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RECOMMENDED AMOUNTS OF MACRONUTRIENTS BEFORE AND AFTER TENNIS MATCHES

Mario Oršolić[1*], Petar Barbaros Tudor[2], Antonija Šarić[1]

[1]Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology Osijek, Franje Kuhača 18, 31000 Osijek, Croatia
[2]University of Zagreb, Faculty of Kinesiology, Horvaćanski zavoj 15, 10000 Zagreb, Croatia

review paper

Summary

Tennis is one of the most popular sports played year-round. It is estimated that almost 60 million people are included in some sort of tennis matches and competitions. A tennis match can last longer than five hours at the professional level, so in tennis, similar to other sports that may last for extended periods of time, nutrition is considered an extremely important factor for ensuring the necessary energy during matches, as well as for the recovery period after the mentioned activities. The purpose of this paper is to investigate the area of the required intake of carbohydrates, protein, and fat before and after matches, to identify the desirable values that would ensure the necessary energy and expedite the recovery of tennis players after a match. Considering that tennis players use both the aerobic and the anaerobic energy systems as they play, carbohydrates are considered to be the main source of energy before and after matches, while proteins are considered to be extremely important factors for recovery after the activities. Unlike the mentioned food ingredients, the intake of fat has not been explored to that extent, from the aspect of the necessary intake before and after a match, but the daily recommended intake of 1.0 do 1.5 g/kg is very well known. Research has shown that the recommended values for the intake of carbohydrates before a match are 6 g/kg to 12 g/kg and 8 to 10 g/kg after a match. The desirable intake of protein just before a match is 0.3 g/kg and the same amount after a match (within 2 hours after the activity). Literature search has shown that the intakes are not uniform and that they depend on numerous factors, like sex, age, body mass, time of the match, length of the match, temperature, surface, tennis balls, and similar.

Keywords: tennis, carbohydrates, protein, fat, recovery

Introduction

Tennis, as it is played today, attracts millions of players and fans all over the world. Tournaments and many other tennis-related events are held year-round. Competitive tennis is played according to the rules of the International Tennis Federation (ITF) and its competitions range from high-level professional events, e.g. Grand Slams and the Olympic Games, to ITF male and female tournaments for beginners and players in wheelchairs. The Association of Tennis Professionals (ATP) and the Women's Tennis Association (WTA) encompass more than 60 (WTA) to 80 (ATP) tournaments in about 40 countries all around the world, which are organised in various categories, accompanied by reward funds and ranking points. Due to the large number of tournaments, there are many options for players at all levels who wish to compete during any week throughout the year. Apart from that, tennis is also a recreational sport, enjoyed by people of all age groups. It is the only sport played on various courts, with various types of tennis balls, and the matches are played in the best-of-three or best-of-five sets format. Changes in the scoring system, the duration of the matches, various surfaces, and the type of tennis balls may affect the physical and the physiological requirements for playing tennis matches (Fernandez et al., 2006). It is played year-round and it is one of the most popular sports today. It is estimated that almost 60 million players are included in some type of tennis competitions at the local, national, or international levels (Kondric at al., 2013). It is oriented around tournament play, which can result in a busy competition calendar, frequent travel, and unpredictable amounts of time spent playing competitive matches (Ranchordas et al., 2013). Tennis is characterised by short periods of active play (4-10 s), active recovery (10-20 s), and a longer passive recovery (60-90 s) (Fernandez et al., 2006). A tennis match often lasts longer than one hour, and in some cases longer than five hours, while the effective play time, i.e. the percentage of total play time in a match, is 20-30 % on clay courts and 10-15 % on fast courts. During that period, a player runs 3 m per stroke and 8 to 12 m total per point, which is 300 to 500 m of high-intensity activity total in a match that lasts for three sets. The number of exchanged strokes in an average point is four, and the exchanges in a match usually last less than eight seconds (five to seven) (Fernandez et al., 2006). A tennis match is characterised by fast and explosive movements, including accelerations, decelerations, jumps, and strokes from various positions and situations on the court. The length of a match from one hour to more than five hours, as well as severe mechanical and physiological stress, has significant consequences for the human body, so the

*Corresponding author: mario.orsolic@ptfos.hr

speed of the strokes, running speed, maximum muscle strength, and the precision of strokes are significantly reduced during a tennis match (Kovacs, 2007).

Considering that an appropriate diet has a direct effect on the optimisation of energy reserves in the human body, some dietary regimes may reduce tiredness, and adequate nutrition and hydration are considered to be some of the most important factors in the prevention of injuries (Kondric et al., 2013). Some types of diets may facilitate recovery from injuries, while some forms of nutrition have direct effects on the health status of athletes. It is not surprising that nutrition is considered to be one of the key optimisation factors in the total development of an athlete in modern sports. There are various indicators that show that nutrition knowledge is a protective factor against potential doping. This obviously increases the need to initiate a wide-ranging educational programme on sport nutrition in tennis, as well as in other sports (Kondric et al., 2013).

The economic effect of tennis is significant, regarding financial rewards, tournament sponsorships, as well as coverage from various forms of media. All of this sets significant demands for the physical and psychological preparation of the participating players, as well as for nutrition advice as it pertains to training regimes and matches (Ranchordas et al., 2013).

Based on previous research, our aim is to provide guidelines on the appropriate amounts of carbohydrates, protein, and fat that should be consumed before (to improve performance) and after (for quicker recovery) a tennis match, in order to help the current and future tennis players, as well as all those who take care of their development.

Importance of nutrition in tennis

The physiological requirements of a tennis match are complex and dependant on highly variable interactions between technical, tactical, physical, and weather conditions. The surface, style of play, duration of the match, stage of play, temperature, and humidity all effect energy requirements, which means that the dietary habits are one of the main challenges in the situation. Furthermore, factors like the surface and the tennis balls have an effect on the speed and the bounce of the tennis balls, which ultimately affects the duration of the match, and consequently, the expenditure of energy (Ranchordas et al., 2013).

Table 1. Estimated energy expenditure according to sex and match duration. Calculated from: Christmass et al. (1998), O'Donoghue et al. (2001), Smekal et al. (2001), Girard et al. (2006), Fernandez-Fernandez et al. (2007), Hornery et al. (2007), Mendez-Villanueva et al. (2007), Murias et al. (2007), Fernandez-Fernandez et al. (2008) and Martin et al. (2011)

	Energy expenditure	
	Women AS±SD	**Men** AS±SD
kJ/min	30.9±5.5	45.3±7.3
kcal/min	7.4 ±1.3	10.8±1.8
kcal/kg/hour	7.5±0.5	8.4± 0.5
60 min match (kcal)	443±79	649±105
90 min match (kcal)	664 ±118	973±157
150 min match (kcal)	1107±196	1622±262
300 min match (kcal)		3244±524

The research conducted by Ranchordas et al. (2013) states that the nutrition challenges facing highest-level tennis player are unique, competitions that last year-round, extensive travel, and unpredictable amount of time spent playing a match require a complex nutrition strategy. It is important to match the training with the diet for a competitive programme, if tournaments are dominant throughout the year. Top tennis players must maintain optimal body mass throughout the year so they can adjust their energy intake during the short periods of rest or travel. The research conducted by Kovacs and Baker (2014) included four areas of recovery techniques which are usually used in tennis, proposing that interventions may enhance the recovery of athletes and improve performance in the future. One of those four recovery techniques is dietary intervention. Tennis players use the combination of anaerobic and aerobic energy systems, both of which rely on carbohydrates as the primary source of energy, so the main components of nutrition related to recovery include the intake of water and electrolytes for rehydration, replenishment of stored

carbohydrates, and the intake of protein for the recovery of muscles. They state that tennis matches, especially longer and more intensive ones, probably reduce the levels of glycogen. Therefore, the intake of carbohydrates before the following match is important for the recovery of tennis players.

Fleming et al. (2018) conducted a study on the diet and the recovery of tennis players before, during, and after matches, in which they state that 51% of the tennis players said that they consume unbalanced meals consisting of carbohydrates, protein, and fat the day before the match. Among the players, 27% said that they choose carbohydrates as dominant meals, and 13% said that they choose carbohydrates and protein only so they would meet the dietary regimes for the match. The analysis emphasizes the significant intake of carbohydrates as the dominant meal before matches among top players, when compared to lower-level players, which indicates that top players are more aware of the importance of carbohydrates. A second analysis was used to determine that junior players choose carbohydrates as the dominant meal before matches more often than adult players.

The results on dietary habits right after matches state that 34% of the players said that carbohydrates are dominant in meals, 26% said protein, 19% said that they eat balanced meals, 9% use sports drinks, and 9% said that they do not consume anything. 61% of the players said that they consume balanced meals in the period of 3 h after the match, and 44% of the players do so before they go to sleep.

On the day after the match, 39% of the players stated that they consume "nothing specific". This analysis indicates that some of the players are not adapting their diet for the days designated for rest and recovery. This is concerning due to the strong evidence that supports the use of nutrition strategies after training as key tools for supporting recovery. Technical and body conditioning performance reduces during tennis tournaments, and this is connected to tiredness (Ojala and Häkkinen, 2013), it is therefore important to implement effective strategies for improving performance, as shown in other sports (Rossi et al., 2017).

Vitale and Getzin (2019) made an overview and dietary recommendations for sports where endurance is the dominant factor. They state that there has been significant progress in understanding the dietary needs of athletes, and that the literature stills contains many differences. They also state that nutrition science is a complex and constantly developing subject, and that sport nutrition includes the areas of sport medicine, sport science, dietetics, culture, and even media.

Recommendations for macronutrients intake

Carbohydrates

In his survey research "*Carbohydrate Intake and Tennis: Are there benefits?"* Kovacs (2006) states that the intake of carbohydrates in extended aerobic training has shown to be effective for improving performance and delaying tiredness. He further states that it is necessary to maintain adequate concentrations of glucose and glycogen in order to perform optimal strokes and court movements. In general, athletes should consume the amount of carbohydrates recommended by the American College of Sports Medicine and the National Association of Sports Trainers, 30-60 g/h of carbohydrates during training. Carbohydrates may be in the form of glucose, saccharose, maltodextrins, or a highly glycaemic starch. Fructose should be limited due to the possibility of gastrointestinal discomfort. This amount of carbohydrates may be acquired by drinking 600-1200 ml/h of a solution containing 4-8 % of carbohydrates (4-8 g/100 ml) (Convertino et al., 1996). Athletes must maintain an appropriate daily energy intake, so Burke et al. (2001), in their review, stated the required amounts of carbohydrates for athletes, and reached the conclusion that the intake should be increased to 7-10 g/kg per day (tournament week) in order to maintain the sufficient supply of energy for efficiency and to encourage recovery (30-60 g/h). Galloway and Maughan (2010) stated that the period for taking carbohydrates during training or during matches should have the goal of creating a regular flow of carbohydrates from the intestines to the bloodstream. Considering that carbohydrates could be counterproductive when ingested in excessive amounts (>60-90 g/h) or concentrations (>7-8 %), it is advisable to take lower quantities regularly, e.g. during every switch, instead of taking large quantities during a single switch. Jung et al. (2005) stated another additional benefit of consuming carbohydrates / beverages with electrolytes during extended periods of training, which proves that it delays the start of muscle cramps caused by training. Regarding carbohydrates, it is said that many years have shown that a diet with a high share of carbohydrates leads to an increased level of glycogen in the muscles (Bergstrom, 1967), which contributes to optimum performance, especially in endurance-type activities (Hargreaves, 2004). It is also known that a diet with a low share of carbohydrates (<15% of the total energy intake) can have adverse effects on training and high-intensity endurance, and both of those are key aspects of a tennis match (Ranchordas et al., 2013). Outside of competition, top tennis players train between 4 and 6

hours per day and only take short rests, which maintains the energy requirements at a high level year-round. As a general guideline, top tennis players need to maintain a regularly high level of carbohydrates, in the range of 6-10 g/kg per day, in order to ensure the required levels of glycogen, and women usually require somewhat lower amounts than men (Ranchordas et al., 2013). These recommendations should be adapted to the daily energy expenditure. Top tennis players should make sure to be adequately charged and hydrated before every match, however, that can be a challenge considering they do not know how long a match may last. Furthermore, a delayed start of a tournament can disrupt the trained routines practiced before matches, which can lead to an insufficient amount of ingested food or hunger, or playing a match with a stomach full of undigested food. Other issues may arise if the tennis players are playing more than one match per day, e.g. if they are participating in both the singles and the doubles competitions at tournaments. This situation may result in inadequate or sometimes unknown recovery times for players, which makes any subsequent energy charging more difficulty. In that case, recovery may only include the intake of carbohydrates, because they can be digested more easily, and proteins are left out, which jeopardises optimal recovery. Apart from that, an unexpected result or an early drop from a tournament could mean that the athletes had been eating excessively during the preparation period. Tennis players should seek guidelines from a qualified sport nutrition expert in order to resolve these issues and to increase efficiency (Ranchordas et al., 2013). According to the research by Kovacs and Baker (2014) and the proposal of other researchers, the recommendation for the intake of carbohydrates during recovery depend on the demands of training and competitions. When the period between training sessions or matches is less than 8 hours of recovery, they recommend the intake of 1.0-1.2 g/kg of carbohydrates immediately after the first training session or match. This percentage of carbohydrate intake should be repeated every hour during 4 h. The carbohydrate intake time is especially important if the athlete has two training sessions or matches in a single day. If there is one or more days between intensive training sessions, the time for the replenishment of glycogen is less urgent, under the condition that enough carbohydrates are consumed during the 24 hours after a training session or a match. The daily requirement for carbohydrates in the process of supporting recovery, muscle recuperation, and the replenishment of glycogen in the liver (i.e. within 24 h between tennis matches) is 5-7 g/kg of carbohydrates per day for moderate training (1 h per day) or 6-10 g/kg of carbohydrates per day for moderate to highly intensive training (1-3 h per day). The types of meals consumed in short periods of recovery should contain easily digestible sources of carbohydrates. The players should avoid ingredients rich in fat, protein, and fibre to avoid the risk of gastrointestinal problems. Vitale and Getzin (2019) stated that carbohydrates (as blood glucose and muscle glycogen) have the advantage of creating more ATP per oxygen (O2) volume when compared to fat, but the depletion of the carbohydrate supply in the liver and muscles is connected to tiredness, reduced activity, and reduced concentration. The research by Jäger et al. (2017) states that the common position of the Academy of Nutrition and Dietetics (AND), Dietitians of Canada (DC), and the American College of Sports Medicine (ACSM) is that moderate training (1 h per day) requires 5-7 g of carbohydrates per kilogram of body weight per day, while moderate to high intensity training (1-3 h per day) requires 6-10 g/kg per day. Athletes in endurance sports who are extremely dedicated to daily activity (4-5 hours of moderate to high intensity training every day) may require up to 8-12 g/kg per day. Before a competition, if the event lasts <90 min, it is usually recommended to simply “top up” the glycogen levels to replenish the muscle and liver glycogen lost during the previous day by consuming meals rich in carbohydrates, with at least 6 g/kg (Getzin et al., 2017) and up to 7-12 g/kg (Jäger et al., 2017), in the 24-hour period before the event. Jäger et al. (2017) state that for competitions lasting less than 60 minutes there is no need to ingest exogenous carbohydrates, but if the activities last more than 60 minutes, they recommend active strategies for maintaining the availability of carbohydrates. For events lasting 1-2.5 h, it is usually recommended taking 30-60 g per hour in a 6–8 % carbohydrate solution (concentrations usually found in commercial sport drinks), and in an ideal situation, they would be taken every 10-15 minutes. For events lasting more than 2.5 h, higher intake of carbohydrates of 60-70 g/h and up to 90 g/h are connected to increased performance. In the last several years, some athletes have been manipulating their carbohydrate level by using a strategy that includes a lower intake of carbohydrates and a higher intake of fat. Periodic training sessions under the conditions of availability with lower glycogen content / low glucose can encourage the regulation of fatty oxidation routes, conserve glycogen levels, and extend the time before exhaustion (Getzin et al., 2017).

Proteins

Ranchordas et al. (2013) stated that there is limited data on the dietary intakes and requirements of protein

for racket sports, and most of the published guidelines are directed toward athletes who are training in strength of endurance sports, while tennis requires some aspects of both strength and endurance and cannot be compared directly. That is why it is more appropriate to evaluate the protein requirements for tennis players based on the volume and the intensity of training or competitions. Further in their overview, they compared the daily intake of protein by 4 university female tennis players during season and post-season, and it was from 1.3 g/kg per day and 1.2 g/kg per day (Nutter, 1991), and for 7 female tennis players aged 19 who trained 4 hours per day, 6 days per week, the protein intake was low and it was from 0.8 g/kg per day (Gropper et al., 2003). The protein intake guidelines for top level athletes, high-intensity and long training sessions on a daily basis, state that he recommended quantity is 1.6 g/kg/day, and usually lower for female athletes due to the lower energy input. Due to the deficiencies of research related to nutrition in top-level tennis, it is important to consider the time, type, and quantity of the consumed protein, in combination with other nutritious substances. The research by Kovacs and Baker (2014) states that proteins are another important factor for the recovery of tennis players. The recommended period for taking protein is as soon as possible after training or a match. In order to meet the daily requirements for protein, it is recommended that tennis players engaged in high-intensity and long training sessions ingest 1.6 g/kg of protein per day (Ranchordas et al. 2013). This is similar to 1.2-1.7 g/kg of protein per day recommended for endurance athletes (Rodriguez et al. 2009). It is important to reiterate that tennis trainers and players should consider the individual needs and inclinations of athletes. However, further research is required to determine the optimal quantity and time for taking liquids, carbohydrates, and protein for recovery after training, for athletes of various levels of maturity, especially regarding physiological and practical challenges related to tournament play. Tennis competitions are not only unique because of their regime of stops and movements, they are also characterised by the short time available for dietary replenishment between matches during tournaments. Quick recovery is especially important in this situation, that is why this area requires further extensive research. In their research, Phillips and Van Loon (2011) have stated that athletes training in sports where endurance is the dominant factor favour protein less when compared to carbohydrates. The adequate intake and the time of intake are crucial for every athlete, regardless whether they are training in a sport that requires more endurance or strength. Athletes require a higher intake of protein than what is currently recommended as the daily intake, 0.8 g/kg per day, so they could adapt to their training and improve their activity. The Academy of Nutrition and Dietetics (AND), Dietitians of Canada (DC), and the American College of Sports Medicine recommend the intake of protein for athletes in the range of 1.2 to 2.0 g/kg per day. Athletes may believe that "more is better" and increase their intake of protein without recommendations. However, a daily intake of protein above the recommended level (1.2-2.0 g/kg/day and/or individual meals with doses above 0.3 g/kg) have not been proven to provide any additional benefits. Temporary intake of more than 2.0 g/kg per day may be useful during short periods of increased training intensity that exceed an athlete's regular regime, but a higher total protein intake after that does not provide additional endurance for athletes (Jäger et al., 2017). For sports where strength is dominant, it is usually recommended to consume higher quantities, and lower quantities are recommended for endurance sports, depending on individual requirements, so Thomas et al. (2016) recommend 1.4-2.0 g/kg per day. During endurance training (if it is particularly intensive), the recommendation is to take approximately 0.25 g/kg of protein per hour, to reduce any possible muscle damage.

Fat

Ranchordas et at. (2013) stated that fat contributes to energy replenishment, especially during matches or training, but carbohydrates are the dominant source of energy in tennis. Similar to protein requirements, no study was conducted to investigate the daily requirement of fatty foods for top-level tennis players. One of only a few studies was conducted to investigate the dietary profiles of male tennis players. Fat intake was reported as the percentage of total energy intake, where 70% of the athletes spent >30% of their total energy from fat (Juzwiak, 2008). The suggested daily fat intake required to ensure the adequate supply for endurance training during >2 hours per day is 2 g/kg (Stellingwerff, 2011). This recommendation should not be applied to tennis directly, because matches include significant high intensity strain and carbohydrates are the main source of energy. Even though it is understood that moderately low body fat facilitates speed and agility on the court and increases heat tolerance, there is no scientific evidence that suggests low body fat is required for becoming a successful tennis player. Instead, the success of players with low fat and high muscle mass provide evidence that there are advantages of having low body fat. Regardless of the dietary requirements of athletes, some sources of fat must be included in the diet to

enable the absorption of vitamins which are soluble in fats, hormone synthesis, and support the efficient function of cellular membranes. Fats are the basic components of cellular membranes, they have a role in signalling and transport, as well as nerve function, they provide isolation and vital protection to the organs, and they are a source of essential nutritious fatty acids. Athletes who limit fat to <20% of total energy are susceptible to low intakes of vitamins and carotenoids soluble in fat, essential fatty acids, including n-3 (omega-3) fatty acids (Thomas et al., 2016). Some athletes competing in endurance sports have recently become interested in keto-adaptation ("fat adapted" or "low training") diets with high fat contents and low carbohydrate contents (Volek et al., 2014). This resurgence of interest in fat is based on higher oxidation of fat and glucose under the conditions of lower intensity training (<70% VO2max) (Getzin et al., 2011).

According to Tipton and Wolfe (2004), Table 2 shows the dietary guidelines for the stages of training: general preparation, specific preparation, competition (in season), and the transitional or transfer period. The table also contains: goals and characteristics of training, dietary goals and specificities, and the intake of carbohydrates, protein, and fat (g/kg/day).

Table 2. Dietary guidelines adapted according to Tipton and Wolfe, (2004)

Stages of training				
	General preparation	**Specific preparation**	**Competition / in season**	**Transition**
Goals and characteristics of training:	Basic strength and basic aerobic development of low and high intensity activities	Tennis-specific energy system and development of strength/maximum intensity training. Higher intensity, lower volume	Maintaining/ stabilising the technique, strength, and speed, "wavy" high and low intensity activities	Physiological and psychological recovery and renewal Lowest volume and intensity
Dietary goals and specificities:	Ensure sufficient amounts of energy and macro micro-nutrients to support high-volume training and muscle adaptations.	Energy intake can be reduced considering that the volume is reducing, but still provide sufficient nutrients and liquids to support the adaptation.	Ensure a sufficient diet for hydration and optimisation of recovery and performance. Energy could be further reduced.	Reduce the intake of energy and carbohydrates to the lowest level, approaching the levels of inactive/ sedentary individuals.
Carbohydrates (g/kg/day)	6-7	7-8	8-10	4-5
Protein (g/kg/day)	1.5 - 1.7	1.5 - 1.7	1.5 - 1.7	1.5 - 1.7
Fat (g/kg/day)	1.1 - 1.5	1.1 - 1.5	1.0	1.0

Considering that the daily requirements for carbohydrates, protein, and fat before training, during training, and after training depend on the level of training and can become confusing for an athlete, Table 3 contains the necessary lowest and highest limits that should be consumed in meals.

Table 3. Dietary guidelines according to Vitale and Getzin, (2019)

Nutrients	**Daily requirements**	**Before training**	**During training**	**After training**
Carbohydrates	5-7 g/kg/day (1 h/day) 6-10 g/kg/day (1-3 h/day) 8-12 g/kg/day (4≥ h/day)	6 g/kg/day (<90 min) 10-12 g/kg/day (> 90 min) + 1-4 g/kg (1-4 h before events)	30-60 g/h (<2.5 h) 60-70 g/h (>2.5 h) 90 g/h (>2.5 h, if tolerable)	8-10 g/kg/day (first 24 h) 1.0-1.2 g/kg/h (first 3-5 h) or 0.8 g/kg/h + protein (0.3 mg/kg/h) or caffeine (3 mg/kg)
Protein	1.4 g/kg/day 0.3 g/kg every 3-5 h	0.3 g/kg just before (or after training)	0.25 g/kg/h (in case of high intensity training/ eccentric)	0.3 g/kg within 0-2 h (or before training)
Fat	Do not limit to <20% of total caloric energy Unclear role of CLA, omega-3, MCT supplements Consider limiting the intake of fat only during carbohydrate charging or before a match because of GI			

Conclusion

In the overview of the studies we made for the purpose of evaluating the intake of carbohydrates protein, and fat before and after training or a tennis match, we have determined that there are not many studies that covered this topic. Due to the specificities of the sport (time the match starts, length of the match, temperature, surface, tennis balls…), it is very important to determine the optimal time and quantity for taking nutrients. Considering energy expenditure, a balanced intake of carbohydrates, protein, and fat can play a key role in the final result. However, more studies are required to determine the optimal quantity and time for taking carbohydrates, protein, and fat before a match, and for recovery after a match.

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