

The contribution of cryotherapy to the phenomenon of muscle overcompensation after intense lactic acid exertion in senior male volleyball players

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Abstract:

The objective of this study is to determine the benefits of using cryotherapy (ice bath) on the phenomenon of muscle overcompensation after intense lactic exercise. The study was conducted on a sample of 20 volleyball players from the MCB Laghouat club. To do this, we used a pre-experimental approach with a pre-test and a post-test, applying an ice bath at -20°C and a CMJ to assess the regression of vertical jump height. The physical and statistical data showed that $T = -2.35$, which have demonstrated that cryotherapy, following intense lactic exercise, promotes muscle recovery and contributes to the elimination of post-exercise pain. In contrast, passive recovery requires a prolonged convalescence period.

KEY WORDS: Cryotherapy; Physical Recovery; Volleyball; Countermovement Jump (CMJ)

الملخص:

الهدف من هذه الدراسة هو تحديد فوائد استخدام العلاج بالتبريد (الحمام الجليدي) على ظاهرة التعويض الزائد للعضلات بعد مجهود شديد. أجريت الدراسة على عينة من 20 لاعب كرة طائرة من نادي MCB Laghouat. ولهذا الغرض، استخدمنا نهجاً تجريبياً مسبقاً مع اختبار مسبق واختبار لاحق، حيث قمنا بتطبيق حمام جليدي عند درجة حرارة -20 درجة مئوية و CMJ، من أجل تقييم تراجع القفز العمودي. أظهرت البيانات الفيزيائية والإحصائية ما يلي: $T = -2.35$ ، أثبتت أن طريقة العلاج بالتبريد، بعد مجهود بدني مكثف، تعزز استعادة العضلات وتساهم في التخلص من آلام ما بعد التمرين. في المقابل، تتطلب الاستعادة السلبية فترة استشفاء طويلة.

الكلمات المفتاحية: العلاج بالتبريد؛ التعافي البدني؛ الكرة الطائرة؛ الإرتقاء العمودي (CMJ)

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1-Introduction:

The field of sports recovery has undergone remarkable changes, moving from traditional methods to innovative approaches. This article looks at the historical development of recovery techniques. 'Knowing how to train means knowing how to recover.' This quote is from Michel Pradet's book *La Préparation Physique* (Physical Preparation) (published by INSEP in 1996). This means that recovery is an integral part of the training process.

Athletes know the importance of effective training, but they do not always pay as much attention to sports recovery. Noubli-dih Amel (2023) affirmed that « intensive practice is a particular and specific exercise that requires special vigilance against sports injuries caused by overtraining». However, athlete recovery is perhaps just as essential to performance and endurance, and deserves the same attention. Recovery strategies are a key element of athletic performance. Professional athletes and, increasingly, average active adults are taking advantage of new recovery therapies to speed up recovery time, reduce inflammation and take care of themselves. The main obstacle is access to expensive recovery technology in a safe, controlled and convenient environment.

Abbas Lakhdar, & al.(2018) mentionned that «the recovery process occurs after physical training with maximum or high training loads or after competitions. Fatigue is a temporary decline in performance capacity or the inability to continue physical effort as required . It is a positive physiological and chemical phenomenon that occurs in the body's systems and organs ». Recovery is a period during which the body engages in higher-than-normal metabolic activity, compared to a period of pure rest, in order to allow all the systems used during exercise to restructure themselves. In effect, it is a process of regaining what has been lost. In sports, it refers to all the processes implemented to enable athletes to regain their physical integrity, such as physical and mental relaxation. It is essential to relax physically by doing a short stretching session to reduce muscle tension, loosen up the muscles and prepare them for new performances. Massage or self-massage is also a good way to relax and recover physically. However,

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there is a close link between the mind and body. This is the basis of all forms of active relaxation, such as autogenic training, progressive muscle relaxation, meditation, yoga, etc. Ten minutes is enough to reduce tension and lactate concentration in the muscles and promote good recovery. Among the effective recovery methods is the use of cold, which is considered a valuable ally. The Kneipp method consists of taking a shower, alternating between hot and cold water five to eight times for thirty seconds each time. Hot water stimulates blood circulation and relaxes tendons and muscles, while cold water relieves muscle pain. Sleep is therefore an integral part of good recovery, both in terms of quantity and quality. It is during this phase that the body regenerates, repairs minor injuries and trauma, and muscle growth takes place. This is an easy method for athletes to apply after intense training. Cryotherapy or ice baths are an increasingly popular recovery method among professional and amateur athletes. This technique involves immersing the body in an ice bath, usually after training or competition. The use of ice baths dates back several centuries, with its origins in ancient cold bathing practices. In the 19th century, doctors began to study the effects of cold on the human body, laying the foundations for modern cryotherapy. The result: ice baths are a natural and versatile solution for improving muscle recovery and overall health. Véronique Billat (1998) points out that there are three key points to remember for good recovery: Knowing how to relax physically and mentally is essential for proper recovery. Cold is a powerful ally in reducing inflammation, and sufficient hydration promotes cell regeneration.

Sports recovery is a relatively new field of research. In the past, scientists focused primarily on the impact of training methods on performance. However, as the demands of athletic performance have increased significantly, athletes and coaches have expanded their investigations beyond training, exploring other avenues for optimising performance. The question that arises is: how can athletic conditioning be prepared by relying on the athlete's recovery and muscular supercompensation? This requires the adoption and integration of new recovery techniques.

Elite and professional athletes often recover from injuries more quickly because they have access to the best scientists and sports

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advisors and are in peak physical condition to begin with. For example, if an elite athlete tears their anterior cruciate ligament, they may undergo the same anterior cruciate ligament reconstruction surgery as the average person, but all the structures supporting their knee are strong, which can facilitate recovery and rehabilitation. In addition, when physical performance is the goal, time must be devoted to physiotherapy and other rehabilitation protocols. Many elite athletes incorporate dedicated recovery times and techniques into their daily routine, hence the use of specialised athletic performance centres such as the Centre for Research and Athletic Performance, which help elite athletes reach and exceed their highest levels of performance, mitigate the risk of injury and re-injury, and integrate active recovery into their strength training.

Philippe Burtin (2010) emphasises that training programming is goal-oriented. It is specific, adaptable and progressive. It incorporates periods of progression and recovery. Among the effective recovery strategies in sports training, it is important to consider the preferred recovery method after intense training in order to optimise the phenomenon of supercompensation.

1.1 Partial questions

- Is the counter-movement jump test a relevant indicator of the physical condition of senior male volleyball players?
- What impact does anaerobic lactic training have on vertical jump height in volleyball players, and what is the estimated recovery time?
- What role does ice bathing play in the sports recovery process following intense lactic effort?

Study hypothesis

Among the various useful recovery methods, there is one that is preferred for accelerating the phenomenon of overcompensation after intense physical exertion.

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Partial hypotheses

- The counter-movement jump test can reveal the physical condition of senior male volleyball players.
- Anaerobic lactic training has a significant influence on improving vertical jump height in volleyball players, accompanied by an accurate estimate of the recovery time required.
- The use of an ice bath after lactic training helps to eliminate lactic acid levels and reduce muscle soreness.

2- General objective of the study:

Training, especially high-level training for competitive athletes, involves putting the body under stress. It improves physical condition and performance by pushing the body beyond its limits. The body then repairs and strengthens itself so that it is ready for the next challenge. This strengthening process takes place during rest. Without adequate rest, athletes risk exhaustion rather than improvement. To recover, athletes must provide their bodies with the resources necessary to conserve energy and rebuild strength after intense physical activity: sleep, nutrients, blood flow, etc. Research into the best recovery routines for athletes has identified ways to make the body more effective and efficient in providing and utilising these resources, thereby improving recovery time and results.

Advances in sports science have been accompanied by developments in recovery methods. The introduction of cryotherapy, compression garments and advanced physiotherapy techniques has brought about significant improvements. These methods aim to reduce recovery time, relieve pain and prevent injury. Sports recovery therefore relies primarily on rest and basic physiotherapy. Techniques such as massage, hydrotherapy and stretching are the fundamental elements of this programme. Nutrition and hydration are also essential for replenishing energy reserves and repairing muscle damage.

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Our study falls within the field of physical preparation for athletes and aims to:

- Assess the physical fitness of volleyball players using the counter-movement jump test.
- Assess the influence of anaerobic lactic training on the vertical jump of senior male volleyball players.
- Determine the type of recovery after intense lactic effort.
- Demonstrate the means of recovery available at the local level.
- Propose useful techniques for club coaches who work without a physical trainer.

3- Procedural definition of the concepts mentioned in the research:

- Training

Training is a process during which athletes are exposed to repeated stimuli in order to create useful adaptations that delay fatigue, increase power, refine motor coordination, or reduce the risk of injury, because 'High-intensity exercise training contributes to the production and accumulation of blood lactate' (Menzies, P., et al. 2010). The outcome of training depends on the type of stimulus. Understanding this cause-and-effect relationship between dose and response is sufficient to design an appropriate training programme. (Michael Lambert and Iñigo Mujika, 2018)

Overcompensation

This is a phenomenon of 'overcompensation' that is sometimes used as a strategy to optimise performance for an important competition. The principle of overcompensation can be described as a planned break from sustained training followed by a period of recovery and optimised performance (Kentta and Hassmen 1998).

- Passive recovery

Passive recovery is a period of complete rest and absolute physical inactivity, during which the body is left in a state of tranquillity to promote repair and regeneration after physical exertion. Unlike active

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recovery, which includes light physical activity, passive recovery focuses exclusively on rest, sleep, and sometimes the application of techniques such as massage or cold showers, without any muscular exertion.

- Cryotherapy (Ice bath)

Cryotherapy is a cold treatment that applies very low temperatures to part or all of the body to destroy cells, reduce inflammation and pain, or promote muscle recovery.

Localised cryotherapy

Using cryotherapy devices that specifically target areas of pain or swelling, it can be practised locally (on a specific area) or globally (whole body), and comes in various forms, such as the application of liquid nitrogen to the skin or intense cold chambers.

- Active recovery and mobility training

Active recovery involves low-intensity exercises that aim to increase blood flow and prevent muscle stiffness. These exercises include walking, light cycling, stretching, and yoga.

- Rest

Rest is a key component of all sports recovery protocols. Effective training puts your body under stress and even damages your muscles at a microscopic level, prompting your body to rebuild itself and become stronger. Without rest, your body has no chance to rebuild itself effectively.

Similar studies

In the study by Lourençon et al. (2023), the study was conducted on 32 professional footballers who were monitored, and the staff used indicators to determine training load and fitness levels, including the CMJ. The flight time and height of the CMJ jump were relevant indicators for determining the athletes' objective fitness level. The CMJ was performed just before training began two days before the match, and negative correlations were found with the training load calculated three days before the match. The higher the RPE, the lower the jump height and the shorter the flight time, resulting in lower performance.

Belkacem Zemmouri study (2015): This study addressed the most important recovery methods and means aimed at renewing,

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compensating for and restoring the ability to perform a certain load again in order to continue training and competitions without any negative impact on the athlete. This is to avoid possible injuries resulting from muscle fatigue, which sometimes leads to exhaustion and a decline in the athlete's performance, and in some cases leads the athlete to stop practising.

Study by Ali Houcie Acheknati (2020). This research aims to determine the effectiveness of certain recovery methods on the rate of recovery from muscle pain in long-distance swimmers in Kuwait. The researcher used the experimental method for both experimental groups based on pre-post measurements to verify their suitability for the research objectives and hypotheses. The research sample was intentionally selected from among Al-Qadisiyah players for long-distance swimmers for the 2015-2019 training seasons, comprising ten swimmers in addition to eight swimmers outside the basic research sample to conduct the exploratory research experiment. The researcher conducted a survey study on a sample of the studied community and outside the basic sample consisting of (8) swimmers from Al-Qadisiyah long-distance swimmers and outside the basic research sample for the age level below (19) years old in the period from 01/02/2015 to 05/02/2015 AD under the same conditions as the basic research experiment. One of the most important results was the use of the sauna as a healing method, which leads to positive physiological changes in heart rate, blood sugar and lactate – systolic and diastolic blood pressure.

4- The methodological procedures used in the study:

4-1 Method and tools:

Study approach

In this study, we used the counter movement jump (CMJ) test to study the recovery time of senior male volleyball players after intense lactic effort, applying pre- and post-tests. To do this, we followed a pre-experimental approach without a control group in order to better understand the requirements of the study.

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Study population and samples

The study population consisted of volleyball players from the Laghouat province. Our sample consisted of 20 senior male athletes playing volleyball in the national division one-B club MCBL Laghouat.

Study methods and resources

- The scientific foundations of the tool

The CMJ test and athletic fitness : The countermovement jump (CMJ) can be used to observe neuromuscular fatigue.

The countermovement jump (CMJ) test is an assessment of lower limb power consisting of a vertical jump that begins with a rapid descent before an explosive upward impulse. This movement exploits the stretch-shortening cycle to measure lower body power and explosive strength, and can be used to detect muscle asymmetries or strength deficits in an athlete. The test measures the height of the jump, but can also assess the force developed on the ground using specific technologies.

Purpose of the test

- Assess lower body power: The CMJ is a reliable and reproducible indicator of lower limb power.
- Measure explosive strength: It allows the analysis of an athlete's ability to produce maximum force quickly.
- Detect asymmetries: The results can reveal imbalances in strength between the legs, which can be indicators of injury risk.
- Track training progress: The test helps to evaluate the effectiveness of training programmes

and identify needs.

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Test steps: How to perform the test

1. Starting position: The athlete stands with their hands on their hips to avoid the effect of swinging their arms, which could skew the results.
2. Counter-movement: Without stopping, the athlete quickly bends their knees and hips downwards to a depth of their choice.
3. The jump: Immediately after the downward movement, the athlete jumps as high as possible, fully extending the ankle, knee and hip joints.
4. The landing: The landing is made on the balls of the feet, returning to the starting position.

Measurement and analysis

Jump height: The most common measurement is the maximum height reached during the jump.

Measurement technologies: Tools such as contact mats, force platforms, high-speed cameras or position transducers are used for accurate measurement and power and force calculations. Multiple attempts: It is common to perform several jumps (e.g., three), and the best result is recorded as the performance.

Cryotherapy:

Cryotherapy involves exposing the body to very cold temperatures (usually between -8°C and -12°C) for a short period of time (3 to 5 minutes). The aim is to reduce inflammation and muscle pain, stimulate blood circulation and speed up recovery. In other words, cryotherapy temporarily reduces muscle temperature, stimulates vasoconstriction and reduces inflammation and pain.

- **Statistical tools :** The researchers used Excel to transcribe and analyze the results of the study using the following parameters:

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- Arithmetic mean: $M = \Sigma X/n$: M) arithmetic mean.
- T-Test
- Standard deviation

4-2 Presentation and Analysis of Results:

Analysis of the first hypothesis

-The counter-movement jump test can reveal the physical condition of senior male volleyball players.

Table N°1: Presentation of morphological components and counter-movement jump results before exercise

Criterion	High cm	Weight kg	Age year	Result C.M.J before exercise in cm
N°=20				
Mean	191,25	81,83	27,65	67,52
Standard deviation	4,11	5,30	5,02	4,62

According to the table below, the average height and weight is (191.25 cm, 81.83 kg), which indicates that the players have a morphological profile suited to high-level competition. With regard to the assessment of physical condition, the vertical jump (CMJ) test

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allowed us to assess the volleyball players' vertical jump capacity in order to obtain an accurate representation of their physical condition. Good vertical jump ability requires a combination of strength-speed, explosive strength and lower limb muscle strengthening. Based on this analysis, we can conclude that the CMJ test is a relevant indicator of physical fitness.

Analysis of the second hypothesis

- Anaerobic lactic training has a significant influence on improving vertical jump height in volleyball players, accompanied by an accurate estimate of the recovery time required.

To better address the hypothesis below, we applied the CMJ test to our study sample.

Table N°2: Presentation of counter-movement jump results before exercise and Result of CMJ after 24 hours of exercise (without cryotherapy)

Criterion	Result of C.M.J before exercise in cm	Result of CMJ after 24 hours of exercise in cm (without cryotherapy)
N°=20		
Mean	67,52	55,6
Standard deviation	4,62	3,16
T.test	T= -2.201	

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Table 2 illustrates the results of the volleyball players' vertical jump according to the CMJ test, prior to exercise, with an average of 67.52 cm and a standard deviation of 4.62. In contrast, the CMJ results, measured 24 hours after exercise in passive rest conditions, show an average of 55.6 cm and a standard deviation of 3.16. This indicates a significant decline in vertical jump height following intense exercise prior to the pre-test. The t-test analysis reveals a significant difference of -2.201 between the pre-test and post-test, in favour of the results obtained during the pre-test.

Analysis of the third hypothesis

-The application of a post-workout ice bath of a lactic nature contributes to the elimination of lactic acid levels and the reduction of muscle soreness.

Table N°3: Presentation of counter-movement jump results before exercise / Result of CMJ after 24 hours of exercise (without cryotherapy)/ Result of CMJ after 24 hours of exercise (with cryotherapy)

Criterion	Result of C.M.J before exercise in cm	Result of CMJ after 24 hours of exercise in cm (without cryotherapy)	Result of CMJ after 24 hours of exercise in cm (with cryotherapy)
N°=20			
Mean	67,52	55,6	63,3
Standard deviation	4,62	3,16	5,31

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T.test	T= -2.235
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The table below illustrates the comparison of results between the C.M.J before exercise, the C.M.J after 24 hours of exercise (without cryotherapy) and the C.M.J after 24 hours of exercise (with cryotherapy). The statistical data revealed that the regression mentioned in Table 2 is greater than that observed between the C.M.J before exercise and the C.M.J after 24 hours of exercise with cryotherapy (67.52 > cryotherapy 63.3 > passive recovery without cryotherapy 55.6).

5- Discussion and interpretation of the results

The CMJ test is a physical test that assesses a person's vertical jump. This same test also assesses lower limb strength (Weineck, 1997). In our study, we used this test to estimate the physical fitness of senior male volleyball players at the MCBL club, as vertical jumps require explosive white fibre strength and red fibre speed. The extension distance of the lower limb during the push phase. ‘This anthropometric variable depends on segmental lengths, but also on joint mobility, and has a considerable influence on the time taken to produce power by the lower limb extensors, and consequently on power, for the same mechanical work (identical jump height and body mass).’ In fact, during any type of effort, whether during a training session or a competition, the body will adapt more or less quickly to the demands of that effort, depending on its level of training.

To gain a more precise understanding of the phenomenon of muscle overcompensation and the disruption of the stabilisation of the physiological homeostasis threshold, we applied the vertical jump (CMJ) in our study and, during the training session, we focused our efforts on intense lactic development, which requires a recovery period of up to three to four days. Billat (1998) states that intense anaerobic lactic effort requires a minimum recovery period of 48 to 72 hours. This led us to explore the phenomenon of cooling in volleyball players. The T-test result of -2.235 between the variables mentioned in

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Table 3 reveals a significant value that justifies the use of cryotherapy, particularly ice baths.

Furthermore, data corroborates that cooling is beneficial for post-exercise recovery. Cryotherapy by immersion in cold water (10 minutes at 10 °C) has a favourable effect after intense training. The differences observed were significant in terms of physical performance markers.

6-Conclusion

Muscle recovery and supercompensation have become areas of constant innovation. Modern technologies combined with improved traditional methods allow athletes to maximise their performance while reducing the risk of injury. Advances in the personalisation of recovery approaches (based on data collected by connected devices and artificial intelligence) point to increasingly effective and targeted methods.

Practising a sport or physical activity can tire the body, which needs a certain amount of time to recover. It is the quality and proper management of this recovery that will enable you to resume physical and sporting activity for health purposes.

The analysis of new technologies and methods of post-training recovery and muscle supercompensation focuses on optimising the body's regeneration after intense physical exertion in order to improve future performance while minimising the risk of injury. In recent years, innovative technologies and approaches based on scientific research have emerged to improve muscle recovery and promote muscle supercompensation (the phenomenon whereby the body adapts and becomes more efficient after a recovery phase).

Recovery can begin immediately after exercise or, conversely, be deliberately programmed in the form of delayed cycles. Conversely, the physical trainer or doctor may schedule periods of supercompensation.

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During the recovery period, the athlete must not only allow the joints, muscles and tendons to regenerate and return to good working order, but also allow the metabolism to eliminate waste and replenish reserves. This necessarily requires the implementation of a diet adapted to recovery.

Heart rate remains the preferred indicator for determining the body's degree of recovery. All athletes should know their baseline heart rate and monitor it regularly. Fitness weight should be a good criterion for proper recovery. Athletes can also check their body temperature every morning at rest, upon waking. Cryotherapy is recommended after exercise to eliminate muscle soreness and reduce lactic acid. In other words, recovery through ice baths is a second phase of preparation for athletes to receive the load of the following training session.

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