Title:

Adequacy of usual intake of Japanese college athletes in various sports clubs

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Abstract

Background: While many studies have been published on nutrient intake assessment for performance improvement and deficiency prevention in single-sport athletes, few studies have addressed nutrient intakes in athletes from a various sports.

Aim: The aim of this study was to determine whether Japanese college athletes meet the Dietary Reference Intakes (DRIs) and sports nutrition recommendations (SNRs).

Methods: Dietary intake was assessed in 1,049 Japanese college athletes from a variety of sports using a validated brief-type self-administered diet history questionnaire. The prevalence of inadequate intakes was estimated by comparing the DRIs and SNRs.

Results: For protein, riboflavin, niacin, vitamins B-6, vitamins B-12, folate, magnesium, zinc, and copper, < 10% of females and males consumed diets that fell below the estimated average requirement (EAR) in the DRIs. A large proportion of female and male college athletes demonstrated intakes that were below the EAR for vitamin A (7.8% and 19.0%, respectively), thiamin (10.4% and 23.9%, respectively), calcium (20.4% and 29.7%, respectively), and iron (24.2% and 2.5%, respectively). Regarding DG for chronic disease prevention in the DRIs, over half of both female and male athletes exceeded the DG for saturated fat acid and sodium, and fell below the DG for dietary fiber. Few of both female and male had intakes below the SNRs for protein and carbohydrates.

Conclusion: The results of the present study reveal the nutrient intake status of Japanese college athletes by comparing the DRIs and SNRs. Most meet the SNRs for optimal performance, but not the DRIs for health.

Introduction

For athletes, adequate nutrition intakes have an important role in improving performance, conditioning, and recovery (Bonilla et al., 2020; Burke and Hawley, 2018). Given that athletes are likely to continue their dietary habits after retirement (Arliani et al., 2014; Yao et al., 2020), assessing athletes' nutrient intake is important not only for their athletic success but also for their post-retirement health (Hołowko-Ziółek et al., 2020).

Several papers have been published that assess whether athletes were meeting the Dietary Reference Intakes (DRIs) and sports nutrition recommendations (SNRs) (Gibson et al., 2011; Heaney et al., 2010; Ishizu et al., 2022; Jenner et al., 2019; Juzwiak et al., 2008; Kim et al., 2019; McCrink et al., 2021; Steffl et al., 2019). Steffl et al. published a meta-analysis describing the current state of macronutrient intake in junior and senior soccer players (Steffl et al., 2019). Jenner et al. published a systematic review of the literature to assess the dietary intakes of professional and semi-professional team sport athletes over the age of 18 years (Jenner et al., 2019). According to these reviews, protein intake is adequate, but carbohydrate intake is inadequate in terms of macronutrient intake (Jenner et al., 2019; Steffl et al., 2019). Next, micronutrients adequacy studies revealed suboptimal folate (Gibson et al., 2011; Heaney et al., 2010; Juzwiak et al., 2008), calcium (Gibson et al., 2011; Kim et al., 2019), and magnesium levels (Gibson et al., 2011).

While many studies have been published on the assessment of nutrient intakes for performance improvement and deficiency prevention in single-sport athletes, few studies have addressed nutrient intakes in athletes from a various sports (Gibson et al., 2011; McCrink et al., 2021). The aim of this study was to determine whether Japanese college athletes in various sports clubs were meeting the DRIs and SNRs.

Methods

Participants and study design.

From October to December 2014, a self-administered questionnaire was used to conduct a cross-sectional study on college athletes who belonged to the club of University of Tsukuba (Ibaraki, Japan). The research was carried out after receiving approval from the ethics committee of Tsukuba (tai26-49). This research was carried out following the Helsinki Declaration.

Each club's survey method was set to be a collective survey method. Details about the study's design and participant characteristics have already been published elsewhere (Kakutani et al., 2019).

We requested a survey from representatives of all 46 sports-oriented clubs at University of Tsukuba that have a school of health and physical education, excluding clubs in school medicine and medical science, and circles. A total of 1,451 college athletes belonged to the 46 clubs that requested the survey. Athletes from a variety of sports disciplines, including individual sports (i.e., track & field, judo, tennis, swimming, gymnastics, and skiing) and team sports (i.e., football, baseball, rugby, American football, basketball, handball, and volleyball) were welcome to participate in the survey. We conducted the survey with 42 clubs that agreed to participate. There were four clubs that did not participate in the survey; two clubs were out of communication, one club has suspended its activities, and one club was close the convention. 1,049 college athletes took part in the survey. All participants provided written informed consent. Subjects with missing data on sex (gender) or resident type (n = 4) were excluded. As students over 25 years of age are extremely rare in Japanese universities, those over the age of 25 years (n = 1) were excluded. As dietary assessment by questionnaire has the potential for reporting error, subjects suspected of under- or over-reporting their energy intake were excluded (Okubo and Sasaki, 2004). Subjects with a reported energy intake of less than half the energy requirement for the lowest physical activity category according to the recommended Dietary Reference Intakes for Japanese, 2020 (Ministry of Health, Labour and Welfare, 2020) were excluded. Those with a reported energy intake greater than or equal to 1.5 times the energy requirement of the highest physical activity category (n = 65) were also excluded. The final sample included 979 students, 269 females and 710 males, between the age of 18 and 24. No students who meet both of these exclusion criteria were found.

Dietary assessment

Dietary habits over the previous month were assessed using a previously validated brief-type self-administered diet history questionnaire (BDHQ)(Sasaki, 2004), which is a condensed version of a validated self-administered diet history questionnaire (Sasaki et al., 1998).

The BDHQ estimates the dietary intake of 58 food and beverage items and 99 nutrients with reference to the Standard Tables of Food Composition in Japan (Council for Science and Technology, 2015). The dietary intake of the 58 food and beverage items was classified based on previously validated food groups (Kobayashi et al., 2011). The BDHQ was validated for the intake of nutrients and food group intake using 16-day weighed dietary records from Japanese adults as the gold standard (Kobayashi et al., 2011, 2012). The average correlation coefficients used in the this study ranged from 0.17 to 0.52 for the food groups and from 0.27 to 0.65 for the nutrients (Kobayashi et al., 2011, 2012).

To allow for a comparison of nutrient intake and the Japanese DRIs values, we adjusted the reported dietary intake based on the assumption that each participant's energy intake was equal to her/his estimated energy requirement (EER) rather than her/his reported energy intake (Okubo et al., 2010). The formula is as follows: energy-adjusted nutrient intake (unit/day) = reported nutrient intake (unit/day) × EER (kcal/day)/reported energy intake (kcal/day). Because the intensity and amount of training varied by sports, the EER value was calculated based on the individual's physical activity level estimated from the sports (2.0 for skill sports; 2.5 for ball game sports and martial arts sports; 2.8 for endurance spots). This level for each sport was based on previous studies using the double-labeled water method (Sagayama et al., 2019; Sagayama, Hamaguchi, et al., 2017; Sagayama, Kondo, et al., 2017; Yoshida et al., 2019).

Determination of Nutrient Intake Adequacy

To assess nutrient intake adequacy, nutrient intakes were compared with age and gender-specific reference values in the Japanese DRIs using a cut-point method, as previously reported (Carriquiry, 1999; Murakami et al., 2018; Okubo et al., 2010).

Biotin, iodine, selenium, chromium, and molybdenum were excluded from the current study due to a lack of adequate food-composition tables in Japan (Council for Science and Technology, 2015).

Different reference values are established in DRIs based on their purpose (Institute of Medicine, 2000). The estimated average requirement (EAR) is defined as "the average daily-nutrient-intake level estimated to meet the requirements of half the healthy individuals in a particular life stage and gender group." The Adequate Intake (AI) is defined as "a recommended average daily-nutrient-intake level based on observed or experimentally determined approximations or estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate." The DG is defined as "the average daily-nutrient-intake level (or ranges) that Japanese should currently aim to consume primarily to prevent chronic diseases" (Ministry of Health, Labour and Welfare, 2020).

We calculated the percentage of college athletes who consumed less than the EAR for protein, vitamin A, thiamin, riboflavin, niacin, vitamin B-6, vitamin B-12, folate, vitamin C, calcium, magnesium, iron, zinc, and copper. Additionally, we calculated the percentage of athletes who consumed greater than or equal to the AI for n-6 PUFA, n-3 PUFA, vitamins D, E, and K, pantothenic acid, potassium, phosphorus, and manganese. The Tolerable Upper Intake Level (UL) of several nutrients has been established in the Japanese DRIs for males and females aged 18–29 years (i.e., vitamins A, D, E, and B-6, niacin, folate, and iron). We calculated the proportion of college athletes who consumed more than the UL.

A Tentative Dietary Goal for Preventing Lifestyle-related Diseases (DG) is provided in the Japanese DRIs for macronutrient balance (% of energy from protein, total fat, SFA, and carbohydrate), dietary fiber, sodium, and potassium (Ministry of Health, Labour and Welfare, 2020). DG has not been established for other nutrients. We calculated the percentage of college athletes who consumed nutrient intake that was outside (below or above) the DG range.

Furthermore, protein and carbohydrate intakes (g/kg weight) were also compared with SNRs (Thomas et al., 2016).

Data Organization and Processing

Data were organized and processed using Microsoft® Excel for Mac 2024 and IBM SPSS Statistics version 27. Energy and nutrient intakes were presented in units of daily intake (e.g. g/day). Protein, total fat, saturated fatty acid (SFA), and carbohydrate intakes were also calculated as a percentage of the daily energy intake using crude values for comparison with DG in the DRIs. In addition, protein and carbohydrate were also calculated in g/kg weight/day to match the units in SNRs.

Results

[insert Table1]

Table 1 shows the basic characteristics of the 979 Japanese college athletes from 34 sports. Next, table 2 and 3 show the participants' mean macronutrient intake in comparison with DRIs for people aged 18–29, as well as SNRs. None of the females and males demonstrated usual protein intakes below the EAR, and 0.7% of females and 4.8% of males demonstrated diets that fell below the SNR. The 10th percentile value for usual protein intake was about twice the EAR and was higher than the lower limit of the SNRs. In contrast, 43.9% of females and 54.8% of males demonstrated diets that below the DG for protein. In terms of SFA, researchers estimated that 56.1% of females and 33.7% of males exceeded the DG. The 90th percentile value for SFA intake was less than 1.5 times the DG for both female and male. Female and male median usual intake of n-6 PUFA and n-3 PUFA were both higher than the AI for both nutrients. Few females and males exhibited usual carbohydrate intakes below the DG (> 13%), and 5.2% of females and 5.2% of males exhibited diets that were below the SNR. An estimated 50.6% of females and 59.2% of males demonstrated diets that fell short of the DG for dietary fiber. The 10th percentile value for dietary fiber intake was above half of the DG for both female and male.

[insert Table2]

[insert Table3]

Also, we compared female and male vitamins and minerals intakes to the corresponding DRIs (Tables 4 and 5, respectively). For riboflavin, niacin, vitamins B-6, vitamins B-12, folate, magnesium, zinc and copper, < 10% of females and males consumed diets that fell below the EAR. In contrast, a moderate percentage of females and males demonstrated usual intakes of thiamin (10.4% and 23.9%, respectively), calcium (20.4% and 29.7%, respectively), and iron that were below the EAR (24.2% and 2.5%, respectively). In terms of potassium, 17.5% of females and 21.5% of males demonstrated diets that were less than the DG. Furthermore, 99.6% females and 99.2% of males demonstrated sodium intake that exceeded the DG. For sodium in both females and males, the 10^{th} percentile value was higher than the DG and the 50^{th} percentile value was more than twice the DG. It is worth noting that none of the college athletes in this study exceeded the UL for vitamin D, niacin, vitamin B-6, folate, calcium, iron, and copper.

[insert Table4]

[insert Table5]

Discussion

To the best of our knowledge, this is the first study to assess the adequacy of usual macronutrients and micronutrients intakes of Japanese college athletes from various sports clubs. The primary findings of this study indicate inadequate dietary intakes of SFA, dietary fiber, vitamin A (male), thiamin (male), sodium, potassium, calcium, and iron (female) in comparison to Japanese DRIs. In contrast, the protein and carbohydrate intake of Japanese college athletes in this study was shown to be adequate in comparison to SNRs required to improve performance and enhance recovery. Previous of elite female athletes (Heaney et al., 2010), junior elite female soccer athletes (Gibson et al., 2011), male football players (McCrink et al., 2021), and non-athlete Japanese female college students yielded results that were generally consistent with the current study (Okubo et al., 2010).

Next, although the SNR for protein is set higher than the EAR in this study, a low percentage of participants demonstrated intakes below the SNR, 0.7 percent for females and 4.8 percent for males. The EAR for protein is based on an amount that maintains the concentration in the body at half of the population (Ministry of Health, Labour and Welfare, 2020). The SNR for dietary protein is the general range needed to support metabolic adaptation, repair, remodeling, and protein turnover in athletes (Thomas et al., 2016). A systematic review of studies on professional and semi-professional athletes found that they consume enough protein in comparison to the SNR (Jenner et al., 2019). Several studies of late-teenage athletes reported rates comparable to the current study for athletes who did not meet the SNR (Gibson et al., 2011; Heaney et al., 2010). For example, Heaney et al. discovered that 30% of elite female athletes consumed less protein than the SNR (Heaney et al., 2010). Protein SNR is an amount that can be adequately obtained in a typical diet, but some athletes, such as students with inadequate support and environment and female athletes with low energy intake, may be at risk of deficiency and require attention.

In this study, the dietary protein intake of Japanese college athletes met the EAR and SNR but was below the DG recommended lower limit for dietary protein. This discrepancy may stem from a predominant preference for carbohydrates and fats as primary energy sources among the athletes. Notably, 56.1% of the female athletes surveyed exceeded the DG for SFA intake. Excessive SFA intake is positively associated with elevated blood total cholesterol and LDL cholesterol levels, both established risk factors for cardiovascular disease (Mensink et al., 2003). Consequently, the DRIs for Japanese set the DG of SFA as a nutrient whose intake should be reduced (Ministry of Health, Labour and Welfare, 2020). The results of the present study showed that many athletes have intakes above DG for SFA, but less than 10% have intakes above 1.5 times DG. Therefore, it would not be difficult to increase the number of those with an adequate intake of SFA.

The percentage of those who consumed carbohydrates below the SNR in the present study was as high as 64.7% in females and 41.7% in males. The SNR for carbohydrate is the range of intake needed for fuel and recovery in athletes participating in endurance programs (eg, 1–3 h/day mod-high-intensity exercise) (Thomas et al., 2016). Since carbohydrate are extremely unlikely to be deficient in Japanese, the EAR and AI in DRIs have not been established (Ministry of Health, Labour and Welfare, 2020). Consistent with the results of the present study, inadequate carbohydrate intake in athletes has been reported in previous United States and European studies. According to a systematic review of studies of professional and semi-professional athletes, they consume insufficient amounts of carbohydrates in comparison to the SNR (Jenner et al., 2019). Many other studies found that many athletes with carbohydrate intakes below the SNR perform better (Heaney et al., 2010; McCrink et al., 2021; Steffl et al., 2019). A study of

Gaelic male football players, for example, discovered that 95.2% demonstrated carbohydrate intakes below the SNR (McCrink et al., 2021). Because the Japanese diet is characterized by grains such as rice, beans such as soybeans, and fish, the carbohydrates intake is higher than in the United States and European countries (Menotti et al., 1999). However, carbohydrate consumption is declining among Japanese people, particularly among young women, as a result of dietary changes such as reduced rice consumption (Otsuka et al., 2014). As a result, consuming a diet that meet the SNR for carbohydrates may be more difficult for Japanese athletes, particularly young females, as well as for United States or European athlete. In fact, a study of Japanese female athletes found that they were not getting enough carbohydrate (Ishizu et al., 2022). As previously stated, dietary protein intake is also insufficient, so care should be taken not to reduce protein intake as a result of increased carbohydrate intake.

In the current study, more than half of both female and male athletes demonstrated inadequate dietary fiber intake below the DG of DRIs Japan (50.6% and 59.2%, respectively). Previous studies with athletes yielded similar results (Gibson et al., 2011; McCrink et al., 2021). According to the findings of a meta-analysis of prospective studies and clinical trials, striking dose-response evidence suggests that the relationship between relatively high dietary fiber intake and several non-communicable diseases may be causal (Reynolds et al., 2019). As a result, the DRIs for Japanese establish the DG of dietary fiber as a nutrient to be increased in intake (Ministry of Health, Labour and Welfare, 2020). For health reasons, athletes need to pay attention not only to their carbohydrate intake per body weight, but also to their dietary fiber intake in carbohydrates. Since most of the athletes in the current study have dietary fiber intakes greater than half the DG, there does not appear to be a need to double their intake.

The percentage of those with inadequate intake of VB group, particularly VB1, is moderate in the current study consistent with the results of previous studies (Gibson et al., 2011; Heaney et al., 2010; Kim et al., 2019). The VB group of nutrients, including VB1, plays an important role in energy metabolism, and several studies have indicated that severe deficiencies may result in decreased performance (van der Beek et al., 1988). However, in studies reporting performance decrements, the intake of VB1 is roughly 0.43 mg/day (0.13 mg/1,000kcal/day) (van der Beek et al., 1988), which is even lower than the 10^{th} percentile value in the current study participants. The 10^{th} percentile values for female participants in the current study were 0.90 mg/day and 0.97 mg/day for male participants. Next, VB1 is a nutrient with EAR in Japanese DRIs based on the amount that saturates the concentration in the body in half of the population, rather than the amount that would cause symptoms of insufficiency or deficiency (Ministry of Health, Labour and Welfare, 2020). This could be one of the reasons for the higher percentage of those in our study who demonstrated inadequate VB1 intake. Overall, while increasing VB1 intake is desirable to improve VB1 nutritional status in Japanese college student athletes, the proportion of those at high risk of immediate VB1 deficiency and decreased performance is likely to be small.

The results of this study indicate that there is some variation in nutrient intake among Japanese college student athletes. This variation may be due to differences in dietary patterns among generations in Japan. A recommended dietary pattern in Japan is meals that combines a staple, main and side dishes. Some studies have reported an association between the frequency of meals combining a staple, main, and side dishes and adequate nutrient intake (Ishikawa-Takata et al., 2021; Kakutani et al., 2015). However, young adults in Japan are less likely than other age groups to have meals that combine a staple, main, and side dishes (Ishikawa-Takata et al., 2021). This may have influenced the variation in nutrient intake among Japanese college student athletes.

The current study exhibits at least three significant limitations.

First, while the BDHQ used for the dietary assessment was a validated questionnaire, the foods asked for were limited. As a result, we must be cautious about misestimating some nutrients, particularly SFA (underestimation) and vitamin A (overestimation) (Kobayashi et al., 2012). However, in the current study, energy adjustment using EER is used to reduce the impact of misestimation. We did not measure physical activity in the current study, for feasibility reasons. Physical activity should be measured in future studies, if possible, to ensure adequate energy adjustment.

Second, because DRIs for Japanese does not adequately account for changes in requirements in athletes with extremely high physical activity, Japanese DRIs for athletes may be inappropriate (too low), at least for some nutrients (Ministry of Health, Labour and Welfare, 2020). Calcium and iron requirements, for example, may increase as a result of increased loss caused by heavy sweating and increased sweat concentration associated with physical activity (Baker and Wolfe, 2020). However, no micronutrient DRIs are available for athletes. Future research should look into how much micronutrient requirements increase with increased physical activity and what level of recommendation is appropriate.

Finally, participants for this study were drawn from a single university. Furthermore, when compared to percentage of Japanese university students who living alone, which is about 40%, the participants in this study were more likely to live alone (JASSO, 2018). The sample of Japanese college athletes enrolled in this study, conversely, came from 33 different competition events. As a result, the findings of this study can be applied to college athletes with similar characteristics to those evaluated in this study.

Conclusion

When compared with the current Japanese DRIs, this sample of Japanese college athletes' usual intake was adequate for some nutrients, including protein, VB group (except thiamin), magnesium, zinc, and copper (assessed based on EAR), as well as n-6 PUFA, n-3 PUFA, vitamin D, E, and K, pantothenic acid, potassium, phosphorus, and manganese (assessed based on AI). However, we discovered insufficient intakes of vitamin A (male), thiamin (male), calcium and iron (female). Also, we discovered excess intakes of SFA and sodium, as well as insufficient intake of protein (% energy), dietary fiber, and potassium. When compared with the SNRs, the usual intakes were moderate adequate for protein and carbohydrates.

The results of the present study reveal the nutrient intake status of Japanese college athletes by comparing the DRIs and SNRs. The results of the present study indicate that most of them meet the SNRs to promote optimal performance, but not the DRIs to maintain and improve health. Japanese college athletes face a significant nutrient intake problem. However, in order to improve the nutrient intake of Japanese college athletes, there is insufficient evidence on the dietary cultural and lifestyle factors that influence the dietary choices of athletes. Therefore, the impact of dietary culture and lifestyle factors would need to investigate in future studies.

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Data availability statement

Data generated during this study are available from the corresponding author upon reasonable request.

Authors' contributions

YK, NO, MO and IS designed for the study. YK collected and analyzed the data. YK wrote the main manuscript text. All authors reviewed and approved the final manuscript.

Declaration of conflicting interests

Miho Ono and Ikuko Sasahara are employees of Ajinomoto co., Inc. The other authors have no conflicts of interest to declare.

Consent for publication.

Written informed consent was obtained from the participants for publication of this article.

Ethical Statement

The research was carried out after receiving approval from the ethics committee of Tsukuba (tai26-49). This research was carried out following the Helsinki Declaration.

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