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Heart rate recovery as a critical determinant in weightlifting

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역도선수의 경기력 결정요인으로서 심박수 회복에 관한 연구

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Abstract : Despite its profound impact on athletic performance, the significance of heart rate recovery (HRR) has been insufficiently addressed in the filed of sports science, particularly in the context of weightlifting characterized by brief and intense exertions involving heavy weights. Serving as a valuable indicator of autonomic nervous system and cardiovascular function, HRR assumes a pivotal role in weightlifting. This comprehensive review aims to delineate the specific demands for HRR in weightlifting, shedding light on the often overlooked cardiovascular considerations within training regimes focused on strength and power. The investigation scrutinizes the repercussions of HRR on weightlifting performance, seeking to elucidate how inadequate recovery intervals may result in physiological and psychological consequences. These consequences encompass a distorted perception of effort, disruption of coordination, compromised posture due to irregular breathing, and an overall decline in lifting capacity. The review systematically presents compelling evidence pertaining to heart rate response and recovery patterns during weightlifting, underscoring the critical importance of well-structured rest periods. Furthermore, the review delves into a comprehensive discussion of factors influencing HRR in weightlifting, encompassing variables such as sex, age, cardiovascular function, hydration, nutrition, and psychological aspects. Finally, a key emphasis is placed on the integration of

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effective HRR techniques into the training regimens of weightlifters, thereby ensuring sustained and optimized performance outcomes.

Keywords : Weightlifting, Heart rate recovery, Athletic performance, Cardiovascular function, Exercise training

1. Introduction

In sport science and athletics, in which precision and maximum effort are paramount, the importance of heart rate recovery (HRR) as an often-underappreciated facet of physiological insight demands careful consideration for optimal athletic performance. HRR is a physiological parameter that represents the rate at which an individual's heart rate declines after the cessation of exercise and valuable indicator of autonomic nervous system (ANS) function and cardiovascular fitness (1-2).

From a physiological standpoint, HRR is intricately linked to the ANS, which controls heart rate. During exercise, sympathetic nervous system activity increases to meet the heightened metabolic demand (3-4). Upon exercise cessation, parasympathetic nervous system activity should predominate, rapidly decreasing heart rate (3). The kinetics of HRR are influenced by various factors, including age, fitness level, and most importantly exercise intensity and duration (5-7). Thus, by understanding the role and implications of HRR, athletes, coaches, and sports scientists can make informed decisions regarding athletic performance.

Weightlifting, a sport that primarily aims to maximize strength and power, involves short bursts of intense effort lifting a barbell with extreme weight generated by the force of gravity. Weightlifting is divided into two categories: the snatch and the clean and jerk. The technical characteristics of these movements and their adaptations differ, but physiological attributes are generally similar regardless of competition style. These lifts are typically completed within seconds, during which the metabolic demand rapidly increases and the heart rate spikes significantly due to the effort required to lift the heavyweight. While weightlifting itself may not be an aerobic exercise demanding a cardiovascular response like running and swimming, it still places demands on the cardiovascular system and affects HRR (8-10).

Therefore, this review provides a comprehensive overview of HRR's role in the unique context of weightlifting, shedding light on its importance for of top-level or highly skilled weightlifter, for whom small differences can determine rankings. Through a detailed exploration of HRR in the context of weightlifting, this research aims to contribute valuable insights that can enhance training strategies and performance optimization for athletes in this discipline.

2. Research method

2.1. Database Selection

A comprehensive literature search was conducted to identify relevant studies. The electronic databases cited in the current study were systematically searched: PubMed, Scopus, Web of Science, and Google Scholar. These databases were selected for their extensive coverage of scholarly articles across various disciplines.

2.1. Search Terms

A combination of keywords and vocabulary terms was employed to enhance the sensitivity and specificity of the search. The search terms

included the 'weightlifter', 'weightlifting', 'resistance exercise', 'heart rate recovery', 'exercise performance', 'hydration', etc. The Boolean operators "AND" and "OR" were used to combine the terms appropriately.

2.3. Exclusion Criteria

Exclusion criteria were applied to eliminate studies that did not meet the predefined standards. Database were excluded if (i) not being available in English, (ii) conducted on animals as well as those involving non-human subjects iii) manuscripts were not available in full text.

3. Results and discussion

3.1. Demands for HRR in weightlifting

The traditional training paradigm for weightlifters primarily focuses on physical and muscular strength and power development through resistance training and/or anaerobic exercise (9, 11-12). Weightlifters aim to build a solid strength foundation of strength. This typically involves lifting heavier weights using less repetition and longer rest periods by incorporating a variety of compound exercises that target specific muscle groups. In addition, as the competition season approaches, the emphasis shifts toward developing greater power and explosiveness to ensure peak conditioning (13-15). Thus, weightlifters complete significant training volumes throughout their training sessions, although cardiovascular function may not be the main focus.

Each individual weightlifting repetition is brief and intense, but the accumulation of multiple sets and repetitions can contribute to cardiovascular demands over the course of a training session. The same occurs in top-level competitions with limited rest periods between lifts (10, 13). Athletes typically follow a structured format with specific time limits and a rest period after each lifting attempt in competition. This time interval allows the heart rate to recover to some extent before the next lift which means that the time constraint can influence the weightlifting performance. In other words, the ability to efficiently manage heart rate between trials is crucial for sustaining one's performance, particularly in terms of managing heart rate spikes between lifting attempts (16-17).

3.2. Heart rate response and recovery pattern during weightlifting

Notably, direct heart rate response and recovery pattern investigations in weightlifting athletes are lacking; instead, it is possibly postulated based on general knowledge and common principles that are widely accepted in the field of exercise physiology and sport science (15, 18-19).

- Pre-competition phase: Before weightlifting competitions begin, athletes establish a baseline heart rate. This baseline can vary depending on a multitude of individual factors. Parameters such as an athlete's physical fitness level, underlying anxiety levels, and other psychological variables all exert an impact.

- Warm-up phase: As the competition approaches, athletes complete a structured warm-up routine to prepare for the competition. During this phase, the heart rate gradually increases as the physiological system prepares for the forthcoming physical exertion. The intensity and duration of this warm-up orchestration can influence heart rate response.

- Competition phase: At the start of the competition, heart rate spikes significantly, especially during the actual weightlifting attempts. This spike in heart rate is driven by the intense effort and the body's augmented demand for oxygen and energy. Notably, the dynamics of heart rate may vary across distinct lifting phases (e.g., the snatch and the clean and jerk) and weight being lifted.

- Recovery phase between attempts: Between lifting attempts, athletes have a brief rest or chance to recover. During this time, the heart rate typically decreases from the peak attained

during the weightlifting action. Recovery rate and completeness vary by factors such as cardiovascular function, rest duration, and mental state.

- Post-competition phase: After the competition ends, athletes complete a cool-down phase consisting of stretching and low-intensity exercises. As the body returns to a recovery and resting state, the heart rate gradually decreases.

Monitoring heart rate during different phases of weightlifting competitions can provide valuable feedback to athletes and coaches. It can also assist with fine-tuning warm-up protocols, evaluating the athlete's preparedness for each performance and ensuring that adequate recovery occurs between lifts. Moreover, monitoring HRR patterns over time can increase our understanding of an athlete's physiological conditioning and help refine training programs for future competitions.

3.3. Impact of HRR on weightlifting performance

An increased heart rate is a natural response to the challenge of weightlifting. However, the failure of HRR to return to a manageable level during weightlifting competitions can have several physiological impacts on performance, potentially hindering an individual's ability to perform at their best.

First and foremost, HRR provides a window into cardiovascular system function. A heart rate that remains stubbornly high after the intense exertion of lifting a heavy weight indicates reduced oxygen delivery to working muscles (20). Oxygen is vital for muscle contractions, and any delay in its supply can significantly influence weightlifting performance. As a result, athletes will experience early-onset fatigue, making it more difficult to sustain proper technique and generate sufficient power during attempts. Moreover, an inefficient HRR is also related to the clearance of lactic acid. Weightlifting triggers the production of lactic acid in working muscle, a natural by-product of anaerobic metabolism (21). Namely, an impaired HRR signifies that the body is struggling to remove the lactic acid efficiently, consequently curtailing an athlete's lifting capacity and performance at their peak (20-21, 22).

The physiological consequences extend beyond these points. HRR failure can lead to a skewed perception of effort (23). Weightlifters might perceive their performance as significantly more strenuous than it actually is. Psychological doubt creeps in, while motivation takes a hit. Suddenly, the barbell feels heavier, and the mental barrier becomes a formidable obstacle to overcome. More importantly, it is essential to underscore the significance of technical precision and coordination in weightlifting (23-24). In cases of inadequate concomitant respiratory control, in which the degree of ventilation does not meet the heightened demands of exercise, the body's ability to efficiently exchange oxygen and carbon dioxide becomes compromised. This ultimately leads to a delayed HRR between lifts, potentially impeding subsequent lifts. Ultimately, HRR failure can compromise coordination and posture resulting from irregulated breathing patterns in supporting the physiological demand of intense weightlifting performance (23, 25-26). These disturbances can degrade overall lifting technique efficiency and effectiveness. This is not just a matter of mistaken movements. It also carries substantial implications for safety as it significantly increases the risk of injury and even negatively impacts one's overall health (27).

To mitigate these physiological and psychological impacts and enhance weightlifting performance, it is important for athletes to address the underlying factors contributing to HRR failure. Furthermore, monitoring heart rate and signs of incomplete or impaired HRR can help weightlifters adjust their routines and make informed decisions about their long-term training as needed to optimize performance and minimize the negative effects of unmanageable HRR.

3.4. Factors affecting HRR in weightlifting

HRR in weightlifting is influenced by various factors, reflecting the complex interplay between its physiological and psychological components. Hence, in this section, we aimed to highlight the multifaceted nature of the components of weightlifting.

Sex and age impact HRR in weightlifting. Studies have shown a difference between males and females during and after intense physical activities such as weightlifting (5, 7). Males tend to have larger hearts and greater stoke volumes, which can affect heart rate and HRR (7). Sex-based hormonal disparities, including variations in testosterone and estrogen levels, exert a substantial impact on various aspects of cardiovascular function, encompassing heart rate variability and cardiac autonomic control, thereby contributing to differential heart rate response and recovery patterns (28-29). Age is another significant factor affecting HRR in weightlifters. Young athletes tend to experience shorter recovery periods than their older counterpart (30). This can be attributed to the inherent vitality of the cardiovascular system in younger individuals that result in more rapid adjustments following intense exercise sessions. On the other hand, older athletes experience age-related alterations in cardiac function, including reduced cardiac elasticity, decreased stoke volume, and decreased overall efficiency, all of which may collectively contribute to a decelerated HRR (5, 31-32).

Cardiovascular function influences HRR in weightlifting. While weightlifters mostly prioritize strength and power, robust cardiovascular function may be equally crucial. Efficient cardiovascular function promotes oxygen delivery to the muscle, delaying fatigue and supporting sustained efforts between and during intense weightlifting attempts (10). An athlete's cardiovascular endurance, which is sometimes overlooked in weightlifting, plays a central role in how efficiently the heart rate can return to its baseline level after intense lifting efforts. Athletes with higher cardiovascular function often exhibit improved stoke volume, cardiac output, and overall cardiac efficiency, facilitating the rapid clearance of metabolic byproducts and optimization oxygen delivery efficacy to working muscle (3, 32-35) usually the whole body in weightlifting. Accordingly, enhanced cardiovascular function contributes to a more robust and responsive cardiovascular system, allowing for swifter HRR between lifts (35-36). Therefore, the need to incorporate proper HRR techniques and strategies related to cardiovascular function in the training regimens of weightlifters extends beyond HRR itself, influencing their resilience and sustained excellence in weightlifting performance.

It is widely accepted that maintaining optimal hydration levels is a fundamental prerequisite for sustaining efficient cardiovascular system function (37-39). Hydration influence the blood's viscosity and volume, facilitating the transportation of oxygen and nutrients to the muscles and organs, thus contributing to proper muscle contraction and coordination. Conversely, dehydration can significantly disrupt physiological function, which in turn places additional strain on the heart and circulatory system (39-40). This distorts the HRR, making it more difficult and prolonging the elevation of heart rate during and after exercise. The characteristics of weightlifting, involving intense efforts and increased cardiovascular demand, underscores the importance of maintaining an optimal fluid balance for efficient recovery, especially in HRR (41). Therefore, weightlifters must establish their hydration strategies well before entering a competition. Adequate fluid intake in the hours leading up to a workout lays the foundation for optimal hydration. The preemptive approaches ensuring proper hydration adequately prepare the weightlifter's cardiovascular system for the upcoming performance. Furthermore, to replenish fluid losses after exercise, weightlifters must prioritize timely rehydration, consuming fluids containing a mix of water, carbohydrate, and electrolytes (38, 42). This strategic approach not only

supports hydration, but it promotes proper muscle function and efficient heart rate regulation (40, 43)

Adequate energy availability, supported by a well-maintained glycogen store, ensures that weightlifters have the endurance required for successive lifts. A balanced combination of carbohydrates and proteins replenishes glycogen stores and accelerates rapid muscle recovery, promoting an efficient HRR (44-46). Moreover, maintaining stable blood glucose levels through consistent nutritional intake enhances the controlled dynamics of heart rate between and during weight lifts (47). However, beyond the aforementioned scientific principles, weightlifters rely on practical wisdom gained through their experiences, understanding the delicate balance between nutritional sufficiency and insufficiency, including hydration status. Therefore, most of all, weightlifters must maintain their own delicate equilibrium that contributes to an effective HRR.

It is important to acknowledge that the psychological response to performance is an inseparable part of psychological influence. The presence of elevated stress or anxiety about exercise performance can introduce a distinct psychological response to the HRR equation (48-50), which in turn may contribute to a potentially delayed or poor recovery process. Accordingly, weightlifters may experience heightened feelings of stress or anxiety before, during, or after their lifting session (51). This psychological distress can manifest as increased heart rate, muscle tightness, and even altered breathing patterns, which can persist beyond the lifting session and affect the post-exercise recovery phase (51-52). Fortunately, there are practical strategies available to weightlifters to address and mitigate the psychological challenges. The incorporation of relaxation techniques and preparations, such as muscle relaxation, guided imagery, or meditation, can effectively counteract elevated stress and anxiety, enabling weightlifters to return to more relaxed physiological state and have a more efficient HRR (53).

4. Conclusion

This comprehensive review illuminates the pivotal role of HRR in the elite weightlifters, unraveling its profound impact on the intricate balance between physiological and psychological facets governing athletic performance. The investigations underscores the multifaceted nature of HRR, emphasizing its influence on critical elements such as oxygen supply, breathing patterns, and overall lifting capacity in the dynamic context of weightlifting.

Exploring the possible elements in weightliting, the review highlights the interconnected aspects of sex, age, cardiovascular function, hydration, nutrition, and psychological aspects, all intricately shaping the dynamic landscape of HRR in weightlifting. By exploring the demands for HRR within the sport, the analysis provides a detailed examination of heart rate responses during distinct competition phases. Moreover, it probes into the physiological and psychological ramifications of HRR failure, offering valuable insights into how this phenomenon impacts the ability to perform optimally between lifts.

Ultimately, a central theme emerges regarding the need for weightlifters to meticulously manage the optimal cardiovascular function, hydration levels, and nutritional support, and psycholgical stability, recognizing their synergistic impact on HRR and, consequently, overall performance in weightlifting.

Understanding HRR patterns not only serves as a performance metric but also empowers athletes and coaches to make informed decisions regarding tailored training regimens and targeted recovery strategies. This detailed exploration contributes to the evolving discourse within sports science, providing a robust foundation for ongoing research and advancements in the optimization of athlete performance, particularly within the unique domain of weightlifting.

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