Journal of Physical Education and Sport ® (JPES), 18(3), Art 246, pp. 1685 - 1691, 2018
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Energy balance amongst soldiers in the armed forces of the Czech Republic, the course of a normal week and continuous training

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Published online: September 30, 2018
(Accepted for publication August 12, 2018)
DOI:10.7752/jpes.2018.03246

Abstract:

Objective: The research dealt with a comparison of energy intake and output of professional soldiers of the Armed Forces of the Czech Republic. The aim was to determine whether the energy balance of members of the 7th Mechanized Brigade remained steady over the course of the one week of continuous military training. *Methodology:* The investigated group comprised 74 volunteers – professional soldiers aged 31.89 ± 9.64 years. The measurement was conducted continuously over the period of six days. The energy intake was determined based on the composition of their diet created by a commissary officer. Energy expenditure was determined using ActiGraph GT1M accelerometers complemented by the recording protocols of the week's physical activity. *Results:* It follows from the investigation that the energy intake (3,840.38 ± 291.93 kcal) during the training was higher than the energy expenditure (2,739.58 ± 100.82 kcal) and that every day (on average by 1,100.8 kcal per day). The actual energy intake also differed from the energy intake determined by the decree (16,590 kJ). It exceeded this value for two days and was insufficient for four days. *Conclusions:* Over the course of the continuous training, a positive energy balance resulted in saving excess energy in the form of fat reserves.
Key words*:* ActiGraph, energy balance, energy intake, energy output, monitoring

Introduction

Soldiers, similarly to athletes, also perform a variety of activities with different demands on energy. Various challenges regarding the individual's needs have to be tackled, ranging from the effort to achieve a sufficient energy intake to cover the high energy demands to the necessity of limiting the energy intake in order to keep or reduce one's body weight (Maughan & Burke, 2006).

In order to ensure an appropriate diet dose, the food allowances and energy values determined by the Decree of the Ministry of Defence No. 266/1999 Coll., the menu for soldiers during continuous training needs to be created by a nutritionist. The basic daily diet dose (energy intake) for soldiers during comprehensive field military training is 16,590 kJ (90 g proteins, 112 g fat, and 460 g carbohydrates). One portion of a meal prepared by a cook contains 150 g of meat and 120 g of a side dish.

All the ongoing processes in our body need energy. Energy expenditure (EE) is influenced by several factors: age, sex, body weight, body height and training. The amount of energy released by the organism per day may be expressed in three components: basal metabolism, the specific dynamic effect of food and the thermic effect of activity (Wilmore, Costill, & Kenney, 2008). According to Vilikus et al. (2004) and Wilmore et al. (2008), basal metabolism may be defined as the minimal production of energy ensuring maintenance of homeostasis (maintenance of growth and renewal of cells in an organism, ensuring resting activity of all organs, etc.). The specific dynamic effect of food amounts to approximately 10% of the total daily energy expenditure and is described by Wilmore et al. (2008) as the increase in the metabolic level resulting from digestion, absorption, transport, metabolism and saving of food intake. The thermic effect of the activity includes basic activities of everyday life (walking, standing, sitting, body washing, etc.), various forms of physical work, as well as performance or recreational sporting activities (Hamar & Lipková, 2001). As stated by Powers and Howley (1997), this part of energy expenditure is the most variable out of the three components involved in energy expenditure. It amounts to 5-40% of the daily energy consumption. The basic energy expenditure necessary to maintain vital signs at an adult person is around 2,000 kcal per day. Further need of calories, exceeding this amount, depends on the individual's activity. For an average sedentary lifestyle, an additional 500 kcal are needed; for athletes, the additional amount of calories needed is approximately 2,500 kcal per day (Ganong, 2005).

In order to have a stable body weight, it is important to maintain a steady energy balance where energy intake is balanced with energy expenditure. In case of excessive energy intake (a positive energy balance), the excess energy is saved in the form of fat reserves and the individual's body weight increases. In contrast, if the energy intake is extremely low (negative energy balance), the human body even has to use the energy saved in the reserves, so the body weight decreases (McArdle et al., 1991).

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Methodology

The investigated group was comprised of volunteers – professional soldiers of the Armed Forces of the Czech Republic, members of the 7th Mechanized Brigade. The one-week measurement of physical activity was voluntary and was conducted with the consent of the participants. The measurement was conducted over the course of continuous military training, from Monday to Saturday. Out of the participants of the continuous military training taking place in the respective week, 74 participants aged 31.89 ± 9.64 years, regardless of gender and physical condition, took part in the monitoring. During the monitoring week (in May), the weather was sunny to partly cloudy with day temperatures of 12-18°C. The somatic parameters of the monitored group are listed in Table 1.

Table1. Somatic parameters of the monitored group

Parameter	M	SD	Min	Max
Weight [kg]	81,8	13,0	50,0	110,0
Height [cm]	179,0	7,4	152,0	193,0
Age [years]	29,9	4,5	22,3	42,5
BMI [kg/m^2]	25,5	3,1	19,4	32,1

Continuous military training is implemented in accordance with the provisions of Act No. 221/1999 Coll., and The Basic Code of the Armed Forces of the Czech Republic (Základní řád ozbrojených sil České republiky, 2001). Continuous military training means a continuous sequence of training activities conducted for no less than 48 hours. Table 2 provides an example of a schedule for one day of continuous military training.

Table 2. Example of a one-day timetable for the training week

Time	Activity
06,00 – 06,30	Reveille and morning hygiene
06,30 – 07,00	Breakfast time
07,00 – 13,00	Patrolling – mobile patrol - 1st platoon
	Combat shooting – 2nd platoon
13,00 – 13,30	Lunch time
13,30 – 19,00	Search operations – 2nd platoon
	Search operations – 1st platoon
19,00 – 19,30	Dinner time
19,30 – 22,00	Preparing for the next day job
22,00 – 06,00	Guarding the base – 1st platoon
	Rest mode at the base – 2nd platoon

Over the course of continuous service for at least 24 hours, a soldier is provided with meals free-of-charge beginning with the first meal served after the beginning of the continuous service and ending with the last meal served before the end of the continuous service (Decree of the Ministry of Defence No. 266/1999 Coll.). The energy intake (EI) of soldiers within one week of continuous training in a training area was determined on the basis of the composition of their diet created by a commissary officer. Table 3 provides an example menu for one day of continuous military training.

Table 3. The sample of 1 day of the weekly menu

	Name	Amount	Total kJ
Breakfast	Cake DUO cottage cheese, poppy	220 g	2984
	Milk yoghurt	400 ml	1160
Lunch	Chicken with red pepper	1 serving	927
	Pasta	1 serving	920
Dinner	Staffer peppers in tomato sauce	1 serving	720
	Dumplings	1 serving	1500
	Banana	1	398
Adding	Sparing orange water	1,5 l	1305
	TWIX biscuit	58 g	1195
	Cookies hazelnut OPAVIA	179 g	3700
Total		14809≈ 3538,6 kcal/per day	

As shown by Table 3, a correct dieting regime was observed, i.e. regular meals, at least three times per day (Decree of the Ministry of Defence No. 266/1999 Coll.), and the soldiers received the appropriate diet dose including a food allowance (Decree of the Ministry of Defence No. 272/1999 Coll.).

Energy expenditure (EV) over one week of continuous training in a training area was measured with ActiGraph GT1M uniaxial accelerometers ensuring continuous monitoring of physical activity. ActiGraphGT1M accelerometers measure the frequency, length and intensity of physical movement and enable objective monitoring of participants' physical activity without any age restriction. From the time over which the device was worn and from the physical activity it recorded, it was possible to count the participants' physical inactivity where energy expenditure equalled the state of the organism with minimal physical movement. In such a state, the energy demand was similar to that of the resting metabolism. By dividing the average active energy expenditure by the time over which the accelerometer recorded physical activity, we determined the average active performance of the individual participants. Notwithstanding its simple construction, this accelerometer is regarded as a valid and reliable device for monitoring of physical activity, particularly if monitored over several days or a week (Aadland et al. 2015, Abel et col. 2008, Rohtney et al. 2008). It is harmless to health and does not emit any electromagnetic waves (Mitáš et al., 2007). During the day, the device was only removed for showering, bathing or swimming, as it is not waterproof. ActiGraphGT1M saves average records in one-minute intervals and enables determining how many minutes the participant spends on light, moderate, or vigorous physical activity over days and weeks (Mitáš et al., 2007). Uniaxial accelerometers such as an ActiGraph are only able to measure acceleration on the vertical plane; their validity of measurement in higher speeds of running locomotion may thus be lower – that is, the energy expenditure may be undervalued (Brage et al., 2003). The device can monitor and store temporary data on activity in relatively short time intervals for days or weeks (Montoye et al., 1996).

Figure 1 shows the ActiGraph GT1M accelerometer. Figure 2 shows the correct way to wear it.

Fig. 1. ActiGraph GT1M accelerometer (Mitáš et al., 2007)

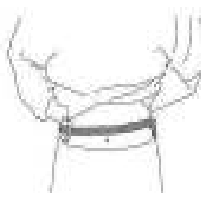

Fig. 2. Illustration of proper carrying of the device (Mitáš et al., 2007)

The subsequent processing of measured data was conducted with the ActiPA2006 software created for the research purposes of the Center for Kinanthropology Research at the Faculty of Physical Culture of Palacký University Olomouc (Chytil, 2006).

Results

Table 4 provides a comparison of EI based on the appropriate diet doses with the measured EE data.

Table 4. Energy intake and expenditure during the training week [kcal]

Day	Energy intake		Energy expenditure [kcal]					
	kJ	kcal	M	Med	Min	Max	R_Q	SD
Monday	14809	3538,6	2564,80	2636	1670	3202	2303	383,84
Tuesday	14589	3486,0	2864,80	2874	1916	4125	2668	459,55
Wednesday	16532	3950,3	2691,85	2675	1739	3530	2477	356,55
Thursday	17404	4158,7	2826,83	2798	1848	3632	2490	452,35
Friday	17715	4233,0	2793,71	2787	1692	4089	2608	490,38
Saturday	15383	3675,7	2695,51	2678	1771	4279	2369	480,42

The average daily number of steps was 10,186 (± 2,738). Figure 3 shows a comparison of average daily physical activity and inactivity.

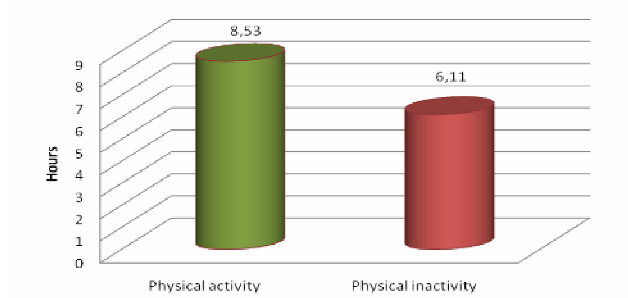

Fig. 3. The average value of the physical activity and the inactivity

Figure 4 shows a comparison of the average intensity of physical activity amongst soldiers during the continuous training. The average intensity of physical activity is divided into three categories (Frömel, Novosad & Svozil, 1999): light intensity (< 3 METs; < 4 kcal/min; walk); moderate intensity (3-6 METs; 4-7 kcal/min, cycling at 10-15 km/h), and vigorous intensity (> 6 METs; >7 kcal/min, cycling at >15 km/h).

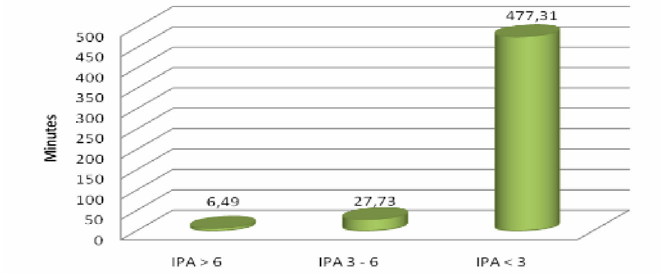

Fig. 4. Average intensity of physical activity according to the MET categorization

Figure 5 illustrates the average active performance [kcal/hr] and the average active energy expenditure [kcal].

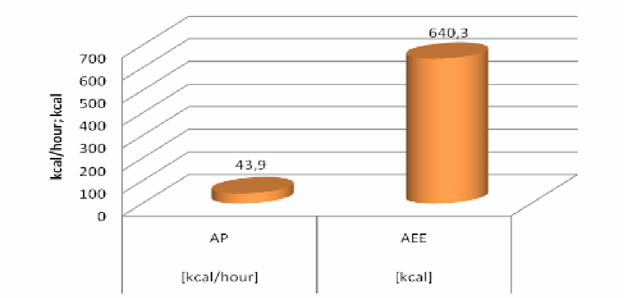

Fig. 5. Average active power [kcal/hour] and the average active energy expenditure [kcal]

Figure 6 shows the difference between the energy intake actually received by the soldiers on the individual days of one week of continuous training based on their diet doses, and the energy intake determined by the Decree of the Ministry of Defence No. 266/1999 Coll.

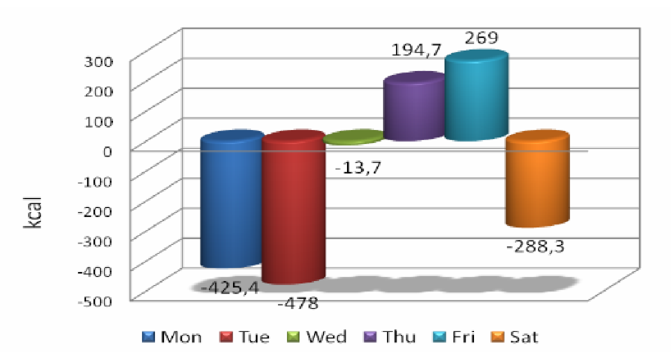

Fig. 6. The graphic representation of the actual EI over the EE specified by the decree [kcal]

Figure 7 shows the ratio of soldiers' energy intake [kcal] and output [kcal] on the individual days of one week of continuous training. The lowest energy expenditure, recorded on Monday, was 2,564.8 kcal.

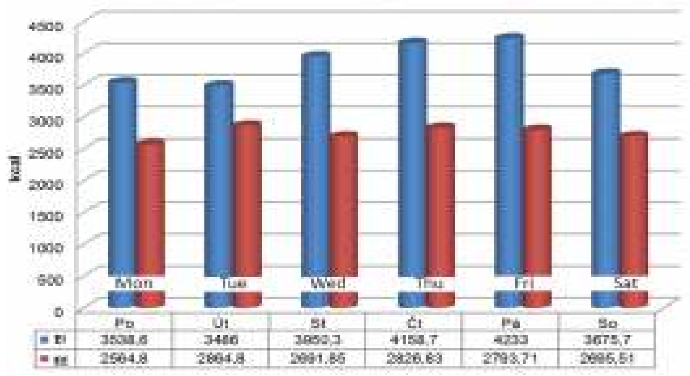

Fig. 7. The graphical depiction of the comparison of the EI and î [kcal]

Figure 8 illustrates what amount of kilocalories per day the soldiers' energy intake was higher than their energy expenditure on the individual days of one week of continuous training.

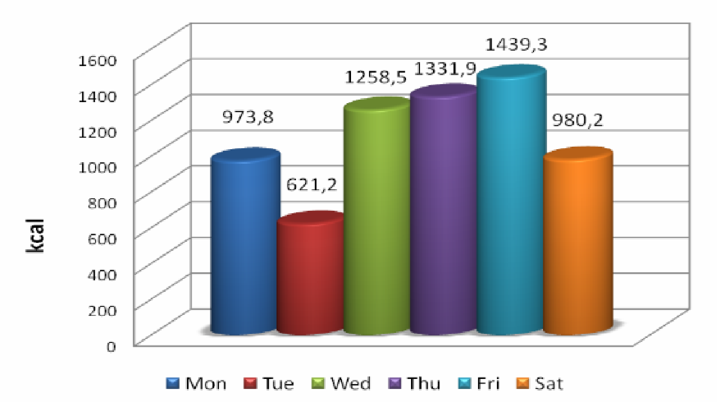

Fig. 8. The graphical representation of elevation the EI over the EE [kcal]

Discussion

The average daily EI was 3,840.38 ± 291.93 kcal, comparable for instance to EI of the American special operation forces – 3,249.92 kcal (Margolis et al., 2014). This is a significant difference compared to Israeli soldiers – 2,792 ± 124 kcal (Burstein et al., 1996), or Malaysian soldiers – 2,190 ± 197 kcal (Ismail et al., 1996).

The average daily EE was 2,739.58 ± 100.82 kcal, compared to the EE of members of the American army at CBRN (chemical, biological, radiological and nuclear) training – 2,420 kcal (Goetz et al., 2011), the EE of a fire brigade – 2,585 ± 406 kcal (Heil, 2002), the EE of Malaysian soldiers – 2,886 kcal (Ismail et al., 1996) or the EE of the American special operation forces – 3,903.8 kcal (Margolis et al., 2014). If soldiers perform an activity with an energy expenditure higher than that accounted for in the individual diet doses, they are entitled to food allowances. In order to ensure the necessary energy and nutrition values, these two parameters are defined for both the diet doses and the food allowances. In order to enable simple diet planning, the average weight composition of food consumption per person and day is also specified for diet doses and food allowances (Decree of the Ministry of Defence No. 266/1999 Coll.).

The basic diet dose for the Czech soldiers during training amounts to 16,590 kJ, compared to 13,598 kJ for soldiers of the special operation forces of the American army (Margolis et al., 2014).

After the average daily EI from the soldiers' menu was determined and subsequently compared to the average daily EE, a significant disparity occurred. The energy balance was positive on every day of measurement (by1,100.8 kcal on average). With regard to the fact that the EI actually received by the soldiers based on their diet doses was lower for four days than the EI determined by the Decree, the difference between their EI and EE was even more noticeable. It can therefore stated that the excess energy is saved in the soldiers' bodies in the form of fat reserves and their body weight thus increases.

Up to one half of the soldiers currently suffer from overweight; one out of seven suffers from obesity that has to be treated. For this reason, the Chief of the General Staff of the Czech Armed Forces has decided to tighten the standards for physical re-examination. Medical products for metabolism acceleration and promotion of fat burning have also been purchased. These have been distributed among the soldiers recommended by the garrison doctor based on the annual preventive check-up undergone by all professional soldiers. The successfulness of these products has not yet been assessed (Soumar & Oberman, 2010).

Table 5 shows the difference between EI [kcal] and EE [kcal] on the individual days of continuous training including examples of physical activity equal to this amount of excess energy. The listed examples of sport activities and their energy demands are calculated for an average person weighing 70 kg.

Table 5. The elevation the energy intake [kcal] over the energy expenditure [kcal]

Day	+ kcal	Physical activity
Monday	973,80 kcal	1 hour running at 13 km/hour speed
Tuesday	621,20 kcal	1 hour running at 9 km/hour speed
Wednesday	1258,45 kcal	1 hour of ice hockey
Thursday	1331,87 kcal	1 hour of cycling, race tempo
Friday	1439,29 kcal	2 hours running at 10 km/hour speed
Saturday	980,19 kcal	1 hour running at 13 km/hour speed

Uniaxial accelerometers measure acceleration in one direction, usually on the vertical plane. The principle of utilization of accelerometers, to estimate physical activity, is based on the direct proportionality of acceleration to muscle work. This is why it is also related to energy output (Montoye et al., 1996). They measure not only the intensity, but also the movement itself. Not all activities, however, manifest themselves as acceleration or deceleration. The average daily number of steps (10,186 steps ± 2,738) in one week of continuous training in a training area may be classified as "regular moderately intensive movement without any competitive sport". The soldiers thus fulfil the health recommendation regarding the daily number of steps (Máček et al., 2010).

Conclusions

It is apparent that the EI of professional soldiers during continuous training was higher than their EE and this every day, notwithstanding the fact that the actually received EI differed from that determined by the decree. The actual EI was excessive on two days (by 814 kcal and 1,125 kcal), and insufficient on four days (-58 kcal, -1,207 kcal, -1,781 kcal, and -2,001 kcal). Over the course of the continuous training, the excess energy was thus saved in the form of fat reserves. The legislation only concerns the issue of EI during training. The Decree of 1999 states the exact amount of kJ a soldier should receive daily. It has not yet been investigated, however, whether this amount is sufficient or excessive at present.

Acknowledgments

Thanks to doc. Mgr. Josef Mitáš, Ph.D. for providing data processing assistance and all people who were a part of the research. The research was supported by the research grant from the GAČR 15-13980S.

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