

Differences of energy intake and energy expenditure of elite Taekwondo players receiving summer vs. winter intensive training

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Kang Ok Cho. Differences of energy intake and energy expenditure of elite Taekwondo players receiving summer vs. winter intensive training. *JENB*, Vol. 18, No. 2, pp.169-174, 2014 **[Purpose]** This study aimed to evaluate the energy expenditure and energy intake as an experiment of energy balance of elite Taekwondo players receiving summer vs. winter intensive training. **[Methods]** The summer training group (STG, $n = 15$) and the winter training group (WTG, $n = 18$) wore an accelerometer for the measurement of energy expenditure and maintained a daily dietary record for measurement of energy intake, for seven consecutive days during summer or winter intensive training. **[Results]** The total energy expenditure (TEE) (834.1 kcal, $p < .001$), the total counts (1,867 counts, $p = .038$), and the energy expenditure during moderate (384.6 kcal, $p < .001$) and vigorous activity (351.8 kcal, $p < .001$) were significantly lower in the STG than in the WTG. On the other hand, the macronutrient intake showed that intake of energy (902.7 kcal, $p < .001$), carbohydrates (82.6g, $p < .001$), and protein (93.9g, $p < .001$) in the STG were significantly lower than those of the WTG. When comparing TEE and total energy intake, the STG consumed 902.7 kcal less as energy than the WTG, while the STG performed 834.1 kcal more as TEE than that of the WTG. **[Conclusion]** In conclusion, both of the summer and winter intensive training are not proper for energy balance condition. Therefore, to promote the optimal energy balance during the summer or winter intensive training period, a training and sports nutrition program based on the amount of energy expenditure and energy intake for Taekwondo players should be considered. **[Keyword]** Taekwondo; energy balance; energy expenditure; energy intake; sports nutrition

INTRODUCTION

Taekwondo is a Korean martial art and sport with its origin dating back at least 1000 years. After reports that practicing Taekwondo can promote intellectual and emotional growth and has positive impact on physical health while providing social benefits, its popularity has been on the rise [1,2]. Despite these advantages, due to the competitive nature of this sport, injuries or even disabilities can result in some players, which in turn could prevent them from engaging in the match with the best of their abilities [3,4].

An annual training for Taekwondo players consists of the preparation, competition, and transitional periods. The competition stage requires a special program during the preparation period that helps with the players' cell adaptation and maintenance of healthy muscular and nervous systems, so that their highest performance can be exhibited during the competition games

[5]. Thus, during this particular period, it is advised that athletes receive comprehensive management and protection that covers physical, technical, tactical, and mental aspects [6-8]. However, the typical professional taekwondo players, who are mostly students, usually practice challenging and repetitive routines that include exercise, stay-in-camp training, and combat, which obviously affect their performance in the competition games.

Particularly, intensive camp training during hot or cold weather could impose both physical and mental stress on players [5,6]. During the summer training, the amount of metabolic heat exceeds heat loss and dehydration may either be a direct or indirect factor for heat illness ranging from muscle cramps to life-threatening hyperthermia. On the other hand, winter training environment contribute to hypothermia, frostbite, and diminished exercise capability and performance [9]. Some studies reported that stress caused energy imbalance

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which may influence stress-induced physiological and psychological responses. Thereby, the energy imbalance and hot or cold weather training environment were attributed to the stressors for elite players [10].

Appropriate energy balance is an important goal for athletes, particularly during intensive training. In addition, maintaining energy balance along with adequate nutrient intake optimizes sports performance and overall health [11]. According to studies, it is believed that people who do not have professional athlete career can increase their physical capacity through summer training rather than winter training activities, because there are less temptations of food because appetite tends to be lower in hot weather and media devices can be used for the purpose of entertainment during the training [7,8,12]. However, it is still not clear whether that theory also applies to professional athletes, and more importantly, whether a summer or winter environment is more suitable for maximizing the effectiveness of training for players who receive training at a camp.

Therefore, this study sets the conditions for both the summer and winter intensive training groups of Taekwondo athletes to undergo the same exercise program, and their level of activities and consumption of calories were analyzed in order to find the energy balance condition that can maximize the effectiveness of the training of Taekwondo players.

METHODS

Participants

Taekwondo athletes (summer training group; STG, $n = 15$; winter training group; WTG, $n = 18$) were recruited through invitations disseminated by the coaching staff over a 6-month period of a semester. This study was approved by the ethics committee of the Seoul National University. Informed consent was obtained from all participants before the start of the study, in accordance with the policies and procedures of the institutional review board. All participants were instructed to maintain their typical diet and physical activity patterns during the study.

Taekwondo program

Table 1 shows the Taekwondo program for intensive summer or winter training. Subjects participated in the same training program (a 4-week of summer or winter intensive training program). To study of differences between summer and winter intensive training, all Taekwondo players were

Table 1. Training program of Taekwondo

Time	Training program	
Training I (08:00-09:30)	10 km run, speeding run	
Training II (10:30-12:00)	Technical training, tactical training	
Training III (14:00-17:00)	Real competition	
Training IV (19:00-20:30)	Personal training, image training,	

Table 2. Baseline of physical characteristics (Mean \pm SD)

Variables	Summer training group ($n = 15$)	Winter training group ($n = 18$)	p -value
Age (years)	22.1 \pm 2.4	21.3 \pm 2.1	.993
Height (cm)	174.7 \pm 17.3	175.0 \pm 15.6	.870
Weight (kg)	69.4 \pm 9.4	68.3 \pm 8.3	.708
Body mass index (kg/m ²)	22.9 \pm 4.4	22.3 \pm 3.4	.095
Muscle mass (kg)	54.6 \pm 7.3	55.3 \pm 6.6	.262
Fat mass (kg)	11.9 \pm 4.7	11.2 \pm 3.4	.708
Systolic blood pressure (mmHg)	115.9 \pm 13.6	115.2 \pm 12.8	.912
Diastolic blood pressure (mmHg)	74.9 \pm 8.8	73.6 \pm 9.8	.154
Experience as player (years)	8.7 \pm 2.9	8.7 \pm 3.1	.998

instructed to participate in a same Taekwondo program. The subjects received technical, physical, tactical, and image training seven times a week. The training sessions on Mondays, Tuesdays, Thursdays, and Saturdays were of moderate intensity, the training sessions on Wednesday and Friday were of sub-maximal intensity, and the training session on Sunday was of maximal intensity [11].

Physical characteristics

Anthropometric measurements were collected using the restricted protocol of the International Society for the Advancement of Kinanthropometry [13]. Body composition was determined via bioelectrical impedance (Inbody 3.0, Biospace, Korea) and all participants were instructed to weigh with an empty bladder immediately after waking up in the morning and before breakfast [14]. Blood pressure was measured on the right arm using a standard mercury sphygmomanometer (Baumanometer, USA). Physical characteristics of the subjects are presented in Table 2. Before participation of the intensive summer or winter Taekwondo program, physical characteristics of the summer training group and winter training group were examined to verify that there are no significant differences.

Measurements of energy expenditure

Physical activity was measured as energy expenditure with an accelerometer. The accelerometer (Actical, Minimeter, USA) was secured to the anterior to the iliac crest with an elastic belt and worn for 7 days during the second week of the summer or winter intensive training program. Prior to measurement, the age, sex, height, and weight of each participant were entered into the device. The total energy expenditure, activity energy expenditure, and time of activity depending on the PA intensity and frequency were individually measured. The results were automatically stored. Using the recorded data, the energy expenditure was calculated based on Muffin's formula, and this was used to calculate the basal metabolic rate [15]. Activity counts were converted to energy expenditure using the Actical software; the total energy expenditure (TEE), total counts (TAC), and energy expenditure during light activity (EEL), moderate activity (EEM), and vigorous activity (EEV) were determined. In this study, 60-second sampling epochs were used, and the average values of TEE, TAC, EEL, EEM, and EEV were used per day for over 7 days [12, 15,16].

Measurements of energy intake

For the measurements of energy intake, all participants maintained a daily dietary record during the same 7 days while the accelerometer was worn (at the second week of the summer or winter intensive training program). We asked the subjects to record their intake of all food and to quantify the portion of foods consumed, by referring to the information on weight or volume provided on the food package or by using standardized measures. Data from the dietary diaries were analyzed using the Can-pro program (Version 3.0, Korean Nutrition Society, Korea), which is a nutrient intake assessment program developed by the Korean Nutrition Society. Based on the dietary intake data provided by the subjects, the average daily intake of energy, carbohydrates, protein, and fat were determined [12]. To determine the average daily energy, carbohydrate, protein, and fat intake, all participants recorded their daily dietary information using the dietary recall method. The foods that could not fit into a standard measure were described by the dimensions of their shape with a grid measured in centimeters, to allow these measurements to be done accurately [16].

Data analyses

Data analyses were conducted using the SPSS package (Version 18.0, Chicago, USA), and descriptive statistics are presented as mean \pm standard deviation. Mean comparisons

between the summer and winter training were analyzed using independent sample *t*-tests. The alpha level (α) of $p < .05$ set a priori was considered to be statistically significant in all analyses.

RESULTS

Energy expenditures according to the intense activity level

The comparison of energy expenditure between the WTG and STG is presented in Table 3. The TEE (834.1 kcal, $p < .001$), TAC (1,867 counts, $p < .001$), EEM (384.6 kcal, $p < .001$), and EEV (351.8 kcal, $p < .001$) were significantly higher in the STG than in the WTG. However, the EEL value showed no significant difference between the STG and WTG.

Table 3. Energy expenditures according to physical activity level (Mean \pm SD)

Variables	Summer training group	Winter training group	<i>p</i> -value
TEE			
TEE (kcal)	5,670.6 \pm 189.9	4,836.5 \pm 123.2	< .001
kcal/kg body weight	81.7 \pm 6.4	70.8 \pm 4.7	< .001
TAC (counts)	16,235 \pm 175.7	14,368 \pm 129.410	.038
EEL (kcal)	753.2 \pm 84.3	657.1 \pm 98.8	.154
EEM (kcal)	3,009.3 \pm 245.5	2,623.7 \pm 146.1	< .001
EEV (kcal)	1,908.7 \pm 216.1	1,556.9 \pm 175.8	< .001

Abbreviations; TEE = total energy expenditure, TAC = total counts, EEL = energy expenditure of light intense activity, EEM = energy expenditure of moderate intense activity, EEV = energy expenditure of vigorous intense activity.

Table 4. Total amount of macro-nutrients intake (Mean \pm SD)

Macro-nutrients	Summer training group	Winter training group	<i>p</i> -value
Total energy			
Total intake (kcal)	3,754.3 \pm 306.6	4,657.0 \pm 413.5	< .001
kcal/kg body weight	54.1 \pm 7.3	68.2 \pm 8.5	< .001
Carbohydrate			
Total intake (g)	506.9 \pm 147.1	589.5 \pm 152.2	< .001
g/kg body weight	7.3 \pm 0.9	8.6 \pm 1.7	< .001
% of total energy intake	59.1 \pm 10.8	56.6 \pm 9.8	< .001
Protein			
Total intake (g)	210.6 \pm 19.9	304.5 \pm 20.3	< .001
g/kg body weight	3.0 \pm 0.3	4.5 \pm 0.7	< .001
% of total energy intake	16.2 \pm 8.7	23.7 \pm 6.6	< .001
Fat			
Total intake (g)	97.8 \pm 13.7	97.9 \pm 23.2	.980
g/kg body weight	1.4 \pm 0.4	1.4 \pm 0.7	.980
% of total energy intake	23.7 \pm 6.3	21.7 \pm 6.8	.113

Composition of energy intake

The composition and comparison of energy intake between the WTG and STG is presented in Table 4. Comparisons of the daily macronutrient intake showed that the intake of total energy (902.7kcal, $p < .001$), carbohydrates (82.6g, $p < .001$), and protein (93.9g, $p < .001$) in the WTG were significantly higher than those of the STG. However, fat intake of the STG and WTG did not show significant difference.

DISCUSSION

This study focused on the energy expenditure and energy intake of Taekwondo players during summer or winter intensive training period. As previously mentioned, adequate attainment of energy balance becomes an important goal for athletes, particularly during heavy training or multiple daily workouts, because maintaining energy balance with appropriate nutrient intake optimizes exercise performance and the training response [11,12]. Yet, due to the weight-class in Taekwondo, athletes continually strive to maintain a lean, light body mass. As a result, energy intake often intentionally falls short of energy expenditure, and a relative state of malnutrition develops. In particular, the energy demands of Taekwondo have been well quantified in conjunction with dietary factors, especially in young Taekwondo athletes.

In this study, the energy expenditure and energy intake of participants in a summer and winter intensive training program were analyzed. The summer or winter intensive training program in this study was the most common program for Taekwondo athletes who are ready to participate in a competition, for maintaining their physical condition during the competition period. We tried to recruit Taekwondo players with similar characteristics to participate in this study, for the purpose of the analysis.

Accelerometers measure the acceleration of the body and quantify the intensity, frequency, and duration of physical activity, by providing estimations of energy expenditure [17]. Accuracy in estimation of energy expenditure is a problem in both the general public and in athletic populations. Accelerometers have been increasingly utilized as a valid instrument for studies on physical activity [15]. A single Taekwondo match has 3 rounds of 2 minutes each, and the factors that determine a practitioner's performance include the ability to develop power instantly, the speed of the attack, agility to smoothly convert from attacking to blocking, muscular endurance to achieve repeated movement, and the anaerobic capacity to move rapidly and explosively. Thus, comprehensive

training and appropriate diet are required to improve one's athletic fitness and performance in Taekwondo [12].

We found that the summer training group performed 834.1 kcal more as the TEE value than that of the winter training group. However, a comparison of dietary energy intake values between the groups revealed that the winter training group consumed 902.7 kcal more than that of the summer training group. In other words, this result showed that the energy balance between TEE and energy intake were environment-dependent. During the Taekwondo training in this study, players were exposed to unbalanced energy management, since it was during the summer or winter intensive training period. In general, people are able to exercise and work in many different cold or hot weather environments. For the most part, cold or hot weather is not a barrier to performing physical activities. Many factors-including the environment, clothing, body composition, health status, nutrition, and exercise intensity-interact can determine if exercising in the cold or hot temperature elicits additional physiological strain and injury risk [9,10]. The TEE, EEM, and EEV values in the summer training players in this study were significantly high compared to those of the winter training players. This means that the moderate and vigorous physical activities were enhanced to the total energy expenditure during the summer intensive training compared to the winter intensive training.

Nutrient intake in athletes is usually compared by recommendations developed for the general population according to age, gender, and country [18]. Susan *et al.* [19] reported that the Nutrient Reference Values (NRV) and Dietary Reference Intake (DRI) include the Estimated Average Requirement (EAR) and RDI/A (Recommended Dietary Intake/Allowance), which specify the nutrient intake required to meet the needs of half (50%) and nearly all (97-98%) healthy individuals, respectively. However, the mean nutrient intake for athletes is most often reported and used to assess nutritional adequacy. Dietary surveys of athletes often report inadequate or inappropriate dietary intake compared to athletes' nutritional or population dietary reference recommendations [18,19]. These data represent an effort to understand energy balance based on training environmental characteristics. The proportions of Taekwondo players in this study met the minimum sport nutrition recommendations for 1.2 g/kg as protein [20] and 5.0 g/kg as carbohydrate [21], in both WTG and STG. In addition, the winter training players showed an energy intake of 4,657.0 kcal, while the summer training players showed an intake of 3,754.3 kcal. Some studies reported that stress caused energy imbalance, which was attributed to the inclination to intake more food [22-24]. Moreover, Lemmens *et al.* [25] and Cho *et al.* [26] showed that the hot or cold

weather during training acted as a stressor. The appropriate attainment of energy balance becomes an important goal for athletes, particularly during a heavy training or multiple daily workouts [27]. We found that the summer training group performed 834.1 kcal more as the total energy expenditure value than that of the winter training group. On the other hand, it was revealed that the summer training group consumed 902.7 kcal less than that of the winter training group. These results indicated that neither the summer intensive training nor winter intensive training for Taekwondo players is appropriate for the maintenance of energy-balanced condition. Therefore, when attempting to enhance Taekwondo player's physical condition during the summer or winter intensive training period, the nutrition program based on the energy expenditure and energy intake should be considered according to the training environment.

The current study was conducted to evaluate energy intake and training in elite Taekwondo players. Among the many powerful variables associated with nutrient intake, fluid intake was not included in the current study because the Can-pro program cannot analyze the water contents of food. In addition, due to the lack of existing data, it was impossible to directly compare data from the present study with other studies of Taekwondo players. Thus, another limitation of the present study is that the comparisons were made with athletes of other sports. Therefore, more studies on the nutrient intake of Taekwondo players are needed to provide more comprehensive data to ultimately promote optimal health and performance in Taekwondo players.

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