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Original Paper

Validity of Dietary Surveys in Physically Active Japanese Male Students

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Abstract

Under or overestimating dietary intake is considered a serious problem in dietary surveys. We compared estimated energy intake (EI) with measured total energy expenditure (TEE) in 22 physically active Japanese male students (age: 20.6 ±1.2 years: active group) and 37 physically non-active male students (age: 19.3±1.4 years: control group). EI was estimated by a food frequency questionnaire (FFQg). TEE was calculated by using the time study method with a measured basal metabolic rate.

The accuracy of EI (EI/TEE) was 0.57 in the active group and 0.74 in the control group; showing a significant difference between the two groups ($p < 0.01$). EI/TEE was negatively associated ($r = -0.395$, $p < 0.05$) with BMI in the control group, but not in the active group. Intake of confectioneries, oils and fruits in the active group was significantly higher ($p < 0.01$, $p < 0.05$, $p < 0.01$ respectively) than the control group. Intake of confectioneries and fruits per 1,000kcal was significantly higher ($p < 0.05$, $p < 0.01$ respectively) but grains were significantly lower ($p < 0.01$) in the active group than the control group. EI/TEE was positively associated ($r = 0.539$, $p < 0.05$) with intake of fish per 1,000kcal in the active group. These results suggested that underestimating dietary intake might occur more often among physically active male students than physically inactive male students and it seemed to be associated with their lack of interest in food rather than psychological factors.

Introduction

Obesity in men is increasing in Japan lately, and the correlation between obesity and metabolic syndrome is drawing attention [1]. Changes in life style and dietary habit were being blamed for this increase; however, it is pointed out that healthcare professionals need to do more to support individuals in realizing the problem and changing their behavior [2]. Dietary surveys are widely employed as the basic method to establish subjects' dietary intake with the weighed dietary record method considered most appropriate.

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However, the weighed dietary record method involves some trouble for the subjects, and it is not easy to ensure complete understanding and compliance. There is even some risk of increased statistical error if the survey with the method is conducted without sufficient understanding among the subjects, with the possibility of inaccurate records, or, in some cases, alterations to their usual diet. Further, with the weighed dietary record method, a prolonged survey period is necessary, making it difficult for practical use in dietary consulting sessions. Therefore in dietary consulting sessions, the rough estimation-record method and the food-frequency questionnaire, where frequency of intake and average amount of portions are chosen from the listed food items, are widely used in Japan and abroad. However, since there are many more foods outside the list that are commonly eaten and individual variety in amounts used in cooking, it is difficult to cover all the food intake accurately using the estimation-records and the food-frequency questionnaires, which often leads to underreporting by the subjects. In the west where the methodologies were established earlier, this underreporting has been recognized as a problem for some time [3,4]. It is also reported that there are physical, psychological, cultural and other factors for the underreporting [5-9]. The research including Okubo *et al.* [10] and Murakami *et al.* [11] showed the level of underestimation being approximately between −20% to −8% in Japan. The studies conducted have mainly covered female student subjects with a low level of physical activity. It is predicted that among male students, there is a big difference in the levels of physical activity between those in sports clubs and everyone else. It has been also reported that dietary surveys for sportsmen are difficult to conduct [12]. Therefore in this investigation, the validity of a dietary survey for male students who belong to a sports club was attempted by comparing them with male students who were not involved in sporting activities. Murakami [13] reported, after researching 17 western originated papers, the selective underreporting of dietary intake applies only to certain foods and nutrients, not to all foods and all nutrients universally, whatever survey method is chosen. While the Murakami report is based on data taken in the West, considering that items or contents of food are influenced by the social environment such as dietary customs, it was predicted that there might be a particular set of underreporting and underestimating in Japan. Therefore the investigation was conducted with the aim of finding the existence of underreporting and underestimates of specific foods or nutrients in Japan.

If there is no change in the weight, it is generally assumed that the intake and expenditure of the energy are equal. Therefore the validity of the dietary survey was explored by comparing the energy intake, obtained from the food-frequency questionnaires, and the energy expenditure. To measure energy expenditure, the Doubly Labeled Water (DLW) method is known to be most accurate. However, it is expensive and difficult to run in an educational environment. In this study, by actually measuring the basal metabolism of the individuals, the per capita energy expenditure that represents the individual as closely as possible was attempted. It was predicted that sufficiently accurate energy expenditure is obtained by using the individual basal metabolic rate and the time study method where the individual's level of activities was assessed using a detailed record for 3 days.

Methods

1. Subjects

Two groups were chosen. The active group consisted of 22 male students (age: 20.6±1.2 years) drawn from University K in O prefecture, who belong to the rugby and the badminton clubs and practice 3 to 4 days a week, 2 to 3 hours at a time. The control group consisted of 37 male students (age: 19.3±1.4 years) with no habit of sporting activities. Prior to the commencement of the investigation and physical examination, the consent of the subjects was requested and obtained after first briefing them on the study,

Table 1 Physical characteristics of subjects

	Control group	Active group
Number of subjects (n)	37	22
Age (y)	19.3±1.4 [3]	20.6±1.2
Height (cm)	170.9±5.5	172.4±6.1
Weight (kg)	67.0±13.1	71.3±14.4
BMI (kg/m^2) [1]	22.9±4.7	23.9±4.0
%BF [2]	17.7±8.1	14.1±6.6

[1] BMI: body mass index
[2] %BF: percentage of body fat
[3] mean±SD

its objectives and procedures. The physical characteristics of the subjects are shown in Table 1.

2. Study method

Physical examination, basal metabolic measurement, the food-frequency questionnaire and 3 days of time study were conducted concurrently for all the subjects. Before the commencement of the survey, the subjects were told to continue to conduct everyday life as usual, and not try to increase or decrease their weight. As for the validity of the dietary survey, the ratio of Energy Intake (EI) derived from the food-frequency questionnaire (FFQg) and the Total Energy Expenditure (TEE) derived from the time study were investigated as the accuracy of EI. As for the selective underreporting of certain food and nutrients, investigation focused on the correlation between the accuracy of EI (EI/TEE) and the amount of intake by food and nutrients categories. The examinations and survey were conducted in the manner described below:

2. 1. Physical examination and measurement

The examination and measurement of the subjects were conducted in early mornings, after passing urine with light clothing on. The height and weight were taken using a height gauge (manufactured by TT), and the scale with a body fat reading (TBF501, manufactured by Tanita), respectively. The Body Mass Index (BMI) was obtained by the following formula: weight (kg) / height^2 (m). Body fat was measured using an Eiken type skin thickness measurement instrument at two points; at the midpoint between the radiale and the acromiln at the back side of the upper dominant arm and at the point immediately below the lateral angle of the shoulder blade of the dominant arm [14]. The values from these measurements were applied to the formulae of Nagamine and Suzuki [15] and Brozek *et al.* [16]

2. 2. The basal metabolism

Measurements were conducted between May and June 2006. The subjects were asked to fast from 9.pm the previous day except for water and tea. On the day of the measurement, they were asked to come to the unit with an empty stomach. The collection of expired air using the Douglas bag method was performed after 30 minutes rest on a bed. The density analysis of oxygen and carbon dioxide were conducted using an Aeromonitor 300S (manufactured by Minato Ikagakusha). The expiratory volume was measured by using a dry-gas meter (manufactured by Shinagawa-sha). At the same time, pulse rate, breathing rate, temperature (using a Terumo electronic thermometer), and blood pressure (using a mercury manometer manufactured by Sanden Medical Industry) were taken and compared against the normal range to confirm that the subjects were in a resting state. The room temperature at the time of physical examination and measurement was between 22.6 to 29.2℃ using an Assman ventilated psychrometer (manufactured by Shibata). The metabolism of this early morning, empty stomach, resting state under the above mentioned condition was set as the basal metabolic rate and the value of which was used to calculate the daily energy expenditure [17].

2. 3. Daily Total Energy Expenditure (TEE)

Daily Total Energy Expenditure was calculated based on the 3 day time study method (activity record methods) [18]. We gave the subjects both written and verbal instructions on how to keep the activity record with an example of a completed recording sheet. After the activity recording sheets were submitted, a trained researcher checked and asked each subject to record every minute of the 3 days in as much detail as possible. The relative metabolic rate was based on the values presented in the fifth edition of the Nutrient Requirement for Japanese [19]; the basal metabolic rate was calculated from the actual measurement. Each of the relative metabolic rates was decided by a skilled registered dietitian.

2. 4. Food intake survey

The self-administered 'Excel Eiyo-kun, Food-Frequency Questionnaire' produced by Yoshimura [20] was distributed to all the subjects following a briefing by a nationally registered dietitian. The outcome of the questionnaire was analyzed using computer software from the same company in order to calculate the daily energy intake (EI) as well as the amount of intake in foods and nutrients categories.

2. 5. Statistical processing

All the values are shown as the average with mean ± standard deviation. For the correlation, the *Pearson test* was used. As for the test of the average value difference between groups, a non-student *t-test* was used with a less than 5% risk deemed as significant.

Results

1. Basal metabolic rate and daily energy expenditure

Table 2 shows the basal metabolic rates and the daily energy expenditures of both the active group and the control group. There were no significant differences in the physical characteristics between the two groups; however, the basal metabolic rates were higher in the active group. The average of daily energy expenditure was significantly higher ($p < 0.01$) in the active group with 3,754±657 kcal while it was 2,542±620 kcal in the control group; showing more than a 1,000kcal difference. The difference was derived from energy expenditure during physical activities, with the active group expending more than double that of the energy of the control group. As for the Physical Activity Level [21], the average of the active group was 2.19 with 82% falling into 'high' and 18% falling into 'medium' while the average of the control group was 1.62 with 89% falling into either 'middle' or 'low'.

Table 2 Basal metabolic rate and daily total energy expenditure of subjects

	Control group (n = 37)	Active group (n = 22)
BMR (kcal/day) [1]	1,570±268 [5]	1,724±316
BMR (kcal/kg/day)	23.7±3.0	24.3±2.1
AEE (kcal/day) [2]	972±494	2,030±450 [6]
AEE (kcal/kg/day)	14.7±8.0	29.0±6.7 [6]
TEE (kcal/day) [3]	2,542±620	3,754±657 [6]
TEE (kcal/kg/day)	38.4±9.1	52.7±45.6 [6]
Physical activity level [4]	1.62±0.30	2.19±0.26 [6]

[1] BMR: basal metabolic rate
[2] AEE: activity energy expenditure
[3] TEE: total energy expenditure
[4] Physical Activity Level: TEE/BMR
[5] mean±SD
[6] Significantly different from control group: p<0.01

2. Correlation between energy expenditure and energy intake

Figures 1 and 2 show the correlation between the daily energy expenditure and energy intake. The control group showed significant ($p < 0.05$) and positive correlation ($r = 0.392$). However, the active group did not show any significant correlation between expenditure and intake.

3. Energy expenditure and intake

Table 3 shows the energy expenditure and intake. For both groups, the Total Energy Expenditure (TEE) was significantly ($p < 0.01$) higher than the Energy Expenditure (EI). The difference was 1,658±853kcal in the active group and 714±606kcal in the control group; significantly greater ($p < 0.01$) in the active group. When the accuracy of the EI was assessed as the ratio of EI against TEE (EI/TEE), the average scores were 0.57 in the active group and 0.74 in the control group. The accuracy of EI was significantly lower ($p < 0.01$) in the active group with all the subjects scoring less than 1.

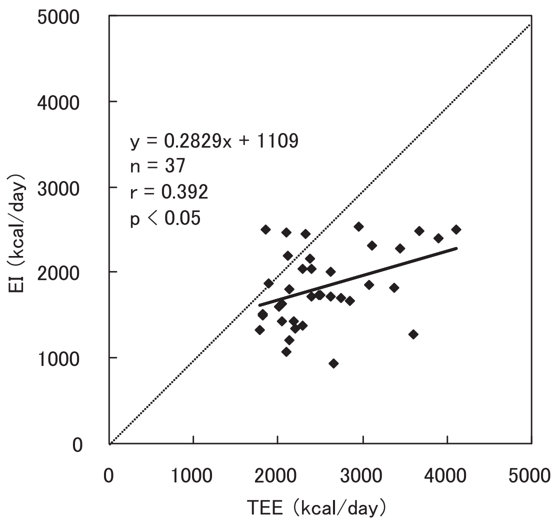

Fig. 1 Correlation between total energy expenditure (TEE) and energy intake (EI) in the control group

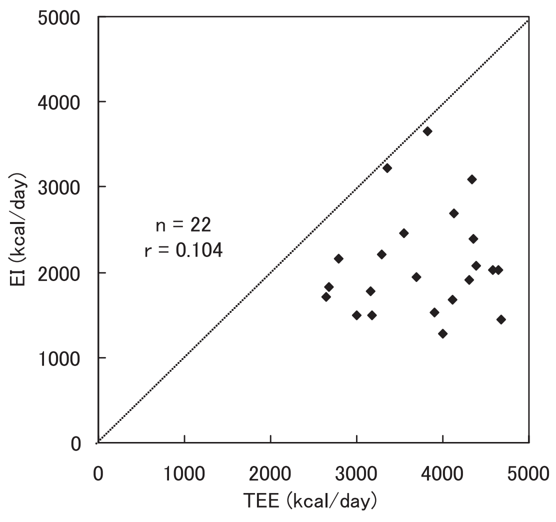

Fig. 2 Correlation between total energy expenditure (TEE) and energy intake (EI) in the active group

Table 3 Energy intake and energy expenditure of subjects

	Control group (n = 37)	Active group (n = 22)
EI (kcal/day) [1]	1,828±448 [4]	2,096±617
TEE (kcal/day) [2]	2,542±620 [5]	3,754±657 [5,6]
ΔEnergy (kcal/day) [3]	−714±606	−1,658±853 [6]
EI / TEE	0.74±0.20	0.57±0.18 [6]

[1] EI: energy intake
[2] TEE: total energy expenditure
[3] ΔEnergy = energy intake−total energy expenditure
[4] mean±SD
[5] Significantly different from EI: p<0.01
[6] Significantly different from control group: p<0.01

4. Correlation between BMI and accuracy of EI (EI/TEE)

Figures 3 and 4 show the correlation between BMI and the accuracy of EI. Significant ($p < 0.05$) and negative correlation ($r = -0.395$) between BMI and the accuracy of EI was observed in the control group, but not in the active group. Figures 5 and 6 show the correlation between BMI and energy intake per 1kg of body weight. Significant ($p < 0.01$) and negative correlation ($r = -0.505$) was observed in the control group, but not in the active group.

5. Correlation between food and nutrient intake and accuracy of EI (EI/TEE)

Table 4 shows the correlation between accuracy of EI and the amount of intake of the three major nutrients and food items drawn from the food-frequency questionnaire. As for the average intake of energy and the three major nutrients, the active group exceeded the control group, but not significantly. As for the intake energy ratio, fat takes up 31.5±3.7 (%E) in the active group, which is over the recommended limit of 30% in the Dietary Intake Reference for Japanese [21], and 28.7±5.4 (%E) in the control group. For both groups, the correlation between the accuracy of EI and intake ratios (%E) of protein, fat and carbohydrates were not observed.

As for the amount of food grouped by food item categories, intake of confectionaries, oils and fruits were significantly higher ($p < 0.01$, $p < 0.05$, $p < 0.01$ respectively) in the active group. Comparing the intake constituent per 1,000kcal, the active group was significantly lower ($p < 0.01$) in grain, but significantly

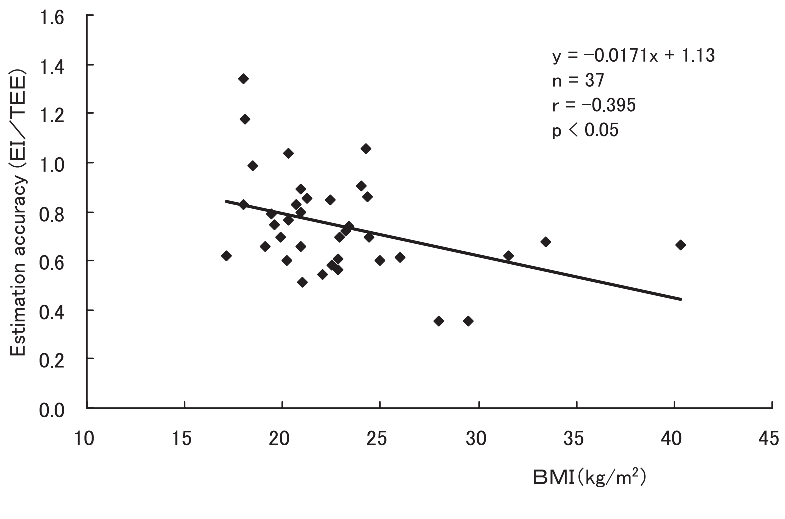

Fig. 3 Correlation between BMI and accuracy of EI (EI/TEE) in the control group

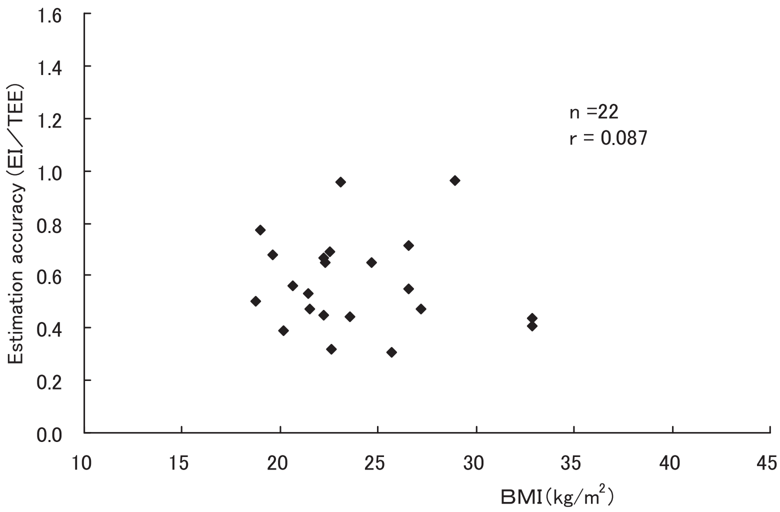

Fig. 4 Correlation between BMI and accuracy of EI (EI/TEE) in the active group

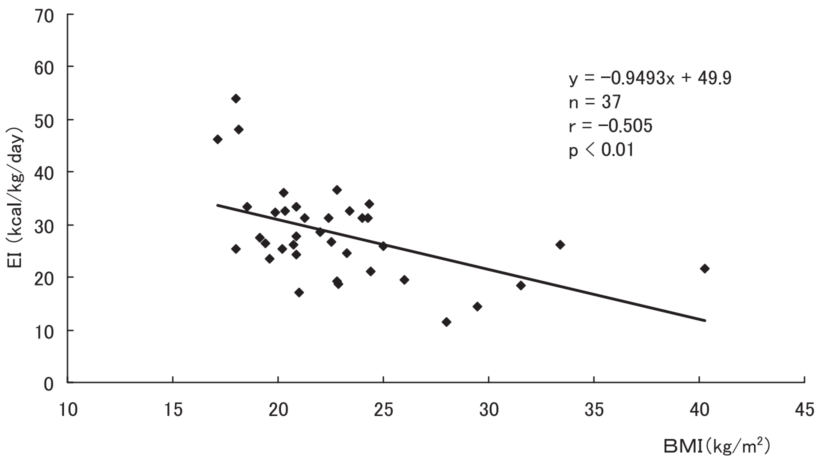

Fig. 5 Correlation between BMI and energy intake per 1kg body weight in the control group

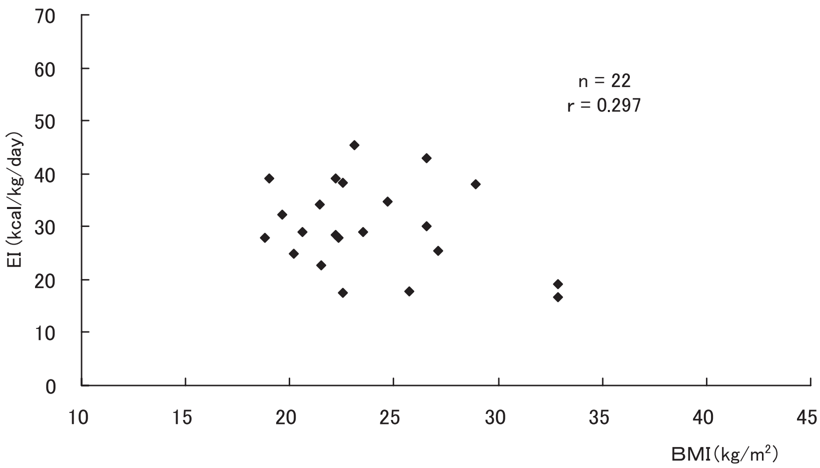

Fig. 6 Correlation between BMI and energy intake per 1kg body weight in the active group

Table 4 Relation of estimation accuracy of intake (the ratio of energy intake with a food-frequency questionnaire to total energy expenditure) in control group and in active group to intake of selected nutrients and foods

	Control group (n=37)		Active group (n=22)	
	Mean ± SD [1]	r [2]	Mean ± SD	r
Nutrients				
Energy (kcal/day)	1,828±448	0.594 *	2,096±617	0.831 *
Protein (g/day)	59.8±16.1	0.527 *	63.1±20.2	0.754 *
Fat (g/day)	58.1±17.8	0.409 *	74.2±27.5	0.747 *
Carbohydrates (g/day)	252.7±72.7	0.600 *	281.3±77.0	0.854 *
Protein (%EI)	13.1±1.7	0.012	12.0±1.4	0.029
Fat (%EI)	28.7±5.4	-0.089	31.5±3.7	0.162
Carbohydrates (%EI)	58.2±6.5	0.070	56.5±4.5	-0.143
Foods (g/day)				
Grains	417.9±172.0	0.368	386.6±150.8	0.296
Potatoes	17.7±18.3	0.031	20.4±18.7	0.211
Sugar	5.0±4.3	0.403 *	3.7±3.0	0.204
Confectioneries	69.9±55.0	0.447 *	128.0±113.4 [3]	0.592 *
Oils	10.0±4.1	0.042	14.2±10.3 [4]	0.540 *
Soybeans	39.5±50.5	0.280	33.9±24.6	0.018
Fruits	17.5±18.3	0.237	40.9±49.1 [3]	0.382
Green and yellow vegetables	43.3±45.2	0.324	42.8±18.2	0.169
Other vegetables	58.8±50.6	0.384	71.2±52.3	0.080
Fish and shellfish	34.8±32.8	0.264	33.0±34.1	0.705 *
Meat	77.9±36.0	0.088	93.7±48.5	0.201
Eggs	31.0±21.3	-0.077	30.2±16.0	0.415 *
Milk and dairy products	190.0±165.8	0.042	161.6±106.9	0.104
Juice	193.7±157.5	-0.001	225.3±150.9	0.230
Foods (g/day/1,000kcal)				
Grains	228.0±77.6	0.035	188.4±70.0 [3]	-0.235
Potatoes	9.3±8.8	-0.049	10.0±8.3	-0.044
Sugar	2.8±2.4	0.221	1.8±1.6	-0.016
Confectioneries	37.0±25.5	0.276	59.2±36.8 [4]	0.298
Oils	5.6±2.3	0.323 *	6.4±3.0	0.315
Soybeans	20.3±23.8	0.209	17.0±13.2	-0.210
Fruits	9.3±9.4	0.172	19.0±21.5 [4]	0.266
Green and yellow vegetables	23.0±22.6	0.205	21.1±9.6	-0.320
Other vegetables	30.4±23.9	0.301	34.9±23.0	-0.260
Fish and shellfish	18.9±17.0	0.109	14.2±11.6	0.539 *
Meat	43.7±20.1	-0.195	44.9±19.6	-0.246
Eggs	17.4±13.2	-0.230	14.2±5.7	-0.024
Milk and dairy products	104.0±84.3	-0.087	78.8±53.2	-0.160
Juice	127.3±105.9	-0.245	109.1±61.6	-0.118

[1] Mean ± SD : with food-frequency questionnaire (FFQg)
[2] r : Spearman correlation coefficient *p<0.05
[3] Significantly different from control group: p<0.01
[4] Significantly different from control group: p<0.05

higher in confectionaries ($p < 0.05$) as well as in fruits ($p < 0.05$). As for the correlation between the accuracy of EI and intake per 1,000kcal, significant ($p < 0.05$) and positive correlation ($r = 0.539$) was observed in the active group for intake of fish and shellfish, while in the control group, significant ($p < 0.05$) and positive correlation ($r = 0.323$) was observed for oils.

Discussion

In this study, the validity of dietary surveys for physically active male students was investigated by comparing them with ordinary male students who were not physically active. If there is no change in weight, it is generally assumed that the intake and expenditure of the energy are equal; however, in this study, the energy expenditure exceeded the intake in all subjects in the active group. Regarding the measurement methods of energy expenditure, Ebine *et al.* [12], using the healthy Japanese male students as subjects, the validity of the Time Study method employing the daily Total Energy Expenditure measured by the DLW method as the validity reference was investigated. This reported that overestimation tends to happen for some with less energy expenditure while underestimation tends to happen for some with more energy expenditure; however the underestimation was only 3.9% lower than that using the DLW method on average. One of the factors for this over and under estimation in Ebine's paper was thought to be caused by the use of the reference value, not the actual measurement, in the calculation of basal metabolism. By using the value derived from the actual measurement in this paper, it was predicted that the energy expenditure would come out close to the reality. The validity of the dietary survey was assessed as the accuracy of EI (EI/TEE). The average value for the active group was 0.57 which was significantly lower ($p < 0.01$) than the average of the control group at 0.74, showing a stronger tendency of underreporting among the active group. Further, in the active group, significant correlation between the energy expenditure and intake was not observed. Yanai *et al.* [22], reported that underestimation or underreporting occurs more often with those who are not interested in food, among ordinary female and male students, as well as those with a higher BMI or who are trying to lose weight. It was assumed that while the physically active students are interested in increasing activities such as training to enhance their competitiveness in their sport, they are not particularly interested in food compared to the general student population, which can lead to underestimation and underreporting. In this study, the correlation between BMI and the accuracy of EI was not observed among the physically active students. Also, significant ($p < 0.01$) and negative correlation ($r = -0.505$) was observed, with higher BMI and lesser energy intake per 1kg of body weight, among the control group but not in the active group. It is assumed that those male students who belong to a sports club and lead physically active lives see their weight and higher BMI, not as obesity, but more positively as part of building a stronger physique, and do not even have a desire to lose weight. Therefore the underreporting of the intake among the active group can possibly be attributed to their low interest in food rather than psychological factors.

As for the selective underestimation and underreporting, there is no definitive result so far. In the West, Goris *et al.* [23] reported the underreporting of fat, while Heitmann *et al.* [24, 25] and Rosell *et al.* [26] reported that underestimation of energy was bigger than protein. In Japan, Murakami *et al.* [27] reported selective overestimation of protein and underestimation of fat among Japanese young females. In this study, the fat energy ratio in the active group was higher than the control group; however, the correlation between the energy ratio of the three major nutrients and the accuracy of EI was not observed. Since the underestimation of energy and nutrients is the result of accumulated underreporting of individual food items, it was thought that more investigation was required to know which food items were underreported. Poppit *et al.* [28] has reported the validity of self-administered records of food intake by the investigation where 33 female subjects in an accommodation unit were asked to recall and record what they had eaten the day before while being secretly observed round the clock. The report pointed out the underreporting of snacks between three meals, as well as the estimated intake of carbohydrates and sugar, was significantly lower than the actual intake observed. Yanai *et al.* [29] has conducted a food-frequency questionnaire for 11 physically active Japanese female students after they had the same food for 10 days, and reported that the estimated amount taken for fruits, grain sugar, green and yellow vegetables, as well as pulses were lower (29∼45%) than the amount actually taken. Since actual intake of each food item cannot be identified in this study, the individual tendencies of food intake and underreporting was investigated by assessing whether there was a correlation between the intake of each food item per 1,000kcal and the accuracy of EI. In this study, the active group showed significantly higher intake of confectionaries, oils and fruits than the control group and with the comparison of intake per 1,000kcal, the active group showed significantly lower intake of grains but higher intake of confectionaries and fruits than the control group. However the correlation between the intake of these food items and the accuracy of EI was not observed. Yanai *et al.* [29] has also reported that errors in estimation could easily occur in Japan, since the amount of grain is counted as 'a bowl of rice' and 'a portion of udon-noodle', which can vary from individual to individual. In addition to this, it was assumed from this study, that the active group tends to eat more irregularly, leaving the grains in the form of the staple food in the proper meal context, but eating more snacks. As with the underestimation of snacks reported by Poppit *et al.* [28], these irregular eating habits seem to be contributing to the inaccurate estimation of food intake. It was also observed, in this study, the significant ($p < 0.05$) and positive correlation ($r = 0.539$) between the intake of fish and the accuracy of EI among the active group, which suggests the selective underreporting of fish among the active group. Though intake of fish is recommended for its beneficial property of n-3 fatty acid for preventing 'life-style related diseases' [21], its actual intake by the younger generation is decreasing annually [1]. Considering the fact that those who eat more fish estimate their food intake more correctly, it is predicted that raising interest in eating fish, which represents the Japanese traditional food culture, may lead to more correct estimations of food intake. Since the food items, which have positive correlation with the accuracy of EI, are generally thought to be easily underreported and underestimated, raising interest regarding the intake of fat and oil will lead to the correct estimation of food intake, which ultimately may lead to the prevention of these life style related diseases.

From this research, it was suggested that physically active male students tend to underreport and underestimate their food intake compared to physically non-active students. This result suggests that extra attention may be needed when dietary consultations are conducted with sportsmen and women. In addition to a survey of food intake, a comprehensive approach including the eating habits survey is needed to customize consultations according to the subjects' interests. Correction of irregular eating habits and promotion of Japanese style meals consisting of a main staple food, a main dish and a sub dish, will lead to better estimation and assessment of food intake.

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