GATORADE SPORTS SCIENCE INSTITUTE

Nutrition & Recovery Needs of the Basketball Athlete

A Report from the 2013 GSSI Basketball Taskforce

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Introduction

General sports nutrition recommendations have been developed for team-sport athletes. While all team sports are considered intermittent, or "stop-and-go," great variability exists in the rules and duration of games, practice structure, number of players, physiologic demands, environment and physicality. These unique characteristics of different team sports lead to varying contributions of agility, speed, power, strength and metabolic systems for successful play. The specific components of fitness as well as the logistics of the game should all be taken into consideration when developing sports nutrition and hydration plans for the practices, games, training sessions and tournaments of a particular sport.

In timely connection with the 2013 NBA All-Star Weekend, the Gatorade Sports Science Institute brought together experts working in the game of basketball to discuss scientific insights related to the nutrition and hydration needs specific to basketball athletes and translate those insights into practical advice. This publication is written for sports-health professionals working with basketball athletes and outlines the structure of the game and demands on the athlete, as well as nutrition and hydration recommendations to help the basketball athlete achieve their performance and recovery goals.

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CHAPTER 1:

Introduction: The Game of Basketball

Introduction

In order to determine the nutrition and hydration needs of a basketball player, and develop plans to help meet those needs, the structure of game day, practices, and the off-season must be considered. The rules of the game, which allow for frequent substitutions, time-outs, breaks between quarters (high school and professional) and a halftime break, lend themselves to incorporating good nutrition and hydration habits. These habits should be developed and maintained in practices and training sessions throughout the year.

An actual game of basketball is of fairly short duration, ranging from 32-48 min of total playing time depending on the level. However, like any sport, players have responsibilities before and after a game, during which time nutrition and hydration should also be a consideration. During the season, practices will vary in duration and intensity, although most teams will practice, lift weights, prepare with film sessions, or compete six days per week. Basketball is a long season; for high school and college athletes it spans semesters and the holidays, which in many cases influences the nutrition and training of the athletes. Tournaments and playoffs provide unique challenges with multiple games in one day or games on consecutive days. Lastly, although off-season expectations vary based on the level, most basketball players are engaged and hydration plans should be developed within the structure of the game as well as with consideration for training and practices throughout the season and year-round.

Part I: High School

Alan Stein

Introduction

High school is a unique time period in working with athletes because of the wide range of age, maturity, and physical stature. Regardless of these differences, in general, many high school basketball players have poor nutritional habits, do not get sufficient sleep, and lack proper recovery and training techniques. Addressing these issues is vital to keeping players healthy and maximizing their performance.

The Competitive Season

High school basketball games usually occur 2–3 times per week and are structured as four 8-min quarters with a 10-min halftime. Most high schools will play 25–35 games per season, depending on tournament play. The structure of game day varies widely amongst high schools. Some may have a walk-through or shoot-around right after school on weekdays and in the morning of a weekend game.

Coaches may have a set meal coordinated with a walk-through; others leave it up to the individual athletes and parents. During the warm-up, most coaches will take the team into the locker room at a set time, which can be used as a planned fueling opportunity. Because of the great variability in schedules and strategies of different coaches, as well as school rules on eating and drinking during the day, an individual approach needs to be used to ensure players are adequately fueled.

The frequency of practices during the season will vary depending on the game schedule, but are usually 4–5 times per week, approximately 2 hours in duration, and consist of moderate to high-intensity drills focused on skill work, conditioning, and offensive and defensive sets and schemes. The afternoon prior to most games, teams usually gather for 30–45 min to discuss the opponent's scouting report, walk through plays, and get in additional shooting practice of low to moderate intensity. In addition, some coaches hold film sessions before practices 1–2 times per week, which require about 15–20 min of mental intensity. Most coaches will also maintain in-season strength workouts about 1–2 times per week, 20–30 min in duration, with moderate intensity. The timing of practices and workouts varies greatly, often due to gym availability and coaches' schedules, since most don't coach basketball full time. The player's lunch schedule and school policies are another consideration. Therefore, high school players need help in determining not only the right foods to eat, but also the right time to eat in relation to their school day and practice/training/game schedules.

The Off-Season

The landscape of high school basketball in the United States has changed vastly over the past 20 years. For both males and females, the now year-round mental and physical demands of the sport are at an all-time high, as is the competition to earn a college scholarship. The two biggest changes include specializing in basketball at an earlier age and participation on AAU travel teams in addition to their high school team, thus making it a year-round sport. The structure of practices and training programs of high school basketball players should be adjusted accordingly to accommodate for these two trends. For example, players participating in the sport at this level of commitment could benefit from a year-round strength and conditioning program focused on injury prevention, using sound recovery techniques (including adequate sleep), and developing good nutrition and hydration habits.

Part II: College Basketball

Jeffery Stein, DPT, ATC

Introduction

Collegiate basketball athletes usually range in age from about 18–22 years. While physically and physiologically they are a more uniform group than a high school team, maturity levels vary greatly. The transition during the freshman year can be difficult for some as they move away from home for the first time. Transition challenges include establishing healthy eating and sleeping habits. Also during the

freshman year, players are usually introduced to more intense collegiate strength and conditioning programs, and many players will greatly change their body composition over their collegiate careers. Lastly, the student-athletes have class, practice, and eating schedules that vary each day and from semester to semester. Athletes must be able to juggle their academic schedules and the demands of their sport, as well as the social environment of a college campus. The day-to-day variability in schedules means preparation is important for proper fueling throughout the day.

The Competitive Season

College basketball games are structured with two 20–min halves with a 15–min halftime. Many colleges will play about 25–35 games per season, depending on the level (NCAA Division I, II, III, NAIA, or NJCAA) and tournament play. NCAA teams must follow the 20–hr rule, which states teams are allowed up to 20 hrs of team activities per week, not including competition. Team-related activities can include practice, film, and weight training. Most programs will practice 4–6 days per week, depending on the game schedule, and practices may be up to 3 h of high-intensity work. In addition to on-court time, athletes are expected to attend film sessions, strength train, and attend to injuries in the training room when needed. Overall, the time commitment is greater than as a high school athlete. The travel requirement during the competitive season is also greater and, depending on the level, more time-intensive. While the top Division I programs charter flights to return home the night after a game, smaller schools rely on bus trips and spend significant time on the road. The provision of food and nutrition services also varies based on level. Most top-level schools have a sports dietitian on staff for consultation and education, but even at the Division I level, the use of a registered dietician varies greatly between schools. At the majority of the major and mid-major universities, athletes are provided a "training table," or a cafeteria with foods selected specifically for the athletes. However, per NCAA rules, only one meal at the training table can be provided per day while the athletes are on campus. Snacks, such as fruits, nuts, and bagels, can also be provided along with occasional meals on special occasions. At smaller schools, athletes rely on their own cafeteria plan, and the budget is often limited to provide meals and snacks on the road. Overall, the demands of the sport increase at the collegiate level compared to the HS and AAU levels, along with the increased demands placed on the athlete to also handle their academic, family, and social lives. The increased demands combined with the increased independence of the athlete make it difficult to ensure that they are appropriately fueling and getting enough rest.

The Off-Season

The majority of collegiate basketball players are one-sport athletes and dedicate the off-season to improving their game, although multi-sport athletes are found at every level of competition. Most collegiate basketball players will be given a short time off after the competitive season, usually 2–4 weeks, to recharge and catch up on family and school matters as necessary before starting back with skill work and strength and conditioning workouts.

Basketball commitments during the off-season will vary depending on the level and coaching demands. Spring semester workouts can range from captain-led workouts and open gyms to coach-led individual skill workouts that vary from 1 to 5 athletes at a time. The non-competitive season is also prime time for the strength and conditioning program to ramp up to work toward the specific goals set for each athlete. During the summer, athletes at smaller colleges are usually at home and often balance an off-season training program provided by their coach with a summer job. At larger schools, the athletes are usually on campus for summer school and summer workouts. These workouts include strength and conditioning sessions 3–5 days per week and on-court workouts with the coaches. Overall, during the off-season the NCAA allows up to 8 h of team-related activity per week, 2 h of which can be direct contact, with the basketball coaches on the court.

Back on campus in the fall, again the commitment will vary depending on the level. Most teams will start up with open gyms and strength and conditioning workouts as soon as the athletes arrive back on campus. Shortly after the start of the school year, individual workouts might take place with the coaching staffs. During the preseason, coaches can work with players on the court for up to 2 h per week, preparing for the competitive season.

Part III: Professional Basketball

Jack Ransone, PhD, ATC

Introduction

The best of the best basketball players make it to the professional level. For the first time, the athlete's schedule is completely dedicated to the sport; however, there are also increased demands for the athlete's time for charity work, endorsements, social obligations, etc.

The Competitive Season

For male athletes in the United States, the National Basketball Association (NBA) regular season runs October-April, with the playoffs extending into June. It is not unusual to play 3 to 4 games per week with the possibility of competing on back-to-back days. Each team plays 8 preseason games and 82 games in the regular season. Teams competing in the World Championship finals will play over 100 games in a season and postseason. Women play in the Women's National Basketball Association (WNBA), whose regular season of 34 games runs June—September, with playoffs extending into October. For both leagues, most team practices are short (less than 1 h) and infrequent due to game and travel demands. Travel requirements are extensive, including a minimum of 42 regular season games on the road for the NBA and 17 for the WNBA. Both the NBA and WNBA have the luxury of traveling by charter airplane and staying at the best 5-star hotels with excellent restaurants. Many teams also employ or consult with a sports dietitian. However, nutrition is still a challenge, as most players seek meals on their own at restaurants outside the control of the team. Additionally, during a game, hydration is always a challenge. Inadequate hydration during competition can be further compromised by the demand for air travel immediately post game (low humidity environment of the fuselage) for half of the regular season games. Given the length of the regular season, frequency of games, and travel demands, proper nutrition and hydration practices are important and should be planned into the schedule wherever possible.

The Off-Season

Professional athletes are employed based on their ability to stay competitive. Therefore, the off-season is a period of time to recover from the long season, rehab injuries, develop a base fitness level, and focus on skill development. Overall the schedule is very individual. For example, younger NBA players might play in the summer league, while veterans may focus more on recovery and some specific skill work. All players will participate in training camp and preseason games, essentially extending the competitive season.

Table 1. Comparison of High School, College and Professional Basketball Structure

	~ Age Range (yr)	Game Duration (min)	Game Structure	Halftime Duration (min)	Considerations Related to Fueling Opportunities
High School	14-18	32	8-min quarters	10	• Practice and game times vary • School rules related to food intake during the day • Parent and coach schedules • Other sports
College	18-22	40	20-min halves	15	• Class schedules vary from semester to semester • Food is often provided, but not always • Travel (air and bus) • Late-night studying/activities
Professional (NBA)	19-36	48	12-min quarters	15	• The game is their job • Considerable air travel, long series on the road • NBA: 82 regular season games with additional 16 wins to claim championship • WNBA: 34 regular season games with additional 7 wins to claim a championship
Professional (WNBA)	22-34	40	20-min halves	15	

CHAPTER 2:

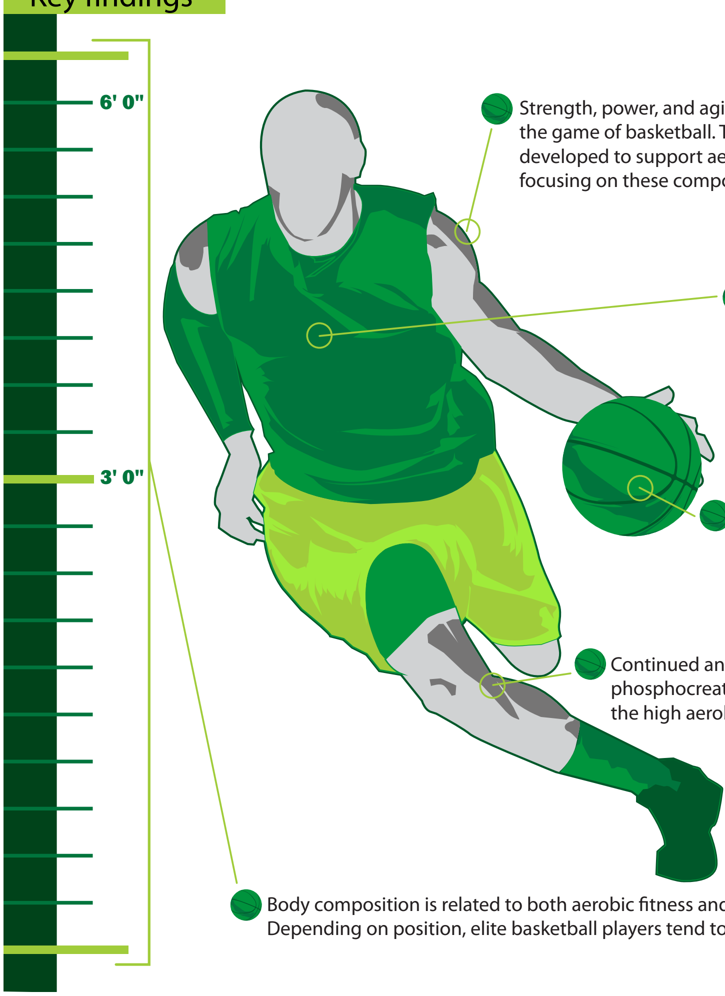
Physiologic Profile of Basketball Athletes

Jack Ransone, PhD ATC

Introduction

The sport of basketball requires specific skills that can be completed under dynamic conditions, in most cases while moving at a high speed or while changing directions. As a result, successful basketball athletes tend to possess high strength, power and agility while maintaining a fairly lean body composition. While most of the skill work is performed at a high intensity, a certain level of endurance is important to meet game demands throughout the duration of the contest. In comparison to other team sports, the aerobic demand is less than soccer, but more than baseball and volleyball. While the demands and characteristics of the athletes differ by position, they are not as drastically different as a sport like football. This paper explores scientific data on structural and functional demands of elite basketball players to establish the physiological profile of successful athletes.

Key findings



- Strength, power, and agility are important predictors of success in the game of basketball. Training and nutrition plans should be developed to support aerobic and anaerobic energy systems while focusing on these components of fitness.
- Given the anaerobic and aerobic requirements, and the knowledge that a player may run close to 3 miles over the course of the game, coaches and strength & conditioning personnel should not ignore aerobic or endurance training.
- Basketball is an intermittent sport with a significant anaerobic metabolism demand to support performance of high-intensity skills.
- Continued anaerobic performance depends on the ability of the muscle to regenerate phosphocreatine (PCr). This is an oxygen-dependent process, which in part may explain the high aerobic demand of the sport.
- Body composition is related to both aerobic fitness and anaerobic power. Depending on position, elite basketball players tend to be tall and lean.

Energy Demands

The game of basketball is characterized by frequent starts, stops, and changes of direction, all maintained over a period of time. While a quarter of game play for a high school athlete lasts 8 minutes of clock time, an average segment of play may last only 12–20 s.[20] However, basketball players have been found to cover about 4500–5000 m (2.8–3.1 mi) during a 48–minute game.[4] Also, in a simulated practice game, players were found to spend only 34.1% of the time playing, 56.8% walking, and 9.0% standing.[20] Therefore, both the aerobic and anaerobic metabolic systems are required.[3,4,24] When designing training and nutrition programs, it is important to note that the overall physical load, based on heart rate, and oxygen demand are greater for games than scrimmage practice situations.[19] Analyses of physiological requirements of basketball in the past 20 years showed a major reliance on the anaerobic metabolism across positions,[7] with secondary reliance on the aerobic energy system.

The anaerobic energy systems supply energy for high-intensity, short-duration muscle contractions, and are composed of the ATP/PCr system and anaerobic glycolysis. The first, ATP/PCr, generates the energy molecule adenosine triphosphate (ATP) from phosphocreatine (PCr) and is dependent on the ability of the muscle to regenerate the PCr molecule. The second, anaerobic glycolysis, relies on glucose derived from muscle glycogen. Overall, the anaerobic energy systems are responsible for success in the large volume of jumps, sprints, accelerations and decelerations that occur during a game.[14,16] Research has found that a player will have 1,000 changes of movement patterns, those changes occurring on average every 2 s;[6] relying on the ability of the muscle to produce a large amount of energy quickly. It is clear that training the anaerobic energy system is a key to success in the game of basketball.

The aerobic energy system uses oxygen to convert glucose and fat to energy and helps maintain the lower intensity and longer duration movements, which represent about 65% of the active game time.[16] Coaches often overlook the contribution of the aerobic energy system for success in basketball; however, aerobic capacity is related to successful performance of high-intensity work over a period of time. For example, a positive correlation was found between basketball-specific repeated sprint ability from game results to maximal oxygen uptake (VO_2max), indicating aerobic system maintenance during the last stages of the game.[17] In other studies, VO_2max was correlated to the duration of running and jumping during a simulated game[20] and to oxygen uptake and intensity during game play.[16,24] Average VO_2max values for female and male basketball players have been reported in the range of 44.0–54.0 and 50–60 mL/kg/min, respectively,[26] although values vary by position, with guards tending to have a higher aerobic capacity than centers.[23] One study suggests that monitoring the heart rate of players during practice is related to VO_2max and could help to enhance the quality of practice in establishing and maintaining a level of aerobic fitness.[8]

The relatively high level of aerobic demand, despite the high percent of playing time spent walking and standing, suggests aerobic metabolism is critical in the removal of lactate and the restoration of PCr, which are known to be oxygen-dependent processes.[22] The regeneration of PCr provides the muscle with energy to continue high-intensity contractions. Overall, the intermittent activity pattern in basketball demands aerobic capabilities sufficient to sustain repeated short bouts of high-intensity exercise.[2] The rules of the game, which allow ample substitution and provide rest periods during time-outs, halftime and between quarters, help promote the ability of the aerobic energy system to replenish the anaerobic system for sustained-high intensity efforts.

Body Composition

Body composition, or the amount of lean muscle mass as compared to fat mass, is usually a consideration for most sports, and different compositions may predict success in different sports. While height, of course, is determined by genetics, changes in body composition can be achieved through proper training and nutrition. For many basketball players, maintaining their weight and lean mass through the long competitive season is often the biggest issue.

Most elite basketball athletes tend to be relatively tall and lean. A specific body composition may not be an essential factor for success in basketball as in other sports, although it strongly determines a player's position. The guard position is usually characterized by a lower body mass, body fat percentage, and height, while the forward and center positions are usually taller, heavier, and have a higher percent of body fat.[23] A strong relationship exists between body composition, aerobic fitness, anaerobic power, and positional roles in elite basketball.[5,20]

Little data exists on the typical body composition of high school basketball players. One study has been published in which high school male (n=61) and female (n=54) players in Madison, WI, were described.[9] The female athletes weighed an average of 61.54 ± 8.68 kg (135.39 ± 19.10 lbs) with 20.45 ± 4.65 % body fat, and the males weighed an average of 74.95 ± 12.02 kg (164.89 ± 26.44 lbs) with 11.98 ± 4.30 % body fat. Vertical jump, sprint times, and agility testing were performed; however, the results were not analyzed in relation to body composition.[9]
On the professional level, **Table 1** summarizes the average anthropometrics of draftees and free agents in the NBA from 1997 to 2012.[25] Overall, the data on height, body mass and composition of basketball teams suggests that players vary widely in body size independent of success rates.[14,18,21]

Table 1. NBA Draft/Free Agent Average Measurements

1997—2012 (N = 4196)[25]

	Vertical Height (in)	Weight (lbs)	Percent Body Fat	Wingspan (in)
Guards	74.68″	199.32	7.57%	79.26″
Forwards	79.14″	232.9	9.05%	84.36″
Centers	82.99″	247.23	9.8%	86.37″

Strength, Power, and Agility

Strength, power, and agility are important predictors of basketball performance.[12,15,26] For example, lower body strength has been shown to be a strong predictor of playing time,[12] and together with upper body strength is responsible for successful under-the-basket movement execution. Delextrat et al[5] showed that elite players achieved significantly better performances in the 1-repetition maximum (1-RM) bench press (+18.6% or 223 lbs) as compared to average-level players. Interestingly, there appears to be a steady decline in upper body strength over the past six years as observed in NBA Pre-Draft Combine workouts, where 10% of draft-eligible players could not bench press the minimum 185 lbs.[25]

Agility is the ability to move quickly and change directions under control to execute sport skills, whereas power is the ability to rapidly combine speed and strength, the best example of which may be sprinting and jumping abilities. Elite players have been found to have superior agility and sprint times compared to average-level players.[5] By position, point guards were found to be faster than forwards and centers in agility tests with surprisingly no differences among these players in sprint tests.[10] Significant differences have been found in vertical jump performance between different levels of basketball players,[5,10] suggesting that the best players tend to jump higher than others. Some basketball players have vertical jump values as high as 35″ in order to fulfill requirements for top-level performance.[1,15,21] **Table 2** shows Combine assessment data of NBA players illustrated by position.[25] Overall, to meet the demands of the game, basketball athletes should focus on strength, agility and power development, using short and intense exercises. However, as described above, aerobic fitness should not be ignored, so a training program should also include work to build the cardiovascular base.

Summary

Basketball combines a variety of individual and collective skills that are executed in the context of competitive play. Ideal physique and physiology are not sufficient for excellence in basketball.[15] However, understanding these components and using this knowledge to create training and nutrition plans can benefit athletes of all skill levels. While strength, power and agility may predict success in basketball, the sport does have an endurance component and the aerobic and anaerobic systems contribute to the overall energy demands. Lastly, game and strategic differences in playing style could impact the physiological requirements of the basketball player and should not be discounted.[11]

Table 2. Average Combine Assessment Data of NBA Players by Position

1997—2012 (N = 4196)[25]

	Vertical Leap (in)	Run Vertical Jump (in)	Bench Press (185 lbs)	Box Agility (sec)
Guards	29.06″	34.62″	9.9 reps	9.48
Forwards	27.37″	32.77″	11.2 reps	10.44
Centers	25.72″	30.29″	12.3 reps	11.35

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CHAPTER 3:

Sport Nutrition for Basketball: Science-Based Recommendations

Lawrence L. Spriet, PhD

Introduction

Basketball is a demanding stop-and-go sport where the energy demands of the player are constantly changing. Players could be completely stopped during time-outs, stoppages in play and foul shots, or could be walking or jogging on the court at low exercise intensities. On the other hand, players may be hustling down the court or back on defense at a fast pace, or going full out in sprint-like fashion for a short period of time when driving the basket, attacking, or defending on a fast break. The skeletal muscles that allow athletes to move in the ways needed to effectively play basketball are most impressive in their ability to handle this spectrum of energy demands.

This chapter will examine how the muscles are able to provide the energy needed to play basketball at a high level and how nutrition plays an essential role in providing the fuels the muscles need to make sure energy provision is optimal in all situations and never runs out! The brain also benefits from proper nutrition and is heavily influenced by what an athlete eats and drinks. Therefore, nutritional guidelines and goals have been established for stop-and-go sports like basketball, which give the athletes, athletic trainers, nutritionists, coaches, and other team personnel general guidelines to follow, realizing that each player is an individual and will need one-on-one attention. There are previous reports that have examined nutrition for team sports including basketball.[1,4,11]

Key findings

In stop-and-go sports like basketball, large amounts of energy are needed from the aerobic and anaerobic sources in muscles.

Anaerobic energy from glycolysis and phosphocreatine allow for quick and powerful movements like bursting, jumping and sprinting.

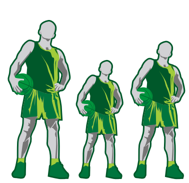
The aerobic system also helps during periods of recovery (jogging, light running on the court and stoppages in play) to replenish the phosphocreatine store and remove by-products of glycolysis (lactate and H^+).

Carbohydrate is the fuel of choice for basketball, as it is the dominant fuel for aerobic energy production and is also the only fuel for anaerobic energy production through glycolysis.

Proper nutrition in the days and hours before training/competition can maximize the body's store of carbohydrates (muscles and liver).

Carbohydrate intake during training/competition can provide fuel for the muscles and keep the brain happy and on task.

Recovery nutrition right after training/competition should include ~1-1.2 g carbohydrate/kg body mass/hr and 20-25 g of protein to help muscles replenish the body stores of glycogen and increase muscle protein synthesis. A proper meal should follow 1-3 hours after exercise.



These are general nutrition guidelines for basketball players, but many factors require that players are dealt with on an individual basis (body size, energy and decision making demands of position, training vs. competition, time in the season, individual variability, overtraining, and health status).

Experts in sports nutrition know that "diet significantly influences athletic performance" and that "all athletes should adapt specific nutritional strategies before, during and after training and competition to maximize their mental and physical performance".[5] Another way of saying this is, "a proper diet can't make an average basketball player elite, but a poor diet can make an elite basketball player average!"

Where Do Basketball Players Get Their Energy?

The contributions of the aerobic and anaerobic energy systems were discussed briefly in Chapter 2. However, a thorough understanding of these systems is crucial to appreciating the development of sports nutrition recommendations for basketball players and warrants further detail here.

Skeletal muscles continually produce a compound called adenosine triphosphate (ATP), which is the immediate source of energy for muscle contraction and ultimately movement. The muscles do this in two main ways. The first is referred to as oxidative or "aerobic" energy production, which occurs in the cellular compartments called mitochondria where oxygen is used to burn fat and carbohydrate for fuel. The second is via processes in the cell that do not need oxygen and fall under the category of "anaerobic" energy production. The two main sources of anaerobic ATP production are 1) the glycolytic pathway (called anaerobic glycolysis) with the use of carbohydrate as a fuel and 2) by using phosphocreatine (PCr) that is stored in the muscles.[13]

Aerobic energy production is the default energy production system and can provide ATP for long periods of time at quite a high rate. This system responds to exercise training and the capacity for ATP production can increase by 20%—50% in most people, depending on where they are starting from. The system can be compromised if the individual runs out of fuel, meaning not enough carbohydrate (CHO) or fat. This system also takes some time (~60—120 s) to fully turn on when beginning exercise or transitioning from low to higher exercise intensities. So, it could be argued that this system has some limitations when playing a stop-and-go game like basketball, as it is a game of transitions. That's where the anaerobic energy systems come in to help.

The anaerobic systems (glycolysis and PCr) specialize in turning on very quickly (almost like a light switch) and producing ATP at high rates, higher than the aerobic system can handle. The latter is very important, as sprinting, jumping, and bursting activities in basketball require very high rates of energy production. The muscles need contributions from the aerobic system and both of the anaerobic systems to meet these needs. The down-sides to using the anaerobic systems are that they can run out quickly (PCr) or are associated with fatiguing by-products like increasing acidity (H^+) in the muscles (glycolysis). When repeated bursts of activity are needed, like in a game of basketball, the depletion of CHO stores in the body can also limit the glycolytic system. Both anaerobic systems can be used repeatedly in a game of basketball, but the glycolytic system is generally more susceptible to fatigue due to increasing muscle acidity or CHO depletion. The PCr system has some advantages, as it is not slowed down by acidity and can be regenerated and recover in the muscle in as little as ~90 s of rest or light activity. During an intermittent game like basketball, PCr can be used over and over when periods of sprinting are followed by lighter activity and/or rest, and then more sprinting. On the other hand, the capacity of the glycolytic system can be improved by ~20% with exercise training, while the capacity of the PCr system does not change with training.

To summarize, the ability to play basketball at a high level requires both a high aerobic capacity and a high capacity to produce anaerobic ATP. The aerobic system produces continual amounts of oxygen-requiring energy, while the anaerobic system supplements during transitions to higher intensities and when athletes sprint, burst, or jump, where the energy need is too much for the aerobic system. In most basketball situations, other than stoppages in play, both systems are working together to produce the required energy. It is not a scenario where the aerobic system works alone or the anaerobic system works alone, as they work together in most instances.

There are some additional points that need to be made. The first is that CHO is the fuel of choice for the aerobic system during intense exercise. At 50% of a person's maximal oxygen uptake (VO_2 max), fat and CHO contribute about equally to fuel provision, but as the intensity climbs to ~80% VO_2 max and beyond, CHO and specifically muscle glycogen becomes the dominant fuel **(Figure 1)**. This has been shown in well-trained males and females.[9,10] Carbohydrate is also the fuel of choice for sprinting, as the glycolytic pathway can only use CHO as a fuel and not fat or protein. So, if a basketball player is running the court at a high aerobic intensity and already using mainly CHO as a fuel, a sudden sprint will require more CHO, along with some PCr, to produce additional anaerobic energy. CHO provides a lot of energy when used for aerobic energy production (~36 mol ATP/mol CHO), but considerably less when used for anaerobic energy production (only 3 mol/mol CHO). So, sprinting, bursting, and jumping costs a lot of CHO in exchange for the ability to produce energy quickly on the court. This can be seen in **(Figure 2)**,

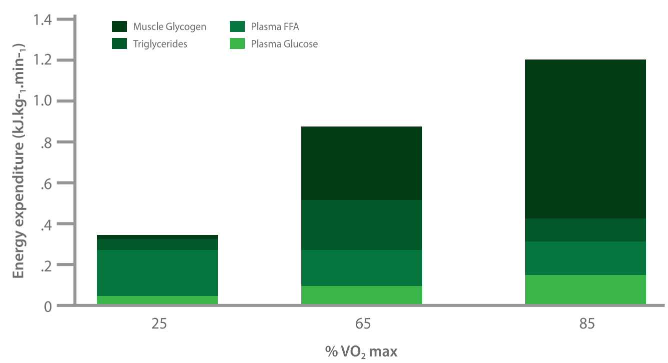


Figure 1 Schematic of energy expenditure and fuel use at varying exercise intensities. KJ, kilojoules. FFA, free fatty acids. VO_2 max, maximal oxygen uptake. Redrawn from Romijn et al.[9]

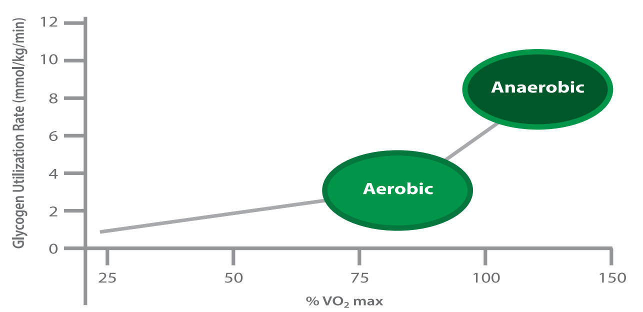


Figure 2 Estimated rate of muscle glycogen use in the aerobic (up to 100% maximal oxygen uptake, VO_2 max) and anaerobic (>VO_2 max) exercise intensity ranges.

as muscle glycogen use rises exponentially when athletes work at power outputs above ~100% VO_2max. Fortunately, athletes normally keep the bursts, jumps, and sprints short, but make sure they have ample CHO in the body before the practice or game and also ingest some CHO during the activity. The second point is that the aerobic system also plays a large role in helping athletes quickly recover from intense activity. When PCr is degraded, it can quickly resynthesize when the activity slows to a low intensity or the athlete stops moving. The energy to recover the PCr comes from ATP produced aerobically such that the PCr store can be replenished in about 90 s. Importantly, the higher your aerobic capacity (VO_2 max), the quicker the PCr replenishment occurs! The aerobic system also contributes to recovery in a second way by using lactate as a fuel in muscles when we move to a low intensity (jogging or walking the court) or stop moving. Removal of lactate from the muscles and blood helps remove the acidity that builds up when engaging in sprint and burst activities, and this helps lessen the feeling offatigue. The bottom line here is that fit players recover more quickly than less-fit players. The third point is that genetic endowment plays a large role in an athlete's capacity to produce aerobic and anaerobic energy and there is a large variation between individuals. However, energy provision is not the only determinant of success, as skill, ability to focus, determination, training, proper nutrition, etc., all play a role in the ultimate success of a basketball player.

The Importance of Carbohydrate as a Fuel for Basketball Players

Carbohydrate is the fuel of choice for stop-and-go sports like basketball. The members attending the IOC Consensus Conference on Sport Nutrition concluded, "In stop-and-go team sports, performance is limited by energy, and particularly carbohydrate intake".[5] Because of this important role, trained players store a large amount of carbohydrate (as glycogen) in the muscles they use to play the sport. There is also a large amount of glycogen stored in the liver in a well-fed player. The liver's job is to release CHO in the form of glucose into the blood to maintain a blood concentration of about 5 mM at all times **(Fig. 3)**. During exercise, the contracting muscles take up a lot of glucose from the blood, and the liver has to match this by replacing the used glucose. If unsuccessful, the person's blood glucose drops, and they feel hypoglycemic, as the brain also relies mainly on glucose and is not happy when the level drops below normal. When exercise is intense and prolonged, the athlete can assist the liver in maintaining the blood glucose level by drinking a sports drink that has glucose or other forms of CHO. The ingested CHO quickly gets into

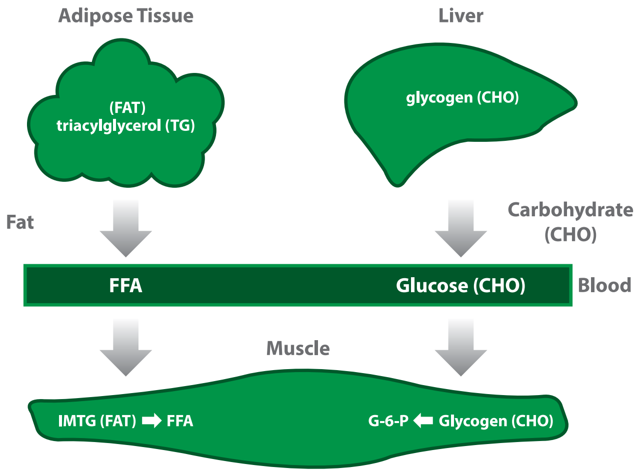


Figure 3 Schematic of energy sources available to contracting skeletal muscle at rest and during exercise. FFA, free fatty acids. G-6-P, glucose-6-phosphate. Both FFA and G-6-P enter ATP-producing pathways. Redrawn with permission from A.E. Jeukendrup.

the blood and can be used by the muscles, heart, and brain. There is also strong evidence that the ingestion of CHO during exercise stimulates the CHO receptors in the mouth to activate brain motor activity and reward centers, which may reduce the perception of fatigue and increase alertness and focus.[2] Mouth rinsing has also been shown to improve running performance.[7,8]

A similar situation exists with fat—trained people store a significant amount of fat directly in the muscles as intramuscular triacylglcyerol or triglyceride. Muscles can also take up fat in the form of free fatty acids from the blood, as it is released from adipose throughout the body **(Fig. 3)**. However, fat only plays a significant role as a fuel at low to moderate aerobic exercise intensities and at rest, and is not a fuel for anaerobic energy production. Protein can also be used as an aerobic fuel, but this does not occur to any great extent in well-fed athletes. Protein plays major roles in assisting with CHO and fat energy metabolism during exercise and stimulating muscle protein synthesis during recovery from exercise. In summary, given the importance of CHO as a fuel for basketball players, it comes as no surprise that there are general guidelines for CHO intake in the days and hours leading up to a training session, or game, during the activity itself, and also following the training session, or game. Numerous studies using dietary recall techniques with basketball players suggest that athletes do not always reach these goals.[3,6,12] The recovery phase after exercise is also the beginning of preparation for the next session as elite players are training or playing most days and often several times a day in tournaments

Summary

Playing basketball at a high level requires large amounts of energy provision by the skeletal muscles. Well-trained basketball players have high capacities to produce energy from both the aerobic and anaerobic energy systems. A high aerobic capacity (VO_2 max) also speeds up recovery during the numerous periods of jogging or walking on the court and the stoppages in play during training and games. Carbohydrate is the fuel of choice for basketball players, as it serves as a fuel for both the aerobic and anaerobic energy producing systems. Fat is also used at lower intensities and during stoppages in play as an aerobic fuel. Clear guidelines are available for maximizing the availability of carbohydrate before, during, and after training and games. A small amount of protein ingestion following activity is also important to speed muscle recovery.

Table 1. CHO Intake Guidelines

PRE-TRAINING/COMPETITION PREPARATION—DAYS

Moderate duration/low-to-moderate intensity basketball training/game: 5-7 g CHO/day/kg body mass (bm)

Moderate-to-heavy intensity basketball training/game: 7-12 g CHO/day/kg bm

Repeated bouts of moderate-to-heavy intensity basketball training/games (tournaments): 10-12+ g CHO/day/kg bm

These guidelines ensure that muscles are loaded with glycogen.

PRE-TRAINING/COMPETITION PREPARATION—HOURS

Ingestion of CHO-rich meal after overnight (fast) and 2—4 hours before training/competition

Smaller amounts of CHO (snacks) in the final 2 hours before training/competition (~30 g CHO/hr to individual preference). These guidelines ensure that liver is loaded with glycogen, muscle glycogen is topped up, and the brain stays alert.

CARBOHYDRATE INTAKE DURING BASKETBALL TRAINING AND GAMES

Ingest fluid, electrolytes, and CHO in ~6% solution (14 g CHO/8 oz or 60 g/L)

Ingest 500—1000 mL/hour of sports drink (30-60 g CHO/hr) as per individual need, preference, etc.

Some team sports players prefer ~2%—3% CHO solution, and could add additional carbohydrate from a solid or semisolid.

RECOVERY FOLLOWING TRAINING/COMPETITION

Ingest CHO (~1–1.2 g CHO/hr-for-first 2—3 hours) immediately postexercise to start replenishment of liver and muscle glycogen stores

Ingest 20—25 g of protein to increase muscle protein synthesis and put the muscle in positive protein balance (protein synthesis is greater than protein degradation)

Eat a proper meal no later than 1—3 hours after training/activity. Snacks high in CHO are substituted if repeated training or games occurs on the same day

Eating after exercise allows the recovery of the muscle and liver to begin.

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CHAPTER 4:

Hydration Science and Strategies for Basketball

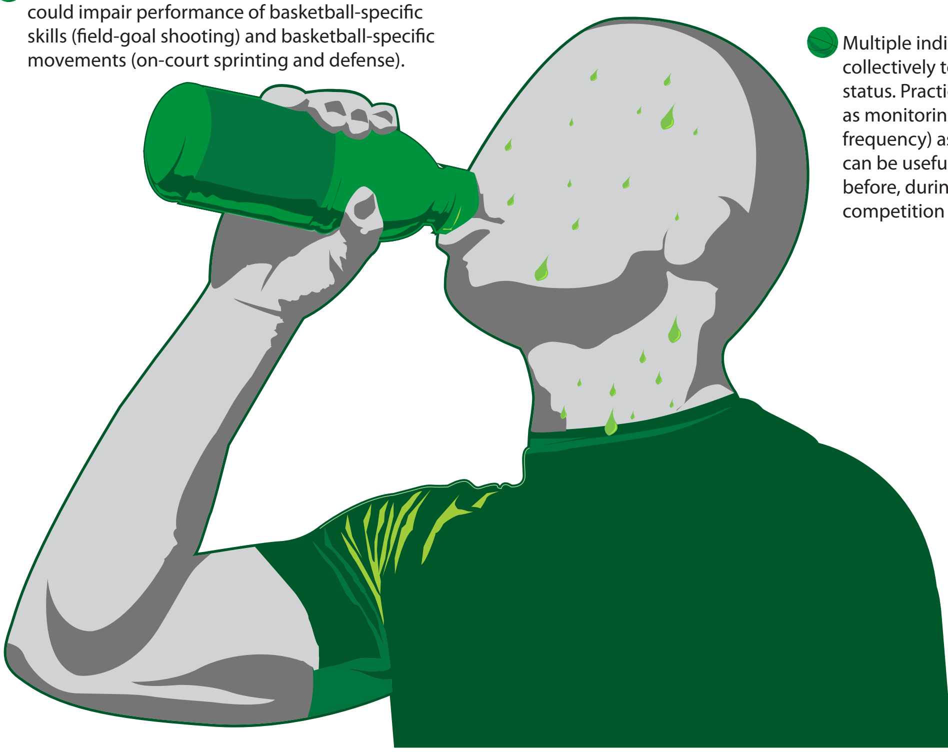
Lindsay B. Baker, PhD

Introduction

Body water loss through sweating occurs during exercise to dissipate body heat and, therefore, prevent sharp rises in body core temperature. Thermoregulatory sweat losses can be large, particularly during high-intensity or prolonged activity such as a ~2 h basketball practice or game. When fluid intake is less than sweat loss, a body water deficit, or dehydration, occurs. The purpose of this chapter is to 1) provide an overview of the effect of dehydration on basketball performance, 2) discuss what is currently known about off-court and on-court hydration practices of basketball players (to determine the most common hydration issues that need to be addressed), and 3) recommend practical hydration strategies that can be implemented by coaches and trainers to ensure players are well-hydrated before, during, and after practice/competition. Throughout this chapter, dehydration will be expressed as a percentage of body weight deficit (e.g., 2% dehydration is equivalent to 2% loss of body weight, which is 3 lb in a 150 lb player). The term euhydration will be used to denote "normal" body water content or maintenance of baseline body weight by ingesting fluid to completely replace sweat losses incurred during a workout.

Key findings

- Research indicates that ≥2% dehydration could impair performance of basketball-specific skills (field-goal shooting) and basketball-specific movements (on-court sprinting and defense).
- Multiple indices should be used and interpreted collectively to obtain an estimate of hydration status. Practical assessment techniques, such as monitoring urine (color, concentration, and frequency) as well as changes in body weight, can be useful in guiding fluid intake needs before, during, and after training or competition **(see Table 1)**.



- The descriptive literature indicates that relatively low levels of dehydration accrue in most players during basketball practice/games as long as drink breaks are provided. However, it appears that off-court/pre-practice hydration may be inadequate, especially in male athletes.

Effect of Dehydration on Performance

Basketball is a sport characterized by intermittent bouts of high-intensity activity interspersed with periods of low activity repeated over a prolonged time. Thus, success in the game of basketball is dependent upon both aerobic and anaerobic performance as well as sprinting, strength, and jumping ability. Research suggests that some, but not all, of these components of the game may be impacted by hydration status. Dehydration (>2%) has been found to consistently impair aerobic performance; however, mild to moderate dehydration (up to 2—5%) does not appear to affect athletes' muscular strength, jumping, short-term sprinting, or anaerobic performance.[17,18]

The game of basketball also involves the execution of complex sport-specific skills, which are dependent upon motor skill and cognitive function. There is evidence from studies in the general population and with athletes that dehydration (>2%—3%) impairs postural balance,[9,11,12] cognitive performance, mood, and mental readiness.[17,18] Cognitive research specific to basketball is limited; however, one study has found that dehydration (1%—4%) impairs vigilance-related attention in male high school and college basketball players.[3]

A few studies have also tested the impact of dehydration on basketball-specific skills during a simulated game. In 2006, Dougherty et al[10] compared the effect of 2% dehydration vs. fluid replacement to maintain euhydration on skill performance of 12—15 year old competitive basketball players. Performance was assessed during four quarters of basketball drills designed to incorporate various aspects of the game, including field-goal and free-throw shooting, repeated sprints, vertical jumps, and defensive slides. Compared to the players' performance during the euhydration trials, 2% dehydration resulted in significantly slower total sprinting (78 ± 9 s vs. 83 ± 10 s) and lateral movement (68±8 s vs. 73±8 s) times as well as a lower shooting percentage (53±11% vs. 45±9%) over the course of the entire simulated game. In 2007, Baker et al[4] employed a similar basketball protocol to investigate the effect of progressive (1% to 4%) dehydration vs. euhydration on performance in skilled 17—28 year old basketball players. In this study, the players' total game performance deteriorated as dehydration progressed from 1% to 4%. Compared to euhydration, the players' total number of shots made during the simulated game were 5, 6, 8, and 10 fewer, and the total time to complete sprinting and lateral movement drills were 7, 20, 26, and 57 sec slower with 1%, 2%, 3%, and 4% dehydration, respectively.

One additional study has tested the effect of dehydration vs. euhydration on basketball performance.[13] In this study, ten male players completed a 40–min simulated "2 on 2 full court" game with or without drinking. During the fluid-restricted trial, players accrued 1.9% dehydration throughout the simulated game, whereas euhydration was maintained with water during the fluid-ingestion trial. No statistically significant differences in field-goal or free-throw shooting performance were observed between trials. However, during the fluid-restricted trial, players experienced an 8.1% decrease in field-goal percentage between the first and second half of the simulated game. By contrast, field-goal percentage increased by 1.6% in the fluid-ingestion trial. Although this difference did not reach statistical significance, a net 9.7% difference in shooting performance would almost certainly be of practical significance to players and coaches, and could even determine the outcome of a game. All of the aforementioned performance studies involved male players, but similar detrimental effects of dehydration would be expected in female basketball athletes.

Fluid Balance in Basketball Players

Off-Court Hydration Habits

Fluid intake habits off the court are important in determining how well-hydrated an athlete is at the start of a training session or game. There are no data available on the pregame or pre-practice hydration status of teen basketball players. However, observational studies have consistently found that young (9–16 year old) athletes in various other sports commonly show up to practice or competition already in a dehydrated state,[8,19] as indicated by pre-exercise urine specific gravity (USG) measurements ≥ 1.020.[17] Studies with professional male basketball players have found similar results; Osterberg et al[15] observed a USG >1.020 in 15 out of 29 players' pre-game samples during NBA summer league competition. However, it is interesting to note that female players may not follow the same trend. Brandenburg & Gaetz[5] assessed pre-game USG in 17 female (24 ± 3 years) Canadian national-level players and found that players were well-hydrated prior to each game (average USG of 1.005 ± 0.002 and 1.010 ± 0.005 before two separate games).

On-Court Hydration Habits

Once exercise begins, fluid losses occur from thermoregulatory sweating. Thus, fluid intake is needed to prevent significant dehydration (i.e., ≥2% body mass loss) during training or competition. Sweating rates can vary considerably among players (and even from day-to-day within players) because of differences in genetics, body size, heat acclimation status, exercise-intensity, and environmental conditions. One study observed sweat losses of 16–18 year old basketball players training at the Australian Institute of Sport.[6] The male players' sweating rate was 1039 ± 169 mL/h (35.1 ± 5.7 oz/h) and 1371 ± 235 mL/h (46.4 ± 7.9 oz/h) during winter and summer training sessions, respectively. Their sweating rate during competition was 1587 ± 362 mL/h (53.7 ± 12.2 oz/h) and 1601 ± 371 mL/h (54.1 ± 12.5 oz/h) in the winter and summer sessions, respectively. The female players' sweating rate was 687 ± 114 mL/h (23.2 ± 3.9 oz/h) and 680 ± 139 mL/h (23.0 ± 4.7 oz/h) during winter and summer training sessions, respectively. Their sweating rate during competition was 976 ± 254 mL/h (33.0 ± 8.6 oz/h) and 917 ± 253 mL/h (31.0 ± 8.6 oz/h) in the winter and summer sessions, respectively. Thus, for both sexes, sweating rates were higher in games compared to practices, perhaps due to higher exercise intensities during games. However, despite differences in gym temperature (~63–68°F in winter and ~74–81°F in summer), there were minimal seasonal variations in sweating rate during in-door practices and games.

Despite the large sweat losses incurred during training and competition, the descriptive literature suggests that most basketball players do a relatively good job of drinking enough fluid to prevent significant fluid deficits. For example, Broad et al,[6] found that less than 10% of the athletes accrued ≥2% dehydration throughout a training session or game and most players (~50%—70%) accrued <1% dehydration. Similar findings have been reported in other observational studies with male and female adolescent basketball players.[7,14] The volume of ad libitum fluid intake by an athlete during exercise is largely dependent upon fluid availability.[16] Thus, the lack of significant in-game dehydration found in basketball is likely related to the structure of the game, which is conducive to frequent stoppage of play, allowing opportunity for fluid intake during time-outs, player substitutions, and halftime.

Hydration Strategies

Practical Hydration Assessment Techniques

Practical indices of hydration status include body weight (e.g., fluctuation in morning body weight or change from before to after exercise), urine (e.g., color or USG), and thirst. Although each of these indices is somewhat limited in their precision and accuracy (compared to more-expensive, laboratory-based techniques), they can still be effective in estimating fluid intake needs, especially when used/interpreted collectively and in the proper context.[17] For example, first morning nude body weight can be a useful indicator of hydration status. For a euhydrated individual who is in "energy balance," morning body weight (after voiding) is stable and not expected to deviate by >1%.[1] Thus, when a first morning nude body weight deviates from "normal" morning body weight (established by regular measurements over a period of several days) by >1%, the individual may be hypohydrated, especially if accompanied by dark/concentrated urine and thirst. As previously discussed, body weight assessments can also be used to gauge an athlete's sweat loss during a workout. Acute body weight change (e.g., from pre- to post-exercise of a <3 h workout)[17] represents 16 oz of water loss per 1 lb of body weight loss.[1]

Recommendations

Because of the deleterious effects of dehydration on basketball performance, it is recommended that athletes start practice well-hydrated, drink enough fluid to prevent ≥2% body weight deficit during a practice session or game, and rehydrate to replace any remaining body-fluid deficit after a workout. Rapid and complete rehydration is especially important if the athlete is participating in a practice session or game within the same day.[17,18]

Table 1 contains detailed hydration strategies to aid proper hydration before, during, and after training/competition. Considerations for the composition of the fluid replacement beverage are also provided. It is recommended that sodium be consumed with water to help simulate thirst, replace sweat electrolyte losses, and retain ingested fluids. Providing a chilled beverage with the addition of flavor and sweetness can also improve beverage palatability and voluntary fluid itake.[17]

Table 1. Hydration Strategies Before, During, and After Training/Competition

Occasion around Training/Competition	Hydration Assessment Technique	Definition	Recommendations
Before	Morning body weight Urine Specific Gravity Urine color	In a euhydrated individual who is in "energy balance," morning body weight (after voiding) is stable and not expected to deviate by >1%. Determine "normal" (euhydrated) baseline body weight by taking daily measurements (over a period of ≥3 days). Specific gravity is a measure of urine concentration. A urine sample < 1.020 is indicative of euhydration. This technique requires an instrument called a refractometer. Light yellow (like lemonade) is indicative of euhydration. Dark yellow or brown (like apple juice) is indicative of dehydration. Clear urine is indicative of overhydration.	If morning body weight has dropped by >1% from "normal," then drink fluid to reestablish baseline body weight. Slowly drink beverages (e.g., ~5–7 mL/kg) at least 4 h before the exercise task. If no urine is produced, or urine is dark or highly concentrated, slowly drink more fluid (e.g., another ~3–5 mL/kg) about 2 h before the event. Consuming beverages with sodium (110-270 mg/8 oz) and/or small amounts of salted snacks or sodium-containing foods will help retain the consumed fluids.
During	Change in body mass	Measure pre- and post-workout body weight to determine expected sweat loss during training and games of various intensities, durations, and environmental conditions. Body weight should be taken with minimal dry clothing or nude, if possible.	Avoid significant body weight deficit (i.e., ≥2%). Also, avoid any body weight gain. Drink 16 oz of fluid for each 1 lb of sweat lost during the course of a workout. Consuming a beverage with sodium (110-160 mg/8oz) helps replace sweat sodium losses and stimulate thirst.
After	Change in body mass	Compare post-workout body weight to pre-workout body weight. Body weight should be taken with minimal dry clothing or nude, if possible.	Drink ~24 oz of fluid for each 1 lb of body weight deficit* Consuming a beverage with sodium (110-270 mg/8oz) and/or small amounts of salted snacks or sodium-containing foods helps replace sweat sodium losses, stimulate thirst, and retain the ingested fluids.

*Rapid and complete rehydration is especially important if participating in a practice session or game within the same day; otherwise normal eating and drinking practices (i.e., water and sodium intake with post–exercise meals and snacks) is usually sufficient to reestablish euhydration. Definition: Euhydration, "normal" body water content, which is maintained by drinking enough fluid to replace sweat losses, as indicated by maintenance of body weight

Source: Sawka, M.N., L.M. Burke, E.R. Eichner, R.J. Maughan, S.J. Montain, and N.S. Stachenfeld (2007). American College of Sports Medicine position stand. Exercise and fluid replacement. Med. Sci. Sports Exerc. 39:377-390.

Summary

Taken together, the literature suggests that basketball players' off-court (i.e., pregame) hydration habits may be more inadequate than on-court fluid intake behavior. Dehydration by ≥2% of body weight has been found to impair basketball skill performance, and greater levels of dehydration can further degrade performance. Furthermore, fluid intake during a game does not compensate for poor pregame hydration status. Therefore, strategies to ensure that a player begins training or competition in a well-hydrated state should be considered just as important as in-game hydration strategies.

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CHAPTER 5:

Recovery Nutrition for the Basketball Athlete

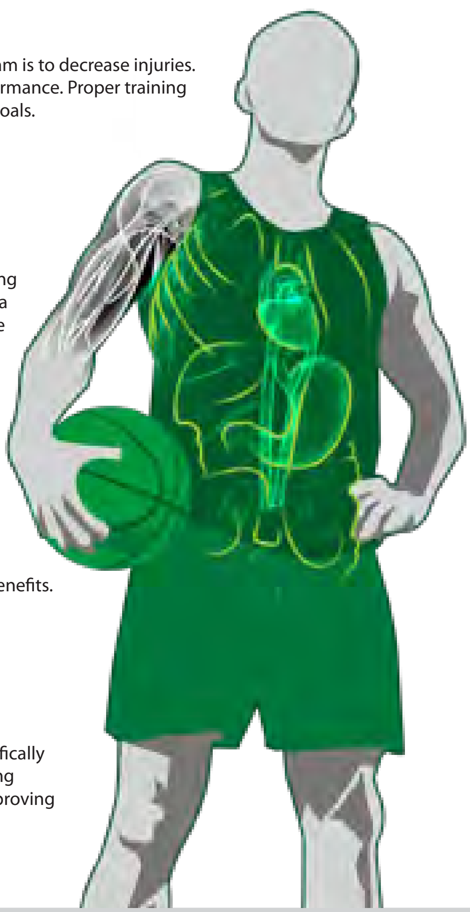
Keith Baar, PhD

Introduction

Skill is essential to performance in basketball. But at a certain level, everyone has skill. What sets one skilled athlete apart from another is their strength, speed, and power. Strength, speed and power are dependent on a player's muscle mass, muscle type (fast vs. slow), ability to send the right signals to the muscle from the brain, and the stiffness of the connective tissue that connects the muscle to the bone. When athletes train, these are the things that they are trying to improve (all, except a player's muscle type, can be improved with training). Every coach knows that when you train a team, some individuals respond better than others. In part, this is due to genetics. But a large part of the difference can be the result of differences in nutrition. This chapter will introduce simple ways that athletes can use nutrition to improve the response to training. For more information on this topic, please see a more thorough review.[12]

Key findings

- The primary goal of any training program is to decrease injuries. The secondary goal is to improve performance. Proper training and nutrition facilitates both of these goals.
- Proper nutrition is the key to maintaining muscle mass and strength throughout a basketball season. This is especially true in athletes that are still growing.
- Protein is a key component to proper nutrition. However, rather than simply consuming excess protein, consuming small protein-rich meals evenly spaced throughout the day provides greater benefits.
- Eating a meal rich in amino acids, specifically leucine, as soon as possible after training augments the effects of training by improving muscle protein synthesis.



- Proteins such as whey or milk that result in a rapid and prolonged increase in leucine in the blood maximize the increase in muscle protein synthesis and strength.
- Connective tissue is also essential to the health and performance of high school basketball players.
- Rapid plyometric movements increase stiffness and performance, but also increase the risk of injury. Slow lengthening movements decrease stiffness and the risk of injury.
- While there is no good evidence that any nutritional intervention will change connective tissue health or performance, eating some whey protein or gelatin enriched with vitamin C before training may help.

Maintaining and growing muscle

An athlete's strength, speed, and power are dependent on their muscle mass, which may be increased through strength training. However, without the proper nutrition, strength training is not enough to increase mass and strength,[13] and it is extremely difficult to build strength when also practicing for long hours at a high intensity.[7] In fact, it is not uncommon for an athlete to lose weight during a season as a result of the sheer amount of training and competition. In rapidly growing individuals such as teenage basketball players, weight loss can be even more dramatic. Some of the weight lost will be from a decrease in body fat, but it is just as common to lose muscle mass. The goal of recovery nutrition is to help maintain/grow muscle and make sure that any weight lost during the season is fat. The key to this is not only how many calories the athlete takes in, but also the type of food and when they eat it.

An athlete's muscle mass is determined by the balance between how much muscle protein they make and how much muscle protein they break down. In a fasting athlete, both muscle protein synthesis and breakdown go up following training. The result is that a fasted athlete cannot build muscle mass. The body only starts to build muscle when supplied with protein.[15] When an athlete eats protein after training, it increases protein synthesis more than training alone, and proteins rich in essential amino acids prevent some of the rise in protein breakdown.[15] The result is a big shift in balance so that athletes can begin to add muscle mass.

Because of the important role of protein in stimulating muscle protein synthesis during recovery, athletes should consume protein within about the first 30 minutes after training. The timing of the protein intake is important for two reasons: 1) blood flow and 2) molecular signaling. If an athlete consumes protein soon after training, the muscles that were just trained will have more blood flow, and therefore more of the protein from the meal will be delivered to the muscles they are training. When the amino acids from the protein meal arrive at the muscle, they turn on signaling processes that activate muscle protein synthesis. The end result is that simply shifting some of your athlete's protein intake to the period immediately after training will result in more amino acids getting to the muscle and more protein synthesis.

So, it is clear that nutrition in recovery from training can improve muscle growth, but what should athletes be eating? As far as the recovery period, the amino acids are the key. Adding carbohydrates to a recovery drink/meal has no further beneficial effect specifically on muscle protein synthesis or degradation. As far as the amino acids, the focus should be to have all of the essential amino acids and a high amount of the branched chain amino acid leucine. It is also important that the protein is easy to absorb. For example, a steak has all of the essential amino acids but is difficult to absorb. Simply grinding the steak into hamburger makes it easier to absorb and will get more amino acids to the muscle. In a similar way, the two protein components of milk are absorbed at different rates. Casein is slowly digested because it clumps in the acid of the stomach, whereas whey is rapidly absorbed and is richer in leucine than soy-based proteins. The high leucine level triggers muscle protein synthesis, whereas the rest of the essential amino acids are needed to make the new protein. The result is that taking leucine-rich whey protein in recovery from training results in more protein synthesis and muscle growth than either soy or casein.[14] The best sources of leucine-rich proteins are milk, eggs, and whey-based recovery products.

The next question is how much leucine-rich protein should athletes consume? There are a number of studies that suggest that an athlete should take 0.25g of protein per kilogram of body weight after training **(Figure 1)**.[10] This means that a 175lb (~80kg) athlete would want to get 20g of protein, whereas a smaller, 130lb (~60kg) athlete would want to get 15g of protein. Any more protein intake at one time will not benefit the muscles.

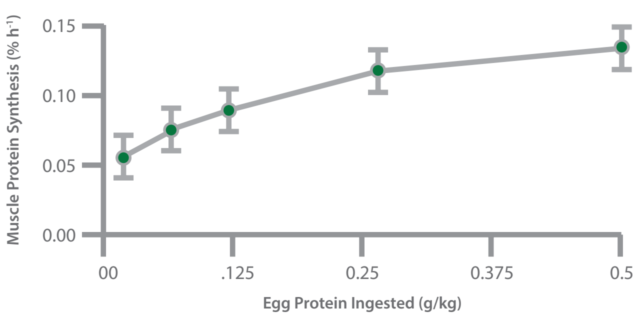


Figure 1 Consuming 0.25g protein per kg body weight results in the maximal increase in muscle protein synthesis.[10]

This data suggests that taking 0.25g/kg of a leucine-rich protein within 30 minutes of training will result in the best response within an athlete's muscles. However, it is important to remember that recovery doesn't end 30 minutes after training. In fact, after strength training, muscles are more sensitive to protein feeding for at least 24 hours.[3] That means that every time athletes eat protein for a full day after training, they make more muscle protein. As a result of this increased sensitivity, it is important to eat that 0.25g/kg amount of protein at meals every 3–4 hours throughout the day. In fact, eating the same total amount of protein in smaller doses more frequently, or bigger doses less often, are not as good at increasing muscle protein synthesis[2]

This is in contrast to the habits of high school basketball players, who normally eat a small, protein-deficient breakfast, a moderate-protein lunch, and a large-protein dinner **(Figure 2A)**. Since protein synthesis and degradation are dependent on the presence of amino acids, the result is a net protein breakdown (more dark green areas under the line than green areas above it). If instead an athlete would consume 0.25g/kg protein first thing in the morning and then every 3—5 hours from there on, they would synthesize more protein than they break down, resulting in a gain in muscle mass **(Figure 2B)**. Taking the same amount of protein right before bed can boost muscle growth even more. Protein before bed delays the sleep (fasting)-induced shift toward negative protein balance, saving muscle from breakdown.

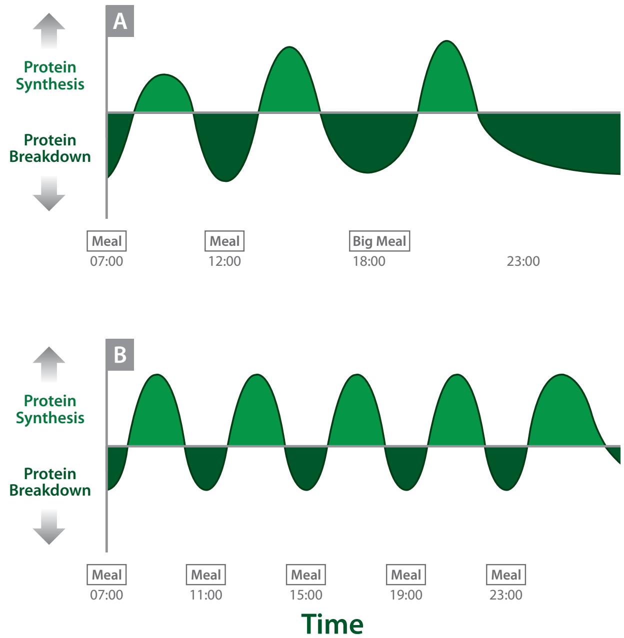


Figure 2 (A) A typical diet of a high school basketball player with a protein-deficient breakfast and a huge protein dense dinner. (B) An idealized dietary schedule where the athlete eats 0.25g of protein per kilogram first thing in the morning and every 3—4 hours after that culminating in a pre-bedtime snack.

Improving connective tissue health and function

Another component of strength, speed, and power is the stiffness of an athlete's connective tissue. Connective tissues include not only an athlete's tendons and ligaments, but also the collagen within a muscle that transfers the force made by the muscle to the tendon and bone. Athletes and their coaches normally only think of connective tissues when they have an injury. A pulled hamstring or a ruptured anterior cruciate ligament (ACL) is failed connective tissue and will need extensive rehabilitation. Young female basketball players are four times more likely to experience this type of injury than their male counterparts[1], and therefore the issue of connective tissue health is especially important to women's basketball coaches. However, beyond health, connective tissue is important in performance.

There is a direct relationship between muscle-tendon stiffness and jump height.[5] The best way to increase muscle-tendon stiffness and jump performance is to perform rapid plyometric exercises (jumps, sprints, bounds, or playing in actual basketball games). However, even though this is good for performance, greater muscle-tendon stiffness is associated with an increased incidence of muscle injury,[9] so exercise caution with a lot of plyometric activities in training. Reversing muscle-tendon stiffness is as easy as doing the same movements slowly and concentrating on the negative or lengthening phase (i.e., the lowering phase of a toe raise).[8] Therefore, performing slow movements in training can decrease an athlete's stiffness (and likelihood for injury).

The issue of connective tissue function is especially important for high school athletes for one other reason: The core of a tendon doesn't change after the age of 18.[6] Therefore, what high school athletes do during this critical window will shape their tendons for the rest of their lives.

So, it is clear that there is a balance between performance and injury when it comes to connective tissue and that fast plyometric movements increase stiffness and slow lengthening movements decrease stiffness. What is less clear is how these processes can be enhanced with nutrition. First, unlike muscle, connective tissue doesn't have a large blood flow. Instead, tendons and ligaments work more like sponges. When stretched or loaded, fluid is squeezed out, and when relaxed, new fluid is sucked in. This means that nutrients that might improve tendon and ligament function need to be in the blood stream before exercise. Second, there are only a handful of studies in humans that have shown a nutritional intervention that improves connective tissue. One recent study showed that consuming ~10g of whey protein before and after resistance exercise resulted in more hypertrophy of not only the muscle but of the tendon as well.[4] The result was an improvement in the rate of force development, in part due to the tendon adaptation. From some basic research, we can suggest some other things that might work, but they have yet to be validated in humans. The most promising nutrients for connective tissue health are vitamin C and proline. In culture, we can make ligaments stronger by adding vitamin C and proline.[11] These nutrients are found in gelatin, so we have been advising young athletes and those who are prone to injury to eat ¼–½ cup of vitamin C- enriched gelatin about 30 minutes before training. However, we still don't have any scientific evidence that this decreases injury or improves performance.

Summary

Differences in strength, speed, and power differentiate skilled basketball players from the elite. Building strength, speed, and power requires proper training AND nutrition. To increase muscle mass and strength through a basketball season, an athlete should consume 0.25g of leucine-rich protein per kilogram of body weight every 3–4 hours and within about the first 30 minutes after training. Proteins such as milk, whey, eggs, and meat are ideal for this purpose. Not only is muscle important for strength, but we are also learning that connective tissue plays an important role. However, we don't yet know whether we can improve this with nutrition.

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CHAPTER 6:

Sleep and Athletes

Shona L. Halson, PhD

Introduction

Sleep is extremely important for performance, learning, development and physical and mental health.[3] Some of the consequences of inadequate sleep include: a reduction in academic performance, mood disturbance, increases in risk-taking behaviour and drowsy driving.[11] From an athletic perspective, reductions in performance, decision-making ability, learning and cognition can occur alongside reductions in immune function and an increased susceptibility to weight gain. While this chapter will outline the importance of sleep for all athletes, additional focus will be placed on the adolescent athlete. It is becoming increasingly clear that adolescence (ages 12–18 yrs) is a period of development where sleep is particularly important. What is also becoming obvious is that many adolescents do not obtain the recommended amount of sleep.[11] This chapter will discuss consequences of reduced sleep, how much sleep is required, reasons for poor sleep and strategies that can be utilized to enhance sleep quality, and quantity in athletes and adolescents.

Key findings

- Decreased sleep quality and quantity can impair performance in basketball players.
- Recent evidence suggests that enhancing sleep may also enhance performance in basketball players.
- Athletes may take longer to fall asleep and have lower sleep efficiency than non-athletes.
- Adolescents require greater than 9 hours per night of sleep, yet many adolescents sleep significantly less than 9 hours per night.
- Social demands, technology and caffeine can interfere with total sleep time.
- To create optimum sleep quality and quantity, maintain a regular sleep routine to ensure an appropriate sleep environment.
- To assess sleep, begin with a detailed sleep diary.

Consequences of reduced sleep

Athletic Performance

While there is limited research on exercise performance and sleep, a small number of studies have examined the effect of partial sleep deprivation on athletic performance in adults. Reilly and Deykin[13] reported decrements in a range of psychomotor functions after only one night of restricted sleep; however, muscle strength, lung power and endurance running were unaffected.[13] Reilly and Hayles[14] reported similar effects in females following partial sleep deprivation, with gross motor functions being less affected by sleep loss than tasks requiring fast reaction times.[14] Reilly and Percy[15] found a significant effect of sleep loss on maximal bench press, leg press and dead lifts, but not maximal bicep curl. Submaximal performance, however, was significantly affected on all four tasks and to a greater degree than maximal efforts. The greatest impairments were found later in the protocol, suggesting an accumulative effect of fatigue from sleep loss.[15]

From the available research it appears that submaximal prolonged tasks may be more affected than maximal efforts, particularly after the first two nights of partial sleep deprivation.[15]

Other consequences

There are a number of other biological functions that can be altered following sleep deprivation. Changes in glucose metabolism and neuroendocrine function as a result of chronic, partial sleep deprivation may result in alterations in carbohydrate metabolism, appetite, food intake, and protein synthesis. Ultimately these factors can all negatively influence an athlete's nutritional, metabolic and endocrine status and hence potentially reduce athletic performance.

Effects of Sleep Extension

Another means of examining the effect of sleep on performance is to extend the amount of sleep an athlete receives and determine the effects on subsequent performance. Mah et al,[9] instructed six basketball players to obtain as much extra sleep as possible following two weeks of normal sleep habits. Faster sprint times and increased free-throw accuracy was observed at the end of the sleep extension period. Mood was also significantly improved, with increased vigour and decreased fatigue.[9] While limited, this data suggests that increasing the amount of sleep an athlete receives may significantly enhance performance.

Effects of Napping

Athletes suffering from some degree of sleep loss may benefit from a brief nap, particularly if a training session is to be completed in the afternoon or evening. Waterhouse et al[16] are one of the only groups to investigate the effects of a lunchtime nap on sprint performance following partial sleep deprivation (4 h of sleep). Following a 30-min nap, 20-m sprint performance was increased (compared to no nap), alertness was increased, and sleepiness was decreased. In terms of cognitive performance, sleep supplementation in the form of napping has been shown to have a positive influence on cognitive tasks following a night of sleep deprivation (2 h).[12] Naps can markedly reduce sleepiness and can be beneficial when learning skills, strategy or tactics.[12] Napping may be beneficial for athletes who have to routinely wake early for training or competition and for athletes who are experiencing sleep deprivation.[16]

How much sleep are athletes getting?

According to a 2005 Gallup Poll in the USA, the average self-reported sleep duration of healthy individuals is 6.8 h on weekdays and 7.4 h on weekends.[7] However, the sleep habits of elite athletes have only recently been investigated. Leeder et al[8] compared the sleep habits of 26 elite athletes from Olympic Sports (Canoeing, n=11; Diving, n=14; Rowing, n=10; Short-track speed skating, n=11) using actigraphy over a four-day period to that of age-and sex-matched non-sporting controls. The athlete group had a total time in bed of 8:36 ± 0:53 hr:min, compared to 8:07 ± 0:20 in the control group. Despite the longer time in bed, the athlete group had a longer sleep latency (time taken to fall asleep) (18.2 ± 16.5 min vs. 5.0 ± 2.5 min), a lower sleep efficiency (estimate of sleep quality) than controls (80.6 ± 6.4% vs. 88.7 ± 3.6%), resulting in a similar time asleep (6:55 ± 0:43 vs. 7:11 ± 0:25 hr:min). The results demonstrated that while athletes had a comparable quantity of sleep to controls, significant differences were observed in quality of sleep between the two groups.[8]

While the above data was obtained during a period of normal training without competition, athletes may experience disturbed sleep prior to important competition or games. Erlacher et al[4] administered a questionnaire to 632 German athletes to assess possible sleep disturbances prior to competition. Of these athletes, 66% (416) reported that they slept worse than normal at least once prior to an important competition. Of these 416 athletes, 70% reported problems falling asleep, 43 reported waking up early in the morning and 32% reported waking up at night. Factors such as thoughts about competition (77%), nervousness about competition (60%), unusual surroundings (29%) and noise in the room (17%) were identified as reasons for poor sleep.[4]

In a study from the Australian Institute of Sport, athletes and coaches ranked sleep as the most prominent problem when they were asked about the causes of fatigue/tiredness.[5] Sleep characteristics ranked first when athletes were asked about the aspects of the clinical history that they thought were important.

Therefore, it appears that sleep disturbances in athletes can occur at two time points: 1) prior to important competitions and 2) during normal training. This sleep disruption during normal training may be due to poor routine as a consequence of early training sessions, poor sleep habits (i.e., watching television in bed), nocturnal waking to use the bathroom, caffeine use, and excessive thinking/worrying/planning. While not documented in the literature, anecdotal evidence also suggests that athletes such as soccer players who compete at night also have significant difficulties falling asleep post competition.

How much sleep do adolescents need?

Research suggests that the sleep needs of adolescents do not differ from that of younger children.[10] Evidence suggests that when adolescents are allowed to sleep as much as they want, they sleep for an average of 9.25 hrs per night.[2] Further, during mid-puberty, there is an increased desire to sleep during the day even when sufficient sleep occurred at nighttime.[2] From the literature available, it appears that adolescents require a minimum of 9 hrs per night of sleep.

How much sleep are adolescents getting?

Despite the recommendation that 12–18 year olds obtain a minimum of 9 hrs of sleep per night, research shows that adolescents sleep between 7.5 and 8.5 hrs per night.[11] While there is certainly going to be individual differences, it is clear that many adolescents are not meeting the minimum requirements for the recommended hours of sleep.

Causes of poor sleep in adolescents

There are a number of factors that may explain the poor sleep observed in adolescents, and these can be broken down to internal and external factors.

Internal factors

A shift in circadian rhythm occurs during puberty as a result of changes in the timing of melatonin release.[11] Melatonin is a hormone that when released precipitates sleepiness. The delay in release of melatonin in adolescents results in the later feelings of sleepiness, the later subsequent bedtime, and the later wake-up time.

External factors

As mentioned above, adolescents have a propensity to go to bed later and wake up later the following morning based on biological factors. However, due to school and extracurricular activities, most adolescents do not have the opportunity to wake later in the morning on school nights and potentially weekends, depending on their sporting schedule. This significantly reduces their sleep opportunity.

Adolescence is usually associated with increased social demands. This can include time spent "in person" or electronically. There is an increasing trend for adolescents to communicate via telephone, SMS, email, Facebook and Twitter into the late evening. As many adolescents experience sleep deprivation, they have increased levels of daytime sleepiness, which may result in caffeine and/or energy drink intake to feel alert and more awake. Caffeinated beverages can have a significant impact on the time taken to fall asleep.

When do adolescents sleep?

The changes that occur with development result in adolescents feeling sleepy later in the evening when compared to children.[11] Specifically, sleep onset time (time at which a person falls asleep) occurs later in the evening, and wake-up time is later in the morning.[6] The reasons for this delay will be discussed below; however, the result of the delay is most often reduced total sleep time due to the requirement to attend school or training the following morning.

One study found that in a group of 20 healthy adolescents, average sleep onset time was 12:44 a.m. with a rise time of 8:18 a.m., resulting in 7.7 hrs of sleep.[1] In addition, adolescents tend to have more variable sleep patterns across the week when compared to children and adults.[6] This is evidenced by significant differences between school-night and weekend sleep onset time, wake-up time and total sleep times. Reports suggest that adolescents delay their bedtime by 1–2 hrs on weekends, and they may sleep in 3–4 hrs later on weekends compared to school nights.[10] This typically results in more sleep obtained on weekends, as the adolescent is able to fit his or her sleep pattern to their more favoured bedtime and wake-up time due to no influence of school schedules. However, this also results in significantly altered routines across a 7-day week.

How to assess sleep

A simple sleep diary in which information on bedtime, wake-up time, total sleep time, caffeine consumed prior to sleep, activities performed before going to bed, perceptions of sleep quality, and daytime functioning is recorded can be very useful. The National Sleep Foundation (http://www.sleepfoundation.org/) has excellent resources including diaries for adults and teens, which can be helpful to gain insight into sleep habits. A sleep clinician can conduct a detailed sleep history and assessment to determine if the athlete has a clinical sleep disorder. Psychiatric and medical conditions may need to be considered due to their interaction with sleep. A sleep clinician may conduct sleep assessments using actigraphy (wearing of a wristwatch to detect movement during sleep) or polysomnography (overnight stay in a sleep laboratory to measure brain activity and other physiological functions).

Solutions to sleep problems

Many of the strategies suggested for optimising sleep in adults also apply to the adolescent. However, there are some specific tips and tricks that may be useful for this age group. **Table 1** includes some of the guidelines from The National Sleep Foundation (www.sleepfoundation.org).

Table 1. Sleep Solutions from the National Sleep Foundation (www.sleepfoundation.org)

- Naps can help pick you up and make you work more efficiently, if you plan them right. Naps that are too long or too close to bedtime can interfere with your regular sleep.
- Make your room a sleep haven. Keep it cool, quiet and dark. If you need to, get eyeshades or blackout curtains. Let in bright light in the morning to signal your body to wake up.
- No pills, vitamins or drinks can replace good sleep. Consuming caffeine close to bedtime can hurt your sleep, so avoid coffee, tea, soda/pop and chocolate late in the day so you can get to sleep at night. Nicotine and alcohol will also interfere with your sleep.
- When you are sleep deprived, you are as impaired as when driving with a blood alcohol content of .08%, which is illegal for drivers in many states. Drowsy driving causes over 100,000 crashes each year. Recognize sleep deprivation and call someone else for a ride. Only sleep can save you!
- Establish a bed-and wake-time and stick to it, coming as close as you can on the weekends. A consistent sleep schedule will help you feel less tired since it allows your body to get in sync with its natural patterns. You will find that it's easier to fall asleep at bedtime with this type of routine.
- Don't eat, drink, or exercise within a few hours of your bedtime. Try to avoid the TV, computer and telephone in the hour before you go to bed. Stick to quiet, calm activities, and you'll fall asleep much more easily.
- If you do the same things every night before you go to sleep, you teach your body the signals that it's time for bed. Try taking a bath or shower (this will leave you extra time in the morning), or reading a book.
- Try keeping a diary or to-do lists. If you jot notes down before you go to sleep, you'll be less likely to stay awake worrying or stressing.
- Most teens experience changes in their sleep schedules. Your internal body clocks can cause you to fall asleep and wake up later. You can't change this, but you can participate in interactive activities and classes to help counteract your sleepiness. Make sure your activities at night are calming to counteract your already heightened alertness.
- Sleep, you'll be less likely to stay awake worrying or stressing.

Summary

Sleep is one of the body's most important biological functions with roles in performance, cognition, learning, development and mental and physical health. While there are numerous consequences as a result of inadequate sleep, identifying sleep problems and following the recommended sleep guidelines can help ensure sporting performance is maximized.

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GATORADE SPORTS SCIENCE INSTITUTE®

CHAPTER 7:

Fueling the Basketball Athlete: The Practitioner's Approach

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Introduction

Basketball is an intermittent, high-intensity sport requiring both physical agility and mental acuity. Energy demands during the basketball season are substantial and may be even higher during off-season training. Choosing foods that will provide the energy to support competition and training is essential and can also be quite challenging. Unlike high-level college or professional basketball players who have the means and opportunity to eat a proper diet, smaller-school college players and high school athletes have variable access to resources. This chapter will focus on the principles of fuel selection in a variety of situations with the goal of accommodating all players.

Key findings

- Carbohydrate, found in fruits and vegetables as well as grains (bread, pasta and rice), is the body's preferred fuel during basketball practices and games.
- Dietary carbohydrate is stored as glycogen in the liver and muscles and becomes depleted after 90-100 minutes of high-intensity exercise. Eating a diet rich in carbohydrate (5-10 g/kg body weight) and consuming carbohydrate during play helps prevent depletion of glycogen stores, which results in muscle fatigue.
- Protein is important to build and repair muscle. Basketball players should get 1.4-1.7 g/kg body weight per day. However, an athlete eating adequate amounts of food usually consumes plenty of protein without the need for supplementation.
- Pregame meals should be high in carbohydrate and low in fat and fiber with the goal of providing energy, eliminating hunger, and reducing the risk of gastrointestinal distress. Pregame meals should always be practiced prior to competition, as each athlete responds differently.
- During practices and games, athletes should fuel with 30-60 g/h carbohydrate and hydrate with the right amount of fluid with electrolytes to replace sweat losses and minimize body weight changes.
- If an athlete has less than 24 hours between training sessions or games, he/she should place a high priority on recovery nutrition. Carbohydrate intake of 1.0-1.2 g/kg and about 20 g of protein helps to restore muscle glycogen and supplies amino acids for muscle protein synthesis, respectively.
- Tournament play is marked by high-intensity games and short recovery time. Good recovery nutrition following games and smart pre-game meal selection can make the difference between winning it all and going home early.

Daily Energy Needs

The energy requirements of high-school basketball players can be considerable. In a recent study by Silva et al,[4] energy expenditure in elite high-school-aged female and male basketball players during the season was measured to be over 3,500 and 4,600 kcals/day, respectively. Although total energy intake is important to counteract weight loss during the season, the source of the calories is critical to provide the muscle with the right type of fuel.

Carbohydrate

The muscle's preferred fuel during high-intensity activities such as basketball is carbohydrate. The body stores carbohydrate as glycogen in the liver and skeletal muscle. Carbohydrate stored in the liver maintains blood glucose between meals. The liver stores between 75–100 g of carbohydrate, enough to maintain blood glucose during a 12-hour fast. Most people have used up the majority of their liver glycogen by the time they awaken in the morning, which is why it's so important for athletes to eat before a morning practice. Skeletal muscle stores an additional 300–400 g of carbohydrate. Unlike liver glycogen, the muscle uses its supply of carbohydrate to fuel exercise, and training can nearly double the amount of glycogen the muscle can store.[3] This is advantageous because the more glycogen in the muscle, the longer an athlete can sprint, jump, and run. When muscle glycogen stores are full, most athletes have enough to fuel 90–100 minutes of high-intensity activity. Terms such as "hitting the wall" or "bonking" are used to describe the phenomenon that happens when an athlete's glycogen stores run low. While individual practices and games may not be enough to deplete muscle glycogen, inadequate carbohydrate intake coupled with daily training can deplete muscle glycogen over the course of several days. This leaves a player fatigued or with a feeling of "heavy legs."

Basketball players should consume a high-carbohydrate diet; that is to say that at least 55% of total calories in the diet should come from food rich in carbohydrate such as fruits, vegetables, bread, pasta, and rice. Most sports dietitians recommend carbohydrate intake based on body mass to ensure an athlete consumes adequate energy from carbohydrate. The range of carbohydrate intake suggested for basketball players is 5–7 (and up to 10) g/kg body weight (see sample diet below). The amount will vary depending upon playing time and the time of year (preseason, in-season, or postseason).

Protein

Protein is important for building and maintaining lean body mass. Although many athletes take supplements and make efforts to increase dietary protein to build muscle mass, this is usually unnecessary if they are eating a well-balanced diet with sufficient energy and protein intake spaced throughout the day. Research shows that protein intake of 1.8 g/kg body weight is the upper limit for muscle protein synthesis.[2] For a 63 kg (140 lb) player, that's about 115 g of protein. A player that weighs 82 kg (180 lb) may need up to 150 g. As shown in the sample menu, this is easily met with adequate energy intake. While eating protein above this amount is not harmful for healthy people, it often displaces energy from carbohydrate in the diet, which, as discussed above, is the muscle's preferred fuel. While the muscles will utilize protein when carbohydrate is low, this is an inefficient metabolic process and will leave the athlete feeling run down and fatigued. The recommendation for daily protein intake for basketball players is 1.4–1.7 g/kg of body mass.

Fat

Dietary fats are important for the synthesis of hormones and cell membranes, as well as proper immune function. Athletes should strive to eat heart-healthy fats such as mono-unsaturated fats (olive oil, avocado) as well as omega-3 fats (salmon, flaxseed) and avoid saturated fats (beef fat, lard) and trans fats (margarine and processed foods). Energy intake from fat should make up the remainder of calories after protein and carbohydrate recommendations are met.

Sample Menu: 63 kg (140 Pound) Player

Breakfast: 2 cups Life Cereal, 300 ml (10 oz) skim milk, banana, 300 ml (10 oz) orange juice

Snack: Apple, 2 TBS peanut butter, 28 g (1 oz) pretzels

Lunch: 1 Turkey Sandwich on Wheat Bread, 10 baby carrots, chocolate pudding cup

Snack (pre-practice): 600 ml (20 oz) Gatorade, granola bar

Dinner: 1.5 cups spaghetti with marinara, tossed salad with dressing, 3 pieces garlic toast, 240 ml (8 oz) skim milk

2557 kcal; 6.5 g Carbohydrate/kg body mass; 1.4 g Protein/kg body mass

Sample Menu: 81 kg (180 Pound) Player

Breakfast: 2 cups Life Cereal, 360 ml (12 oz) skim milk, banana, 360 ml (12 oz) orange juice

Snack: Apple, 2 TBS peanut butter, 56 g (2 oz) pretzels

Lunch: 2 Turkey Sandwich on Wheat Bread, 10 baby carrots, chocolate pudding cup

Snack (pre-practice): 600 ml (20 oz) Gatorade, granola bar

Dinner: 3 cups spaghetti with marinara, tossed salad with dressing, 3 pieces garlic toast, 360 ml (12 oz) skim milk

Evening Snack: 360 ml (12 oz) blueberry banana smoothie

3262 kcal; 6.5 g Carbohydrate/kg body mass; 1.6 g Protein/kg body mass

Pregame Meals

The goal for any pre-competition meal is to help with the body's energy needs (e.g., top off liver glycogen) while eliminating the distraction of hunger and reducing the risk of gastrointestinal problems. Appropriate meals or foods should be high in carbohydrate, low in fat, and low in fiber (See **Table 1**). A good rule of thumb for carbohydrate is the following equation:

(body weight in kilograms) x (hours prior to competition) = grams of carbohydrate

For example, a player weighing 68 kg (150 lb) and eating 3 hours prior to the game could eat: 68 kg x 3 hours = 204 grams of carbohydrate This would be equivalent to a small meal including a turkey sandwich, an ounce of pretzels, a granola bar, and 1 L (33 oz) of Gatorade ® Thirst Quencher . On the other hand, if this player is eating 1 hour prior to the game, only about 70 g of carbohydrate should be consumed. An appropriate snack may be 1 liter (33 oz) of Gatorade ® Thirst Quencher and an ounce of pretzels. It is very important that each player find what foods and beverages work best for her or him by experimenting before and during practices. Each person is a bit different, and one player's "lucky" meal may leave her teammate with stomach cramps.

Table 1. Carbohydrate content of select foods

Food	Serving Size	Carbohydrates (g)
Pretzels	1 oz	25
Gatorade ® Thirst Quencher	20 oz	35
Banana	medium	25
Granola Bar	2 bars	30
Animal Crackers	14	25
Raisins	¼ cup	30

Fueling During Games

Basketball games last 32–48 minutes of total playing time, depending on the level. Although it is unlikely that a player will drain his muscle and liver glycogen stores, supplementing with carbohydrate during the game may help maintain performance in the fourth quarter. Research shows that both cognitive function[5] and sprint speed[1] are maintained in basketball-type protocols when subjects are supplemented with carbohydrate rather than a placebo. Again, players should experiment during practices to find what foods and beverages work best for them; however, Gatorade ® Thirst Quencher, sports gels or chews, portions of sports bars, or oranges have been used by many. The recommended amount of carbohydrate to consume to maintain performance is 30–60 g/h. Therefore, given the game duration, an athlete should find the best solution to take in 30–60 g of carbohydrate over the course of a game. Using Gatorade ® Thirst Quencher, for example, 16–32 oz will meet the carbohydrate needs and provide fluid and electrolytes.

Importantly, all forms of carbohydrate supplementation should also include fluid replacement, as dehydration is detrimental to basketball performance. Fortunately, basketball lends itself to natural breaks in the action. Time-outs, breaks between quarters, and halftime are opportunities for players to refuel and rehydrate. As mentioned previously, consuming foods or fluids should be practiced during training to determine the most effective strategy. To determine an individual's sweat rate, weigh your players before and after a practice session in the same clothing, after toweling off excess sweat. If they lost weight, they didn't drink enough fluid and should consume an additional 16 oz per pound of body weight lost in the next practice. Each player should aim to lose < 2% body weight during practices and games (e.g., 3 lbs, for a 150-lb, player), and the amount that each player will need to maintain hydration will be different. Likewise, each player may prefer and tolerate different forms of carbohydrate. Players should be encouraged to find the combination of foods and fluids that works best to maintain hydration and energy while reducing the risk of stomach cramps.

Recovery

Recovery nutrition is very important when players have less than 24 hours between games or training sessions. In the 30–60 minutes immediately following exercise, the muscles used during exercise are especially sensitive to amino acids and glucose in the blood and are able to use them for muscle protein synthesis and glycogen restoration, respectively. Eating a meal or drinking a recovery shake during this "window" of time allows the muscle to recover its glycogen stores much more quickly than the same meal eaten 2 or 3 hours after exercise. Recommended carbohydrate intake is 1.0–1.2 g of carbohydrate/kg body weight and about 20 g protein. For a 68 kg (150-lb.) person, this would be about 82 g carbohydrate (328 kcal). Some players prefer liquid meals for recovery, as they may not have an appetite following competition. Many commercial recovery, products are available; however, chocolate milk and other foods are also appropriate **(See Table 2)**. Although it is important to consume carbohydrate and protein during the time immediately following competition, players should make a point of eating a well-balanced meal within 2 hours to give the muscles another "dose" of fuel. Athletes should also rehydrate after practices and games with about 20–24 oz, of fluid, preferably with sodium, for every pound of body weight lost.

Tournament Play

The principles of pregame meals and recovery should be followed for teams entering tournament play. Most basketball teams participating in tournament play will not play more than one game per day; however, they may play back-to-back games with less than 24 hours to recover. In this scenario, it becomes essential that players are provided with foods that supply carbohydrate to restore their muscle glycogen reserves, protein to help with muscle protein synthesis, and fluid to rehydrate. **Table 2** provides examples of foods that can help kick-start recovery. Teams that must play more than one game per day or play in the evening and again in the morning should consume pregame meals that are high in carbohydrate, low in fat, and low in fiber. Breakfasts may include toast or bagels with jam, a small stack of pancakes with syrup, or ready-to-eat cereal with skim milk. Lunches or dinners may consist of pasta with marinara sauce, a low-fat sandwich or wrap, or soup with bread. Again, the goal of a pregame meal is to provide energy without causing gastrointestinal distress.

Table 2. Recovery "meals"

Food	Serving Size	Carbohydrates (g)	Protein (g)
Gatorade Recover® Protein Shake	1 bottle	45	20
Low-fat Chocolate Milk	24 oz	72	22
Bagels with turkey breast and mustard	2 medium bagel with 3 oz turkey breast	76	31
Quaker Oatmeal Squares with Skim Milk	1.5 cups cereal + 16 oz skim milk	90	25
Greek Yogurt and fruit juice	6 oz yogurt soace + 16 oz juice	80	20

Summary

Developing the skills needed to become a great basketball player requires endless hours of time spent shooting, passing, ball-handling, and conditioning. Ignoring proper nutrition is like building a high-performance sports car and putting the wrong gas in the tank; it cannot operate optimally unless its engine is given high-grade fuel. Such is the case with athletes. Although the body can function on "junk food," it will not perform as well as it could when given the proper types of food in the correct amounts at the optimal times. Eating a variety of whole grains, fruits and vegetables, lean sources of protein, and healthy fats will provide high-quality fuel for the best possible performance.

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