Nutrition Periodization in Recreational Endurance Athletes During Training Camp – Case Study

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ABSTRACT

Both training and dietary practices used by athletes greatly vary. Current sports nutrition guidelines promote dietary manipulation of energy-yielding nutrients specific to the period of training. The study explores the ad libitum nutrition practices of four healthy adult recreational athletes during a 2-week cycling training camp (~100 km·d^{-1}, ~240 min·d^{-1}) with particular attention to the current sports nutrition recommendations. Based on evidence-based guidelines, peri-exercise carbohydrate (CHO) and protein (PRO) intake periodization cut-off levels were set for athletes. Training days were categorized as hard (HARD, two training units/day), middle (MID, one training unit/day), and easy (LOW, no training). Fourteen-day diet records were used and analyzed by nutritional software for energy intake (EI), carbohydrate (CHO), and protein (PRO) intake. The 2-week mean daily energy intake (EI) was 1.3× higher than the predicted total daily energy expenditure, irrespective of the training day category, resulting in ~500 kcal·d^{-1} energy surplus. Daily EI intakes exceeds total daily energy expenditure in male participants during all training days, but not in female (modest negative energy balance in HARD and MID days), in contrast to female athlete Sufficient daily CHO (> 6 g·kg) were met by all participants independent of the training day. In the 2h post-exercise period, PRO intake exceeded the current recommendations 4.6-fold, and CHO intake was significantly lower after a second training session on HARD days (0.7 g·kg·h^{-1}) than a recommendation (1.2 g·kg·h^{-1}). Mean in-exercise CHO intake (~11.5 g·h^{-1}) was significantly under the moderate 30 g·h^{-1} recommendation. In conclusion, recreational athletes' dietary behaviours are inconsistent with current sports nutrition periodization guidelines. Gender differences were observed in maintaining high exercise-based energy demands by proper nutrition, especially during training days. Daily or during and post-exercise CHO and PRO intakes were not adjusted to the training sessions' volume, intensity, or duration.

Keywords: nutrient timing; nutritional strategy; energy intake; carbohydrates

INTRODUCTION

Athletes preparing for the main part of the training season frequently undertake training camps with high volumes of endurance training to improve performance. Consequently, energy intake monitoring should be prioritized to avoid low energy availability (LEA). Each acute training session should be periodized to reach the desired adaptation or performance during the training camp within the training program. Periodized nutrition manipulation with macronutrient availability allows the coordinated inclusion of sports nutrition for a given training phase into an athlete's program (Mujika, Halson, Burke, Balagué & Farrow, 2018).

New findings of recent years show the benefits of commencing of a training session with intentionally reduced endogenous and exogenous CHO availability to promote muscle adaptation (Burke, 2010). In line with matching the fuel availability with actual muscle needs, the area of sports nutrition periodization can be extended and scientifically defined (Burke et al., 2018).

The attempts of intentional manipulation with CHO availability in elite athletes with regular, systematic endurance training to promote adaptation in coordinance with the novel findings were described elsewhere (Heikura, Burke, Mero, Uusitalo & Stellingwerff, 2017; Marquet et al., 2016; Heikura, Stellingwerff, Mero, Uusitalo & Burke, 2017; Gejl et al., 2017). Practical models of CHO periodization are likely to be highly individualized according to the training structure as well as the athlete's specific training goals (Impey et al., 2018). The variable volume and intensity of cycling training create nutritional challenges regarding athletes' energy availability status and macronutrient intake (Burke, 2001; Drenowatz, Eisenmann, Carlson, Pfeiffer & Pivarnik, 2012).

Current dietary guidelines acknowledge differences in the nutrient requirements and goals for different sessions or phases of training. Recommendations targeted especially on total energy and fuel availability as well as on sufficient energy availability in accordance with carbohydrate (CHO) and protein (PRO) intake in the proximity to exercise (Thomas, Erdman, & Burke, 2016). Current understanding, however, perceives manipulation of carbohydrate availability as the primary means of periodizing sports nutrition (Stellingwerff, Morton & Burke, 2019in support of training periodization there has been an emergence around the concept of nutritional periodization. Within athletics (track and field; Impey et al., 2018; Burke et al., 2018).

Therefore, the periodization of sports nutrition is a strictly planned process in which the primary task of sports nutrition is to support the athlete's training outcomes (Jeukendrup, 2017). Each athlete must adapt to an individual nutrition plan that suits their performance or recovery needs. It was shown that the sub-elite athletes tend to reduced CHO intakes even as training loads increase, contrary to evidence-based guidelines (Kopetschny, Rowlands, Popovich & Thomson, 2018). To what extent sub-elite, recreational athletes are familiar with and follow the current sport nutrition guidelines focusing on meso- (e.g. within training camp), and micro- (within training day) macronutrient and energy periodization is less known, in contrast to the practices of elite-level athletes (Heikura, Stellingwerff & Burke, 2018).

Therefore, the study aims to explore the nutrition practices of recreational athletes during 14-days cycling training camp with attention to the periodization of Sports nutrition evidence-based guidelines.

METHODS

Subject characteristics

The characteristics of the participants are outlined in Table 1. All athletes perform regular cycling training (5-8000 km per year) with the purpose to compete and all may be classified as trained/developmental category according to McKay et al. (2022). .Each athlete undertook a 14-days training camp in Tuscany, Italy in 2019. Each athlete approved and provided written permission for this publication.

Table 1. Subject characteristics

Athlete (gender)	Age (y)	Body weight (kg)	BMI ($kg \cdot m^{-2}$)	VO_{2max} (ml·kg·min)	Body fat (%)	Heart rate$_{rest}$ (bpm)
1 (M)	29	76.1	23.5	61.4	11.7	50
2 (M)	53	76.3	22.8	68.2	14.0	40
3 (M)	21	65.3	20.2	69.0	8.8	49
4 (F)	27	69.9	22.6	60.0	13.3	42

Note. Body composition measured via bioelectric impedance analysis

Training assessment

All participants kept detailed training logs, including information on duration and volume (min and km) and intensity (HR). The intensity for each session was monitored via Garmin sports watch with a chest belt. The number of training units per day was chosen as a criterion for differentiating the variability in training load as this corresponds with a significant difference in the duration of the training sessions (p=0.009). As such we categorize the training days as hard (HARD, two training units/day), middle (MID, one training unit/day) and easy (LOW, no training) training days.

Heart rate reserve (HRR) calculated for each particular training session revealed that all training sessions were of the same relative intensity, as confirmed by the non-significant difference when adjusted for HARD (26 training units, ~ 52-65 % HRR) and MID (18 training units, ~55–66 % HRR) training days. (Table 2).

A total of 26 and 18 training days with HARD and MID training volume were analyzed for nutritional habits (Table 5). There were three days without training (LOW) for each athlete. The training consisted only of road or bike cycling sessions.

Table 2. Training characteristics during the cycling camp (data expressed as Mean±SD)

Athlete	Training day category (n)	Training			
		Intensity (% HRR)	**Distance (km)**	**Duration (min)**	**$EE_{exercise}$ (kcal·kg·min^{-1})**
1	HARD (7)	65.0±6.3	110.6±14.7	270.4±38.5	0.12±0.01
	MID (4)	66.1±11.2	98.7±13.2	214.0±31.5	0.12±0.024
2	HARD (8)	56.1±7.0	115.8±13.1	292.6±24.8	0.08±0.01
	MID (3)	55.9±4.9	101.0±15.1	227.0±44.5	0.06±0.007
3	HARD (4)	52.4±6.8	82.5±8.7	265.3±36.4	0.09±0.004
	MID (7)	56.7±5.1	79.4±30.2	211.7±43.0	0.10±0.009
4	HARD (7)	61.1±3.5	92.4±19.4	242.0±32.7	0.14±0.008
	MID (4)	58.5±2.3	107.6±7.5	234.3±23.6	0.13±0.012

Nutritional analyses

Fourteen-day diet records were used to assess food intake. The food of the cyclists was either chosen by the riders themselves or was prepared by a dietitian. Professional dietitians prepared the main meals served before and after the training sessions (correspond to breakfast, lunch, dinner, and second dinner). Meals were served collectively in a dining room, but individuals followed intake ad libitum without control. The known weight (from labels) of food used to prepare meals by dietitian was either recorded or was directly weight using digital kitchen scales (Sencor SKS 5020WH; Accuracy 1 g). The researchers educated each participant on how to record the food intake and participants were given a printed record sheet with a predefined set of grammage of food weight possibilities (e.g. spoon, plate, package, portion). A total of 56 whole-day food records were analyzed for energy intake (EI) and macronutrient composition using online dietary software *kaloricketabulky.cz*. Nutrition information not listed in the software database gathered from the packaging and dietary supplement labels were entered manually into the software program.

INDIVIDUALIZED ENERGY, CHO AND PRO INTAKE DURING TRAINING CAMP

Energy balance

Basal metabolic rate (BMR) was predicted using a Cunningham formula (Cunningham, 1980) Data from heart rate monitors (GARMIN Edge 830) were used to determine the exercise energy expenditure ($EE_{exercise}$). The total daily energy expenditure (TDEE) (kcal·kg-1), was then predicted from the BMR and physical activity level (PAL) multiples. The formula TDEE = BMR × PAL was used for LOW days, and PAL was set as 1,4. For MID and HARD training days TDEE = (BMR × PAL) + $EE_{exercise}$ was used with PAL set as 1,5 (Rodriguez, Di Marco & Langley, 2009; Thomas et al., 2016). Energy availability (EA) was calculated individually for each training day (MID and HARD) from heart-rate based $EE_{exercise}$, EI (14-day diet records) and bioelectric-impedance analysis based fat-free mass (IN Body 230) (Loucks, Kiens & Wright, 2011).

Nutrient intake periodization

To assess adherence to the sports nutrition guidelines, we set numeric cut off levels of CHO and PRO intake in the proximity of exercise to objectively determine the relevance of the nutrient intake within the given training load. The rationale for setting the nutrients and energy is introduced in Table 3. The particular cut-off levels match current evidence-based pre-exercise, during and post-exercise nutrient intake guidelines that optimise performance and recovery (Kerksick et al., 2017; Thomas et al., 2016).

Table 3. Nutrient intake periodization cut-off levels during HARD and MID training days

HARD (2 training sessions/day)[1]			MID (1 training session/day)		
Periodization	**CHO**	**PRO**	**Periodization**	**CHO**	**PRO**
2 h Pre-Ex I	2 $g \cdot kg^{-1}$	-	2 h Pre-Ex	2 $g \cdot kg^{-1}$	-
Dur-Ex I	30 $g \cdot h^{-1}$		Dur-Ex	30 $g \cdot h^{-1}$	-
Between-Ex I-II	1.5 $g \cdot kg \cdot h^{-1}$	0.3 $g \cdot kg^{-1}$	3 h Post-Ex	1.2 $g \cdot kg^{-1}$	0.3 $g \cdot kg^{-1}$
Dur-Ex II	30 $g \cdot h^{-1}$	-	-		
3 h Post-Ex II	1.2 $g \cdot kg \cdot h^{-1}$	0.3 $g \cdot kg^{-1}$			

Note. [1]in HARD days (two training sessions, morning session = Ex I and afternoon session = Ex II) the period between Ex I and Ex II training session represents ± 2 h period.

Statistical analysis

All data were managed in the Excell software. Statistical analyses were conducted using software Statistica (StatSoft CR s.r.o., Czech Republic). To show absolute athlete-specific nutritional data and along with the heterogeneity of the sample, descriptive statistics were used with data presented as mean ± standard deviation (SD). To compare the group data, Pre- and Post-Ex CHO and PRO intakes for all athletes, daily energy balance data (e.g. energy intake, energy expenditure, energy availability, CHO, and PRO intakes) were presented relative to the body weight (e.g. $g \cdot kg^{-1}$, $g \cdot kg \cdot h^{-1}$, $kcal \cdot kg \cdot min^{-1}$). A coefficient of variance (CV) was used to assess inter-variable changes.

RESULTS

The relative daily CHO and PRO intakes interindividualy differ. However, mean relative daily energy, CHO, and PRO intakes were not different between the HARD, MID and LOW training days (Tab. 4). Mean CV_{energy} in HARD and MID days was 12,2 % and 17,8 %, respectively.

Table 4. Energy, CHO and PRO intakes during the cycling camp (data expressed as Mean±SD)

Athlete	**Training day category (n)**[1]	**Nutrition**			
		CHO ($g \cdot kg \cdot d^{-1}$)	**PRO ($g \cdot kg \cdot d^{-1}$)**	**EI ($kcal \cdot kg \cdot d^{-1}$)**	**CV_{energy} (%)**
1	HARD (7)	9.8±2.5	3.7±0.9	88.5±15.4	17.4
	MID (4)	10.2±2.5	3.7±0.2	90.4±16.8	18.6
	LOW (3)	9.8±3.3	3.7±1	87.1±22.7	26.1
2	HARD (8)	9.4±1.2	3.2±0.4	84.4±8.1	10.8
	MID (3)	7.1±1.8	3.0±0.3	69.8±13.1	23.1
	LOW (3)	7.7±2.4	3.0±0.4	71.5.3±13.2	14.6

3	HARD (4)	9.5±1.4	2.8±0.2	75.2±7.9	10.5
	MID (7)	8.2±2.1	3.4±0.5	74.5±8.9	11.9
	LOW (3)	10±1.1	3.2±0.5	85.8±3.7	4.3
4	HARD (7)	7.5±0.7	3.1±0.4	73.4±7.5	10.2
	MID (4)	6.6±0.9	3.2±0.3	65.8±11.8	17.9
	LOW (3)	6.1±1.4	2.8±0.4	64.3±9.4	14.6

Note. [1] n = total number of training days in the given category included in the analysis

Absolute TDEE (kcal) was higher in HARD and MID days compared to the LOW days in all athletes. Contrary to male athletes, no difference was observed between HARD and MID days in female athlete, despite twice the training units per day (Tab. 5). Significant positive energy balance (EI:TDEE ~1.73) was reported in LOW days, however, positive energy balance was found in MID and HARD days as well (~1.13 and ~1.12 ratio, respectively).

Table 5. Individual energy balance data during the training camp (data expressed as Mean±SD)

Training day category	Athlete	EI (kcal)	$EE_{exercise}$ (kcal)	TDEE (kcal)	Energy balance (kcal)	EI:TDEE ratio
HARD	1	6188.1±1079.4	2442.4±152.4	5410.0±152.4	+ 778.1±1052.6	1.14
	2	5899.6±565.6	1796.4±308.2	4711.2±308.2	+ 1188.5±475.9	1.25
	3	4912.3±517.5	1648.5±285.5	4563.3±285.5	+ 349.0±418.6	1.07
	4	5133.1±521	2454.9±353.9	5204.7±353.9	- 71.5±525.7	0.98
MID	1	6318.0±1177.5	2011.5±575.6	4979.1±575.6	+ 1338.9±1447.5	1.26
	2	4998.0±819.6	1133.3±341.1	4048.1±341.1	+ 949.9±1098.6	1.23
	3	4862.9±580.8	1305.7±366.4	4220.5±366.4	+ 642.3±556.4	1.15
	4	4600.3±826.9	2352.3±381.3	5102.1±381.3	- 501.8±898.2	0.90
LOW	1	6089.7±1584.6	-	3137.4±520.0	+ 2952.2±1803.7	1.97
	2	4994.3±922.9		3463.3±270.5	+ 1713.9±653.1	1.44
	3	5600.3±238.4		3086.8±22.9	+ 2513.5±216.2	1.81
	4	4491.0±657.1		2658.8±130.6	+ 1832.2±653.2	1.68

Overall, due to the surplus in energy intake, EA sufficiently meets the optimum levels of 45 kcal·kg FFM^{-1}. Interestingly the EA was not different during the HARD (~59kcal·kg FFM^{-1}) in comparison to the MID (~56kcal·kg FFM^{-1}) training days in men being over the 45 kcal·kg FFM^{-1}in men (athletes 1-3), but not women (37,1 and 44,2 kcal·kg FFM^{-1} in MID and HARD days, respectively) (athlete 4). Importantly, EA in HARD days was ≥ 44 kcal·kg FFM^{-1} in all athletes (Fig.1).

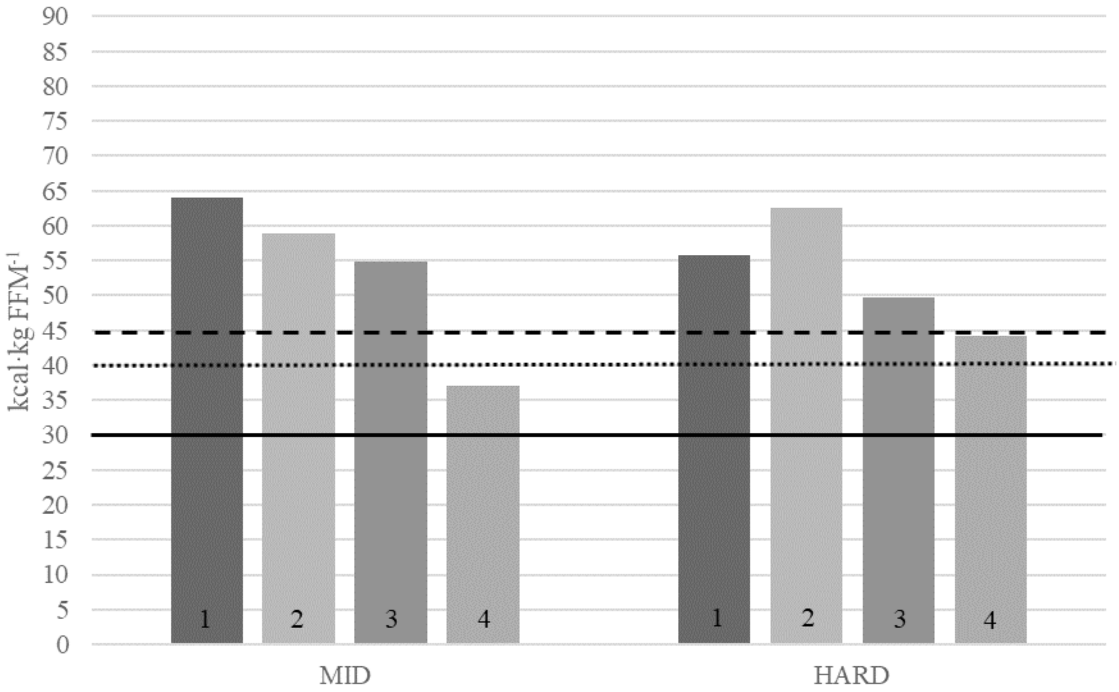

Figure 1. Mean energy availability in MID and HARD days for individual athletes (1-4)

Note. Dashed line and dotted line depict the optimal EA for women (45 kcal·kg FFM^{-1}) and men (40 kcal·kg FFM^{-1}); full line depicts the level considered to be low energy availability in both males and females

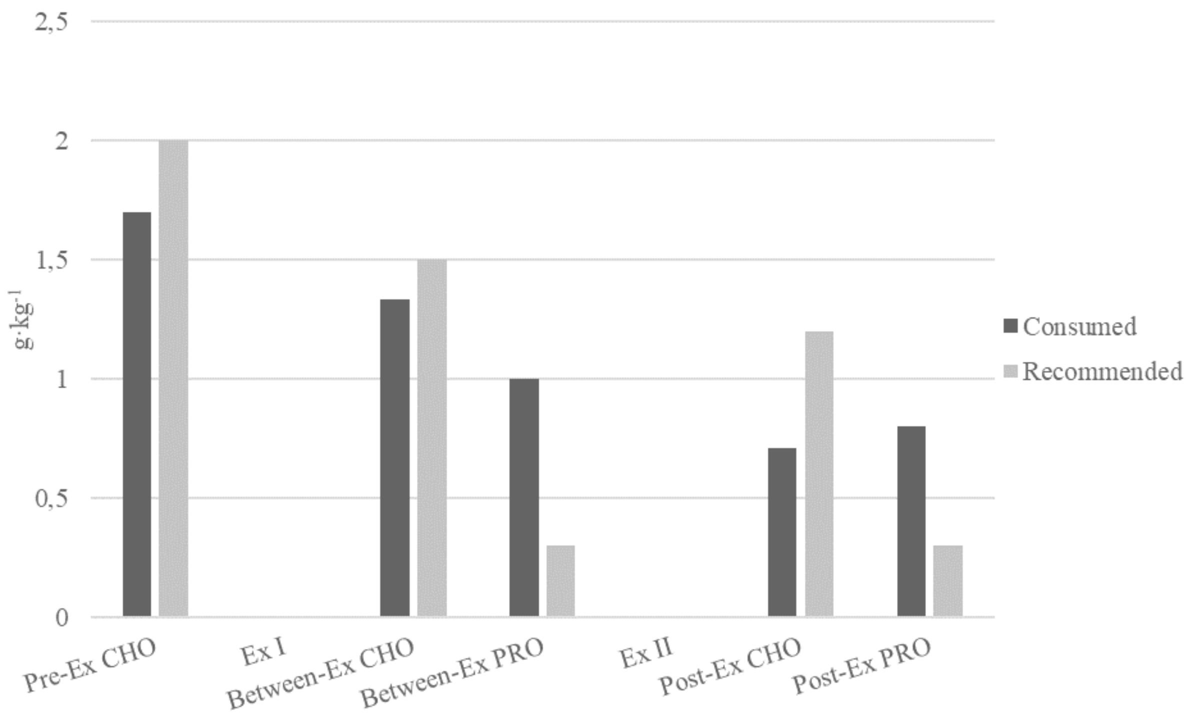

Figure 2. Pre- and Post-exercise nutrient periodization in HARD days

Note. Illustrates the difference between "consumed" (mean peri-exercise nutrient amounts for all training units meals) and "recommended" (described in Table 3; Post-Ex CHO is expressed in g·kg·h^{-1}

The mean CHO intake in HARD days after the second training session (~ 0.7 g·kg·h^{-1}) was nearly two times lower than recommended (1.2 g·kg·h^{-1}). In contrast, protein intake was higher than recommendations (0.3 g·kg^{-1}) in both post-Ex time periods in HARD (Between - Ex PRO, 0.8 g·kg^{-1} and Post-ExPRO, 1 g·kg^{-1}) and MID days (1.3 g·kg^{-1} (Fig. 2,3).

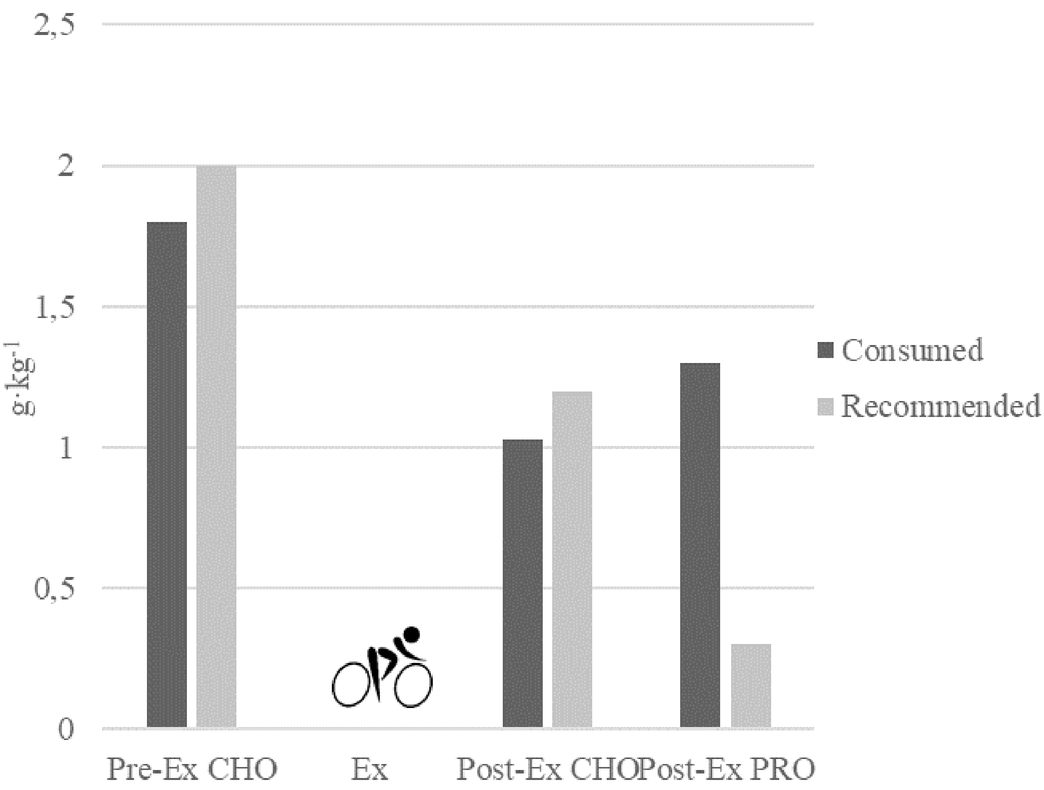

Figure 3. Pre- and Post-exercise nutrient periodization in MID days

Note. Illustrates the difference between "consumed" (mean peri-exercise nutrient amounts for all training units meals) and "recommended" (described in Table 3; Post-Ex CHO is expressed in g·kg·h^{-1}

In overall, CHO intake during exercise was significantly lower than elementary recommendations (30 g·h^{-1}). The CHO intake level was independent of the training day category and did not significantly differ (Fig. 4).

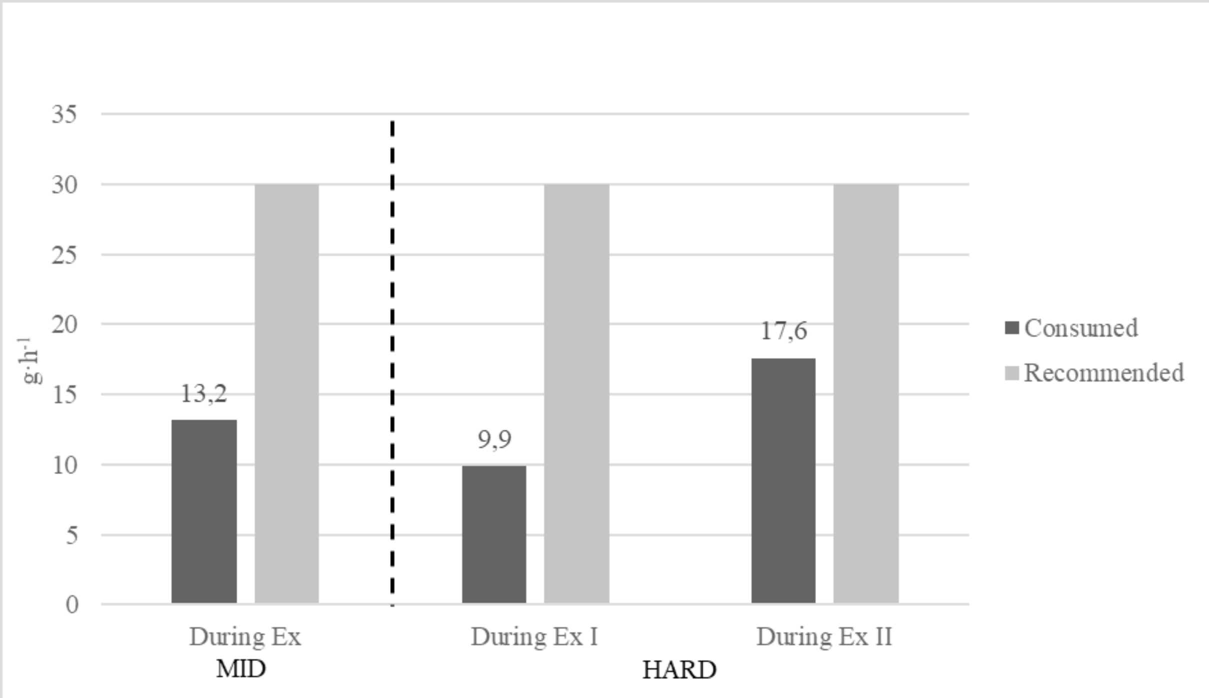

Figure 4. Carbohydrate intake during exercise in HARD and MID days

Note. Illustrates the difference between "consumed" (mean CHO intake during all training units) and "recommended" (described in Table 3)

DISCUSSION

The case study aimed to explore the area of sports nutrition periodization according to the current evidence-based guidelines. The current study describes the nutritional habits of 4 recreational athletes during the high-volume cycling training camp with particular attention to the achievement of current sports nutrition periodization guidelines (Burke et al., 2018; Jeukendrup, 2017). More specifically, the study aimed to associate athlete's CHO, PRO and energy intake within training camp with the variability in daily training load.

We found that the athletes' total energy and CHO intakes during the training camp meet and exceed the current guidelines for optimizing performance and recovery. However, we found that energy and CHO intake were independent of the training load, suggesting an inability to periodize the nutrition effectively.

The predicted training intensity based on HRR was below 60 % VO_{2max} for most training units, irrespective of the training phase and overall daily training volume (one or two training units/day). Therefore, to differentiate the variability in daily training load, we categorize the days as HARD (two training units/day), MID (one training unit/day) and LOW (no training). The participants' training program was not periodized as the calculated mean exercise intensity (% HRR) for HARD and MID days was the same (58.7±4.8 % and 59.3±4 % of HRR, respectively) (Tab 2).

It has been demonstrated that implementing a nutrition-training intervention involving individual periodized CHO availability requires careful planning and the expertise of a sports dietitian

(Stellingwerf, 2012). However, athletes seemed to be well aware of guidelines that emphasize optimal CHO availability around high-intensity training sessions (Vogt et al., 2005; Heikura et al., 2018). Even though strategically manipulating CHO availability before, during or after exercise has been found to provoke a beneficial adaptive response (Impey et al., 2018), we found no signs of deliberate lowering CHO availability within the microcycle or particular training session.

Energy intake

The most interesting observation was that the daily energy intake was higher than expenditure irrespective of the total daily training volume leading to a significant mean positive energy balance during the camp (~ 1060 kcal·d^{-1}), with a substantial daily surplus of ~ 2200 kcal and ~ 500 kcal in non-training and training days, respectively (Tab. 5). Elite athletes and recreational athletes are vulnerable to LEA (Vanata & Steed, 2013), and sports nutrition knowledge is also reduced (Trakman, Forsyth, Devlin, & Belski, 2016). The EA for training days exceeds the 45 kcal·kg FFM^{-1} limits (Loucks, Kiens, & Wright, 2011), reaching 53.0±9.5and 53.7±15.1 for HARD and MID days, respectively. This can be explained by the rigid relative daily energy intake of ~73-78 kcal·kg^{-1} irrespective to the training day category, however, with gender differences (3 males and 1 female athlete ~EI 80,8 and 67 kcal·kg^{-1}, respectively). This translates in lower EA in MID days in female athlete (~37 kcal·kg^{-1}), but still within an acceptable range (Areta et al., 2021). Furthrmore, significant daily energy intake inconsistency was observed in HARD days (-71 kcal), MID days (-500 kcal) and LOW days (+1800 kcal) in the female athlete but not in males. This suggests gender differences in the ability to adjust energy intake with total energy expenditureSignificant interindividual differences were observed for EA during HARD (44-62 kcal·kg FFM^{-1}) and MID (37-64 kcal·kg FFM^{-1}) days. Analysis of reported daily EI revealed no ‘under-reporting’ in all athletes as an EI:BMR ratio was < 1.5. However ‘over-reporting’ behavior where EI:BMR ratio exceeds >2.5 may be expected for LOW days or MID and HARD days, respectively. In particular, over-reporting was identified in 69.6 % of all training days in which reported PRO intake was high (~3 g·kg^{-1}). This corresponds with PRO being the most often misreported nutrient (Magkos & Yannakoulia, 2003) including retrospective (diet recall, food-frequency questionnaire, and diet history. The energy intake coefficient of variation in LOW days interindividually ranges from 4,2–26,1 %, reflecting poor ability to periodize energy intake. Unfortunately, we did not record body weight to show if this extreme energy dysbalance led to body weight gain.

It must be noted that - firstly, athletes in our sample were not familiar with nutrition periodization and secondly, an experienced sports dietitian, who also prepared meals, was present during the camp. On the one side, we believe dietitian presence allows controlling for proper food choices and nutrient composition of food consumed, therefore eliminating interindividual differences in options for food delivery. On the other side, it may indirectly promote the ad libitum athlete’s food consumption during the camp, especially with the impact on non-training days. Therefore, it may be questioned to what extent the presence of the chef may have affected the ad libitum intake and adherence to guidelines (author’s own recognition). It may be speculated that if there would be a strategically planned nutritional program, a professional dietitian may assist in controlling specific nutrient intake, which is in line with current guidelines (Thomas et al., 2016).

Carbohydrate intake

The CHO intake during the training camp interindividually ranges from 6-10 g·kg·d^{-1}which is in line with practices of endurance-based disciplines. However, when considering the variability in daily training volume, there was no significant difference between the mean CHO intake for HARD and MID and even LOW days, 8.9±0.8, 7.8±1.0, 8.2±1.5 g·kg·d^{-1}, respectively. Only one participant (female) reduced CHO intake markedly in non-training days. However, her intake reached sufficient levels of 6.1 g·kg·d^{-1} (Burke, 2001).

Periodization of nutrients

Current guidelines around PRO intake for all types of athletes promote the regular intake of modest amounts (~ 25 g) (Schoenfeld & Aragon, 2018) of high-quality PRO over the day, including soon after the completion of key training sessions (i.e., sessions of high intensity and/or high duration (>90 min) (Jäger et al., 2017). The post-exercise per-meal PRO intake recommendation adjusted for body weight (~ 0.3 g·kg^{-1}) was 4,6 times higher for MID (1,4 g·kg^{-}1) and similarly high for a first and second exercise session in HARD days (1.0 g·kg^{-1} and 1.2 g·kg^{-1}). All athletes exceeded the recommendation in all training sessions. We hypothesized that this resulted from high postexercise energy intake rather than PRO target intention as the daily PRO intake exceeded 3 g·kg^{-1} independently of the training day category.

Three hours post-exercise, the PRO intake in MID days accounted for 39.3 % of daily PRO intake. Similarly, on HARD days, the post-exercise PRO intake accounted for nearly 60 % (32.2 % for Ex 1 and 25.8 % for Ex 2) of total daily PRO.

Post-exercise CHO intake in HARD accounted for 15.5 and 8.4 % of daily CHO intake after Ex 1 and Ex 2, respectively. In MID, CHO intake accounted for 17.5 % of daily CHO intake. Athletes generally aimed to achieve high CHO availability with no signs of intentional manipulation. The CHO intake before exercise reached 90 % of the recommendation for 2h time frame period before exercise in MID and 85 % in HARD days (in both cases 1.8 g·kg^{-1} vs. 2.0 g·kg^{-1}). However, CHO intake during exercise was significantly lower (more then two-fold) than moderate 30 g·h^{-1} recommendations. We found the in-exercise CHO intake fulfilment to be 55 % of the recommendation in MID, 33.7, and 67 % in HARD for Ex 1 and 2, respectively. This may not limit the endogenous CHO availability and performance as athletes generally follow high CHO intake. All training sessions reported by athletes and included in the analysis lasted more than 120 min. This justifies the promotion of high CHO availability, as glycogen levels limit exercise capacity (Impey et al., 2018)compete high' paradigm. Despite this fact, CHO were not ingested in 36 % of all training sessions. Furthermore, even high-intensity training sessions expressed as % HRR not correlated with higher CHO intake (r = 0.19) (Fig. 5).

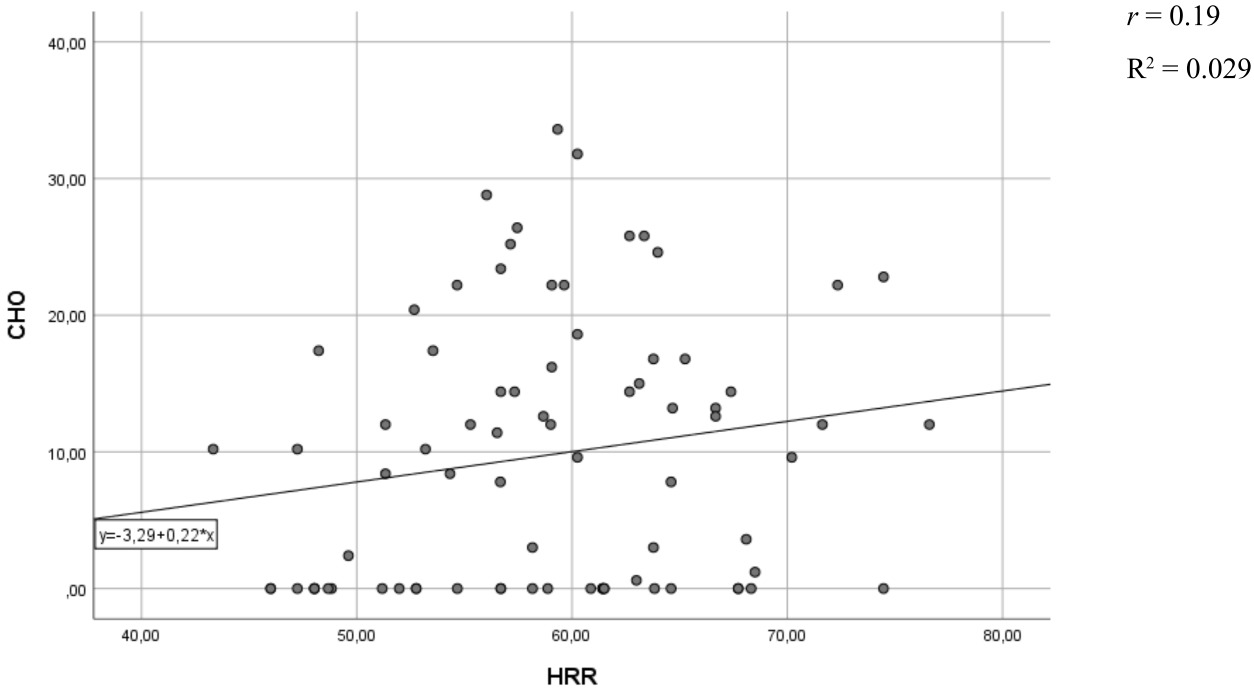

Figure 5. Carbohydrate intake during all training sessions in relation to the intensity (% HRR)

We believe that any form of sports nutrition periodization in recreational athletes should be coordinated with a trainer or educated dietitian and may hardly result from experience and ad libitum food intake. We show a positive energy balance, high CHO and PRO intake irrespective of training volume. This supports that athletes follow sports nutrition guidelines without considering new findings. Moreover, we found that gender differences in applying recommendations to practice should be considered and carefully interpreted as there is still limited understanding on this topic (Areta et al., 2022).

CONCLUSIONS

The case study revealed that the recreational athletes, rather than strategically manipulating nutrient delivery outside the training, focus on the total daily energy intake to compensate for the energy expenditure, which led to a significant positive energy balance (~ 500 kcal). No signs of deliberate CHO and PRO intake distribution to meet current sport nutrition guidelines were identified. Although daily CHO intakes meet current CHO guidelines promoting high endogenous CHO availability, daily or post-exercise CHO intakes were independent of the number of training sessions, intensity or duration and gender-different.

What the study brings new

Recreational athletes are not able to follow scheduled eating patterns. Moreover, recreational athletes do not adjust energy and nutrient delivery to the training program. Sports dietitian plays an essential role in assisting athletes to fulfil current sports nutrition periodization guidelines.

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