

From Physiology to Psychology: A Multidimensional Analysis of Recovery Strategies for Young Athletes

Zeyu Han

Shanghai Mingsui Creative School, Shanghai, 201201, China

Justinhanzeyu@163.com

Abstract. Young athletes are often at risk of physical fatigue and injury during intense competition and training, making post-competition rehabilitation particularly important. Effective rehabilitation not only helps them regain strength and reduce the likelihood of injury, but also improves overall athletic performance. Science-based post-competition rehabilitation can help young-athletes maintain good physical condition, extend their athletic careers, and enhance their academic and athletic performance. This paper analyzes the effectiveness of post-competition recovery strategies in improving the athletic performance of young athletes, focusing on physiological, physical, and psychological recovery methods. It emphasizes the importance of proper nutrition and rest for physiological recovery, highlighting their role in muscle repair and energy replenishment. Physical recovery strategies such as stretching, massage, and low-intensity activities were examined to understand the benefits of these strategies in relieving muscle tension and improving flexibility. The study also explored mental recovery techniques, including relaxation exercises and psychological support, to understand their impact on stress management and mental resilience. This research highlights the significance of employing a multifaceted approach to recovery techniques in order to enhance overall performance. By adopting efficient recovery protocols, athletes are able to attain superior recovery outcomes, boost their competitive advantage, and potentially prolong their athletic careers. The manuscript advocates for additional investigations to fine-tune these strategies and assess their long-term advantages for sustained athletic success.

Keywords: Physical therapy, training recovery, athletic performance, young athletes, psychology of sports.

1. Introduction

In the realm of competitive sports, the dichotomy of winners and losers reigns supreme, leading athletes to dedicate substantial time to enhancing their performance in this regard. Within this context, a distinct category emerges: young-athletes. These young competitors are challenged not only to excel athletically on the field but also to manage the demands of their academic responsibilities. Therefore, effective recovery strategies post-competition are crucial for these athletes as they transition from the intensity of athletic events. It is better for adolescent athletes to quickly regain their physical strength after a competitive match, reengage in learning tasks, and improve their performance in the next match. In order to achieve this, the aim of this paper is to provide a detailed analysis of the physiological, physical, and psychological aspects of post-competition recovery in order to provide a detailed analysis of post-

competition recovery for improving athletic performance in adolescent athletes. The structure of this paper includes an integrated research approach to each recovery dimension and recovery strategy.

2. Literature Review

2.1. Characteristics of young athletes

By looking at athletes, many young athletes have jumping, agility and acceleration on par with their adult counterparts. For example, Kylian Mbappé, who rose to fame as a youngster in Ligue 1, showed exceptional explosiveness, while LeBron James showed NBA-level speed and jumping ability as early as high school. Young athletes seem to have the potential to match adult athletes in terms of explosiveness. However, significant improvements in explosiveness or jumping ability do not seem to be common for adult athletes, and few athletes have made significant progress in these areas as adults. Instead, young athletes seem to be able to quickly gain significant growth through rapid compound stretching and contraction training. It is unlikely that adult athletes who have trained professionally for many years lack rapid compound stretching and contraction training.

2.2. Physiological aspects

2.2.1. Muscle recovery

DOMS is muscle pain, stiffness, or “muscle warmth” that occurs after strenuous or unusual exercise. It can be the result of temporary microscopic scarring and inflammation in the muscle tissue. It peaks 1-2 days after strenuous exercise. It usually resolves within 4 days. DOMS can occur in anyone, regardless of fitness level. Any form of physical exertion that places strain on the muscles can lead to Delayed Onset Muscle Soreness (DOMS), such as resistance training or high-intensity workouts. [1]

Usually within two to three days after a training session (especially strength training), people feel soreness in the trained muscles, sometimes even affecting our daily lives. In fact, from a microscopic point of view, the process of our training (especially strength training) has led to a mild tear by way of loading the muscle fibers, however, after this, the body repairs it and allows the muscle to recover to a level stronger than the original to ensure that it can cope with the load next time, this is one of the simple principles of how humans become stronger after training, however, it is not that the muscle feels sore and painful that means that the training is in place, as mentioned earlier, excessive soreness can interfere with daily life, and it is not just being sore that means the training is up to scratch, this needs to be differentiated.

Ways to minimize the impact of muscle soreness while still making training progress. Warming up before exercise prepares a person mentally and physically for exercise. Dynamic and static stretching stimulates the interplay between nerves and muscles, thereby enhancing the range of motion. Nonetheless, there remains a lack of definitive evidence demonstrating that warm-ups effectively mitigate Delayed Onset Muscle Soreness (DOMS) [1]. Moreover, people often cool down after exercise with dynamic or static stretching. However, there is no reliable evidence that this helps to reduce DOMS. Active cooling may accelerate cardiovascular and respiratory recovery. Consequently, active cooling may foster a feeling of tranquility that individuals might consider advantageous. Nonetheless, the review highlights that active cooling does not contribute to the prevention of muscle soreness or enhance recovery [1]. Additionally, gradually adapting to a new workout routine can help prevent DOMS. Progressively augmenting the intensity or duration of physical exercise can ameliorate muscle strain and mitigate post-exercise discomfort.[1]

3. Energy Recovery

3.1. The basic nutrition

Proper nutrition is important for muscle repair and overall recovery. A balanced diet rich in protein, carbohydrates, and healthy fats helps muscle repair and replenish glycogen stores. After exercise

nutrition, including protein and carbs, has been shown to enhance the recovery of muscle and performance.

3.1.1. Protein

Protein is a crucial component of the human body, facilitating both growth and the repair and renewal of bodily tissues. It is essential for forming human cells and tissues, serving as the sole source of nitrogen within the body.[2]

3.1.2. Lipids (fat)

Lipid consists of various fatty acid components, which include phospholipids, glycolipids, sterols, and steroids, among others.[3] Lipid is an important component of the cell membrane. Cholesterol or synthetic steroid hormone, vitamin D, and bile acid raw materials.

3.1.3. Carbohydrates

Carbohydrates are compounds containing carbon, hydrogen and oxygen. Carbohydrate is the most abundant organic matter in nature. Stores and provides energy. Carbohydrates in the body release energy and provide faster. They are the main energy source for the nervous system and myocardium, and the main fuel for muscle activity. They play an important role in maintaining the normal energy supply of the nervous system and the heart, enhancing endurance and improving efficiency. Carbohydrates are essential compounds that form the structural framework of living organisms and are active participants in cellular composition and a variety of metabolic processes.[4]

3.2. Vitamins and minerals

Vitamins in the human body cannot be synthesised, or the amount of synthesis is relatively small, cannot meet the needs of the body, must be supplied through the outside world to maintain normal life activities of a class of low molecular organic compounds, is one of the body's essential nutrients, is divided into fat-soluble vitamins and water-soluble vitamins of the two categories. Most minerals are metal elements, mainly iron, zinc, copper, manganese, and selenium, as well as iodine, cobalt, fluorine, chromium, vanadium, etc. They are generally combined into compounds or complexes in the body. They are extensively found across different tissues, exhibiting a relatively stable concentration, primarily derived from dietary sources, with animal-based foods containing a higher concentration and greater variety compared to plant-based foods.[5]

4. Sleep Recovery

Sleep health is an important factor in athletic performance. Athletes are highly susceptible to inadequate sleep (i.e., less than 7-8 hours of sleep per night), poor sleep quality (e.g., difficulty falling asleep or maintaining sleep, or other sleep difficulties), daytime sleepiness and fatigue, poor sleep schedules (e.g., too early or too late), irregular sleep schedules, and disturbances in sleep and circadian rhythms (especially insomnia and sleep apnea). Individually or in combination, these problems may affect athletic performance in a number of ways. Sleep deprivation and/or poor sleep quality can affect muscle strength, speed, and other aspects of physical performance. Sleep problems can also increase the risk of concussions and other injuries and affect recovery from injuries. Cognitive functions can be influenced across various domains, such as vigilance, information retention, decision-making processes, and innovative thinking. Furthermore, sleep significantly impacts psychological well-being, which is crucial not only for optimizing athletic performance but also for the holistic health of the athlete.[6]

5. Physical Recovery

5.1. Active recovery

Active recovery involves low-intensity exercise after a strenuous workout and aims to promote recovery by enhancing blood flow to the muscles and reducing soreness. Common forms of exercise include light

jogging, cycling and yoga. This approach helps to improve blood circulation, promote the elimination of metabolic waste products, and relieve delayed onset muscle soreness (DOMS). Moreover, active recovery offers psychological advantages, enabling athletes to unwind and concentrate without excessive physical strain, all while preserving their fitness levels.[7] Figure 1 illustrates the concentrations of capillary blood lactate during both passive and active recovery phases. Additionally, Table 2 presents the ratings of perceived exertion (RPE) recorded immediately following the five climbing intervals.

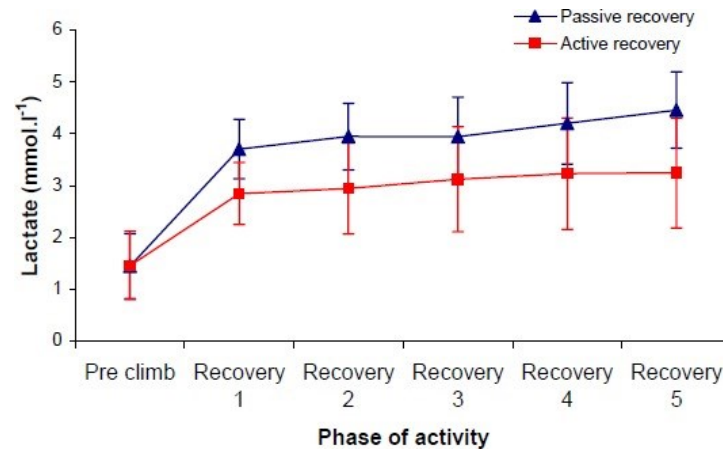


Figure 1. Capillary blood lactate concentrations for passive and active recoveries (mean ± SD).[7].

Table 1. RPE scores immediately post the five periods of climbing. Data are means (±SD)[7]

	Post Climb1	Post Climb2	Post Climb3	Post Climb4	Post Climb5
Active Recovery	12.3(2.3)	13.7(2.0)	15.2(2.0)	16.3(1.8)	17.3(1.8)
Passive Recovery	12.8(1.6)	14.3(1.9)	15.9(1.9)	17.3(1.9)	17.1(1.8)

5.2. Passive recovery

Passive recovery involves promoting the body's recovery through rest, relaxation or physical therapy (e.g., massage, cold packs, etc.) rather than engaging in any form of activity after intense exercise. This approach helps muscle repair, reduces fatigue, improves mental status, reduces the risk of injury, and promotes better quality sleep. Unlike active recovery, which emphasizes low-intensity exercise to improve blood flow and speed recovery. An effective form of passive recovery, acupuncture, which excels at relieving muscle tension and promoting overall recovery.

In one study, researchers first divided participants into two groups: an experimental group receiving acupuncture treatment and a control group receiving no intervention. The experimental group showed significant improvements in their muscle soreness ratings (MSR) at all time points after acupuncture treatment. At the 24-, 48- and 72-hour assessments, the experimental group showed significantly lower muscle soreness than the control group, demonstrating the effectiveness of acupuncture in relieving muscle fatigue and discomfort. In addition, the study observed a slight downward trend in the mean DMOS symptom response after acupuncture treatment, which, although not considered significant, still indicates that acupuncture may have some positive impact on symptom management. This finding triggers further thoughts on the mechanism of acupuncture, perhaps by regulating the nervous system and promoting blood circulation, acupuncture helps to reduce recovery time after muscle injury.[8]

6. Psychological Recovery

6.1. Mental health and athletic performance

Psychological factors have a significant impact on athletes' performance, influencing their mental and emotional state during competition. Motivation plays a crucial role; intrinsic motivation often drives

athletes to give their best than extrinsic rewards. Self-confidence is equally important; it encourages athletes to take risks and deal with challenges, thereby improving performance. Focus and concentration are vital for skill execution, while distraction hinders performance. The implementation of efficacious anxiety and stress management strategies, including visualization and affirmative self-dialogue, enhances athletic performance in high-pressure situations. The use of mental imagery enables athletes to conduct mental simulations of their performance, thereby augmenting their preparedness and self-assurance.[9] Pre-competition routines create a sense of control and reduce anxiety, while positive thinking exercises allow athletes to maintain a sense of presence and minimize overthinking. Incorporating mental training into athletic practice can significantly improve athletic performance and is therefore an important component of a comprehensive athletic training program.

6.2. Mindfulness training

Five research studies on positive thinking training for athletes were compiled through meta-analysis, and the results showed that positive thinking interventions had a large effect on psychological factors in athletes ($d = 0.81$, 95% CI = [0.53, 1.10], $p < 0.001$). There was a high degree of heterogeneity among the included studies ($I^2 = 77\%$, $p = 0.001$) (Table 2).[10]

Table 2. Pooled effect sizes of mindfulness-based interventions on mindfulness-related psychological components among athletes.[10]

	Experimental			Control				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV,Fixed,95%CI
Carol R. Glass 2019	2.43	20.34	20	1.83	19.05	24	23.1%	0.03[-0.56,0.62]
Carraca, B 2018	18.38	4.83	28	15.74	3.07	29	28.5%	0.65 [0.11,1.18]
Cian Aherne 2011	23.83	15.29	6	-1	9.48	7	4.2%	1.85[0.47,3.24]
Fengbo Liu 2021	6.14	12.39	29	-5.15	13.9	28	27.5%	0.85[0.30,1.39]
john scott-Hamilton 2016	0.74	0.43	27	-0.06	0.42	20	16.7%	0.81[0.53,1.10]

6.3. Pressure management

Stress affects athletes in several ways: first, moderate stress can increase hormone levels, such as adrenaline performance, increase heart rate and energy supply, and enhance focus and motivation; however, excessive stress can lead to anxiety and insomnia, which can lead to distraction and poor decision-making. Second, chronic stress may lead to physical fatigue and mental health problems such as depression and anxiety disorders. In addition, stress may affect athletes' social relationships and overall well-being. Therefore, managing stress appropriately is key to an athlete's success. Elite athletes typically cope with the stress of competition by engaging in daily positive self-talk, meditation, setting specific goals and maintaining focus. They tend to engage in mental preparation and visualization exercises to improve self-confidence and resilience. Non-elite athletes, conversely, may depend on external assistance, including motivation from coaches and support from teammates.[11] Good stress management not only helps to improve performance, but also enhances mental toughness to cope with future challenges more effectively

7. Conclusion

Research findings show that physiologic recovery methods play a crucial role in accelerating muscle repair and replenishing energy levels. Proper nutritional intake, such as timely protein and carbohydrate supplementation after a race, can promote muscle recovery and energy replenishment. In addition, adequate rest and sleep are indispensable factors in the recovery process. They help the body repair damaged tissues and enhance the function of the immune system, thus reducing the incidence of injuries and illnesses.

In physical recovery, stretching, massage, and low-impact exercises are highly effective. Stretching reduces muscle tension and improves joint flexibility, minimizing sports injury risks. Massage enhances blood circulation, reduces soreness, and boosts comfort. Additionally, low-impact activities like swimming and cycling allow athletes to recover without increasing strain.

Psychological recovery strategies play a crucial role. Research indicates that relaxation techniques and psychological support can lower stress and bolster mental resilience in athletes. Following intense competition, athletes often encounter psychological hurdles, and interventions like counseling, meditation, or breathing exercises assist in mindset adjustment and fostering positivity.

Integrating physiological, physical, and psychological recovery methods enhances athletic performance. A holistic approach to recovery enables athletes to rebound from training and competition more effectively, thereby improving performance and prolonging careers. Future research should investigate the long-term impacts of these strategies and optimize the integrated recovery framework for peak athletic results. This program supports physical recovery and significantly promotes mental health, establishing a strong foundation for young-athletes' ongoing success.

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