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Changes in Physical Fitness and Anthropometrics Differ between Female and Male Recruits during the Finnish Military Service

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Abstract

Introduction. Military training is often similar for male and female recruits despite sex differences in physical performance, which may influence with training adaptations. The present study aimed to compare changes in physical fitness and anthropometrics between Finnish female and male recruits during military service.

Methods. A total of 234,690 male and 3,549 female recruits participated in fitness tests at the beginning and end month military service between 2005 and 2015. Anthropometric measurements were body mass, height, body mass index (BMI) and waist circumference (WC). Fitness tests consisted 12-minute running, standing long jump and timed sit-ups and push-ups.

Results. No changes were observed in body anthropometrics, while most of the fitness test results improved in both sexes. After adjustment for service time, branch, age, initial fitness test results, BMI and WC, improvement in running test performance was 158m (95% CI 142-173m, $p \leq 0.001$) greater in male than female recruits. Similarly, improvements were larger in male recruits for push-ups (5 reps/min, 95% CI 5-6, $p \leq 0.001$), sit-ups (2 reps/min, 95% CI 2-3, $p \leq 0.001$) and standing long jump (12 cm, 95% CI 11-13 cm, $p \leq 0.001$) when compared with females.

Conclusions. The study revealed sex differences in adaptations to the standardized military training. Both male and female recruits improved their physical fitness, but smaller gains were observed in females using the same training program. The mechanisms explaining sex differences in adaptations to military training, and whether tailored training programs are needed specifically for female recruits to reduce sex differences during military service, warrants further study.

1. Introduction

It is known that military operations are physically and mentally demanding. Therefore, it is logical that one goal of military training is to optimize the physical performance of soldiers before they enter demanding operations. It is also known that there are sex differences in physical fitness in favor of males, which are mainly due to the differences in body size, muscle mass and hormonal profile of females[1]. Military tasks like lifting or carrying heavy loads may require maximal efforts even for males and may sometimes be too demanding for females[2]. However, it seems that military units typically implement almost equal training for male and female recruits, without taking into account physiological sex differences, which may place female recruits at a higher risk for musculoskeletal injuries during military training[2, 3]. In fact, several studies have shown that females have a higher risk of injuries and / or premature discharge during military service, mainly due to lower aerobic and muscle fitness or differences in body composition [4, 5, 6]. For example, in Finland, one in four female recruits are prematurely discharged from military service, which is far more than the discharge rate (15%) in male recruits[7].

Earlier studies focusing on military training programs have shown that the physical fitness of male recruits increases during military service, especially during the basic training period and among recruits who were overweight or had lower initial aerobic and / or muscle fitness[8, 9,10]. On the other hand, in the latter part of military service, physical fitness may increase at a slower rate or even decrease, especially among well-trained recruits[9, 11]. However, few studies have examined training responses in female recruits during military service, and comparisons between male and female recruits are particularly rare [12, 13]. Some studies that have been performed reported higher average fitness levels in male recruits before and after military training. However, the same studies observed that the difference in fitness between male and female recruits narrowed as a result of standardized military training, suggesting that females can adapt to military training at least as well as males. However, in a recent review article, Varley-Campbell et al[14] encouraged further studies to evaluate sex differences in response to demanding military training.

Finnish national defense is based on compulsory military service for men and voluntary service for women, while no sex-specific limitations exist for service branches, military carrier, or combat roles. Military training programs are similar for both sexes. However, by observing differences in training adaptations, it may be possible to optimize military training sex-specifically. Therefore, the purpose of this study was to compare changes in physical fitness and anthropometrics between female and male recruits during Finnish military service between 2005-2015. A secondary purpose was to evaluate associations between initial fitness level and the respective fitness changes during military service in male and female recruits. In addition, associations between changes in physical fitness and body composition were examined. Based on earlier studies, it was hypothesized that changes in physical fitness and body composition would be similar for males and females.

2. Methods

A retrospective data analysis was used to compare changes in physical fitness between male recruits and female recruits during military service in the Finnish Defence Forces between the years 2005 and 2015.

A total of 234,690 male conscripts and 3,549 female recruits (age 20 yrs.) across different military branches (Army, 82.4%; Navy 10.1%; Air Force 5.9%; others 1.5%) participated twice in the fitness tests as part of their military service, which varied in duration between 6 (regular soldiers), 9 months (special tasks) and 12 months (unit leaders). 57 percent of males performed their military service in 6 to 9 months and 43% in 12 months while the respective proportions of females were 26% and 74%. Mean height of the male recruits was 1.79±0.07 m, and for females 1.67±0.06 m. Mean initial body mass of male and female recruits was 77±13 kg and 65±9 kg, respectively.

Initial fitness tests were conducted by a trained instructor during the first two weeks of military service, and the follow-up tests during the last six weeks of service regardless of service time. Tests protocols were same for both sexes. Individual results were stored in a database according to the standards determined by the Training Division of the Defence Command. The sample size varied between years, depending on the annual numbers of male and female recruits entering the service. The data were anonymized before scientific use.

Recruits gave their written informed consent to participate in military service, including the fitness tests, after a physical examination by medical doctors. Safety instructions were given to the recruits before each fitness test, including information about the following indications for interrupting the tests: onset of angina-like symptoms, shortness of breath, wheezing, leg cramps, claudication, light-headedness, confusion or nausea[15]. This study was approved by the Defence Command of Finnish Defence Forces and conducted according to the 1975 Declaration of Helsinki.

Anthropometric data included results of body mass (BM), height and waist circumference (WC), while the physical fitness data consisted of records of 12-min running, standing long jump, 1-min sit-up and 1-min push-up test results. Body anthropometrics were measured by a physician during the medical examination. Body mass was measured using commercial scales (Seca 803, Hamburg, Germany) with an accuracy of 100 g while subjects wore light sport clothing without shoes. Height was measured in a standing position using a stadiometer with an accuracy of 5 mm. Body mass index (BMI) was calculated.

All fitness tests, protocols, and techniques were standardized according to the Fitness Test Manual of the Training Division[15]. Endurance performance was measured with a 12-minute running test[16] on outdoor tracks during the summer season and on indoor tracks during winter months. Recruits were encouraged to run with maximal effort at progressively increasing running speed. The 12-minute running test result was maximal distance that can be run in 12 minutes with an accuracy of 10 meters.

Muscle fitness tests consisted of standing long jump, sit-ups and push-ups. Approximately 5 minutes of recovery was allowed between tests. Lower body explosive power was assessed by maximal standing long jump, and results were expressed in meters. The longest jump of three trials was used for analyses. Muscle endurance was determined based on the number of push-ups (upper body muscles) and sit-ups (trunk muscles) completed in 60 seconds.

In general, military service consists of three main training periods, which are basic training, special training and unit training. Each period lasts approximately 8 weeks. Military training consists of progressively increasing physical training, including combat training and field shooting (10 h/week), marching (3 h/week), sports-related training (5 h/week) and other physically demanding training like military drills (2 h/week) for approximately 20 hours per week. Military training also consists of overnight field exercises lasting 30-40 days.[8]

Data are presented as means with standard deviation and confidence intervals (95% CI) where appropriate. Significance of changes between non-adjusted baseline and follow-up measures of dependent variables of body composition (body mass, body height, body mass index) and physical fitness (12-min running test, sit-ups, push-ups, standing long jump) tests for both sexes as well as between sexes, were analyzed using paired samples T-tests. P-values less than 0.05 were defined as significant. The data were additionally stratified into quintiles (Q1 – Q5) separately for each baseline fitness test result for male and female recruits. Thereafter, between-sex differences in the changes in continuous variables were estimated with analysis of covariance (ANCOVA) using adjustments for service time, branch, age, baseline fitness test results, BMI and WC. Pearson correlation coefficients were calculated to find associations between changes in physical fitness and changes in body composition, combining the data of male and female recruits. Commercial software (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.) was used for statistical analyses.

3. Results

No changes were observed in mean BM, BMI or WC in male or female recruits during military service (Table 1). Group comparisons revealed no differences in changes between male and female recruits in body composition, with the exception of a larger decrease in WC of female recruits, which was 2.5 cm (95% CI 2.1-2.8 cm, $p \leq 0.001$) more than in males, when adjusted for service time, branch, age and WC 1.

In general, all the fitness test results of female recruits were worse than those of males at the beginning and end of military service (all fitness tests, $p \leq 0.001$). Absolute, non-adjusted values are presented in Figure1. Mean distance in the 12-min run increased by 4.3% in male recruits (2461 vs. 2565m, $p \leq 0.001$) and by 2.3% (2187 vs. 2234m, $p \leq 0.001$, Figure 1) in females. Pre-post sex-differences increased in the 12 min running test from 11.1 to 13.9%. After adjustment for service time, branch, age, test result 1, BMI 1 and WC 1, the improvement in running test performance was 158m (95% CI 142-173m, $p \leq 0.001$) larger in male than female recruits.

The mean number of push-ups increased by 15.9% in males (32 vs. 37 reps/min, $p \leq 0.001$), and by 18.5% (21 vs. 25 reps/min, $p \leq 0.001$, Figure 1) in females. Pre-post sex-differences decreased in push-ups from 34.4 to 32.4%. Despite the higher absolute change in females, improvement in the push-up test was 5 reps/min (95% CI 4.7-5.8, $p \leq 0.001$) more in males than females, after adjustment for service time, branch, age, test result 1, BMI 1 and WC 1.

Mean number of sit-ups in male recruits increased by 10.2% (37 vs. 41 reps/min, $p \leq 0.001$), and in females by 9.0% (34 vs. 37 reps/min, $p \leq 0.001$, Figure 1). Pre-post sex-differences increase in sit-ups from 8.1 to 9.8%. After adjustment for service time, branch, age, test result 1, BMI 1 and WC 1, improvement in the sit-up test was 2 reps/min higher (95% CI 1.9-2.8, $p \leq 0.001$) in males than females.

The mean result in standing long jump improved by 1.0% both in male (2.18 vs. 2.20 m, $p \leq 0.05$) and female (1.76 vs. 1.78, $p \leq 0.05$, Figure 1) recruits. Pre-post sex-difference in standing long jump performance did not change. However, after adjustment for service time, branch, age, test result 1, BMI 1 and WC 1, the improvement in male recruits was 12 cm (95% CI 11.0-12.8 cm, $p \leq 0.001$) higher than in females.

Pearson correlation analysis for both sexes combined showed that changes in 12-minute running distance correlated weakly and inversely with changes in BMI ($r=-0.16$, $p<0.001$) and WC ($r=-0.16$, $p<0.001$). Body mass was weakly and inversely associated with changes in WC ($r=-0.27$, $p<0.001$).

After dividing the data into quintiles based on initial running test results, the three least fit groups of female recruits improved their 12-minute running distance, while in males the four least fit groups improved their running test results during military service (Table 2). After similarly dividing the data based on muscle fitness tests, both men and women improved standing long jump performance in the three lowest quintiles, whereas decreased performance was observed in the highest two quintiles (Table 2). Moreover, both men and women improved push-ups and sit-ups performance in the four lowest quintiles, while the highest quintile for both sexes showed a decrease in performance (Table 2).

4. Discussion

The present study examined whether there are differences between males and females in the way that body anthropometrics and physical fitness change during military service lasting several months. This study demonstrated that almost all measured physical fitness components improved both in male conscripts and female recruits during military service. No between-sex differences were observed in body anthropometrics, except when adjusted for service time, branch, age and baseline waist circumference a larger decrease in WC in female recruits was observed. Interestingly, improvements in aerobic capacity and in all muscle fitness test results were larger in males than females. Also, despite their higher overall initial fitness level, males were more likely to show positive training adaptations than females during their military service.

A systematic review consisting 29 studies[14] concluded that the physical training responses in men and women undergoing military training are almost similar, while both sexes will improve their physical performance by standard military training program. In a similar sex comparison, Yanovich et al.[12] observed reduced relative sex-differences in all fitness variables, except for push-up performance, after four months of basic military training. For example, at the beginning of military service, males achieved a 22% faster time on the 2 km running test, but this difference decreased to 18% after training. While the pre-post difference between males and females increased in a push-up test (from 13% to 30%), the gap got smaller for sit-up performance by the end of the follow-up (from 3% to 1%)[12]. More recently, Wood et al.[13] studied fitness adaptations to 20-weeks of mixed-sex basic military training. The between-sex difference in 2.4 km running time decreased from 50% to 37% during the follow-up. In addition, sex-differences in the 2-min push-up and sit-up tests also decreased from 12% to 10% and from 49% to 19%, respectively.

In this study, pre-post sex-differences increased in the 12 min running test, push-ups and sit-up tests, whereas the initial sex-difference in standing long jump performance did not change. However, ANCOVA analyses, using the changes in female results as a reference, revealed significantly larger improvements in all measured fitness variables in male recruits. As in previous studies, there were significant differences in fitness level between the sexes before and after military service. The present results diverged slightly from the outcomes of Varley-Campell et al[14]. They noticed that pre-post physical training responses tended to be greater in female than male although the overall changes were minor in both sexes.

In the present study, military training generally induced beneficial physical fitness adaptations both in male and female recruits. These changes are positive from the perspectives of military readiness and national health promotion. This also revealed that the greatest improvements in 12-minute running distance were observed in male and female recruits with the lowest baseline running performance. Similar findings were reported by Mikkola et al.[9], who found that male conscripts who were overweight or had poor initial fitness showed the greatest improvements in physical fitness during military service. Positively, also recruits with initially average fitness level improved their aerobic and muscle fitness. Only recruits in the highest initial fitness group did not improve their physical fitness. However, the present findings highlight that military service did not induce similar gains in physical fitness of male and female recruits.

For many recruits, military service consists of activities that require a higher physical load than they are accustomed to. Some studies have demonstrated that daily physical activity of recruits can easily exceed 10,000 steps while wearing combat gear (25-35 kg) and carrying other extra load[17]. Therefore, a high baseline level of physical fitness is an important element of successful service that helps to lower the likelihood of injuries or premature discharge from the service. It has been shown that, compared with males, female recruits have a four-fold risk of premature discharge from the Finnish military service due to injuries[7]. Overall, the discharge rate is higher in female recruits than in males (25 vs. 15%) during military service[7].

The changes in relation to baseline fitness quintiles showed that the most positive adaptations to military training were observed in the less fit groups, whereas performance in the highest quintiles decreased in both male and female recruits. On the contrary, the lowest fitness quintiles showed improvements in all measured fitness variables in male and female recruits. Thus, it can be speculated that the total volume of physical training may be too low for the fittest male recruits and too high for females, inducing some overloading[18]. This suggestion is partly supported by previous studies which have reported higher relative training loads for females during identical 12 to 14-week military basic training [19, 20]. Nevertheless, as the physical fitness levels were different for the same quintiles of men and women and still the upper quintiles decreased in both sexes, it may appear that other factors than the volume of physical training plays a part. The associative underlying factors warrants therefore future studies. Another possibility in the present study may be that the volume of high-intensity training was too low for the fitter recruits to achieve optimal training stimulus. However, the highest quintiles in women represented fitness level of the lower quintiles in men and despite there existed improvement in men and decrease in women in for example aerobic fitness. The reason for this remains unknown. Nevertheless, it has been [21] shown that military training, especially the basic training, includes a large amount of endurance-based military training at low intensities, which may cause some interference with maximal endurance capacity, strength development and explosive power output. Moreover, Grier et al.[22] reported that combined strength and endurance training may be the optimal way to improve physical fitness of female recruits during service, as opposed to traditional single mode endurance or strength training programs. Supporting the previous suggestions for training modifications, Rudzki et al.[23] reported significant decreases in discharge rates of both male and female recruits while reducing total running hours, by including more progressive march training and deep-water running. Varley-Campbell et al.[14] stated that the physical training gains were around 10% across the outcomes documented in their systematic review consisting similar military training for males and females. Training gains were smaller than can be achieved in women with specific, progressive, periodized training programs [24, 25]. They suggested that alternative training program may be needed to support women in passing the physical employment standards in military settings and during their military career.

As earlier mentioned, male recruits were performing their compulsory military service, while the service was voluntary for female recruits, resulting in a highly selective and motivated female sample. Weaker training responses to standardized military training in females may also partly be related to this discrepancy. Despite the lower baseline fitness level compared to males, female recruits may still represent higher fit and pretrained individuals among general female population in Finland and therefore trainability may be weaker than that of male recruits. Thereby, female recruits may require more variation in training stimulus for more effective training responses. Nevertheless, these issues warrant further studies. The limitations of the present study include lack of detailed information about the volume and intensity of the physical training.

5. Conclusions

In conclusion, the present study showed that aerobic capacity and muscle fitness of male and female recruits generally improved during military service. However, the improvements were larger in males compared with female recruits, demonstrating the existence of sex differences in training adaptations between male and female recruits who performed the same military training program. In addition, regardless of sex, recruits who were the least fit when entering military service improved their physical fitness the most, and conversely, those with the highest baseline fitness levels actually showed decreases in physical performance. Thus, during military service, more individually tailored training programs consisting of combined endurance and strength training may be warranted.

Key messages

- Optimal physical performance adaptations during military service likely require more individualized physical training programs, especially for female recruits.
- Physical training should consist of more variation in training intensities, while currently the most of training is performed with lower intensities.
- Tailored training programs should be offered during selection events of military service, especially for females to reduce the sex-gap at the beginning of military service.

- More studies related to mechanisms explaining sex differences in adaptations to military training are needed.

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Table 1. Mean values and standard deviations for height (H), body mass (BM), body mass index (BMI) and waist circumference (WC) in tests 1 and 2 for female and male recruits.

	H1 (cm)	H2 (cm)	BM 1 (kg)	BM 2 (kg)	BMI 1	BMI 2	WC 1 (cm)	WC 2 (cm)
Male n=138130	179±7	179±7	77.0±13.3	77.0±12.1	24.0±3.8	23.9±3.4	84.4±10.1	83.8±9.0
Female n=2234	167±6	167±6	65.2±9.5	65.7±9.0	23.4±3.1	23.5±2.8	76.9±8.4	76.7±8.0

Table 2. Changes in 12-minute running distance (m), standing long jump (SLJ, m), push-up and sit-up performance (reps/min) relative to initial test results (Diff.) for each percentile group (Q); Q1: least fit, Q5: fittest group at baseline.

Male				Female			
Quintiles	N	Diff.	SD	Quintiles	N	Diff.	SD
12-min running				12-min running			
Q1 (400-2179 m)	43455	294	312	Q1 (400-1955 m)	637	200	287
Q2 (2180-2392 m)	44068	173	260	Q2 (1956-2129 m)	634	90	181
Q3 (2393-2555 m)	43811	104	251	Q3 (2130-2269 m)	633	35	183
Q4 (2556-2770 m)	43984	37	244	Q4 (2270-2425 m)	652	-3	173
Q5 (2771-4070m)	43492	-75	250	Q5 (2430-3320m)	635	-74	221
SLJ				SLJ			
Q1 (0.90-1.99 m)	43085	0.10	0.19	Q1 (1.00-1.59 m)	561	0.09	0.16
Q2 (2.00-2.10 m)	46794	0.05	0.15	Q2 (1.60-1.70 m)	807	0.04	0.14
Q3 (2.11-2.25 m)	44850	0.02	0.14	Q3 (1.71-1.80 m)	561	0.01	0.12
Q4 (2.26-2.40 m)	48470	-0.02	0.13	Q4 (1.81-1.95 m)	632	-0.07	0.11
Q5 (2.41-3.15 m)	37119	-0.06	0.14	Q5 (1.96-2.72 m)	585	-0.06	0.15
Push-up				Push-up			
Q1 (1-21 reps)	45936	9.3	9.1	Q1 (1-11 reps)	638	10.3	9.6
Q2 (21-27 reps)	42706	7.6	8.9	Q2 (12-17 reps)	528	7.1	8.8
Q3 (28-34 reps)	41012	5.9	8.7	Q3 (18-23 reps)	642	4.5	9.1
Q4 (35- 42 reps)	48537	3.4	8.7	Q4 (24-31 reps)	640	1.7	8.5
Q5 (43-100 reps)	41837	-1.2	11.7	Q5 (32-83 reps)	607	-3.7	11.5
Sit-up				Push-up			
Q1 (1-28 reps)	45959	8.7	9.0	Q1 (1-25 reps)	663	8.9	9.0
Q2 (29-34 reps)	44143	5.4	7.7	Q2 (26-31 reps)	575	4.1	6.7
Q3 (35-39 reps)	37048	3.9	7.3	Q3 (32-36 reps)	627	2.3	6.3
Q4 (40-46 reps)	48781	2.1	6.9	Q4 (37-42 reps)	632	1.0	6.4
Q5 (47-99 reps)	45345	-1.1	7.6	Q5 (43-78 reps)	666	-1.1	6.2

Figure 1. Mean absolute values, standard deviations and differences in 12-minute running and muscle fitness results between tests 1 and 2 for male (M) and female (F) recruits. Significant change between test 1 and test 2, * $p<0.05$.