Physical fitness and anthropometrics in Finnish soldiers during their early career: Prospective changes during a 3-year follow-up

Abstract

Introduction Physical fitness is a fundamental capability required of military personnel but studies focusing on longitudinal changes in physical fitness and anthropometrics in soldiers are lacking. The aim was to evaluate physical fitness and anthropometrics in soldiers during their early career.

Methods A 3-year prospective study included 180 male soldiers (baseline age 26±2 yrs.) with measures of a 12-min running test, standing long jump, sit-up and push-up tests, and body mass, height and waist circumference. Baseline data were stratified into tertiles and the changes within each tertile were analyzed using dependent t-tests and analysis of variance.

Results 12-min running test distance decreased on average by 2% (-54 m), sit-up performance 3% (-1.5 reps/min), push-up performance 4% (-1.9 reps/min) and standing long jump performance 1% (-2.1 cm) over the 3-year period ($p<0.05$). Both aerobic and muscular fitness decreased consistently among the highest baseline tertile (12-min running test: -70 m, sit-ups: -3.2 reps/min, push-ups: -7.5 reps/min, standing long jump: -5.5 cm, $p<0.001$), whereas both aerobic and muscular fitness levels were maintained and push-up performance was improved ($p<0.05$) in the lowest baseline tertiles. Body mass increased on average by 4% (+3.4 kg) and waist circumference (WC) 4% (+3.9 cm) ($p<0.001$) and these increases were observed for all baseline tertiles ($p<0.05$).

Conclusions Small decrements in physical fitness and anthropometrics exist during the early career of soldiers. The changes in physical fitness differed according to baseline fitness levels. The results indicate that support for exercise training may be needed even in a soldiers` early career.

Key Messages:

- Both aerobic and muscular fitness decreased during a 3-year follow up of early career in Finnish officers
- Body mass and waist circumference increased during a 3-year follow up of early career in Finnish officers
- The greatest decline in physical fitness was observed in military officers with the highest baseline fitness level
- Body mass and waist circumference increased systematically across their baseline levels

Introduction

Physical fitness is one of the fundamental capabilities required of soldiers as it can directly affect occupational success and task completion. Therefore, physical fitness standards exist to ensure sufficient fitness levels required to succeeds in a variety of occupational tasks in the military. Physical fitness is not only related to completion of specific military tasks but is also inversely related to musculoskeletal injuries[1,2], sick leaves[3], and health outcomes[4]. In addition, physical fitness may mitigate stress responses during high psychophysiological challenges[5] that soldiers often meet in military operational settings[6]. Due to the requirements and multiple benefits of physical fitness for military occupational performance and readiness, information related to changes in physical fitness during soldiers` careers is of importance.

Previous studies have investigated time trends in physical fitness outcomes in the military, in part, because decreasing fitness levels might represent challenges for safe and secure task completion and appointments to tasks that require a high level of fitness, such as special operators. The largest studies to date have been conducted in conscript study samples in Finland and Switzerland. [7-8] In Finnish conscripts aerobic fitness has decreased since the 1970s but the decrease has diminished in the last decade. [7] In Swiss conscripts, no change in aerobic fitness and muscle power but increase in core stability and decrease in balance was observed over a 10-year period.[8] Nevertheless, there is less prospective information regarding changes in physical fitness during early career of officers.

In Norwegian Air Force cadets aerobic fitness was unchanged and a small reduction in percent body fat was observed during the cadets` academy education. [9] A recent study has shown in Norwegian male cadets that aerobic fitness decreased, while muscle power and muscular endurance increased, during their education period of 3-years.[10] Moreover, increased waist circumference and decreased sit up performance was observed in Air Force Reserve Officer` Training Corps (ROTC) cadets during the 4-year education, while push-up performance and aerobic fitness remained unchanged.[11]

Regrettably, these recent studies have only included cadets and, there is considerably less information about what happens after graduation and during the early career of an officer. In fact, to the best of our knowledge, there are not any studies addressing this issue. Therefore, the main aim of the present study was to prospectively examine physical fitness, including aerobic and muscular fitness, and anthropometrics in Finnish officers during the first 3-years of their professional officer career. Secondly, these trajectories were studied separately for each military branch including the associations between baseline physical fitness and anthropometric outcomes with their respective changes. It was hypothesized that physical fitness would be maintained or declined, whereas BMI and waist circumference would be increased.

Methods

The present longitudinal study design included 180 officers, who had graduated from National Defence University in 2013 or 2014. In the Finnish Defence Forces (FDF), all soldiers perform physical fitness tests and body composition measurements annually. The test results are recorded to the personal database of the FDF and the information can be used to research and development purposes. Physical fitness and body composition data were collected from the official database of the FDF for baseline results recorded in 2013 or 2014 (PRE) and for the respective 3-year follow-up results recorded in 2017 and 2018 (POST). Data for this present register-based study were provided to the research group in an anonymized form from the administrative personnel data records after receiving a permission from the Personnel Division of the Defence Command and ethical approval from the National Defence University (HM751).

Participants

The present prospective study design included 180 officers. At baseline, the participants who had started their officer career in 2013 were 27±2 years old and those who started in 2014 were 26±1 years old. After the 3-year follow up their ages were 30±2 and 29±1 years, respectively. Mean age for each military branch at the follow-up were as follows: Army: 29±2, Navy: 29±2 and Air Force: 28±1. The body height was on average 180.5±9.8 cm and body mass 81.5±15.4 kg.

Physical fitness tests

All physical fitness tests, protocols, and techniques were standardized according to the Fitness Test Manual of the Training Division. [12] Aerobic fitness was measured by a 12-minute running test on a flat 400-m outdoor sport track in the autumn, spring and summer with results being recorded to an accuracy of 10 meters. Muscular fitness tests consisted of standing long jump, sit-up and push-up tests, which were assessed in indoor facilities. A supervised warm-up of 15 minutes consisting of jumping, running and

calisthenic exercises was completed prior to testing. When testing muscular fitness there was a recovery period of 5 minutes between each test. Lower body muscular power was assessed by standing long jump on a specifically designed gym mat. The longest jump of three trials was used for further analyses. Three trials were completed with a 1-minute of rest between trials. The distance was measured to the closest 1 cm. The participants were first instructed of the correct technique, before they performed a warm-up and some practice jumps. The participants were instructed to jump horizontally forwards as far as possible from a standing position without falling backward upon bilateral landing.

Muscular fitness was assessed with 1-minute push-ups and sit-up tests for trunk and upper body performance. The maximal number of repetitions completed were recorded for each movement. [12] The push-up test measures arm and shoulder extensor muscle endurance. At the start, the participants laid face down on the floor, feet at shoulder width apart and hands positioned so that thumbs could reach the shoulders while other fingers were pointing forward. Before starting the test, the participants were instructed to extend their arms to the start position and to keep the feet, trunk, and shoulders in the same line during the test performance. A successful repetition was counted when the participant lowered his torso by flexing his arms to an elbow angle of 90° and returned to the starting position by extending his arms. Sit-up test measured performance of abdominal and hip flexor muscles. At the start, the participant laid on his back while legs were supported from the ankles by an assistant. The knees were flexed at the angle of 90°, elbows pointing upward with fingers crossed behind the back of the head. A successful repetition was counted when the participant lifted his upper body from the starting position and brought elbows to the knee-level. The total number of repetitions during one minute were recorded.

Anthropometrics

Anthropometric variables (body height, body mass and waist circumference, body mass index (BMI)) were measured by an instructor before the testing session. Body mass was measured wearing light sport clothing and without shoes using a commercial scale. Body height was measured in a standing position using a stadiometer. Waist circumference was measured at the level of iliac crest after exhaling using a tape measure.[12]

Statistics

Data was analysed with PASW-software (PASW for Windows 26.0.1). Descriptive statistics including means, standard deviations and 95 % confidence intervals were calculated. Normality of the data was assessed using Shapiro-Wilks test. Dependent t-tests were used to assess prospective changes in physical fitness and anthropometric variables between the PRE and POST conditions. Pearson correlation coefficients were used to assess correlations between the baseline fitness levels and baseline anthropometric measures with their respective changes. Physical fitness and anthropometric variables were stratified into tertiles based on the baseline fitness levels and the prospective changes within each tertile were detected and compared using analysis of variance (ANOVA). Similarly, the prospective changes were detected within each military branch (Army, Navy, Air Force) and compared using analysis of variance (ANOVA). The sample size varied depending on the outcome variable in the Army between 125 and 135, 25-29 in the Navy, and 6-10 in the Air Force (tables 1 & 2). Significant difference was set at p-level <0.05.

Results

Changes in physical fitness and anthropometrics during the 3-year follow-up.

For the whole study sample, aerobic fitness decreased on average by 2% (-54 m), sit-up performance by 3% (-1.5 reps · min^{-1}), push-up performance by 4% (-1.9 reps · min^{-1}) and standing long jump performance by 1% (-2.1 cm) over the 3-year period (fig 1). These decrements were observed in the Army ($p<0.05$) but not in the Navy and Air Forces (table 1). For the whole study sample, body mass, BMI and waist circumference increased on average by 4% each (+3.4 kg, +1.0, +3.9 cm, respectively). These increases were specifically observed in body mass, BMI, and waist circumference for the Army and Navy but not the Air Force ($p<0.05$) (table 2).

Associations of baseline levels with changes in physical fitness and anthropometrics

Baseline levels in muscular fitness were inversely correlated with their changes after the 3-year follow-up (sit-ups: $r= -0.41$, $p<0.001$, push-ups: $r= -0.52$, $p<0.001$, standing long jump: $r= -0.24$, $p=0.001$), and a similar weak inverse correlation was found for aerobic performance ($r= -0.19$, $p=0.018$). Baseline waist circumference was inversely but weakly correlated with its change ($r= -0.27$, $p=0.001$), whereas no other significant correlations were observed in body composition characteristics. The changes according to baseline tertiles revealed that push-ups were increased in the lowest tertile, while decreased in the mid and highest tertiles ($p<0.05$). A decrease in sit-ups was observed in the mid and highest tertiles while standing long jump and aerobic fitness decreased only in the highest tertile (table 1). Illustrations of the changes in physical fitness variables according to the baseline tertiles are presented in figure 2. In addition, increases in body mass, BMI and waist circumference were observed across all baseline tertiles (table 2).

Discussion

The present study revealed, on average, a small but significant decrease in both aerobic and muscular fitness and increases in body fat indices in Finnish officers during a 3-year period in their early career. In addition, both aerobic and muscular fitness were maintained in the lowest baseline fitness tertiles, whereas physical fitnessconsistently decreased in the highest baseline tertiles. Body mass, BMI and waist circumference were increased and the increases were evident for all baseline tertiles after the 3-year follow up.

Aerobic fitness decreased by 2 % and muscular fitness by 1-4 % in 29-30 years old officers after the 3-year follow-up period. The average changes were small in magnitude and the level of physical fitness was, on average, at rather good level compared to physical fitness norms in the FDF even after the decreases. Therefore, the trends observed in physical fitness and measures of body composition seem unlikely to compromise overall military operational readiness and performance. As an example, the current minimum requirements in the 12-minute running test for Service Personnel of the FDF vary from 2000m for headquarter duties to 2800m for operative field duties. Although the changes were small (1-4%) it must be kept in mind that the decreases existed after only a short period of 3 years during the early career of the Service Personnel. If these observed negative changes continue progressively in later phases of a military career, the trend would likely be of concern from the perspective of military performance and readiness particularly for military personnel with duties requiring higher levels of physical fitness such as military operative field duties. Previous studies among the general population suggests that physical fitness and muscle mass begin to decrease more pronouncedly during the third and fourth decade of the human lifespan.[13] Nevertheless, the present study findings suggest that in the Service Personnel, the decreasing trend in physical fitness and increasing trend in body fat indices may start earlier than commonly observed in general population. Similarly, 30-34 years old US army soldiers had lower aerobic fitness and higher body fat content compared to younger soldiers. [14] It may also be speculated that the decrease in physical

fitness is more a reflection of changes in physical training and nutrition behavior when moving from standardized restricted Military Academy life into the military working life of the service personnel. Although, there are no studies in military study samples, a previous study in police officers may indirectly support this view. [15] Aerobic and anaerobic fitness as well as muscular endurance were higher in Police cadets (~28 yrs.) when compared to incumbent police officers (~38 yrs.). [15] In addition, Police cadets had lower body fat content compared to incumbent police officers. Importantly, age was a modifying factor partly explaining these differences. [15]

To the best our knowledge, this is the first study investigating prospective changes in physical fitness among professional Military Service Personnel thus, direct comparisons cannot be made to other military study samples. Nevertheless, a recent study investigated prospective changes in physical fitness and anthropometrics of cadets with a similar 3-year follow-up period as used in the present study.[10] The investigated cadets were 3 years younger (~23 yrs. at baseline) than the participants in the present study, however,in line with the present study, Aandstad et al. (2020) observed a decrease in aerobic fitness. In contrast to the current study, however, the cadets improved their muscular fitness over the 3 year follow-up period. Similarly to the present study, the changes were of small magnitude ranging from 2-4% decrease in aerobic fitness to 3-20 % improvements in muscular fitness. Other prospective studies in cadets with 3-4 yearfollow-ups have reported mostly no change in physical fitness[9,11], although improvement in muscular fitness and a decrease in upper body muscular endurance have also been reported. [11] Improvements in physical fitness in cadets have been more consistent in short-term follow-ups (< 1 year). [16-19]

When comparing the findings of the present study and the previous studies with cadets it must be taken into account that some differences in the study and working environment exist in addition to differences

in the age of the participants. During cadet training, physical exercise and education is typically included in the curriculum to inform and teach the cadets how to train, whereas during the career of professional Service Personnel, such as the present study sample, similar support does not necessarily exist. In the FDF, for example, all professional soldiers are allowed to spend 2 hours of their weekly working hours exercising, but in most units the physical training is not supervised or controlled and thus, the outcome is dependent on individual knowledge and intrinsic motivation.

Interestingly, the observed decreases in physical fitness were most consistent in those with the highest fitness levels at baseline, whereas individuals in the lowest fitness levels could maintained muscular fitness and even improve push-up performance. Nevertheless, according to rather large standard deviations within the tertiles, there appears to be individual differences. In addition, these results indicate that individuals with lower fitness can adapt their exercise behavior during their first working years or that they benefit from peer support. Further studies assessing these predictive factors in the military environment are warranted. Collectively, however, the results obtained raise the question if support for physical training and thereby physical fitness maintenance needs to be more optimized by tailoring individual physical training programs based on previous baseline fitness levels.

Among the military branches, differences were observed between the Army, Navy, and Air Force. All physical fitness components decreased only in the Army officers, whereas body mass, BMI and waist circumference increased only in the Army and Navy officers. Some of the differences in these changes may be relate to different study sample sizes within a given military branch, as sample sizes were considerably lower in the Navy and the Air Force compared to the Army. It is, however, worth noting that physical fitness requirements may vary slightly between the branches thereby effecting either selection of personnel for a given branch or training and nutrition behavior accordingly.

There appears to be several factors during the early career of Service Personnel, which may be related to exercise behavior and thereby to physical fitness. Such factors may include new demands from military occupation in general, numerous military field training days, and, on the other hand, challenges in combining family and working life. Together these factors can induce a variety of changes in officers` behavior. As a consequence, these changes may be reflected as decreased physical training volume and non-optimal diet leading to negative changes in physical fitness and body composition in early career of the officers, as observed in the present study.

Strengths and limitations

The strengths of the present study include a 3-year follow-up period with a large and representative sample size. The results add previously undiscovered changes in physical fitness and anthropometrics during the early career of professional officers. The present study has also some limitations. First, when the data was stratified according to military branches, the Air Force included only 6-10 participants. Therefore, results of the Air Force should be interpreted with caution due to lack of statistical power. Second, although beyond the scope of the present study, no other background information other than age and military branch were available with no information about the exercise training and physical activity behavior. Further studies are therefore warranted to identify predictive factors explaining the changes in physical fitness and anthropometrics, such as exercise, physical activity and nutritional behavior, combining both quantitative and qualitative study methods.

Conclusions

Both aerobic and muscular fitness decrease and BMI and waist circumference increase among Finnish officers during a 3-year period of their early career. In addition, both aerobic and muscular fitness were maintained in the lowest baseline fitness tertiles, whereas physical fitness was consistently decreased in the highest baseline tertile. Body mass, BMI and waist circumference increased and the increases were evident for all baseline tertiles after the 3-year follow up. The small negative changes observed may be a result of altered exercise and nutritional behavior, which may be influenced by new demands when starting the military officer career, numerous military field training days during the early career, and, on the other hand, challenges in combining family and working life. The present results also indicated that baseline fitness levels were associated with changes in physical fitness. Therefore, officers with different fitness levels may need different kind of support in their exercise and nutritional behavior during early career in the military.

References

1. Wardle SL, Greeves JP. Mitigating the risk of musculoskeletal injury: A systematic review of the most effective injury prevention strategies for military personnel. *J Sci Med Sport*. 2017; 20 (Suppl 4): S3-S10.
2. Dijksma I, Zimmermann WO, Hertenberg E-J, Lucas C, Stuiver MM. One out of four recruits drops out from elite military training due to musculoskeletal injuries in the Netherlands Armed Forces. *BMJ Military Health*. 2020; 001420.
3. Kyröläinen H, Häkkinen K, Kautiainen H, Santtila M, Pihlainen K, Häkkinen A. Physical fitness, BMI and sickness absence in male military personnel. *Occup Med (Lond)*. 2008; 58(4):251-256.
4. Vaara JP, Fogelholm M, Vasankari T, Santtila M, Häkkinen K, Kyröläinen. Associations of maximal strength and muscular endurance with cardiovascular risk factors. *Int J Sports Med*. 2014; 35(4): 356-360.
5. Wyss T, Boesch M, Roos L, Tschopp C, Frei KM, Annen H, La Marca R. Aerobic Fitness Level Affects Cardiovascular and Salivary Alpha Amylase Responses to Acute Psychosocial Stress. *Sports Med Open*. 2016; 2(1): 33.
6. Tornero Aguilera JF, Fernandez Elias V, Clemente-Suárez VJ. Autonomic and cortical response of soldiers in different combat scenarios. *BMJ Military Health*. 2020;019-001285
7. Santtila M, Pihlainen K, Koski H, Vasankari T, Kyröläinen H. Physical Fitness in Young Men between 1975 and 2015 with a Focus on the Years 2005-2015. *Med Sci Sports Exerc*. 2018; 50(2): 292-298.
8. Wyss T, Roos L, Studer F, Mäder U, Beuchat C, Staub K. Development of physical fitness performance in young Swiss men from 2006 to 2015. *Scand J Med Sci Sports*. 2019; 29(4): 586-596.
9. Aandstad A, Hageberg R, Sæther O, Nilsen RO. Change in anthropometrics and aerobic fitness in air force cadets during 3 years of academy studies. *Aviat Space Environ Med*. 2012; 83(1): 35–41.
10. Aandstad A, Sandberg F, Hageberg R, Kolle E. Change in Anthropometrics and Physical Fitness in Norwegian Cadets During 3 Years of Military Academy Education. *Mil Med*. 2020; 11.
11. Mackey CS, DeFreitas JM. A longitudinal analysis of the U.S. Air Force reserve officers' training corps physical fitness assessment. *Mil Med Res*. 2019; 6(1): 30.
12. Pihlainen K, Santtila M, Ohrankämmen O, et al. *Fitness Test Manual of the Finnish Defence Forces*. Tampere, Finland: Second edition. Prima Edita. 2011; ISBN 978951220534; 11-12.
13. Kenny GP, Yardley JE, Martineau L, Jay O. Physical work capacity in older adults: implications for the aging worker. *Am J Ind Med*. 2008; 51(8): 610-625. Review.
14. Abt JP, Perlsweig K, Nagai T, Sell TC, Wirt MD, Lephart SM. Effects of Age and Military Service on Strength and Physiological Characteristics of U.S. Army Soldiers. *Mil Med*. 2016;181(2): 173-179.
15. Orr, R.M., Dawes, J.J., Pope, R., & Terry, J. (2018). Assessing differences in anthropometric and fitness characteristics between police academy cadets and incumbent officers. Journal of Strength and Conditioning Research, 32(9), 2632-2641.
16. Daniels WL, Kowal DM, Vogel JA, Stauffer RM. Physiological effects of a military training program on male and female cadets. *Aviat Space Environ Med*. 1979; 50(6): 562–566.

316 17. Oliver JM, Stone JD, Holt C, Jenke SC, Jagim AR, Jones MT. The effect of physical readiness
317 training on reserve officers' training corps freshmen cadets. *Mil Med*. 2017; 182(11): e1981–6.
318 18. Harwood GE, Rayson MP, Nevill AM. Fitness, performance, and risk of injury in British army
319 officer cadets. *Mil Med*. 1999; 164(6): 428–434.
320 19. Borges JH, Hunter GR, Silva AM, et al. Adaptive thermogenesis and changes in body
321 composition and physical fitness in army cadets. *J Sports Med Phys Fitness*. 2019; 59(1): 94–
322 101.

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Table 1. The differences between baseline (PRE) and the 3-year follow-up (POST) in physical fitness according to baseline fitness tertiles and military branches.

	Sit-ups (reps · min^{-1}) PRE	**Sit-ups** (reps · min^{-1}) POST	**Push-ups** (reps · min^{-1}) PRE	**Push-ups** (reps · min^{-1}) POST	**Standing long jump** (cm) PRE	**Standing long jump** (cm) POST	**12-min running test** (m) PRE	**12-min running test** (m) POST
lowest tertile	40.7±5.3	41.3±6.4	33.7±5.4	36.7±9.7 *	222.7±12.0	223.2±16.2	2538±98	2512±142
mid tertile	49.8±1.5	47.7±5.5 *	46.2±2.8	44.2±7.8 *	243.6±4.0	241.2±11.7	2768±54	2729±165
highest tertile	56.4±3.3	53.2±4.8 ***	58.5±6.9	51.0±6.6 ***	261.7±7.3	256.2±10.0 ***	3066±157	2996±199 ***
Army (n=126-135)	48.7±7.6	47.2±7.6 *	45.2±10.7	43.1±10.4 *	241.6±18.5	239.3±19.8 *	2810±244	2761±264 ***
Navy (n=27-29)	47.0±7.6	46.2±7.2	49.0±11.8	47.5±7.3	241.2±17.1	238.9±16.7	2786±255	2763±253
Air Force (n=6-10)	48.4±6.5	45.8±7.2	41.2±10.1	40.7±5.9	229.2±18.2	229.9±12.5	2661±191	2584±135

* p<0.05 compared to pre-value, *** p<0.001 compared to pre-value

Table 2. The differences between baseline (PRE) and the 3-year follow-up (POST) in anthropometrics in the whole study sample and according to baseline anthropometric tertiles and military branches.

	Body mass (kg) PRE	**Body mass** (kg) POST	**BMI** PRE	**BMI** POST	**Waist circumference** (cm) PRE	**Waist circumference** (cm) POST
All	81.4±9.9	84.8±10.6 ***	25.0±2.6	26.0±3.0 ***	86.9±8.5	90.8±8.9 ***
lowest tertile	72.0±5.0	75.6±7.3 ***	22.3±1.2	23.4±2.0 ***	78.6±4.4	84.4±6.7 ***
mid tertile	81.9±2.1	86.0±5.3 ***	24.8±0.5	25.8±1.3 ***	86.7±2.0	89.5±4.5 ***
highest tertile	93.1±5.9	95.5±7.3 ***	27.8±1.8	28.9±2.4 ***	96.8±5.4	99.6±7.5 *
Army (n=125-132)	87.4±8.5	91.3±9.1 ***	25.1±2.7	26.2±3.0 ***	82.0±9.9	85.6±10.7 ***
Navy (n=25-28)	85.4±6.2	89.1±6.5 *	24.6±2.0	25.4±2.2 *	79.6±8.9	82.2±9.6 *
Air Force (n=10)	85.3±12.1	89.0±10.7	25.0±3.7	25.5±3.9	79.4±12.1	81.0±11.3

* p<0.05 compared to pre-value, *** p<0.001 compared to pre-value

Figure 1. The differences between baseline (PRE) and the 3-year follow-up (POST) in physical fitness

Figure 2. Changes in physical fitness according to their respective fitness tertiles at baseline.