ORIGINAL ARTICLE

Summer training camp decrease food intake in adolescent rugby football players

Les stages sportifs d'été réduisent les apports alimentaires chez les joueurs de rugby

C. Nagayama [a,*], K. Muto [a], M. Iwami [a], M. Ishihara [b], T. Tobina [a]

[a] Faculty of Nursing and Nutrition, University of Nagasaki, Manabino1-1-1, 851-2195 Nagayo-Cho, Nishisonogi-gun, Japan
[b] Graduate School of Human Health, University of Nagasaki, Manabino1-1-1, 851-2195 Nagayo-Cho, Nishisonogi-gun, Japan

Summary Sufficient and well-balanced nutrients promote optimal athletic performance. This study investigated appetite and food intake in adolescent rugby football players before and during a summer training camp. Eleven male national-level athletes who took part in a 6-day camp participated in this study. To calculate their physical activity level, participants wore heart-rate monitors during simulated rugby game training and accelerometers at other times. All participants took photographs of the food they ate during camp. The meals provided in the dormitory were recorded with the weighed-food record method. Before and after the camp, an ad libitum buffet test was carried out to assess appetite. Although there was no significant difference between total energy expenditure and total energy intake during the camp (15730 ± 1765 kJ·day^{-1} vs. 14838 ± 1708 kJ·day^{-1}, respectively), the mean energy deficit was $-892 \pm 2,107$ kJ·day^{-1} and 82% of participants had insufficient intake. Energy and carbohydrate intake in the buffet test were lower after camp than before (energy: 7122 ± 1385 kJ after vs. 8226 ± 1329 kJ before, $P < 0.05$; carbohydrates: 250 ± 47 g after vs. 297 ± 40 g before, $P < 0.05$). Over the 6-days of a summer training camp, adolescent male national-level rugby football players were in a negative energy balance and had insufficient carbohydrate intake. Additionally, rugby plays decreased energy and carbohydrate intake at ad libitum buffet meals at the end of camp.

* Corresponding author.
   E-mail address: c-nagayama@sun.ac.jp (C. Nagayama).

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Résumé   Des apports nutritionnels bien équilibrés et en quantité suffisante favorisent une performance athlétique optimale. Ce travail étudie l'appétit et les apports alimentaires chez des joueurs de rugby adolescents, avant et pendant un stage sportif d'été. Onze athlètes masculins de niveau national ayant pris part à un stage de six jours ont participé à cette étude. Pour calculer leur niveau d'activité physique, les participants portaient des cardiofréquencemètres lors de l'entraînement simulé de rugby, et des accéléromètres en dehors de ces sessions. Tous les participants photographiaient la nourriture qu'ils prenaient pendant le stage. Les repas fournis au dortoir étaient enregistrés par la méthode de pesée des aliments. Avant et après le stage, un buffet test ad libitum a été mis en place pour évaluer l'appétit des participants. Bien qu'il n'y ait pas eu de différence significative entre la dépense énergétique totale et l'apport énergétique total pendant le stage (respectivement 15730 ± 1765 kJ·jour^{-1} et 14838 ± 1708 kJ·jour^{-1}), le déficit énergétique moyen était de -892 ± 2107 kJ·jour^{-1} et 82 % des participants présentaient une consommation insuffisante. Les apports énergétiques et glucidiques lors du buffet test étaient inférieurs après le stage qu'avant (apports énergétiques : 7122 ± 1385 kJ après le stage, contre 8226 ± 1329 kJ avant, $p < 0,05$; glucides : 250 ± 47 g après le stage, contre 297 ± 40 g avant, $p < 0,05$). Sur les 6 jours de stage sportif d'été, les joueurs de rugby de niveau national, adolescents et masculins, présentaient un bilan énergétique négatif et une prise de glucide insuffisante. De plus, les jeux de rugby ont réduit les apports énergétiques et glucidiques des repas pris lors du buffet ad libitum à la fin du stage.
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1. Introduction

Sufficient and well-balanced nutrients help athletes achieve optimal performance. Because of their high physical activity levels, athletes have greater energy requirements than non-athletes [1—4]. Energy requirements vary with changes in training volume and intensity, which fluctuate with the yearly training plan and competition cycle. Therefore, energy expenditure and intake from daily meals must be balanced.

Intake of carbohydrates and protein immediately after exercise has been demonstrated to promote muscle glycogen storage [5,6] and muscle protein synthesis [7,8]. However, high-intensity exercise can decrease appetite and food intake [9—11], a phenomenon known as ''exercise-induced anorexia'' [12]. Previous studies [10,11] have shown that absolute energy intake was lower after high-intensity exercise compared with control. Many other studies have reported that energy expenditure during exercise is not replenished by post-exercise meals [12,13]. Athletes may experience decreased performance and compromised health if they do not receive adequate nutrition after high-volume training [14]. Rugby and American football require high levels of strength and power; weight control is very important for these players because weight is directly linked to exercise performance. Such players often participate in several days of training camp during which the intensity and quantity of training increases, with increased likelihood of inadequate energy and nutrient intake [15]. If appetite is suppressed by intense exercise, as described above, the risk of inadequate intake may be high. In this case, information about what kinds of food are easy to eat is essential for nutrition support for weight management, performance, and health maintenance. Much of the research on exercise-induced anorexia has focused on sedentary or obese/overweight people who do not have regular exercise habits [10,16]. There is little information on this phenomenon in contact sports athletes. The effect of exercise on appetite and food intake may be different in highly fit individuals who regularly exercise than in sedentary individuals [17]. Additionally, previous studies have been conducted in the laboratory with treadmills or ergometers [13]. However, laboratory-based studies are difficult to interpret because their results may not directly apply to free-living athletes.

This study investigated appetite and food intake in adolescent rugby football players before and during summer training camp.

2. Materials and methods

2.1. Participants and experimental design

Eleven adolescent male national-level rugby football players who participated in a 6-day summer training camp in August 2015 were recruited for this study. Participants were informed both orally and in writing about the experimental procedures and the possible risks and benefits of the study; written informed consent was obtained from all participants and their parents. This study was approved by the ethics committee of the University of Nagasaki.

A total of three ad libitum buffet tests were performed: one 17 days before camp (pre), one 2 days before camp (baseline), and one on the final day of camp (post). The pre-test was performed to habituate participants to the ad libitum buffet test environment. Subjects arrived at the laboratory 4 or 5 days before camp for anthropometric

and exercise testing; anthropometric measurements were repeated on the final day of the camp.

2.2. Anthropometric and exercise testing

All anthropometric measurements were made with the subjects wearing only shorts. Standing height was measured to the nearest 0.1 cm with a stadiometer. Body weight (BW) was measured to the nearest 0.001 kg. Body density was measured with the air displacement method (BodPod; COSMED Co., Ltd., Rome, Italy). Body fat percentage (% FAT) was calculated with the Brozak formula [18]. Fat mass (FM) and fat-free mass (FFM) were calculated with the formulas FM = BW (kg) × % FAT ÷ 100 and FFM = BW (kg) − FM (kg). Total body water was measured with bioelectrical impedance analysis (InBody720; InBody Japan Inc., Tokyo, Japan).

After anthropometric measurements, all participants performed an incremental workload exercise test on a cycle ergometer (Colival-1000ss; Lode Inc., Groningen, Netherlands) to measure maximal oxygen uptake. After a 4-minute warm-up at 10 watts, the exercise load was increased by 1 watt every 4 seconds (15 watts·minute^{-1}) until exhaustion. Expired air was collected in neoprene bags over 1-minute periods at several points during sub-maximum exercise and every minute near maximal intensity. The volume of expired air was measured with a dry gas meter (DC-5; Shinagawa Inc., Tokyo, Japan). O_2 and the CO_2 fractions were analyzed with a mass spectrometer (ARCO-2000; Arco System Inc., Chiba, Japan). The plateau phenomenon of oxygen consumption (VO_2) during exercise was observed in only seven of the 11 participants. Therefore, the maximal and peak VO_2 were defined as the peak VO_2 in this study.

2.3. Energy expenditure and dietary intake during training camp

Energy expenditure and dietary intake were measured on 4-days of the camp, excluding the first and final days. Participants' energy expenditure during the camp was calculated with a heart rate monitor and accelerometer. Subjects wore heart rate monitors (RS300x; Polar Electro Japan Co., Ltd., Kempele, Finland) twice each day (morning and afternoon) during training periods. The training menu was a simulated rugby game including runnning, pushing, tackling and kicking. At other times, they wore an accelerometer (Lifecoder GS; SUZUKEN Co., Ltd., Nagoya, Japan) [19], except when bathing or sleeping. Basal metabolic rate was estimated as 28.5 (kcal) × FFM (kg), according to the Japan Institute of Sports Science [20]. Daily total energy expenditure was computed by summing the estimated values from the heart rate monitor, accelerometer, and basal metabolic rate. Daily physical activity level (PAL) was also calculated.

Dietary intake was recorded over a 4-day period during the camp, using a combination of self-reported food record and the weighed food record methods. Each participant recorded the food they ingested during the camp by photographing their food, with chopsticks as a reference length. Meals provided by the camp dormitory three times per day (breakfast, lunch, and dinner) were recorded with the weighed-food method. The food was weighed to the nearest 0.1 g with a digital scale (EJ-3000; A&D Co., Ltd.,

Tokyo, Japan). Food-record analyses were performed by a single registered dietician who converted food units into weights and calculated the nutrient values ingested with nutrient-value calculation software (Excel Eiyokun Ver. 6.0; Kenpakusya Co., Ltd., Tokyo, Japan). These values were compared with recommendations [21,22].

2.4. Profile of mood state

Participants completed self-reported surveys (Profile of Mood States, Japanese short version; Kaneko Shobo Co., Ltd., Japan) prior to ad libitum buffet testing to assess mood status. Thirty questions were included in the questionnaire; participants responded to the questions on a five-point scale to indicate how well the given adjective described their mood over the past week (0, not at all; 1, a little; 2, moderately; 3, quite a bit; and 4, extremely frequently). The questions covered six mood factors (Tension—Anxiety, Depression—Dejection, Anger—Hostility, Vigor, Fatigue, and Confusion).

2.5. Subjective appetite and ad libitum food intake

A visual analogue scale (VAS) and ad libitum buffet test were used to measure appetite. The VAS [23] was a series of 10-cm scales from most negative to most positive ratings, with words anchored at each to assess hunger, satiety, fullness, prospective food consumption, and desire to eat something fatty, salty, sweet, and savory. We translated the questions to Japanese with the assistance of a professor of cookery science.

The ad libitum buffet test was conducted to assess food intake. A buffet meal consisting of 39 foods [24] (Table 1) was presented to participants for 1 h at dinnertime (between 19:00 h and 20:00 h); participants were instructed to eat until satiated. Participants were supervised, silent, and partitioned from each other while eating. Foods were provided in excess of expected consumption, and the same items were available to participants at each trial. The paper tray with the food was weighed to the nearest 0.1 g with a digital scale (EJ-3000; A & D Co., Ltd., Tokyo, Japan) before and after the meal to measure how much food was consumed. The energy and macronutrient intakes were calculated with the nutritional information on food labels; the 2010 standard tables of food composition in Japan were consulted for foods without labels.

2.6. Statistical analysis

Data were analyzed with statistical software (StatView 5.0; SAS Institute Inc., Cary, NC, USA). Paired t-tests were used to compare baseline and post-camp body composition and to compare energy expenditure and energy intake during the camp. One-way ANOVA and Turkey—Kramer post hoc tests were used to assess the effect of training camp on ad libitum buffet food intake, subjective appetite, and mood states. Pearson's correlation coefficient was used to examine relationships between subjective appetite and ad libitum buffet

Table 1 List of food served during the dinnertime buffet test.

Cooked white rice	200 g	Milk	500 ml	Pickled plum	15 g
White bread	60 g	Low-fat milk	500 ml	Seasoned powder	10 g
Wheat noodle	180 g	Orange juice	200 ml	Seasoned laver	1 g
Crescent	20 g	Apple juice	200 ml	Sliced cheese	18 g
Hamburger	170 g	Barley tea	600 ml	Processed cheese	18 g
Fried chicken	110 g	Cola	250 ml	Strawberry jam	20 g
Sliced ham	40 g	Sprite	250 ml	Margarine	7 g
Grilled fish	65 g	Yogurt	75 g	Mayonnaise	15 g
Non-oil tuna	75 g	Pudding	70 g	Ketchup	8 g
Natto	50 g	Potato crisps	60 g	Soy sauce	3 g
Vegetable salad	110 g	Chocolate cookies	40 g	Non-oil dressing	15 g
Tomatoes	150 g	Rice cracker	12 g	French dressing	15 g
Oranges	120 g				
Banana	100 g				

The amount of the foods shows us the potion size.

food intake. P values < 0.05 were considered statistically significant. All values are shown as mean ± standard deviation.

3. Result

3.1. Participants' characteristics

Participants' characteristics are presented in Table 2. There were no significant differences in mean BW, FFM, FM, % FAT, or total body water before versus after camp, although there were individual variations in these differences.

3.2. Physical activity and macronutrient intake during camp

Energy expenditure, PAL, and nutrient intake during camp are shown in Tables 3 and 4. Total energy expenditure and PAL were 15730 ± 1765 kJ·day^{-1} and 2.2 ± 0.2, respectively. The training menu was a simulated rugby game including runnning, pushing, tackling and kicking. The participants trained 340 minutes per day over the duration of camp and average heart rate during the training corresponded to about 50% VO$_2$ max; however, training was intermittent and maximum heart rate reached upper limits comparable to VO$_2$ max.

Mean daily total energy intake for the 4-days was 14838 ± 1708 kJ·day^{-1}, the mean energy deficit was -892 ± 2107 kJ·day^{-1}, and 82% of participants had insufficient intake; however, the difference between energy intake and expenditure was not significant.

On average, carbohydrate, protein, and fat intake accounted for $62.3 \pm 3.5\%$, $13.3 \pm 1.0\%$, and $24.4 \pm 2.5\%$, respectively, of total energy intake. When considered relative to body weight, intake of carbohydrate, protein, and fat were 7.9 ± 1.1 g·kg^{-1}·day^{-1}, 1.7 ± 0.2 g·kg^{-1}·day^{-1}, and 1.4 ± 0.1 g·kg^{-1}·day^{-1}, respectively. According to recommendations, protein intake was adequate in all participants; however, carbohydrate and fat intake were found to be inadequate in 55% and 9% of participants, respectively.

3.3. Profile of mood states

The Tension—Anxiety score was lower post-camp than pre-camp (2 ± 2 vs. 4 ± 3, respectively). The Fatigue score was higher post-camp than at baseline (9 ± 4 vs. 6 ± 4, respectively) (Fig. 1). There were no significant differences in Depression—Dejection, Anger—Hostility, Vigor or Confusion scores between different time points.

Table 2 Characteristics of the 11 Participants.

	Baseline	Post
Age (years)	17 ± 1	
Height (cm)	170.1 ± 4.7	
VO$_2$ peak (ml·kg^{-1}·min^{-1})[a]	39.2 ± 2.7	
Body weight (kg)	69.3 ± 7.0	69.5 ± 6.9
BMI (kg·m^{-2})	23.9 ± 2.4	24.0 ± 2.4
Fat free mass (kg)	59.6 ± 5.2	59.3 ± 5.2
Body fat percentage (%)	13.8 ± 3.2	14.5 ± 3.6
Total body water (kg)	44.4 ± 3.5	4.3

All values are means ± standard deviations for the 11 participants.

[a] The plateau phenomenon of oxygen consumption during exercise was observed in only 7 of the 11 participants.

Table 3 Energy expenditure and physical activity level during training camp.

		Mean ± SD	Min—Max
Basal metabolic rate	(kJ·day-1)	7105 ± 624	5947—8276
Energy expenditure from exercise (kJ·day^{-1})[a,c]		6912 ± 1430	4837—9032
Energy expenditure from daily activity (kJ·day^{-1})[b]		1714 ± 596	753—2,687
Total energy expenditure (kJ·day^{-1})		15730 ± 1765	11536—17639
Physical activity level		2.2 ± 0.2	1.9—2.6

All values are means ± standard deviations for the 11 participants.
[a] Individually measured with heart rate monitor.
[b] Individually measured with accelerometer.
[c] The training menu was a simulated rugby game including runnning, pushing, tackling and kicking. The participants trained 340 minutes per day over the duration of camp and average heart rate during the training corresponded to about 50% VO_2 max; however, training was intermittent and maximum heart rate reached upper limits comparable to VO_2 max.

**Table 4** Energy expenditure and energy and macronutrient intake during camp.

		Mean ± SD	Min—Max	Recommen-dation	Percentage of subjects lower than recommendation	Percentage of subjects higher than recommendation
Energy intake	(kJ·day^{-1})	14838 ± 1708	12554—17783	Total energy expenditure[a]	82	18
Carbohydrate intake	(g·kg body weight^{-1})	7.9 ± 1.1	5.5—9.6	8.0—12.0[b]	55	0
	(% energy)	62.3 ± 3.5	57.2—68.6			
Protein intake	(g·kg body weight^{-1})	1.7 ± 0.2	1.4—1.9	1.2—2.0[b]	0	0
	(% energy)	13.3 ± 1.0	11.6—15.0			
Fat intake	(g·kg body weight^{-1})	1.4 ± 0.1	1.2—1.6	20.0—30.0[c]	9	0
	(% energy)	24.4 ± 2.5	19.8—27.8			

All values are means ± standard deviations for the 11 participants.
[a] Individually measured with heart rate monitor and accelerometer.
[b] Position of the Academy of Nutrition and Dietetics, Dietitians of Canada, and the American College of Sports Medicine: Nutrition and Athletic Performance, 2016.
[c] Dietary Reference Intakes for Japanese, 2015.
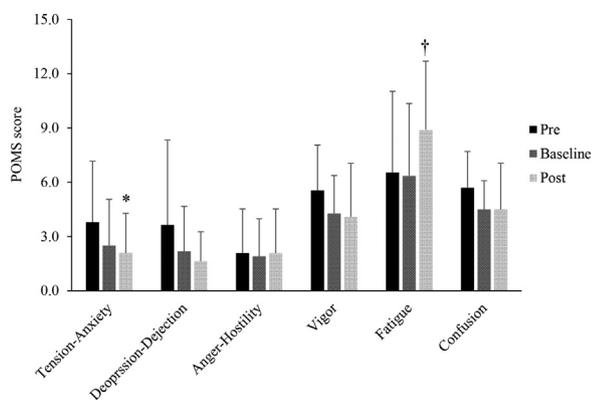
Figure 1 Changes in profile of mood state. Columns represent means ± standard deviations for the 11 participants. Participants completed self-reported surveys (Profile of Mood State, Japanese short version; Kaneko Shobo Co., Ltd., Tokyo, Japan) prior to ad libitum buffet test at dinnertime. *: Significant difference vs. Pre ($P < 0.05$, Tukey—Kramer). †: Significant difference vs. Baseline ($P < 0.05$, Tukey—Kramer).

3.4. Effect of summer training camp on subjective appetite and ad libitum food intake

No significant differences were observed in self-reported hunger, satiety, fullness, prospective food consumption, or desire to eat sweet, salty, savory, or fatty foods before versus after the camp.

Summer training camp had a significant effect on energy and macronutrient intake in the ad libitum buffet test (Fig. 2). Post-hoc analysis revealed that energy and carbohydrate intakes were significantly lower at post-camp testing than at pre-camp testing or at baseline (energy: 7122 ± 1385 kJ vs. 8389 ± 1252 kJ and 8226 ± 1329 kJ, respectively; carbohydrate: 250 ± 47 g vs. 291 ± 39 g and 297 ± 40 g, respectively). Additionally, fat intake was significantly lower at post-camp testing than at pre-camp testing (47 ± 12 g vs. 59 ± 17 g, respectively); however, there was no difference in fat intake between post-camp and baseline. The difference in protein intake was not significant. Mean macronutrient intake (carbohydrate, protein, and fat), expressed as percentages of total energy,
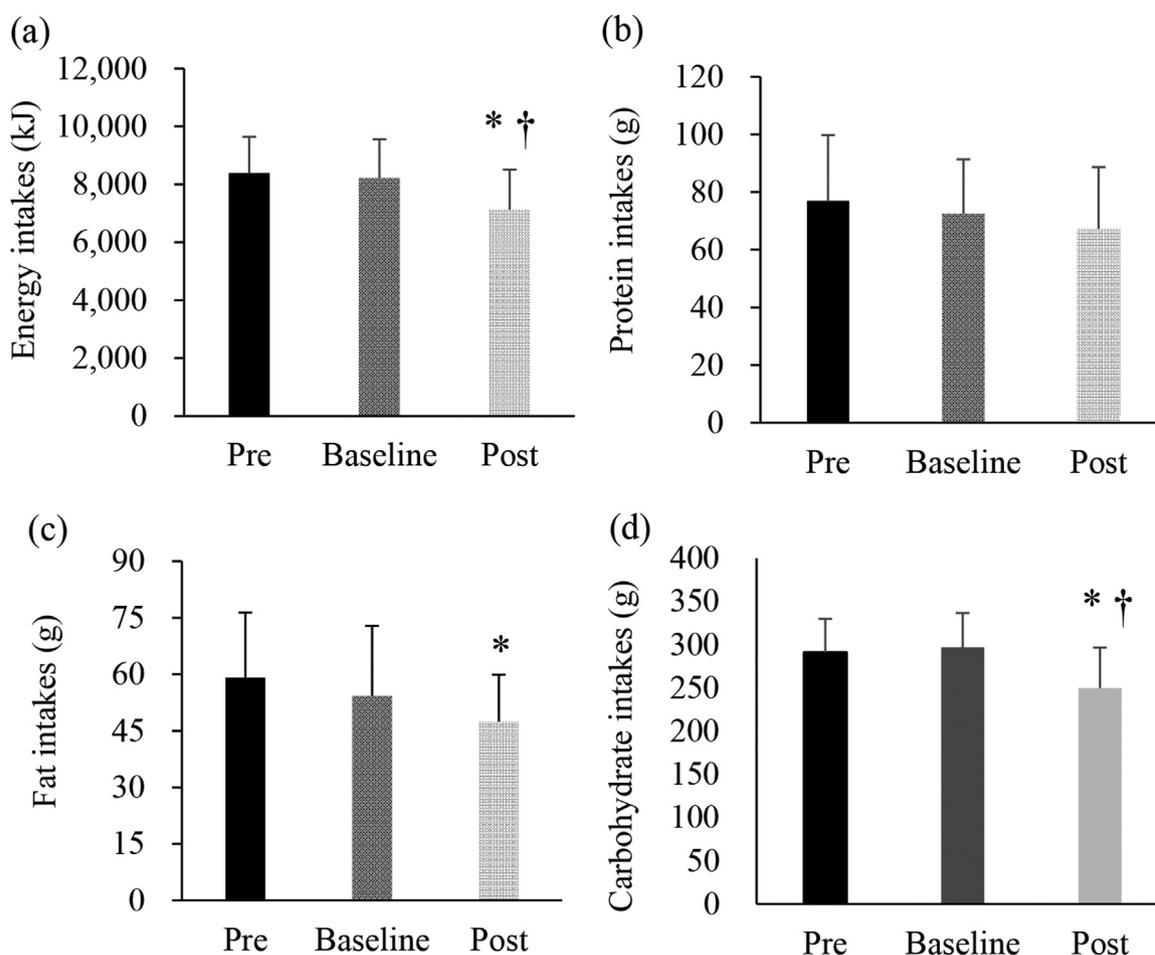
Figure 2   Effect of summer training camp on energy (a), protein (b), fat (c), and carbohydrate (d) intake from food and drink sources in the ad libitum buffet test at dinnertime. Columns represent means ± standard deviations for the 11 participants. *: Significant difference vs. Pre ($P < 0.05$, Tukey−Kramer). †: Significant difference vs. Baseline ($P < 0.05$, Tukey−Kramer).

were 60 ± 6%, 15 ± 3%, and 25 ± 5% respectively. These ratios were not significantly different among pre-camp, baseline, and post-camp time points.

4. Discussion

The purpose of the present study was to investigate appetite and food intake in adolescent rugby football players during summer training camp. We demonstrated that over a 6-day period in summer training camp, male adolescent rugby football players were in a negative energy balance and had insufficient carbohydrate intake.

In a recent systematic review of nutrient intake among adolescent competitive athletes, Noll et al. [25] found that athletes did not adjust their nutrient intake to the demands of the training load or different training sessions. Our study showed similar results. However, the study of Noll et al. [25] assessed dietary intake in athletes during normal daily life. Few studies have focused on the training camp period, during which energy and nutrient demands are expected to increase with training intensity and volume. Briggs et al. [15] reported that the type of training had a direct impact on the degree of energy deficit, highlighting the fact that heavy training days and match days were particular threats

to energy balance. Similarly, in this study energy balance was influenced by exercise-induced energy consumption. We also investigated energy and nutrient status during a normal training period separate from training camp (data not shown) and found that although the energy expenditure was 4446 kJ less than during training camp, energy intake was only 681 kJ lower. As a result, the energy balance during the normal training period was +2873 kJ, whereas it was −892 kJ during training camp. The energy deficit during training camp resulted from increased exercise-induced energy consumption, which was three times higher during camp versus on a normal training day (6912 ± 1430 kJ vs. 2020 ± 868 kJ, respectively).

It has been shown that the carbohydrate requirements to restore muscle glycogen increase as the exercise volume increases [26]. Burke et al. [27] proposed 5−7 g of carbohydrates·kg^{-1}·day^{-1} for moderate training and 6−12 g·kg^{-1}·day^{-1} for intensive training. However, Lun et al. [28] investigated dietary intake among elite Canadian athletes and reported that carbohydrate intake but not protein intake were below recommendations. Previous published research within this population showed carbohydrate intakes ranging from 3.4 to 7.2 g·kg^{-1}·day^{-1}. Likewise, in the present study carbohydrate intake but not protein

intake was below recommendations (7.9 ± 1.1 g·kg^{-1}·day^{-1}; Table 4). This finding suggests that carbohydrate intake may be deficient if the training time is long, such as during training camp.

In addition, we found that energy and carbohydrate intake at ad libitum buffet meals significantly decreased after training camp compared to pre-camp and baseline intake, although subjective appetite did not change over that time.

Our study demonstrated the presence of exercise-induced anorexia, as proposed by King et al. [12]. In a meta-analysis, Schubert and colleagues [17] systemically reviewed the effect of an acute bout of exercise on relative energy intake and reported that energy loss induced by exercise was large and was not compensated by subsequent energy intake, and that the effect of increased exercise on absolute energy intake was trivial and was not statistically significant. Several studies have reported no meaningful change in absolute energy intake in response to a single bout of exercise [13,29—33]. By contrast, in our study, absolute energy intake significantly decreased after the training camp, a finding that agreed with some previous studies [11,34]. This finding indicates that the training camp in the present study caused more profound appetite suppression than the exercise in previous studies. This difference from previous reports may have been caused by differences in exercise duration, intensity, mode, and/or environmental temperature. First, the exercise in previous studies was transient and exercise duration ranged from 30 to 120 minutes; in contrast, the training camp in our study was continuous and participants trained 340 minutes per day over the duration of camp. Consistent exercise over several days may have a stronger appetite-suppressing effect than transient exercise.

Second, high-intensity exercise has been found to significantly reduce subjective appetite and food intake compared with low- or moderate-intensity exercise [10,11]. High-intensity exercise ($\geq 70\%$ VO$_2$max) causes a greater decrease in subjective appetite and food intake compared with exercise of low ($< 50\%$ VO$_2$max) or moderate ($50—70\%$ VO$_2$max) intensity, suggesting that appetite depression depends on exercise intensity [10,11,35]. In the present study, average heart rate during the training corresponded to about 50% VO$_2$ max; however, training was intermittent and maximum heart rate reached upper limits comparable to VO$_2$ max. A substantial portion of the training in the present study was categorized as high-intensity exercise, which may have had a large impact on reduced food intake after the camp. On the other hands, some previous studies showed that endurance at low intensity (oxidizing fat) results in a reduction in food intake while short bouts at high intensity may increase appetite due to glycogen depletion and hypoglycemia.

Third, previous studies have compared the impact of acute exercise mode on appetite [9,29]. However, no studies have examined the effect of training that combined several modes of exercise for training actual athletes. The training in the present study was not of a single type, as in previous studies, but was complicated, combining several aerobic and resistance exercises (e.g. running, sprinting, pushing, kicking, and throwing). Our findings suggest that training that combines various types of exercise may cause greater appetite suppression than single-mode exercise. To support athletes' performance, more research examining the effects of actual athletic training on appetite is needed.

Environmental temperature during exercise is another major factor affecting appetite. Most previous studies have been performed in a laboratory setting, where the temperature was likely maintained at optimal levels and did not vary with the season. The wet-bulb globe temperature during training in this study was $25.3—31.0\,°C$ (temperature: $26.1—33.1\,°C$, humidity: $50.2—80.2\%$); thus, participants were training in a hot environment. Ambient temperature during exercise may affect energy balance regulation [36]. Wasse et al. [37] reported that 1 h of running in a hot environment ($30\,°C$) tended to decrease energy intake at ad libitum meals whereas energy intake was increased in a cool environment ($10\,°C$), compared with running in a temperate environment ($20\,°C$). In this study, training in a hot environment is considered a factor that further promoted appetite decline.

Participants' subjective appetite according to VAS did not change before versus after the training camp, despite the decrease in food intake. Correlations between the delta appetite ratings prior to the ad libitum meal and delta energy intake in the ad libitum meal between pre- and post-camp were $r = -0.042$ for hunger, $r = -0.220$ for satiety, $r = -0.104$ for fullness, and $r = 0.421$ for prospective consumption, indicating no significant relationship between the pre-meal appetite ratings and meal energy intake. These results show that perceived appetite ratings according to VAS assessed before a meal were not a good indicator of meal energy intake in active adolescent males. Many previous studies have reported that orexigenic sensations (e.g. hunger) were low after strenuous exercise, whereas anorexigenic sensations (e.g. satisfaction, fullness, prospective food consumption) were elevated [9—11]. This discrepancy between studies may be related to the habitual physical activity level of participants. A recent review [38] reported that habitually active individuals appear to have increased sensitivity to the energy balance, compared with inactive individuals. Schubert et al. [17] found that absolute energy intake after acute exercise was greater among active individuals than among less active individuals. In this study, the participants regularly engaged in moderate- or high-intensity exercise, so subjective appetite may not have decreased easily, although actual energy consumption decreased. In other words, individuals with a high level of physical activity are less likely to feel anorexia, which could lead to lack of energy and nutrients after vigorous exercise. For this reason, nutritional support for such exercise-induced anorexia is necessary.

Food intake at the buffet test meal decreased or did not change after camp compared with intake pre-camp and at baseline. Although the difference was not significant, cold wheat noodle intake did increase slightly (data not shown). This finding indicates that cold wheat noodles are a relatively easy-to-eat source of carbohydrate intake. The ease of eating could be related to the temperature of the food and ease of chewing or swallowing. Most studies on appetite and exercise have focused on the amounts of ingested energy and nutrients. Few studies have evaluated

which foods are easy to eat or preferred during exercise-induced anorexia.

5. Conclusions

In conclusion, over a 6-day period during summer training camp, adolescent male national-level rugby football players were in a negative energy balance and had insufficient carbohydrate intake. Additionally, summer training camp decreased the intake of energy and carbohydrates at ad libitum buffet meals at the end of camp. However, consumption of appropriate foods, such as noodles or pasta, will help to replenish energy and carbohydrates. There are differences between transient exercise in a laboratory setting versus actual training conditions in the effect on subsequent appetite and food intake. Therefore, more studies that investigate appetite and food preferences under actual training conditions are necessary to improve athletic performance.

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Disclosure of interest

The authors declare that they have no competing interest.

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