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CLINICAL FEATURE
REVIEW

Evidence-based post-exercise recovery strategies in basketball

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Abstract

Basketball can be described as a moderate-to-long duration exercise including repeated bouts of high-intensity activity interspersed with periods of low to moderate active recovery or passive rest. A match is characterized by repeated explosive activities, such as sprints, jumps, shuffles and rapid changes in direction. In top-level modern basketball, players are frequently required to play consecutive matches with limited time to recover. To ensure adequate recovery after any basketball activity (i.e., match or training), it is necessary to know the type of fatigue induced and, if possible, its underlying mechanisms. Despite limited scientific evidence to support their effectiveness in facilitating optimal recovery, certain recovery strategies are commonly utilized in basketball. It is particularly important to optimize recovery because players spend a much greater proportion of their time recovering than they do in training. Therefore, the main aim of this report is to facilitate useful information that may lead to practical application, based on the scientific evidence and applied knowledge specifically in basketball.

Keywords

Basketball, Recovery, Nutrition, Fatigue, Ergogenic aids, Hydration

History

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Introduction

Basketball is the second most popular sport in the world with over 450 million players regularly playing the game either on a competitive or recreational level in 213 countries.[1] During the last decade, elite basketball has become more competitive, with increasingly condensed game schedules. Top players must deal with many national and international championships with, on average, a game played every 2.5 days.[2] In addition, the new rules introduced in 2000 by Federation International Basketball Association had a profound effect on the game, including a greater total time spent in high-intensity activities and a greater number of actions per game.[2] Overall, these changes have made the game faster, affecting players' physical characteristics.[3,4] In addition, to successfully cope with ever-increasing demands, players regularly train intensively, without enough time to fully recover between sessions.[5] Therefore, how to recover faster after training and competition becomes a central question in basketball practice nowadays.[6]

Optimal recovery has been shown to result in the restoration of organic and psychological states.[7] Recovery from competition or training is dependent on the exercise, and it is thus essential to understand the specific mechanisms of fatigue and influences from external factors.[8] Compared to other team sports, the main differences specific to the demands placed on basketball players during practice and matches are faster and shorter accelerations and decelerations, explosive change of directions, jumps and several contacts among players that could potentially create trauma.[9] Players are also characterized by a large muscle mass and body size, which could influence their susceptibility to fatigue compared to smaller or leaner athletes.[10] Therefore, it is important to establish procedures to prevent injuries, aid recovery and optimally train basketball players.[11]

In the scientific literature, a considerable number of recovery methods used to enhance recovery have been discussed.[12] Their use depends on the type of activity performed, the time until the next training session or event and equipment and/or coaching or medical staff available. The main recovery methods practically used by teams include nutritional practices (CHO, proteins, vitamins, creatine [Cr]), ergogenic aids, active

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Table 1. Recovery methods in basketball with benefits.

Study	Subjects	Exercise	Recovery	Measurement timing	Findings	Reference
Lin ZP (2009)	30 Male elite university basketball players	Heart rate (HR_{max}) Oxygen consumption (VO_{2max}) Blood lactate concentration	Acupuncture at the Neiguan (PC6) and Zusanli (ST36) acupoints	Beginning at 15 min prior to exercise and continuing until exhaustion	↓ HR_{max}, VO_{2max} and Blood lactate concentration	[53]
Montgomery PG (2008)	29 Male players	Performance tests (sprint and agility performance, vertical jump, 20-m acceleration, 20-m time, sit-and-reach flexibility	Carbohydrate + stretching Cold-water immersion Full-leg compression garments	Pre and post 3-day tournament style basketball competition	Cold-water immersion: ↑ performance tests; than carbohydrate + stretching and full-leg compression garments.	[9]
Zhao J (2012)	20 Elite female basketball players	Pittsburgh Sleep Quality Index Serum melatonin 12-minute run	Red-light treatment	Baseline and post-intervention (14 days)	Improved sleep, serum melatonin level, and endurance performance	[52]
Delextrat A (2014)	9 Men + 8 women National-level basketball players	Countermovement jump (CMJ) and repeated sprint ability (RSA)	Massage Massage and stretching (MAS)	Immediately after a competitive match	Men: both treatments ↑ CMJ. Women: MAS ↑ RSA Women > men	[38]
Delextrat A (2013)	8 Men + 8 women National-level basketball players	CMJ and RSA	Massage Cold-water immersion	24 h after a competitive match	Cold-water immersion: ↑ CMJ	[40]

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recovery, stretching, hydrotherapy, compression garments, massage, psychological means, rest and sleep, and acupuncture. However, there is a lack of consensus on the benefits of many of these approaches in the scientific community.

While several reviews about recovery methods have been published in other team sports, such as soccer [13] and rugby, [14] to our knowledge there has been no review or report about recovery in basketball. This review was conducted in accordance with the recommendations of the Preferred Reporting Items for Reviews statement, through a computer-based literature research that was performed up until August 2015 using two online databases: Medline (PubMed) and Cochrane. The keywords used were *Basketball recovery*, *nutrition*, *fatigue*, *ergogenic aids* and *hydration*. The inclusion criteria in this review consisted of studies on the effect of different methods on recovery in basketball (see Table 1).

Therefore, this practical report will focus on specific recovery processes in basketball and will attempt to provide information for coaches, physiologists and team physician members.

Recovery post training or competition

Nutritional approaches

Carbohydrates and proteins

Carbohydrates (CHOs) should be included in rehydration beverages to improve palatability and to aid in the immediate restoration of muscle glycogen stores.[12] From a nutritional point of view, basketball players use CHOs as the primary source of fuel during exercise, given the type of training they perform and the characteristics of competition.[4] After a training session or match, muscular stores of CHO are depleted, and thus consuming CHO and protein during recovery has been shown to positively affect subsequent exercise performance and could be of benefit for the athletes involved in multiple training or competition sessions on the same or consecutive days.[15] The ideal combination will be of rapidly absorbed CHO together with hydrolyzed whey protein, using 3–4:1 ratio, being 1 g/kg the amount of the recommended CHO.[16] Eating and drinking the right kind of fuel after exercise is important for restoring energy levels and repairing muscle damage. Refueling with CHO, protein and fluid within 30 min after exercise helps muscles recover faster. Within this context, it has been established that consumption of macronutrients, particularly CHO and possibly a small amount of proteins and leucine (doses: 0.3 g/kg of CHO, 0.2 g/kg of protein and 0.01 g/kg of leucine), in the early recovery period after practice can enhance muscle glycogen resynthesis [17] per day during the season. However, futures studies should analyze the ingestion of CHO in combination with protein in different dosages to determine which dose will enhance post-recovery specifically with basketball players. Finally, according to Schröder et al. (2002), in their usual daily practice, players consumed CHO (12.7%), with other nutrients: amino acids (14.5%) and proteins (12.7%), during one season.[18]

Vitamins

Oxidative stress occurs when the body does not have enough capacity to defend itself against free radicals. Reactive oxygen species is the main source of oxidative stress and plays a major role in the initiation and progression of damage to the muscle fibers after exercise.[19] Several antioxidants have been introduced to protect the cells from free radicals such as vitamins C and E, carotenoids and flavonoids.[20]

Oxidative stress may be involved in the aging process, cell damage, muscular fatigue and overtraining,[21] specially during maximal exercise in basketball, given that greater utilization of aerobic metabolism in playing competitive basketball than previously expected, with values of VO_2 of 33.4–4.0 and

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36.9–2.6 mL/kg/min for females and males, respectively.[22] Within this context, the consumption of vitamins C and E may strengthen the antioxidant defense system by decreasing reactive oxygen species of athletes involved in maximal- or high-intensity exercise.[23] Regarding the nutritional habits of players, it has been shown that multivitamins were the most frequently used supplements among these athletes (50.9%), followed by sport drinks (21.8%).[18]

Creatine

Since 1992, the interest in Cr as a nutritional supplement has dramatically increased. Over the past two decades, the main focus of research has been on the ergogenic value of Cr.[24] In basketball, Shi (2005) concluded that supplementation of CHO and Cr could promote the recovery of physical performance, demonstrating its efficacy in a sport like basketball characterized by high-intensity efforts.[25] In this sense, data from top-level Spanish players showed that low-dose supplementation with Cr monohydrate did not produce laboratory abnormalities for the majority of the health parameters during three competition seasons.[26]

β-Alanine

An ergogenic aid can be broadly defined as a technique or substance used for the purpose of enhancing performance.[27] β-Alanine supplementation has become a common practice among different sports. Although the mechanism by which chronic β-alanine supplementation could have an ergogenic effect is widely debated, the popular view is that β-alanine supplementation augments intramuscular carnosine content, leading to an increase in muscle buffer capacity, a delay in the onset of muscular fatigue, and a facilitated recovery during repeated bouts of high-intensity exercise.[28]

β-Alanine supplementation has been shown to improve high-intensity exercise performance and capacity. However, its effect on recovery is not clear, but some authors indicated that β-alanine supplementation in highly trained athletes could be of importance.[29] However, nowadays there is no scientific evidence about the ergogenic effect of β-alanine in team sports (including basketball). Among the most recent investigations, the focus has been on the effect of β-alanine supplementation and sodium bicarbonate ($NaHCO_3$) on high-intensity efforts, but these studies have been performed on endurance exercise.[30] Therefore, it could be interesting to analyze the effects of these supplements in basketball, since it is an intermittent sport with a 40-min game with a variety of multidirectional movements such as running, dribbling and shuffling at variable velocities and jumping.[31] Finally, if combining β-alanine and $NaHCO_3$ supplementation, the results demonstrated that supplementation with acute $NaHCO_3$ improved repeated-sprint performance more than either a combination of $NaHCO_3$ and β-alanine or β-alanine alone.[32]

Cool-down recovery techniques

Active recovery. Cool-down is a widely accepted practice after training sessions, used to reduce heart rate (HR_{max}) to resting values; stretch muscles; remove lactate concentration; *resynthesize* high-energy phosphates; replenish oxygen in the blood, body fluid and myoglobin; and support the small energy cost to sustain an elevated circulation and ventilation.[33,34] However, despite being considered as essential for optimum performance, there is no investigation that has identified the optimum cool-down process in basketball. However, active recovery is a more practical option for athletes,[35] thus future investigations should analyze the physiological effect of basketball competition. In this way, recent studies speculate that time-consuming, cooling-off routines usually performed by shooters before each free throw may be functional.[36]

Stretching. Post-event cool-down strategies relying on stretching techniques should not be done with the goal to drastically improve flexibility. Dynamic stretching has gained popularity, due to a number of studies showing an increase in high-intensity performance compared to static stretch modalities.[37]

However, post competition, static stretching is not recommended as a way to improve flexibility and reduce adhesions caused by physical activity.[12] Delextrat et al. (2014) demonstrated that female basketballers benefit slightly more from the combination treatment (massage + stretching) than men, and therefore this type of recovery intervention should be adopted by physiotherapists especially the first in women teams within 2 h after training or matches, in particular during tournaments where matches are played daily.[38] Both recovery procedures improved perceptions of overall fatigue and leg soreness, with greater benefits of the combination on leg soreness.[38]

Hydrotherapy

One method gaining popularity as a means to enhance post-game or post-training recovery is immersion in cold water. Much of the literature on water immersion as a means to improve athletic recovery appears to be based on anecdotal information, but it is suggested that this method can improve recovery 24–72 h after exercise.[39] In this study, the immersion in cold water occurred within 5 min of the completion of the match and consisted of five 2-min intermittent immersions of the lower limb (up to the iliac crest) in a cold-water bath (11.8°C), separated by 2-min rest in ambient air (sitting, room temperature of 20.8°C). Ice was added to the bath at regular intervals to maintain water temperature at 11 ± 0.78°C. In basketball, few articles have analyzed the effect of water immersion on recovery. They demonstrated that it is more useful than massage in the recovery from basketball matches.[40] It has been shown that a tournament elicited small to moderate impairments in physical performance, and that immersion in cold water appears to promote better restoration of physical measures, such as 20-m acceleration, than CHO and stretching routines or compression garments.[9]

Compression garments

Compression garments are articles of clothing such as socks or pantyhose that provide support that is especially useful for athletes. The utilization of compression garments has also been adopted for athletes due to their potential benefits for physical performance and recovery.[41] Compression garments apply mechanical pressure to the body and compress and support underlying tissues.[42] The garments can come in varying degrees of compression and therefore enhance

recovery. In this case, no evidence has been reported about this technique in basketball, with only Montgomery et al. showing that after a 3-day tournament, compression garments + CHOs + routines stretching was less effective for recovery than cold-water immersion.[9]

Massage

Many athletes consider sports massage as an essential part of their training and recovery routine. These athletes report that a sports massage helps them to train more effectively, improve performance, prevent injury and fasten recovery. Massage was effective in alleviating delayed onset muscular soreness (DOMS) by approximately 30% and reducing swelling.[43] However, in the recent study, we demonstrated that massage did not have any effect on repeated sprint ability (RSA).[40] Contrary, including stretches to a massage routine improves recovery from official matches in basketball players.[38] This was the first study to analyze the impact of massage on recovery in basketball.

Psychological techniques

To ensure that athletes maximize the benefits from demanding training sessions and remain robust enough to cope with multiple performances, it is vital that individual athletes have the ability to recognize when and how they need to recover.[8] Burnout is defined as a state of mental, emotional and physical exhaustion brought on by persistent devotion to a goal in which its achievement is dramatically opposed to reality.[44] Recently, it was demonstrated that an increase of self-control could reduce negative anxiety effects and improve player's performance under pressure.[45]

On the other hand, session Ratings of Perceived Exertion (RPE) seems to be a viable tool in monitoring internal load.[46,47] These responses might help coaches to plan appropriate loads, thus maximizing recovery and performance.[48] However, more studies are necessary to understand the effectiveness of RPE on recovery after training or match in basketball.

Rest and sleep

The amount of sleep an athlete gets appears to have a large impact on sports performance.[49] In the last season, after the lock out in National Basketball Association (NBA), interviews with players revealed that they were not doing much to compensate for the loss of sleep and instead were feeling the effects of the condensed season. An investigation conducted by Steenland and Deddens (1997) certified that after analyzing the effect of travel and rest on performance over 8.495 games in the NBA over eight seasons, more time between games significantly improved performance and that this effect was constant over time.[50] Recently, Mah et al. (2011) concluded that improvements in specific measurement of sprinting time, shooting accuracy, and free throw percentage occurred after sleep extension, thus indicating that optimal sleep is beneficial in allowing athletes to reach their peak athletic performance.[51] Finally, recent research demonstrated the effectiveness of body irradiation with red light in improving the quality of sleep of elite female players and offered a nonpharmacologic and noninvasive therapy to prevent sleep disorders after training.[52]

Other practices

Acupuncture

In one interesting study, the authors analyzed the effects of acupuncture stimulation on athletes' recovery ability in 30 university basketballers. The results showed that the acupuncture group had significantly lower HR_{max}, oxygen consumption (VO_{2max}) and blood lactate concentration. They concluded that acupuncture schemes are effective to enhance the recovery ability for elite basketball athletes.[53]

Limitations

Probably one of the most limitations of this article is the little evidence of recovery strategies in basketball. For that, new research lines are necessary to understand the potential effect of the different methods in basketballers.

Conclusion

Recovery from training is recognized as one of the most important parts of a training regimen. To maximize recovery strategies, CHOs and fluids play an important role after exercise. High muscle glycogen concentrations and being hydrated is important, which can be achieved by high CHO consumption plus leucine and adequate drinking. Unclear ergogenic effects on performance include induced metabolic alkalosis via bicarbonate ingestion plus β-alanine. Cold-water immersion may be an effective strategy to reduce DOMS 24 h after a match. Massage in combination with stretching presented positive effects on recovery immediately after a match. A number of nutritional factors have been suggested to affect recovery: for example, to improve sleep, a high glycemic index diet before bed time and maintenance of a balanced and healthy diet may help. Strategies such as warming the skin, hydrotherapy and the adoption of appropriate sleep hygiene are other tools used to aid in sleep promotion. Ensuring that athletes gain an appropriate quality and quantity of sleep may be important for optimal athletic performance. Red-light treatment may also improve sleep. Finally, future research is needed to identify which resources are more effective at providing individual recovery strategies.

Declaration of interest

The authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

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