JOURNAL OF THE INTERNATIONAL SOCIETY OF SPORTS NUTRITION
2025, VOL. 22, NO. 1, 2479709
https://doi.org/10.1080/15502783.2025.2479709

Taylor & Francis
Taylor & Francis Group



# Macronutrient requirements and intake by professional male rugby players

Maryke Meyer [a], Elmine du Toit [a], Riette Nel [b] and Derik Coetzee [c]

[a]Department of Nutrition and Dietetics, Faculty of Health Sciences, Bloemfontein, South Africa, University of the Free State; [b]Department of Biostatistics, Faculty of Health Sciences, University of the Free State, Bloemfontein, South Africa; [c]Department of Exercise and Sports Sciences, Faculty of Health Sciences, University of the Free State, Bloemfontein, South Africa

## ABSTRACT

**Background:** Rugby union is a high-contact team sport where professional rugby players are exposed to considerable training and game loads in pre-season and in-season. Some studies have shown that rugby players' dietary intake remains inadequate for the three macronutrients (carbohydrates [CHO], proteins and fats) required for optimal performance. This study aimed to describe the macronutrient intake of professional male rugby players at Zebre Rugby Club in Parma, Italy, during in-season, and to compare players' macronutrient intake to international recommendations.
**Methods:** Thirty-four professional male rugby players participated in the cross-sectional study. A self-developed questionnaire, a food frequency questionnaire and food records (on training and competition days and off day) were used to investigate players' macronutrient intake. Anthropometric measurements were obtained using the International Society for the Advancement of Kinanthropometry (ISAK) standardized techniques. Descriptive statistics were calculated, and associations were investigated using chi-square, Fisher's exact and Wilcoxon rank tests as applicable.
**Results:** The players' median age was 25.8 years (range 20.6–33.0 years) and 47.5% were Italian. Most players (64.7%) held forward positions and had a median of 5 years (range 2–14 years) of professional experience. More than 75.0% of players lived with a spouse or partner and 30.3% earned between 4 000–4 999 euros per month. The median body weight and height of players were 106.9 kg and 186.3 cm, respectively. The forwards weighed heavier ($p < 0.0001$) than the backs, which was expected due to positional demands, with no significant difference in height distribution. The median body mass index ($p < 0.0001$), waist circumference ($p < 0.001$) and waist-to-height ratio ($p < 0.03$) of forwards were higher than the backs. Additionally, the median body fat percentage of all players exceeded the international recommendation of 8–17% for rugby union players. The American College of Sports Medicine (ACSM), International Olympic Committee (IOC) and International Society of Sports Nutrition (ISSN) recommend an intake of 5.0–8.0 g/kg body

**ARTICLE HISTORY**
Received 7 August 2024
Accepted 9 March 2025

**KEYWORDS**
Macronutrients; nutrition; dietary intake; performance; rugby union

**CONTACT** Elmine du Toit dutoitwc@ufs.ac.za Department of Nutrition and Dietetics, University of the Free State, 205 Nelson Mandela Drive, Bloemfontein, 9300 South Africa

weight (BW)/day CHO, 1.5–2.0 g/kg BW/day proteins and 20–35% total energy (TE) from fats for rugby players. The overall median intake of the three-day food records for all the players was 2.7 g/kg BW CHO, 1.7 g/kg BW protein and 35.1% TE from fat. On each of the three reported days, 90.0% of players' CHO intake fell below the recommended range, with almost all players (>90.0%) consuming less than the recommended amount of carbohydrates and almost 30.0% of players consuming below the recommended amount of protein on competition day. At least 50.0% of players' protein and fat intake was within the recommended range on each of the three reported days.
**Conclusion:** The study's findings can assist various stakeholders at Zebre Rugby Club to align rugby players' dietary requirements to their workload, and encourage players' adherence to dietary guidelines and recommendations. It is advised that attention be focused on accurate dietary education, intake and monitoring to promote individualization and optimal performance and recovery. Future research is needed to adapt standardized macronutrient recommendations for rugby-specific requirements and address obstacles that may impede the optimal intake of macronutrients.

## 1. Introduction

Rugby union (RU) as a team sport has evolved rapidly over the years [1,2] from the spontaneous play made by William Webb Ellis on the playground of a school in a town called Rugby, with few rules and regulations [3,4], to a world-wide regulated professional sport with players and viewers in the millions [3,5,6]. The modern game of rugby is a multifaceted sport combining various degrees of physicality and skill [7,8]. Rugby union as a field-based team sport is contested by two teams over an 80-minute game divided in two 40-minute halves, with a break of 15 minutes [3]. A rugby team comprises 15 players, eight forwards (numbers 1–8) and seven backs (numbers 9–15) on the field at a time. Each position has its own unique physical and fitness characteristics [9,10] and game-play demands [11–13].

Rugby greatly involves high-intensity activities such as sprinting, rucking, mauling and tackling, as well as low-intensity activities that include jogging, walking or standing [10,14]. Forwards and backs are estimated to cover a distance of >5 000 m and >6 000 m, respectively, during a match [15,16]. The different positions within the team can require a different physicality and set of responsibilities per player [14,16,17]. The difference in physicality between forwards and backs has been well documented [14,16,17] and is associated with the physical demand/responsibility of each position [14,16,18].

Generally, the forwards are seen as the team's defense unit mostly involved in the tackling, mauling and rucking to stop and gain possession of the ball [14,16], using their strength for collisions occurring at high speed and force. Forwards are supported by the running assistance of the backs [16] who cover an overall longer distance at higher speeds made possible by the availability of more space on the field [15,16], engaging in some collisions, although to a lesser degree than forwards [14].

Notably, both forwards and backs are involved in activities of supramaximal intensities of different physical demands related to the position of play [15,16]. Roberts et al. [15]

indicated that forwards (88%) and backs (96%) spent more time engaged in activities of low intensity. However, forwards (12%) spent more time engaged in high-intensity activities than the backs (4%). Lacome et al. [19], who evaluated the physical demands of rugby, found that 40% of movement during a match was of moderate intensity. This may be due to multiple factors (such as the game plan and weather conditions) that can contribute to a change in movement and collisions in a match, as reported by Schoeman et al. [14].

Lacome et al. [19] noted that activities of high intensity cause fatigue. In agreement, Benardot [20] stated a well-established aerobic capacity and aerobic endurance are required by rugby players, which can only be fueled by macronutrients. Furthermore, Schoeman et al. [14] also noted the increased risk of injury caused by the numerous collisions players in certain positions are exposed to in a match. In addition to energy loss and fatigue, the dynamic and interactive movements with the exposure to numerous collisions in a match contribute to muscular damage or injury [14,16,21].

Professional rugby players are exposed to considerable heavy training loads in pre- and in-season [22,23]. Gabbett [24] inferred in this regard that the acute:chronic training load hypothetically is a common predictor of player injury, player fitness and team performance. Therefore, from a nutrition perspective, attention should be drawn to the macronutrients in rugby players' diets to sustain their performance and recovery outcomes. Consequently, physical attributes, such as strength, speed, agility and decision-making [8,25] during competition and training sessions, contribute to the sport's success [7,8,26]. Players' success is further enhanced by nutritional support to meet the physical and physiological demands of rugby [27–29]. However, Black et al. [28] stated that there is very little information on the energy expenditure of rugby union players.

It is scientifically accepted that nutrition remains an important component in sport. Evidence-based strategies of nutritional intake have proven to be beneficial to performance in training or competition and recovery thereafter [30,31]. Of the numerous nutritional strategies available to athletes in various sports disciplines [30], the significance of macronutrients (CHO, proteins and fats) is based on each substrate's biological role in the body, in addition to the direct effect on performance and recovery in sport [27,28,30].

The sport of rugby involves a combination of strength and endurance [16,20] upon specific physical attributes to assist the playing position's responsibilities in the team [16,27]. Therefore, rugby would benefit from players obtaining an adequate macronutrient intake [20,32], which biologically assists the physical and physiological demand that rugby entails [16,27], and thus contributes to players' performance in the sport and recovery thereafter [20,28,33]. Additionally, training, competition and recovery are three areas in rugby where macronutrients play a vital role in performance success [28,33]. However, nutritional recommendations and requirements in these three areas may differ [28,30,34].

Consequently, various international sports committees have set out macronutrient recommendations for athletes, covering a range of sporting durations and intensities [35,36] aimed at optimizing an athlete's performance and recovery through adequate macronutrient intake [28,33,36].

However, despite current recommendations [27,35,36], athletes struggle to meet the proposed requirements [20,35] resulting from following self-determined dietary strategies that are not as effective as scientifically planned nutritional strategies [31,37]. Bradley et al. [38] found that in-season, forwards and backs reported a lower than recommended carbohydrate (≈3.5 g/kg/day) intake accompanied by a high protein (≈2.7 g/kg/day) and moderately high fat (≈1.5 g/kg/day) intake. Tavares et al. [39] also highlighted the greater focus of elite rugby players on protein intake because of the high-impact collisions in rugby union, which leads to notable muscle damage during training and even more in competition. Therefore, protein ingestion is very important for muscle repair, adaptation and growth (hypertrophy) [40,41]. Black et al. [28] concluded that although there was some variability in the percentage fat, some studies reported an average total fat intake that was within the recommended range for health [36,42]. To date, no studies were conducted that compared the international sports committees' guidelines on macronutrient intake for professional rugby union players before, during and after competition.

Jenner et al. [35] and Black et al. [28] asserted that inadequate macronutrient intake among team sport players, particularly in rugby union, is related to the stigma surrounding the physical attributes required by the sport. It should be noted that a wide range of supplements is used by rugby players, which depends on the individual player's needs, dietary intake, and goals [38]. In addition, having knowledge of sports nutrition may be an important contributing factor toward nutritional consideration and practices among athletes aimed at meeting nutritional requirements [43,44] apart from their demographic variables, for example, social and economic circumstances [45,46].

At present, limited specific nutritional recommendations are available for the sport of rugby or its players. However, rugby players' dietary requirements are based on recommendations and guidelines in line with the sport's duration and training intensity [28,36,40], in addition to the physical demands of the game [35]. These aspects led to the questions (i) are rugby players aware of their nutritional requirements, and (ii) are players meeting their macronutrient requirements?

Zebre Rugby Club in Parma, Italy, had gone through administrative changes during the summer of 2017, which, in many respects, improved the management of the club [47]. However, the team continues to struggle to move up from the lower position of the European Challenge Cup pool and United Rugby Championship log [48]. As nutritional intake, in particular macronutrient intake, is known to improve performance and recovery [36,49], it was regarded as potentially beneficial to investigate if players were meeting their nutritional performance-related goals. Therefore, the primary aim of this study was to describe the CHO, protein and fat intake in senior, professional male rugby players at Zebre Rugby Club during in-season, and to compare their intake to international recommendations and requirements based on the intensity and duration of competition and training sessions.

## 2. Materials and methods

### 2.1. Study design

A descriptive, cross-sectional study design was applied whereby the researcher collected data at a single point in time.

### 2.2. Study population and sample size

The research population for this study consisted of professional male rugby players at Zebre Rugby Club in Parma, Northern Italy. The researcher resided in Parma, with knowledge of and access to the club and its players, as well as having a special interest in the nutritional intake of professional rugby players, and wanted to investigate this topic.

At the time of the study, 54 professional male rugby players were contracted by the club. Two team members at Zebre Rugby Club were not eligible to participate in the study due to injury. Therefore, the sample size consisted of 52 team members of which 34 members agreed to participate, with the researcher including as many eligible players as possible to participate in the study.

### 2.3. Study procedure and data collection

For this study to commence, various procedural steps were taken to obtain the necessary data for analysis and interpretation. Permission was obtained from the Italian Rugby Federation (IRF), the President of Zebre Rugby Club, the Italian Ethics Committee, and the Health Sciences Research Ethics Committee (HSREC) of the University of the Free State in Bloemfontein, South Africa. Information about the study was provided in English and Italian to the staff, dietitian and professional rugby players at Zebre Rugby Club. Players were further enlisted through WhatsApp and the snowball effect. The pilot study was conducted on three professional rugby players with no changes to the data collection instruments. Thereafter, data collection commenced. The data were captured and cleaned in Microsoft Excel and FoodFinder software (Medical Research Council; Cape Town, South Africa) [50], analyzed on FoodFinder and exported to Microsoft Excel software. Data capturing was reviewed by the co-authors. Data were finally cleaned and analyzed by a biostatistician and the results were interpreted.

### 2.4. Sociodemographic information questionnaire

For this study, a self-developed questionnaire containing closed-ended and open-ended questions was used. The questionnaire was divided into four sections, with questions pertaining to sociodemographic factors determined in the first section. The questionnaire was handed out to each participating rugby player for self-completion at scheduled appointments.

### 2.5. Anthropometric measurements

Various techniques were used in this study for anthropometric measurement and nutritional assessment. For anthropometric measurements, height and weight were used to assess body mass index (BMI), height and waist circumference (WC) for waist-to-height ratio (WtHR), skinfold landmarks, and Tanita bioelectrical impedance body composition analyzer (Tanita Corporation; Tokyo, Japan) for body fat percentage (BF%). Guidelines proposed by the International Society for the Advancement of Kinanthropometry (ISAK) [51] were followed to allocate the four anatomical landmarks to measure the four skinfolds and for anthropometric measurement. All anthropometric equipment was calibrated as recommended by the manufacturers' guidelines. For nutritional assessment, a self-developed questionnaire and dietary assessments consisting of a food frequency questionnaire (FFQ) and a three-day food record evaluated by the FoodFinder software were used.

#### 2.5.1. Height

Height was measured to the nearest 0.1 cm [51] using the Seca 213I (Seca GmbH; Hamburg, Germany) stadiometer.

#### 2.5.2. Weight

The calibrated Tanita MC-780 MA bioelectric impedance analysis (BIA) instrument was used to measure the weight of each rugby player. The players were required to stand barefoot on the scale's platform distributing their weight evenly on both feet, without external assistance [51]. Weight was measured to the nearest 0.1 kg [51,52].

#### 2.5.3. Body mass index (BMI)

BMI was calculated by the rugby player's current weight in kilograms divided by their height in meters, squared. BMI = weight/height$^2$ (kg/m$^2$) [53]. The normal range for BMI is between 18.5 kg/m$^2$ and 24.9 kg/m$^2$ [53], but this calculation does not distinguish between body fat and lean body mass (muscle).

#### 2.5.4. Waist circumference (WC)

An inelastic, fiberglass measuring tape was used to measure WC in cm to the nearest 0.1 cm [51]. The universal cut of value for males is <102 cm [54].

#### 2.5.5. Waist-to-height ratio (WtHR)

WtHR was calculated by WC in centimeters (cm) divided by height in cm; WtHR = WC/height (cm/cm) [55,56]. The WtHR cut-off value is ≤0.5 for normal weight in males [56].

#### 2.5.6. Body fat

Body fat was measured by using a calibrated Tanita MC-780 MA BIA scale and software [20,57,58].

#### 2.5.7. Body fat percentage (BF%)

It was calculated by using the Durnin Womersley equation [59]. The recommended BF% for international rugby players is 8–17% [60].

### 2.6. Dietary assessment

Dietary assessment was evaluated by retrospective (the Food Frequency Questionnaire [FFQ]) and prospective (food record) techniques [61]. Furthermore, the FoodFinder software [50] was used in conjunction with data recorded in the food records to estimate the macronutrient intake of each professional rugby player.

### 2.7. Food frequency questionnaire

The FFQ was used to indicate the weekly intake of food items and included in the self-developed questionnaire. A non-quantitative FFQ was used to cross-reference professional rugby players' food records and determine how often food items were consumed.

### 2.8. Food record

The food record was completed on nonconsecutive training day, competition day, and off day. Players were required to indicate pre-match, within-match and post-match intakes on competition day for analysis. The intakes were appraised to CHO, protein and fat recommendations established by various international sports committees, based on the volume and intensity of competition and training sessions [20,30,36,62].

### 2.9. FoodFinder software

A profile was compiled for each food record entry. The information from these records was entered into the newest version (2023) of the FoodFinder software [50]. The food records captured by the researcher were analyzed by the software to provide the individual macronutrient values for each of the three days [63]. The macronutrient values of each day were compared to the recommendations of international committees [20,30,36,62]. Additionally, the average macronutrient values from the three days were used to evaluate the average dietary intake of the rugby players.

### 2.10. Validity and reliability

In a recent study on the reliability and validity of the low-cost BIA, Vasold et al. [64] found that the Tanita BIA, among other BIA equipment, provided high reliability (95% confidence interval [CI] 0.987; 0.995) and validity (95% CI 0.972; 0.979) in body composition analysis. Furthermore, BIA is on par with assessment by skinfold thickness and provides a noninvasive alternative that requires less operator training [65].

The questionnaire to determine sociodemographic factors was available in Italian and English for players to complete in the language of their choice. Straightforward, easy-to-understand questions were used in the questionnaire.

The researcher and an Italian interpreter administered the questionnaire and were present throughout the completion of the questionnaire to attend to any queries from the players.

To obtain valid data for food records, players were given an example and guide on accurate food recording, portion size and completing a food record by the researcher in the presence of the Italian representative. Food record forms, with an easy-to-follow layout, were provided in Italian and English for players to complete in the language of their choice. Additionally, only three days' food records were required to encourage compliance.

To ensure reliability, a portion size guide, food grouping guide and food item description form were provided and explained to each rugby player in Italian or English.

### 2.11. Statistical analysis

Descriptive statistics, namely median and percentiles for numerical data (when the numerical data distribution was skewed), and frequencies and percentages for categorical data, were calculated. Associations were calculated and depending on the distribution, the T-test or Kruskal–Wallis test for numerical data, and the chi-square or Fisher's exact test for categorical data, were used. P-values $<0.05$ were considered significant. The data analysis for this study was generated using SAS software, version 9.4 (SAS Institute Inc., Cary, NC, USA).

### 2.12. Ethical considerations

All participants provided informed consent to be included in the study. The research was approved by the University of Modena Ethics Committee (Comitato Etico Area Vasta Emilia Nord; ref. no. 129/2021/OSS/UNIPR) and the Health Sciences Research Ethics Committee (HSREC) of the University of the Free State in Bloemfontein, South Africa (ref. no. UFS-HSD2020/1800/3108).

## 3. Results

The players' median age was 25.8 years (range 20.6–33.0 years) and 47.5% were Italian. Most players (64.7%) held forward positions and had a median of 5 years (range 2–14 years) of professional experience. All players completed a primary level of education and were predominantly single (41.1%). More than 75.0% of players lived with a spouse or partner and 30.3% earned between 4 000–4 999 euros per month.

The players' anthropometric characteristics are summarized in Table 1. The median body weight and height of players were 106.9 kg and 186.3 cm, respectively. The forwards weighed heavier ($p < 0.0001$) than the backs, which was expected due to positional demands, with no significant difference in height distribution. The median BMI ($p < 0.0001$), waist circumference ($p < 0.001$) and waist-to-height ratio ($p < 0.03$) of forwards were higher than that of the backs. Collectively the players' median body fat percentage exceeded the international recommendation of 8–17%. However, when considering positional groups, the backs fell within the international range.

The dietary intake of players, summarized in Table 2, was analyzed from the self-reported food record completed on a nonconsecutive training day, competition day and off day. The median, interquartile range (IQR), and minimum and maximum range of macronutrient intake by all players on the particular days are shown in Table 2. The overall median intake of the food records for all the players was 2.7 g/kg BW CHO, 1.7 g/kg BW protein and 35.1% TE from fat (1.1 g/kg BW fat). As per the positional groups, the median intake of the food records for forwards was 2.5 g/kg BW CHO, 1.6 g/kg BW protein, 34.3% TE from fat (1.0 g/kg fat), and the backs 2.7 g/kg BW CHO, 1.7 g/kg BW protein, with 35.5% TE from fat (1.1 g/kg BW).

In terms of macronutrient intake according to the recommended range, adapted from international sport committees' guidelines (Table 3), most of the players fell below the recommended CHO range of 5.0–8.0 g/kg BW on training day ($n = 34$; 100.0%), competition day ($n = 32$; 94.1%) and off day ($n = 33$; 97.1%). However, for protein, more

**Table 1.** Anthropometric characteristics of Zebre rugby club players.

| Variables | All players ($N$ = 34) | Forwards[†] ($n$ = 22) | | Backs ($n$ = 12) |
|---|---|---|---|---|
| **Body composition** | | | | |
| *Weight (kg)* | | | | |
| Median | 106.9 | 112.8 | | 93.4 |
| IQR | 95.4–115.3 | 107.5–119.0 | | 90.2–95.8 |
| Range | 76.7–132.0 | 98.8–132.0 | | 76.7–104.0 |
| p-value | – | | 0.0001* | |
| *Height (cm)* | | | | |
| Median | 186.3 | 189.3 | | 183.5 |
| IQR | 182.3–194.6 | 183.3–198.3 | | 181.8–188.3 |
| Range | 171.7–202.5 | 178.6–202.5 | | 171.7–195.4 |
| p-value | – | | 0.08 | |
| *BMI (kg/m$^2$)* | | | | |
| Median | 30.1 | 31.5 | | 26.8 |
| IQR | 28.0–32.7 | 30.1–33.1 | | 25.7–29.2 |
| Range | 23.8–35.3 | 26.0–35.3 | | 23.8–31.6 |
| p-value | – | | 0.0001* | |
| *WC (cm)* | | | | |
| Median | 92.8 | 94.9 | | 87.7 |
| IQR | 88.4–96.5 | 91.6–99.4 | | 85.2–90.9 |
| Range | 81.3–105.6 | 83.5–105.6 | | 81.3–95.3 |
| p-value | – | | 0.001* | |
| *WtHR (cm)* | | | | |
| Median | 0.49 | 0.49 | | 0.47 |
| IQR | 0.47–0.52 | 0.48–0.53 | | 0.45–0.49 |
| Range | 0.43–0.57 | 0.43–0.57 | | 0.45–0.52 |
| p-value | – | | 0.03* | |
| **Skinfold and body fat** | | | | |
| *Sum of four skinfold sites (mm)* | | | | |
| Median | 44.2 | 46.5 | | 34.7 |
| IQR | 33.7–49.3 | 38.9–52.8 | | 30.2–42.0 |
| Range | 25.3–72.1 | 28.5–72.1 | | 25.3–51.5 |
| p-value | – | | 0.005* | |
| *Tanita BIA body fat percentage (%)* | | | | |
| Median | 18.5 | 20.4 | | 15.8 |
| IQR | 15.9–21.7 | 18.3–23.8 | | 12.1–17.5 |
| Range | 9.8–26.4 | 12.5–26.4 | | 9.8–20.2 |
| p-value | – | | 0.001* | |
| *Durnin and Womersley [59] equation body fat percentage (%)* | | | | |
| Median | 17.6 | 18.1 | | 15.9 |
| IQR | 15.4–19.3 | 16.0–20.9 | | 13.0–17.6 |
| Range | 10.6–23.5 | 12.2–23.5 | | 10.6–19.3 |
| p-value | – | | 0.01* | |

*.p < 0.05 was considered statistically significant.
†.IQR, interquartile range; BMI, body mass index; WC, waist circumference; WtHR, waist-to-height ratio; BIA, bioelectric impedance analysis.

than half of players fell within the 1.2–2.0 g/kg BW range on training day (n = 20; 58.8%), competition day (n = 22; 64.7%) and off day (n = 22; 64.7%). A similar distribution of players fell within or exceeded the fat recommendation of 20–35% TE on competition day and off day.

Table 4 shows the results for macronutrient intake before, during and after competition. In general, the majority of the players' ($n$ = 32; 94.1%) CHO intake prior to competition did not meet the minimum recommendation of 1.0 g/kg BW and more than half of the players ($n$ = 19; 55.9%) exceeded the protein recommendation of 0.15–0.25 g/kg BW. The pre-competition meal/snack of all but one forward ($n$ = 21;

**Table 2.** Median carbohydrate, protein and fat intake of Zebre rugby players on a - training day, competition day and off day.

| Variables | CHO (g/kg BW) | Protein (g/kg BW) | Fat (g/kg BW) | Fat (% of TE) |
|---|---|---|---|---|
| **All players (*N* = 34)** | | | | |
| *Training day* | | | | |
| Median | 2.6 | 2.0 | 1.1 | 34.6 |
| IQR | 1.5–3.4 | 1.9–2.4 | 0.9–1.3 | 27.5–41.6 |
| Range (min, max) | 0.7–4.3 | 0.9–3.8 | 0.3–2.3 | 23.6–50.7 |
| *Competition day* | | | | |
| Median | 3.1 | 1.3 | 1.0 | 34.8 |
| IQR | 2.2–3.5 | 1.2–1.5 | 0.9–1.2 | 27.7–41.1 |
| Range (min, max) | 0.6–6.4 | 0.7–2.6 | 0.5–2.3 | 20.0–58.8 |
| *Off day* | | | | |
| Median | 2.3 | 1.7 | 1.1 | 35.8 |
| IQR | 1.5–2.8 | 1.3–2.1 | 0.9–1.4 | 29.3–43.7 |
| Range (min, max) | 0.7–5.3 | 0.6–2.7 | 0.3–2.0 | 25.0–54.2 |
| **Forwards (*n* = 22)** | | | | |
| *Training day* | | | | |
| Median | 2.2 | 1.9 | 1.0 | 35.1 |
| IQR | 1.4–3.0 | 1.5–2.5 | 0.8–1.3 | 29.1–41.6 |
| Range (min, max) | 0.9–4.3 | 0.9–3.8 | 0.3–2.3 | 23.6–50.7 |
| *Competition day* | | | | |
| Median | 3.0 | 1.3 | 0.9 | 33.7 |
| IQR | 2.1–3.3 | 1.1–1.5 | 0.8–1.2 | 27.8–41.1 |
| Range (min, max) | 0.6–5.4 | 0.7–2.6 | 0.5–2.3 | 20.0–56.0 |
| *Off day* | | | | |
| Median | 2.3 | 1.7 | 1.0 | 34.2 |
| IQR | 1.5–2.8 | 1.3–2.0 | 0.8–1.4 | 29.2–42.1 |
| Range (min, max) | 0.7–4.9 | 0.6–2.7 | 0.3–2.0 | 25.0–45.6 |
| **Backs (*n* = 12)** | | | | |
| *Training day* | | | | |
| Median | 2.7 | 2.0 | 1.1 | 31.3 |
| IQR | 2.0–3.5 | 2.0–2.4 | 1.0–1.4 | 26.7–41.6 |
| Range (min, max) | 0.7–3.4 | 1.9–3.3 | 0.7–2.0 | 24.0–49.2 |
| *Competition day* | | | | |
| Median | 3.2 | 1.4 | 1.1 | 35.2 |
| IQR | 2.6–4.1 | 1.2–1.5 | 1.0–1.3 | 28.8–42.0 |
| Range (min, max) | 1.9–6.4 | 1.0–2.1 | 0.7–2.2 | 23.4–58.8 |
| *Off day* | | | | |
| Median | 2.3 | 1.8 | 1.2 | 40.1 |
| IQR | 1.4–2.8 | 1.4–2.2 | 1.0–1.6 | 33.3–46.5 |
| Range (min, max) | 1.2–5.3 | 1.1–2.5 | 0.7–2.0 | 27.7–54.2 |

CHO, carbohydrates; BW, body weight; TE, total energy; IQR, interquartile range; min, minimum; max, maximum.

95.5%) and back ($n = 11$; 91.7%) player did not meet the minimum CHO recommendation (1.0 g/kg BW). Approximately two-thirds ($n = 14$; 63.6%) of the forwards and more than a third of the backs ($n = 5$; 41.7%) exceeded the protein recommendation (>0.25 g/kg BW).

No dietary intake was reported during the duration of the match by any players (Table 4). The median duration of play (minutes) reported by the forwards was 60.0 minutes (IQR 50; 80, range 19–80 minutes). The backs played for a median duration of 50.0 minutes (IQR 29; 80, range 23–80 minutes).

Post-competition more than two thirds of players exceeded the proposed CHO (n = 23; 67.6%) and protein (n = 26; 76.5%) range, as shown in Table 3. No back player fell within the recommended CHO range, as opposed to two (9.1%) forward players. The post-

**Table 3.** Macronutrient intake of Zebre rugby players compared to recommended range according to international sport committees' guidelines [20,30,36,62].

| Variables | Day Training n (%) | Competition n (%) | Off n (%) |
|---|---|---|---|
| **Carbohydrates** | | | |
| Reference range 5.0–8.0 g/kg BW | | | |
| *All players (N = 34)* | | | |
| Below range | 34 (100.0) | 32 (94.1) | 33 (97.1) |
| In range | 0 (0.0) | 2 (5.9) | 1 (2.9) |
| Above range | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| *Forwards (n = 22)* | | | |
| Below range | 22 (0.0) | 21 (95.5) | 22 (100.0) |
| In range | 0 (0.0) | 1 (4.5) | 0 (0.0) |
| Above range | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| *Backs (n = 12)* | | | |
| Below range | 12 (0.0) | 11 (91.7) | 11 (91.7) |
| In range | 0 (0.0) | 1 (8.3) | 1 (8.3) |
| Above range | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| **Protein** | | | |
| Reference range 1.2–2.0 g/kg BW | | | |
| *All players (N = 34)* | | | |
| Below range | 3 (8.8) | 10 (29.4) | 4 (11.8) |
| In range | 20 (58.8) | 22 (64.7) | 22 (64.7) |
| Above range | 11 (32.4) | 2 (5.9) | 8 (23.5) |
| *Forwards (n = 22)* | | | |
| Below range | 3 (13.6) | 7 (31.8) | 2 (9.1) |
| In range | 13 (59.1) | 14 (63.6) | 16 (72.7) |
| Above range | 6 (27.3) | 1 (4.6) | 4 (18.2) |
| *Backs (n = 12)* | | | |
| Below range | 0 (0.0) | 3 (25.0) | 2 (9.1) |
| In range | 7 (58.3) | 8 (66.7) | 6 (50.0) |
| Above range | 5 (41.7) | 1 (8.3) | 4 (33.3) |
| **Fat** | | | |
| Reference range 20–35% of TE | | | |
| *All players (N = 34)* | | | |
| Below range | 0 (0.0) | 0 (0.0) | 0 (0) |
| In range | 18 (52.9) | 17 (50.0) | 17 (50.0) |
| Above range | 16 (47.1) | 17 (50.0) | 17 (50.0) |
| *Forwards (n = 22)* | | | |
| Below range | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| In range | 11 (50.0) | 12 (54.6) | 13 (59.1) |
| Above range | 11 (50.0) | 10 (45.4) | 9 (40.9) |
| *Backs (n = 12)* | | | |
| Below range | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| In range | 7 (58.3) | 5 (41.7) | 4 (33.3) |
| Above range | 5 (41.7) | 7 (58.3) | 8 (66.7) |

BW, body weight; TE, total energy.

competition meal/snack of most of the forward (n = 16; 72.7%) and back players (n = 10; 83.3%) exceeded the recommended protein range.

In terms of food frequency (Table 5), seven food groups were evaluated, namely fruit and vegetables; grains and cereals; meat, poultry, fish, legumes; dairy and dairy products; fats and oils; beverages, and sugar and sweets. Furthermore, each food group was further divided into food items of similarity.

With regard to fruits and vegetables (Table 5), fruits were further divided into six groups of similarity, with nearly a quarter or more players (>*n* = 8; 23.5%) indicating no fruit intake in each of the fruit groups, except tropical fruit. Merely

**Table 4.** Macronutrient intake of Zebre rugby club players before, during and post-competition [20,30,36,62].

| Variables | Players | | |
|---|---|---|---|
| | All players ($N$ = 34) n (%) | Forwards ($n$ = 22) n (%) | Backs ($n$ = 12) n (%) |
| **Pre-match (1–4 hours prior)** | | | |
| ***Carbohydrates*** | | | |
| Reference range 1.0–4.0 g/kg BW | | | |
| <1.0 | 32 (94.1) | 21 (95.5) | 11 (91.7) |
| 1.0–4.0 | 2 (5.9) | 1 (4.5) | 1 (8.3) |
| >4.0 | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| ***Protein*** | | | |
| Reference range 0.15–0.25 g/kg BW | | | |
| <0.15 | 11 (32.3) | 6 (27.3) | 5 (41.7) |
| 0.15–0.25 | 4 (11.8) | 2 (9.1) | 2 (16.6) |
| >0.25 | 19 (55.9) | 14 (63.6) | 5 (41.7) |
| During match (>60 mins) | | | |
| ***Carbohydrates*** | | | |
| Reference range 30–60 g/hour (mouth rinse/glucose) | | | |
| 30–60 minutes | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| >60 minutes | 0 (0.0) | 0 (0.0) | 0 (0.0) |
| Post-match (0–4 hours after) | | | |
| ***Carbohydrates*** | | | |
| Reference range 1.0–1.2 g/kg BW | | | |
| <1.0 | 9 (26.5) | 6 (27.3) | 3 (25.0) |
| 1.0–1.2 | 2 (5.9) | 2 (9.1) | 0 (0.0) |
| >1.2 | 23 (67.6) | 14 (63.6) | 9 (75.0) |
| ***Protein*** | | | |
| Reference range 0.25–0.4 g/kg BW | | | |
| <0.25 | 2 (5.9) | 2 (9.1) | 0 (0.0) |
| 0.25–0.4 | 6 (17.6) | 4 (18.2) | 2 (16.7) |
| >0.4 | 26 (76.5) | 16 (72.7) | 10 (83.3) |

two players indicated a daily intake of either citrus or tropical fruits. Additionally, over a third of players ($n = 13$; 38.2%) indicated consuming starchy vegetables three times per week, followed by a third ($n = 11$; 32.3%) of players consuming green, red and orange vegetables three times a week. Approximately a quarter ($n = 9$, 26.5%) of players reported consuming a vegetable daily from the various vegetable groupings.

In terms of grains and cereals (Table 5), approximately one in three players ($n = 10$; 29.4%) consumed white rice twice a week, with half of these players ($n = 5$; 14.7%) consuming whole wheat/brown basmati rice twice a week. White pasta ($n = 13$; 38.3%) was eaten more often than whole grain pasta ($n = 8$; 23.5%), three to four times per week. However, white bread/assortments ($n = 12$; 35.4%) and wholewheat/brown bread assortments ($n = 10$; 29.4%) were consumed by more than a quarter of players three to four times per week.

In terms of meat, poultry, fish and legumes (Table 5), less than half of the players ($n = 15$; 44.1%) consumed poultry four times per week, while cured meats ($n = 9$; 26.5%) and eggs ($n = 8$; 23.5%) were consumed two to three times per week. Roughly one in three players ($n = 10$; 29.4%) consumed fish one to two times per week, legumes twice a week and meat four times per week, respectively. However, about a third of players ($n = 11$; 32,4%) consumed protein supplements five times per week.

**Table 5.** Food frequency report of zebre rugby players ($N = 34$).

| | Weekly frequency | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | None | 1x | 2x | 3x | 4x | 5x | 6x | 7x (daily) |
| Food frequency variables | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) |
| *Fruits and vegetables* | | | | | | | | |
| Apple, pear | **11 (32.4)** | **11 (32.4)** | 4 (11.8) | 6 (17.7) | 0 (0) | 1 (2.9) | 1 (2.9) | 0 (0) |
| Berries: strawberries, raspberries, blueberries, blackberries, kiwifruit, passionfruit | **13 (38.2)** | 10 (29.4) | 8 (25.5) | 2 (5.9) | 0 (0) | 1 (2.9) | 0 (0) | 0 (0) |
| Citrus fruits: oranges, grapefruit, mandarins, limes, lemons | 8 (23.5) | 6 (17.7) | **13 (38.2)** | 3 (8.8) | 2 (5.9) | 0 (0) | 1 (2.9) | 1 (2.9) |
| Melons: watermelons, sweet melons, etc. | **12 (35.3)** | 9 (26.5) | 9 (26.5) | 4 (11.8) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Stone fruit: nectarines, apricots, peaches, plums, olives | 8 (3.5) | 5 (14.7) | **10 (29.4)** | 9 (26.5) | 0 (0) | 2 (5.9) | 0 (0) | 0 (0) |
| Tropical fruit: bananas, mangoes, pineapple | 3 (8.8) | 4 (11.8) | 7 (20.6) | 7 (20.6) | 4 (11.8) | **(8 23.5)** | 0 (0) | 1 (2.9) |
| Cruciferous vegetables: cabbage, cauliflower, brussels sprouts, broccoli, radish, turnips | **11 (32.4)** | 3 (8.8) | 5 (14.7) | 9 (26.5) | 4 (11.8) | 0 (0) | 1 (2.9) | 1 (2.9) |
| Green vegetables: kale, black cabbage, spinach, collard greens, lettuce, microgreens, salad greens, zucchini, green beans, peas, cucumber, avocado | 0 (0) | 2 (5.9) | 8 (23.5) | **11 (32.4)** | 5 (14.7) | 3 (8.8) | 2 (5.9) | 3 (8.8) |
| Red/orange vegetables: carrots, beetroot, pumpkin, butternut, bell peppers, chili peppers, tomatoes, eggplant/aubergine, red cabbage (radicchio) | 2 (5.9) | 2 (5.9) | 7 (20.6) | **11 (32.4)** | 6 (17.7) | 3 (8.8) | 1 (2.9) | 2 (5.9) |
| Starchy vegetables: potatoes, sweet potato, corn | 3 (8.8) | 0 (0) | 7 (20.6) | **13 (38.2)** | 6 (17.7) | 2 (5.9) | 2 (5.9) | 1 (2.9) |
| Other vegetables: onion, shallots, mushrooms, garlic, fennel | 5 (14.7) | 4 (11.8) | 7 (20.6) | **8 (23.5)** | 3 (8.8) | 5 (14.7) | 0 (0) | 2 (5.9) |
| *Grains and cereals* | | | | | | | | |
| Polenta | **31 (91.2)** | 2 (5.9) | 1 (2.9) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Quinoa | **28 (82.4)** | 3 (8.8) | 1 (2.9) | 2 (5.9) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Farro | **26 (76.5)** | 4 (11.8) | 4 (11.8) | 0 (0) | 0 (0) | 0 (0)) | 0 (0) | 0 (0) |
| Couscous | **25 (73.5)** | 8 (23.5) | 0 (0) | 1 (2.9) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |

(*Continued*)

Table 5. (Continued).

| | Weekly frequency | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | None | 1x | 2x | 3x | 4x | 5x | 6x | 7x (daily) |
| Food frequency variables | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) |
| Porridges (Quaker oats, etc.) | **20 (58.8)** | 6 (17.7) | 3 (8.8) | 1 (2.9) | 0 (0) | 0 (0) | 0 (0) | 4 (11.8) |
| Cereals (Kellogg's, Weetabix, Nestle, etc.) | **14 (41.2)** | 1 (2.9) | 5 (14.7) | 4 (11.8) | 2 (5.9) | 4 (11.8) | 1 (2.9) | 3 (8.8) |
| Risotto (arborio, carnaroli, etc.) | **14 (41.2)** | 4 (11.8) | 8 (23.5) | 6 (17.7) | 0 (0) | 1 (2.9) | 0 (0) | 1 (2.9) |
| White rice | 7 (20.6) | 3 (8.8) | 10 (29.4) | **8 (23.5)** | 4 (11.8) | 0 (0) | 1 (2.9) | 1 (2.9) |
| Wholewheat/brown basmati rice | **15 (44.1)** | 3 (8.8) | 5 (14.7) | 3 (8.8) | 3 (8.8) | 3 (8.8) | 1 (2.9) | 1 (2.9) |
| White pastas | 4 (11.8) | 1 (2.9) | 4 (11.8) | **7 (20.6)** | 6 (17.7) | 6 (17.7) | 2 (5.9) | 4 (11.8) |
| Whole grain pastas | **14 (41.2)** | 6 (17.7) | 4 (11.8) | 3 (8.8) | 5 (14.7) | 1 (2.9) | 0 (0) | 2 (5.9) |
| White bread and assortments | **9 (26.5)** | 2 (5.9) | 4 (11.8) | 6 (17.7) | 6 (17.7) | 3 (8.8) | 1 (2.9) | 3 (8.8) |
| Wholewheat/brown bread and assortments | **14 (41.2)** | 2 (5.9) | 5 (14.7) | 5 (14.7) | 5 (14.7) | 1 (2.9) | 0 (0) | 2 (5.9) |
| Brioche, biscotti, torta | **13 (38.2)** | 4 (11.8) | 9 (26.5) | 3 (8.8) | 2 (5.9) | 1 (2.9) | 1 (2.9) | 1 (2.9) |
| *Meat, poultry, fish and legumes* | | | | | | | | |
| Eggs | 2 (5.9) | 5 (14.7) | **8 (23.5)** | **8 (23.5)** | 5 (14.7) | 2 (5.9) | 3 (8.8) | 1 (2.9) |
| Fish: hake, salmon, tuna, squid, prawns, mussels, etc. | 6 (17.7) | **10 (29.4)** | **10 (29.4)** | 5 (14.7) | 3 (8.8) | 0 (0) | 0 (0) | 0 (0) |
| Legumes: chickpeas, assorted beans, lentils, split peas | **12 (35.3)** | 6 (17.7) | 10 (29.4) | 5 (14.7) | 1 (2.9) | 0 (0) | 0 (0) | 0 (0) |
| Meat: beef, horse, pork, lamb, etc. | 0 (0) | 3 (8.8) | 3 (8.8) | 8 (23.5) | **10 (29.4)** | 7 (20.6) | 1 (2.9) | 2 (5.9) |
| Cured meats: bacon, prosciutto cooked/raw, salami, pepperoni, bresaola, etc. | 2 (5.9) | 4 (11.8) | **9 (26.5)** | **9 (26.5)** | 6 (17.7) | 1 (2.9) | 1 (2.9) | 2 (5.9) |
| Poultry: chicken and/or turkey | 1 (2.9) | 1 (2.9) | 0 (0) | 6 (17.7) | **15 (44.1)** | 5 (14.7) | 3 (8.8) | 3 (8.8) |

(*Continued*)

**Table 5.** (Continued).

| | Weekly frequency | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | None | 1x | 2x | 3x | 4x | 5x | 6x | 7x (daily) |
| Food frequency variables | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) |
| Protein supplement | 2 (5.9) | 3 (8.8) | 2 (5.9) | 5 (14.7) | 3 (8.8) | **11 (32.4)** | 4 (11.8) | 4 (11.8) |
| *Dairy and dairy products* | | | | | | | | |
| Cheese: ricotta, cottage cheese, cream cheese | **12 (35.3)** | 6 (17.7) | **12 (35.3)** | 2 (5.9) | 0 (0) | 1 (2.9) | 0 (0) | 1 (2.9) |
| Cheese: mascarpone, cheddar, parmesan, brie, mozzarella, feta | 2 (5.9) | 2 (5.9) | 8 (23.5) | **9 (26.5)** | 5 (14.7) | 3 (8.8) | 1 (2.9) | 4 (11.8) |
| 2% or low-fat milk | **19 (55.9)** | 1 (2.9) | 4 (11.8) | 3 (8.8) | 1 (2.9) | 2 (5.9) | 1 (2.9) | 3 (8.8) |
| Full-cream milk | **15 (44.1)** | 0 (0) | 2 (5.9) | 1 (2.9) | 6 (17.7) | 7 (20.6) | 1 (2.9) | 2 (5.8) |
| Full-cream yoghurt and drinking yoghurt | **22 (64.7)** | 3 (8.8) | 2 (5.9) | 4 (11.8) | 1 (2.9) | 2 (5.9) | 0 (0) | 0 (0) |
| Low-fat yoghurt and drinking yoghurt | **17 (50.0)** | 1 (2.9) | 3 (8.8) | 7 20.6) | 2 (5.9) | 1 (2.9) | 2 (5.9) | 1 (2.9) |
| *Fats and oils* | | | | | | | | |
| Seeds (sunflower, sesame) | **31 (91.2)** | 1 (2.9) | 2 (5.9) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Nuts | 5 (14.7) | 3 (8.8) | **10 (29.4)** | 8 (23.5) | 6 (17.7) | 1 (2.9) | 1 (2.9 | 0 (0) |
| Margarine | **31 (91.2)** | 1 (2.9) | 1 (2.9) | 0 (0) | 1 (2.9) | 0 (0) | 0 (0) | 0 (0) |
| Butter | **19 (55.9)** | 2 (5.9) | 3 (8.8) | 5 (14.7) | 3 (8.8) | 1 (2.9) | 0 (0) | 1 (2.9) |
| Olive oil/extra virgin olive oil | 0 (0) | 1 (2.9) | 2 (5.9) | 2 (5.9) | 11 (32.4) | 6 (17.7) | 2 (11.8) | **8 (23.5)** |
| Other oils (peanut, sunflower, etc.) | **27 (79.4)** | 0 (0) | 3 (8.8) | 1 (2.9) | 1 (2.9) | 0 (0) | 1 (2.9) | 1 (2.9) |
| *Beverages* | | | | | | | | |
| Water | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 1 (2.9) | 0 (0) | 1 (2.9) | 32 (94.1) |
| Energy drinks (Red Bull, Lucozade, Monster) | **23 (67.7)** | 2 (8.8) | 6 (17.7) | 1 (2.9) | 1 (2.9) | 0 (0) | 0 (0) | 0 (0) |
| Sport drinks (Powerade, Gatorade, O'Sonyq) | **18 (52.9)** | 7 (20.6) | 4 (11.8) | 3 (8.8) | 2 (5.9) | 0 (0) | 0 (0) | 0 (0) |
| Fruit juice: sweetened | **20 (58.8)** | 2 (5.9) | 8 (23.5) | 2 (5.9) | 2 (5.9) | 0 (0) | 0 (0) | 0 (0) |
| Fruit juice: unsweetened | **24 (70.6)** | 3 (8.8) | 3 (8.8) | 2 (5.9) | 2 (5.9) | 0 (0) | 0 (0) | 0 (0) |
| Fizzy drinks/soda | **17 (50.0)** | 3 (8.8) | 7 (20.6) | 4 (11.8) | 2 (5.9) | 0 (0) | 0 (0) | 1 (2.9 |

(*Continued*)

**Table 5.** (Continued).

| | | Weekly frequency | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | None | 1x | 2x | 3x | 4x | 5x | 6x | 7x (daily) |
| Food frequency variables | | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) | n (%) |
| Artificially sweetened fizzy drinks/soda | | **18 (52.9)** | 5 (14.7) | 3 (8.8) | 2 (5.9) | 3 (8.8) | 3 (8.8) | 0 (0) | 0 (0 |
| Iced tea: sweetened | | **28 (82.4)** | 2 (5.9) | 3 (8.8) | 1 (2.9) | 0 (0) | 0 (0) | 0 (0) | 0 (0 |
| Iced tea: unsweetened | | **29 (85.3)** | 0 (0) | 0 (0) | 3 (8.8) | 0 (0) | 1 (2.9) | 0 (0) | 1 (2.9 |
| Cordials | | **29 (85.3)** | 3 (8.8) | 2 (5.9) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Coffee/tea: sweetened | | **28 (82.4)** | 1 (2.9) | 1 (2.9) | 1 (2.9) | 1 (2.9) | 0 (0) | 0 (0) | 2 (5.9 |
| Coffee/tea: unsweetened | | 11 (32.4) | 1 (2.9) | 0 (0) | 0 (0) | 2 (5.9) | 3 (8.8) | 2 (5.9) | **15 (44.1)** |
| Beer | | 9 (26.5) | **15 (44.1)** | 6 (17.7) | 4 (11.8) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Ciders | | **33 (97.1)** | 1 (2.9) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Dry red wine (Chianti, Barolo, etc.) | | **22 (64.7)** | 6 (17.7) | 4 (11.8) | 2 (5.9) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Sweet red wine (Lambrusco, Brachetto d'Acqui, etc.) | | **26 (76.5)** | 5 (14.7) | 2 (5.9) | 1 (2.9) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Dry white wine (Chardonnay, Prosecco, Pinot Grigio, etc.) | | **26 (76.5)** | 5 (14.7) | 1 (2.9) | 2 (5.9) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Sweet white wine (Moscato, Vin Santo) | | **32 (94.1)** | 2 (5.9) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Digestives (grappa, amaretto, limoncello) | | **31 (91.2)** | 2 (5.9) | 1 (2.9) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Other alcohol | | **27 (79.4)** | 5 (14.7) | 2 (5.9) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Other beverages | | **33 (97.1)** | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 1 (2.9) |
| *Sugar and sweets* | | | | | | | | | |
| Candy (marshmallows, jelly babies) | | **28 (82.4)** | 1 (2.9) | 4 (11.8) | 0 (0) | 0 (0) | 0 (0) | 1 (2.9) | 0 (0) |
| Sugar (white/brown) | | **22 (64.7)** | 3 (8.8) | 3 (8.8) | 3 (8.8) | 1 (2.9) | 0 (0) | 0 (0) | 2 (5.9) |
| Honey/jam | | 5 (14.7) | 5 (14.7) | **7 (20.6)** | 8 (23.5) | 3 (8.8) | 1 (2.9) | 1 (2.9) | 4 (11.8) |
| Candy (toffees, fudge) | | **29 (85.3)** | 2 (5.9) | 2 (5.9) | 0 (0) | 1 (2.9) | 0 (0) | 0 (0) | 0 (0) |
| Syrups | | **30 (88.2)** | 3 (8.8) | 1 (2.9) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 (0) |
| Biscuits (homemade/store bought) | | **16 (47.1)** | 5 (14.7) | 4 (11.8) | 6 (17.7) | 1 (2.9) | 1 (2.9) | 1 (2.9) | 0 (0) |
| Energy bars (Kellogg's, Syform, Enervit, etc.) | | **25 (73.5)** | 2 (5.9) | 3 (8.8) | 3 (8.8) | 1 (2.9) | 0 (0) | 0 (0) | 0 (0) |
| Chocolate (bars/slabs) | | **13 (38.2)** | 7 (20.6) | 9 (26.5) | 2 (5.9) | 1 (2.9) | 1 (2.9) | 1 (2.9) | 0 (0) |
| Gelato/ice-cream | | **13 (38.2)** | 9 (26.5) | 8 (23.5) | 2 (5.9) | 2 (5.9) | 0 (0) | 0 (0) | 0 (0) |
| *Additional question* | | | | | | | | | |
| Are there any other foods you consume on a weekly basis not listed | **No** | 31 (91.2) | | | | | | | |
| | **Yes** | 3 (8.8) | Multivitamins, super greens, omegas and carbohydrate (CHO) gels | | | | | | |

In terms of dairy and dairy products (Table 5), cheeses including cheddar, parmesan and mozzarella ($n = 32$; 94.1%) were consumed more often weekly than ricotta, cottage cheese and cream cheese ($n = 22$; 64.7%). Most players did not use 2% low-fat milk ($n = 19$; 55.9%) or full-cream milk ($n = 15$; 44.1%). Full-cream and low-fat yogurt were consumed three times a week by 11.8% ($n = 4$) and 20.6% ($n = 7$) of players, respectively.

In terms of fats and oils (Table 5), margarine ($n = 31$; 91.2%) and seeds ($n = 31$; 91.2%), other oils (peanut, sunflower) ($n = 27$; 79.4%) and butter ($n = 19$; 55.9%) were not used by players. Lastly, olive oil and extra virgin olive oil were consumed by all players, with a third of players ($n = 11$; 32.4%) consuming these oils four times weekly.

In terms of beverages (Table 5), 94.1% of players ($n = 32$) consumed water daily. One in five players ($n = 7$; 20.6%) consumed sports drinks only once a week. Only two (5.9%) players used sugar daily.

## 4. Discussion

The median weight, body mass index, waist circumference and waist-to-height ratio of forwards were higher than those of the backs. The median body fat percentage of the whole group exceeded recommendations. This group of rugby players did not meet recommendations for CHO intake on all three days but mostly met the recommendations for protein and fat intake.

In their systematic review on the dietary intake of athletes, Janiczak et al. [66] reported that the average intake of CHO among athletes was 1.1–3.4 g/kg BW/day, falling short of the recommendation. The average protein intake was 2.4–4.6 g/kg BW/day, exceeding the recommendation [66]. Similar findings were reported by Jenner et al. [35] in the systematic review of the dietary intake of professional and semiprofessional team sport athletes. In 15 out of 17 studies evaluating training day macronutrient intake, male athletes' CHO intake of 2.4–4.9 g/kg BW/day did not meet the ISSN guideline of 5.0–8.0 g/kg BW/day. In eight of the studies, protein intake exceeded 2.0 g/kg BW/day and nine studies reported fat intake above the recommended guideline of 35% TE [30,35].

Furthermore, in the study on the macronutrient intake between three sport categories – endurance, team and strength – Wardenaar et al. [67] concluded that CHO intake was inadequate, showing 48.3% of endurance, 50.5% of team and 96.2% of strength athletes did not meet the moderate CHO recommendation of 5.0 g/kg BW/day. However, besides these findings, protein intake among all three disciplines also fell below the moderate recommendation of 1.2 g/kg BW/day, where most athletes in each discipline failed to obtain the necessary requirements [67].

The median CHO intake of the food records in the present study, was 2.6 g/kg BW/day for forwards and 2.7 g/kg BW/day for the backs, both groups falling short of the recommended range [30]. The median CHO intake of the food records for all players in this study was 2.7 g/kg BW/day, which was comparable to the South African study by Van Aardt [68], who reported an estimated daily median CHO intake of 2.6 g/kg BW/day among professional rugby players in Mpumalanga on a training day, competition day and off day. Additionally, Van Aardt [68] compared players' intake to standard guidelines set by the ACSM and ISSN, and found that all the players fell below the CHO guidelines on all three days. In the present study (Table 2), 94.1% of players fell below the CHO guidelines for all three days. Janiczak et al. [66] suggested the reason for such low CHO intake among team sport players may result from a lack of knowledge of the role that CHO plays in sports.

A CHO intake of 5.0–8.0 g/kg BW CHO per day could be perceived as a large amount of CHO that players may find challenging to consume, or could be a result of self-determined dietary strategies [31,37]. Nevertheless, failing to achieve the necessary CHO requirements for a given sport will have a negative impact on players, such as early onset of physical and/or cognitive fatigue or delayed recovery after training and competition, affecting overall performance outcomes [20,30]. Therefore, these issues should be addressed to ensure optimal sports performance and recovery.

In the present study, the players' median protein intake (1.7 g/kg BW) was comparable to a professional New Zealand team [69] but lower than the mean protein intake of more than 2.4 g/kg BW reported for teams in New Zealand [27] and Europe [40]. Benardot [20] found that rugby players greatly overestimate their protein requirements for muscular development and body composition requirements. This may explain the excessive intake of protein and sub-optimal CHO intake among players. However, in the present study, the protein intake of the players did not exceed the recommended range as reported previously [27,42,43,68], but was within the range on all three reported days (Table 2). Additionally, on average over the three days, 62.7% of players in the present study fell within the recommended protein range compared to 21.3% of players in the study by Van Aardt [68].

Furthermore, in the present study, the median fat intake of all players was 34.6% TE (or 1.1 g/kg BW), falling within the recommended range [27]. This finding was contrary to the studies by Lohman et al. [43] and Lako et al. [70], who found that rugby players exceeded the recommended fat intake, which was 39.8% of TE in the Australian study [43] and >35.0% TE in the Fiji study [70]. Similarly, Posthumus et al. [27] reported excessive fat intake by New Zealand rugby players (41.0%; 1.8 g/kg BW). As shown in Table 1, the median fat intake of Zebre rugby players fell within the recommended range on the training (34.6% TE) and competition (34.8% TE) days. However, their fat intake exceeded the recommendation on the off day by a small margin (35.8% TE). On the contrary, Van Aardt [68] reported fat intake of 36% TE on the training day and 37.0% TE on the competition day. However, similar to our findings, the players in his study also exceeded the recommended fat intake (41% TE) on the off day [68]. Results from the present study may differ from other studies due to cultural differences regarding the amount of fat used during food preparation and intake, although this argument is purely speculative and should be investigated.

No studies could be found to compare to international sports committees' guidelines for athletes' macronutrient intake before, during and after competition. However, Jenner et al. [35] noted in a systematic review that three out of seven studies indicated inadequate CHO intake prior to, during and after competition. Furthermore, no trend on the intake of CHO, protein or fat on competition day was reported [35]. Evaluation of results in the present study is therefore reviewed by what is present in the literature. A meal containing 1.0–4.0 g/kg BW CHO will replenish liver and glycogen stores prior to competition to improve performance [20,30]. Some protein should be included in the pre-competition meal [30], with the benefit of assisting muscle protein synthesis (MPS) during exercise. In the present study (Table 3), 94.1% of players' pre-competition meals and/or snacks consumed one to four hours prior to the match, were below the minimal CHO intake of 1.0 g/kg BW, while more than half of the players (55.9%) exceeded the proposed protein intake of 0.15–0.25 g/kg BW.

According to international guidelines, exercise lasting 45–75 minutes requires minimal amounts of CHO to replenish some losses [30,36]. However, in the present study, no players reported any intake during the match with a median match time of 60 minutes played. After a competition, glycogen stores may be depleted and depending on the sport, such as rugby, muscle damage may be evident. Consequently, CHO and protein should be consumed after intense activity [30]. We found that post-competition, 67.6% and 76.5% of players exceeded the 1.0–1.2 g/kg BW CHO and 0.25–0.4 g/kg BW protein requirements, respectively.

In a Kenyan study, Kamande et al. [71] reported on food frequency intake per week, as done in the present study. However, their grouping of food groups differed in some instances. According to the study by Kamande et al. [71], 43.0% and 48.0% of players consumed fruit and vegetables, respectively, five to six times per week. However, in the present study (Table 5), more players (47.1%) consumed fruits less frequently, one to two times per week, and vegetables (44.7%) more frequently, three to four times per week.

A higher percentage of Kenyan players (31.0%) consumed grains and cereals three to four times per week [71] in comparison to players (17.1%) in the present study. This might be due to players' higher regard for dietary protein in supporting performance or the misperception of CHO and weight gain [20], and might be the result of most players not meeting the recommended CHO recommendation proposed by international sports committees.

Meat, poultry, fish and legumes were consumed less frequently, one to two times per week, by 34.9% of the Kenyan players' [71] compared to 39.7% of the players in the present study, who consumed meat, poultry, fish and legumes three to four times per week. In the present study, the main source of protein consumed by 23.5% of players five to six times per week was meat, followed by 61.8% consuming poultry three to four times per week. Most Kenyan players (35.8%) consumed a protein shake three to four times per week [71], while in the present study, 44.2% of players used protein shakes five to six times per week.

In the study by Kamande et al. [71], spreads included margarine, butter and jam, with less than a quarter of Kenyan players using these products five to six times per week. In the present study, butter and margarine were not used by 55.9% and 91.2% of players, respectively. The fat source mostly consumed in the present study was nuts (41.2%) and olive oil (38.3%) three to four times a week.

In the Kenyan study [71], water was consumed daily by 64.4% of players, compared to 94.1% in the present study. Furthermore, fewer players omitted the use of energy bars/shakes (29.9%) [71] compared to 73.5% of players in the present study.

To our knowledge, no study has published the findings of a FFQ on rugby players similar to the study by Kamande et al. [71], which provides new insight into rugby players' potential dietary intake.

When considering frequency of food intake, a daily intake of two fruits and three vegetables is recommended [30,72]. However, the reported intake of fruit and vegetables, as determined by the FFQ, did not meet this recommendation. Fiber-rich foods, such as grains, legumes, nuts and seeds, oats, Weetbix, whole grain pasta, rice and bread [73,74] were not consumed by a third ($n = 11$; 32.4%) of players, possibly limiting their fiber intake. In terms of protein recommendations, more than a quarter of players (29.4%) consumed fish twice per week, meeting the recommended fish intake [75]. However, the Mediterranean Diet's red meat recommendation of three times per week [75] was exceeded. Approximately a quarter of players (23.5%) used olive oil daily, which is considered as a healthier fat source by the National Heart Foundation of Australia [75] and the Heart and Stroke Foundation of South Africa [74]. Lastly, based on the present study's observations, Zebre rugby players seemed to have an inadequate intake of CHO.

### 4.1. Limitations

The current study included only one professional rugby team ($N = 34$). Therefore, the findings reflect the individual characteristics of the observed sample and may not be representative of other professional rugby teams.

Due to time constraints and players' compliance, dietary assessment in the current study was limited to nonconsecutive three-day intake food records. Dietary records were self-reported by players where incidences of over-reporting and/or under-reporting might have occurred. The South African food database FoodFinder (version 2023) [50] was used to evaluate the nutritional intake from the three-day food records. However, not all the food items recorded were listed on the FoodFinder software, and therefore, alternative sources of information, recognized by the Italian Ethics Committee, were used, namely Italian [76], American [77] and French [78] food databases. Some nutritional values were unavailable; however, the macronutrients (CHO, protein and fat) were all accounted for.

## 5. Recommendations

Male rugby union players should focus on increasing dietary carbohydrate intake aiming to meet the international sports committees' recommended range. On competition days, they should focus on pre-competition foods that would provide adequate CHO and protein, but at the same time would not induce gastric distress; for example, two to four hours before competition rice with chicken or fish, baked potato/sandwich/wrap/pita with animal protein such an egg/chicken/fish, or plant protein such as nut butter or oats with milk/banana. In the period 30–60 minutes before competition, a smoothy, rice cakes, toast with nut butter or sports gel [20,30] could be consumed. Furthermore, during competition, players should consume an isotonic sports drink or energy gel during water breaks or at half-time for competitions lasting 60 minutes or longer [20,30].

## 6. Conclusion

The dietary recommendations were not optimally adhered to by players in the study. Most players' CHO intake was below the recommended range on all three days of observation (training day, competition day and off day). However, contrary to some studies [27,38,40,43,68], most players were within the recommended range for protein and fat intake, yet these findings remain concerning as under- and overestimated reporting of intake were observed. Furthermore, pre-competition macronutrient intake one to four hours before competition, fell short of the recommended requirement, with the majority of players exceeding the protein recommended range. Carbohydrates were not consumed during competition by players exceeding 60 minutes of game time, or it was not recorded by the players. Lastly, post-competition macronutrient intake within four hours after competition mostly exceeded the CHO and protein recommendations.

## Acknowledgments

The authors thank Dr. Daleen Struwig, medical writer/editor, Faculty of Health Science, University of the Free State, for technical and editorial preparation of the manuscript.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

## Funding

This work was supported by the We did not receive funding, but requested funds from Open Access fund, University of the Free State. We also requested funds from the publication fund of the School of Health and Rehabilitation Sciences, University of the Free State.

## ORCID

Maryke Meyer http://orcid.org/0000-0001-8455-4008
Elmine du Toit http://orcid.org/0000-0002-3153-7447
Riette Nel http://orcid.org/0000-0002-3889-0438
Derik Coetzee http://orcid.org/0000-0002-3151-6582

## References

1. Beaumont B. The future of the game. In: Davies B Baker J, editors. The dynamics of modern rugby. Oxfordshire: Routledge; 2021. p. 178–184.
2. Watson N, Durbacha I, Hendricks S, et al. On the validity of team performance indicators in rugby union. Int J Perform Anal Sport. 2017;17(4):609–621. doi: 10.1080/24748668.2017.1376998
3. World Rugby. Rugby's history and ethos. 2023 [cited 2024 Jul 15]. Available from: https://www.world.rugby/the-game/beginners-guide/history
4. O'Callaghan L. Rugby union: an historical overview. In: Davies B Baker J, editors. The dynamics of modern rugby. Oxfordshire: Routledge; 2021. p. 1–11.
5. World Rugby. About World Rugby. 2023 [cited 2024 Jul 15]. Available from: https://www.world.rugby/organisation/about-us/overview
6. Till K, Weakley J, Read DB, et al. Applied sport science for male age-grade rugby union in England. Sports Med. 2020;6(1):14. doi: 10.1186/s40798-020-0236-6
7. Herbert P, Wiltshire H. The demands of a collision sport. In: Davies B Baker J, editors. The dynamics of modern rugby. Oxfordshire: Routledge; 2021. p. 11–21.
8. Okamoto N. Agility test for rugby using sidestep. Football Sci. 2015 [cited 2024 Jul 11];12:11–17. Available from: https://www.jstage.jst.go.jp/article/jssfenfs/12/0/12_11/_pdf
9. Tierney P, Blake C, Delahunt E. Physical characteristics of different professional rugby union competition levels. J Sci Med Sport. 2021;24(12):1267–1271. doi: 10.1016/j.jsams.2021.05.009
10. Posthumus L, Macgregor C, Winwood P, et al. Physical and fitness characteristics of elite professional rugby union players. Sports (Basel). 2020;8(6):85. doi: 10.3390/sports8060085

11. Nicholls M, Coetzee D, Schall R, et al. Analysing match-related performance indicators in super rugby competitions: a study of the 2017–2019 seasons. Int J Sports Sci Coach. 2024;19(3):1066–1081. doi: 10.1177/17479541231198211
12. Donkin C, Venter R, Coetzee FF, et al. Positional in-match running demands of university rugby players in South Africa. Front Psychol. 2020;11:1591. doi: 10.3389/fpsyg.2020.01591
13. Schoeman R, Schall R. Comparison of match-related performance indicators between mayor professional rugby competitions. Int J Perform Anal Sport. 2019;14(3):344–354. doi: 10.1177/1747954119848419
14. Schoeman R, Coetzee D, Schall R. Positional tackle and collision rates in super rugby. Int J Perform Anal Sport. 2015;15(3):1022–1036. doi: 10.1080/24748668.2015.11868848
15. Roberts SP, Trewartha G, Higgitt RJ, et al. The physical demands of elite English rugby union. J Sports Sci. 2008;26(8):825–833. doi: 10.1080/02640410801942122
16. Bevan WH. Positional demands of a tier 2 international rugby union team using GPS metrics, match performance indicators and worst-case scenarios. Res Invest Sports Med. 2022;8(3):721–735. doi: 10.31031/RISM.2022.08.000687
17. Lindsay A, Draper N, Lewis J, et al. Positional demands of professional rugby. Eur J Sport Sci. 2015;15(6):480–487. doi: 10.1080/17461391.2015.1025858
18. Yamamoto H, Takemura M, Iguchi J, et al. In-match physical demands on elite Japanese rugby union players using a global positioning system. BMJ Open Sport Exerc Med. 2020;6(1):e000659. doi: 10.1136/bmjsem-2019-000659
19. Lacome M, Piscione J, Hager JP, et al. A new approach to quantifying physical demand in rugby union. J Sports Sci. 2014;32(3):290–300. doi: 10.1080/02640414.2013.823225
20. Benardot D. Advanced sport nutrition. 3rd ed. Champaign, IL: Human Kinetics; 2021.
21. Peek RJ, Middleton KJ, Gastin PB, et al. Position specific peak impact and running demands of professional rugby union players during game play. Int J Sports Sci Coach. 2021;16(5):1162–1168. doi: 10.1177/17479541211004065
22. Ren X, Henry M, Boisbluche S, et al. Optimization of training for professional rugby union players: investigating the impact of different small-sided games models on gps-derived performance metrics. Front Physiol. 2024;15:339137. doi: 10.3389/fphys.2024.1339137
23. Quarrie KL, Raftery M, Blackie J, et al. Managing player load in professional rugby union: a review of current knowledge and practices. Br J Sports Med. 2017;51(5):421–427. doi: 10.1136/bjsports-2016-096191
24. Gabbett TJ. The training-injury prevention paradox: should athletes be training smarter and harder? Br J Sports Med. 2016;50(5):273–280. doi: 10.1136/bjsports-2015-095788
25. Pasin F, Caroli B, Spigoni V, et al. Performance and anthropometric characteristics of elite rugby players. Acta Biomed. 2017;88(2):172–177. doi: 10.23750/abm.v88i2.5221
26. Tucker R, Lancaster S, Davies P, et al. Trends in player body mass at men's and women's rugby world cups: a plateau in body mass and differences in emerging rugby nations. BMJ Open Sport Exerc Med. 2021;7(1):e000885. doi: 10.1136/bmjsem-2020-000885
27. Posthumus L, Fairbairn K, Darry K, et al. Competition nutrition practices of elite male professional rugby union players. Int J Environ Res Public Health. 2021;18(10):5398. doi: 10.3390/ijerph18105398
28. Black KE, Black AD, Baker DF. Macronutrient intakes of male rugby union players: a review. Int J Sport Nutr Exerc Metab. 2018;28(6):664–673. doi: 10.1123/ijsnem.2017-0400
29. Alaunyte I, Perry JL, Aubrey T. Nutritional knowledge and eating habits of professional rugby league players: does knowledge translate into practice? J Int Soc Sports Nutr. 2015;12(1):18. doi: 10.1186/s12970-015-0082-y
30. Bean A. The complete guide to sports nutrition. 9th ed. London: Bloomsbury Sport; 2022.
31. Beck K, Thomson JS, Swift RJ, et al. Role of nutrition in performance enhancement and postexercise recovery. Open Access J Sports Med. 2015;6:259–269. doi: 10.2147/OAJSM.S33605
32. Baker LB, Heaton LE, Nuccio RP, et al. Dietitian-observed macronutrient intakes of young skill and team-sport athletes: adequacy of pre, during, and postexercise nutrition. Int J Sport Nutr Exerc Metab. 2014;24(2):166–176. doi: 10.1123/ijsnem.2013-0132

33. Bytomski JR. Fueling for performance. Sports Health. 2018;10(1):47–53. doi: 10.1177/1941738117743913
34. Chantler S, Wood-Martin R, Sutton L. Sports nutrtion in moderan rugby. In: Davies B Baker J, editors. The dynamics of modern rugby. Oxfordshire: Routledge; 2021. p. 22–32.
35. Jenner SL, Buckley GL, Belski R, et al. Dietary intakes of professional and semi-professional team sport athletes do not meet sport nutrition recommendations – a systematic literature review. Nutrients. 2019;11(5):1160. doi: 10.3390/nu11051160
36. Potgieter S. Sport nutrition: a review of the latest guidelines for exercise and sport nutrition from the American college of sport nutrition, the International Olympic Committee and the International society for sports nutrition. S Afr J Clin Nutr. 2013;26(1):6–16. doi: 10.1080/16070658.2013.11734434
37. Bentley MRN, Mitchell N, Backhouse SH. Sports nutrition interventions: a systematic review of behavioural strategies used to promote dietary behaviour change in athletes. Appetite. 2020;150:104645. doi: 10.1016/j.appet.2020.104645
38. Bradley WJ, Cavanagh B, Douglas W, et al. Energy intake and expenditure assessed 'in-season' in an elite European rugby union squad. Eur J Sport Sci. 2015;15(6):469–480. doi: 10.1080/17461391.2015.1042528
39. Tavares F, Smith TB, Driller M. Fatigue and recovery in rugby: a review. Sports Med. 2017;47(8):1515–1530. doi: 10.1007/s40279-017-0679-1
40. Bradley WJ, Cavanagh BP, Douglas W, et al. Quantification of training load, energy intake, and physiological adaptations during a rugby preseason: a case study from an elite European rugby union squad. J Strength Cond Res. 2015;29(2):534–544. doi: 10.1519/JSC.0000000000000631
41. MacKenzie K, Slater G, King N, et al. The measurement and interpretation of dietary protein distribution during a rugby preseason. Int J Sport Nutr Exerc Metab. 2015;25(4):353–358. doi: 10.1123/ijsnem.2014-0168
42. Burrows T, Harries SK, Williams RL, et al. The diet quality of competitive adolescent male rugby union players with energy balance estimated using different physical activity coefficients. Nutrients. 2016;8(9):548. doi: 10.3390/nu8090548
43. Lohman R, Carr A, Condo D. Nutritional intake in Australian football players: sports nutrition knowledge and macronutrient and micronutrient intake. Int J Sport Nutr Exerc Metab. 2019;29(3):289–296. doi: 10.1123/ijsnem.2018-0031
44. Trakman GL, Forsyth A, Devlin BL, et al. A systematic review of athletes' and coaches' nutrition knowledge and reflections on the quality of current nutrition knowledge measures. Nutrients. 2016;8(9):570. doi: 10.3390/nu8090570
45. Birkenhead KL, Slater G. A review of factors influencing athletes' food choices. Sports Med. 2015;45(11):1511–1522. doi: 10.1007/s40279-015-0372-1
46. Spronk I, Heaney SE, Prvan T, et al. Relationship between general nutrition knowledge and dietary quality in elite athletes. Int J Sport Nutr Exerc Metab. 2015;25(3):243–251. doi: 10.1123/ijsnem.2014-0034
47. Parma Z. Our story. 2022 [cited 2024 Jul 15]. Available from: https://www.zebreparma.it/en-ww/who-we-are.aspx
48. Parma Z. EPCR challenge cup. 2023 [cited 2024 Jul 15]. Available from: https://www.zebreparma.it/en-ww/epcr-challenge-cup-22-23.aspx
49. Kerksick CM, Wilborn CD, Roberts MD, et al. ISSN exercise & sports nutrition review update: research & recommendations. J Int Soc Sports Nutr. 2018;15(1):38. doi: 10.1186/s12970-018-0242-y
50. South African Medical Research Council. FoodFinder. [cited 2024 Jul 15]. Available from: https://foodfinder.samrc.ac.za/
51. International Society for the Advancement of Kinathropometry (ISAK). International standards for anthropometric assessment. Potchesfstroom, South Africa: ISAK; 2006 [cited 2024 Jul 24]. Available from: https://www.isak.global/

52. Tanita. Body composition analyzer: MC-780MA instruction manual. Tokyo: TANITA Corporation; 2015 [cited 2024 Jul 15]. Available from: https://www.manualslib.com/manual/843465/Tanita-Mc-780ma.html#product-MC-780MA
53. World Health Organization (WHO). Body mass index – BMI. Geneva: WHO; 2024 [cited 2024 Jul 15]. Available from: https://www.who.int/data/gho/data/themes/topics/topic-details/GHO/body-mass-index
54. World Health Organization (WHO). Waist circumference and waist-hip ratio: report of a WHO expert consultation. Geneva: WHO; 2008 [cited 2024 Jul 25]. Available from: https://www.who.int/publications/i/item/9789241501491
55. Ahmad N, Adam SIM, Nawi AM, et al. Abdominal obesity indicators: waist circumference or waist-to-hip ratio in Malaysian adults population. Int J Prev Med. 2016;7(82):82. doi: 10.4103/2008-7802.183654
56. Rezende AC, Souza LG, Jardim TV, et al. Is waist-to-height ratio the best predictive indicator of hypertension incidence? A cohort study. BMC Public Health. 2018;18(1):281. doi: 10.1186/s12889-018-5177-3
57. Thivel D, Verney J, Miguet M, et al. The accuracy of bioelectrical impedance to track body composition changes depends on the degree of obesity in adolescents with obesity. Nutr Res. 2018;54:60–68. doi: 10.1016/j.nutres.2018.04.001
58. Verney J, Schwartz C, Amiche S, et al. Comparisons of a multi-frequency bioelectrical impedance analysis to the dual-energy X-ray absorptiometry scan in healthy young adults depending on their physical activity level. J Hum Kinet. 2015;47(1):73–80. doi: 10.1515/hukin-2015-0063
59. Durnin JV, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. Br J Nutr. 1974;32(1):77–97. doi: 10.1079/bjn19740060
60. Potgieter S, Visser J, Croukamp I, et al. Body composition and habitual and match-day dietary intake of the FNB maties varsity cup rugby players. S Afr J Sports Med. 2014;26(2):35–43. doi: 10.7196/SAJSM.504
61. Burke LM. Dietary assessment methods for the athlete: pros and cons of different methods. 2015 [cited 2024 Jul 15]. Available from: https://www.gssiweb.org/sports-science-exchange/article/sse-150-dietary-assessment-methods-for-the-athlete-pros-and-cons-of-different-methods/1000
62. Thomas DT, Erdman KA, Burke LM. Position of the academy of nutrition and dietetics, dietitians of Canada, and the American college of sports medicine: nutrition and athletic performance. J Acad Nutr Diet. 2016;116(3):501–528. doi: 10.1016/j.jand.2015.12.006
63. Wolmarans P, Kunneke E, Laubscher R. Use of the South African food composition database system (SAFOODS) and its products in assessing dietary intake data: part II. S Afr J Clin Nutr. 2009 [cited 2024 Jul 11];22(2):59–67. Available from: https://www.ajol.info/index.php/sajcn/article/view/49090
64. Vasold KL, Parks AC, Phelan DML, et al. Reliability and validity of commercially available low-cost bioelectrical impedance analysis. Int J Sport Nutr Exerc Metab. 2019;29(4):406–410. doi: 10.1123/ijsnem.2018-0283
65. Wang L, Hui SSC. Validity of four commercial bioelectrical impedance scales in measuring body fat among Chinese children and adolescents. Biomed Res Int. 2015;2015:1–8. doi: 10.1155/2015/614858
66. Janiczak A, Devlin BL, Forsyth A, et al. A systematic review update of athletes' nutrition knowledge and association with dietary intake. Br J Nutr. 2022;128(6):1156–1169. doi: 10.1017/S0007114521004311
67. Wardenaar F, Brinkmans N, Ceelen I, et al. Macronutrient intakes in 553 Dutch elite and sub-elite endurance, team, and strength athletes: does intake differ between sport disciplines? Nutrients. 2017;9(2):119. doi: 10.3390/nu9020119
68. Van Aardt R. Nutritional assessment of professional rugby players in Mpumalanga: are requirements being met according to current sports nutrition standards? [Unpublished MSc

dissertation]. Bloemfontein: University if the Free State; 2019. [cited 2024 Jul 15]. Available from: https://scholar.ufs.ac.za/handle/11660/10023

69. Roberts CJ, Gill ND, Beaven CM, et al. Application of a nutrition support protocol to encourage optimisation of nutrient intake in provincial academy rugby union athletes in New Zealand: practical considerations and challenges from a team-based case study. Int J Sports Sci Coach. 2023;18(6):2263–2276. doi: 10.1177/17479541221124119
70. Lako J, Sotheeswaran S, Christi K. Food habits and nutritional status of Fiji rugby players. Int J Sport Health Sci. 2010 [cited 2024 Jul 11];4(8):1887–1892. Available from: https://publications.waset.org/11286/food-habits-and-nutritional-status-of-fiji-rugby-players
71. Kamande PW, Bukhala P, Konyole SO. Nutritional knowledge and practice of elite rugby players in Kenya. Afr J Food Agric Nutr Dev. 2022;22(4):20148–20160. doi: 10.18697/ajfand.109.22385
72. World Health Organization (WHO). Healthy diet. 2020 [cited 2025 Jan 16]. Available from: https://www.who.int/news-room/fact-sheets/detail/healthy-diet
73. British Dietetic Association (BDA). Fibre. 2025 [cited 2025 Jan 16]. Available from: https://www.bda.uk.com/resource/fibre.html
74. Heart and Storke Foundation of South Africa. Healthy eating. 2023 [cited 2025 Jan 16]. Available from: https://heartfoundation.co.za/healthy-eating/
75. National Heart Foundation of Australia. How to follow a heart healthy eating pattern. 2025 [cited 2025 Jan 16]. Available from: https://www.heartfoundation.org.au/healthy-living/healthy-eating/heart-healthy-eating-pattern
76. Banca Dati di Composizione. Banca dati di composizione degli alimenti per studi epidemiologici in Italia (BDA). 2024 [cited 2024 Jul 15]. Available from: https://bda.ieo.it/
77. U.S. Department of Agriculture. FoodData Central. [cited 2024 Jul 15]. Available from: https://fdc.nal.usda.gov/fdc-app.html#/
78. French Agency for Food, Environmental and Occupational Health & Safety (ANSES). French food composition table. 2020 [cited 2024 Jul 15]. Available from: https://ciqual.anses.fr/