QUALITY IN SPORT
eISSN 2450-3118 · Open Access · Peer-reviewed
apcz.umk.pl/QS Nicolaus Copernicus University in Toruń

MARKOWSKI, Bartłomiej, GRZYWACZ, Martyna, DOBROWOLSKA, Agnieszka, RZĄSA, Marta, ZIĘBKA, Wojciech, DZIEWIĘCKA, Oliwia, KWIECIŃSKI, Wojciech, MĄDRZAK, Julia, IWASZKO, Magdalena, and KACZMARCZYK, Agata. Cold Water Immersion as Supporting Method for Post-Exercise Recovery and a Potential Tool for Improving General Health – A Narrative Review. Quality in Sport. 2026;73:75280. https://doi.org/10.12775/QS.2026.73.75280

ARTICLE TIMELINE
Received: 12.08.2026. Revised: 30.08.2026. Accepted: 06.09.2026. Published: 14.09.2026.

The journal has been awarded 20 points in the parametric evaluation by the Polish Ministry of Higher Education and Science (Annex to the announcement of 05.01.2024, No. 32553). Unique Journal Identifier: 201398. Scientific disciplines assigned: Economics and Finance (Field of Social Sciences); Management and Quality Sciences (Field of Social Sciences).
Punkty Ministerialne z 2019 – aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).

Cold Water Immersion as a Supporting Method for Post-Exercise Recovery and a Potential Tool for Improving General Health – A Narrative Review

Bartłomiej Markowski
ORCID https://orcid.org/0009-0006-2538-9907
bartekmarkowski1904@gmail.com
Medical University of Lodz, Poland

Martyna Grzywacz
ORCID https://orcid.org/0009-0002-4366-4379
martynagrzywacz99@gmail.com
Central Clinical Hospital of the Medical University of Lodz , Poland

Agnieszka Dobrowolska
ORCID https://orcid.org/0009-0000-5645-7518
dobrowolska58@gmail.com
Maria Skłodowska-Curie Provincial Hospital, Zgierz, Poland

Marta Rząsa
ORCID https://orcid.org/0009-0000-6817-6940
marta.rzasaa@gmail.com
Maria Skłodowska-Curie Provincial Hospital, Zgierz, Poland

Wojciech Ziębka
ORCID https://orcid.org/0009-0000-6835-6773
ziebka.wojciech@gmail.com
A. Falkiewicz Specialist Hospital in Wroclaw, Poland

Oliwia Dziewięcka
ORCID https://orcid.org/0009-0008-7784-1680
odziewiecka24@wp.pl
A. Falkiewicz Specialist Hospital in Wroclaw, Poland

Wojciech Kwieciński
ORCID https://orcid.org/0009-0004-2891-6974
wojciechkwiecinskimed@gmail.com
Independent Public Healthcare Centre in Szamotuly, Poland

Julia Mądrzak
ORCID https://orcid.org/0009-0007-3387-9225
juliamadrzak21@gmail.com
Faculty of Medicine, Kazimierz Pułaski University of Radom, Radom, Poland

Magdalena Iwaszko
ORCID https://orcid.org/0009-0000-6010-5443
iwaszkomagda1102@gmail.com
Jan Biziel University Hospital No. 2 in Bydgoszcz , Poland

Agata Kaczmarzyk
ORCID https://orcid.org/0009-0005-7448-9827
agata.kaczmarzyk@stud.umed.lodz.pl
Central Clinical Hospital of the Medical University of Lodz , Poland

Abstract

Background. Cold Water Immersion (CWI) is a widely used recovery strategy in sports; however, its effectiveness depends on the type of exercise performed and the intended training goals. This narrative review evaluated the effects of CWI on post-exercise recovery, neuromuscular function, training adaptations, and general health.

Materials and methods. A systematic search of PubMed, Scopus, and Web of Science databases was conducted to identify experimental studies, randomized controlled trials, systematic reviews, and meta-analyses investigating the effects of CWI. The available evidence was narratively reviewed and qualitatively synthesized.

Results. CWI reduces delayed onset muscle soreness (DOMS), improves perceived recovery, and may accelerate neuromuscular recovery following high-intensity exercise. However, regular CWI application after resistance training may attenuate hypertrophic adaptations. Evidence regarding the general health benefits of CWI remains limited.

Conclusions. CWI represents an effective short-term recovery strategy; however, its application should be tailored to individual training objectives. Further research is required to establish optimal protocols and determine long-term physiological effects.

Keywords: cold water immersion, recovery, DOMS, neuromuscular function, training adaptations

Introduction

Intense physical exercise, particularly involving eccentric muscle contractions, repeated sprint efforts, and high-intensity activities, may lead to temporary impairments in muscle function known as exercise-induced muscle damage (EIMD). This phenomenon is characterized by reduced force-generating capacity, decreased range of motion, the occurrence of delayed onset muscle soreness (DOMS), and increased concentrations of biochemical markers associated with muscle structural damage, such as creatine kinase (CK) and myoglobin (Mb). These symptoms may persist for several days and negatively affect the ability to perform subsequent training sessions, which is particularly relevant in sports requiring frequent competition and short recovery intervals.

One of the most commonly used strategies to support post-exercise recovery is Cold Water Immersion (CWI), which involves immersing part or the entire body in cold water after physical exercise. This method is widely applied in both elite and recreational sports due to its accessibility and potential influence on physiological processes involved in recovery. Commonly used protocols involve water temperatures below 15°C and exposure durations ranging from several to several dozen minutes.

The mechanisms underlying the effects of CWI are primarily associated with the body's response to cold exposure. A reduction in tissue temperature leads to vasoconstriction, decreased blood flow in superficial tissues, and reduced formation of post-exercise swelling. Following the completion of cold exposure, increased blood flow occurs, which may support metabolite transport and tissue repair processes. Furthermore, cold exposure influences nerve conduction and pain perception, potentially contributing to reduced subjective muscle soreness following intense exercise.

Despite its widespread practical application, the effectiveness of CWI remains a subject of scientific debate. Numerous studies indicate beneficial effects of this method in reducing DOMS and accelerating the recovery of neuromuscular function after intense exercise. At the same time, evidence suggests that regular CWI application immediately after resistance training may reduce activation of molecular pathways associated with muscle hypertrophy, potentially limiting long-term training adaptations.

The effectiveness of CWI depends on multiple factors, including water temperature, exposure duration, type of exercise performed, and the purpose of its application. In athletes requiring rapid restoration of performance capacity between competitions, CWI may represent a valuable recovery tool. However, during training periods focused on developing strength and muscle mass, routine use of CWI should be considered individually.

The aim of this review is to analyze current scientific evidence regarding the effects of Cold Water Immersion on post-exercise recovery, neuromuscular function, exercise capacity, training adaptations, and selected aspects of general health.

Research Materials and Methods

This study employed a narrative literature review methodology. Searches of the PubMed, Scopus, and Web of Science databases were conducted to identify scientific publications investigating the effects of Cold Water Immersion (CWI) on post-exercise recovery, muscle function, physiological responses, and long-term consequences of this intervention. The search strategy included combinations of the following keywords: "cold water immersion", "cryotherapy", "recovery", "exercise", "muscle damage", "DOMS", "neuromuscular function", and their equivalents using Boolean operators (AND/OR).

The review included original experimental studies, randomized controlled trials (RCTs), systematic reviews, and meta-analyses examining the application of CWI in athletes and physically active individuals. Particular attention was given to studies evaluating the effects of cold immersion on markers of muscle damage (CK, Mb, LDH), perceived muscle soreness, neuromuscular function parameters, exercise performance, and adaptive processes occurring in response to training.

The analyzed publications included various CWI protocols involving different water temperatures, exposure durations, and types of preceding exercise. Due to substantial methodological heterogeneity among studies, a qualitative synthesis of results was performed instead of a quantitative analysis.

The selection of literature was based on current scientific evidence regarding the use of cold immersion in sports and exercise physiology. The findings from the included studies were comparatively analyzed to determine potential benefits, limitations, and practical applications of CWI.

During the preparation of this manuscript, artificial intelligence tools were used as editorial support, including improvement of linguistic consistency, adaptation of the writing style to academic standards, organization of the manuscript structure, and assistance with formatting references according to APA 7 guidelines. All suggestions generated by the tool were subsequently reviewed and modified by the author. The author assumes full responsibility for the scientific accuracy and final version of the manuscript.

Discussion

1. Effects of Cold Water Immersion on Post-Exercise Recovery

Cold Water Immersion (CWI) is one of the most commonly used strategies for supporting recovery following intense physical exercise. Particular interest in this method is observed among athletes participating in disciplines requiring frequent competitions or short recovery intervals between training sessions. Potential mechanisms responsible for the effects of CWI include reductions in tissue temperature, alterations in blood flow, limitation of post-exercise swelling, and modulation of nerve conduction and pain perception. However, the impact of this method on actual restoration of muscle function depends on exercise characteristics, the applied protocol, and the recovery parameters being assessed.

One of the most frequently investigated areas of research is the effect of CWI on recovery following exercise-induced muscle damage (EIMD). A study involving 18 healthy women evaluated the effectiveness of a five-day cold immersion protocol following intense eccentric exercise of the hamstring muscles. Participants performed a series of maximal eccentric contractions and subsequently underwent 14-minute immersions in water at 14°C or passive recovery for five consecutive days. The CWI group demonstrated a faster recovery of maximal voluntary isometric contraction (MVC), reduced delayed onset muscle soreness (DOMS), improved range of motion, and faster normalization of plasma myoglobin concentration. These findings suggest that repeated cold exposure may reduce both functional and biochemical consequences of muscle damage.

Similar results have been reported in studies involving exercise protocols characteristic of team sports. A randomized controlled trial conducted among soccer players investigated the effect of CWI on recovery following a 90-minute protocol simulating match demands. Cold-water immersion was compared with neutral-water immersion. Researchers assessed maximal voluntary contraction force, muscle activation, parameters of central and peripheral fatigue, sprint performance, and markers of muscle damage.

The application of CWI was associated with a smaller decline in MVC and faster restoration of neuromuscular function compared with the control condition. Players using cold immersion recovered their ability to perform high-intensity efforts more rapidly, suggesting that this method may be particularly beneficial in situations requiring short recovery periods between consecutive training sessions or competitions.

Benefits associated with CWI have also been observed in combat sports. A study conducted among highly trained Brazilian jiu-jitsu athletes compared the effects of a 19-minute immersion in water at approximately 6°C with passive recovery following an intense training session. Researchers analyzed markers of muscle damage, perceived soreness, subjective recovery, and upper- and lower-limb power production. Following CWI, lower lactate dehydrogenase (LDH) concentrations, reduced muscle soreness, and higher perceived recovery scores were observed compared with passive recovery. These results suggest that cold immersion may support the restoration of performance capacity following intense physical demands characteristic of contact sports.

However, it should be emphasized that the effectiveness of CWI is not consistent across all conditions. A study comparing two cold-water immersion protocols (9°C and 14°C) with passive recovery assessed the influence of water temperature on recovery following exercise-induced muscle damage. Both protocols reduced perceived muscle soreness compared with the control condition; however, only immersion at 14°C was associated with faster recovery of maximal isometric strength. At the same time, no significant differences were observed between groups for most analyzed parameters, suggesting that water temperature alone may not be the only factor determining the effectiveness of CWI.

The results of a meta-analysis conducted by Poppendieck et al. (2013) indicate that the influence of cooling strategies on athlete recovery is moderate and varies depending on the analyzed outcome measure. The authors demonstrated that CWI may improve perceived recovery and reduce muscle soreness, whereas its effects on direct performance-related measures, such as strength and endurance capacity, are less consistent. They also emphasized the importance of individually adjusting cooling protocols according to exercise characteristics and training objectives.

Table 1. Main studies investigating the effects of CWI on post-exercise recovery

Author	**Participants**	**CWI protocol**	**Main findings**
Vaile et al.	18 women	14°C, 14 min for 5 days	↓ DOMS, ↑ MVC, faster normalization of Mb
Pointon et al.	Soccer players	CWI vs. neutral water immersion	↑ neuromuscular function, ↑ sprint recovery
Fonseca et al.	BJJ athletes	6°C, 19 min	↓ LDH, ↓ DOMS, ↑ subjective recovery
Poppendieck et al. (meta-analysis)	36 studies	Various protocols	Moderate improvement in recovery, greatest effect on DOMS

2. Effects of Cold Water Immersion on Neuromuscular Function and Exercise Performance

Beyond its effects on perceived muscle soreness and markers of muscle structural damage, an important area of research regarding Cold Water Immersion (CWI) is its potential influence on the restoration of neuromuscular function and the ability to perform subsequent exercise. This aspect is particularly relevant for athletes participating in sports characterized by repeated high-intensity efforts, such as team sports, combat sports, and disciplines requiring short recovery periods between consecutive performances.

One of the mechanisms through which CWI may influence post-exercise function is the reduction of tissue temperature and limitation of cardiovascular strain following intense exercise. A study conducted under conditions of elevated ambient temperature evaluated the effects of cold immersion on neuromuscular recovery following exercise simulating the demands of team sports. Ten athletes completed a protocol involving repeated sprints and high-intensity running at an environmental temperature of 32°C, after which they underwent 20 minutes of cold-water immersion or passive recovery.

The analysis included maximal voluntary contraction (MVC), central muscle activation, core body temperature, heart rate, and selected markers of muscle damage. CWI resulted in a faster reduction in body temperature and decreased cardiovascular strain. During the first hours following exercise, faster improvements in MVC and central muscle activation were also observed in the CWI group. However, after 24 hours, differences between groups were reduced, suggesting that the beneficial effects of CWI may be primarily short-term.

Similar observations have been reported in studies examining the effects of CWI following resistance exercise. In an experiment involving 10 physically active men, researchers compared the effects of a 10-minute immersion in water at 10°C with active recovery consisting of low-intensity cycling. Maximal and submaximal muscle function, intramuscular temperature, and selected biochemical markers were assessed.

CWI was not shown to accelerate recovery of maximal strength or improve vertical jump performance more effectively than active recovery. However, participants who used cold immersion were able to perform a greater amount of work during a subsequent submaximal exercise test. Additionally, reduced myoglobin concentrations were observed, which may indicate a lower degree of muscle damage. These findings suggest that CWI may not directly enhance maximal muscle performance immediately after exercise but may improve tolerance to subsequent training loads.

The effects of CWI on neuromuscular function have also been investigated in contact sports. In an experiment conducted among rugby players, researchers applied a protocol reflecting match demands, including sprint efforts, high-intensity running, and repeated physical contacts. After completing the exercise protocol, athletes underwent either a 20-minute CWI session or passive recovery.

The researchers assessed maximal voluntary contraction, muscle activation, electromyographic activity (EMG), contractile properties of the muscles, and perceived muscle soreness. The results demonstrated that CWI accelerated the restoration of neuromuscular parameters immediately after recovery, including increases in MVC, central activation, and electromyographic activity. Furthermore, athletes reported lower levels of muscle soreness during the first hours following exercise. However, no significant changes were observed in blood markers of muscle damage, suggesting that the primary effect of CWI may involve improvements in functional recovery and fatigue perception rather than direct limitation of structural muscle damage.

The findings of the meta-analysis by Poppendieck et al. (2013), which examined the effects of different cooling strategies on athlete recovery, should also be considered. The authors indicated that CWI may improve selected recovery-related parameters; however, the magnitude of the effect depends on the type of test performed, measurement timing, and characteristics of the preceding exercise. The greatest benefits were observed for subjective recovery assessment and reduction of muscle soreness, whereas effects on objective performance indicators were more limited.

Table 2. Effects of CWI on Selected Recovery Parameters

Parameter	Effect of CWI	Strength of evidence
DOMS	Reduction	High
Subjective recovery	Improvement	High
MVC	Slight improvement	Moderate
Sprint performance	Possible improvement	Moderate
CK	Inconsistent results	Low
LDH	Possible reduction	Moderate
Myoglobin	Possible reduction	Moderate
Range of motion	Improvement	Moderate

3. Effects of Cold Water Immersion on Long-Term Training Adaptations

Despite numerous reports indicating beneficial effects of Cold Water Immersion (CWI) on short-term post-exercise recovery, increasing attention has been directed toward the potential consequences of regular CWI use in the context of long-term training adaptations. This issue is particularly important in resistance training, where the primary goal is to stimulate adaptive changes leading to increases in muscle strength and hypertrophy.

Muscle adaptation following resistance exercise depends on the activation of numerous cellular mechanisms, including increased muscle protein synthesis, activation of satellite cells, and regulation of signaling pathways associated with hypertrophic processes. One of the key regulators of these processes is the mechanistic target of rapamycin (mTOR) pathway and its downstream effector p70S6K, which plays an important role in controlling muscle protein translation. Due to its analgesic effects and potential ability to reduce inflammatory responses, CWI may influence some of the mechanisms responsible for training adaptation.

One of the most important studies investigating this issue was conducted by Roberts et al. (2015), who examined the effects of regular CWI application after resistance training on muscle strength development and hypertrophy. The study included 21 physically active men participating in a 12-week resistance training program. After each training session, participants performed either a 10-minute cold-water immersion protocol or active recovery.

Following completion of the training program, the active recovery group demonstrated greater increases in muscle strength and hypertrophy compared with the CWI group. Additionally, only the active recovery group showed increases in the cross-sectional area of type II muscle fibers, a greater number of myonuclei per muscle fiber, and improved performance during isokinetic work capacity testing. These findings suggest that regular CWI immediately after resistance training may attenuate some processes responsible for optimal muscle adaptation.

The mechanisms responsible for these differences have also been investigated in studies assessing the molecular response following a single resistance exercise session. It has been demonstrated that CWI following resistance training reduces satellite cell activation and decreases p70S6K signaling responses compared with active recovery. Since satellite cells play an essential role in muscle remodeling and increasing growth potential, reduced activation of these cells may partially explain the lower gains in muscle mass observed after long-term CWI use.

Similar conclusions have been presented in reviews examining the molecular mechanisms underlying cold immersion. Authors suggest that although CWI effectively reduces muscle soreness and improves perceived recovery, its repeated application after hypertrophy-oriented training may limit activation of anabolic pathways by reducing inflammatory responses and altering signaling processes required for muscle adaptation.

However, it should be emphasized that the potential negative effects of CWI do not apply to all types of training. In endurance sports or disciplines requiring frequent repetition of high-intensity efforts, the priority is often rapid restoration of functional capacity rather than maximizing hypertrophy. In such situations, reducing inflammatory responses and perceived fatigue may provide practical benefits.

Research investigating endurance training indicates that the influence of CWI on long-term adaptations is less clear. Although single cold exposure sessions may affect selected mechanisms associated with mitochondrial biogenesis and metabolic responses, current

evidence is insufficient to confirm significant improvements in long-term endurance adaptations among individuals regularly using CWI.
Therefore, the application of CWI should depend on the primary training objective. In athletes undergoing periods of intensive competition, where rapid recovery between events is essential, this method may serve as an effective recovery strategy. Conversely, during phases focused on increasing strength and muscle mass, regular CWI immediately after resistance training may potentially reduce the full adaptive response of the body.

4. Application of Cold Water Immersion Beyond Sports Recovery

In recent years, Cold Water Immersion (CWI) and other forms of controlled cold exposure have gained popularity not only as strategies supporting sports recovery but also as potential methods for improving general health and psychological well-being. Interest in this area results from observed physiological responses to cold exposure, including changes in autonomic nervous system activity, hormonal responses, stress regulation, and potential effects on immune and metabolic processes.
A systematic review with meta-analysis evaluated the effects of cold exposure on selected physiological, psychological, and cognitive parameters in healthy adults. The analysis included 11 studies involving more than 3,000 participants, using various cold exposure protocols, including water temperatures ranging from 7°C to 15°C and exposure durations from 30 seconds to 2 hours. The included studies assessed changes in body temperature, cardiovascular parameters, autonomic responses, inflammatory markers, stress levels, sleep quality, and overall well-being.
The results indicated that physiological responses to cold exposure depend on the timing of measurements and the characteristics of the applied protocol. Immediately after cold exposure, increases in selected markers of stress and inflammatory responses were observed, which may reflect the body's adaptive physiological reaction to a short-term environmental stressor. At later measurement points, reductions in perceived stress levels and improvements in some indicators of psychological well-being were reported.
Despite interest in the potential influence of CWI on immune system function, current evidence does not allow for definitive confirmation of significant short-term immunological changes following cold immersion. Some observational studies suggest that regular cold exposure may be associated with long-term benefits, such as improved sleep quality, increased stress tolerance, and reduced sickness-related absence.

One of the most frequently cited studies investigating the influence of regular cold exposure on general health was the randomized controlled trial conducted by Buijze et al. (2016). The study included 3,018 healthy adults aged 18–65 years who had not previously practiced regular cold showers. Participants were randomly assigned to groups performing cold showers after warming the body for 30, 60, or 90 seconds, or to a control group.

The intervention lasted 30 consecutive days, after which participants could continue cold showers according to personal preference for an additional 60 days. The primary outcome measure was the number of sick days and associated work absence. The results demonstrated that individuals practicing cold showers experienced a 29% reduction in sickness absence compared with the control group. However, no significant difference was observed in the total number of illness days between groups.

The authors also reported no serious adverse effects associated with the intervention. These findings suggest that regular cold exposure may influence selected aspects of daily functioning, particularly subjective health perception and the ability to maintain occupational activity. However, the mechanisms responsible for these effects remain incompletely understood.

Despite the growing popularity of CWI outside the sports environment, current scientific knowledge still has important limitations. Available studies differ substantially regarding water temperature, exposure duration, intervention frequency, and participant characteristics. Furthermore, many studies rely on small sample sizes or observational designs, limiting the ability to draw definitive conclusions regarding long-term health effects.

5. Limitations of Cold Water Immersion

Despite numerous potential benefits, Cold Water Immersion (CWI) is not a method without limitations. One important aspect is the possibility of temporary reductions in exercise performance immediately after cold exposure. This may be particularly relevant for athletes who are required to perform subsequent tasks involving maximal speed, power, or movement precision within a short period after the intervention.

A study involving 30 healthy individuals evaluated the effects of a 15-minute immersion in water at 5°C on lower-limb speed and power performance. Immediately after the exposure, reductions in performance were observed in the 40-yard sprint test and vertical jump test. The decrease in sprint performance persisted for approximately 20 minutes, whereas reduced muscle power lasted for around 10 minutes. In subsequent measurements, these parameters gradually returned to baseline values.

The mechanisms responsible for temporary reductions in exercise capacity primarily include decreased muscle temperature, reduced nerve conduction velocity, and alterations in the contractile properties of muscle fibers. Therefore, the timing of CWI application should be carefully planned and adjusted according to subsequent training sessions or competitive demands.

Although CWI may support recovery over several hours following exercise, an immediate return to activities requiring maximal power or speed may be limited due to short-term functional changes caused by cold exposure.

Conclusions

Based on current scientific evidence, Cold Water Immersion can be considered an effective method supporting short-term recovery following intense physical exercise. The most consistently demonstrated effects include reductions in delayed onset muscle soreness, improvements in subjective recovery perception, and partial acceleration of neuromuscular function restoration.

The greatest practical application of CWI is observed in sports disciplines requiring frequent repeated high-intensity efforts, such as team and contact sports, where rapid restoration of performance capacity may significantly influence competitive outcomes.

At the same time, the effects of CWI on long-term training adaptations depend on the primary training objective. Regular use of cold immersion immediately after resistance training may limit processes associated with muscle hypertrophy by reducing activation of anabolic pathways and cellular adaptive mechanisms. Therefore, this method should be applied strategically, particularly among individuals whose primary goal is the development of strength and muscle mass.

Outside the sports context, CWI demonstrates potential benefits associated with improved subjective well-being and reduced sickness-related absence; however, the current level of scientific evidence does not allow definitive conclusions regarding its effects on general population health.

In summary, Cold Water Immersion may represent a valuable component of a recovery strategy; however, its application should consider exercise characteristics, training goals, and individual physiological responses. Further research is required to determine optimal CWI protocols and clarify its long-term physiological consequences.

Table 3. Characteristics of Selected Studies Investigating the Application of Cold Water Immersion (CWI)

Study	Temperature (°C)	Immersion duration	Type of exercise	Main effects
Vaile et al.	14	14 min	Eccentric exercise	↓ DOMS, ↑ MVC
Roberts et al.	10	10 min	Resistance training	↓ hypertrophy
Pointon et al.	10	10–20 min	Match simulation	↑ neuromuscular function
Fonseca et al.	6	19 min	Brazilian jiu-jitsu	↓ LDH, ↓ DOMS
Buijze et al.	Cold shower	30–90 s	General population	↓ sickness absence

Table 4. Benefits and Limitations of Cold Water Immersion

Benefits	Limitations
Reduction of DOMS	Potential limitation of hypertrophy
Improvement of subjective recovery	Lack of standardized protocols
Faster restoration of neuromuscular function	Inconsistent effects on CK levels
Useful during periods of frequent competition	Temporary reduction in power immediately after immersion
Easy accessibility	Individual variability in response

Disclossure

Author Contributions

Conceptualization: Bartłomiej Markowski, Marta Rząsa, Wojciech Ziębka, Julia Mądrzak

Formal analysis: Bartłomiej Markowski, Martyna Grzywacz, Agnieszka Dobrowolska, Oliwia Dziewięcka, Wojciech Kwieciński

Investigation: Martyna Grzywacz, Marta Rząsa, Agnieszka Dobrowolska, Magdalena Iwaszko

Methodology: Bartłomiej Markowski, Martyna Grzywacz, Wojciech Ziębka, Oliwia Dziewięcka, Wojciech Kwieciński

Resources: Marta Rząsa, Agnieszka Dobrowolska, Agata Kaczmarzyk, Oliwia Dziewięcka

Supervision: Bartłomiej Markowski, Marta Rząsa, Agata Kaczmarzyk, Magdalena Iwaszko

Visualization: Bartłomiej Markowski, Martyna Grzywacz, Agnieszka Dobrowolska, Wojciech Ziębka, Julia Mądrzak, Wojciech Kwieciński

Writing – rough preparation: Bartłomiej Markowski, Marta Rząsa, Magdalena Iwaszko

Writing – review & editing: Martyna Grzywacz, Agnieszka Dobrowolska, Agata Kaczmarzyk, Wojciech Ziębka, Julia Mądrzak

All authors have read and agreed with the published version of manuscript.

Funding

This research received no external funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

The authors confirm that the data supporting the findings of this study are available within the article's bibliography.

Conflicts of Interest

The authors declare no conflicts of interest.

References

Bleakley, C. M., & Davison, G. W. (2010). What is the biochemical and physiological rationale for using cold-water immersion in sports recovery? A systematic review. *British Journal of Sports Medicine, 44*(3), 179–187. https://doi.org/10.1136/bjsm.2009.065565

Bouchiba, M., Bragazzi, N. L., Zarzissi, S., Turki, M., Zghal, F., Grati, M. A., Daab, W., Ayadi, F., Rebai, H., Ibn Hadj Amor, H., Hureau, T. J., & Bouzid, M. A. (2022). Cold water immersion improves the recovery of both central and peripheral fatigue following simulated soccer match-play. *Frontiers in Physiology, 13*, Article 860709. https://doi.org/10.3389/fphys.2022.860709

Broatch, J. R., Petersen, A., & Bishop, D. J. (2018). The influence of post-exercise cold-water immersion on adaptive responses to exercise: A review of the literature. *Sports Medicine, 48*, 1369–1387. https://doi.org/10.1007/s40279-018-0910-8

Buijze, G. A., Sierevelt, I. N., van der Heijden, B. C., Dijkgraaf, M. G., & Frings-Dresen, M. H. W. (2016). The effect of cold showering on health and work: A randomized controlled trial. *PLOS ONE, 11*(9), e0161749. https://doi.org/10.1371/journal.pone.0161749

Cain, T., Brinsley, J., Bennett, H., Nelson, M., Maher, C., & Singh, B. (2025). Effects of cold-water immersion on health and wellbeing: A systematic review and meta-analysis. *PLOS ONE, 20*(1), e0317615. https://doi.org/10.1371/journal.pone.0317615

Clarkson, P. M., & Hubal, M. J. (2002). Exercise-induced muscle damage in humans. *American Journal of Physical Medicine & Rehabilitation, 81*(11 Suppl), S52–S69. https://doi.org/10.1097/00002060-200211001-00007

Didehdar, D., & Sobhani, S. (2019). The effect of cold-water immersion on physical performance. *Journal of Bodywork and Movement Therapies, 23*(2), 258–261. https://doi.org/10.1016/j.jbmt.2018.05.001

Fonseca, L. B., Brito, C. J., Silva, R. J. S., Silva-Grigoletto, M. E., Silva Junior, W. M., & Franchini, E. (2016). Use of cold-water immersion to reduce muscle damage and delayed-onset muscle soreness and preserve muscle power in jiu-jitsu athletes. *Journal of Athletic Training, 51*(7), 540–549. https://doi.org/10.4085/1062-6050-51.9.01

Hohenauer, E., Costello, J. T., Deliens, T., Clarys, P., Stoop, R., & Clijsen, R. (2020). Partial-body cryotherapy (-135°C) and cold-water immersion (10°C) after muscle damage in females. *Scandinavian Journal of Medicine & Science in Sports, 30*(1), 35–45. https://doi.org/10.1111/sms.13593

Howatson, G., & van Someren, K. A. (2008). The prevention and treatment of exercise-induced muscle damage. *Sports Medicine, 38*(6), 483–503. https://doi.org/10.2165/00007256-200838060-00004

Huang, Y. C., & Chen, H. T. (2025). Effect of cold-water immersion treatment on recovery from exercise-induced muscle damage in the hamstring. *European Journal of Sport Science*. https://doi.org/10.1002/ejsc.12235

Ihsan, M., Watson, G., & Abbiss, C. R. (2016). What are the physiological mechanisms for post-exercise cold water immersion in the recovery from prolonged endurance and intermittent exercise? *Sports Medicine, 46*, 1095–1109. https://doi.org/10.1007/s40279-016-0483-5

Machado, A. F., Almeida, A. C., Micheletti, J. K., Vanderlei, F. M., Tribst, M. F., Netto Junior, J., & Pastre, C. M. (2017). Dosages of cold-water immersion post exercise on functional and clinical responses: A randomized controlled trial. *Scandinavian Journal of Medicine & Science in Sports, 27*(10), 1066–1072. https://doi.org/10.1111/sms.12734

Pointon, M., & Duffield, R. (2012). Cold water immersion recovery after simulated collision sport exercise. *Medicine & Science in Sports & Exercise, 44*(2), 206–214. https://doi.org/10.1249/MSS.0b013e31822b0977

Pointon, M., Duffield, R., Cannon, J., & Marino, F. E. (2012). Cold water immersion recovery following intermittent-sprint exercise in the heat. *European Journal of Applied Physiology, 112*, 2483–2494. https://doi.org/10.1007/s00421-011-2218-3

Poppendieck, W., Wegmann, M., Ferrauti, A., Kellmann, M., Pfeiffer, M., & Meyer, T. (2013). Cooling and performance recovery of trained athletes: A meta-analysis. *International Journal of Sports Physiology and Performance, 8*(3), 227–242. https://doi.org/10.1123/ijspp.8.3.227

Roberts, L. A., Nosaka, K., Coombes, J. S., & Peake, J. M. (2015). Cold water immersion enhances recovery of submaximal muscle function after resistance exercise. *American Journal of Physiology-Regulatory, Integrative and Comparative Physiology, 309*(12), R1490–R1500. https://doi.org/10.1152/ajpregu.00180.2014

Roberts, L. A., Raastad, T., Markworth, J. F., Figueiredo, V. C., Egner, I. M., Shield, A., Cameron-Smith, D., Coombes, J. S., & Peake, J. M. (2015). Post-exercise cold water immersion attenuates acute anabolic signalling and long-term adaptations in muscle to strength training. *The Journal of Physiology, 593*(18), 4285–4301. https://doi.org/10.1113/JP270570

Vaile, J., Halson, S., Gill, N., & Dawson, B. (2008). Effect of hydrotherapy on the signs and symptoms of delayed onset muscle soreness. *European Journal of Applied Physiology, 102*, 447–455. https://doi.org/10.1007/s00421-007-0605-6