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Energy expenditure and intake in judo athletes during training camp

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Key words: physical activity, training of judo, SenseWear Armband, (SWA), expenditure of energy, intake of energy

Summary

Introduction. This study aimed to assess total energy expenditure (TEE), physical activities and energy intake in high-level judo athletes.

Material and methods. Twenty junior and senior Flemish judo players completed a food diary and activity diary (AD) and simultaneously wore a Sensewear armband (SWA) during a 3 days judo training camp.

Results. TEE was significantly lower when estimated with the SWA compared to the activity diaries (respectively 3137 ± 505 versus 3554 ± 595 kcal/day). SWA values were higher for the non-sport activities compared to the estimates from the diaries. Estimated energy expenditure for randori, the most practiced type of exercise (mean time: 162 ±49 min/day) was significantly lower for the SWA (707±258 kcal/day) versus the sport specific estimate from the diaries (1545±401 kcal/day).

Conclusions. Estimation of energy expenditure in judo athletes is complex. Energy expenditure during randori as estimated with the SWA is rather low when compared to the reference values. The combination of different methods such as activity diaries and SWA may improve the estimate of the energy expenditure in judo athletes.

Introduction

For optimal athletic performance, recovery and body composition, athletes need to synchronize diet and physical activities. Especially in judo athletes, where competition is organized in weight categories, the balance between energy intake and energy expenditure is of uttermost importance [1]. Data concerning energy intake during training and competition preparation – often a weight reduction period- are available [2,3,4]. However, the literature lacks data on the energy balance during the training period of judo athletes. When not in weight reduction period, special attention needs to be given to energy intake, providing sufficient energy for basal metabolism, physical activities, and recovery without caloric overshoot [5]. A highly positive energy balance during training periods may result in excessive weight gain with negative consequences for the following weight reduction period.

In order to properly harmonize an athlete's dietary intake and training program, assessing the energy balance and physical activity status of the athlete is required [6,7,8]. Energy expenditure during training in judo athletes is not well described. The training program of a judo athlete is diverse, and consists of judo specific training (technique and randori) and non-specific training (resistance training, endurance training), [9,10].

Randori, which is a type of fight training, can be categorized as a high intensity activity with an intermittent pattern of activity and relative rest more or less comparable with a competition fight [10]. The diversity of the training program, the unstructured activities during the randori training, and the contact with the opponent, make it very difficult to estimate energy expenditure with most of the available methods.

Monitoring should be done in the athlete's normal environment enabling maintenance of habitual activity participation and dietary intake. Therefore, the methods used to determine activity pattern and dietary intake should preferably be as accurate as possible and at the same time easy in use with a minimal burden on the athlete.

An activity diary (AD) is considered to be one of the most accurate subjective techniques, despite the high participant burden [8].

Though self-report methods can be a principal source of information, other approaches or the use of combined measures may be needed to characterize better an athlete's activity level. Reporting the results with different instruments provides a more complete description of activity levels and permits triangulation of outcomes [11].

The SenseWear Armband (SWA) combines five different sensors into one device attached as an armband around the upper arm. The SWA has shown to give reliable estimates of TEE in healthy free living adults [12,13,14]. Johannsen et al. [14] found a significant agreement between the SWA and doubly labeled water estimates of TEE. Fruin and Rankin [15] found the SWA to provide valid and reliable estimates of energy expenditure at rest and on an ergometer as compared to indirect calorimetry.

On the other hand, the SWA does not provide information on the type and context of all other activities. Moreover, several studies have shown the SWA to underestimate the energy cost of most activities and this underestimation increases with increasing exercise intensity [14]. Still, the SWA remains highly feasible in use. More particularly, for judo research, the sensor can be worn under the judogi and allows all judo movement and contacts.

It was the aim of this study to assess TEE of judo athletes by means of a 3 days activity diary and a multi sensor activity meter, the SWA. It was also the aim to describe judo specific energy expenditure (randori, technique training). Total Energy Intake (TEI) data obtained by 3 days food records were used to calculate the energy balance.

Material and methods

Subjects

Twenty judo athletes of national (n=4) and international (n=16) level took part in the experiment (mean age 19.6±2.4 years of age). The athletes were followed 3 days during a judo training camp. Due to the limited availability of the SWA (3 instruments), data were collected on 7 different training camps.

In accordance with the university's ethical committee they were asked to give their written informed consent.

Body weight

Body weight was measured every morning before breakfast in minimal clothing using a Soehnle 63691 balance, accurate up to 100 g.

Energy expenditure and physical activities

Basal energy expenditure (BEE) was calculated using the Harris & Benedict formulas (Frankenfield et al., 1998).
Respectively:
BEE♂ = 66 + (13.7 x weight (kg)) + (5 x body height (cm)) – (6.8 x age (years)
BEE♀ = 655 + (9.6 x weight (kg)) + (1.8 x body height (cm)) – (4.7 x age (years)

Body weight was the average weight over the 3 days while self reported body height was used.

During the training camp, athletes completed a physical activity diary (AD) reporting the type and time spent in the different activities. After the training camp, MET intensity scores for non-sport activities were attributed discriminating between time spent in supine position (1 MET), for sitting position (1.5 METS), standing position (2.2 METS) or light activities such as walking (3 METS).

Energy expenditure for non-sport activities was calculated according to the following formula:
Energy Expenditure (non-sport activities) in kcal
= BEE (time in minutes) X METS/1440

Sport activities were analyzed separately using sport specific energy expenditure values as proposed by McArdle, Katch & Katch [16]. Briefly, sport specific energy expenditure values (in kcal) are given per kilogram of bodyweight. This reference gives a very high energy expenditure for judo, referring to judo competition. As randori training is generally split in randori time (50%) and real rest time (50%) only half of the energy expenditure value as proposed by McArdle, Katch & Katch was used for the calculation of the energy expenditure during randori training. For the other types of sport activity the values as proposed by McArdle, Katch & Katch [16] were used.

Total energy expenditure (TEE) was estimated by adding up the non-sport activity energy expenditure and the energy expenditure during sport activities.

The SenseWear Pro3 Armband (BodyMedia Inc., Pittsburgh, PA) was worn on the back of the right upper arm during the 3 days of the training camp. The SWA is a multiple-sensor device collecting data from a skin temperature sensor, near-body temperature sensor, heat flux sensor, galvanic skin response sensor, and a biaxial accelerometer. The skin temperature sensor and near-body temperature sensor (a vent on the side of the armband) consist of sensitive thermistors in contact to the skin relying on change in resistance with changing temperature. The heat flux sensor uses the difference between skin temperature and near-body temperature to assess heat loss. The galvanic skin response sensor measures the conductivity of the skin between two electrodes in contact to the skin. The conductivity of the skin varies according to physical and emotional stimuli. The biaxial accelerometer registers the movement of the upper arm and provides information about body position. The information from the sensors, together with gender, age, height, and weight, are incorporated into proprietary algorithms to estimate energy expenditure. These algorithms are activity specific and are automatically applied on the basis of an analysis of the pattern of signals from the sensors. Energy expenditure was calculated at 1-min intervals, using Sensewear Professional Software, including data from all sensors, together with gender, age, body height, and weight.

The SWA has to be taken off when showering, bathing, swimming, or in case of hinder. In such case, the SWA stops measuring and automatically takes the calculated BEE for energy expenditure during the period when not worn.

Combination of the data from the activity diary (time and duration of the different activities) and the SWA output (kcal/minute) allowed the analysis of sport specific energy expenditure as estimated by the SWA.

Energy intake

During the same period the SWA was worn, total energy intake (TEI) was estimated based on the completion of a 3-day food diary. The athletes were clearly instructed to maintain their normal eating pattern and to report all foods as accurately as possible considering preparation, composition and portion size. For the latter they were asked to weigh off the items, using a household balance (Proline KS5, precision ±1g). When not feasible, household measures were given to make an estimate of the portion size. The dietician/researcher was always available for help or information during the completion period. Diaries were analysed by one and the same investigator using the Belgian food data bank [17].

Statistics

Statistical analysis was performed with SPSS 17.0. The Kolmogorov-Smirnov test was used to test for normal distribution of the data. To compare TEE according the AD and the SWA, and to compare TEI with TEE as estimated by the AD and SWA, a paired t-test was applied. Comparisons between different groups were carried out using the unpaired t-test procedure. Comparison between the time spent in different sport activities was carried out using a oneway ANOVA procedure. The significance level was set at $p < 0.05$.

Results

Subjects' characteristics are given in Table 1. The female subjects (n=12) were older (20.5 ±2.3 years) compared to the male subjects (n=8), (18.3±1.9 years) (p=0.035). No hindrance was reported concerning the wearing of the SWA.

As indicated by the daily reported body weight, body weight remained stable over the entire training camp (respectively 65.1 ± 9.3; 65.0 ± 9.1; 65.0 ± 9.3 over the 3 days, p>0.05).

The mean total training time over the 3 days period was over 3 hours per day. Time spent in different types of training is presented in Table 2.

Data collection during several training camps (with different training programs) resulted in a considerable variability for the time spent in different activities. Most attention is given to judo specific activities with significantly more randori training compared to all other types of training ($p < 0.01$). No differences were found between the time spent for other sport activities (all $p > 0.05$).

Total energy expenditure, energy expenditure without sports, energy expenditure during sport activities and energy expenditure for the different sport activities as estimated from the diaries and the SWA are given in Table 3. Day to day values as well as mean values over the 3 days are presented.

TEE as estimated by the combination of non-sport and sport activities from the AD, was always higher compared to the TEE as estimated by the SWA. Significant differences were found on every training day and for the mean value over the 3 days.

For the estimation of non-sport activities significant lower values were detected for the AD method compared to the SWA on training day 1 and 2 but not on training day 3. Mean value of the non-sport activities as measured over the 3 days was significantly lower for the AD method compared to the SWA.

Energy expenditure for all sport activities together as estimated from the AD (sport specific energy expenditure) was significantly higher compared to energy expenditure as estimated with the SWA. This finding holds for the 3 training days as well as for the mean value over the 3 days.

Analysis of the different training activities indicated that the estimation of energy expenditure during randori training, based on sport specific energy expenditure values as proposed by McArdle, Katch & Katch [16], was almost double compared to the estimation by the SWA ($p < 0.05$). Again, this significant difference was noticed on the 3 training days and hence also for the mean value over 3 days.

For the other training activities (technique, running, resistance training) only on day 1 a significant difference was detected for running activity with higher values for the diaries compared to the SWA estimation.

Energy intake as calculated from the food diaries was comparable over the different days: 2690±886 kcal on day 1, 2675±775 kcal on day 2 and 2901±988 kcal on day 3 ($p > 0.05$) resulting in a mean intake of 2913±697 kcal/day.

When comparing TEI with the TEE a significant negative energy balance is detected when the TEE was calculated from the AD on day 1 and day 2 but not on day 3 (Figure 1). Mean TEE calculated from the AD over the 3 day evaluation period was significantly above the mean TEI calculated over the same period ($p < 0.01$). When estimating TEE with the SWA, a negative energy balance was detected on day 1 and day 2 and not on day 3. Mean SWA calculated TEE was not significantly different from mean TEI.

Table 1. Description of the subjects

	n	Age (years)	Weight	Height
Males	8	18.3±1.9	68.6±9.3	171±9
Females	12	20.5±2.3	62.8±7.9	167±6
Total	20	19.6±2.4	65.1±9.3	168±9

Table 2. Time (min) spent in different sport activities

Training type	Day 1	Day 2	Day 3	Mean
Randori (min)	185±63	154±93	146±61	162± 49
Running (min)	7±14	10±16	2±6	6±7
Running (min)	13±33	4±17	19±27	12±18
Technique (min)	18±28	27±46	18±44	21±37
Total (min)	223±68	194±81	185±86	201±39

Table 3. Daily and mean total energy expenditure and expenditure (kcal) for the different activities estimated from the AD and the SWA. * Indicates a significant difference between the AD and the SWA values. EE= energy expenditure

	Day 1		Day 2		Day 3		Mean	
	AD	SWA	AD	SWA	AD	SWA	AD	SWA
TEE (kcal)	3747±788	3212±654*	3454±547	3198±701*	3461±774	3000±504*	3554±595	3137± 05*
TEE without sport (kcal)	1953±328	2189±517*	2029±356	2262±509*	2167±946	2114±620	2009±258	2227±407*
EE-Sport (kcal)	1793±611	1023±403*	1308±500	850±379*	1440±693	768±430*	1545±401	901±300*
EE- Randori (kcal)	1553±585	843±345*	1165±696	686±453*	1226±579	624±257*	1315±463	707±258*
EE-Technique (kcal)	88±142	69±113	137±252	123±237	92±229	74±183	106±195	89±167
EE-Running (kcal)	72±151	32±67*	80±135	110±194	22±54	10±26	58±67	51±63
EE-Resistance (kcal)	80±207	79±212	27±119	19±84	93±131	91±134	66±105	63±104

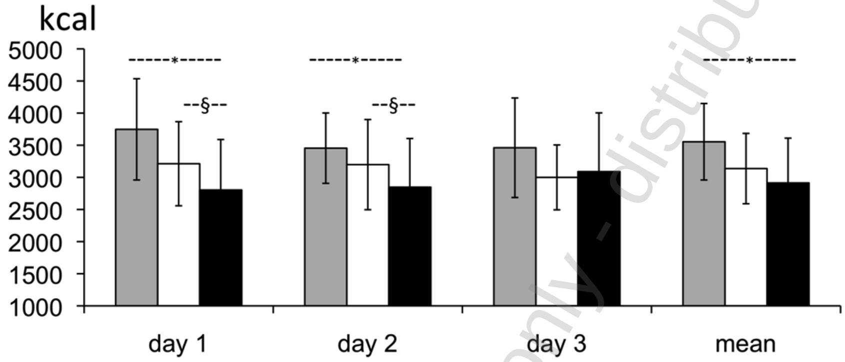

Figure 1. Comparison between TEE as estimated from the diary and the SWA compared to energy intake. (-----*------)= p<0.05 when comparing TEE estimated from the AD (■) with TEI; (--§--)=p<0.05 when comparing TEE (□) estimated from the SWA with TEI (■)

Discussion

Knowledge of an athlete's TEE and energy expenditure during physical activities is a requisite to properly plan dietary intake according to the specific needs and goals of the individual [6,7,8]. In this special group of high level judo athletes (16 international level and 4 national level) we simultaneously assessed TEE and TEI in combination with detailed information on participation in training activities which offers new insights in the energy and physical activity status that can be taken in consideration when programming training and dietary intake.

All subjects showed a good compliance to the 2 diaries and the wearing of the SWA. This may be explained by the presence of the researcher/dietician, an international judoka participating at the different training camps, and hence always available for information during the completion of the diaries.

Analysis of the diaries indicated that mean total training time varied from almost 4 hours on day 1 to 3 hours on day 3. During the training camps, with in general the availability of high level judo athletes from other countries, most of the training time is dedicated to randori with less attention to running, resistance and technique training.

The high standard deviations in the energy expenditure for the training activities can be explained by the variability of the program during the different training camps. Only the randori training was strictly scheduled during the different training camps whilst the other activities showed an irregular pattern with for example some athletes performing no resistance training at all compared to athletes with 60 minutes of resistance training daily.

When comparing the TEE as estimated by the AD versus the SWA we always recorded significant lower values with the SWA. More detailed analysis of the different activities indicates that the SWA gives higher energy expenditure values for daily, non-sport activities compared to the estimates from the diaries. On the other hand, the energy expenditure for sport activities is generally lower when estimated by the SWA compared to the AD. Especially the energy expenditure for randori, the most important training activity during the different training camps, is much lower when assessed with the SWA compared to the AD. Randori, is a high intensity intermittent activity without a predictable movement pattern, which seems difficult to register with the SWA. As reported elsewhere, the SWA instrument seems very suitable for the estimation of daily physical activity but seems to under estimate for high intensity activities [18]. The latter was found for running, which is a more structured and predictable activity compared to randori training. The under estimation of the SWA compared to the values proposed by Mc Ardle, Katch & Katch [16] seems to be substantial.

On the other hand the values as estimated in our experiment are in good agreement with the values as estimated by Degoutte et al. [4] using diaries and a sport specific energy expenditure estimate for judo. In these French judo athletes mean daily energy expenditure was 3325±144kcal/day compared to 3554 ±595 kcal/day and 3137±505kcal/day respectively with the diaries method and the SWA method. Analysis of daily energy expenditure without sport activity (1818±72 kcal/day) is comparable with our dairy estimated energy expenditure (2009±258 kcal/day) while it seems lower compared to the SWA estimated expenditure (2227±407 kcal/day). Daily sport activity in the French study accounted for 1746±119 kcal/ day compared to our diary estimates of 1545± 401 kcal/day. This is in contrast to the SWA values in our study, which reveals a lower energy expenditure due to sport activities (901±301 kcal/day). Moreover, in the French study a mean training activity of 2 hours/day judo training only, was taken into account. When using their judo specific energy expenditure value (12 kcal/h/kg) on our randori data, a mean daily energy expenditure for randori of 2109 kcal is obtained. If we used the values proposed by McArdle, Katch & Katch [16] without taking into account the specific nature of randori training (50% randori and 50% rest) then a value of 2630 kcal is obtained. This is almost 4 times higher compared to the SWA estimate.

A significant negative energy balance was calculated when comparing energy intake, as estimated by 3 days food records, with the energy expenditure as estimated by the diaries on the first and the second day and for the mean value over the 3 days. The energy balance was negative only on day one and two when SWA values for energy expenditure were used.

Energy intake in our study (44.8±10.0 kcal/kg.day) was close to the intake as reported for French judo athletes (42.8 ± 2.6 kcal/day), Degoutte et al. [4] and for Japanese judo athletes (43.0± 12.0 kcal/day and 38.4±5.6 kcal/day) for the two experimental groups as reported by Umeda et al. [3].

The constant body weight over the different days is in contrast to the findings of a negative energy balance. Hence, as is the case in most of the self reporting studies an underestimation of energy intake and an overestimation of energy expenditure may have occurred [7]. In the light of a neutral energy balance, the SWA seems to deliver an acceptable estimate of the TEE.

Conclusion

The estimation of energy expenditure in judo athletes remains an endeavour. Due to the structured nature of some training items and the unstructured nature of other items a combination of energy expenditure estimation methods may be advised. Although the SWA seems give low energy expenditure values for the randori activity it delivers acceptable values for the other types of physical activity. Therefore, we advice the combination of AD with the SWA. The SWA can help to refine the AD since it records minute by minute the activity and it allows to add time markers (e.g. beginning of a certain training; end of a certain activity). Additional research is necessary to obtain more conclusive results on the energy expenditure during judo specific activities.

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