PROFILES OF PHYSICAL ACTIVITY DURING FIELD EXERCISES FOR ACTIVE DUTY MILITARY PERSONNEL: A PILOT STUDY

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Abstract. The aim of this pilot study was to identify the profiles (intensity) of physical activity during field exercises using the example of active duty military personnel of the defence forces.

Forty-one active duty servicemen from the Scouts Battalion participated in the pilot study as subjects. To record movement, we applied activity and intensity accelerometers (ActiGraph LLC, Pensacola, FL, USA). The subjects carried accelerometers during the observation period on their right hip and removed them in water environments, i.e., when swimming and washing. The current study deals with the movement activity of active duty servicemen during field exercises where daytime movement activity dominates over the sedentary intensity level. The rate of occurrences of high and very high movement intensity indicates the need and readiness to conduct short-term and intensive activities. Different movement activity profiles characterise the versatile nature of activities carried out by active duty servicemen, and the distribution of tasks in military units.

Keywords: military service, physical activity, movement profile

1. Introduction

The physical training and preparedness of members of the defence forces is an essential foundation of national defence. The main purpose of physical training is to guarantee a sufficient preparedness of members of the defence forces for carrying out the tasks set to them during wartime and peacetime. All members of the defence forces have to be able to cover longer and shorter distances, carry their own equipment and lift additional weight.

Despite the increasing number of technical and technological solutions, the importance of physical training has not decreased in the military sphere, rather the other way around. Physical training conributes to decreasing the risk of injury[1] and is a prerequisite for better adapting to different stress factors like sleep deprivation, lack of water, lack of energy, and thermal stress[2, 3].

In field conditions, soldiers are engaged in diverse physical activities that depend on multiple factors, including tactical tasks, activities of the opposing side, etc. Modern technological solutions can measure the volume and intensity of a physical load using objective characteristics. In the military sphere, SLS sensors[4], muscle activity sensors[5] and physical activity monitors[6] have been applied.

The application of physical activity monitors or accelerometers is an increasing trend in studies of physical activity in different population groups. In the military sphere, physical activity monitors have been used for assessing the physical load and energy uptake of conscripts taking the base course in the Finnish Defence Forces[7] and during the training period of recruits in the US Army[8]. In field exercises, physical activity monitors have been used by marines of the Swedish Armed Forces[9] and soldiers of the Finnish Defence

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1 **Jones, B. H.; Knapik, J. J**. 1999. Physical training and exercise-related injuries. Surveillance, research and injury prevention in military populations. – Sports Medicine, Vol. 27(2), pp. 111–125.

2 **Kyröläinen, H.; Pihlainen, K.; Vaara, J. P.; Ojanen, T.; Santtila, M**. 2018. Optimising training adaptations and performance in military environment. – Journal of Science and Medicine in Sport, Vol. 21(11), pp. 1131–1138.

3 **Vaara, J. P.; Groeller, H.; Drain, J.; Kyröläinen, H.; Pihlainen, K.; Ojanen, T.; Connaboy, C.; Santtila, M.; Agostinelli, P.; Nindl, B**. 2022. Physical training considerations for optimizing performance in essential military task. – European Journal of Sport Science, Vol. 22(1), pp. 43–57.

4 **Jurvelin, H.; Tanskanen-Tervo, M.; Kinnunen, H.; Santtila, M.; Kyröläinen, H**. 2020. Training load and energy expenditure during military basic training periood. – Medicine & Science in Sports & Exercise, Vol. 52(1), pp. 86–93. [**Jurvelin et al**. 2020]

5 **Friedl, K. E**. 2018. Military applications of solder physical monitooring. – Journal of Science and Medicine in Sport, Vol. 21, pp. 1147–1153.

6 **Ojanen, T.; Häkkinen, K.; Vasankari, T.; Kyröläinen, H**. 2018. Changes in physical performance during 21 d of military field training in warfighters. – Military Medicine, Vol. 183(5–6), pp. 174–181. [**Ojanen et al**. 2018]

7 **Jurvelin et al**. 2020.

8 **McAdam, J.; McGinnis, K.; Ory, R.; Young, K.; Fruge, A. D.; Roberts, M.; Sefton, J**. 2018. Estimation of energy balance and training volume during army initial entry training. – Journal of the International Society of Sports Nutrition, Vol. 15(1), pp. 55+.

9 **Monnier, A.; Larsson, H.; Nero, H.; Djupsjöbacka, M.; Äng, B. Ä**. 2019. A longitudinal observational study of back pain incidence, risk factors and occupational physical activity in Swedish maine trainees. – BMJ Open, May 14, 9(5).

Forces[10]. In military missions, accelerometers have been used by members of the Finnish Defence Forces in the Middle East[11].

Objectively measured feedback contributes to enhancing a soldier's efficiency and avoiding negative energy and fluid balance as well as fatigue. Similarly, with objective feedback, the physical training of a soldier can be arranged with more expediency and efficacy corresponding to real needs, and for the purpose of coping in an emergency.

The aim of this pilot study was to identify the profiles of physical activity (intensity) during field exercises using the example of active duty military personnel of the defence forces.

2. Methods

The pilot study was conducted within the framework of the research project "Analysis of physical abilities of active duty servicemen", coordinated with the administration of the Estonian Defence Forces and provided with permission from the Research Ethics Committee of the University of Tartu (No 323/R, 19 Oct. 2020).

2.1. Data Collection

The personnel employed by the Scouts Battalion were asked to participate in this study. Forty-one active duty servicemen of the Scouts Battalion participated in the pilot study as subjects. Initially, 47 servicemen were drafted and 6 dropped out for various reasons. Their physical activity was monitored in field exercise conditions in October 2020.

In order to record movement activity and intensity, we used accelerometers (ActiGraph LLC, Pensacola, FL, USA). The subjects carried accelerometers during the observation period on their right hip and removed them in water environments, i.e., when swimming and washing. The total time period of wearing the accelerometer varied from 4 to 16 days, depending on the subjects' tasks during field exercises.

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[10] **Ojanen et al**. 2018.

[11] **Pihlainen, K.; Santtila, M.; Vasankari, T.; Häkkinen, K.; Kyröläinen, H**. 2018. Evaluation of physical load during 6-month international crisis management operation. – International Journal of Occupational Medicine and Environmental Health, Vol. 31(2), pp. 185–197. [**Pihlainen et al**. 2018]

Daytime movement was recorded from 6 a.m. to 10 p.m. and nighttime movement from 10 p.m. to 6 a.m. The monitored parameters were recorded at 15s intervals within a 24h period and calculated as a daily average index per each subject.

Daytime and nighttime physical activity was established by analysing the data on steps and individual movements recorded by the accelerometer during a fixed period, as calculated for the subjects' average movement activity and intensity by day, at night, and within 24h.

Movement activity and intensity were set with the help of the accelerometer. Movement activity was determined with a fixed number of steps and movement intensity was determined with a fixed number of movements.

Physical activity was divided into five intensity levels according to average intensity[12]:

1. "sedentary intensity" – less than 100 counts/min
2. "low intensity" – 100–1,951 counts/min
3. "moderate intensity" – 1,952–5,724 counts/min
4. "high intensity" – 5,725–9,498 counts/min
5. "very high intensity" – more than 9,498 counts/min

2.2. Statistical Analysis

Means and standard deviations of means were calculated from individual values by standard procedures. Mean values were analysed for statistical differences with a two-way analysis of variance (ANOVA). The Mann-Whitney test was used to compare differences between two independent groups. Results were considered statistically significant for a value of $p < 0.05$.

3. Results

On average, active duty servicemen spent 69.4% of their time during a 24h cycle at field exercises being physically active; this was distributed between daytime and nighttime activity as 55% and 14.4%, respectively.

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[12] **Freedson, P. S.; Melanson, E.; Sirard, J**. 1998. Calibration of the computer science and applications, inc accelerometer. – Medicine & Science in Sports & Exercise, Vol. 30(5), pp. 777–781.

The average number of steps was 9,472, out of which 8,332 steps were taken by day and 1,276 at night. The individual number of steps in a 24 h cycle varied from 3,492 to 13,932. The number of steps taken during daytime varied from 2,902 to 11,611. All active duty servicemen were also active during nighttime, the number of steps varying from 32 to 3,145 (Table 1).

Table 1. Mean active time (minutes) and count of steps during daytime and nighttime (m ± SD)

	Daytime	Nighttime	Total in 24 hrs
Active time (min)	791.5±73.2	207±143.6	1012.5±186.9
% of 24 h	55%	14.4%	69.4 %
Steps	8332.6±2016.5	1276.7±809.1	9472.3±2402
Steps min/max	2902/11611	32/3145	3492/13932

The activities of active duty servicemen during 24 h on field exercises had different movement intensities. Both in daytime and nighttime, low intensity (including sedentary) activities prevailed. By day, the average sedentary intensity time covered 551.1 min (minimal and maximal results being 437 and 670.9 min, respectively). At night, the average sedentary intensity time was 169 min and the respective maximal time was 420.4 min. Not all subjects conducted activities of high and very high intensity (Table 2).

Table 2. Mean time (minutes) of different physical intensity types during daytime and nighttime (m ± SD)

	Day		Night	
	av±SD	Min/Max	av±SD	Min/Max
Sedentary int	552.1±50.7	437/670.9	169±132.5	21.5/420.4
Low int	169.7±37.2	95.2/285.6	27.4±14.6	2.3/61.8
Moderate int	61.8±19.4	23.2/109.1	10.2±7.1	0.3/30.2
High int	7.1±6.0	0.0/23.6	0.7±1.4	0.0/8.4
Very high int	0.8±2.0	0.0/10	0.1±0.3	0.0/1.7

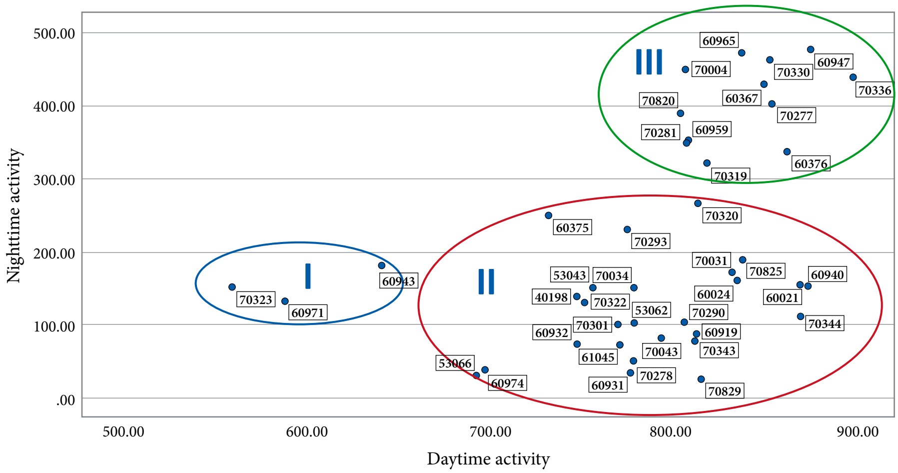

Figure 1. Scatter diagram of movement activity during 24 h

Profile I stands for low movement activity (n=3), profile II stands for moderate movement activity (n=26), profile III stands for high movement activity (n=12).

The longest active time was recorded for active servicemen of movement profile III (1,247±71 min). Moderate active time (911±117 min) was shown for active servicemen of profile II, and the shortest (752±50 min) for active servicemen of profile I. Mean activity time differed statistically significantly ($p \leq 0.001$) between all profiles. Non-active time was the shortest for active duty servicemen of profile III (193±71 min) which was significantly different from the results of their counterparts of profiles I and II (Table 3).

Table 3. Mean active and non-active time (minutes) for different movement profiles (m ± SD)

	Profile I		Profile II		Profile III	
	Active time	Non-active time	Active time	Non-active time	Active time	Non-active time
av±SD	752±50	688±50	911±117***	529±110	1247±71***###	193±71***###
% of 24 h	52.2	47.8	63.3	36.7	86.6	13.4

*** $p < 0.001$ represents significant difference from profile I
represents significant difference at $p < 0.001$ from profile II
Statistical differences by two-way analysis of variance (ANOVA) were used.

During daytime, the mean indicators for sedentary intensity were higher in activity profile III (589±37 min), differing significantly ($p \leq 0.001$) from the results of profiles I and II. The mean indicators for moderate intensity were significantly higher ($p \leq 0.01$) for profiles II and III compared to profile I. The mean indicators for high intensity were significantly higher ($p \leq 0.001$) for profiles II and III compared to profile I. The mean indicators for very high intensity for profile II (1.2±2.4 min) were significantly higher ($p \leq 0.05$) than for profile I.

During nighttime, the mean indicators for sedentary intensity for activity profile III (356±50 min) were significantly higher ($p \leq 0.001$) than the results for profiles I and II. The times for light intensity were longer for profile III (39.5±10.5 min) compared to profiles I ($p \leq 0.001$) and II ($p \leq 0.01$). Significantly shorter times for high intensity were observed in profile I (0.1±0.103 min) compared to the results of profiles II ($p \leq 0.01$) and III ($p \leq 0.05$) (Table 4).

Table 4. Mean time [minutes] of physical intensity for diferent activity profiles [m ± SD]

	Day			Night		
	I	II	III	I	II	III
Sedentary int	443±8.6	550±35***	589±37*** ##	132±19	101±79	356±50*** ###
Low int	119±28	173±39	178±18	15.1±0.17	24.9±14**	39.5±10.5*** ##
Moderate int	33.6±7.4	64±18**	66.8±15**	7.8±1.2	10.5±7.1	10.8±7.0
High int	0.1±0.12	7.0±5.6***	5.4±3***	0.1±0.103	1.0±1.6**	0.3±0.2*
Very high int	0.1±0.07	1.2±2.4*	0.2±0.3	0.0	0.1±0.3	0.0

*p < 0.05; **p < 0.01; ***p < 0.001 represent significant differences from profile I
#p < 0.05; ## p < 0.01; ### p < 0.001 represent significant differences from profile II
Statistical differences by two-way analysis of variance (ANOVA) were used.

4. Discussion

The intensity of the physical activity of the Scouts Battalion's military personnel is characterised by three physical activity profiles, changing intensity and considerable individual variation.

4.1. Average time of physical activity and non-activity

Forty-one active duty servicemen of the defence forces who participated in the planned field exercises were subjects to the current pilot study. The participants were active for 69.4% of the time within a 24h period, the average number of steps being 9,472. This undoubtedly amounts to a considerable physical load; in order to cope with it, sufficient physical training is necessary. According to earlier studies, taking 10,000 steps constitutes a normal daily movement load for heathy adults[13]. While counting steps, movement rate and step frequency are also important factors. Furthermore, subjects' free will and enjoying the movement is considered to be essential. In our study, the participants' activities were strictly regulated for the purpose of performing the duties set to them. In addition, the subjects carried equipment that considerably increased their physical load. For this reason, the movement activity indices and volumes measured with accelerometers cannot be directly compared to the respective data collected in civil life and under conditions where participants wear light clothing and move on hard surfaces.

The average movement activity rate (69.4%) of active duty servicemen within 24h is distributed between daytime (55%) and nighttime (14%) movement activities. The remaining non-active time period is important for recovery. A separate study would be needed to establish whether the non-active time period that we registered in our participants is sufficient for recovery under conditions where activities take place around the clock and non-active time for sleep at night is fragmentary. However, it has been pointed out that soldiers' sleep time and quality can considerably affect their preparedness[14].

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[13] **Tudor-Locke, C.; Craig, C. L.; Brown, W. J. et al**. 2011. How many steps/day are enough? For adults. – International Journal of Behavioral Nutrition and Physical Activity, Vol. 8, pp. 79+.

[14] **Devine J. K.; Choyowski, J.; Burke, T.; Carlsson, K.; Capaldi, V. F.; McKeon, B.; Sowden, W. J**. 2020. Practice parameters for the use of actigraphy in the military operational context: the Walter Reed Army Institute of Research Operational Research Kit-Actigraphy (WORK-A). – Military Medical Research, Vol. 7, Article 31.

4.2. Intensities

In this study, movement activity was divided into five levels of intensity and all of them were defined in the present study and recorded during daytime and nighttime. This shows the diverse nature of activities conducted by active-duty servicemen during field exercises, and also certain similarities between activities carried out by day and by night. Differences between nightly and daily movement activities lie mainly in their volume (duration). The necessity for different physical abilities can be estimated with the movement activity volume. Aerobic endurance is needed to successfully perform sedentary activities and low intensity movement activities. The better the endurance-related working capacity of a soldier is, the longer he can carry out set tasks. Furthermore, aerobic working capacity is essential to recover from short-term intensive activities. Moderate-intensity movement activity duration presumes a good level of muscle endurance, and movements involving high or very high intensity presume the existence of both sufficient muscle strength and anaerobic endurance.

Both in day and nighttime, the dominant movement activity of active duty servicemen was sedentary activity, and activities involving higher intensity occurred to a lesser extent. This is not surprising since sedentary time includes all low intensity activities such as guarding, monitoring, etc. Our Finnish colleagues[15] who measured soldiers' movement activities during a crisis in South Lebanon also noted that their movement intensity was low.

Military tasks and duties can be extremely varied, and in our study, this becomes clear from large individual differences. Both during day and nighttime, movement activities differed considerably in volume as well as minimal and maximal values. In addition, high and very high movement activity levels were not detectable for all subjects.

4.3. Profiles

Three movement activity profiles characterise the movement patterns of active duty servicemen during field exercises. The low-activity profile (I) involves relatively low daytime and nighttime movement activity. The medium-activity profile (II) is characterised by a considerably high daytime and nighttime movement activity. The high-activity profile (III) includes high movement activity by day and night. In all movement profiles, low intensity (including

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15 **Pihlainen et al**. 2018.

sedentary) movement types were dominant. High and very high movement intensity occurred mostly in profile II. For profiles I and III, nighttime movement activity was not very high. Whether this was caused by a concrete task or fatigue emerging in profile III characterised by a generally high movement activity is not clear.

Additionally, more specific studies would be needed concerning the considerably higher daytime and nighttime activity and the shortest non-active time that emerged in movement profile III, so that fatigue and exhaustion could be avoided. In such cases, more attention should be paid to the conscious consumption of fluids and food; this approach has been applied in elite sports. Previous studies have also noted that the physical load of soldiers is exceptionally high and can be compared to that of professional athletes[16].

5. Conclusion

The current study deals with the movement activity of active duty servicemen during field exercises where sedentary intensity level is dominant for daytime movement activities. The occurrence of high and very high movement intensity indicates the need and readiness to conduct short-term and intensive activities. Different movement activity profiles characterise the versatile nature of activities carried out by active duty servicemen and the distribution of tasks in military units. Comprehensive physical training is a prerequisite for coping and carrying out tasks in field conditions. The results of the pilot study are interpreted in the context of concrete field service periods, duration, and the goals and tasks set for active duty servicemen.

Shortcomings of this study include a considerable variability in wearing accelometers, and not taking into account the body mass of active duty servicemen and assessing possible fatigue.

Further studies of movement activity in active duty servicemen should focus on energy expenditure, length of rest period, and assessment of preparedness in field conditions.

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[16] **Jurvelin et al**. 2020.

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