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Changes in physical performance during 21 days of Military Field Training in Warfighters

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INTRODUCTION

It is important that soldiers in the Armed Forces train continuously during peace time to ensure mission readiness. Warfighters deployed in the field are often exposed to different kinds of stressors including physical, psychological, environmental and nutritional ones. They are required to undergo a combat training in a multistressor environment in order to be ready for similar situations in the case of war. The training can be short or long term, and it can also include courses lasting several weeks.

Military Field Training (MFT) involves several different kinds of physical activities (e.g. marching long distances with heavy loads, run, jump and crawl during combat drills, lift and carry heavy objects), and it also exposes soldiers to multiple other physiological stressors. These stressors include exertional fatigue, sleep deprivation and energy deficits, which all have been shown to lead to decreased physical performance[1,2,3,4,5,6,7,8,9] induced by different types of MFT.

In the previous training studies lasted less than three (3) weeks, MFT has been shown to lead deficits in cardiorespiratory endurance[10], muscle endurance[11] , ability to produce power of the lower body[2,6] and decline in body mass, fat mass and fat free mass[1,2,3,6,10,11]. Eight or more weeks of strenuous military training has been shown to cause drastic declines in warfighters` maximal strength and power[5,7,12] and requires an appropriate recovery period from a physiological point of view before deployment. In the past, it has also been demonstrated that the warfighters are often exposed to extended periods of caloric deficit, lack of sleep or disturbed sleep and high energy expenditure depending on operational tasks and situation.[3,8]

Previous studies examining responses during MFT have mainly concentrated on hormonal and neuromuscular changes while there are limited data available on measured physical activity during MFT. Physical activity during MFT can be measured by subjective measures such as self-report questionnaires[13,14,15,16] , logs, diaries and by objective measure such as accelerometers[17] and pedometers.

Wyss et al.[18] observed during their basic training that physical activity among Swiss Army training schools varied according to occupational specialties. Simpson et al.[19] and Knapik et al.[20] measured physical activity during the US Army Basic Combat Training period, but no detailed data on actual MFT has been reported. Aandstad et al.[21] found that Norwegian Home Guard soldiers had a higher intensity of physical activity during civilian life compered to military training, although during military training the total amount of physical activity was higher.

Metabolic equivalent (MET) is defined as the ratio of the metabolic rate to the resting metabolic rate. Tudor-Locke et al.[22] have classified that over 10000 steps per day can be classified as a physically active. A MET value is equivalent to 3.5 ml/kg/min, which equals to the oxygen cost of sitting quietly.[23,24] Physical activity can be divided into sedentary (SED) (<1.5 MET), light (LPA) (1.5-2.99 MET), moderate (MPA) (3.0-5.99 MET) and vigorous (VPA) (≥6.0) physical activity. Vincent et al.[25] and Chappel et al.[26] have reported physical activity for firefighters in METs, while Redmond et al.[27] and Wyss et al.[18] have reported MET values for warfighters.

During military training it is important to mitigate the operational circumstances. MFT typically consists of high psychological and physiological stressors and normally include energy and sleep restriction as well as extreme weather conditions. To study the physiological changes during MFT, examination of the amount of physical activity is also necessary. Therefore, the purpose of the present study was to investigate changes in physical activity and neuromuscular performance among male Finnish Army conscripts during a 21-day MFT and to evaluate their recovery after MFT. The study also aimed to distinguish whether there were any associations between the above mentioned variables and to study if four days of recovery at the end of the prolonged combat training period was enough to return all of the measured variables to the baseline level.

METHODS

Subjects

Sixty-one (n=61) Finnish Army male conscripts who were doing their compulsory service volunteered as subjects for the present study. Present study was a part of a larger study and included also physiological measurements which will be reported separately. Twelve (12) individuals dropped out mainly due to discomfort of having to give blood samples and the lack of motivation to participate in the study. Therefore, forty-nine (49) subjects completed the study. The subjects were 19-22 years old male conscripts. The mean (±SD) age was 20±1 years, height of 179±6 cm, body mass 73.5±8.7 kg and body fat 12.6±5.0 %.

Before the study, all the subjects were fully informed of the experimental design and the possible risks that could be associated with it. The subjects were informed that they could cancel their participation in the present study at any stage if they so wished without any consequences. Every subject signed an informed consent before the study commenced. This study was conducted according to the provisions of the Declaration of Helsinki and was granted ethical approval by the Ethical Committee of the University of Jyväskylä. The study was also approved by the Finnish Defence Forces.

Experimental Design

A week before MFT, all the subjects were tested for baseline of the study. The same tests were also performed on the 12^{th} day of the MFT, in the end of MFT and after a recovery period of four days. Body composition, muscle endurance tests (sit-ups, push-ups) and standing long jump were measured during the measurement days. Physical activity (PA) was monitored before MFT, throughout the whole twenty-one days MFT and also after the recovery period. Daily diaries were collected to follow the workload and mood states of the conscripts.

The PRE measurement week was a normal training week for the conscripts at the garrison. They had lectures in the classroom, rifle maintenance and preparation for MFT. The entire 21-day MFT period, which was divided into three phases, was performed in field conditions.

During the first phase (ST), the subjects performed combat drills and shooting exercises with live ammunition. The goal for each conscript was to improve their combat and shooting skills and advance their weapon handling abilities. In this phase, the objective was not to physically exhaust the conscripts but rather to ensure that each of them maintained a high level of performance by ensuring that they had an appropriate amount of rest and sleep. The normal training day started at 07:00 and ended not later than 19:00 o`clock.

In the second phase (MFT), they practiced moving from their base to their attacking positions for the last phase. The tasks performed included reconnaissance, combat maneuvers, patrolling and tactical road marches. In the third and last phase (MFT), they executed their combat mission as a part of larger military exercise. The tasks were the same as in the second phase. After the prolonged MFT, the subjects had four days of recovery, two at home and two at the garrison before the final measurements were taken.

Measurements

Body Composition

Body mass (BM), muscle mass (SMM) and fat mass (FM) were determined using bioelectrical impedance analysis (BIA) (InBody 720, Biospace Ltd, Seoul, South Korea). The measurement was taken after an overnight fast, in the morning between 06:00 – 07:00. The subjects were instructed not to eat anything after their evening meal which was around 19:00. The BIA estimates of body composition have shown to highly correlate with the dual-energy x-ray absorptiometry (DXA) method (r=0.82-0.95).[28]

Aerobic Performance

Aerobic performance was measured with a 3.2 km March Test[29,30] before and after MFT. The load during the March Test was 20 kg and it was performed on the same track at both times, and the total time was measured. The conscripts also performed a 12-min running test before MFT[31]. It was performed in a 400m track at garrisons.

Standing Long Jump and Muscle Endurance Tests

Standard Finnish army fitness tests (standing long jump and muscle endurance tests, sit-ups and push-ups), were measured before and after MFT and after 4 days of recovery. In the standing long jump, the conscripts had three (3) attempts, and the best result was selected for further analysis. The jumps were performed in sport clothing in an indoor gym. For muscle endurance tests, the participants were instructed to perform as many repetitions in sit-ups and push-ups, as they were able to do during 60 s. There was a recovery period of at least 5 min between the tests. Before each test participants were instructed to use correct technique. Only the completed trials with adequate technique were accepted for final results. Standing long jump has been shown to be highly repeatable (CC=0.95).[32] Similar findings have been shown also for sit-ups (CC=0.93-0.95) and push-ups (CC=0.83-0.93).[33]

Physical Activity

Physical activity was monitored using a tri-axial accelerometer (Hookie AM20, Traxmeet Ltd, Espoo, Finland). The device was attached to the waist with an elastic belt. The validity (CC=0.96) of the device has been reported by Vähä-Ypyä et al.[34] The device measured several different variables including the total number of steps, running steps and intensity of activity by categorizing it according to metabolic equivalents during each day[35]. The subjects were instructed to keep the accelerometer on them at all times. The acceleration data was collected in raw mode (milligravity, mg). After the measurement period the stored data were transferred to a hard disk and analysed in 6-second epochs. We used cut-points, which have been previously determined from adults´ raw acceleration data by using mean amplitude deviation (MAD), were used to classify the intensity or employees´ intensity-specific PA (light, moderate, vigorous) and to separate SB from PA[34.] Physical activity was analyzed and presented for the following variables: number of steps, running steps, metabolic equivalents (METs), sitting and standing time, time in light physical activity (LPA) (1.5-3.0 METs), moderate physical activity (MPA) (3.0-6.0 METs), vigorous physical activity (VPA) (> 6.0 METs) and with the highest average MET in 1, 3, 10, 20 and 60 min and for the whole day.

Questionnaires

Questionnaires were used to collect information concerning the amount of sleep, stress levels, fatigue and several other factors. Each morning the conscripts were given a new diary to fill in, and in the next morning the previous diary was collected. The subjects were asked to write down how many hours they slept each night to the nearest half an hour (for example 7.5 hours) and to rate the RPE of the whole previous day. The Ratio of Perceived Exertion (RPE) was measured on a scale of 6-20, six meaning very light and twenty meaning very heavy physical exertion.[36].

Statistical Analysis

The data for the present study was analyzed using SPSS Statistics 22 program. For calculating means, standard deviations, and Pearson product moment correlation coefficients conventional statistics were used. The data was analyzed using multivariate analysis of variance with repeated measures. Probability adjusted *t* tests were used for pairwise comparisons when appropriate. A general linear model, with repeated measures ANOVA was used to analyze the differences between the different measuring points. Bivariate correlation was used for correlation analysis where the changes in the variables between the different time points were tested. Also the simple regression analysis was used. The $p < 0.05$ criterion was used for establishing the statistical significance.

RESULTS

Anthropometry

The declines in BM, SMM and FM after MFT were all significant, and the values recovered during the 4-day recovery period, except BM and SMM which did not returned to the PRE values. BM declined from 73.5±8.7 to 71.6±8.2 kg, but recovered to 73.0±8.3 kg as seen in table 1. The same trend was found also in SMM and FM. The change in BM and in SMM correlated negatively with the change in VPA ($r = -0.374$ $p = 0.016$ and $r = -0.337$ $p = 0.031$, respectively) as seen in table 4.

Physical performance

As Table 2 demonstrates sit-ups declined from the PRE (46±9 reps/min) values to both MID (40±8 reps/min) and POST (42±8 reps/min) measurement points (all, $p<0.001$) and declined even more for RECO (34±11 reps/min) measurement. In push-ups, declines in the POST (34±10 reps/min) and RECO (34±13 reps/min) measurements ($p<0.001$) from the PRE (40±13 reps/min) and MID (39±12 reps/min) values were observed. Standing long jump declined in all measurement points MID (220±20 cm), POST (216±20 cm) and RECO (213±20 cm) as compared to the PRE (229±23 cm) values ($p<0.001$). In addition, there was a declining trend from MID to POST ($p<0.01$) and from POST to RECO ($p<0.05$). There was no change ($p>0.05$) in 3.2 km loaded march time between the PRE (23:57±4:12 min:s) and POST (23:44±5:02 min:s) measurement points. No correlations were found with the changes in physical performance and other measured variables.

Physical activity

As seen in table 3, the total number of steps per day was significantly ($p<0.001$) greater during ST and MFT than during the garrison days. Running steps seemed to be linked to the daily program and were higher during the PRE measurements because of strenuous physical training. There was significantly ($p<0.001$) more light (1.5-3.0 MET) and moderate (3.0-6.0 MET) physical activity during ST and MFT than in the PRE measurements. Vigorous physical activity (>6.0 MET) was significantly lower during MFT than during PRE, ST and RECO. Also the number of running steps was higher during the ST and PRE measurement comparing to MFT and RECO. The highest average MET values were found during ST when looking at 1, 3, 10, 20 or 60 min time period. The highest daily average was found during MFT. There were no correlations in the changes between physical activity and physical performance.

Questionnaires

The Ratio of Perceived Exertion (RPE) was significantly ($p<0.001$) higher during MFT, and the conscripts slept more ($p<0.001$) during MFT than at the other measurement points. The change in PRE compared to the change in the push-up test correlated significantly ($r = -0.408$, $p = 0.007$) as seen in table 4. There was no significant correlation between RPE and other muscle endurance tests or body composition.

DISCUSSION

The present study demonstrated slight decrements in physical performance of warfighters, changes in the muscular endurance levels, physical activity and body composition during the 21-day MFT. The conscripts were overloaded during MFT but 4 days of recovery seemed not to be enough to obtain the PRE measurement values in physical performance. It is important for warfighters to have a good physical fitness level before MFT or combat. Since the prolonged MFT may have adverse effects in warfighters muscular endurance and physical activity levels, it is important to have sufficient recovery time after long MFT to regain combat readiness.

BM, SMM and FM declined during the 21-day MFT, but seemed to recover after four days to the PRE value level. Previous studies[1,2,3,6] have demonstrated the decline in body mass, fat mass and fat free mass after short-term (less than 14 days) MFT. In addition, more than 8 weeks of strenuous military training seems to cause even drastic declines in warfighters body composition.[5,7,12] During long deployments, body mass has been reported to both decline[11,14,37] or increase.[38]

Energy deficit has been reported in earlier studies as a main reason for changes in body composition[1,3]. The work of a warfighter during MFT requires more energy than they get from food. Strenuous military training can lead to decreased body mass, not only by decreased fat mass but also with the decrease in fat free mass. Therefore, it is important from a physiological point of view to have a sufficient recovery period before deployment.

During the present study the soldiers ate regularly three meals during a day. All the meals were made by the maintenance corps in the field near the troops and the quantity of calories was 3300 - 3500 kcal per day. As observed from the data of the activity measurements, the MFT had recovery days and the energy deficit was not so great all the time. It suggests that this was the main reason why the changes in body composition were not as drastic as reported in previous studies.

The present study also demonstrated decrements in warfighters' physical performance during the 21-day MFT. Muscle endurance declined both in sit-ups and push-ups. The decline was found in the MID measurements for sit-ups and in POST measurements for push-ups. In previous studies, Rintamäki et al.[11] have reported a decline in muscle endurance after MFT. The difference in sit-ups and push-ups might be due to the tasks the conscripts performed during MFT. They did not have to carry any heavy loads for long distances during the ST phase of the study. Load carriage performance has been linked to improvement in upper body strength.[20] Muscular endurance has declined or stayed the same during previous MFT studies.[5,6]. The decline in muscular endurance was probably partly explained by the motivation of the conscripts to perform these tests, but they were verbally encouraged to do their maximum effort in all measurement points. Load carriage, living outdoors and energy deficit may have influenced their ability to reach the PRE values in sit-ups and push-ups.

There was also the significant decline in lower body explosive strength (standing long jump) in all measurement points. Nindl et al.[5] and Chester et al.[2] have found that lower body explosive strength measured with vertical jump declined after MFT. It seems that long and high physical activity will negatively affect neuromuscular performance such as standing long jump. Besides the high volume of walking during MFT, load carriage tasks are a factor related to the decline in neuromuscular function. Load carriage has also been shown to increase ground reaction force[40] and, therefore, during the long MFT, load carriage may cause a decline in neuromuscular function. In special force courses, a decrease in vertical jump has also been observed.[5,12] The possible mechanisms for the decline in neuromuscular function may include neural overtraining, incidence of muscle microtrauma and / or decreased viscoelastic properties.

No chance occurred in 3.2 km march time. It seems that the conscripts' neuromuscular capacity was overloaded during MFT. Four days of recovery did not seem to be enough to regain the PRE values. The results suggest that it is important to have enough recovery time after long MFT. Previous studies have shown a decline or no change in aerobic performance during MFT. The more intensive MFT has been, the more decline has been observed in the physical performance variables.

Measured physical activity was significantly higher during MFT than in the PRE measurement. The amount of light and moderate physical activity during MFT was two times greater than in the PRE measurements. The conscript took almost 50 % more steps in MFT. When comparing the amount of steps taken during MFT, it can be concluded that the average of 13937±2276 steps/day during MFT can be defined as highly active when compared to healthy adults.[22,41] Tudor-Locke et al.[22] have classified that over 10000 steps per day can be classified as a physically active. Schulze at al.[42] have reported in the German Army that only the junior enlisted soldiers reached over 10000 steps in a day while non-commissioned officers and officers did not reach 10000 steps per day.

In a another study made with German Soldiers at work and during leisure time it was found that the average step count was 8500 during a day and only 41 soldiers out of 169 reached the recommend step count of 10000 steps/day.[43] Rintamäki et al.[11] reported on average 5797 steps taken during a 12 hours working time in peacekeeping operation in Chad. Aanstadt et al.[21] have found in their study in Norwegian Home Guard - troops that the average step count did not increase during military training when compared to civilian life (average 10500). The average VPA during military training was significantly lower than during civilian life, but there was more MPA during military training compared to civilian life.

Knapik et al.[20] have studied physical activity during the entire US Army Basic Combat Training (BCT) with electronic pedometers. The study showed that trainees performed an average of 16311 ± 5826 steps/day and the highest daily average was found during the field training exercise in which the trainees took an average of 22372 ± 12517 steps/day. During the present study, the highest daily average was 19724 ± 4169 steps/day (Figure 1) and the whole MFT averaged to be 13937±2276 steps/day (Table 3). Thus, it was lower when compared to Knapik´s[20] results, but higher than in the studies of Schultze[42] and Aanstadt[21]. The average daily step count with physically healthy, free-living adults using electronic pedometers were about 7000 to 8000 steps/day.[20] In the studies done by pedometers, it is impossible to distinguish between steps taken during walking and running. The accelerometer and algorithms used in our study made it possible to measure the running steps taken and also the level of activity in MET.

When we look at activity as a level of MET, Vincent et al.[25] have found that firefighters had average of 7:33:00 hours of light activity, 2:36:00 hours of moderate activity and 0:01:00 hours of vigorous activity. Chappel et al.[26] had similar findings also with firefighters 7:10:00 hours of LPA, 2:32:00 hours of MPA and 0:00:02 hours of VPA. Simpson et al.[19] have showed that when measured with accelerometer during US Army BCT the recruits had on average 7:25:30 hours of sedentary activity, 2:20:30 hours of light activity (> 3.0 MET), 1:32:00 of moderate activity (3.0 – 6.0 MET) and 0:38:00 hours of vigorous (> 6.0 MET) activity during a training day. Wyss et al.[18] have studied Swiss conscripts and found that they had LPA 7:33:00 to 8:40:00, MPA 3:45:00 to 5:46:00 and

VPA 0:05:00 to 0:16:00 h:min:s per training day. In the same study they found that the distance covered per day was greater than in a study made by Knapik et al.[20] (15.6 km/day vs. 11.7 km/day).

In the present study we found that the average MPA during ST was 2:12:00 hours and during MFT 2:48:00 hours. That was close to firefighters MPA during their regular shift[25,26] and more than the recruits during US Army BCT[19], but less than the Swiss conscripts[18] during their training. All these studies showed that there was only a couple of minutes VPA during the measured days, thus almost all the activity was either light or moderate.

As observed in table 4 no significant correlations were found between physical performance and activity. The change in BM and in SMM correlated negatively with the change in vigorous physical activity (VPA) ($r = -0.374$, $p = 0.016$ and $r = -0.337$, $p = 0.031$.) Also PRE and the change in push-ups correlated negatively ($r=-0.408$, $p=0.007$).

One limitation to the present study was that we did not measure objectively the amount of sleep the conscript have per night. Also there was variation on the tasks the conscripts did. Few of them were drivers, so they did not have to walk as much as the others. But the variation of activity was not drastic. In the POST measurements, one could see that the motivation of the conscripts was not as good as it could have been. This might have influenced the muscular endurance and 3.2 km march time.

It can be concluded that during MFT, there was significantly more physical activity than during an usual garrison training week. ST seems to have more intensive physical activity, but not a higher total amount of steps. ST had more anaerobic type of activity and more rest time during the nights. MFT was more aerobic type, and the physical activity was divided into longer timeframe during a day. Due to the higher physical activity prolonged MFT seems to lead to energy deficit and to decreases in BM, SMM and FM. Body composition seems to recover during a short term recovery time. Regarding physical performance muscle endurance seems to decrease after MFT. This was observed also in lower body muscle power. There was no change in 3.2 km march time including that aerobic performance stayed almost the same. The present study shows that the recovery from prolonged MFT seems to take more time than 4 days when looked at the muscular endurance and lower body muscle power. It might be advisable to have a low intensity week after the prolonged MFT to ensure the recovery of a warfighter.

References:

1. Alemany JA, Nindl BC, Kellogg MD, Tharion WJ, Young AJ, Montain SJ: Effects of dietary protein content on IGF-I, testosterone, and body composition during 8 days of severe energy deficit and arduous physical activity. J Appl Physiol 2008; 105: 58-64.
2. Chester AL, Edwards AM, Crowe M, Quirk F: Physiological, Biochemical, and Psychological responses to environmental survival training in the royal Australian air force. Mil Med 2013; 178: 829-35.
3. Kyröläinen H, Karinkanta J, Santtila M, Koski H, Mäntysaari M, Pullinen T: Hormonal responses during a prolonged military field exercise with variable exercise intensity. Eur J Appl Physiol 2008; 102: 539-46.
4. Margolis LM, Rood J, Champagne C, Young AJ, Castellani JW: Energy balance and body composition during US Army special forces training. Appl Physiol Nutr Metab 2013; 38: 396-400.
5. Nindl BC, Barnes BR, Alemany JA, Frykman PN, Shippee RL, Friedl KE: Physiological consequences of U.S. Army Ranger training. Med Sci Sports Exerc 2007; 39: 1380-87.
6. Nindl BC, Leone CD, Tharion WJ et al.: Physical performance responses during 72 h of military operational stress. Med Sci Sports Exerc 2002; 34: 1814-22.
7. Richmond VL, Horner FE, Wilkinson DM, Rayson MP, Wright A, Izard R: Energy balance and physical demands during an 8-week arduous military training course. Mil Med 2014; 179: 421-7.
8. Tharion WJ, Lieberman HR, Montain SJ et al.: Energy requirements of military personnel. Appetite 2005; 44: 47-65.
9. Tyyskä J, Kokko J, Salonen M, Koivu M, Kyröläinen H: Association with physical fitness, serum hormones and sleep during a 15-day military field training. J Sci Med Sport 2010; 13: 356-9.

10. Guezennec CY, Sabatin P, Legrand H, Bigard AX: Physical performance and metabolic changes induced by combined prolonged exercise and different energy intakes in humans. Eur J Appl Physiol 1994; 68: 525-30.
11. Rintamäki H, Kyröläinen H, Santtila M et al.: From the subarctic to the tropics: effects of 4-month deployment on soldiers' heat stress, heat strain, and physical performance. J Strength Cond Res 2012; 26(Suppl 2): S45-52.
12. Sporiš G, Harasin D, Bok D, Matika D, Vuleta D: Effects of a training program for special operations battalion on soldiers' fitness characteristics. J Strength Cond Res 2012; 26: 2872-82.
13. Rayson M: The development of physical selection procedures. Phase 1: Job analysis. Contemporary Ergonomics 1998: 393-7.
14. Sharp MA, Knapik JJ, Walker LA et al.: Physical fitness and body composition after a 9-month deployment to Afghanistan. Med Sci Sports Exerc 2008; 40: 1687-92.
15. Jaenen S: Identification of common military tasks. Optimizing operational physical fitness. RTO-TR-HFM-080 2009; 2.1-2.6. Available at https://www.sto.nato.int/publications/Pages/Technical_Reports_List.aspx; accessed April 26, 2017.
16. Martins LC, Lopes CS: Rank, job stress, psychological distress and physical activity among military personnel. BMC Public Health 2013; 13: 716-26.
17. Wyss T, Mäder U: Recognition of military-specific physical activities with body-fixed sensors. Mil Med 2010; 175: 858-64.
18. Wyss T, Scheffler J, Mäder U: Ambularoty physical activity in Swiss army recruits. Int J Sports Med 2012; 33: 716-22.
19. Simpson K, Redmond JE, Cohen BS et al.: Quantification of physical activity performed during US Army Basic Combat Training. US Army Med Dep J 2013; Oct-Dec: 55-65.

20. Knapik JJ, Darakjy S, Hauret KG, Canada S, Marin R, Jones BH: Ambulatory physical activity during United States army basic combat training. Int J Sports Med 2007; 28: 106-15.
21. Aandstad A, Hageberg R, Holme IM, Anderssen SA: Objectively measured physical activity in home guard soldiers during military service and civilian life. Mil Med 2016; 181: 693-700.
22. Tudor-Locke C, Hatano Y, Pangrazi RP, Kang M: Revisiting "How many steps are enough?". Med Sci Sports Exerc 2008; 40(7 Suppl): S537-43.
23. Ainsworth BE, Haskell WI, Whitt MC et al.: Compendium of Physical Activities: an update of activity codes and MET intensities. Med Sci Sports Exerc 2000; 32(9 Suppl): S498-516.
24. Ainsworth BE, Haskell WI, Herrmann SD et al.: Compendium of Physical Activities: A Second Update of Codes and MET Values. Med. Sci. Sports Exerc 2011; 43: 1575–81.
25. Vincent GE, Rodgers ND, Ferguson SA, Aisbett B: Associations between firefighters´ physical activity across multiple shifts of wildfire suppression. Ergonomics 2016; 59: 924-31.
26. Chapel SE, Aisbett B, Vincent GE, Ridgers ND: Firefighter´ Physical Activity across Multiple Shifts of Planned Burn Work. Int J Environ Res Public Health 2016; 13: 973-82.
27. Redmond JE, Cohen BS, Simpson K, Spiering BA, Sharp MA: Measuring physical activity during US Army Basic Combat Training: a comparison of 3 methods. US Army Med Dep J 2013; Oct-Dec: 48-54.
28. Sillanpää E, Cheng S, Häkkinen K et al.: Body Composition in 18- to 88-Year-Old Adults - Comparison of Multifrequency Bioimpedance and Dual-Energy X-ray Absorptiometry. Obesity 2014; 22: 101-9.

29. Kramer WJ, Vescovi JD, Volek JS et al.: Effects of concurrent resistance and aerobic training on load-bearing performance and the army physical fitness test. Mil Med 2004; 169: 994-99.

30. Santtila M, Häkkinen K, Kraemer WJ, Kyröläinen H: Effects of basic training on acute physiological responses to a combat loaded run test. Mil Med 2010; 175: 273-9.

31. Cooper KH: A means of assessing maximal oxygen intake. Correlation between field and treadmill testing. JAMA 1968; 203: 201-4.

32. Markovic G, Dizdar D, Jukic I, Cardinale M: Reliability and factorial validity of squat and countermovement jump tests. J Strength Cond Res 2004; 18. 551-5.

33. Augustsson SR, Bersås E, Thomas EM, Sahlberg M., Augustsson J, Svantesson U: Gender differences and reliability of selected physical performance tests in young women and men. Advanced Physiotherapy 2009; 11: 64-70.

34. Vähä-Ypyä H, Vasankari T, Husu P et al.: Validation of cut-points for evaluating the intensity of physical activity with accelerometry-based mean amplitude deviation (MAD). PLoS One 2015; 10: e0134813.

35. Vähä-Ypyä H, Vasankari T, Husu P, Suni J, Sievänen H: A universal, accurate intensity-based classification of different physical activities using raw data of accelerometer. Clin Physiol Funct Imag 2015; 35: 64-70.

36. Borg, G. Borg´s perceived exertion and pain scales. Champaign, Human Kinetics, 1998.

37. Warr BJ, Heumann KJ, Dodd DJ, Swan PD, Alvar BA: Injuries, changes in fitness, and medical demands in deployed National Guard soldiers. Mil Med 2012; 177: 1136-42.

38. Lester ME, Knapik JJ, Catrambone D et al.: Effect of a 13-month deployment to Iraq on physical fitness and body composition. Mil Med 2010; 175: 417-23.

39. Knapik JJ, Harman EA, Steelman RA, Graham BS: A systematic review of the effects of physical training on load carriage performance. J Strength Cond Res 2012; 26: 585-97.

40. Wang H, Frame J, Ozimek E, Leib D, Dugan EL: Influence of fatigue and load carriage on mechanical loading during walking. Mil Med 2012; 177: 152-6.
41. Tudor-Locke C, Brashear MM, Johnson WD, Katzmarzyk PT: Accelerometer profiles of physical activity and inactivity in normal weight, overweight, and obese U.S. men and women. Int J Behav Nutr Phys Act 2010; 7: 60-70.
42. Schulze C, Lindner T, Goethel P et al.: Evaluation of the physical activity of German soldiers depending on rank, term of enlistment, and task area. Mil Med 2015; 180: 518-23.
43. Schulze C, Lindner T, Goethel P, Müller M, Mittelmeier W, Bader R: Influence of individual determinants on physical activity at work and during leisure time in soldiers: a prospective surveillance study. US Army Med Dep J 2016; Jan-Mar: 53-9.

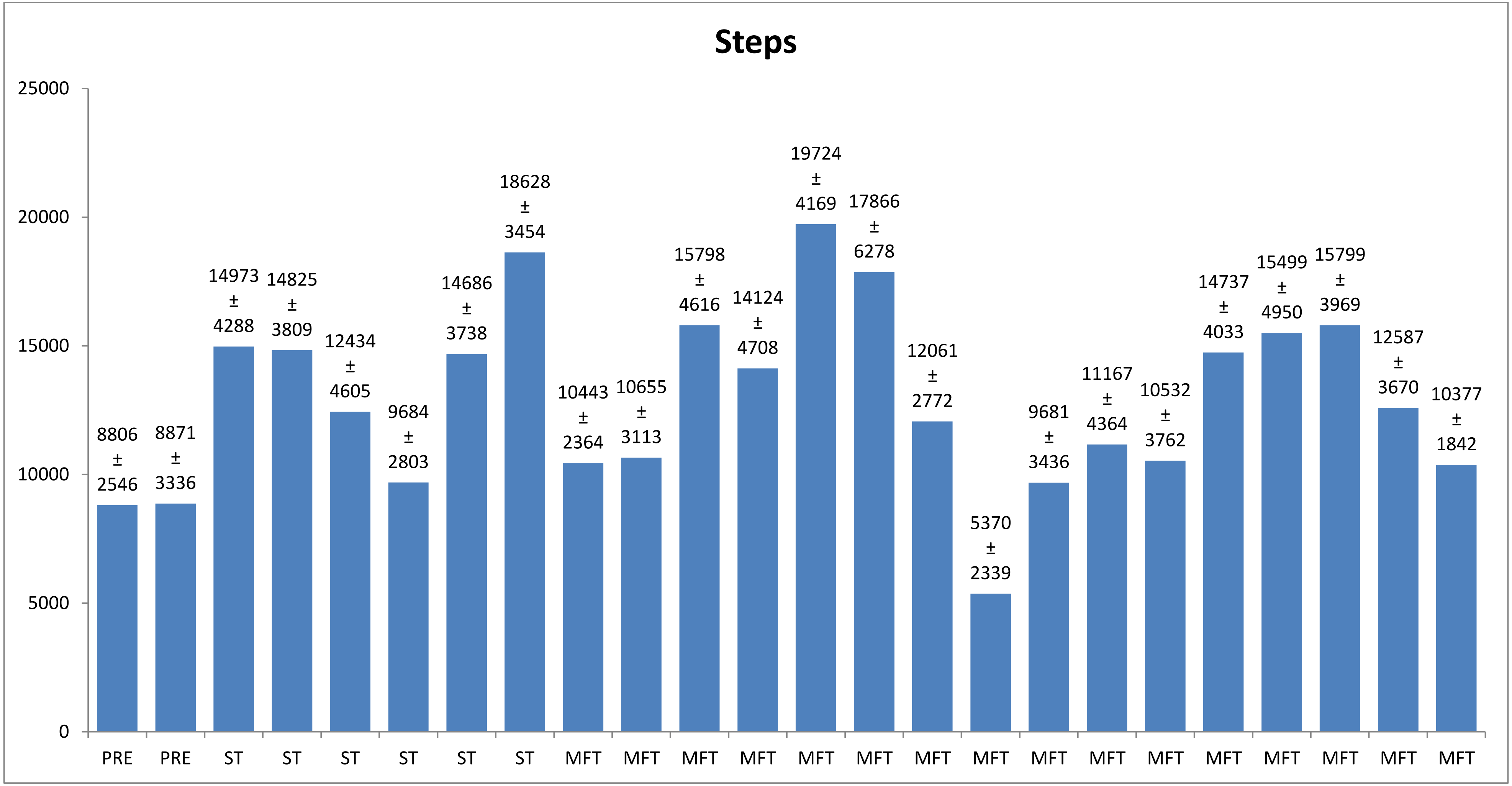

Figure 1. Daily mean and standard deviation of steps of all the participants during the study days.

Abbreviations: PRE, Pre measurements; ST, Shooting training; MFT, Military field training

Table 1. Changes in Body Composition

Body Composition	PRE	POST	RECO
BM (kg)	73.5±8.7	71.6±8.2***	73.0±8.3*†††
SMM (kg)	36.4±3.9	35.9±3.8***	36.1±3.9*†††
FM (kg)	9.5±4.6	8.4±4.0***	9.6±4.1†††
Fat %	12.6±5.0	11.6±4.4***	12.9±4.5†††

Abbreviations: PRE, Before training measurements; POST, Post training measurements; RECO, Recovery measurements; BM, Body mass; SMM, Skeletal muscle mass; FM, fat mass; * = $p<0.05$; ***,††† = $p<0.001$; *, ***, compared to the PRE values; ††† = compared to the MID values.

Table 2. Changes in Physical Performance

Physical Performance	PRE	MID	POST	RECO
Sit-ups (reps/min)	46±9	40±8***	42±8***	34±11***†††‡‡‡
Push-ups (reps/min)	40±13	39±12	34±10***†††	34±13**†
Standing long jump (cm)	229±23	220±20***	216±20***††	213±20***†††‡
3,2 km march (min:s)	23:57±4:12		23:44±5:04	

Abbreviations: PRE, Before training measurements; MID, halfway training measurements; POST, Post training measurements; RECO, Recovery measurements; *,†,‡ = p<0.05; **,††,‡‡ = p<0.01; ***,†††,‡‡‡ = p<0.001; *, ** , ***, compared to the PRE values; †, ††, ††† = compared to the MID values; ‡, ‡‡, ‡‡‡ = compared to POST values.

Table 3. Changes in Physical Activity, Sleep and RPE

Activity	PRE	ST	MFT	RECO
Sitting (h:min:s)	7:11:18±1:05:28	8:27:38±1:10:57***	7:56:54±0:50:10**††	5:53:26±1:38:09***†††‡‡‡
Standing (h:min:s)	2:32:49±0:53:06	2:21:19±0:38:37	2:18:00±0:29:26*	1:58:19±0:38:20***†††‡‡
MET 1.5-3.0 (h:min:s)	1:44:49±0:20:03	2:34:38±0:22:53***	3:03:27±0:23:24***†††	1:40:17±0:22:22†††‡‡‡
MET 3.0-6.0 (h:min:s)	1:23:16±0:22:02	2:12:15±0:23:14***	2:47:59±0:27:23***†††	1:08:03±0:14:48***†††‡‡‡
MET>6 (h:min:s)	0:12:42±0:10:03	0:12:50±0:05:39	0:03:35±0:01:52***†††	0:10:13±0:06:35††‡‡‡
Steps	9550±2569	13722±2379***	13937±2276***	7974±1803**†††‡‡‡
Running steps	699±658	1306±502***	381±205**†††	415±266***†††
MET1min	9.18±2.38	9.95±1.41*	7.59±1.08***†††	8.12±1.88*†††
MET3min	6.58±1.01	7.93±1.14***	5.61±0.61***†††	6.21±1.01†††‡‡‡
MET10min	4.47±0.58	5.82±0.86***	4.21±0.27**†††	4.30±0.48†††
MET20min	3.05±0.52	4.21±0.58***	3.39±0.17***†††	3.01±0.33†††‡‡‡
MET60min	2.54±0.47	3.38±0.42***	2.96±0.14***†††	2.44±0.24†††‡‡‡
METday	1.49±0.02	1.56±0.01***	1.60±0.01***†	1.48±0.12†††‡‡‡

Questionnaires	PRE	ST	MFT	RECO

Sleep (h)	5.7±0.6	5.6±0.8	6.1±0.8**†††	5.7±1.2‡
RPE	8.4±1.4	10.2±1.6***	9.4±1.5**††	7.1±1.3***†††‡‡‡

Abbreviations: PRE, Pre measurements; ST, Shooting training; MFT, Military field training; RECO, Recovery measurements; RPE, Rate of perceived exertion; *,†,‡ = $p<0.05$; **,††,‡‡ = $p<0.01$; ***,†††,‡‡‡ = $p<0.001$; *, ** , ***, compared to the PRE values; †, ††, ††† = compared to the MID values; ‡, ‡‡, ‡‡‡ = compared to POST values.

Table 4. Correlations coefficients between the changes in muscular endurance, aerobic performance and body composition compared to changes in physical activity, sleep and RPE

	Sit-ups		Push-ups		Standing long jump		3,2 km march		BM		SMM		FM	
	r	p	r	p	r	p	r	p	r	p	r	p	r	p
LPA	0.004	0.981	-0.097	0.552	0.051	0.750	-0.126	0.458	-0.19	0.417	-0.035	0.826	-0.09	0.574
MPA	0.017	0.918	-0.158	0.329	-0.120	0.455	0.058	0.732	-0.213	0.180	-0.234	0.140	-0.029	0.858
VPA	0.092	0.566	0.109	0.502	-0.117	0.466	0.010	0.952	*-0.374*	*0.016* *	*-0.337*	*0.031* *	-0.086	0.593
Steps	0.137	0.392	-0.128	0.433	-0.186	0.243	-0.210	0.213	-0.226	0.156	-0.219	0.169	-0.095	0.553
Sleep	0.007	0.965	-0.001	0.996	-0.062	0.686	0.053	0.741	0.073	0.632	0.194	0.203	-0.109	0.477
RPE	0.077	0.626	*-0.408*	*0.007***	0.166	0.287	0.182	0.262	-0.031	0.842	-0.005	0.977	0.001	0.994

Abbreviations: LPA, low physical activity; MPA, medium physical activity; VPA, vigorous physical activity; RPE, rate of perceived exertion; BM, Body mass; SMM, Skeletal muscle mass; FM, fat mass; *= p<0.05; ** = p<0.01.

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STRUCTURED SUMMARY

Introduction

Few studies have reported the amount of physical activity and its associations to physical performance of warfighters during Military Field Training (MFT). The purpose of the present study was to investigate changes in neuromuscular performance and physical activity among male Finnish Army conscripts during a 21-day MFT and to evaluate their recovery during four days after MFT.

Methods

Body composition and physical performance were measured four times during the study (before MFT (PRE), after 12 days (MID), at the end of MFT (POST) and after 4 days recovery (REC)). Physical activity (PA) was measured throughout MFT in a group of healthy young male conscripts (n=49) by using a tri-axial accelerometer. The study was approved by the Finnish Defence Forces and was granted ethical approval by the Ethical Committee of the University of Jyväskylä.

Results

Body mass (BM) declined significantly from 73.5±8.7 to 71.6±8.2 kg but it recovered close to the PRE values (73.0±8.3 kg). The same trend was found also in skeletal muscle mass (SMM) and fat mass (FM). The change in BM and in SMM correlated negatively with the change in vigorous physical activity (VPA) ($r = -0.374$, $p = 0.016$ and $r = -0.337$, $p = 0.031$, respectively). Muscular endurance decreased significantly ($p<0.001$) in sit-ups from the PRE (46±9 reps/min) values compared to MID (40±8 reps/min), POST (42±8 reps/min) and RECO (34±11 reps/min) values. Also in push-ups, the declines in the POST (34±10 reps/min) and RECO (34±13 reps/min) values ($p<0.001$) from the PRE (40±13 reps/min) and MID (39±12 reps/min) values were observed. There was a significant decrease in a standing long jump in all measurement points MID (220±20 cm), POST (216±20 cm) and RECO (213±20 cm) as compared to the PRE values (229±23 cm, $p<0.001$).

There was no change in 3.2 km loaded march time between the PRE (23:57±4:12 min:s) and POST (23:44±5:02 min:s) measurement time points. In PA, the total number of steps per day was significantly ($p<0.001$) greater during shooting training (ST) (13722±2379 steps) and MFT (13937±2276 steps) than during garrison days (9550±2569 steps). In POST, there was significantly ($p<0.001$) more light (1.5-3.0 MET) (2:34:38±0:22:53 h:min:s in ST and 3:03:27±0:23:24 h:min:s in MFT) and moderate (3.0-6.0 MET) (2:12:15±0:23:14 h:min:s in ST and 2:47:59±0:27:23 h:min:s in MFT) physical activity than in the PRE measurements.

Conclusion

The present study demonstrated slight decrements in warfighter physical performance during the 21-day MFT. The conscripts were overloaded during MFT but 4 days of recovery seemed not to be enough to obtain the PRE measurement values in physical performance. The present study showed also changes in the muscular endurance levels and physical activity during the 21-day MFT. It is important for warfighters to have a good physical fitness level before MFT or combat. Since the prolonged MFT may have adverse effects in warfighters muscular endurance and physical activity levels, it is important to have sufficient recovery time after long MFT to regain combat readiness.