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ORIGINAL ARTICLE

Aerobic performance and body composition changes during military service

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Abstract

Objective. To examine the association between aerobic performance and body composition changes by body mass index (BMI). *Design.* 6–12 months' follow-up during military service. *Setting.* Conscripts entering military service in 2005 in Sodankylä Jaeger Brigade (Finland). *Subjects.* 945 men (19 years, SD 1 years). *Main outcome measures.* Height, weight, waist circumference, BMI, and aerobic performance (Cooper test) were recorded. Body composition was measured by bioelectrical impedance analysis (BIA). The measured parameters were fat mass (FM), fat free mass (FFM), and visceral fat area (VFA). All the measurements were performed at the beginning and end of service. *Results.* On average, the military training period improved the running distance by 6.8% (169 m, $p < 0.001$) and the improvements were more pronounced in overweight (223.9 m/9.5%, $p < 0.001$) and obese (273.3 m/13.6 %, $p < 0.001$) conscripts. A strong inverse correlation between aerobic performance and body composition changes was observed, especially for weight ($r = -0.305$, $p < 0.001$) and VFA ($r = -0.465$, $p < 0.001$). A significant association between aerobic performance and changes in weight ($p < 0.001$), waist circumference ($p < 0.001$), FM ($p < 0.001$), and VFA ($p < 0.001$) by BMI was detected. The associated decrease in weight, waist circumference, FM, and VFA with improved aerobic performance was more substantial between overweight and obese compared with normal-weight subjects. *Conclusions.* Favourable changes in body composition are associated with improved aerobic performance during a physical training period such as military service. These findings are pronounced among overweight and obese men and can be applied at the population level in reducing obesity and co-morbidities.

Key Words: *Bioelectrical impedance assessment, Cooper test, fat, military conscripts*

Introduction

During the past few decades, an increasing trend in body weight among Scandinavian young adults has been reported [1,2]. Correspondingly, a decline in physical performance has also been observed [1–3]. Consequent on these trends, the prevalence of metabolic syndrome – a cluster of central obesity-related cardiovascular risk factors – has been reported to be high already in young men [4]. Nonetheless, it exists already in slightly overweight subjects [4].

It is well established that aerobic type of exercise improves body fat distribution and aerobic performance [5,6]. Exercise reduces in particular central obesity [7], and beneficial changes in body fat distribution can be observed even without weight loss [8]. However, a limited number of studies have examined physical fitness in relation to health factors among young age groups [9], and to the best of our knowledge large-scale population-based surveys are lacking.

In Finland, military service is compulsory for males and provides a representative sample of healthy young men of a certain age group among the whole population. We aimed to investigate the associations

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Population-based data are needed on the effects of exercise on body fat distribution in young adults. In the present study, a significant association between aerobic performance improvement and fat reduction was detected. The finding was pronounced among overweight and obese males. These results can be applied at the population level in reducing obesity.

between changes in fat distribution and aerobic performance among young men going through their military service period, which includes high amounts of physical exercise.

Material and methods

In Finland, all male citizens aged 19 are drafted into compulsory military service. In 2005, altogether 1467 men attended military service in the Sodankylä Jaeger Brigade (67°N, 27°E). Their mean age at the beginning of service was 19.2 years (SD 1.0 years, range 18 to 28 years). All conscripts were invited to participate in the present study, and 79% of them ($n = 1160$) attended. The dropout rate was 14% ($n = 169$ cases) during the follow-up period, mainly caused by 140 conscripts who discontinued their military service for physical or mental reasons. There were no significant differences ($p = 0.742$) in the dropout rate between different BMI groups (e.g. 18%, $n = 17$ among those were obese). Complete pairwise data were obtained from 945 men, who also gave their written consent for use of the collected data for scientific purposes. The study protocol was approved by the Ethics Committee of Lapland Central Hospital, Rovaniemi, Finland.

Study protocol

Anthropometric and body composition measurements, and aerobic performance testing were carried out at the beginning and end of military service lasting 6–12 months. More than half (57.5 %; 543/945) of the study subjects served for six months, 9.3 % (88/945) nine months, and the rest, 32.9 % (311/945), 12 months. The duration of service depends on type of training and tasks. Statistical analyses were performed for the entire study population and separately for those who served for six months, because the changes in body composition and fitness are emphasized in the earlier parts of military service [10,11]. All data were collected between 7.30 a.m. and 2.15 p.m. The intended energy content of the food served to every conscript by the military forces is 13.5–15.1 MJ (= 3200–3600 kcal)/day [12]. In addition to food provided by the military forces, the servicemen are permitted to buy and use optional foodstuffs, which make up about 25% of daily energy intake during military service [13].

Physical training during military service

The recommended amount of physical training during the eight-week basic training period at the beginning of military service includes on average four hours' sports-related training (such as running, cross-country skiing, nordic walking, strength training) and eight hours' marching training per week [14]. After the basic training period, the amount of physical exercise depends on tasks and type of training.

Anthropometry and body composition measurements

Waist circumference was measured midway between the lowest rib and the iliac crest. Weight was recorded in association with the body composition analyses (see below) and height was measured with 5-millimetre accuracy. BMI was calculated as weight (kg) divided by the square of the height (m^2). In accordance with the criteria and classification provided by the World Health Organization (WHO), BMI (kg/m^2), was categorized as underweight (< 18.5 kg/m^2), normal weight (BMI = 18.5–24.9), overweight (BMI > 25–29.9) or obese (BMI ≥ 30 kg/m^2). Body composition was analysed by bioelectrical impedance assessment (BIA) device (InBody 720 Body Composition analysis, Biospace Co., Ltd., Seoul, Korea), as described in detail elsewhere [15].

Aerobic performance

Aerobic performance was measured by the Cooper 12-minute running test [16]. The test was performed outdoors and controlled by educated supervisors. The test timing and circumstances were standardized. The conscripts were instructed to run for 12 minutes with maximal effort, and the test result was reported by the distance run with 10 metres' accuracy. The Cooper provides a good estimation for maximal oxygen uptake (VO_{2max}) correlation coefficients being 0.84–0.92 relative to the treadmill VO_{2max} [16,17].

Statistical methods

Body composition at the beginning and end of military service in different BMI groups was compared by paired t-tests. Associations between changes in body composition parameters and the Cooper test result were examined by bivariate

(Pearson's) correlation test. Linear regression analyses were used to examine the effects of body composition change and Cooper test result. The possible interaction between body composition and BMI categories was added to the regression model to investigate whether the change in body composition and Cooper test results have a different association according to the BMI categories. The following variables were controlled in the regression model: service period (entire study population), branch of service (entire study population), and age. The results are presented separately for the six-month training period and for the entire population, with the training period varying from six to 12 months. All values are presented as means ± SD. Significance was set at $p < 0.05$. The statistical analyses were performed using SAS version 9.1.3 for Windows (SAS Institute Inc., Gary, NC).

Results

When examining the entire study population, the results in the Cooper test improved by 6.8% (169 m) during the military service period (Table I). During the six-month training period, the underweight men improved their Cooper test result by 108, normal-weight men by 199, overweight men by 268, and obese men by 281 metres. A similar improvement in the Cooper test according to BMI was observed for the entire study population. Details on weight changes according to BMI have previously been presented by Mikkola et al. (2009) [15]. The Cooper test was associated with changes in weight ($r = -0.241$, $p < 0.0001$), waist circumference ($r = -0.189$), $p < 0.0001$), FM ($r = -0.213$, $p < 0.0001$), FFM ($r = -0.101$, $p = 0.0018$), and VFA ($r = -0.416$, $p < 0.0001$) during the first six months of training. Similar associations were observed for the entire study population: weight ($r = -0.305$, $p < 0.0001$), waist circumference ($r = -0.187$, $p < 0.0001$), FM ($r = -0.288$, $p < 0.0001$), FFM ($r = -0.101$, $p = 0.0019$), and VFA ($r = -0.465$, $p < 0.0001$).

The association between changes in body composition and the Cooper test during military service according to BMI is presented in Figures 1 and 2 (six months of service and the entire study population). A significant association between the Cooper test result and changes in weight ($p < 0.001$), waist circumference ($p < 0.001$), FM ($p < 0.001$), and VFA ($p < 0.001$) by BMI was observed for those who had served for six months, as well as for the entire study population.

The decrease in weight, waist circumference and FM, and connection with an improved Cooper test result was more substantial between overweight subjects compared with normal-weight subjects (after six months of training). This association was also observed to be significantly different for obese compared with normal-weight subjects when examining the entire study population. A reduction in VFA associated with improved Cooper test results was more pronounced in overweight ($p < 0.001$) and obese ($p < 0.001$) subjects compared with normal-weight subjects both for those whose training period was six months and for the entire study population (see Figures 1 and 2).

Discussion

The findings of this study indicate a significant association between beneficial fat distribution changes and improved aerobic performance during military service. These changes had already occurred during the first six months of training and were

Table I. Cooper test results (in metres) of the study subjects by BMI measured at the beginning and end of military service for those who served six months and all (6–12 months' service).

	n	Beginning mean (SD)	End mean (SD)	Change mean (SD)	% change	Paired t-test p-value
Six months						
All	543	2410.0 (346.4)	2628.7 (302.2)	218.7 (271.0)	9.1	< 0.0001
Underweight	23	2592.2 (317.9)	2700.4 (253.2)	108.3 (268.0)	4.2	0.0656
Normal	343	2508.6 (316.8)	2707.4 (283.7)	198.7 (279.6)	7.9	< 0.0001
Overweight	131	2272.4 (283.6)	2540.8 (255.5)	268.4 (260.7)	11.8	< 0.0001
Obese	46	1975.9 (249.4)	2256.5 (233.9)	280.7 (195.7)	14.2	< 0.0001
All (6–12 months)						
All	945	2501.9 (364.6)	2670.9 (301.9)	169.0 (259.3)	6.8	< 0.0001
Underweight	35	2635.7 (281.8)	2728.9 (244.7)	93.1 (231.5)	3.5	0.0230
Normal	624	2602.4 (335.1)	2745.1 (281.4)	142.7 (263.3)	5.5	< 0.0001
Overweight	218	2346.5 (300.6)	2570.4 (259.6)	223.9 (252.7)	9.5	< 0.0001
Obese	68	2009.0 (260.5)	2282.4 (245.5)	273.3 (197.1)	13.6	< 0.0001

Note: n = number of statistics.

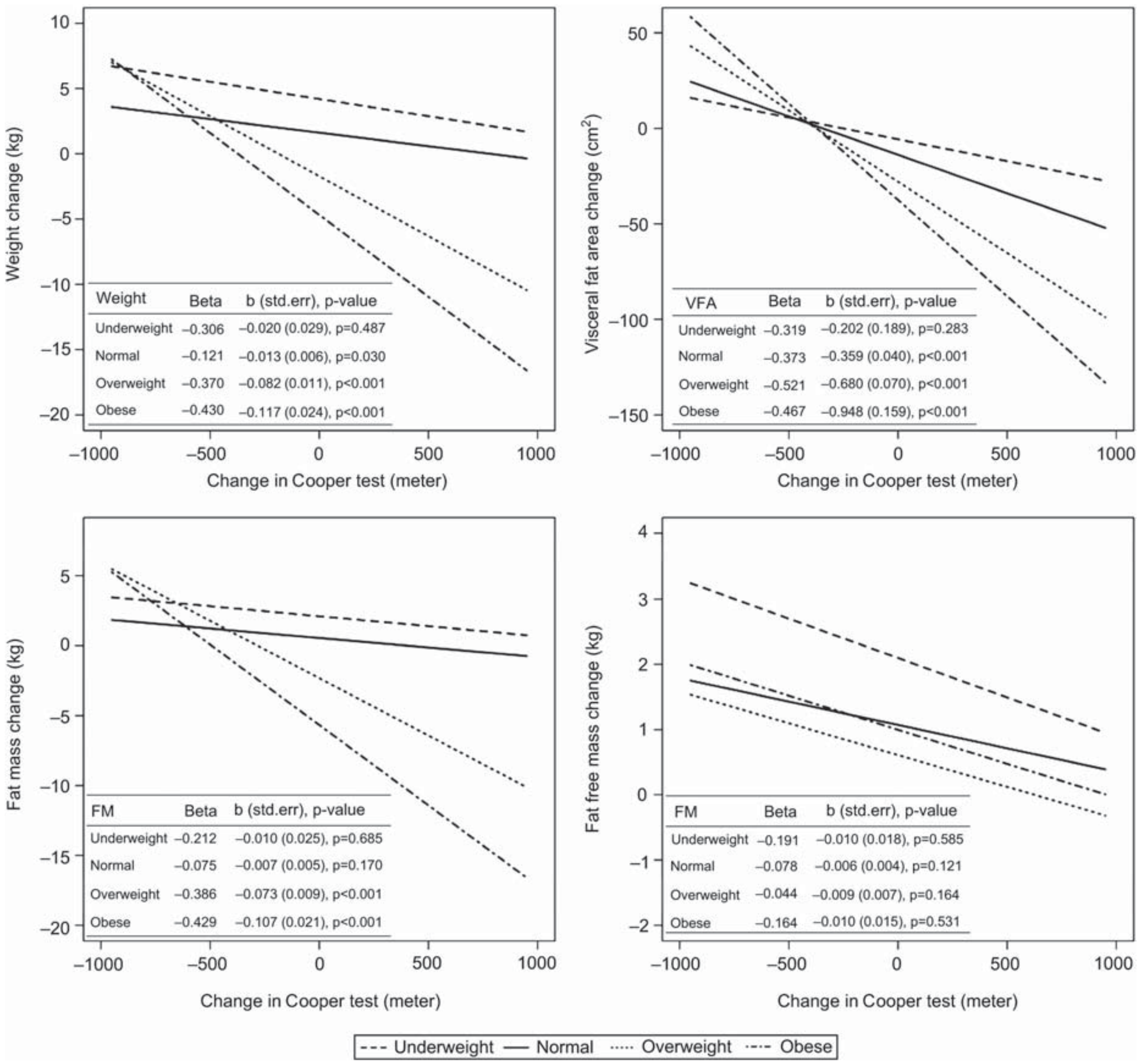

Figure 1. Changes in the Cooper test result, anthropometry, and body composition by BMI during military service (six months of service).

particularly pronounced in overweight and obese conscripts. Among those subjects, favourable changes in body composition (reduction in weight, waist circumference, FM, and VFA) per increased metre in the Cooper test result were more considerable compared with those of normal-weight subjects. For example, depending on the service period, obese conscripts improved their Cooper test result on average by 273–281 m, and the decrease in weight was 40–120 g per 10 increased metres in Cooper test result.

With reference to the improvement in aerobic performance, the Cooper 12-minute running test improved on average by 7–9% during the 6–12-months' training period. The improved aerobic performance is related to increased physical activity, especially endurance training during service. Our results are in accordance with previous military studies showing improvements in aerobic performance by 6–10% [11,18,19] during a military training period. Moreover, the overweight and obese conscripts – who were also in the worst shape at baseline – benefited most from the lifestyle changes associated with military training by improving their aerobic performance by 13.6–14.2%. This is also in accordance with some previous studies, suggesting more pronounced improvements in aerobic performance during the heavy exercise period, such as military service among obese (approximately 12–14%) compared with normal-weight men [11,20]. In our study, the improvement in aerobic performance is probably partially related to the observed weight loss, but can also reflect improved running economy, or better cardiorespiratory fitness. However, the present research design does not allow us to distinguish between these factors.

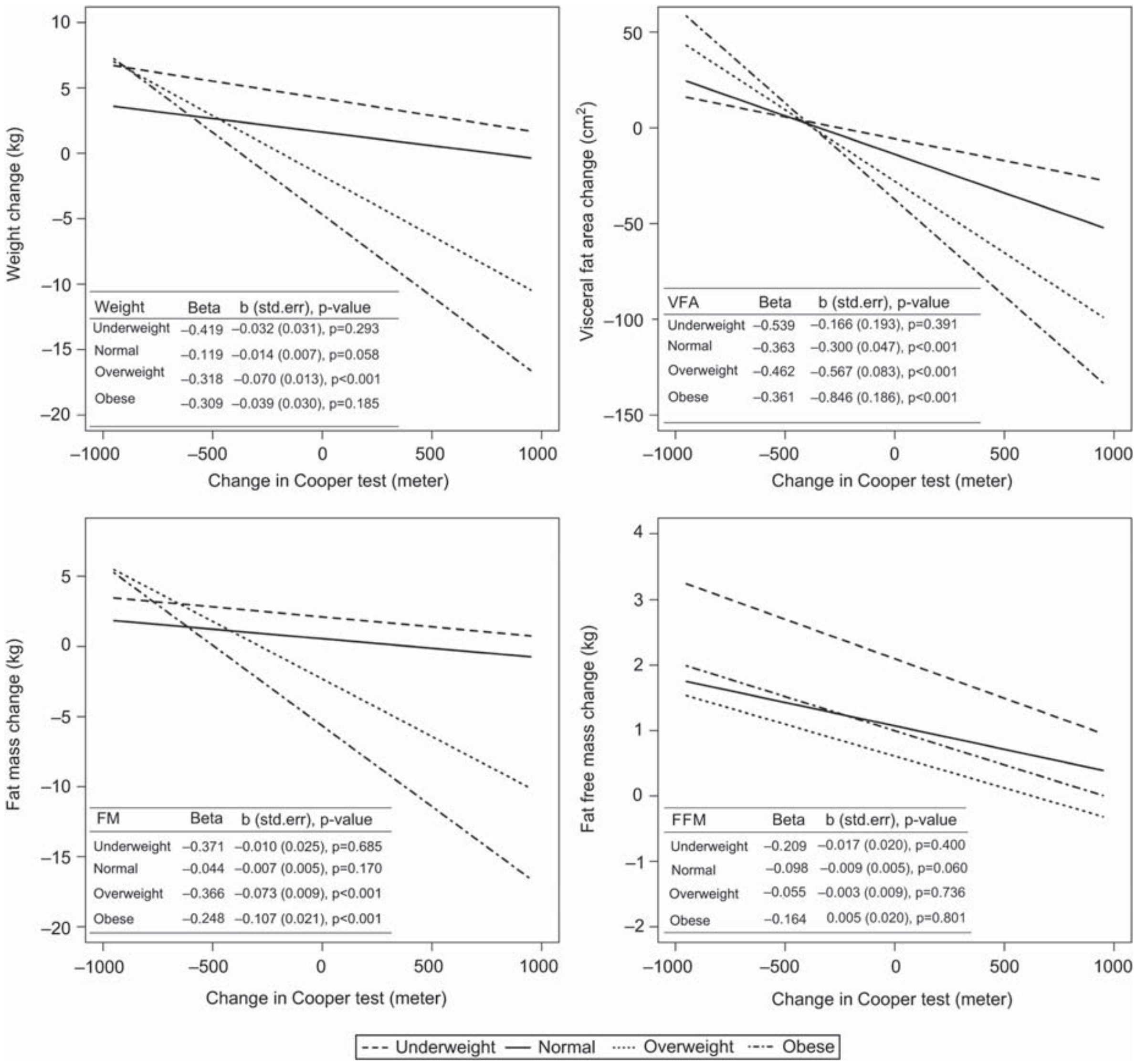

Figure 2. Changes in the Cooper test result, anthropometry, and body composition by BMI during military service (entire study population).

In general, it is well recognized that physical training stimulates positive effects in body composition [21] and that in particular endurance training – also the main type of training during military service – plays an essential role in reducing body fat [22]. In the present study sample, the average FM reduction of 9.7% [15] is in accordance with the previous exercise studies showing fat reductions of 2.7–16.3% [14,18,23]. Regarding the fact that the amount of fat, especially visceral fat, is known to be a major risk factor for several serious public health concerns, such as diabetes [24] and cardiovascular disease [25], the finding in the present study of a very strong association between reductions in fat mass, particularly visceral fat, and improvement in aerobic performance is important.

Considering that during recent decades the prevalence of obesity and overweight has increased in conjunction with decreased physical fitness among young adults [1,2], a lifestyle change such as military service is especially beneficial for overweight and obese young men. An application for fat reduction of young men at the population level is by improving aerobic performance, without any dietary restriction. Therefore, the finding is consequential from the public health perspective in reducing obesity-related morbidity and could also be applied in civilian life.

One of the strengths of the present paper is the study population, consisting of a large and representative, rather unselected sample of healthy Finnish male adults. However, a slight selection does occur in the present study where at baseline approximately 8% of the age group choose non-military service, which is an alternative to compulsory military service in Finland. In addition, approximately 10% of military trainees are exempted from military service during medical examinations for medical reasons. One limitation of the present study is that the exact calorie intake could not be controlled during the military service.

In conclusion, a significant association between improvement in aerobic performance and decrease in the amount of body fat was found in this large population-based sample of young Finnish male adults. Particularly among overweight and obese conscripts, the greater the improvement in aerobic performance, the larger the decrease in body fat. This study adds knowledge concerning non-pharmacological applications to combat the excessive epidemic of obesity in the young male population. Further research is warranted to study the associations between body composition and physical fitness changes against metabolic markers.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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