. The results of the present study support previous findings of improved aerobic capacity and muscular fitness induced by military service [9, 14, 20]. On the other hand, while conscripts in the lowest baseline fitness quartile showed the largest improvements in test results, conscripts in the highest baseline fitness quartile showed the largest decreases in test performance, irrespective of the baseline BMI category. An inverse relationship between the initial fitness level and its change during the basic training phase of military training has also been found in other studies [11, 13]. Furthermore, Santtila et al. [9] showed that most of the positive adaptations occurred during the basic training period, with only small or even no further changes during the following 8 weeks of special training. This suggests that a plateau in training adaptations is reached already during the first eight weeks of military service. Therefore, more variation in training stimulus (intensity and volume) as well as progression of the balance between training load and recovery should be implemented in the later stages of military training in order to induce continuous development of physical fitness throughout military service, especially for conscripts with high initial fitness levels.

More positive adaptations to military training in low-fit subjects and decrements in aerobic fitness of high-fit subjects have also been observed in other countries [13, 23]. In a 10-month follow-up, Dyrstad et al. [23] found that the aerobic capacity of 107 recruits improved by >1% during the first 10 weeks of military training. However, by the end of military service, the average aerobic capacity had slightly decreased from baseline. It should be noted that the initial mean aerobic capacity was clearly higher in the Norwegian study, while the sample size was not as high as in the present study. Nonetheless, Dyrstad et al. [23] observed an increase in aerobic capacity in the lowest fitness category group. More recently, Burley et al. [13] compared changes in physical performance of initially low- and high-fit recruits who completed a 12-week basic training regimen. In response to training, initially high-fit recruits showed a greater tendency towards a decrease in aerobic fitness, as well as decreased performance in several military task simulations, whereas most of their low-fit counterparts showed positive changes.

SLJ was used to assess lower-body explosive power production in the present study, and this fitness outcome decreased in the two highest baseline fitness quartiles. Rosendal et al. [4] found a decrease in unloaded and loaded jump performance after a 12-week basic training period, and concluded that a high volume of endurance activity during military training may have a negative influence on rapid force development of the extensor muscles. It has been shown that high volumes of concurrent strength and endurance training involving the same muscle groups may interfere with the development of explosive power production [24]. Military training typically consists of a high overall volume of unilateral prolonged, low-intensity endurance-type activities, often with inadequate recovery, which may lead to symptoms of overtraining [12, 25]. Similar findings of baseline fitness-related changes in vertical jump performance have been observed during a 9-month combat operation [26]. Sharp et al. [26] observed an increase in vertical jump performance in initially low-fit soldiers, while jump performance decreased in high-fit soldiers. In this case, the suggested mechanism for the negative adaptation was detraining in higher-fit subjects who were already closer to their maximum potential at the beginning of the deployment. Based on differences in training adaptations of low- and high-fit conscripts in the present study, detraining may be one possible explanation for the diminished physical performance of high-fit conscripts. On the other hand, excessive monotonous low-intensity endurance-type physical activity, especially for the lower extremities, during military training may induce overtraining symptoms [25]. These two opposing theories could be tested by using more sophisticated methods such as blood biomarkers or muscle biopsies during longitudinal military training research.

Previous studies have shown significant inverse associations between cardiorespiratory fitness and mortality [27]. It has also been documented that 6-12 months of military service induces beneficial changes in traditional cardiovascular risk factors, such as blood pressure and cholesterol concentrations [15]. Importantly, the observed improvement in aerobic fitness in the present study most likely induced a cardioprotective effect, especially in the obese subjects who improved their 12-min run test result significantly. Furthermore, muscle fitness has been shown to be associated with health outcomes and the association may even be independent of aerobic fitness [28]. Thus, overall improvements in muscle fitness may offer an additive cardioprotective effect. Collectively, combined improvements in physical fitness and body composition during military service may be considered to induce positive health effects in a large number of young men. This highlights the significant role of military service in public health promotion.

This is the first study to present changes in physical fitness and body anthropometrics during military service in large, nationally representative cohorts of young adult men. Nevertheless, this study also has some limitations. For example, the number of subjects varied for different variables due to missing data. However, our results from an eleven-year period describe rather reliably the average changes in male conscripts during 6-12 months of military training between 2005 and 2015. Covariates such as motivation, diet and smoking, all of which may have affected the changes, were not controlled and may be regarded as limitations of the study. The conscripts lived mainly in the garrisons, and the same diet (3200-3600 kcal/day) was maintained throughout their structured military service [20]. Assumedly, diet and energy balance varied between individuals before the military service and therefore, the standardized diet during conscription may also have accounted for changes in body mass as well as fitness variables.

CONCLUSION

Compulsory military service in Finland improves the average aerobic and muscle fitness of conscripts. The positive adaptations are more pronounced in young men who initially have a lower fitness level. Furthermore, obese conscripts and those who are overweight also benefit from military service via its positive effects on body composition. Together, these adaptations may have clinical significance from a public health perspective if they can be maintained to some extent after military service. For the initially high-fit conscripts, increased intensity in endurance and strength training may enhance positive adaptations during military service [13]. One time-efficient solution could be implementation of high-intensity functional training that can be performed at the individual effort level or by using fitness level groups. This concurrent strength and endurance training modality has been shown to induce positive adaptations simultaneously to aerobic and muscular fitness [29]. Another solution might be dividing conscripts into training groups (inactive, moderate, and active) based on their preservice physical activity as Jurvelin et al. [30] recently suggested.

PRACTICAL IMPLICATIONS

- Positive physiological adaptations to military service serve the public health, but also, the aims of the national defense from an operative readiness perspective.
- Some adjustments to physical training such as more progressive training programs and replacement of some of the low-intensity components with higher intensity activities or

strength training are encouraged, especially for conscripts who belong to the highest baseline fitness quartiles.

- These adjustments may help to ensure that the fitness level of the abovementioned subgroups continues to improve or is at least maintained during military service.

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TABLES

Table 1. Study sample descriptive statistics at baseline.

Variable	n (pre-post)	mean±SD (pre)
Body mass (kg)	63 366	77+13
Stature (cm)	56 803	179+7
BMI (kg/m^2)	56 444	24.0±3.8
12-min run (m)	218 810	2461±366
Standing long jump (cm)	220 318	218±26
1-min sit-up (reps/min)	221 276	37±11
1-min push-up (reps/min)	220 028	32±14

Table 2. Pearson correlation coefficients between the baseline test results and their changes (Δ) during military service

Variable	***n***	***R* (baseline vs. Δ)**	***p***
Body mass	60 102	−0.43	<0.001
Stature	56 679	−0.15	<0.001
Body mass index	56 444	−0.47	<0.001
12-min run	218 810	−0.46	<0.001
Standing long jump	220 318	−0.37	<0.001
1-min sit-up	221 276	−0.44	<0.001
1-min push-up	220 028	−0.39	<0.001

FIGURE LEGENDS

Figure 1. Mean changes in 12-min running distance (a), standing long jump (b), 1-min push-up (c) and 1-min sit-up (d) performance of conscripts in the combined baseline BMI category and fitness quartile groups during military service.