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The Role of Cryotherapy in Sports Recovery: A Critical Review of Current Evidence

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ABSTRACT

Background. Cryotherapy, defined as the therapeutic application of cold, is increasingly used in sports medicine to enhance post-exercise recovery and support athletic performance. The most common modalities include whole-body cryotherapy, local cryotherapy, and cold water immersion.

Aim. This article aims to discuss the current evidence on the role of cryotherapy in sports recovery, including its physiological mechanisms, practical applications, benefits, limitations, and impact on training adaptations.

Materials and methods. A focused narrative review of relevant literature was conducted to examine the effects of cryotherapy on muscle soreness, fatigue, inflammation, recovery, and athletic performance. Studies on whole-body cryotherapy, local cryotherapy, and cold water immersion were included.

Summary. Available evidence suggests that cryotherapy may reduce muscle soreness and perceived fatigue in the short term. However, long-term effects remain inconsistent, and frequent post-exercise cooling may impair muscle adaptation and hypertrophy. The review also highlights the gap between scientific evidence and the commercial promotion of cryotherapy.

Conclusions. Cryotherapy may be useful in selected athletic settings, but its application should be individualized and aligned with training goals. Further research is needed to determine optimal protocols and long-term effects on performance.
Keywords: Cryotherapy, Sports Recovery, Cold Water Immersion, Whole-Body Cryotherapy, Local Cryotherapy, Muscle Soreness, Athletic Performance, Inflammation, Exercise Recovery, Post-Exercise Cooling

1. Introduction

Cryotherapy is a treatment method for a variety of ailments that involves lowering the body's temperature using different techniques [1]. Although its origins date back to antient times [2], it continues to gain popularity, especially among athletes and coaches [3]. It is used for its analgesic effects, mood enhancement, reduction of recovery time, and support of athletic performance [2,4].

The International Institute of Refrigeration reports a rapid increase in the use of whole-body cryotherapy (WBC) as a recovery tool [5]. However, growing popularity does not obviate the need to follow evidence-based protocols.

The aim of this review is to present the current state of knowledge regarding cryotherapy as a method for supporting athlete recovery. We will discuss the various types of treatments, their physiological mechanisms of action, and review the most important scientific studies.

2. Materials and methods

A focused narrative review of the relevant literature was conducted to examine the role of cryotherapy in sports recovery and athletic performance. The review aimed to evaluate the current evidence regarding the effects of WBC, local cryotherapy, and cold water immersion (CWI) on post-exercise recovery, muscle soreness, inflammation, and training adaptations. The literature search was based on publications addressing both the physiological mechanisms and practical applications of cryotherapy in athletes and physically active individuals. Particular attention was given to studies comparing different cryotherapy modalities, assessing short- and long-term outcomes, and discussing the potential discrepancy between scientific evidence and the growing commercial promotion of these methods. Clinical trials, randomized studies, systematic reviews, meta-analyses, and narrative reviews were considered in order to provide a broad and critical overview of the topic.

3. Research results

3.1. Types of Cryotherapy Used in Sports

- Whole-body cryotherapy.

WBC involves exposing an individual to extremely low temperatures (from –60 °C to –195 °C) for several minutes in a specially designed chamber. Before treatment, the feet, hands, ears, and respiratory pathways are protected. Due to its physiological effects, WBC can reduce post-exercise muscle soreness and accelerate recovery [5]. However, some studies question its efficacy. Pernigoni et al. found that WBC did not improve post-exercise recovery in baseball players [6], whereas Zembron-Lacny et al. suggest that the treatment may disrupt the cascade of muscle repair processes, thereby delaying regeneration [7].

- Local cryotherapy.

Local cryotherapy methods include ice cuffs, cold packs, cold air, and ice sprays, all of which involve the targeted cooling of soft tissues [8]. In the study by Sarver et al., application of a clinically relevant dose of local cryotherapy produced no significant biochemical or molecular changes in skeletal muscle biopsy samples, calling its biochemical efficacy into question [9]. What is more, Hohenauer et al. found that, following a special jump protocol, local cryotherapy offered no greater benefit for recovery than a control condition [8]. Furthermore, a meta-analysis by Nogueira et al. indicated that local cryotherapy does not appear to accelerate recovery from exercise-induced muscle damage, which is typically manifested by soreness and muscle weakness [10].

- Cold water immersion.

CWI involves submerging the limbs and/or torso in water at 8–15 °C for approximately 15 minutes, either in a single session or in several shorter immersions, with the aim of reducing fatigue and accelerating recovery [11]. A meta-analysis by Moore et al. demonstrates that CWI delivers significant benefits, particularly following high-intensity exercise [12]. Conversely, a clinical trial by Heinke et al. found that CWI may impair performance, likely due to reduced motor nerve conduction velocity caused by cooling [13].

Table 1: Summary of Evidence on Cryotherapy Methods for Post-Exercise Recovery

Cryotherapy Method	**Description**	**Reported Benefits**	**Reported Limitations / Concerns**	**Key References**
Whole-Body Cryotherapy (WBC)	Exposure to extremely low temperatures (–60 °C to –195 °C) for several minutes in a cryochamber.	May reduce post-exercise muscle soreness and accelerate recovery.	Inconsistent evidence; may disrupt muscle repair processes; no improvement in recovery in some athletic populations.	[5-7]
Local Cryotherapy	Targeted cooling (ice packs, cold air, sprays) applied to soft tissues.	Widely used in sports medicine; practical and accessible.	No significant biochemical effects observed; no greater benefit than control; does not accelerate recovery consistently.	[8-10]
Cold Water Immersion (CWI)	Immersion of limbs/torso in 8–15 °C water for ~15 minutes post-exercise.	Shown to reduce fatigue and improve recovery, especially after high-intensity exercise	Potential impairment of performance due to reduced motor nerve conduction velocity.	[11-13]

3.2 Physiological Mechanisms of Cryotherapy

- Effects on inflammation and microcirculation.

Cryotherapy exerts its effects through various physiological mechanisms, primarily by influencing inflammation and microcirculation. The application of cold therapy causes microvasculature alterations that decrease the production of inflammatory mediators, reduce local edema, and disrupt the overall inflammatory response [14]. This anti-inflammatory effect is particularly evident in the reduction of synovial fluid leukocyte count and inflammatory cytokine concentration, as observed in a rat model of knee osteoarthritis [15].

- Reduction of pain and swelling.

The reduction of pain and swelling associated with cryotherapy is attributed to its analgesic effect, which is caused by decreased nerve conduction velocity. However, it's worth noting that while cryotherapy reduced pain scores and analgesic consumption in many studies, its effect on increasing range of motion and decreasing swelling was less frequently reported. Interestingly, continuous cryotherapy devices showed better outcomes in orthopaedic patients after knee arthroscopy procedures compared to other methods [14].

- Changes in hormonal and nervous system responses.

Cryotherapy also influences hormonal and nervous system responses. WBC has been shown to increase circulating BDNF levels, which may contribute to its potential benefits on mental health and cognitive functions [16]. Additionally, cryotherapy can stimulate the production of inflammatory factors such as IFN-γ and IL-2, while decreasing immunosuppressive cells in the spleen or tumor tissue [17]. These changes in the immune system response may have implications for various conditions, including cancer treatment.

- Impact on muscle recovery.

Regarding muscle recovery, cryotherapy is commonly used following exercise, particularly when rapid recovery is required between exercise bouts. However, it's important to note that chronic use of cryotherapy during resistance training may blunt the anabolic training effect, suggesting that its application should be timed appropriately for optimal results [1].

Table 2: Physiological Mechanisms and Effects of Cryotherapy

Physiological Mechanism	**Description and Effects**	**Key References**
Inflammation and Microcirculation	Cryotherapy alters microvasculature, reducing inflammatory mediator production, local edema, and leukocyte infiltration.	[14, 15]
Pain and Swelling Reduction	Analgesic effect due to decreased nerve conduction velocity. Continuous cryotherapy devices more effective post-arthroscopy.	[14]
Hormonal and Nervous System Effects	WBC increases BDNF (potential cognitive benefits). Induces IFN-γ and IL-2 production; reduces immunosuppressive cells, suggesting potential in cancer therapy.	[16, 17]
Muscle Recovery	Useful for acute recovery between exercise bouts. Chronic use during resistance training may blunt anabolic adaptations.	[1]

3.3. Review of Scientific Evidence

3.3.1. Studies on Elite vs. Recreational Athletes

Studies comparing elite and recreational athletes have shown mixed results regarding the effectiveness of cryotherapy. Elite athletes appear to outperform amateur athletes in cognitive functions, particularly in dual tasks [18]. However, the Mental Toughness Questionnaire 48 (MTQ48) showed large degrees of misspecification in factor structures across elite, amateur, and non-athletes, cautioning its use with elite athletes [19].

3.3.2. Effectiveness Depending on Type of Exercise (strength, endurance, interval)

The effectiveness of cryotherapy depends on the type of exercise. For endurance athletes, cryotherapy showed positive effects on training recovery, along with compression garments [20]. However, regular cold water immersion after strength training may attenuate gains in muscle mass and strength by reducing satellite cell activation, ribosomal biogenesis, anabolic signaling, and muscle protein synthesis [21].

3.3.3. Comparison of Different Cryotherapy Methods

Different cryotherapy methods have been studied, including cold water immersion, cryotherapy chambers, and icing. While these strategies are believed to improve post-exercise recovery, the evidence is inconsistent. Cold water immersion's effects on aerobic capacity, lactate threshold, power output, and time trial performance after endurance or high-intensity interval training are equivocal [21].

3.3.4. Short-term vs. Long-term Effects

Regarding short-term vs. long-term effects, the impact of regular cold water immersion on long-term performance and muscle adaptations has been systematically investigated. Short-term benefits for recovery have been observed, but long-term effects on muscle adaptations, especially in strength training, may be detrimental [21].

3.3.5. Potential Side Effects and Contraindications

While the provided papers do not explicitly address the potential side effects and contraindications of cryotherapy, it is important to consider these aspects when evaluating its suitability for endurance athletes. Cryotherapy, particularly WBC, involves exposing the body to extremely cold temperatures for short durations and may carry certain risks. Common side effects include skin irritation, numbness, tingling, and transient redness. In some cases, individuals may experience dizziness, headaches, or cold burns if proper protocols are not followed.

Contraindications for cryotherapy include conditions such as uncontrolled hypertension, cardiovascular disease, respiratory disorders, cold allergies (e.g., cold urticaria), Raynaud’s disease, and neuropathies that impair temperature sensation. Individuals with these conditions may be at increased risk of adverse effects and should avoid cryotherapy unless cleared by a healthcare professional.

Moreover, individual variability in response to cryotherapy underscores the need for personalized recovery strategies. As Li et al. note, no single recovery method consistently benefits all endurance athletes [20]. Factors such as training load, recovery status, and personal tolerance should guide the use of cryotherapy. Athletes and practitioners should monitor responses closely and adjust protocols accordingly to ensure both safety and effectiveness.

In conclusion, while cryotherapy shows promise for certain aspects of recovery, its effectiveness varies depending on the type of exercise, athlete level, and specific application

method. Further research is needed to determine optimal modalities, temperatures, durations, and frequencies of cooling to enhance long-term performance and muscle adaptations [21].

3.4. Critical Analysis – Science vs. Marketing

- The role of influencers and social media.

The role of influencers and social media in promoting cryotherapy for sports recovery presents a complex interplay between science and marketing. While research on WBC suggests potential benefits for neuromuscular recovery and pain relief [16], the marketing of these services often outpaces the scientific evidence. Social media influencers, both human and virtual, play a significant role in shaping consumer perceptions and purchase intentions for health and wellness products [22, 23]. However, the effectiveness of influencer marketing can vary based on factors such as perceived authenticity, use of sensory language, and disclosure of sponsorship [24, 25].

- Discrepancy between research findings and cryotherapy service marketing.

There appears to be a discrepancy between the cautious findings of scientific research and the enthusiastic marketing of cryotherapy services. While some studies indicate potential benefits, public health authorities have expressed safety concerns [16]. This gap highlights the ethical challenges in promoting treatments that may not be fully proven. The use of machine learning models to predict treatment outcomes could potentially bridge this gap, but it also raises questions about the reliability and interpretation of such predictions in marketing contexts [26].

- Ethical aspects of promoting unproven methods in sports.

The ethical aspects of promoting unproven methods in sports recovery through influencer marketing are particularly concerning. The power of influencers to shape consumer behavior combined with the potential risks associated with cryotherapy creates a situation where consumers may be led to make decisions based on marketing hype rather than scientific evidence [16, 27, 28]. This scenario underscores the need for responsible marketing practices and clear disclosure of the current state of scientific knowledge regarding cryotherapy's efficacy in sports recovery.

4. Discussion

Cryotherapy offers several short-term benefits for post-exercise recovery, such as reduced pain and perceived fatigue, but current scientific evidence remains inconsistent, particularly concerning long-term performance and muscle adaptation. Methods such as cold water

immersion (CWI) show some promising results, especially after high-intensity effort, while whole-body cryotherapy (WBC) and local methods yield mixed or limited outcomes. Importantly, chronic use of cryotherapy following strength training may blunt hypertrophic and anabolic responses. The effectiveness of cryotherapy depends on factors such as the timing of application and its ability to maintain reduced muscle temperature. While CWI and WBC may provide short-term recovery benefits, their long-term effects on muscle adaptation and performance remain inconsistent or potentially detrimental. For instance, chronic use of cryotherapy during resistance training may blunt the anabolic training effect [1]. In addition, WBC has been found to attenuate soreness at 24 hours and positively influence peak force at 48 hours compared with CWI and placebo, although many other outcomes were trivial or unclear [3]. Moreover, regular use of CWI after strength training may attenuate gains in muscle mass and strength [21]. The diversity in muscle damage protocols, exposure timing, temperatures, and frequencies of application further limits the ability to formulate precise recommendations [29].

5. Conclusions

Cryotherapy techniques such as CWI and WBC may offer selected short-term benefits for post-exercise recovery, but their long-term effects on performance and muscle adaptation remain controversial. Athletes and coaches should therefore apply cryotherapy selectively, aligning its use with the type of exercise and specific recovery goals rather than relying on routine application. In practice, cryotherapy may be used sparingly and strategically, mainly after competitions or intense endurance sessions, while avoiding regular use during strength-building phases. Further research is needed to optimize cryotherapy protocols and determine whether the observed molecular and morphological effects translate into meaningful improvements in exercise performance [21].

Disclosure

Author's contribution

Conceptualization: K. Bakuła ; methodology: I. M. Nowicka ; software: P. R. Turek; check: E. Dybała; formal analysis: K. Bakuła ; investigation: I. M. Nowicka; resources: E. Dybała; data curation: P. R. Turek; writing-rough preparation: K. Bakuła; writing – review and editing: E. Dybała; visualization: P. R. Turek; supervision: I. Nowicka; project administration: K. Bakuła
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References

1. Kwiecien, S. Y., & McHugh, M. P. (2021). The cold truth: the role of cryotherapy in the treatment of injury and recovery from exercise. *European Journal of Applied Physiology 2021 121:8*, *121*(8), 2125–2142. https://doi.org/10.1007/S00421-021-04683-8
2. Allan, R., Malone, J., Alexander, J., Vorajee, S., Ihsan, M., Gregson, W., Kwiecien, S., & Mawhinney, C. (2022). Cold for centuries: a brief history of cryotherapies to improve health, injury and post-exercise recovery. *European Journal of Applied Physiology*, *122*(5), 1153–1162. https://doi.org/10.1007/S00421-022-04915-5
3. Wilson, L. J., Dimitriou, L., Hills, F. A., Gondek, M. B., & Cockburn, E. (2019). Whole body cryotherapy, cold water immersion, or a placebo following resistance exercise: a case of mind over matter? *European Journal of Applied Physiology*, *119*(1), 135–147. https://doi.org/10.1007/S00421-018-4008-7
4. Huang, T., Dan, L., Wang, W., Ren, J., Liu, X., & Li, J. (2024). Effect of whole-body cryotherapy on recovery after high-intensity training in elite rowers. *Frontiers in Physiology*, *15*. https://doi.org/10.3389/FPHYS.2024.1428554
5. Bouzigon, R., Dupuy, O., Tiemessen, I., De Nardi, M., Bernard, J. P., Mihailovic, T., Theurot, D., Miller, E. D., Lombardi, G., & Dugué, B. M. (2021). Cryostimulation for Post-exercise Recovery in Athletes: A Consensus and Position Paper. *Frontiers in Sports and Active Living*, *3*, 688828. https://doi.org/10.3389/FSPOR.2021.688828
6. Pernigoni, M., Perazzetti, A., Digno, M., Tessitore, A., Kamandulis, S., & Conte, D. (2024). Chill Without Thrill: A Crossover Study on Whole-Body Cryotherapy and

Postmatch Recovery in High-Level Youth Basketball Players. *International Journal of Sports Physiology and Performance*, *19*(11), 1–9. https://doi.org/10.1123/IJSPP.2024-0085

7. Zembron-Lacny, A., Morawin, B., Wawrzyniak-Gramacka, E., Gramacki, J., Jarmuzek, P., Kotlega, D., & Ziemann, E. (2020). Multiple Cryotherapy Attenuates Oxi-Inflammatory Response Following Skeletal Muscle Injury. *International Journal of Environmental Research and Public Health 2020, Vol. 17, Page 7855*, *17*(21), 7855. https://doi.org/10.3390/IJERPH17217855
8. Hohenauer, E., Clarys, P., Baeyens, J.-P., & Clijsen, R. (2016). The effect of local cryotherapy on subjective and objective recovery characteristics following an exhaustive jump protocol. *Open Access Journal of Sports Medicine*, *7*, 89–97. https://doi.org/10.2147/OAJSM.S110991
9. Sarver, D. C., Sugg, K. B., Disser, N. P., Enselman, E. R. S., Awan, T. M., & Mendias, C. L. (2017). Local cryotherapy minimally impacts the metabolome and transcriptome of human skeletal muscle. *Scientific Reports 2017 7:1*, *7*(1), 1–10. https://doi.org/10.1038/s41598-017-02754-5
10. Nogueira, N. M., Felappi, C. J., Lima, C. S., & Medeiros, D. M. (2020). Effects of local cryotherapy for recovery of delayed onset muscle soreness and strength following exercise-induced muscle damage: systematic review and meta-analysis.*Sport Sciences for Health*, *16*(1), 1–11. https://doi.org/10.1007/S11332-019-00571-Z
11. Petersen, A. C., & Fyfe, J. J. (2021). Post-exercise Cold Water Immersion Effects on Physiological Adaptations to Resistance Training and the Underlying Mechanisms in Skeletal Muscle: A Narrative Review. *Frontiers in Sports and Active Living*, *3*, 660291. https://doi.org/10.3389/FSPOR.2021.660291
12. Moore, E., Fuller, J. T., Buckley, J. D., Saunders, S., Halson, S. L., Broatch, J. R., & Bellenger, C. R. (2022). Impact of Cold-Water Immersion Compared with Passive Recovery Following a Single Bout of Strenuous Exercise on Athletic Performance in Physically Active Participants: A Systematic Review with Meta-analysis and Meta-regression. *Sports Medicine (Auckland, N.Z.)*, *52*(7), 1667–1688. https://doi.org/10.1007/S40279-022-01644-9
13. Heinke, L., Javanmardi, S., Rappelt, L., Konrad, A., Schleip, R., Knicker, A. J., Freiwald, J., & Baumgart, C. (2024). Comparison of the effects of cold water immersion and percussive massage on the recovery after exhausting eccentric exercise: A three-

armed randomized controlled trial. *Frontiers in Physiology*, *15*, 1432009. https://doi.org/10.3389/FPHYS.2024.1432009

14. Kunkle, B. F., Friedman, R. J., Curry, E. J., Eichinger, J. K., Kothandaraman, V., Li, X., & Goodloe, J. B. (2021). Orthopaedic Application of Cryotherapy: A Comprehensive Review of the History, Basic Science, Methods, and Clinical Effectiveness. *JBJS Reviews*, *9*(1), e20.00016. https://doi.org/10.2106/jbjs.rvw.20.00016
15. Barbosa, G. M., Ramalho, F. S., Cunha, J. E., Castro, P. A. T. S., Martinho, L. B., Oliveira, F. F. B., Cunha, T. M., Cunha, F. Q., & Salvini, T. F. (2019). Clinical-like cryotherapy improves footprint patterns and reduces synovial inflammation in a rat model of post-traumatic knee osteoarthritis. *Scientific Reports*, *9*(1). https://doi.org/10.1038/s41598-019-50958-8
16. Legrand, F. D., Dugué, B., Costello, J., Bleakley, C., Miller, E., Broatch, J. R., Polidori, G., Lubkowska, A., Louis, J., Lombardi, G., Bieuzen, F., & Capodaglio, P. (2023). Evaluating safety risks of whole-body cryotherapy/cryostimulation (WBC): a scoping review from an international consortium. *European Journal of Medical Research*, *28*(1). https://doi.org/10.1186/s40001-023-01385-z
17. Liao, Y., Liu, S., Wu, J., Chen, Y., Wang, W., & Fu, S. (2023). Low-dose total body irradiation enhances systemic anti-tumor immunity induced by local cryotherapy. *Journal of Cancer Research and Clinical Oncology*, *149*(12), 10053–10063. https://doi.org/10.1007/s00432-023-04928-3
18. Holfelder, B., Schott, N., Klotzbier, T. J., & Eisele, M. (2020). Hot and Cool Executive Function in Elite- and Amateur- Adolescent Athletes From Open and Closed Skills Sports. *Frontiers in Psychology*, *11*(e0206151). https://doi.org/10.3389/fpsyg.2020.00694
19. Vaughan, R., Hanna, D., & Breslin, G. (2018). Psychometric properties of the Mental Toughness Questionnaire 48 (MTQ48) in elite, amateur and nonathletes. *Sport, Exercise, and Performance Psychology*, *7*(2), 128–140. https://doi.org/10.1037/spy0000114
20. Li, S., Brink, M., Kempe, M., & Lemmink, K. (2024). Effectiveness of Recovery Strategies After Training and Competition in Endurance Athletes: An Umbrella Review. *Sports Medicine - Open*, *10*(1). https://doi.org/10.1186/s40798-024-00724-6
21. Hyldahl, R. D., & Peake, J. M. (2020). Combining cooling or heating applications with exercise training to enhance performance and muscle adaptations. *Journal of Applied Physiology*, *129*(2), 353–365. https://doi.org/10.1152/japplphysiol.00322.2020

22. Barari, M. (2023). Unveiling the dark side of influencer marketing: how social media influencers (human vs virtual) diminish followers' well-being. *Marketing Intelligence & Planning*, *41*(8), 1162–1177. https://doi.org/10.1108/mip-05-2023-0191
23. Wang, J., Ye, G., & Yang, J. (2025). Not a human, not for green? The effectiveness of virtual influencers endorsing green products. *Journal of Product & Brand Management*, *34*(4), 468–485. https://doi.org/10.1108/jpbm-04-2024-5105
24. Kay, S., Mulcahy, R., & Parkinson, J. (2020). When less is more: the impact of macro and micro social media influencers' disclosure. *Journal of Marketing Management*, *36*(3–4), 248–278. https://doi.org/10.1080/0267257x.2020.1718740
25. Cascio Rizzo, G. L., Pozharliev, R., Berger, J., & De Angelis, M. (2023). How Sensory Language Shapes Influencer's Impact. *Journal of Consumer Research*, *50*(4), 810–825. https://doi.org/10.1093/jcr/ucad017
26. Setiadi, D. R. I. M., Islam, H. M. M., Trisnapradika, G. A., & Herowati, W. (2024). Analyzing Preprocessing Impact on Machine Learning Classifiers for Cryotherapy and Immunotherapy Dataset. *Journal of Future Artificial Intelligence and Technologies*, *1*(1), 39–50. https://doi.org/10.62411/faith.2024-2
27. Dumas, J. E., & Stough, R. A. (2022). When influencers are not very influential: The negative effects of social media verification. *Journal of Consumer Behaviour*, *21*(3), 614–624. https://doi.org/10.1002/cb.2039
28. Lee, J. A., & Eastin, M. S. (2020). I Like What She's #Endorsing: The Impact of Female Social Media Influencers' Perceived Sincerity, Consumer Envy, and Product Type. *Journal of Interactive Advertising*, *20*(1), 76–91. https://doi.org/10.1080/15252019.2020.1737849
29. Graham, K., Rose, C., Caillaud, C., Siegler, J., & Edwards, K. (2017). Whole-body Cryotherapy as a Recovery Technique after Exercise: A Review of the Literature. *International Journal of Sports Medicine*, *38*(14), 1049–1060. https://doi.org/10.1055/s-0043-114861