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Case Study: A week with a young type 1 diabetic athlete
Caso de estudo: Uma semana com um jovem atleta diabético do tipo 1

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Abstract

Objectives: To depict a week in the life of a young athlete with type 1 diabetes mellitus, regarding glycaemia, insulin administration, physical activity and food patterns.

Methods: Blood glucose monitoring (Accu-Check® Combo), recording of insulin injections (NovoRapid®), dietary assessment (7-day food diary supported by pictures) and energy expenditure estimation (7-day physical activity log and Polar OH-1 heart rate monitor) were performed over 7 consecutive days. Anthropometric measures (height, body mass and skinfolds) were assessed in the beginning.

Results: The athlete measured 1,97m, weighed 109 kg, and presented a sum of 7 skinfolds of 91,2mm. Intake of carbohydrates was 46,8±7,7%, while protein was 26±6,7% and fat was 27,2±5,2% of the total energy intake. The average caloric intake of the week was 1400±173kcal and the highest was 1681kcal, on a match day. Mean pre-workout carbohydrate intake was 0,44±0,30g·kg^{-1},protein was 0,11±0,09g·kg^{-1}, and fat was 0,07±0,07g·kg^{-1}. In the post-workout meal, carbohydrate consumption averaged 0,37±0,28g·kg^{-1}, protein 0,24±0,11g·kg^{-1} and fat 0,17±0,09g·kg^{-1}. On training day 2 there was a morning glucose concentration of 300mg.dL^{-1} and later an episode of hypoglycaemia. On training day 1 and match day 1, glucose levels increased continuously throughout the day.

Conclusion: Great oscillations in blood glucose, poor eating habits and infrequency glucose monitoring were observed. Studies are lacking on this topic and specific recommendations for young athletes with T1DM are warranted to help prevent potential consequences to health and sports performance.

Keywords: Adolescent, Sport, Diabetes, Nutrition.

Resumo

Objetivos: Descrever a semana de um jovem atleta diabético do tipo 1, relativamente à glicemia, administração de insulina, atividade física e padrão alimentar.

Metodologia: A monitorização da glicemia (Accu-Check® Combo), registo de administração de insulina (NovoRapid®), avaliação da ingestão alimentar (diário alimentar com suporte fotográfico) e estimativa do gasto energético (registo de atividade e o monitor de frequência cardíaca - Polar OH-1) foram realizadas durante 7 dias. A avaliação antropométrica (altura, peso e pregas cutâneas) foi realizada no início do estudo.

Resultados: O atleta tinha 1,97m, 109 kg e apresentava um valor da soma de 7 pregas de 91,2mm. O consumo médio de hidratos de carbono (HC) foi 46,8±7,7% do valor energético total, enquanto de proteína foi 26±6,7% e de gordura foi 27,2±5,2%. A média do consumo energético da semana foi 1400±173kcal com um máximo de 1681 kcal, num dia de jogo. A média de consumo de HC no pré-treino foi 0,44±0,30g·kg^{-1}, proteína 0,11±0,09g·kg^{-1}, e gordura 0,07±0,07g·kg^{-1}. No pós-treino, a ingestão de HC foi 0,37±0,28g·kg^{-1}, proteína 0,24±0,11g·kg^{-1} e gordura foi 0,17±0,09g·kg^{-1}. No segundo dia de treino, foi registado um valor de glicose de 300 mg.dL^{-1} e posteriormente um episódio de hipoglicemia. No primeiro dia de treino e jogo, os níveis de glicose no sangue aumentaram continuamente ao longo do dia.

Conclusão: Foram observadas grandes oscilações na glicemia, maus hábitos alimentares e falta de rigor no controlo da glicemia. São necessárias recomendações específicas para atletas jovens com DMT1 para ajudar a prevenir potenciais consequências para a saúde e performance desportiva.

Palavras-Chave: Adolescente, Desporto, Diabetes, Nutrição.

Lista de abreviaturas, siglas e acrónimos

EEE – Exercise Energy Expenditure

HR monitor – Heart Rate Monitor

LCD - Low Carbohydrate Diet

M1 – Match Day 1

MDI - Multiple Daily Injections

MET – Metabolic Equivalent

PA – Physical Activity

PAL – Physical Activity Level

R1 – Resting Day 1

T1DM - Type 1 Diabetes Mellitus

T1 – Training Day 1

TEI - Total Energy Intake

TEE – Total Energy Expenditure

TEF – Thermic Effect of Food

RMR – Resting Metabolic Rate

SD – Standard Deviation

%BF – Percentage of body fat

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Introduction

Type 1 diabetes mellitus (T1DM) is an increasingly noticeable disease, for which the attention of health care professionals worldwide is warranted. In 2018, the prevalence of T1DM in Portugal was 13,6% (20-79 years) and has been increasing globally around 3-4% per year[(1)]. Among children and adolescents, from 0 to 19 years old, the incidence of T1DM was 0,16% in 2015, according to data from the "Registo Nacional – DOCE". T1DM is categorized as an auto immune disease due to ß-cell destruction. Consequently, insulin production is inexistent in these patients, leading to an absolute need for exogenous insulin administration. There are specific criteria to diagnose a person with T1DM which includes: Fasting plasma glucose concentrations ≥ 126 mg/dL (with a minimum fast of 8h) or during an oral glucose tolerance test having a 2-h plasma glucose ≥ 200mg/dL or A1C levels ≥ 6,5%[(2)].

The American Diabetes Association (ADA) recommends that all children with T1DM practice 60 minutes of moderate-to-vigorous-intensity aerobic activity at least three days per week, in order to better control their blood glucose levels and minimise the amount of insulin needed to compensate for higher concentrations[(3, 4)]. However, studies concerning adolescents with T1DM that undertake sport and exercise are currently lacking[(5)]. Therefore, this case-study portrays the disease management behaviours of an athlete with T1DM, hoping to inform future recommendations for young athletes with T1DM. In addition, the current recommendations for young athletes without T1DM, as well as for children and adults with T1DM, to improve health and glycaemic markers will be compared and discussed in this paper.

Objectives

The current case study aims to depict a week in the life of a young athlete with T1DM. We provide a critical view of the results obtained from data collected over seven days on the participant's blood glucose levels, insulin administration practices, physical activity patterns and food habits.

Methods

Presentation of the athlete: This case report follows a young, male, 17-year-old, handball player who has been diagnosed with T1DM for at least 7 years. The participant has been monitored at the hospital of Coimbra since his diagnosis, where he has attained all the knowledge needed to cope with the disease. He started by playing football as a child but changed to handball 4 years ago and has played it ever since.

The participant was recruited from the under-18s and senior teams of a first league, Portuguese handball club. Data was collected to describe the food habits and insulin administration patterns of a young T1DM athlete, as well as the consequent variations in his plasma glucose concentrations over a typical week: four training days (T1, T2, T3 and T4), two match days (M1 and M2) and one resting day (R1). An informed consent was obtained from the adolescent's parents, and ethical approval was granted by the Ethics Committee of the University of Porto.

Anthropometric Evaluation: Weight (using a SECA® robusta 813 digital scale, precision of 0,1 kg), height (using a vertical stadiometer SECA® body meter 206) and skinfolds were measured according to the International Society for the Advancement of Kinanthropometry (ISAK) standards[6] to characterize the participant. Body mass index (BMI) was later calculated[7], as well as the percentage of body fat (%BF) through the equation of Withers, a predictive equation for male athletes that considers the age of the participant[8].

Biochemical markers and insulin injections: The athlete was on a basal-bolus insulin regime with NovoRapid® Insulin, a rapid-acting insulin used in the management of T1DM, both in adult and child patients. NovoRapid® Insulin acts within 10 to 20 minutes and peaks between 1~3 hours after injection, though the effects may last up to 5 hours. Nonetheless, the athlete measures his blood glucose concentrations regularly. To administer insulin, the athlete uses an insulin pump that is connected to a portable device (Accu-Check® Combo) which calculates the insulin dose (using the 'bolus advice mode') required to meet the carbohydrate intake in each meal. When the pump is damaged or low in battery, the athlete uses Fiasp® instead, which is a rapid-acting insulin analog. For the glycaemic record, the athlete was asked to register every blood glucose concentration that he measured throughout the day, giving particular importance to the measurements collected before, during and after exercise. The timings of insulin administration were also registered by the athlete, on a different sheet. During the conduction of this study, the athlete maintained his normal routine, food, and exercise patterns. Additionally, to infer the glycaemic control of the participant over the last three months, the value of glycated haemoglobin (HbA1c) in his last medical exams was recorded.

Diet Assessment: The athlete was asked to fill in several documents, including a 24-h weighed food record (comprising a 7-day food diary) and an activity log. Dietary intake was registered over 7 consecutive days, from a Monday through to Sunday. The participant was instructed on how to complete the questionnaires and a scale was provided to him to facilitate the weighing process. To support the estimation of daily dietary intake, the participant was asked to take photographs of every meal. Total Energy intake (TEI) was calculated using a dietary analysis software, Nutrium®, by converting the foods and recipes reported into macronutrients. Data collected was then compared with the recommendations for adult athletes[9], adolescent athletes[10] and adolescents with T1DM[11, 12].

Energy Expenditure: To estimate the resting metabolic rate (RMR) we used the Cunningham equation, as it is the current most accurate and validated equation to use in athletic populations[13]. The exercise energy expenditure (EEE) was assessed every day, in each handball practice, using a heart rate (HR) monitor (Polar OH-1) on the left arm. All daily activities were monitored through a self-reported activity log filled out by the athlete with the activities performed, the timing and duration of each one, to then use the respective metabolic equivalent (MET) to estimate the total energy expenditure (TEE). The physical activity level (PAL) was obtained by summing the MET values of all activities and dividing by the sum of their durations (hour). As it was possible to estimate EEE using a HR monitor, which provides a more accurate estimation of EEE than METs, the EEE calculated from METs (correspondent to the handball practice) was subtracted from the TEE. The thermic effect of food (TEF) was considered ~10%, as it has been proven to display low interindividual variability[14]. All the values were summed in order to achieve an approximation of the TEE, of each day[14]. The mean and daily TEE resulting from the sum of RMR*PAL, EEE and TEF, as well as the TEI, are presented in Table 3.

Results

The participant's characteristics are described in Table 1. The athlete measured 1,97 m and weighed 109 kg, corresponding to a BMI of 28,1 kg/m^2. Regarding body composition, the athlete's body fat was estimated at 16,6% and fat-free mass at 91,7 kg. The sum of 7 skinfolds (except iliac crest) was 91,2 mm.

The analysis of the athlete's 7-day food record is displayed on Table 2. We have highlighted the absolute amounts of each macronutrient (carbohydrate (CHO), protein and fat), but also the adjusted values per kilogram of body mass and as a percentage of the TEI. Intake of CHO was 46,8 ± 7,7% of the TEI, while protein intake was 26 ± 6,7% and fat intake 27,2 ± 5,2% (mean ± standard deviation (SD)). When converted to g·kg$^{\cdot-1}$d$^{\cdot-1}$, CHO intake was 1,48 ± 0,4; protein was 0,72 ± 0,11 and fat was 0,41 ± 0,08. Specifically, the average TEI of the week (Figure 1) was 1400 ± 173 kcal and the highest, 1681 kcal on a more intense training day (M1). We highlighted the differences in TEI throughout the 7 days of the week (Figure 1), as well as the energy and macronutrient intakes in each peri-exercise meal, to allow for comparison with current sports nutrition guidelines (Figure 2). Mean pre-workout CHO intake was 0,44 ± 0,30 g·kg^{-1}, protein intake was 0,11 ± 0,09 g·kg^{-1}, and mean fat intake was 0,07 ± 0,07 g·kg^{-1}. In the post-workout meal, CHO consumption averaged 0,37 ± 0,28 g·kg^{-1}, protein 0,24 ± 0,11 g·kg^{-1} and fat 0,17 ± 0,09 g·kg^{-1}. Figure 3 illustrates the evolution of plasma glucose levels with each daily meal and the injections of insulin that followed. It is noticeable that the timings of insulin administration mostly coincided with the moments when the athlete checked his glycaemia and consumed food. The participant rarely checked his blood glucose levels, unless the other two conditions presented. The only day when the athlete did all the 3 measurements of the concentrations of blood glucose during practice (before, during and after), as requested in the beginning of the study, was on T3. Most of the days, blood glucose concentrations in the morning were between 100-150 mmol·L^{-1}. However, on day 2, a maximum of 300 mmol·L^{-1} and a minimum of 60 mmol·L^{-1} were registered. Reversely, on T1 and M1, blood glucose levels increased continuously throughout the day. On most days, the athlete had 4 meals throughout the day. Lastly, his Hb1Ac value was 8,5%.

Discussion

The physical characteristics of an athlete can contribute substantially to his performance and success[15]. Our participant's sum of 7 skinfolds was 91,2 mm, slightly above the reference values for Portuguese, male adult handball players, which is 86,7 mm[16].

For the average young athlete with T1DM, no specific nutrition guidelines have been developed to date. Even though the ADA has issued recommendations for adolescents with T1DM on daily CHO (45% - 55% TEI), protein (<15% TEI) and fat (30-35% TEI) intake, no special considerations have been published concerning the adolescent athlete[11, 12]. Comparing the athlete's results with these guidelines, it is evident that the average CHO (46,8%) intake lies between the recommended percentages. However, protein with an average of 23,7% was above the expected intervals, while fat, with 28,8%, was below the recommendations. Our results agree with those of a recent randomized controlled trial which showed that the real consumption of CHO in a group of adult marathon runners with T1DM also failed to meet the recommendations[17]. Additionally, the sample displayed better regulation of their glycaemia, which comes to show that more research is needed to confirm whether the existing recommendations are optimised or should be reviewed[17]. However, according to Sports Dietitians Australia[10], recommendations for the adolescent athlete lie between 6-10 g of $CHO \cdot kg^{-1} \cdot d^{-1}$ for a better daily recovery, assuming an endurance programme of 1-3 hours of exercise per day, 0,99 $g \cdot kg^{-1} \cdot d^{-1}$ of protein and 30%-35% of the TEI for fat. Comparing to the recommendations above, the athlete in the present study did not have an adequate intake of CHO, protein nor fat. For adult athletes, sports nutrition recommendations currently lie at 2-12 $g \cdot kg^{-1} \cdot d^{-1}$ of CHO[9], 1,2-2,0 $g \cdot kg^{-1} \cdot d^{-1}$ of Protein[9] and 20-35% TEI of Fat[18].

Recent studies address the idea that a Low Carbohydrate Diet (LCD) may benefit weight loss in obese T1DM patients and reduce insulin requirements, due to lower CHO intake[19]. On the other hand, the type of diet followed may lead to an increased consumption of saturated fats and result in elevated low-density lipoprotein cholesterol and total cholesterol levels. Moreover, considering that most sports are highly dependent on CHO, not ingesting enough CHO may compromise performance, though evidence of LCD in athletes with T1DM is lacking and only data on non-diabetic athletes exists[19, 20].

As we can see in Figure 1, the TEI of the athlete is consistent during the first 4 days (T1, T2, T3 and T4) and slightly higher in the last three days of the week (M1, M2 and R1). This may be explained by empiric knowledge of the athlete towards the need for nutrition periodization. This concept theorises that the amounts and types of macronutrients in the diet should be adjusted to meet the demands of exercise (intensity and duration). Accordingly, energy and CHO provision should be higher on match days, pre and post-match, and in the 24h before and after competition when aiming for rapid recovery, comparing to training days and rest days[21, 22]. This could explain the higher EI on M1 and M2, as well as on R1, due to recovery. Another possible explanation is the increased control that the participant had over his meals during the week, besides lunch and dinner which were provided by the club. Living away from home during the week allowed him the freedom to choose what to eat and when, as confirmed by the 7-day food record, which comprised choices that could be improved both in terms of quality and quantity to meet the player's needs. However, on match days every meal after lunch was prepared for him and the team by the club and planned by a nutritionist, which may explain his higher caloric intake on M1 and M2.

Furthermore, in Table 3 looking at the TEE and TEI of the athlete, it is clear that the TEE is much higher than the TEI. Were this the case, the athlete would be losing weight, which was not observed. Therefore, underreporting in the 7-day-food diary could be a plausible explanation for this discrepancy. Admitting the athlete was consuming the reported energy and nutrient amounts, these would have been too low to cover for his needs. On the other hand, the TEE could have been overestimated, as HR monitors have been shown to overestimate the energy expenditure in activities that involve the upper limbs[13, 23].

Exercise is known to be beneficial for diabetic athletes due to prompting the utilisation of glucose within the muscle. However, its effects on blood glucose will depend on a lot of factors, including the intensity and type of the exercise performed, its duration, and the levels of circulating insulin[24]. Thus, athletes with T1DM are at a real risk for exercise-induced hypoglycaemia, as they cannot reduce exogenous insulin during exercise and symptoms develop at higher concentrations (65-70 mg.dL^{-1}) than in healthy individuals (50-55 mg.dL^{-1})[25]. Hypoglycaemia is the major challenge to achieving an optimal glycaemic control and is the biggest side effect attributed to physical activity in diabetic patients. According to a recent study, approximately 86% of young athletes with T1DM will develop hypoglycaemia if they begin exercise with blood glucose levels below 126 mg.dL^{-1}[26]. Therefore, it is important to have strategies in place to prevent episodes of hypoglycaemia from occurring.

Therefore, special attention should be paid to the meal before practice. Plenty of studies[18, 27, 28] address the importance of the pre-exercise meal for glycaemia control in T1DM. Blood glucose concentrations before training are recommended to be around 90-250 mg·dL^{-1} in order to prevent an unwanted fluctuation during exercise[4]. Another case-study which followed an athlete with T1DM concluded that the need for CHO intake before practice decreased as the time from insulin administration increased. Other studies have suggested that insulin could be lowered by 20% in athletes on multiple day injections (MDI), which might be effective in some cases[28, 29]. However, insulin dose should not be too low either, seeing as during physical activity (PA) there is excessive hepatic glucose production as a result of the need for glucose in the muscle, which may add to the exogenous provision of CHO. Consequently, insulin is needed to prevent post-absorptive hyperglycaemia[30]. During exercise, studies suggest an ingestion of ~1g·kg^{-1}·h^{-1} of exercise to prevent episodes of hypoglycaemia[27]. Sports nutrition literature suggests that ingestion of approximately 30–60 g·h^{-1}[28] is required to maintain normalised blood glucose levels during exercise. The athlete in this case-study did not follow either of the recommendations, since throughout the 7 days he only ate during one of the training sessions and only due to the hypoglycaemic episode.

In addition to the pre-exercise meal, the post-exercise meal is equally relevant. Current recommendations are to ingest 1-1,5 g of CHO·kg^{-1} during the first 30 min after PA and again every 2h for the next 4-6h, in order to replace glycogen stores[18, 28]. Comparing with data from Figure 2, it is possible to note that the athlete only complies to an intake of 0,48 g·kg^{-1} at dinner (that is his typical post-workout meal), as he does not eat anything immediately after practice. Therefore, the aims for this macronutrient were not accomplished. Since the athlete only checked his blood glucose levels before he ate, it was hard to predict them during PA. The athlete registered hypoglycaemic values on T2 during training (60 mg·dL^{-1}) as shown in Figure 3 and displayed symptoms accordingly. To prevent future events of the like, the athlete should be educated about nutrition strategies to apply around PA. Additionally, the athlete also presented a very high concentration of blood glucose on T2, in the morning. This result may be explained by the dawn phenomenon[31], which happens when the effect of the administered insulin in the day before, disappears. The decrease in insulin availability causes an insufficient repression of hormones, such as growth hormone, which leads hyperglycaemia to occur[32]. The insulin that the athlete was using (NovoRapid®) was of rapid action. However, its effect was only medium-term, maximising at about 5 hours post-administration. Therefore, the dawn phenomenon is a possible explanation for the high concentrations of blood glucose observed in the morning, since the participant slept for about 8h every night.

In Figure 3, it is visible that blood glucose levels on most days did not progress as on T1 and M1, when blood glucose concentrations only rose. Considering that insulin shots were taken during that day, this evolution is not physiologically plausible. If the athlete were to have used a continuous glucose monitor, a higher degree of accuracy in glycaemia control would have been expected[33]. However, for numerous reasons such as incompatibility with handball practising due to high risk of impact and/or instrument fall-off, it was not a viable option for the athlete. The same applies to using a continuous subcutaneous insulin infusion (CSII) instead of taking MDI, as it has been demonstrated to be an effective therapeutic, superior to MDI, and lead to a stable long-term glycaemic control in patients of paediatric age[34].

In terms of the participant's glycaemic control, an HbA1c value of 8,5% had been registered in his last round of medical exams. However, current guidelines for HbA1c goals in children and adults stand at <7%, as it has been shown that below this cut-off, the possibility of future microvascular complications or other compromises, is lower[35, 36]. Therefore, the athlete's oscillations in glycaemia agree with the high level of Hb1Ac observed.

It is important to bear in mind that our participant was still underage and currently living away from his home and parents. We believe that some of the reported glycaemic values may not have been totally representative of the actual glycaemic progress the athlete experienced over each day or may not have been registered exactly when they were measured, since the athlete needed to have the recording document by his side in order to write down the correct blood glucose concentrations that had just been measured.

One of the limitations of this study is the fact that the athlete is minor. This was noticeable when it came to filling in the questionnaires required for this paper, as he did not include a lot of details when it came to the 7-day food record nor the activity record, even after being reminded to fill it out. A valuable information that was requested for the athlete to register but was missing from the records at the end of the week, was the concentration of each insulin injection. These data could have explained blood glucose variations and its knowledge would have been essential to inform adjustments to insulin administration prior to PA, according to current recommendations on this matter[27]. In addition, the athlete did not live with his family during the weekdays. This is a plausible explanation for the lack of quality observed to his eating habits, which reflects upon how well his diabetes are controlled.

Since there is a lack of literature and guidelines for young diabetic athletes, a lot of the recommendations cited in this paper are mostly for adult diabetic athletes. Therefore, there is room for improvement in regard to specific support to this population, that keeps growing.

Conclusions

Great oscillations in blood glucose levels were experienced over 7 days by the young athlete with T1DM in this case study. These results may be explained by poor eating habits, infrequent glucose monitoring and a lack of corrective measures (nutritional or insulinemic) to stabilise glycaemia, particularly during PA. Therefore, there is a need for the athlete to have closer monitorization by his medical team, in specific, by a nutritionist. Studies are lacking on this topic and specific recommendations for young athletes with T1DM are warranted to help prevent potential consequences to health and sports performance.

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APPENDIXES

Table 1. Participant descriptive characteristics

Participant characteristics	
Age (years)	17
Height (m)	1,97
Body mass (kg)	109
BMI (kg/m^2)	28,1
Skinfolds	
Triceps (mm)	14
Subscapular (mm)	8,6
Biceps (mm)	4
Iliac crest (mm)	10,8
Supraspinale (mm)	14,3
Abdominal (mm)	20,6
Frontal thigh (mm)	21
Medial calf (mm)	12,2
Sum of 7 skinfolds	91,2
Sum of 8 skinfolds	105,5
Percent body fat (%)	16,6
Fat-free Mass (kg)	91,7

Notes: Sum of 7 skinfolds (triceps, subscapular, biceps, iliac crest, abdominal frontal thigh and medial calf skinfolds); percent body fat calculated using the Whiters equation[8].

Table 2. Composition of the diet from the 7-day food record

Day	T1	T2	T3	T4	M1	M2	R1	MEAN	SD
Macronutrients									
CHO ($g{\cdot}d^{-1}$)	133	142	123	135	256	171	171	161,6	± 45,6
CHO ($g{\cdot}kg^{-1}{\cdot}d^{-1}$)	1,22	1,30	1,13	1,23	2,35	1,57	1,57	1,48	± 0,4
CHO (%TEI)	42,6	42,7	40,0	46,4	63,2	45,0	48,0	46,8	± 7,7
Protein ($g{\cdot}d^{-1}$)	101	83	86	72	63	74	75	79,1	± 12,2
Protein ($g{\cdot}kg^{-1}{\cdot}d^{-1}$)	0,92	0,76	0,79	0,66	0,58	0,68	0,69	0,72	± 0,11
Protein (%TEI)	32,3	25,1	27,8	24,9	15,4	35,5	21,2	26	± 6,7
Fat ($g{\cdot}d^{-1}$)	35	48	44	37	39	60	49	44,6	± 8,6
Fat ($g{\cdot}kg^{-1}{\cdot}d^{-1}$)	0,32	0,44	0,40	0,34	0,36	0,55	0,45	0,41	± 0,08
Fat (%TEI)	25,1	32,3	32,3	28,7	21,4	19,5	30,8	27,2	± 5,2

Abbreviations: CHO (carbohydrate), **TEI** (total energy intake), **T1** (training day 1), **M1** (Match day 1) and **R1**(Resting day).

Table 3. Total Energy Expenditure and Total Energy Intake

Day	T1	T2	T3	T4	M1	M2	R1	MEAN	SD
RMR	2517	2517	2517	2517	2517	2517	2517		
PAL	2,00	2,16	1,93	1,96	1,77	1,78	1,37		
TEF	127	136	126	121	168	154	147		
EEE	1251	1299	1472	971	1681	688	0	1020	± 529
Total Energy Expenditure	4890	5345	5350	4481	5192	4196	3724	4740	± 627
Total Energy Intake	1270	1362	1263	1206	1681	1544	1472	1400	± 173

The results are presented in kcal. **Abbreviations: RMR** (Resting Metabolic Rate, calculated using the Cunningham equation[13]); **PAL** (Physical activity level, calculated using metabolic equivalents); **TEF** (Thermic Effect of Food); **EEE** (Exercise Energy Expenditure),**T1** (training day 1), **M1** (Match day 1) and **R1**(Resting day).

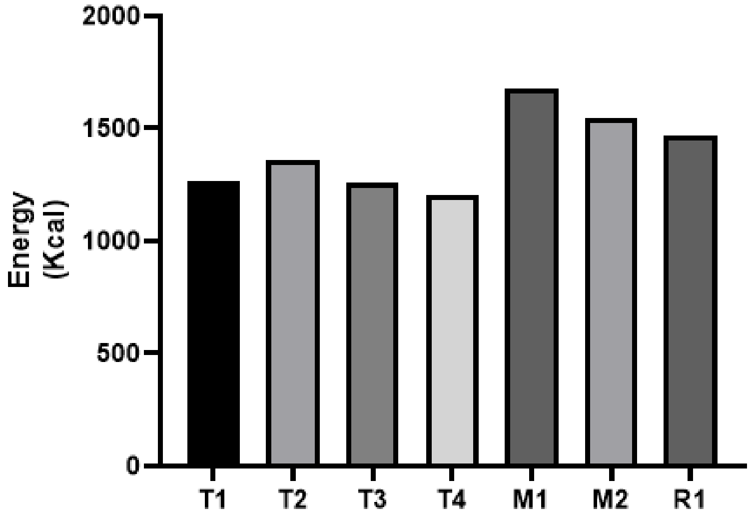


Figure 1. Distribution of the total energy intake in each day of the week.
The results are presented in kcal. **T1** (training day 1), **M1** (Match day 1) and **R1**(Resting day).

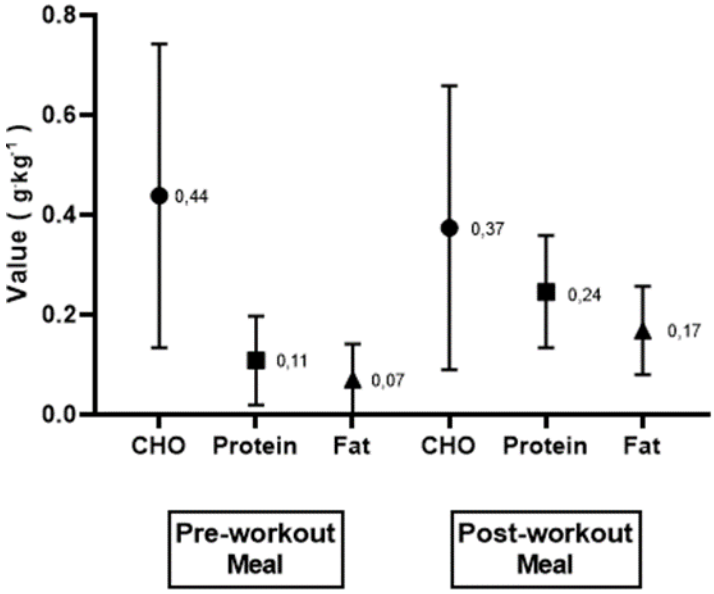
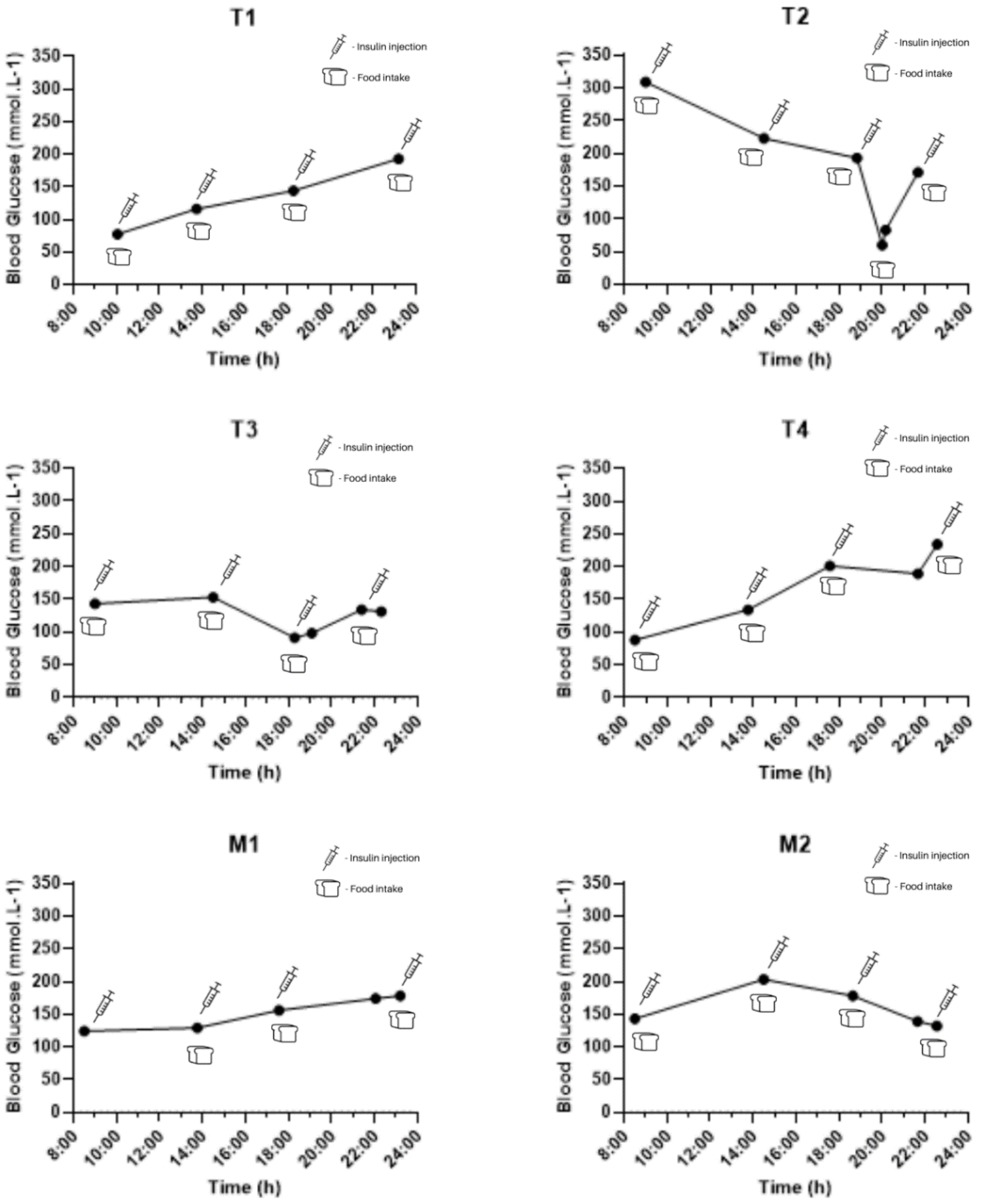


Figure 2. Macronutrient distribution in the pre-workout and post-workout meal.
The results are presented in $g{\cdot}kg^{-1}$. **T1** (training day 1), **M1** (Match day 1) and **R1**(Resting day).



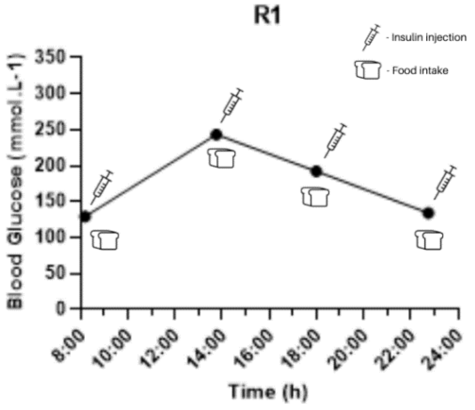


Figure 3. Blood glucose concentrations, CHO intake and insulin administration over 24 hours.

The x axis represents the timeline of each day of the week (T1, T2, T3, T4 - training days; M1, M2 - match days; R1 - rest day) and the y axis refers to the blood glucose concentrations expressed in mmol per litre.