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Activity Pattern, Energy Expenditure and Energy Intake Among Male Athletes During A Training and No Training Days

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ABSTRACT

Physical activity has long been recognized as an important factor in enhancing health and reducing the risk of various chronic diseases. This study aimed to determine the physical activity pattern, total energy expenditure (TEE) and daily energy intake (EI) of a sample of male athletes on a training and no training days, and to compare with non-athletes. The subjects comprised 83 male athletes from various types of sports (athlete group), and 80 inactive men (non-athlete/ control group) aged 18 to 44 years. The TEE of subjects was calculated based on their daily activity. The basal metabolic rate (BMR) was calculated for all subjects based on body weight using the predictive equations of a previous locaI study. Physical activity level (PAL) was calculated as the ratio of TEE to BMR. The energy intake (EI) was obtained using a one day 24-hour diet recall. During a normal day, the mean TEE (2,272 kcal/day) and EI (2,461 kcal/day) of the athletes were not significantly different compared to the non-athletes (TEE=2,268 kcal/day; EI=2,340 kcal/day). However, on a training day, the mean TEE of the athletes was increased to 2,861 ± 638 kcal/day, while the mean EI increased to 2,739 ± 550 kcal/day, with a negative energy balance of 122 kcal. The higher TEE among athletes on the day of having sports training indicated that proper diet planning and nutrition education are vital for the group to achieve energy balance as well as optimal physical performance and overall health status.

Keywords: Physical activity; Energy expenditure; Energy intake; Athletes; Non-athletes

INTRODUCTION

Physical activity is defined as any bodily movement produced by skeletal muscles that requires energy expenditure (WHO, 2020). The assessment of physical activity and energy expenditure of individuals are extremely important in the global context of increasing rates of obesity and type 2 diabetes mellitus and other non-communicable diseases (Hills, Mokhtar & Byrne, 2014).

Mean total daily energy expenditure (TEE) of men depends on the duration of physical activity, and the nature and intensity of the various activities (Ribeyre et al., 2000). In Malaysia, energy expenditure studies were mostly conducted in non-active groups, with the exception of few studies, which were carried out among national athletes and soldiers (Ismail, Wan Nudri & Zawiah, 1997; Wong et al., 2012; Ismail, Isa & Janudin, 1996).

Physical activity has long been recognized as an important factor in enhancing health and reducing the risk of various chronic diseases (DHHS, 1996). Therefore, it would be useful to evaluate the TEE among the physically active groups. The present study was conducted among a sample of

athletes in Kota Bharu, Kelantan, Malaysia with the objective of estimating their TEE and EI on training day and non-training day and to compare with non-athletes.

SUBJECTS AND METHODS

Subject recruitment

This was a cross-sectional comparative study, carried out among 163 healthy male subjects aged 18 to 44 years. The subjects comprised 83 athletes who have participated in different types of sports at various levels of competitions (athlete group) and 80 inactive men (non-athlete group), each given his informed consent before the study began. The athletes were selected from several sport associations in Kelantan, including the Kelantan State Sports Council. The athletes selected were those who were actively involved in sports training with a minimum of 30 minutes a day for at least 3 times a week during the last three months. The non-athlete subjects were those who had not engaged in regular physical activity or engaged in physical activity during the last three months but less than 3 times a week, selected from several government departments in Kota Bharu, Kelantan, Malaysia. The classification for the athletes and non-athletes was based on the criteria suggested by Foss and Keteyian (1998) and Stofan et al. (1998).

Anthropometric measurements and physical activity pattern

The height and weight of subjects were measured using the Seca weighing balance with height attachment (SECA Model 713, West Germany). Body mass index (BMI) was calculated as weight (in kg) divided by height (in m) squared. The percentage of body fat was determined by skinfold thickness method (Durnin & Rahaman, 1967; Durnin & Womersley, 1974).

Physical activity was measured via self-reported diary. All the respondents were instructed to accurately fill their daily activities in the diary card, as suggested by Bouchard et al. (1983). The energy costs (kcal/min) of activities for calculation of energy expenditure was adopted from previous studies as shown in Table 1.

Table 1: Energy cost (kcal/min) of various activities of subjects

Activities	Energy cost* (kcal/min)	Activities	Energy cost* (kcal/min)
Lying/sleep #	1.03	Office work:	
Standing (inactive) #	1.30	Sitting at desk	1.6
		Standing and moving around	1.9
Sitting activities:			
Watching TV/resting#	1.15		
Eating	1.7	Exercise/sports:	
Writing	1.6	Cycling	7.5
Driving car/motor-cycling	1.4	Jogging	6.6
		Running (moderate)	10.0
Walking#	2.68	Running (quickly)	12.0
Praying♀	1.71	Exercise	5.0
Up/down stairs♀	4.02	Badminton	6.3

Personal activities	2.8	Weight lifting	8.2
Domestic work:		Football	8.5
Cooking/preparing meal	2.5	Basket ball	9.0
Tidying up	3.8	Volley ball	3.5
Floor sweeping	2.1	Shooting	3.7
Washing car	3.8	Sepaktakraw	6.3
Washing clothes	3.1	Table tennis	4.4
Gardening	4.2	Tennis	7.1
Ironing	2.1	Hockey	8.7
Taking care of baby/child	2.5		

* *Mean body weight 65 kg [Durnin & Passmore (1967)]*
♀ *Mean body weight 55 kg [Ismail & Zawiah (1988)]*
Mean body weight 62 kg [Ismail & Zawiah (1989)]

Energy expenditure, basal metabolic rate and physical activity level

The TDEE of each subject was calculated as recommended by WHO (1985), by summing up the energy cost for each activity (adjusted for body weight), multiplied by the duration of the activity performed.

Basal metabolic rate (BMR), defines as the minimum energy required while awake to maintain the physiological functions of the body (FAO/WHO/UNU, 2005), was calculated for all subjects based on body weight using the predictive equations [18-30 years: BMR (MJ/d) = 0.0550 (weight) + 2.480 or 30-60 years: BMR(MJ/d) = 0.0432 (weight) + 3.112] of Ismail et al. (1998).

Physical activity level (PAL) of subjects was calculated as the ratio of TDEE to BMR (PAL=TDEE/BMR) (FAO/WHO/UNU, 2005). The PAL of respondents was categorised according to the classification of EFSA (2013). The PAL values of 1.4 1.6, 1.8 and 2.0 reflect low active, moderately active, active and very active lifestyles, respectively.

Energy intake

The food intake of all subjects was obtained using a one day 24-hour diet recall. Household measurements were used to facilitate quantification of portion sizes which were then converted to energy and nutrient intake using a computer package based on the Nutrient Composition of Malaysian Foods (Tee et al., 1997).

Statistical analysis

Data were analysed using SPSS for windows version 10.01. Results are present in mean (± SD). Statistical comparison between groups were analysed using Analysis of Covariance (ANCOVA). Differences were considered to be statistically significant at p values less than 0.05.

RESULTS

The physical characteristics of the subjects are shown in Table 2. The mean age and body weight were no significantly different between the both group respondents. The athletes were significantly taller and had lower mean body mass index (BMI) and percentage of body fat compared to the non-athlete group.

Table 2: Physical characteristics of subjects **(mean ± SD)**

Variable	**Athletes (n = 83)**	**Non-athletes (n = 80)**
Age (yr)	28.4 ± 6.9[a]	29.9 ± 7.2[a]
Weight (kg)	64.2 ± 9.7[a]	66.3 ± 14.1[a]
Height (cm)	168.6 ± 5.4[a]	165.0 ± 5.1[b]
BMI (kg/m^2)	22.6 ± 2.9[a]	24.3 ± 4.6[b]

Body fat (%)	15.7 ± 5.4[a]	20.6 ± 5.8[b]

[a,b] *Within row, figure with different superscripts letters are significantly difference between groups at p<0.05*

Table 3 presents the mean time spent of various activities for one-day by the subjects. Generally during a normal day (non training day), the mean time spent for daily activities by the athletes, including time spent for exercise and sports activities were almost similar compared to the non-athlete group. However, during a training day, the mean time spent for sports activities by the athletes (124 ± 8.6 min/day) increased markly.

Table 3: The mean time spent for various activities of subjects (min/day and %)

Daily activities	Athletes (n = 83)		Non-athletes (n = 80)
	Normal day	Training day	
Lying/ sleep	472 (32.8)	448 (31.1)	425 (29.6)
Sitting	509 (35.3)	412 (28.6)	483 (33.5)
Standing	50 (3.4)	43 (3.0)	53 (3.7)
Walking	92 (6.4)	72 (4.0)	107 (7.4)
Up/down stairs	1 (0.1)	1 (0.1)	4 (0.3)
Personal activities	75 (5.2)	75 (5.2)	75 (5.2)
Praying	35 (2.4)	32 (2.3)	45 (3.1)
Domestic works	69 (4.8)	31 (2.1)	36 (2.5)
Office works	122 (8.5)	202 (14.0)	208 (14.4)
Exercise/sports	15 (1.1)	124 (8.6)	3 (0.2)
Total	1440 (100.0)	1440 (100.0)	1440 (100.0)

During a normal day, the mean TEE (2,272 ± 449 kcal/day) and EI (2,461± 558 kcal/day) of the athletes were not significantly different compared to the non-athlete group (TEE 2,268 ± 533 kcal/day; EI= 2,340 ± 387 kcal/day) (Table 4). During a training day, as the mean time spent for exercise or sports activities of the athlete group increased, the mean TEE of the athletes was increased to 2,861 ± 638 kcal/day, and the mean EI also increased to 2,739 ± 550 kcal/day.

Table 4: Basal metabolic rate (BMR), total daily energy expenditure (TEE), physical activity level (PAL) and daily energy intake (EI) of subjects (mean ± SD)

Variable	Athletes (n = 83)	Non-athletes (n = 80)
BMR (kcal/day)	1429 ± 215[a]	1442 ± 306[a]
TEE (kcal/day)		
Normal day	2,272 ± 449[a]	2,268 ± 533[a]
Training day	2,861 ± 638	-
TEE (kcal/kg/day)		
Normal day	35.2 ± 3.3[a]	34.1 ± 2.3[a]
Training day	44.5 ± 7.3	-
PAL		
Normal day	1.6	1.6
Training day	2.0	-
EI (kcal/day)		
Normal day	2,461 ± 558[a]	2,340 ± 387[a]
Training day	2,739 ± 550	-

[a] *No significant different between groups at p < 0.05*

The mean BMR values were similar for the athletes (1429 ± 215 kcal/day) and non-athlete (1442 ± 306 kcal/day) groups. The mean PAL values of the athletes group during a training/exercise day was 2.0, which was higher compared to the non-athletes (PAL=1.6).

DISCUSSION

In this study, we found that the athlete group had lower mean BMI and percentage of body fat compared to the non-athletes. The results can be explained by the differences of physical activity level among the groups. Regular physical activity may modify body composition and BMI, particularly by reducing body fat (Parizkova, 1989). Similar results were also reported by Withers et al., (1987) based on their studies among athlete and sedentary subjects. A study by Azmi et al. (2009) reported that the mean BMI of general Malaysian population of the same age group was 24.2 kg/m^2, which were relatively higher than the mean BMIs of the athletes and exercise groups of this study. In a study on Malaysian elite athletes at national level, aged 18 – 31 years by Wong et al., (2012), reported that mean BMI (22.7 kg/m2) and percentage of body fat (13.7%) were quite similar with the athlete group of or study.

Based on the activity patterns, we found that the mean time spent for daily activities during a normal day including active activities by the both group subjects were almost similar (3 to 15 minutes or 0.2% to 1.1% of the day). However, during a training day, the mean time spent for exercise and sports activities by the athletes (124 minutes or 8.6% of the day) were significantly higher compared with the non-athletes (3 minutes or 0.2% of the day). The time spent for exercise and sports activities of the athlete groups during a training or exercise day were slightly lower to that of Malaysian national athletes during centralised training which reported spent approximately 4 hours (17% of the day) in activities related to training (Ismail, Wan Nudri & Zawiah (1995). A study of Malaysian soldiers, relatively a physically active group, showed that the mean time spent on heavy activities accounted for 244 minutes or 17% of the day (Ismail, Isa & Janudin, 1996). In comparison with general adult population in Malaysia, Poh et al. (2010), reported that Malaysian men spent only about 11.4 minutes or 0.8% of the day for sports or exercise activities.

Total daily energy expenditure (TEE) of this study was estimated from calculations of BMR based on body weight, and self-reported physical activity recall. The mean TEE of the non-athlete group (34.1 kcal/kg/day) was almost similar as those reported by Ismail and Zawiah (1989) of the sedentary subjects of university students (33.9 kcal/kg/day). The mean TEE of the athletes (44.5 kcal/kg/day) of this study during a training or exercise day was slightly lower when compared to earlier studies on Malaysian national athletes (44 to 55 kcal/kg/day) (Ismail, Wan Nudri & Zawiah, 1997). However, the difference was expected since the measurements on the Malaysian national athletes were taken during centralized training, where the national athletes underwent intensive sport training.

This study found that during normal day or no physical training, the mean TEE of the athlete group was not significantly different compared to the non-athlete group. However, during a training or exercise day, the mean TEE of the athletes increased markly. This finding was similar when compared to some earlier studies in other country. Schulz et al. (1991) assessed the TEE of 20 endurance-trained and 43 untrained young men. During the day of no physical activity, they reported no difference in TEE between the two groups (trained: 2126 ± 186 kcal/day versus untrained: 2154 ± 245 kcal/day). Horton et al. (1994) measured TEE in five cyclists and five age and weight-matched sedentary female. When both groups had no exercise activity, no difference in TEE was found between the two groups (cyclists: 2264 ± 265 kcal/day versus sedentary: 2144 ± 249 kcal/day). However, TEE in the cyclists (3137 ± 419 kcal/day) was much higher than sedentary group (2206 ± 323) when they performed normal daily exercise training.

We also found that, the mean EI (2,461 kcal/day) and TEE (2,272 kcal/day) of the athletes during a normal day were not significantly different compared to the sedentary group (EI=2,340 kcal/day; TEE=2,268 kcal/day). During a training day, the mean EI of the athletes increased to 2,739 kcal/day, while the mean TEE increased to 2,861 kcal/day, with a negative energy balance of 122 kcal. Several previous studies have found athletes are in negative energy balance during training. Ismail, Wan

Nudri & Zawiah (1997) reported that the mean daily energy intake of Malaysian male national athletes during centalised training was 2784 ± 373 kcal/day while the mean daily energy expenditure was 3004 ± 298 kcal/day, with a negative energy balance of 220 kcal. A study among Kenyan endurance runners with a mean age of 21 years were also reported the runners were in negative energy balance during periods of seven days intensive training. However, the negative energy balance in the study was not accompanied by a significant loss in body mass (Fudge et al., 2006). There was one study by Brouns et al. (1989) in which dietary intake was strictly controlled since the subjects were in confinement. Brouns et al. simulated a Tour de France race in a metabolic chamber and calculated the daily energy balance from the energy expended and energy intake as calculated from daily food and fluid consumption. They found a positive energy balance during active rest days whereas during the exercise days, a significant negative energy balance was observed.

The PAL value of the athletes and non-athlete groups of this study was 2.0 and 1.6, respectively, which was similar to the classification by EFSA (2013). According to EFSA, the PAL values of 2.0 and 1.6 reflect very active and moderately active lifestyles, respectively. Similarly, Poh et al. (2010) reported that Malaysian men of general population had mean PAL value of 1.6, while Ismail, Wan Nudri & Zawiah (1997) reported that Malaysian men national athletes had PAL value ranges from 1.99 to 2.58.

The finding of this study can be used as a reference of energy intake for athletes on training and non-training days. For all athletes, in order to maintain the optimal physical performance, energy expenditure must be balanced with energy intake on a day-to-day basis (Pavlou, 1993). A daily food energy intake that is insufficient or exceeds energy expenditure may adversely affect the athlete's body mass, composition and function, and impair performance (Fraczek, Grzelak & Klimek, 2019). Based on this study, for male athletes (very active lifestyle or PAL=2.0), we found that the energy intake (EI) on training days is about 2860 kcal/day or 45 kcal/kg/day. While, on the day of no training activities, the EI for athletes is similar to the non-athlete group (moderately active lifestyle or PAL=1.6), about 2270 kcal/day or 34 kcal/kg/day. The findings of this study support the recommendations of the energy intake (RNI) for Malaysia 2017 (NCCFN, 2017). The RNI for Malaysia 2017 has recommends that the EI for Malaysian male adults, age 19 to 29 years, with PAL value of 1.6 and 2.0 is 2240 kcal/day and 2800 kcal/day, respectively.

CONCLUSIONS

This study found that athletes have a better appearance of physical characteristics than non-athletes. During normal day or the day of no physical activity, the mean TDEE and EI of the athletes were almost similar to the non-athletes. During a training day, the mean TDEE and EI of the athletes increased markly. However, the EI on a training day was insufficient to match their training demand. Proper diet planning together with nutrition education are vital for athletes to achieve energy balance. Inadequate or excessive consumption of energy during physical exercise may affect physical performance and overall health status.

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