Dietary Intake of Endurance Athletes during 12 Weeks of Self-selected Training: An Observational Study

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Running head: Dietary intake of endurance athletes

Abstract

It is recommended that endurance athletes modulate their daily carbohydrate intake according to the demands of training, but there is limited evidence of how this is currently practiced by athletes during real-world, day-to-day training. The purpose of this observational study was to report the dietary intake of endurance athletes across a 12-week period with an emphasis on the relationship between training load and carbohydrate intake. Self-selected training and dietary intake were self-reported using a smartphone app by 46 endurance athletes (61% male) daily for 12 weeks, representing a total of 3,718 days of dietary assessments and 3,160 days of training. Fasted-state training was regularly performed by 65% of athletes and was more common in males (33.6 vs. 17.2%, p = 0.023). Average daily carbohydrate intake for each athlete ranged from 1.2 to 7.2 g/kg (mean 3.9 ± 1.5). At the group level, significant correlations were found between mean daily carbohydrate intake and both percentage of training sessions performed in the fasted state (r = -0.39, p = 0.008) and weekly training volume (r = 0.42, p = 0.004). Participant-level correlations between daily training load and carbohydrate intake ranged from -0.34 to 0.87. Overall, athletes adjust daily carbohydrate intake based on exercise duration, but at the individual level many athletes do not align carbohydrate intake with training load as recommended or do so with minimal adjustment.

Key words: Sports nutrition, Dietary intake assessment, Carbohydrate periodization, Athlete self-monitoring

Introduction

Sports nutrition guidelines recommend carbohydrate intake be individualized to the athlete and their training, a concept referred to as “fueling for the work required” (Impey et al., 2018; Thomas et al., 2016). This approach is characterized by daily fluctuations in carbohydrate intake that match training and competition demands, with potential effects on cellular signaling, exercise capacity, energy balance, and energy availability (Impey et al., 2016; Impey et al., 2018; Mountjoy et al., 2018; Rothschild et al., 2022b; Yeo et al., 2008). Despite the strong theoretical rationale for modulating dietary carbohydrate in relation to training, there is limited evidence of how athletes practice it during real-world, day-to-day training.

To date, knowledge of athlete nutrition practices in the context of their training has largely been limited to surveys (Heikura et al., 2018; Heikura et al., 2017b; Rothschild et al., 2020; Rothschild et al., 2021b), case studies (Stellingwerff, 2012; Strobel et al., 2022), or short-term observations (Heikura et al., 2017a), limiting our understanding of the diet-training relationship in real-world settings. This could be related to several challenges, including athlete adherence to longer-term data collection, difficulty quantifying training loads (particularly when athletes train in multiple exercise modalities), and the lack of any objective method to quantify the relationship between training and dietary carbohydrate intake.

Capturing longer-term dietary intake is important to adequately capture day-to-day variability. It has been reported in non-athletes that 31–64 days of dietary tracking are needed to estimate an individual’s true average energy and macronutrient intake with 95% confidence (Basiotis et al., 1987). Traditionally, performing longer-term data collection has been difficult. However, the wide availability of wearable technologies, smartphone-based diet tracking apps, and web-based fitness platforms has opened up many new possibilities for remote data collection (Souza et al., 2022). Indeed, recent sport science studies have been performed entirely (Bennett et al., 2021) or partially (Maunder et al., 2022) in participants' home training environment. Therefore, the purpose of this observational study was to report the self-selected dietary intake of endurance athletes across a 12-week period with an emphasis on the relationship between training and carbohydrate intake. Because little empirical data exist describing how endurance athletes align dietary carbohydrate intake with training demands in real-world settings, this study was conducted as an exploratory observational analysis without prespecified hypotheses.

Methods

Study design

This observational study monitored the daily self-reported and self-selected dietary intake and exercise training of endurance athletes for 12 weeks. Participants were free to perform any type of exercise and consume any food or beverages, provided it was tracked appropriately. In addition to dietary intake and exercise, measures of sleep, heart rate variability (HRV), and subjective wellbeing were recorded daily. Data presented are from a wider study of endurance training and recovery and are focused on the relationships between dietary intake and training load. Outcomes related to daily recovery have been published elsewhere (Rothschild et al., 2023; Rothschild et al., 2024b). The study was open to anyone aged 18 or older training at least seven hours per week, using a smartphone app to track dietary intake at least five days per week, capturing HRV daily, and tracking sleep using a wearable device. Study protocols and materials were approved by the AUT Ethics Committee (22/7). All participants were informed of the study procedures and provided written informed consent prior to participation.

Participants

Participants were recruited via online advertisements posted on endurance sport–related social media groups and training forums. Therefore, the sample represents a convenience sample of athletes willing to comply with the intensive tracking protocol. The study was completed by 55 endurance athletes (61.8% male, aged 42.6 ± 9.1 years, training 11.6 ± 3.9 hours per week) from 10 countries (Supplemental Fig. 1), but the final analysis included 46 athletes (described in *Data Analysis*). The primary sports represented were triathlon (67.3%), running (20.0%), cycling (10.9%), and rowing (1.8%). The self-reported competitive level included professional (2.6%), elite non-professional (qualify and compete at the international level as an age-group athlete, 34.6%), high-level amateur (qualify and compete at National Championship-level events as an age-group athlete, 25.6%), and amateur (enter races but don't expect to win, or train but do not compete, 37.2%) athletes.

Assessment of self-reported training load

All exercise was recorded in TrainingPeaks software (TrainingPeaks, Louisville, USA). Each session was noted for modality (e.g., bike, run, swim), total time, and session rating of perceived exertion (sRPE (Foster et al., 2021)) using the Borg CR100® scale, which offers additional precision compared with the CR10 scale (Fanchini et al., 2016). Participants were asked to rate the session within 1-h of exercise, but sRPE scores are temporally robust from minutes to days following a bout of exercise (Foster et al., 2021). Additionally, participants noted the amount of carbohydrate consumed within the 4-h pre-exercise window.

Assessment of self-reported dietary intake

Participants were instructed to maintain their typical diet and record all calorie-containing food and drink over the 12-week study. Prior to the study, participants received standardized verbal instructions on how to record dietary intake using the MyFitnessPal application, including guidance on selecting foods from the database, estimating or weighing portion sizes, and recording mixed dishes and packaged foods. Weighing of food was encouraged, but not mandated, and common issues such as underreporting were discussed prior to starting. Non-caloric fluid intake and meal timing were not recorded, except for pre-exercise carbohydrate amounts. Intake was self-reported using the MyFitnessPal application (www.myfitnesspal.com), where participants logged foods and beverages consumed and the application's nutrition database was used to estimate macronutrient intake. Compliance was monitored via connected food logs and enquiring about any unexpected values, determined both visually and using anomaly detection software (*timetk* R package). Incomplete days of tracking (2.2 ± 4.6% of days per participant) were removed from the data. The high level of compliance likely reflects our recruitment strategy, which targeted athletes who were already habitually tracking their diet (in several cases daily for 4+ years) and therefore required minimal prompting from researchers.

Data analysis

Training load was calculated for each workout as sRPE * duration (min) (Haddad et al., 2017), divided by 10 to account for the 100-point scale. Exercise was summed into daily totals for duration and training load, and coded for modality (e.g., swim, bike, run, strength) and if training was performed in the fasted state. Because pre-exercise dietary protein and fat ingestion have minimal effects on substrate oxidation (Rothschild et al., 2022a; Rothschild et al., 2021a), fasted training was defined as consuming <5 g of carbohydrate in the 4-h pre-exercise window. This threshold was chosen to represent a negligible carbohydrate intake unlikely to meaningfully alter circulating glucose or insulin concentrations prior to exercise. On days with multiple sessions, a duration-weighted mean was used to calculate a single value for pre-exercise carbohydrate intake (g). External load metrics (e.g., power, pace) were not collected, as many activities (e.g., strength training, swimming, yoga) lack standardized metrics. Session-RPE was used to quantify training load across modalities, given its validity and reliability across modalities (Haddad et al., 2017).

Participants were instructed to measure body mass in the morning under consistent conditions at least once per week, although more frequent measurements were permitted. Macronutrient intake was normalized to body mass (g/kg) to enable between-subject comparisons. At least 85% of a participant’s training and diet must have been logged to be included in the analysis. Missing values were imputed using multiple linear regression (Kuhn & Johnson, 2013). As an additional check of compliance, trends in reported energy intake were evaluated; unexplained declines over time (not attributable to training load or body weight) were flagged as potential noncompliance.

Details of this analysis are provided in the supplemental files. Participants averaging < 6 h/week of training were excluded due to insufficient training stimulus, as well as departure from their typical training volume (inclusion criteria was ≥7 h/week). Participants who completed ≥6 weeks of tracking but withdrew early due to illness or injury were included (n = 12). After excluding low-training participants (n = 5) and those with unexplained declines in reported intake (n = 4), the final analysis included 46 participants (61% male) and 3,718 days of dietary tracking (80.8 ± 11.7 days per participant).

Statistical analysis

All analyses were conducted in R (v4.5.1), with significance set at $p < 0.05$. Descriptive statistics are provided as mean ± SD. Professional athletes (n = 2) were combined with elite non-professionals for subgroup analyses. Repeated-measures correlation (*rmcorr* package) assessed associations between daily carbohydrate intake and training load, duration, and intensity, accounting for within-subject dependence (Bakdash & Marusich, 2017). Spearman correlations between daily training load and daily carbohydrate intake were calculated separately for each participant, with 2000 bootstrap resamples used to estimate confidence intervals. When summarizing correlations across participants, individual correlation coefficients were Fisher Z–transformed prior to averaging and then back-transformed to Spearman ρ for reporting. We interpret the correlations using conventional thresholds of < 0.4 weak, 0.40–0.69 moderate, and ≥ 0.70 strong, acknowledging cutoff points are inherently arbitrary and should be interpreted alongside confidence intervals, which provide the range of plausible population values and may span multiple interpretive categories (Schober et al., 2018). Linear models estimated differences in weekly training volume and proportion of fasted training days by sex and competitive level. Post hoc contrasts were computed using estimated marginal means (*emmeans* R package) and adjusted for multiple comparisons via the Holm correction. Effect sizes for pairwise contrasts were calculated as standardized mean differences (Cohen's d), using the model residual standard deviation and residual degrees of freedom, and are reported with 95% confidence intervals. This approach was used because the primary interest was in differences adjusted for both sex and competitive level, rather than unadjusted group variability.

To determine the number of days of dietary tracking needed to estimate "true" average nutrient intakes for individuals with a given degree of confidence, the calculations of Basiotis et al. (1987) were used. Each participant's energy and macronutrient intake over the entire recording period was assumed to reflect their typical intake and day-to-day variability. The number of dietary tracking days needed for their intake to be within 10% of usual intake was estimated as:

$$\text{Number of days} = (Z_a)^2 * (\text{intake SD})^2 / (\text{accuracy level})^2 * (\text{mean intake})^2$$

Z_a represents the Z-value from the Standard Normal Distribution Table at the desired level of statistical significance (0.05), and accuracy level was set at 0.1 (10%).

Results

Dietary and training characteristics of participants are shown in Table 1. Fasted-state training was regularly performed by 65% of athletes (defined as at least 1x per week on average). Boxplots of participant-level carbohydrate intake are shown in Figure 1. Mean number of days of dietary tracking needed for average energy, carbohydrate, protein, and fat intake to fall within 10% of their 12-wk average 95% of the time were 18, 54, 22, and 31, respectively (Table 2). Daily intake profiles, including fasted sessions, are shown in Supplemental Figure 2.

Table 1. Dietary and training characteristics of participants[1]

Value	Mass (kg)	BMI	Kcal (kcal/kg)	CHO (g/kg)[2]	Protein (g/kg)	Fat (g/kg)	Weekly training (h)	Average daily exercise duration (h)[3]	Longest single-day exercise duration (h)	Average sRPE (AU)	% Training days fasted training[3]
Mean	71.8	23.5	38.5	3.9	1.9	1.6	11.6	1.9	5.3	36.3	27.2
SD	9.5	2.6	9.2	1.5	0.4	0.6	3.9	0.5	1.6	10.8	22.0
Low	51.1	17.5	21.3	1.2	1.1	0.7	6.1	1.2	2.6	15.9	0
High	94.2	30.3	59.8	7.2	3.2	3.1	23.0	3.3	9.8	72.4	80.6

[1] Values are provided from mean values for each participant throughout the study period. For example, the 'Low' value of 21.3 kcal/kg refers to the participant with the lowest mean daily kcal intake, not the lowest single-day intake. [2]Low and high values are considered separately for each of the macronutrients, meaning the lowest/highest values for CHO, protein, and fat. [3]Values for average daily exercise duration and percentage of days with fasted training are calculated by excluding days without exercise. CHO: carbohydrate, sRPE: session Rating of Perceived Exertion. N = 46.

Table 2. Number of dietary tracking days needed to estimate true average intake[1,2]

Value	Kcal	CHO	Protein	Fat
Mean	18	54	22	31
SD	11	66	12	23
Low	1	10	2	9
High	53	413	54	136

[1] Values are calculated from mean values for each participant. For example, the 'Low' value of 10 for carbohydrate (CHO) refers to the participant with the lowest requirement to estimate their true average intake. [2] Low and high values are considered separately for each of the macronutrients, meaning the lowest/highest values for CHO, protein, and fat.

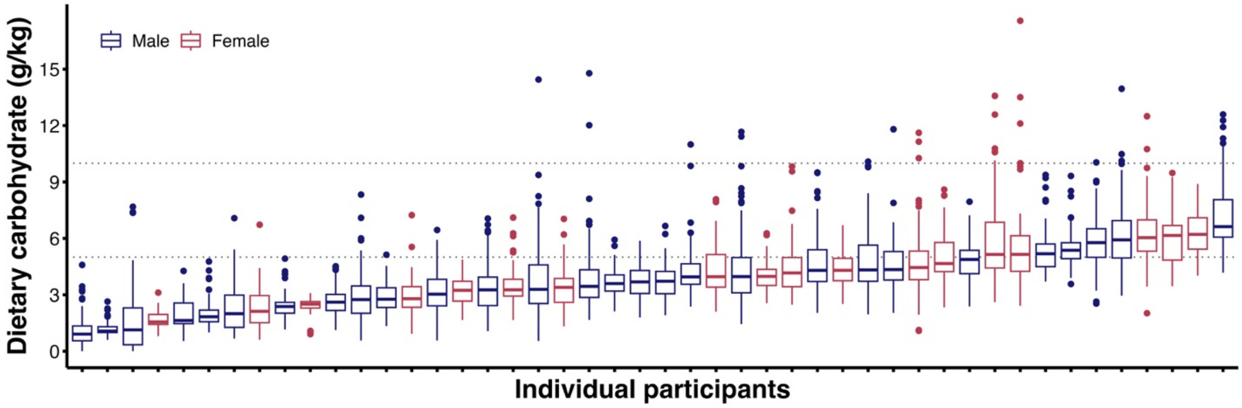

Figure 1. Box plot of daily carbohydrate (CHO) intake for each participant, colored by sex. Dotted lines indicate 5 and 10 g/kg, which is the recommended range for athletes training 1–3 hours per day (Thomas et al., 2016). Mean ± SD values for participant average daily carbohydrate intake are 4.2 ± 1.4 and 3.7 ± 1.5 g/kg for female and male athletes, respectively.

At the group level, significant correlations were found between mean daily carbohydrate intake and both percentage of training sessions performed in the fasted state (r = -0.39, p = 0.008) and weekly training volume (r = 0.42, p = 0.004) (Figure 2). There was no relationship between weekly training volume and percentage of training sessions performed in the fasted state (r = -0.07, p = 0.646, data not shown). Participant-level Spearman correlations between training load and daily carbohydrate intake ranged from -0.42 to 0.83 and are shown for each participant in Figure 3 along with examples highlighting varying correlation and intake ranges. When considering the lower bounds of the confidence intervals, only 12 out of 46 participants (26%) demonstrated moderate or stronger correlations. Correlation plots for all participants are shown in Supplemental Figure 3. Furthermore, daily energy intake showed a moderate relationship with training load (mean within-athlete Spearman ρ = 0.38, range −0.09 to 0.79), indicating that athletes tended to consume more energy on higher training days. To determine whether the relationship between training load and carbohydrate intake was independent of total energy intake, partial Spearman correlations were calculated controlling for daily energy intake. The mean within-athlete partial correlation was ρ = 0.12 (range −0.40 to 0.69), suggesting that carbohydrate intake remained modestly associated with training load even after accounting for changes in total energy intake.

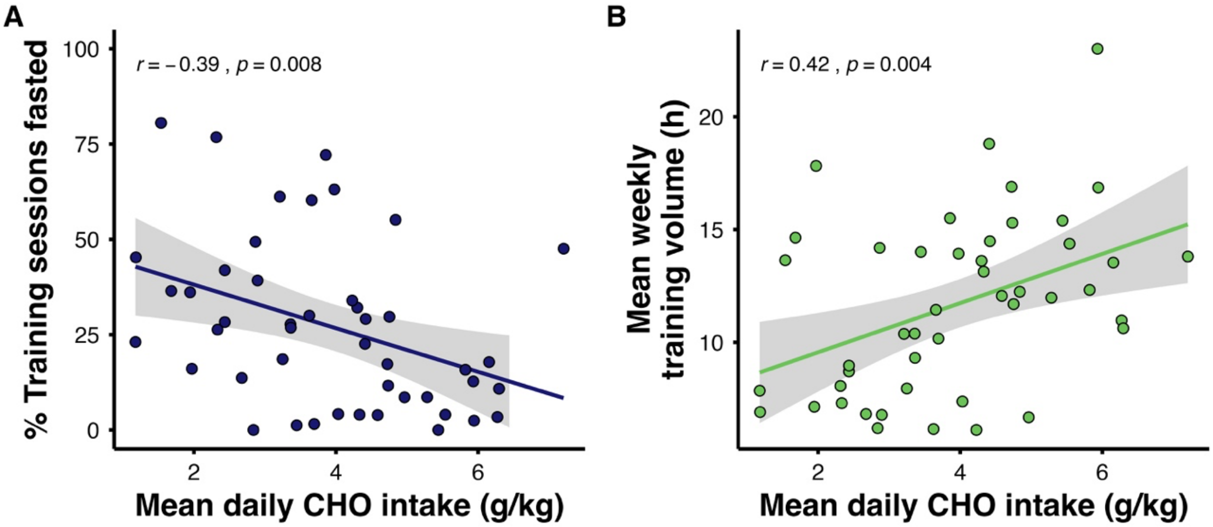

Figure 2. Correlations between mean daily carbohydrate (CHO) intake for each participant and percentage of training sessions performed in the fasted state (A) and mean weekly training volume (B).

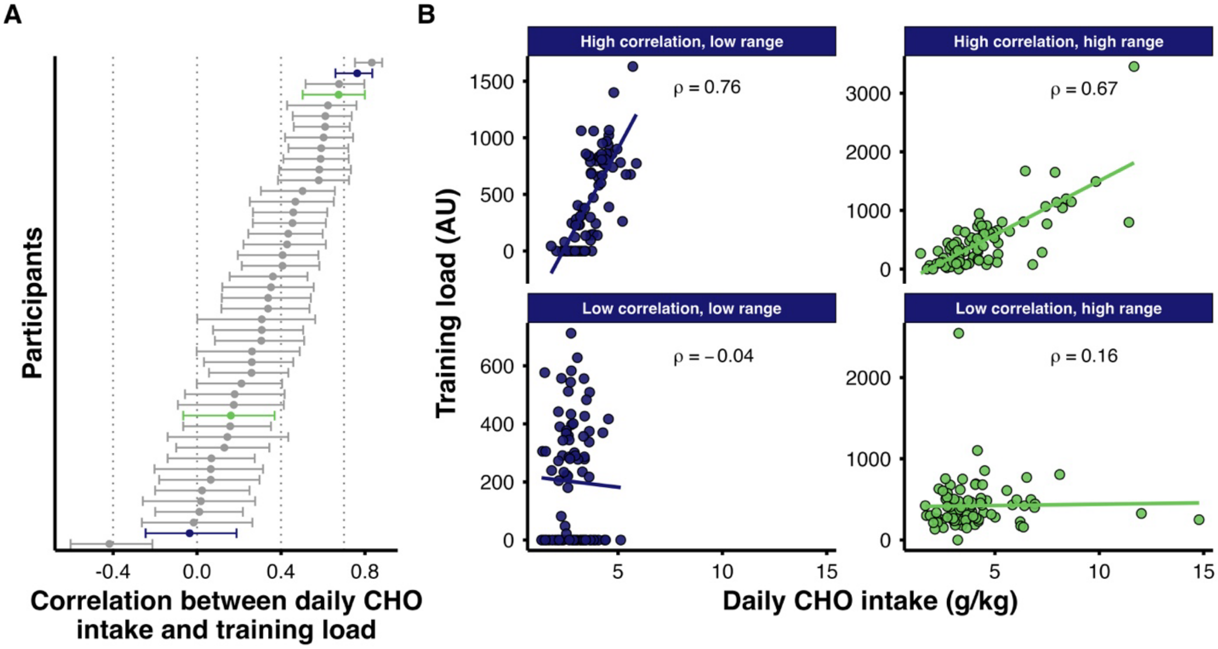

Figure 3. Spearmen correlation (*rho*) values with 95% confidence intervals are shown between training load and daily carbohydrate (CHO) intake for each participant (A), and example data from participants with combinations of low and high correlations and carbohydrate ranges (B). Colored points in (A) correspond to the data shown in (B). Dashed lines in (A) indicate qualitative interpretation cutoffs of 0.4 and 0.7 as moderate and strong correlations, respectively. Training load is the product of session rating of perceived exertion and duration in minutes. Range refers to the difference between an athlete's highest and lowest daily carbohydrate intake and can be inferred in (B) as the horizontal distance of the trend line. AU: arbitrary units.

Sub-group analysis showed males performed a greater proportion of fasted training days than females (33.6 ± 24.0% vs. 17.2 ± 13.9%, p = 0.023), but there was no effect of competitive level (Figure 4A–C). Weekly training volume was higher for elite compared with amateur athletes (13.3 ± 3.8 vs. 9.5 ± 3.1 h, p = 0.035) but did not differ by sex (Figure 4D–F).

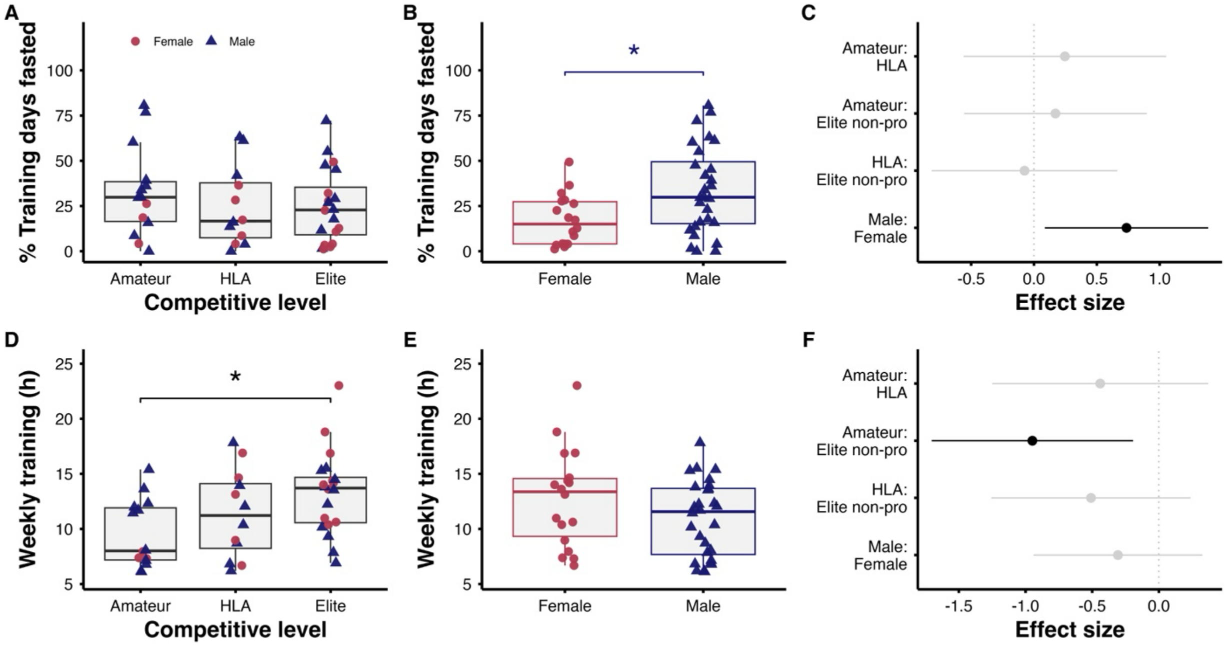

Figure 4. Boxplots of percentage of days training in the overnight-fasted state and weekly training volume, separated by competitive level (A, D) and sex (B, E). Each point represents an individual participant. Effect sizes with 95% confidence intervals for all pairwise contrasts are shown in (C, F). * indicates $p < 0.05$, effect sizes shown in black correspond to pairwise comparisons with significant p-values after adjusting for multiple comparisons. HLA: high-level amateur.

Daily carbohydrate intake in relation to training load, duration, and sRPE is shown in Figure 5A–C. Stronger associations with exercise duration suggest athletes adjust intake more in response to duration than intensity. Pre-exercise carbohydrate intake (4-h window) is shown in Figure 5D–F relative to subsequent training load, duration, and sRPE, with generally weaker associations observed. Prior-day carbohydrate intake is shown in Figure 5G–I, with no associations with next-day exercise.

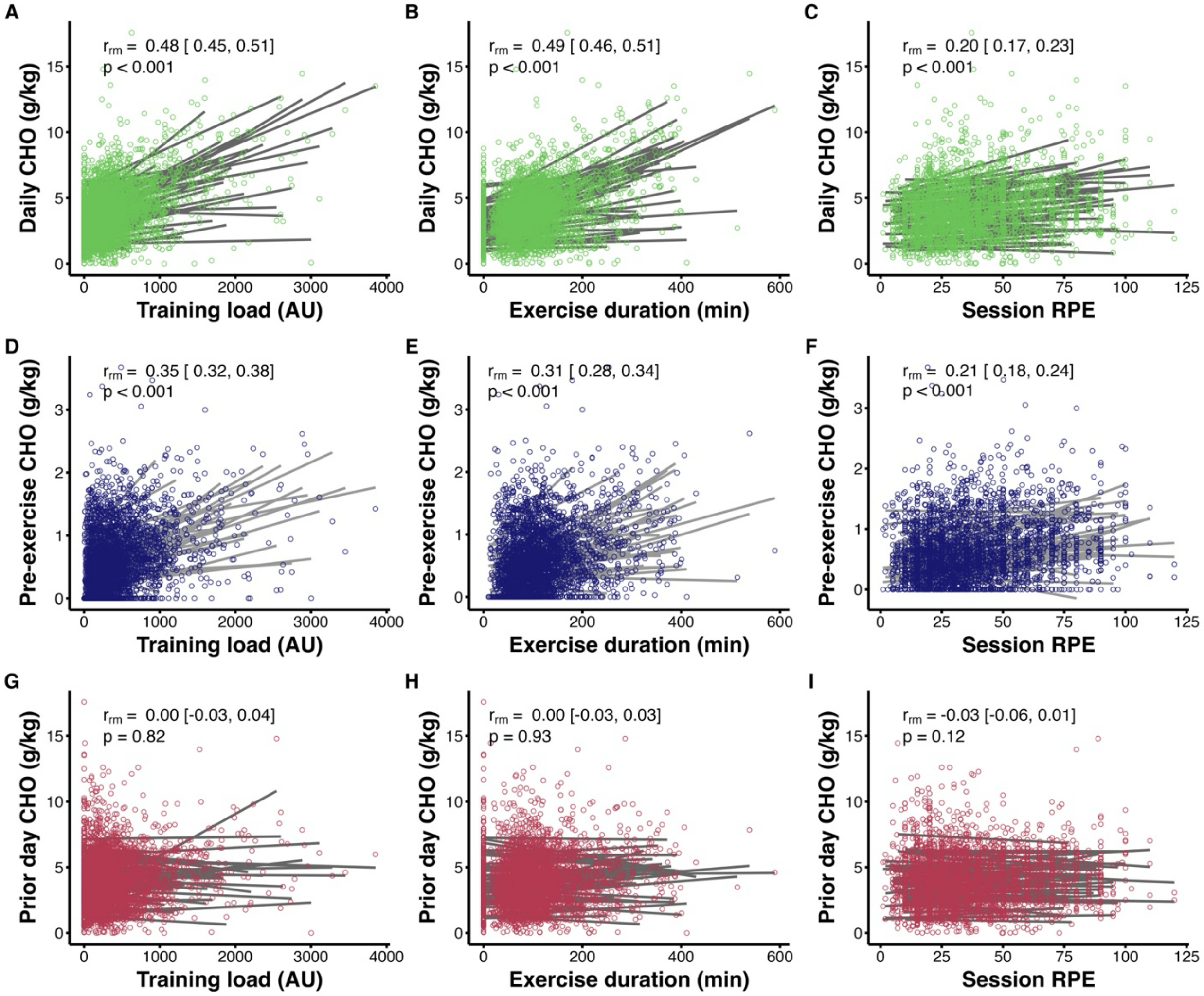

Figure 5. Daily carbohydrate (CHO) intake relative to training load (A), exercise duration (B), and exercise intensity as session rating of perceived (RPE, C), carbohydrate intake within the 4-h pre-exercise window in relation to training load (D), exercise duration (E), and session RPE (F), and prior-day CHO relative to training load (G), exercise duration (H), and session RPE (I). Each point represents a single day. Training load is calculated as the product of session RPE and exercise duration in minutes, divided by 10. Best-fit regression lines are shown in grey for each participant, with repeated-measures correlations [95% Confidence Intervals] given for each plot. AU: arbitrary units, r_{rm}: repeated measures correlation coefficient.

Discussion

This study provides novel data on the self-selected dietary intake of endurance athletes across a 12-week period, emphasizing the relationship between training load and carbohydrate intake. At the group level athletes adjust daily carbohydrate intake based on exercise duration, and to a lesser degree, intensity (Fig. 5). However, at the individual level many endurance athletes are not modulating carbohydrate intake based on changes in training (Fig. 3), or if they are, the magnitude of adjustment is small.

Participants exhibited a wide range of dietary intake (Table 1). Compared with other studies in triathletes performing similar weekly training volumes (Frentsos & Baer, 1997; Worme et al., 1990), average daily energy intake was similar (39 vs. 34–37 kcal/kg), whereas average carbohydrate intake was lower (3.9 vs. 5.0 g/kg), and protein (1.9 vs. 1.4 g/kg) and fat (1.6 vs. ~1 g/kg) intake were higher. These differences could be related to the increased popularity of lower-carbohydrate diets and/or the wide range of daily carbohydrate intakes observed in our study (Fig. 1). It was also found that 65% of athletes regularly performed training sessions in the fasted state, which is remarkably similar the 63% of athletes reporting the use of fasted training in a worldwide survey of ~2000 endurance athletes (Rothschild et al., 2020). Furthermore, the negative relationship between mean daily carbohydrate intake and fasted state training suggests athletes with lower carbohydrate intakes tended to perform a greater proportion of their training sessions in the fasted state (Fig. 2A). This relationship was not observed for total energy intake ($r = -0.18$, $p = 0.24$, data not shown).

A key focus of this analysis was to examine how athletes adjust their intake in relation to their training. Training load can be measured as internal and/or external to the athlete (Impellizzeri et al., 2019). Internal load reflects the relative physiological stress and disturbance in metabolic homeostasis in response to an external load, which is characterized by objective measures such as distance or power (Impellizzeri et al., 2019). Internal load has been recommended as the primary measure when monitoring athletes, as it plays a pivotal role in determining training outcomes and can reflect variations in the stress response to a given external load due to other stressors such as extreme temperature, or accumulated training fatigue (Impellizzeri et al., 2019). The sRPE-based load metric we used provides a measure of internal load, and was chosen as a valid and reliable method for calculating training load across exercise modalities (Haddad et al., 2017), a necessity with multi-sport athletes. We used the CR100® scale, which accounts for the non-linear stimulus-response relationship and overcomes many limitations of other scales (Borg & Borg, 2002). We have previously reported strong correlations (r = 0.75–0.95) between carbohydrate use during exercise and six different training load metrics (including sRPE) during cycling, running, and kayaking sessions (Rothschild et al., 2024a). These findings support the use of sRPE as a proxy for carbohydrate use during exercise and also suggest flexibility in the choice of training-load metrics used in this context.

There was an overall pattern of carbohydrate intake that increased with training load, both at the day-to-day level (Fig. 5) and over the entire study period (Fig. 2B). From this perspective, athletes are generally following the “fuel for the work required” framework (Impey et al., 2018). However, at the individual level the relationship between training load and carbohydrate intake varied greatly (Fig. 3). Similarly, at the group level athletes trained in the overnight-fasted state on 27% of training days, but at the individual level this ranged from 0–81%. This lack of group-to-individual generalizability, known as nonergodicity (Fisher et al., 2018), highlights the importance of individualized analysis of diet-training practices.

Carbohydrate intake tended to increase with training load, largely driven by responses to exercise duration rather than intensity (Fig. 5A–C). This could be because recommendations for carbohydrate intake during exercise are generally made on a per-hour basis. Weaker but positive associations were also observed between pre-exercise carbohydrate intake and subsequent training load and duration (Fig. 5D–F), suggesting general adherence to the "fuel for the work required" framework (Impey et al., 2018). However, individual variability was substantial. The weaker associations with pre-exercise intake may be related to our population of primarily non-professional endurance athletes, many of whom train within the first hour or so of waking in the morning and therefore could have limited time/capacity to consume carbohydrate prior to exercise. It is also conceivable that athletes could eat more carbohydrate on the day prior to a big training session, however this did not seem to occur in any meaningful way (Fig. G–I). Future studies could also examine carbohydrate ingestion during exercise, as carbohydrate availability reflects both endogenous glycogen stores and exogenous carbohydrate consumed before or during exercise (Morton et al., 2025). Our findings are similar to those in elite runners and race walkers, where only modest differences in carbohydrate intake were observed between hard and easy days in females (6.2 vs. 5.8 g/kg), but not in males (7.3 vs. 7.2 g/kg), despite most athletes reporting awareness of periodization strategies (Heikura et al., 2017a).

Among elite athletes, most training occurs within the first few hours after breakfast; therefore, a large proportion of carbohydrate intake on a calendar day may be consumed following, rather than preceding and/or during exercise. In practice, this means much of the intake serves to replenish glycogen stores in preparation for the following day's training rather than fueling the session already completed (i.e., refueling for the work required (Morton et al., 2025)). Recovery, however, is itself a critical component of "fueling for the work required", and numerous studies have shown that restoring muscle glycogen requires higher carbohydrate intakes than are typically achieved in practice. For example, ~10 $g \cdot kg^{-1}$ carbohydrate consumed in the 12 h following exhaustive training restored only ~70% of glycogen (Fuchs et al., 2025), and ~6–8 $g \cdot kg^{-1}$ carbohydrate has only restored muscle glycogen concentrations to ~300 $mmol \cdot kg^{-1}$ dry weight (Hearris et al., 2019; Hearris et al., 2020). These findings suggest that what may appear to be "high" carbohydrate intake on an easier day can in fact be appropriate when viewed through the lens of recovery and readiness for subsequent training.

On the surface, there may appear to be tension between strategic train-low carbohydrate periodization strategies and consuming adequate carbohydrate to fuel (and recover) for the work required/performed. However, fueling for the work required is as much about promoting optimal fueling as it is implementing carefully scheduled periods of low carbohydrate fueling. Athletes with lower training volumes may benefit from train-low sessions, which could provide additional stimulus. In contrast, carbohydrate intake in athletes with high training volumes enables them to achieve the desired training volume, which is the key driver for promoting adaptations. In our data there was a positive relationship between daily carbohydrate intake and weekly training volume (Fig. 3A), yet no relationship between percentage of fasted training sessions and weekly training volume. Regardless of training status, periodization strategies can also help achieve energy balance (or an energy deficit if desired) without compromising the key training sessions in a week.

Longer-duration observational studies can address questions not feasible in controlled laboratory settings. To capture real-world intake across diverse training regimens, we recruited athletes who were already consistently and voluntarily tracking diet and training. Emphasizing the importance of longer-term data collection, our findings suggest ~18–53 days of dietary tracking may be needed for an athlete's average energy and macronutrient intake to fall within 10% of their 12-wk average intake 95% of the time. This is similar to an earlier report in non-athletes that 31–64 days of dietary tracking are needed to estimate an individual's true average energy and macronutrient intake with 95% confidence (Basiotis et al., 1987). Therefore, when the goal is to assess longer-term dietary intake, future studies should strive for similar monitoring durations, while acknowledging the trade-off between longer tracking periods and the ability to recruit adequately powered sample sizes.

This study has several limitations, including the lack of training or performance outcomes and the large reliance on self-reported data. Self-reported dietary assessments are subject to several well-recognized sources of error, including underreporting, inaccuracies in portion size estimation, omitted foods, and potential inaccuracies within food composition databases, which may affect estimates of both energy and carbohydrate intake. It is also possible that reporting behaviors may differ between individuals or demographic groups (e.g., sex), which could influence observed differences in reported dietary intake. While dietary underreporting is common among athletes (Capling et al., 2017), prior studies have typically used short-duration food records rather than smartphone apps. App-based tracking improves compliance compared to paper diaries (Hutchesson et al., 2015), likely due to features such as barcode scanning and saved food lists. It has also been suggested that familiarity with and interest in keeping food records may lead to more reliable estimates of energy intake (Champagne et al., 2002), and food-tracking apps have demonstrated high reliability (Lozano-Lozano et al., 2018). In this context, reliability may be more important than absolute validity, and our focus on within-participant comparisons reduces the impact of between-participant variation in reporting accuracy. All participants were highly motivated and already habitually tracking dietary intake before joining the study. However, the use of highly motivated participants who were already habitually tracking their diet may reduce the generalizability of these findings to the broader population of endurance athletes. It is also possible that athletes who routinely track dietary intake may represent a specific subset of endurance athletes with greater focus on monitoring energy and macronutrient intake, which could influence reported dietary patterns. Although some individual values appear low relative to expected energy requirements, these values were retained as participants reported consistent recording across the study period. Nevertheless, mean daily energy intake was within the range reported in previous studies of triathletes performing similar weekly training volumes (Frentsos & Baer, 1997; Worme et al., 1990), suggesting acceptable reporting accuracy. Importantly, the ecological validity is high, as this reflects the type of data typically used by coaches and nutritionists in practice. Despite its limitations, self-report dietary data is considered critical in providing valuable information about dietary patterns and evaluating questions such as whether intakes are consistent with recommendations (Subar et al., 2015).

Conclusion

This study utilized a novel approach to monitoring endurance athletes throughout 12 weeks of self-selected training to better understand the current real-world application of dietary periodization. We show that many endurance athletes are not following current sport nutrition guidelines to periodize carbohydrate intake based on training load, or if they are, the magnitude of adjustment is small. Our findings also suggest that future observational studies that wish to estimate longer term dietary intake should strive for ~18–53 days of dietary tracking for an athlete's average energy and macronutrient intake to fall within 10% of their true average intake. Finally, future research could focus on developing objective methods to quantify carbohydrate periodization, which would allow more precise evaluation of how athletes adjust carbohydrate intake in relation to training demands.

Author contributions JAR conceptualized and performed the analyses and wrote the first draft of the manuscript. All authors edited and revised the manuscript and approved the final version of the manuscript.

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Conflict of interest The authors declare that they have no conflicts of interest relevant to the content of this manuscript.

Availability of data and material The R code used in this analysis is publicly available at (https://github.com/Jeffrothschild/CTI_code).

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