Physical Activity during a 12 Days Military Field Training in Winter and the Effects on Muscular and Cardiorespiratory Fitness

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ABSTRACT

The purpose of this study was to measure the amount of physical activity during a 12 days military winter training and to investigate whether the operation affects soldiers' muscular and cardiorespiratory fitness. The studied 12 days training was consisted of 6 days combat training followed by 6 days combat shooting training. Altogether 23 male jaegers served as test subjects. Each subject participated three times in a maximal oxygen consumption test (maxVO_2) on a bicycle ergometer and in six muscle performance tests: maximal voluntary isometric knee extension (KE), static jump (SJ), counter movement jump (CMJ) and drop-jump (DJ) (40 cm bench) were performed on a contact mat, and for the measurements of mean anaerobic power (AP) subjects performed five consecutive CMJs; maximal isometric rotation of the wrist (WR) was also measured. The tests were carried out three days before the field operation (T1), at the 5th day of the operation (T2) and at the end of the operation (12th day, T3). Four of the subjects were also equipped with GPS recorders, which measured route, speed, distance, altitude and heart rate.

The average daily temperature during training ranged from 0.5 °C to -11.8 °C. During combat phase the average speed of soldiers was 1.00 - 1.85 km/h. Duration of these operations ranged from 1:33 to 3:14 h, and they were 2.85 - 4.48 km long. During shooting training the values were 1.30 - 1.40 km/h, 1:45 - 2:21 h, and 2.55 - 3.21 km, respectively. During other activities on foot the average daily speed was 0.59 - 1.28 km/h. Resting period during night was on average 4:54 h. SJ increased and only WR declined on T2 and T3 in comparison to T1. Force production time during KE became significantly slower during T2 and T3 compared to T1. In cardiorespiratory fitness there was in relation to the first test a significant difference only in maximal heart rate. A slightly decreasing tendency was observed in other parameters.

In conclusion, the studied winter operation had only minor effect on soldiers' maximal muscle performance, and no effects on maximal oxygen consumption, ventilation or ergometer work load. However, the significantly lower heart rate both in T2 and T3 in relation to T1 may reflect increased efficiency of cardiac function or increased plasma volume possibly due to the training. It seems that the studied training did not produce long term fatigue.

Rintamäki, H.; Oksa, J.; Rissanen, S.; Mäkinen, T.; Kyröläinen, H.; Keskinen, O.; Kauranen, K.; Peitso, A. (2005) Physical Activity during a 12 Days Military Field Training in Winter and the Effects on Muscular and Cardiorespiratory Fitness. In *Strategies to Maintain Combat Readiness during Extended Deployments – A Human Systems Approach* (pp. 18-1 – 18-6). Meeting Proceedings RTO-MP-HFM-124, Paper 18. Neuilly-sur-Seine, France: RTO. Available from: http://www.rto.nato.int/abstracts.asp.

1.0 INTRODUCTION

Locomotion of soldiers on foot while carrying the garments, weapons and other equipments is the main component causing physical strain. Because of increased use of motorized all-terrain vehicles, locomotion on foot has decreased. However, the distance and speed of an individual soldier moving on foot in wintertime field operations are not well known. Therefore the purpose of this study was to quantify, how much and by which speed the soldiers are moving during a 12 days military winter training (Mäkinen et al. 2005).

Cold environment can decrease physical performance by lowering tissue temperatures especially in the peripheral parts of the body, disturbing sleeping, causing hypohydration, changing endocrine responses and by increasing the physical strain of the tasks (e.g., Hackney et al., 1991, Hodgdon et al. 1991, D'Alesandro et al. 1992). Therefore we also investigated whether the winter training affects soldiers' muscular and cardiorespiratory fitness (Oksa et al. 2005, Rissanen et al. 2005).

2.0 MATERIAL AND METHODS

The studied 12 days training was consisted of 6 days combat training followed by 6 days combat shooting training on December 2004. Altogether 23 male jaegers served as test subjects. Their physical characteristics were (mean ± SD): age 19.7 ± 0.7 years, height 176.4 ± 6.8 cm, weight 71.5 ± 9.9 kg and body fat 13.9 ± 2.6 %. Prior to the participation the subjects were briefed on the nature of the study and they gave a written consent to act as voluntary subjects.

Each subject participated three times in a maximal oxygen consumption test ($maxVO_2$) on a bicycle ergometer and in six muscle performance tests: maximal voluntary isometric knee extension (KE), static jump (SJ), counter movement jump (CMJ) and drop-jump (DJ) (40 cm bench) were performed on a contact mat, and for the measurements of mean anaerobic power (AP) subjects performed five consecutive CMJs; maximal isometric rotation of the wrist (WR) was also measured. The tests were carried out three days before the field training (T1), at the 5th day of the training (T2) and at the end of the training (12th day, T3). During the $maxVO_2$-tests external load (starting from 75 W) was increased by 25 W every two minutes until exhaustion. Oxygen consumption and heart rate were measured continuously and maximal work load each subject was able to reach was recorded.

Four jaegers (section leaders) were also equipped with GPS-recorders (FRWD Sport Performance Recorder. Finland), which measured route, speed, distance, altitude and heart rate, and stored the data with 5 sec. interval. During the 12 days training, measurements were done from day 1 (starting at 22 p.m.) to day 11 (ending at 19 p.m.). The recorders were changed twice a day to avoid battery exhaustion. The measurements were analysed to separate the locomotion performed on foot during combat and during other activities, by vehicle, and periods of rest.

3.0 RESULTS

The average daily temperature during training ranged from 0.5 °C to -11.8 °C. Minimal temperature was -20.3 °C. The depth of snow was between 15 and 30 cm.

During combat phase the average speed of soldiers was 1.00 - 1.85 km/h (Table 1). Duration of these trainings ranged from 1:33 to 3:14 hours, and they were 2.85 - 4.48 km long. During shooting training the values were 1.30 - 1.40, 1:45 - 2:21, and 2.55 - 3.21 respectively. During other activities on foot the average daily speed was 0.59 - 1.28 km/h. The length of the resting period during night was on the average 4:54 hours.

In relation to the first test there was a significant difference only in maximal heart rate. A slightly decreasing tendency was observed in other parameters (Table 2). During the training plasma volume increased by 6.8 ± 1.4 % (mean ±SE) and blood volume by 3.2 ± 0.9 %, as calculated from changes in hemoglobin concentration and hematocrite values.

Body mass declined significantly during the training being 70.8 ± 2.0 and 70.3 ± 2.0 kg on T2 and T3, respectively. SJ increased and only WR declined on T2 and T3 in comparison to T1 (Table 3). Force production time during KE became significantly slower during T2 and T3 compared to T1.

Table 1: Average speed, duration, and distance of four soldiers during combat, other activities on foot and by vehicle, and the length of rest period at night (nm = not measured)

Activity	Day										
	1	2	3	4	5	6	7	8	9	10	11
Combat											
Speed (km/h)		1.85	1.07	1.23	1.00			1.30	1.40		1.40
Duration (h:min)		1:33	2:37	3:14	3:01			2:22	1:47		1:46
Distance (km)		2.85	3.10	4.48	3.31			3.21	2.55		2.57
Other activity											
Speed (km/h)	1.22	1.21	0.83	1.05	1.28	0.59	0.83	0.96	1.23	1.03	0.83
Duration (h:min)	2:34	11:56	9:31	8:08	4:58	10:15	6:55	7:30	4:37	14:35	14:43
Distance (km)	2.60	14.54	7.89	8.41	6.30	6.12	5.64	7.23	5.84	14.98	12.18
By vehicle											
Speed (km/h)	22.65	16.47	18.13	14.60	20.91	27.97	26.06	20.03	16.55	20.92	17.16
Duration (h:min)	0:24	1:22	3:16	1:30	0:21	0:39	1:02	0:55	0:08	0:55	0:18
Distance (km)	9.64	21.99	57.31	24.27	9.25	18.25	26.67	18.21	3.00	18.04	5.60
Rest at night											
Duration (h:min)	5:40	2:14	4:25	6:05	nm	6:32	5:15	nm	2:42	6:23	

Table 2: Mean (±SE) maximal oxygen consumption (maxVO_2), maximal ventilation (VE), maximal work load (WL) and maximal heart rate (HR) in the maxVO_2-test

Parameter	T1	T2	T3
VO_2 (ml/kg/min)	45.1 ± 1.1	45.2 ± 1.5	43.9 ± 1.1
VE (l/min)	118 ± 5	118 ± 7	110 ± 5
WL (W)	257 ± 8	256 ± 10	249 ± 8
HR (beats/min)	188 ± 2	181 ± 3*	178 ± 3*

Table 3: Mean (±SE) maximal forces on three consecutive tests

Exercise	T1	T2	T3
KE, kg	123.3 ± 5.3	120.4 ± 6.1	121.0 ± 5.3
SJ, cm	29.0 ± 0.8	32.1 ± 1.0*	31.8 ± 0.7*
CMJ, cm	35.2 ± 1.0	35.1 ± 1.0	34.3 ± 1.0
DJ, cm	20.5 ± 1.2	20.2 ± 1.0	21.3 ± 1.1
AP, W/kg	25.7 ± 0.8	25.9 ± 0.9	25.5 ± 0.7
WR, kg	4.9 ± 0.2	4.3 ± 0.1**	4.6 ± 0.2

* $p<0.05$, **$p<0.01$

4.0 DISCUSSION AND CONCLUSIONS

The present results show the average speed in military winter training during different activities. During these activities, especially during combat, much higher peak velocity is common, but the peak activities are balanced by tasks performed with low speed or without moving at all. The results show that the average speed on foot in snowy forest environment was maximally 1.85 km/h and the daily variation in the distance was large with the peak value of 15.0 km/24h. To evaluate soldiers' activities and performance in field conditions, the modern technology with satellite surveillance is a promising tool.

Twelve days winter time military training had no effect on soldiers' maximal oxygen consumption, ventilation and ergometer work load. This refers to that the training performed was not strenuous enough to produce long term fatigue. On the other hand, prior to participating to maxVO_2-test T2 and T3 the subjects had a possibility to recover due to transportation from the operational area to the laboratory (T2, ca. 3 hours) or due to overnight sleep (T3). Therefore, the results need to be interpreted taking into account the possibility of recovery. However, heart rate was significantly lower both in T2 and T3 in relation to T1, while significant change was not observed in other parameters. This may reflect increased efficiency of cardiac function (e.g. reduced end systolic volume) or increased plasma volume possibly due to training effect induced by the 12 day military training.

The training had minor effect on soldiers' maximal muscle performance. It seems that the soldiers were not engaged in sustained overexertion during the training. According to Nindl et al. (2002) decrements in physical performance were mainly restricted to muscle groups that were over-utilized without adequate recovery during $\leq$3 days operational stress. Like in the case of cardiorespiratory capacity, the subjects were most likely recovered to some extent. Moreover, body mass loss was less than 2 % which may not be enough to decrease physical performance (Fogelholm et al. 1993).

In conclusion, soldiers were able to maintain their cardiorespiratory and muscular performance during long-term military training in the cold. Minor marks of fatigue were seen in the force production time of the lower limbs and in the task that recruits small muscle groups. There were also signs of increased efficiency of cardiac function.

Acknowledgements. We thank Pekka Kiiski and Kari Stenius for making the GPS recordings. We are also grateful to the test subjects for their positive attitude and participation in the study.

5.0 REFERENCES

[1] D'Alesandro MM, Reed HL, Lopez A. Hematological parameters are altered during cold air exposure. Arctic Med Res 1992;51(1):16-22.

[2] Fogelholm GM, Koskinen R, Laakso J, Rankinen T, Ruokonen I. Gradual and rapid weight loss: effects on nutrition and performance in male athletes. Med. Sci. Sports Exerc. 25:371-377, 1993.

[3] Hackney AC, Shaw JM, Hodgdon JA, Coyne JT, Kelleher DL. Cold exposure during military operations: effects on anaerobic performance. J Appl Physiol 1991;71(1):125-130.

[4] Hodgdon JA, Hesslink RL, Hackney AC, Vickers RR, Hilbert RP. Norwegian military field exercises in the arctic: cognitive and physical performance. Arctic Med Res 1991;50 Suppl 6:132-136.

[5] Mäkinen T, Kauranen K, Kiiski P, Stenius K, Rintamäki H, Peitso A. Locomotion of soldiers during 12-day military winter operation measured with GPS-recorder. In: Häkkinen K, Kyröläinen H, editors. International Congress on Soldiers' Physical Performance; 2005; Jyväskylä, Finland, p. 158.

[6] Nindl BC, Leone CD, Tharion WJ, Johnson RE, Castellani JW, Patton JF, Montain SJ. Physical performance responses during 72 h of military operational stress. Med. Sci. Sports Exerc. 34:1814-1822, 2002.

[7] Oksa J, Rissanen S, Keskinen O, Rintamäki H, Peitso A. Effects of 12 days military winter operation on soldiers' cardiorespiratory fitness. In: Häkkinen K, Kyröläinen H, editors. International Congress on Soldiers' Physical Performance; 2005; Jyväskylä, Finland, p. 59.

[8] Rissanen S, Oksa J, Kyröläinen H, Mäkinen T, Santtila M, Mäntysaari M, Rintamäki H, Peitso A. Effects of 12 days military winter operation on neuromuscular performance. In: Häkkinen K, Kyröläinen H, editors. International Congress on Soldiers' Physical Performance; 2005; Jyväskylä, Finland, p. 60.