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

Year: 2020

Version: Accepted version (Final draft)

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Please cite the original version:

Vaara, J.P., Pihlainen, K., Rusila, J., Ojanen, T., & Kyröläinen, H. (2020). Physical fitness and anthropometrics in Finnish soldiers during their early career : prospective changes during a 3-year follow-up. *BMJ Military Health*, Online First. <https://doi.org/10.1136/bmjmilitary-2020-001571>

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

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4 **Abstract**

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

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

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

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

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26 **Key Messages:**

- 27 • Both aerobic and muscular fitness decreased during a 3-year follow up of early career in Finnish officers
28
- 29 • Body mass and waist circumference increased during a 3-year follow up of early career in Finnish officers
30
- 31 • The greatest decline in physical fitness was observed in military officers with the highest baseline fitness
32 level
33
- 34 • Body mass and waist circumference increased systematically across their baseline levels
35

36 **Introduction**

37 Physical fitness is one of the fundamental capabilities required of soldiers as it can directly affect
38 occupational success and task completion. Therefore, physical fitness standards exist to ensure sufficient
39 fitness levels required to succeed in a variety of occupational tasks in the military. Physical fitness is not
40 only related to completion of specific military tasks but is also inversely related to musculoskeletal
41 injuries^{1,2}, sick leaves³, and health outcomes⁴. In addition, physical fitness may mitigate stress responses
42 during high psychophysiological challenges⁵ that soldiers often meet in military operational settings⁶. Due
43 to the requirements and multiple benefits of physical fitness for military occupational performance and
44 readiness, information related to changes in physical fitness during soldiers` careers is of importance.

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

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

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

68

69 **Methods**

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

79

80 *Participants*

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

86

87 *Physical fitness tests*

88 All physical fitness tests, protocols, and techniques were standardized according to the Fitness Test
89 Manual of the Training Division.¹² Aerobic fitness was measured by a 12-minute running test on a flat
90 400-m outdoor sport track in the autumn, spring and summer with results being recorded to an accuracy
91 of 10 meters. Muscular fitness tests consisted of standing long jump, sit-up and push-up tests, which were
92 assessed in indoor facilities. A supervised warm-up of 15 minutes consisting of jumping, running and

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

100

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

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117 *Anthropometrics*

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

123

124 *Statistics*

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

137

138

139 **Results**

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

141 For the whole study sample, aerobic fitness decreased on average by 2% (-54 m), sit-up performance by
142 3% (-1.5 reps · min⁻¹), push-up performance by 4% (-1.9 reps · min⁻¹) and standing long jump performance
143 by 1% (-2.1 cm) over the 3-year period (fig 1). These decrements were observed in the Army (p<0.05) but
144 not in the Navy and Air Forces (table 1). For the whole study sample, body mass, BMI and waist
145 circumference increased on average by 4% each (+3.4 kg, +1.0, +3.9 cm, respectively). These increases
146 were specifically observed in body mass, BMI, and waist circumference for the Army and Navy but not
147 the Air Force (p<0.05) (table 2).

148

149 **Associations of baseline levels with changes in physical fitness and anthropometrics**

150 Baseline levels in muscular fitness were inversely correlated with their changes after the 3-year follow-up
151 (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
152 similar weak inverse correlation was found for aerobic performance (r= -0.19, p=0.018). Baseline waist
153 circumference was inversely but weakly correlated with its change (r= -0.27, p=0.001), whereas no other
154 significant correlations were observed in body composition characteristics. The changes according to
155 baseline tertiles revealed that push-ups were increased in the lowest tertile, while decreased in the mid and
156 highest tertiles (p<0.05). A decrease in sit-ups was observed in the mid and highest tertiles while standing
157 long jump and aerobic fitness decreased only in the highest tertile (table 1). Illustrations of the changes in
158 physical fitness variables according to the baseline tertiles are presented in figure 2. In addition, increases
159 in body mass, BMI and waist circumference were observed across all baseline tertiles (table 2).

160

161 **Discussion**

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

168

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

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

193

194 To the best our knowledge, this is the first study investigating prospective changes in physical fitness
195 among professional Military Service Personnel thus, direct comparisons cannot be made to other military
196 study samples. Nevertheless, a recent study investigated prospective changes in physical fitness and
197 anthropometrics of cadets with a similar 3-year follow-up period as used in the present study.¹⁰ The
198 investigated cadets were 3 years younger (~23 yrs. at baseline) than the participants in the present study,
199 however, in line with the present study, Aandstad et al. (2020) observed a decrease in aerobic fitness. In
200 contrast to the current study, however, the cadets improved their muscular fitness over the 3 year follow-
201 up period. Similarly to the present study, the changes were of small magnitude ranging from 2-4% decrease
202 in aerobic fitness to 3-20 % improvements in muscular fitness. Other prospective studies in cadets with 3-
203 4 year follow-ups have reported mostly no change in physical fitness^{9,11}, although improvement in
204 muscular fitness and a decrease in upper body muscular endurance have also been reported.¹¹
205 Improvements in physical fitness in cadets have been more consistent in short-term follow-ups (< 1 year).

206 ¹⁶⁻¹⁹

207

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

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

216

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

226

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

234

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

242

243 **Strengths and limitations**

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

254

255 **Conclusions**

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

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321 composition and physical fitness in army cadets. *J Sports Med Phys Fitness.* 2019; 59(1): 94–
322 101.

323

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

	Sit-ups (reps · min ⁻¹)	Sit-ups (reps · min ⁻¹)	Push-ups (reps · min ⁻¹)	Push-ups (reps · min ⁻¹)	Standing long jump (cm)	Standing long jump (cm)	12-min running test (m)	12-min running test (m)
	PRE	POST	PRE	POST	PRE	POST	PRE	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

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

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

	Body mass (kg)	Body mass (kg)	BMI	BMI	Waist circumference (cm)	Waist circumference (cm)
	PRE	POST	PRE	POST	PRE	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

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

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

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

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