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Physical fitness and body anthropometrics profiles of the female recruits entering to voluntary military service

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ABSTRACT

Introduction. The physical fitness of male conscripts has decreased, and body mass increased during the last few decades, especially in Nordic countries. However, limited research-based reports are available concerning the physical fitness profiles of female recruits. Therefore, the purpose of this study was to investigate changes in physical fitness and body composition of female recruits entering voluntary Finnish military service between the years 2005 and 2015.

Materials and methods. Data were collected from the initial fitness tests performed in military units during the first two weeks of military service. A total of 3875 healthy female recruits (19.9±2.1 yr.) participated in the fitness tests. Fitness tests consisted 12-min running test and muscle fitness tests, which were sit-ups, push-ups and standing long jump.

Results. Increases in mean body mass (4.2%, p \leq 0.01) and body mass index (3.8%, p<0.01) were observed between 2005 and 2015. In addition, the proportion of overweight and obese female recruits increased by 12% (p \leq 0.001). Mean endurance performance and overall muscle fitness remained unaltered during the study period, except for a decline in push-ups performance. However, the proportion of female recruits with poor endurance performance increased from 19.6% to 27.8% (p \leq 0.001) between 2005 and 2015. Body mass was inversely associated with 12-minute running test distance (r=-0.35, p \leq 0.001) and muscle fitness index (r=-0.25, p \leq 0.001).

Conclusions. In conclusion, the present study revealed that an increasing proportion of female recruits are overweight and/or have poor endurance performance, which are known risk factors for musculoskeletal injuries and premature discharge from military service. Therefore, specialized training programs should be designed specifically for female recruits with lower levels of fitness prior to military service.

Keywords: Endurance performance, muscle fitness, body mass, BMI, conscripts

Physical fitness and body anthropometric profiles of female recruits entering voluntary

military service

INTRODUCTION

Recently, integration of female soldiers into the armed forces has been an emerging topic, especially in the Nordic Countries. As interaction between sexes is restricted in some cultures, it is generally accepted that female soldiers are needed for tasks such as security checks and inspections of same gender persons in crisis management operations. Furthermore, Brundtland et al.¹ suggested that compared to male soldiers, female soldiers exhibit superior cognitive and ethical performance, understanding of cultural differences, and social skills. These qualities are useful in military positions that involve more gender-neutral actions, such as instructing, staff duties or crisis management.

However, demanding physical employment standards or limited physical performance have been the biggest obstacles for females to fully integrate into the military profession². Moreover, it is generally acknowledged that physiological differences exist between females and males in body composition, muscle and cardiorespiratory fitness, metabolic and thermoregulatory function ^{3, 4}. For example, Wood et al.⁵ found large sex differences in anthropometric and physical fitness variables ranging from 2 to 50% between male and female soldiers in South Africa. Smaller body size and lower bone density, combined with lower lean muscle mass and insufficient muscle strength seem to be the main limiting factors for females to achieve the same fitness standards as males ⁶.

Recently, Knapik et al.⁷ reported increases in the mean body mass of U.S. Army female recruits between 1975 and 2013. The increase in body mass was partly due to increased body fat and fat free mass. Their study also revealed a decline in running performance of female recruits but an improvement in muscle fitness over time. Nindl et al.⁴ reported that female soldiers are at a higher risk for musculoskeletal injuries than male soldiers during military training or in operational environments. Moreover, a number of factors are associated with elevated risk of injuries or premature discharge from military service in females, including lower aerobic capacity and muscle fitness, being overweight or having a small body size, and increased running miles during the basic training ⁸⁻¹².

National defense in Finland is based on the general conscription service for males, while military service is voluntary for females. Military training is identical for both genders, and there are no limitations to further military occupational specialties. Female recruits have the possibility to voluntarily leave military service within the first 45 days without stating a reason. Females first entered voluntary military service in 1995. Thereafter, 450-500 females have entered the service annually. Up to 2017, approximately 7000 female soldiers have been trained in military units, and about 300 females have registered as professional soldiers in the Finnish Defence Forces.

In general, there seems to be a lack of research related to the physical fitness profiles of female recruits or soldiers. Therefore, the purpose of the present study was to investigate changes in the initial endurance performance and muscle fitness of young females entering voluntary military service in Finland between the years 2005 and 2015. In addition, changes in body composition were analyzed. Based on previous findings from male conscripts ¹³, it was hypothesized that the body mass of female conscripts would have increased, and endurance performance decreased between 2005-2015, while muscle fitness was expected to have remained unaltered.

METHODS

Experimental Approach

A retrospective cross-sectional descriptive design was used to compare physical fitness outcomes of female recruits from 2006-2015 versus 2005. Individual results of 12-minute running and muscle fitness tests were used as dependent variables, while the year was used as an independent variable.

Subjects

The present dataset consisted of initial anthropometric, endurance performance and muscle fitness test results from 3875 healthy female recruits between 2005 and 2015, which accounted for more than 80 % of the annual female intake. Mean±SD age of the females was 19.9±2.1 yrs. Anthropometric data are presented in Table 1. The fitness test results were annually collected from the military units that trained female recruits during voluntary military service. Fitness instructors conducted the tests during the first two weeks of service. After the tests, the instructors recorded all test results to a database according to the standards determined by the Training Division of the Defence Command. The sample size varied between the years depending on the annual volume of voluntary female recruits entering the service.

The female recruits gave their written informed consent to participate in military service, including the fitness tests, after a physical examination by medical doctors. Fitness tests are an essential part of military training. 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 ¹⁴. Recruits were also fully informed of their right to voluntarily interrupt the fitness tests at any time, while procedures and possible risks of the tests were carefully explained. The present study was conducted according to the most recent provision of the declaration of Helsinki.

Anthropometric measurements were performed by a physician during the medical check at the beginning of military service. The recruits were barefoot and wore light sport shorts during the measurements. Body mass was measured using commercial scales (Seca 803, Hamburg, Germany) with an accuracy of 100 g. Height was measured in a standing position using a tape measure with an accuracy of 5 mm. Thereafter, body mass index (BMI) was calculated and categorized as follows: under 18.50 (underweight), 18.50-25.00 (normal weight), 25.01-30.00 (overweight) and over 30.00 (obese).

All fitness tests, protocols, and techniques were standardized according to the Fitness Test Manual of the Training Division¹⁴. The tests were supervised and demonstrated by instructors. Endurance performance was indirectly assessed by a 12-minute running test ¹⁵. The tests were conducted on outdoor tracks during summer time and in indoor tracks during winter time. Recruits were encouraged to run with maximal effort at progressively increasing running speed. The test results were recorded with an accuracy of 10 meters and thereafter divided into four categories as presented in table 2.

Evaluation of muscle fitness was determined by three tests. Standing long jump was used for the assessment of lower extremity explosive power. Upper extremity and trunk muscle endurance were assessed by push-ups and sit-ups, respectively. Standing long jump was measured from the starting line to the landing point and expressed in meters. The longest jump of three trials was used for analyses. The results of sit-ups and push-ups were recorded as the number of continuous repetitions completed in 60 seconds. The conscripts were allowed at least 5 minutes of recovery between tests. The results of each muscle fitness test were categorized from 0 (poor) to 3 (excellent). Thereafter,

muscle fitness index (MFI) was calculated as the mean of three muscle fitness test classification points. Detailed information regarding the categorized table of MFI is presented in Table 2. A more detailed description of the muscle fitness tests and information concerning test reliability and validity has been published by Santtila et al.¹⁶.

Statistical analyses

Data are presented as means with standard deviations (\pm SD) or standard errors (\pm SE) and distributions (%) where appropriate. Logistic regression was used to assess fitness category levels as a function of year, using the year 2005 as a reference. Regression analyses with linear or exponential fits were used for continuous variables. Annual averages of continuous variables were compared using ANOVA with Tukey Post Hoc test, where appropriate. Pearson correlation coefficients were calculated to find associations between the yearly means of the measured parameters. P-values less than 0.05 were defined as significant.

RESULTS

The mean body mass of the female recruits was 2.8 ± 2.2 kg (4.2%, p<0.01) higher in 2015 than 2005, while no respective differences were observed in mean height. Thus, mean BMI was also higher in 2015 (3.8%, p<0.01) (Table 1). The proportion of overweight and obese female recruits increased from 20% to 32% (R²=0.65, P<0.001) between 2005 and 2015.

The mean 12-minute running test results of the female recruits did not differ between 2005 and 2015 (Figure 1) except for the lower mean result in 2013 (p<0.05). The mean distance in the 12-minute running test of all female recruits was 2187±299 m during the study period. The proportion

of female recruits who ran less than 2000 meters (poor fitness category) increased from 19.6% to 27.8% (p<0.001) between 2005 and 2015 (Figure 1). At the same time, no differences were observed in the proportion of female recruits who ran more than 2800 meters (excellent fitness category).

Average MFI (Figure 2) and the mean results of the individual muscle fitness tests (table 3) did not differ during the study period except for a systematic decrease in push-up performance (p<0.01). However, the proportion of female recruits who achieved excellent or good MFI increased from 49.1% to 51.1% (R^2 =0.25, p<0.001) between 2005 and 2015, while the proportion of female recruits who achieved poor MFI did not differ. Mean standing long jump values were also lower during 2008-2011 and 2013 (p<0.05-0.01) compared to 2005. In addition, the mean number of push-ups performed in 2007 and 2009-2015 were lower (p<0.05-0.01) than in 2005, and the mean number of sit-ups performed in 2009 was lower than in 2005 (p<0.05).

Pearson correlation analysis for the whole study population revealed that 12-minute running distance was positively correlated with standing long jump (r=0.44, p<0.001) and MFI (r=0.51, p<0.001). Body mass was inversely associated with 12-minute running test distance (r=-0.35, p<0.001) and MFI (r=-0.25, p<0.001). BMI was inversely correlated with 12-minute running distance (r=-0.40, p<0.001) and MFI (r=-0.27, p<0.001).

DISCUSSION

The present study compared changes in body anthropometrics and physical fitness outcomes of female recruits entering voluntary Finnish military service between 2005 and 2015. No previous

studies have systematically investigated physical fitness profiles and their changes over time in female recruits. The results revealed an increasing trend in mean body mass but not in height during the follow-up period. Therefore, the proportion of female recruits categorized as overweight or obese in terms of BMI increased during the last ten years. These results are well in line with those of Knapik et al.⁷ who reported increased body mass and BMI of U.S. Army female recruits between 1975 and 2013 due to an increase in both body fat and fat-free mass. On the other hand, Santtila et al.¹³ reported a plateau in the body mass of Finnish male conscripts between 2005 and 2015 following a decade-long linear gain in mass.

Endurance performance of female recruits was assessed using the 12-minute running test, which is a popular and widely used endurance test among military personnel¹⁵. This study revealed no changes in the mean running distance of female recruits between 2005 and 2015. However, the proportion of females who ran less than 2000 meters, and were thus categorized as having poor fitness, increased during the follow-up period, while no change occurred in the proportion of females with excellent fitness. Knapik et al. ⁷ reported a significant decrease in 2-mile running performance of U.S. Army female soldiers between 1998 and 2008. In the present study, the mean distance achieved by female recruits in the 12-minute running test was 12.5% lower than that achieved by male conscripts (2187 vs. 2460 m) during the same follow-up period ¹³. In addition, the present study found that body mass and BMI were both inversely associated with running test distance, showing that female recruits who were overweight or obese had lower aerobic fitness than females of normal weight. These findings support those of Knapik et al ⁷, who suggested that decreased running performance was mainly due to increases in total body weight. Furthermore, endurance performance, muscle fitness, and fat free mass have also been shown to correlate with success in demanding military duties ^{8, 17} like lifting or carrying heavy materials and extra loads.

No changes were observed in the mean MFI of female recruits between 2005 and 2015, except for a decline in upper body muscle fitness and some differences in single muscle fitness test results between the study years. Similar findings were observed in male conscripts by Santtila et al. ¹³, while they reported no changes in MFI between 2000 and 2015, with the exception of improvements in standing long jump performance. As expected, MFI and standing long jump performance in female recruits were associated with running test distance. Thus, females who had better muscle fitness or standing long jump performance tended to have higher aerobic capacity in this study population. It is well known that a high level of muscle fitness and elastic lower limbs improve running economy (e.g. ¹⁸). The present findings are in line with the findings of Knapik et al. ⁷ who observed no decrements or even improvements in the muscle fitness of U.S. Army female recruits between 1984 and 2008.

Annually, approximately 25% of female recruits are prematurely discharged from the Finnish military service during the first 45 days due to their own desire to leave, and mental or physical health reasons. In addition, female recruits have a four-fold higher incidence of musculoskeletal injuries than their male counterparts during military service in the Finnish Defence Forces based on data from the Training Division ¹⁹. The risk of stress fractures and injuries may grow due to increased physical activity during military training, especially among female recruits ⁴. Many studies have shown that being female, having lower aerobic capacity and muscle fitness, being overweight or having a small body size, and higher running miles during the basic training are primary risk factors for injuries or discharge from military service ^{6, 8-12}.

In general, military occupations require high aerobic capacity and muscular strength ⁴. According to Vaara et al.²⁰, almost half of all female soldiers, especially non-commissioned officers (NCO), older

standards of physical fitness in the Finnish Defence Forces are too demanding. As noted earlier, the mean distance achieved by female recruits in the 12-minute running test was markedly lower than that of male conscripts during the same follow-up period ¹³. Furthermore, average muscle fitness test results of female conscripts were 9-32 % lower than those of males ¹³. These findings confirm the physiological differences between females and males ^{4, 5, 6}. Due to these differences, female soldiers should engage in a higher total physical training volume than male soldiers in order to achieve the same absolute fitness level ². Therefore, a special focus on physical training of female soldiers is required ⁴. Combined strength and endurance training for a minimum of 6 months has been recommended for untrained female recruits before entering military service ²¹. Reynolds et al.²² also revealed that periodized strength and aerobic training significantly improved overall physical performance in military duties with a relatively low injury rate. In addition, pre-screening of physical fitness and body composition of female recruits is an important procedure before entering military service.

Interpreting and generalizing the findings of the present study must be done with caution and understanding its limitations. Unlike for males, these data do not represent the whole population of a given age group of females in Finland. As stated before, males are legally required to perform conscription in Finland, while females enter the military service on a voluntary basis. In this regard, comparison between female recruits and male conscripts is not appropriate. Male conscripts form a population-based representative sample of 20 year old men, while female recruits represent only those women who choose to perform voluntary military service (n = about 500 women per year), which is quite a small and biased sample of young Finnish women and does not represent Finnish females in general. In addition, comparison of injury records or physical fitness levels of female recruits who were discharged versus those who successfully completed the military training was not possible due to technical differences between databases or unavailability of data.

In conclusion, the present study shows that the mean body mass and BMI of female recruits have increased from 2005 to 2015. In addition, an increased proportion of female recruits were overweight. Alarmingly, the proportion of female recruits with poor endurance performance has increased, and one in three were characterized as having poor aerobic fitness at the beginning of military service. However, mean aerobic and muscle fitness have remained unaltered except for upper body muscular endurance, measured by the 1-min push-up test. The increasing trend of female recruits being overweight or having poor aerobic and upper body fitness may be challenging for military units whose main task is to train recruits for demanding military duties and operations. Therefore, there is a need for individualized and structured training programs, which are targeted specifically towards female recruits who have a higher injury risk before entering military service ²³. These programs should consist of combined strength and endurance training to improve overall fitness, which is required during demanding military duties and operations. However, it should be noted that there are also some military duties with lower physiological demands for which a lower level of physical performance capacity is adequate.

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Figure legends

Figure 1. Mean values (\pm SE) from the 12-minute running tests (black solid line). The dashed line with black dots represents the relative distribution of excellent results, and the dashed line those

Figure 2. Mean (±SD) muscle fitness index during the study period.

with poor results. All values were compared to the results from 2005.



Muscle fitness index



2 sample size (N), standard deviation (SD) and years when data were collected. *, p<0.05, **, p<0.01

3 indicates significant difference from the reference year 2005.

Year	Ν	Height (cm)	SD	BM (kg)	SD	BMI	SD
2005	171	166.7	5.6	63.8	8.1	22.9	2.7
2006	133	166.6	5.4	63.1	8.2	22.7	2.6
2007	94	166.0	6.0	63.7	8.2	23.1	2.8
2008	99	166.3	5.6	64.4	10.3	23.2	3.4
2009	184	166.6	6.1	65.4*	9.3	23.5*	2.9
2010	226	166.5	5.6	63.9	8.5	23.0	2.8
2011	228	166.7	6.2	65.2*	10.3	23.4*	3.2
2012	251	167.5	6.8	66.0*	9.9	23.5*	3.2
2013	279	167.2	6.5	65.9*	9.4	23.6*	3.0
2014	274	166.7	6.2	65.5*	9.9	23.5*	3.1
2015	334	167.0	5.9	66.6**	10.3	23.8**	3.3

- 1 TABLE 2. Categorized table of female aerobic capacity and muscle fitness test results. Muscle
- 2 fitness index (MFI) was calculated based on three muscle fitness tests.

Test	Fitness class category						
	Poor	Satisfactory	Good	Excellent			
	0 points	1 point	2 points	3 points			
Standing long jump (m)	≤1.65	1.65-1.84	1.85-2.04	≥2.05			
Sit-ups (rep/min)	≤28	28-35	36-43	≥44			
Push-ups (rep/min)	≤14	14-17	18-19	≥20			
12-minute running test (m)	≤2000	2000-2399	2400-2799	≥2800			

Year	N	Standing long	SD	Push-ups	SD	Sit-ups	SD
		jump (m)		(rep/min)		(rep/min)	
2005	216	1.78	0.21	24	13	35	11
2006	261	1.79	0.20	23	12	34	11
2007	279	1.76	0.20	21*	12	34	10
2008	291	1.75*	0.20	23	13	33	11
2009	293	1.74*	0.21	21*	13	32*	11
2010	298	1.74**	0.20	21*	13	34	10
2011	331	1.75*	0.22	22*	11	34	10
2012	368	1.78	0.24	21**	11	34	11
2013	382	1.75*	0.23	20**	12	33	11
2014	384	1.77	0.23	21**	11	33	12
2015	404	1.79	0.22	21**	11	34	11

1	TABLE 3. Mean (±SD) muscle	fitness test results	between 2005	and 2015 (*p≤0.05, **	p≤0.01)
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