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

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25

26 **Contributors Statement**

27 The views expressed are solely those of the authors and do not reflect the official policy or position of
28 the Finnish Defense Forces.

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33

1 **Abstract**

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

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

10 **Results.** No changes were observed in body anthropometrics, while most of the fitness test results
11 improved in both sexes. After adjustment for service time, branch, age, initial fitness test results, BMI
12 and WC, improvement in running test performance was 158m (95% CI 142-173m, $p \leq 0.001$) greater in
13 male than female recruits. Similarly, improvements were larger in male recruits for push-ups (5
14 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
15 (12 cm, 95% CI 11-13 cm, $p \leq 0.001$) when compared with females.

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

21

1 **1. Introduction**

2 It is known that military operations are physically and mentally demanding. Therefore, it is logical
3 that one goal of military training is to optimize the physical performance of soldiers before they enter
4 demanding operations. It is also known that there are sex differences in physical fitness in favor of
5 males, which are mainly due to the differences in body size, muscle mass and hormonal profile of
6 females¹. Military tasks like lifting or carrying heavy loads may require maximal efforts even for
7 males and may sometimes be too demanding for females². However, it seems that military units
8 typically implement almost equal training for male and female recruits, without taking into account
9 physiological sex differences, which may place female recruits at a higher risk for musculoskeletal
10 injuries during military training^{2, 3}. In fact, several studies have shown that females have a higher risk
11 of injuries and / or premature discharge during military service, mainly due to lower aerobic and
12 muscle fitness or differences in body composition^{4, 5, 6}. For example, in Finland, one in four female
13 recruits are prematurely discharged from military service, which is far more than the discharge rate
14 (15%) in male recruits⁷.

15 Earlier studies focusing on military training programs have shown that the physical fitness of male
16 recruits increases during military service, especially during the basic training period and among
17 recruits who were overweight or had lower initial aerobic and / or muscle fitness^{8, 9, 10}. On the other
18 hand, in the latter part of military service, physical fitness may increase at a slower rate or even
19 decrease, especially among well-trained recruits^{9, 11}. However, few studies have examined training
20 responses in female recruits during military service, and comparisons between male and female
21 recruits are particularly rare^{12, 13}. Some studies that have been performed reported higher average
22 fitness levels in male recruits before and after military training. However, the same studies observed
23 that the difference in fitness between male and female recruits narrowed as a result of standardized
24 military training, suggesting that females can adapt to military training at least as well as males.
25 However, in a recent review article, Varley-Campbell et al¹⁴ encouraged further studies to evaluate sex
26 differences in response to demanding military training.

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

11 **2. Methods**

12 A retrospective data analysis was used to compare changes in physical fitness between male
13 recruits and female recruits during military service in the Finnish Defence Forces between the years
14 2005 and 2015.

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

22 Initial fitness tests were conducted by a trained instructor during the first two weeks of military
23 service, and the follow-up tests during the last six weeks of service regardless of service time. Tests
24 protocols were same for both sexes. Individual results were stored in a database according to the
25 standards determined by the Training Division of the Defence Command. The sample size varied

1 between years, depending on the annual numbers of male and female recruits entering the service. The
2 data were anonymized before scientific use.

3 Recruits gave their written informed consent to participate in military service, including the fitness
4 tests, after a physical examination by medical doctors. Safety instructions were given to the recruits
5 before each fitness test, including information about the following indications for interrupting the
6 tests: onset of angina-like symptoms, shortness of breath, wheezing, leg cramps, claudication, light-
7 headedness, confusion or nausea¹⁵. This study was approved by the Defence Command of Finnish
8 Defence Forces and conducted according to the 1975 Declaration of Helsinki.

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

16 All fitness tests, protocols, and techniques were standardized according to the Fitness Test Manual
17 of the Training Division¹⁵. Endurance performance was measured with a 12-minute running test¹⁶ on
18 outdoor tracks during the summer season and on indoor tracks during winter months. Recruits were
19 encouraged to run with maximal effort at progressively increasing running speed. The 12-minute
20 running test result was maximal distance that can be run in 12 minutes with an accuracy of 10 meters.

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

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

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

20 **3. Results**

21 No changes were observed in mean BM, BMI or WC in male or female recruits during military
22 service (Table 1). Group comparisons revealed no differences in changes between male and female
23 recruits in body composition, with the exception of a larger decrease in WC of female recruits, which
24 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,
25 age and WC 1.

1 In general, all the fitness test results of female recruits were worse than those of males at the
2 beginning and end of military service (all fitness tests, $p \leq 0.001$). Absolute, non-adjusted values are
3 presented in Figure 1. Mean distance in the 12-min run increased by 4.3% in male recruits (2461 vs.
4 2565m, $p \leq 0.001$) and by 2.3% (2187 vs. 2234m, $p \leq 0.001$, Figure 1) in females. Pre-post sex-
5 differences increased in the 12 min running test from 11.1 to 13.9%. After adjustment for service time,
6 branch, age, test result 1, BMI 1 and WC 1, the improvement in running test performance was 158m
7 (95% CI 142-173m, $p \leq 0.001$) larger in male than female recruits.

8 The mean number of push-ups increased by 15.9% in males (32 vs. 37 reps/min, $p \leq 0.001$), and by
9 18.5% (21 vs. 25 reps/min, $p \leq 0.001$, Figure 1) in females. Pre-post sex-differences decreased in push-
10 ups from 34.4 to 32.4%. Despite the higher absolute change in females, improvement in the push-up
11 test was 5 reps/min (95% CI 4.7-5.8, $p \leq 0.001$) more in males than females, after adjustment for
12 service time, branch, age, test result 1, BMI 1 and WC 1.

13 Mean number of sit-ups in male recruits increased by 10.2% (37 vs. 41 reps/min, $p \leq 0.001$), and in
14 females by 9.0% (34 vs. 37 reps/min, $p \leq 0.001$, Figure 1). Pre-post sex-differences increase in sit-ups
15 from 8.1 to 9.8%. After adjustment for service time, branch, age, test result 1, BMI 1 and WC 1,
16 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.

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

22 Pearson correlation analysis for both sexes combined showed that changes in 12-minute running
23 distance correlated weakly and inversely with changes in BMI ($r = -0.16$, $p < 0.001$) and WC ($r = -0.16$,
24 $p < 0.001$). Body mass was weakly and inversely associated with changes in WC ($r = -0.27$, $p < 0.001$).

25 After dividing the data into quintiles based on initial running test results, the three least fit groups
26 of female recruits improved their 12-minute running distance, while in males the four least fit groups

1 improved their running test results during military service (Table 2). After similarly dividing the data
2 based on muscle fitness tests, both men and women improved standing long jump performance in the
3 three lowest quintiles, whereas decreased performance was observed in the highest two quintiles (Table
4 2). Moreover, both men and women improved push-ups and sit-ups performance in the four lowest
5 quintiles, while the highest quintile for both sexes showed a decrease in performance (Table 2).

6 **4. Discussion**

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

16 A systematic review consisting 29 studies¹⁴ concluded that the physical training responses in men
17 and women undergoing military training are almost similar, while both sexes will improve their
18 physical performance by standard military training program. In a similar sex comparison, Yanovich et
19 al.¹² observed reduced relative sex-differences in all fitness variables, except for push-up performance,
20 after four months of basic military training. For example, at the beginning of military service, males
21 achieved a 22% faster time on the 2 km running test, but this difference decreased to 18% after
22 training. While the pre-post difference between males and females increased in a push-up test (from
23 13% to 30%), the gap got smaller for sit-up performance by the end of the follow-up (from 3% to
24 1%)¹². More recently, Wood et al.¹³ studied fitness adaptations to 20-weeks of mixed-sex basic
25 military training. The between-sex difference in 2.4 km running time decreased from 50% to 37%
26 during the follow-up. In addition, sex-differences in the 2-min push-up and sit-up tests also decreased
27 from 12% to 10% and from 49% to 19%, respectively.

1 In this study, pre-post sex-differences increased in the 12 min running test, push-ups and sit-up
2 tests, whereas the initial sex-difference in standing long jump performance did not change. However,
3 ANCOVA analyses, using the changes in female results as a reference, revealed significantly larger
4 improvements in all measured fitness variables in male recruits. As in previous studies, there were
5 significant differences in fitness level between the sexes before and after military service. The present
6 results diverged slightly from the outcomes of Varley-Campbell et al¹⁴. They noticed that pre-post
7 physical training responses tended to be greater in female than male although the overall changes were
8 minor in both sexes.

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

19 For many recruits, military service consists of activities that require a higher physical load than
20 they are accustomed to. Some studies have demonstrated that daily physical activity of recruits can
21 easily exceed 10,000 steps while wearing combat gear (25-35 kg) and carrying other extra load¹⁷.
22 Therefore, a high baseline level of physical fitness is an important element of successful service that
23 helps to lower the likelihood of injuries or premature discharge from the service. It has been shown
24 that, compared with males, female recruits have a four-fold risk of premature discharge from the
25 Finnish military service due to injuries⁷. Overall, the discharge rate is higher in female recruits than in
26 males (25 vs. 15%) during military service⁷.

1 The changes in relation to baseline fitness quintiles showed that the most positive adaptations to
2 military training were observed in the less fit groups, whereas performance in the highest quintiles
3 decreased in both male and female recruits. On the contrary, the lowest fitness quintiles showed
4 improvements in all measured fitness variables in male and female recruits. Thus, it can be speculated
5 that the total volume of physical training may be too low for the fittest male recruits and too high for
6 females, inducing some overloading¹⁸. This suggestion is partly supported by previous studies which
7 have reported higher relative training loads for females during identical 12 to 14-week military basic
8 training^{19,20}. Nevertheless, as the physical fitness levels were different for the same quintiles of men
9 and women and still the upper quintiles decreased in both sexes, it may appear that other factors than
10 the volume of physical training plays a part. The associative underlying factors warrants therefore
11 future studies. Another possibility in the present study may be that the volume of high-intensity
12 training was too low for the fitter recruits to achieve optimal training stimulus. However, the highest
13 quintiles in women represented fitness level of the lower quintiles in men and despite there existed
14 improvement in men and decrease in women in for example aerobic fitness. The reason for this
15 remains unknown. Nevertheless, it has been²¹ shown that military training, especially the basic
16 training, includes a large amount of endurance-based military training at low intensities, which may
17 cause some interference with maximal endurance capacity, strength development and explosive power
18 output. Moreover, Grier et al.²² reported that combined strength and endurance training may be the
19 optimal way to improve physical fitness of female recruits during service, as opposed to traditional
20 single mode endurance or strength training programs. Supporting the previous suggestions for training
21 modifications, Rudzki et al.²³ reported significant decreases in discharge rates of both male and female
22 recruits while reducing total running hours, by including more progressive march training and deep-
23 water running. Varley-Campbell et al.¹⁴ stated that the physical training gains were around 10% across
24 the outcomes documented in their systematic review consisting similar military training for males and
25 females. Training gains were smaller than can be achieved in women with specific, progressive,
26 periodized training programs^{24,25}. They suggested that alternative training program may be needed to
27 support women in passing the physical employment standards in military settings and during their
28 military career.

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

10 **5. Conclusions**

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

19 **Key messages**

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

- 1 - More studies related to mechanisms explaining sex differences in adaptations to military training
- 2 are needed.
- 3

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28 33: 1011–25.

- 1 Table 1. Mean values and standard deviations for height (H), body mass (BM), body mass index
 2 (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

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

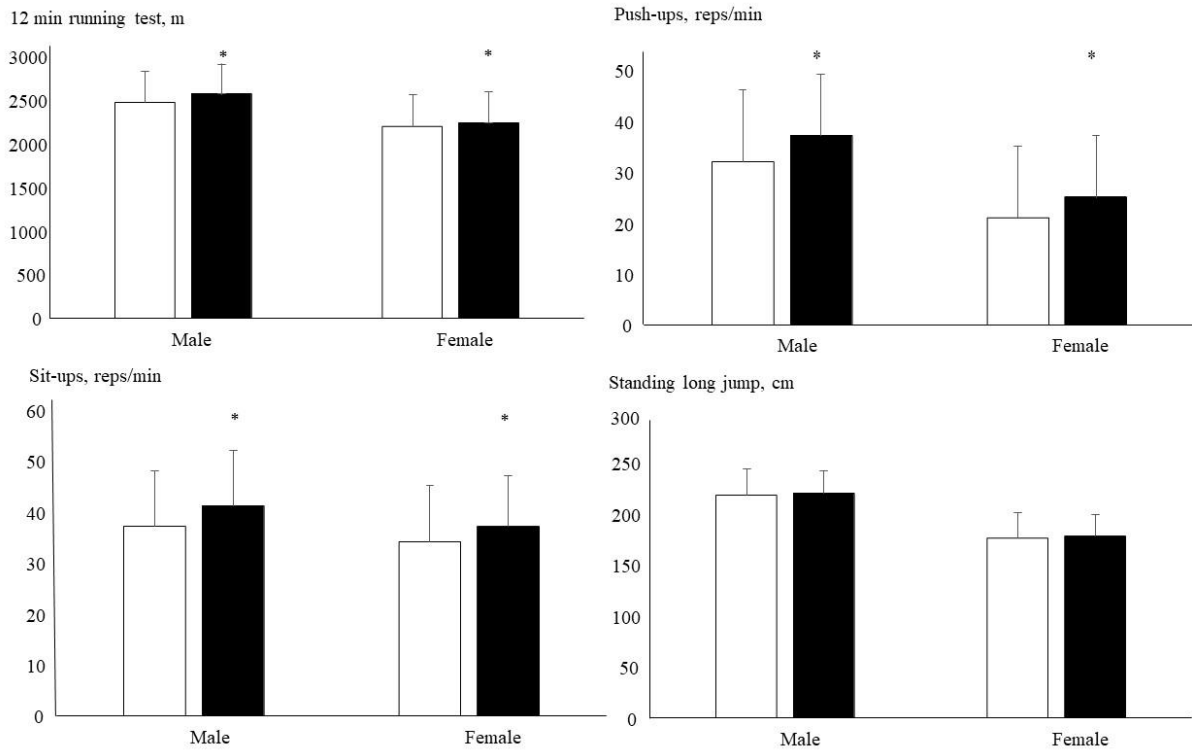
Male				Female			
Quintiles	N	Diff.	SD	Quintiles	N	Diff.	SD
12-min running				12-min running			
Q1 (400-2179 m)	43455	294	312	Q1 (400-1955 m)	637	200	287
Q2 (2180-2392 m)	44068	173	260	Q2 (1956-2129 m)	634	90	181
Q3 (2393-2555 m)	43811	104	251	Q3 (2130-2269 m)	633	35	183
Q4 (2556-2770 m)	43984	37	244	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

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



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