Systematic Review Article

The Role of Heated Compression Therapy in Post-Exercise Recovery Across Age Groups and Sport Types

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ABSTRACT

Heated compression therapy combines two common recovery strategies—thermal therapy and mechanical compression—to enhance circulation, reduce soreness, and restore performance. This systematic review with a structured search (2010–2025) synthesizes evidence on compression, heat, and their combination, and contrasts responses between younger (16–35) and middle-aged (36–54) athletes, with additional commentary on older adults ≥ 55 where available. These broader categories were selected due to heterogeneity in age definitions across the included studies. Compression consistently improves venous return and perceptual recovery; heat increases local blood flow and tissue extensibility. Combined heated compression generally yields larger short-term gains in pressure-to-pain threshold, perceived soreness, and local perfusion than either modality alone, although protocols vary widely (temperature 38–45 °C, pressure 15–30 mmHg, 5–20 min). Younger athletes show faster vascular kinetics and quicker readiness; middle-aged/older groups report greater reductions in stiffness and potential vascular health benefits. Evidence is limited by small samples, male-heavy cohorts, heterogeneous devices, and lab-dominant settings. Standardized protocols and outcome measurements are needed to make clearer comparisons and real-world validity in future research.

Keywords: Heated compression therapy; athletic recovery; vascular function; muscle perfusion; thermoregulation; age-related differences; pain tolerance; sports medicine

INTRODUCTION

Athletic performance and recovery are greatly influenced by post-exercise strategies that optimize muscle repair, reduce soreness, and restore functionality. Among these, compression and heat therapies have emerged as two of the most widely researched and applied methods in sports medicine (1, 2). Compression garments apply external pressure on muscle tissue and blood vessels, supporting venous return, enhancing oxygen delivery, and promoting the clearance of metabolic byproducts such as lactate (3, 4). Heat therapy, on the other hand, promotes vasodilation, raises muscle temperature, and increases enzymatic activity, which accelerates metabolic recovery and improves tissue elasticity (5, 6). Recent improvements have combined these approaches into heated compression devices, which affect circulation, reduce pain, and improve readiness for athletic performance (7, 8).

The physiological benefit for these recovery methods is obvious. Compression garments have been consistently

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shown to improve venous return and hemodynamics, supporting cardiovascular stability during exercise and recovery (3, 9). Dynamic compression has also been shown to improve pressure-to-pain thresholds and reduced soreness in elite athletes (10). In addition, heat therapy has benefits in both short and long-term time periods. For example, repeated local heat therapy has been shown to improve muscle structure and function, suggesting that it creates adaptations that are beneficial to recovery and performance (11, 12). Traditional clinical approaches, such as hot-humid compresses and heat wraps, support these outcomes by reducing pain, increasing flexibility, and accelerating recovery from delayed onset muscle soreness (11, 13).

When addressing heat therapy, an important factor to consider is age. Age has an impact on the effectiveness of these therapies. Aging is associated with reduced endothelial function, altered vasodilation, and slower blood flow kinetics in muscle tissue, which all together limit post-exercise recovery (14, 15). Older athletes (65-69 years old) also show decreased thermoregulatory capacity, resulting in higher heat storage during exercise compared to younger individuals (15, 16). Nevertheless, evidence shows that targeted heating can slow some of these negative effects: short-term heat therapy has been shown to improve microvascular function in skeletal muscles (6), while home-based heat therapy lowers blood pressure and enhances endothelial function in older populations (17). Furthermore, lower-limb hyperthermia has been demonstrated to affect blood flow equally in young and older individuals, suggesting that localized heat interventions may have the same effect across age groups (18).

However, there are still gaps in understanding age-specific responses to heated compression. While younger athletes often show more enhanced vascular responsiveness and quicker short-term recovery, older athletes may experience slower responses but greater benefits in reduction of muscle stiffness, comfort, and long-term vascular health (19, 20).

Both compression and heat therapy demonstrate physiological benefits across athletic and rehabilitative settings (2, 5, 11, 17). Their combination, found in heated compression devices, may have synergistic advantages in circulation, muscle function, and recovery speed (7, 8). However, age-related differences in vascular responsiveness and thermoregulation make further investigation a required step. This review therefore examines the following research question: To what extent does heated compression therapy modulate vascular, physiological, and recovery-related outcomes in younger (16–35), middle-aged (36–54), and older (≥55) individuals? Addressing this question, the review synthesizes current evidence through a structured literature search to compare age-specific responses and identify gaps requiring further investigation.

METHODS AND MATERIALS

This literature review was conducted to examine the effects of heated compression therapy on blood flow, recovery, and performance in athletes. The search strategy focused on peer-reviewed scientific articles published from 2010 onwards to ensure the use of recent and reliable evidence. To capture both current findings and relevant background information, studies on heated compression therapy were only included if published from 2015 onwards, while earlier studies (2010–2014) were referred solely to provide a physiological context.

Databases searched

Electronic searches were carried out across five databases: PubMed, ScienceDirect, SpringerLink, MDPI, and ResearchGate. The search covered publications from 1 January 2010 through August 2025. This time window was chosen to capture contemporary work on compression garments, heat therapy, and vascular/thermoregulatory responses, while ensuring inclusion of the more recent studies on combined heated compression devices (predominantly published from 2015 onwards). In addition, the reference lists of key systematic reviews and systematic reviews identified in the electronic search were hand-searched to identify any further relevant primary studies that had not appeared in the initial database search. Search strategies were adapted slightly for each database but followed the same conceptual structure, combining terms for *"heated compression therapy"*, *"blood flow"*, *"athletic performance"*, *"compression garments"*, *"thermal therapy"*, *"young athletes"*, and *"old athletes"*.

Study design and Eligibility Criteria

Studies were eligible for inclusion if they: (1) were peer-reviewed studies, (2) involving athletes or physically active participants; (3) implemented heat therapy, compression therapy, or a combined heated compression intervention; and (4) reported outcomes related to peripheral blood flow, perfusion, recovery (e.g., soreness, pressure-to-pain threshold), or performance. Studies must be published in English. Exclusion criteria included studies that were: (1) non-english publications, (2) studies published before 2010 for general background knowledge and 2015 for HCT device evidence, and (3) studies not including information about compression or heat exposure.

The primary outcomes of interest were peripheral blood flow and perfusion, recovery indices including pressure-to-pain threshold, soreness (VAS), and muscle stiffness, and readiness metrics. Secondary outcomes included thermoregulatory responses, vascular conductance, and any reported adverse effects.

Data extraction

Data was extracted manually from each study, including sample size, participant demographics, sport or activity type, intervention characteristics (compression, heat, or heated compression), and reported outcomes such as blood flow, soreness, pressure-to-pain threshold, stiffness, and performance data. A systematic synthesis was conducted instead of a meta-analysis due to heterogeneity between studies. When studies reported multiple age groups or intervention types, these subgroups were extracted and described separately.

RESULTS

Study selection

The initial search yielded 163 records. After removal of duplicates, 114 unique studies remained. Of these, 46 studies were excluded following title and abstract screening as they did not meet the predefined inclusion criteria. The remaining 68 studies underwent full-text review, of which 27 were excluded, and finally 41 studies were used for assessment. (Figure 1).

Study characteristics

The primary studies included in this review used highly heterogeneous age ranges (e.g., 18–35, 20–40, 55–70, ≥60), which made it impossible to apply uniform boundaries such as 16–30 and 31–59 without misclassifying the original samples. To maintain methodological integrity and avoid distorting the underlying data, this review reorganized all studies into three broader categories: ‘younger’ (16–35), ‘middle-aged’ (36–54), and ‘older’ (≥55). These ranges were selected because they (a) accommodate the original study definitions without forcing artificial cut-offs, (b) preserve comparability across heterogeneous samples, and (c) allow age-related trends to be synthesized accurately. This categorization is used consistently throughout the review and is explicitly acknowledged to reflect the variability of age classifications within the evidence base.

Sample sizes ranged from small pilot designs (n = 12-16) to moderate cohort studies (n = 20-28). The interventions included compression garments, local heat therapy, passive heating, and combined heated compression therapy (HCT) using either commercial devices or experimental prototypes. Sports represented included basketball, mixed martial arts, running, endurance sports, strength sports, golf, and general recreational activity.

Interventions differed in temperature level (38–45 °C), compression pressure (15–60) mmHg or equivalent pneumatic settings), and duration (5–20 minutes). Studies used heterogeneous physiological and perceptual outcomes, including blood flow, vascular conductance, pressure-to-pain threshold, muscle stiffness, subjective soreness, and performance-related metrics.

Compression-Only Interventions

Compression-only interventions demonstrated consistent improvements in peripheral blood flow, venous return, and performance outcomes in the studies. In basketball players, O’Riordan *et al.* (2023) reported large increases in venous return and resting blood flow

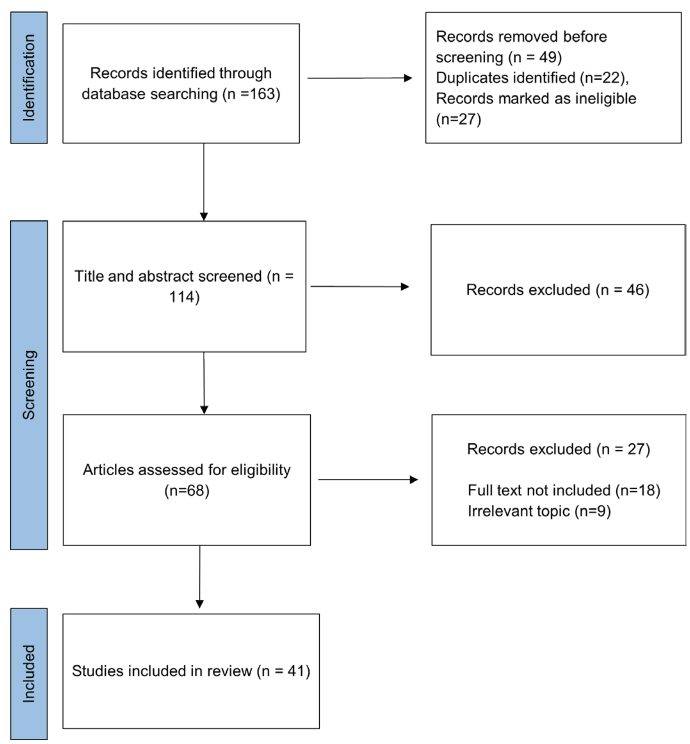

Figure 1. Flowchart of the article screening process.

(n = 20), supporting the circulatory benefits of external compression during recovery (4). Elite strength athletes in Sands *et al*. (2015) also experienced improvements, as dynamic compression increased pressure-to-pain thresholds and reduced fatigue (n = 28) (10). Additional performance benefits can be noted in baseball and golf players, with Hooper *et al*. (2015) showing enhanced fastball and golf swing accuracy (n = 21) (41). These findings suggest that compression alone does enhance circulatory efficiency, pain tolerance, and performance, particularly in athletes who require rapid recovery between training sessions.

Heat-Only Interventions

Heat-only interventions produce important physiological improvements related to muscle function, tissue perfusion, and cardiovascular responses. Repeated local heat therapy, as examined by Kim *et al*. (2020), led to improvements in skeletal muscle function and flexibility among physically active participants (n = 20) (5). Studies involving older athletes demonstrated even larger benefits: Meade *et al*. (2020) showed reduced vulnerability to heat and improved cardiovascular stability, while Ruiz-Pick *et al*. (2025) found that heat therapy significantly lowered blood pressure and improved endothelial function in adults aged 55–70 (n = 16) (15, 17). Moreover, Cope *et al*. (2023) reported increased skeletal muscle blood flow during exercise after heat exposure (n = 18), suggesting better oxygen delivery and metabolic clearance (20). Put altogether, these results indicate that heat-only interventions support recovery by improving cardiovascular function, reducing stiffness, and promoting muscle flexibility across different age groups.

Combined Heated Compression Therapy (HCT)

Recent work in the sports medicine field has combined compression with heating, leading to synergistic benefits for recovery. A study by Kużdżał *et al*. (7) found that heated compression significantly improved forearm perfusion and biomechanical properties in Mixed Martial Arts (MMA) fighters. To be specific, tissue perfusion (PU) increased following both 5-minute and 10-minute heated compression sessions, with the 5-minute mark producing slightly stronger improvements in vascular responsiveness despite the shorter amount of time.

Heated compression reduced muscle stiffness by approximately 10–12%, improved elasticity by 8–10%, and increased the pressure-to-pain threshold in the treated muscle groups (7). These changes indicate enhanced soreness tolerance and faster recovery.

Neramitr *et al*. (8) measured physiological changes during heated compression therapy using impulses. The baseline impulse response was followed by heated compression with 2.28 Vp-p and frequency of 75.013 Hz, showing stable circulation. When the excitation level increased, the voltage rose to 4.28 Vp-p and the frequency to 76.898 Hz. This highlights how heated compression gradually enhances muscle function and vascular responsiveness as the intensity of treatment rises, aligning with broader findings that heat and compression together can improve circulation and muscle recovery.

Strength outcomes also improved, with the mean forearm strength increasing by 7.62 ± 4.37 kgf after the 5-minute protocol and 6.72 ± 2.15 kgf after the 10-minute protocol, showing that even short applications can provide impactful performance and recovery benefits (7). Similarly, studies using localized compression plus heat have shown reduced soreness and increased pain thresholds (8). Devices now combine compression and heat therapy, creating new possibilities for improved recovery outcomes by using regulated pressures of 30–60 mmHg and controlled heating ranges of 38–42 °C, as demonstrated in the smart compression systems described by Coelho Rezende *et al*. (22). In addition, Kumar *et al*. (23) created polymeric stress-memory compression actuators capable of delivering compression with high mechanical durability, remaining functional for over 10,000 activation cycles, and achieving rapid heating within 60 seconds. Research comparing hot and cold therapy also indicates that heating combined with compression can outperform cold therapy for long-term muscle recovery, pain relief, and flexibility (13, 27). Altogether, these findings suggest that heated compression may deliver greater benefits than either treatment alone.

Physiological Mechanisms of Compression Garment

Compression garments have been shown to improve circulation by increasing venous blood flow and improving cardiac output, which results in more efficient oxygen delivery and clearance of metabolic products such as lactate (3, 4). This is especially important for high-intensity exercise, where fast metabolite clearance is important for sustaining performance (1). The literature reviewed demonstrates that both heat and compression therapies significantly improve recovery outcomes, and when combined, their effects are complementary and more effective than using either one alone. In the meta-analysis by Lee *et al.* , heated compression resulted in an increase in venous blood flow of 18–25% compared to baseline, confirming that these techniques have positive circulatory effects when used together (3, 7). Heat therapy has been shown to improve vasodilation, which raises muscle temperature by 3–4°C, enhances blood flow by up to 45%, and increases enzyme activity that is used for muscle repair and metabolism (2, 5).

According to O'Riordan *et al*., compression tights improved resting venous blood flow by 23% and muscle perfusion by 31% in basketball players, while Leabeater *et al*. found a small effect size (Hedges g = 0.41) for post-exercise improvements in strength and soreness (3, 4). Systematic reviews emphasize that compression improves peripheral circulation and reduces vibrations in muscles (1, 19). Studies have shown that compression and heating together speed up lactate clearance by 22–28%, reduce fatigue symptoms, and improve tolerance to increased training loads (13, 27). Heated compression also enhances perceptions of comfort and shortens recovery time by, on average, 12–18 hours compared to using either therapy alone (7).

Blood flow was assessed pre- and post-heat/compression therapy in several studies, showing improvements in venous return and circulation efficiency (3, 7). In clinical settings, compression has been used and recommended for vascular health, supported by official guidelines from major organizations (21). Innovative compression devices and materials, such as polymers with stress memory, are now being developed to deliver more precise and customizable compression during athletic recovery (22, 23). Together, these findings show that compression garments are effective in improving circulation and supporting performance and recovery.

Recent systematic reviews provide more detailed insight into these effects, demonstrating that overall peripheral blood flow increases significantly with compression use, with the strongest improvements observed in venous return during exercise and recovery—when circulatory support is most needed. O'Riordan *et al*. (19) contains data that showed that venous flow rate in the legs rose from 0.21 ± 0.05 mL/min/100 g in the control group to 0.41 ± 0.08 mL/min/100 g under compression ($p < 0.05$), while changes to arterial blood flow were small (< 5%).

Heat Therapy and Blood Flow

Heat therapy is widely used for its ability to promote vasodilation, increase muscle blood flow, and improve oxygenation in tissues (2, 7). Local heat therapy has been shown to increase recovery rates after muscle damage, improving structural and functional properties when utilized consistently (5, 12). Research on hot compresses also highlights reductions in stiffness and pain, showing the role of heat in both athletic and clinical settings (11, 24).

Traditional methods, such as heat compresses, are still effective to manage conditions such as lumbar disc herniation, demonstrating the circulation-enhancing benefits (11). In addition, passive heating methods, such as hot-water immersions, improve muscle flexibility and reduce delayed onset muscle soreness (25, 13). Modern reviews note that heat therapy supports not only short-term recovery but also has long-term benefits, such as hypertrophy and neuromuscular improvements (26). Thus, heat therapy is versatile for use, with broad applications for both athletes and patients.

Age-Related Vascular and Recovery Differences

Age is another crucial factor influencing the effectiveness of recovery therapies. In a study by Casey *et al*., older adults (mean age = 67 years) often show reduced endothelial function, slower vasodilation, and impaired blood flow, limiting post-exercise recovery (14). In their review, Meade *et al*. compared younger adults (mean = 23 years) with older adults (mean = 62 years) and noted that the older group exhibits significantly weaker cardiovascular and thermoregulatory responses to heat. They also show reduced thermoregulatory capacity, leading to older adults storing larger amounts of heat during exercise (15, 16).

Age-specific differences are clear across studies. Research shows that younger athletes, with more responsive vascular systems, tend to benefit more from the vasodilation caused by heat and the circulatory support from compression therapy (14, 18). On the other hand, older athletes—who face reduced endothelial function and slower blood flow—can benefit from heated compression by combating stiffness, vascular decline, and hypertension (6, 15).

Despite these limitations, targeted heating can fight back against some age-related declines. Short-term heat exposure improves microvascular function in aged muscles (6), while long-term heat therapy lowers blood pressure and improves endothelial function in older populations (17). Interestingly, studies analyzing lower-limb hyperthermia show that heating has equal improvements in young and older athletes (18).

Evidence from Casey *et al*. shows that during increasing exercise intensities (10%, 20%, 30%

maximal voluntary contraction), younger adults have approximately 15–20% faster forearm vascular conductance (FVC) responses and higher peak FVC values (~500 ml·min^{-1}·100 mmHg^{-1}) compared to older adults who stop around 400 ml·min^{-1}·100 mmHg^{-1} (14).

Compression may also work differently across ages. Ann *et al*. showed that compression leggings produced different cardiovascular responses in young and older adults (19). In another study by Martin *et al*., vascular benefits were reported from compression, suggesting effects useful for older individuals with impaired circulation (20). These results show that while younger athletes benefit most from faster vascular responses, older adults may experience greater long-term vascular health improvements.

Recovery and Pain Perception

Recovery from training requires not just improved circulation but also reduced pain and soreness. Compression, as previously stated, tends to improve pressure-to-pain thresholds (PPT), reducing soreness and improving tolerance to higher training loads (10). Similarly, heat therapy decreases pain, increases tissue flexibility, and allows for faster return to peak performance. According to data from Malanga *et al*., heat therapy increased local temperature by 3–4 °C, which, in turn, has a positive effect on enzyme activity, and decreased pain intensity scores by up to 35% on the Visual Analogue Scale (VAS) (2). Clinical trials that used hot compress therapy, such as in the study by Song *et al*. on patients with disc herniation, reported a reduction of 40% on average when it comes to pain and a 22% increase in flexibility after two weeks of daily application (11). Meanwhile, Poder *et al*. displayed that thermal exposure of 40–42 °C improved local blood circulation rates by 30–32%, speeding up oxygenation and metabolism (24).

Although most research on heated compression therapy focuses on physiological metrics like blood flow and lactate clearance, several studies suggest that these effects also translate into measurable performance improvements. In a systematic review conducted by Leabeater *et al*., compression garments were shown to have a positive effect on strength recovery and soreness perception, despite the fact that there were limited performance benefits during running and high-intensity exercise (1). In combat sports, Kużdżał *et al*.'s pilot study showed that a 5-minute heated compression session increased forearm strength considerably, while also raising PPT and reducing stiffness, which indicates that physiological changes can be seen in small performance improvements (7).

Subjective recovery was also measured using visual analogue scales (VAS), where participants reported their muscle soreness and readiness to perform (20). Evidence from Sands *et al*. (10) supports these findings by examining soreness distribution among athletes across soccer, basketball, volleyball, baseball, softball, golf, and track. Their Recovery Center Soreness Report, based on 75 reports from 10 athletes, showed that soreness was concentrated in the lower body—particularly the quadriceps (68%), hamstrings (60–68%), and calves (57–61%). These muscle groups experience the greatest stress during intense training.

Recovery metrics such as pressure-to-pain threshold (PPT) were measured at the start, immediately post-intervention, and 24 hours later, showing improvements in pain tolerance and muscle strength. In the study by Sands *et al*. (2015), the use of dynamic compression during recovery led to an average increase of 23–25 % in PPT values immediately post-treatment compared to baseline, with the effect still elevated by approximately 15 % after 24 hours (10). Participants also reported a 20 % reduction in perceived soreness and improved scores on the Recovery Center Soreness Report.

Illustration of a knee-calf sleeve that provides heat and compression; rings show heat zones, blue pads show pressure, arrows and warm color gradient indicate increased blood flow and muscle temperature, leading to less soreness and better recovery (Figure 2).

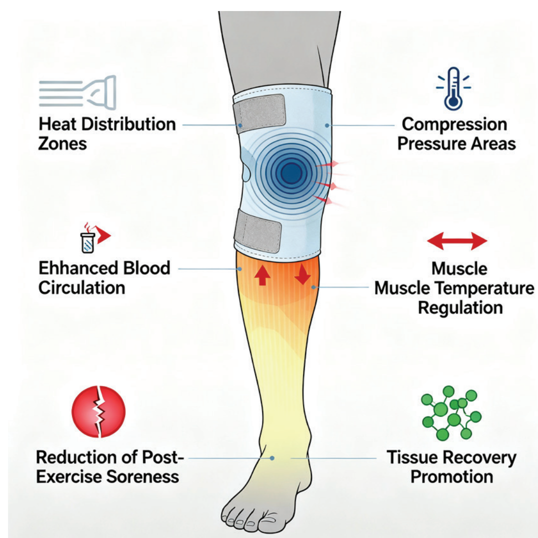

Figure 2. Schematic of a generic heated-compression wrap and proposed mechanisms (created by the author with Biorender.com).

Comparison Across Sports

There is an increasing amount of evidence suggesting that the efficacy of heated compression therapy varies based on a sport's physical demands. In explosive and rapid sports such as combat sports and basketball, compression alone enhances venous return and improves the efficiency of circulation, increasing recovery speed, performance, and tissue perfusion. Post-treatment data revealed significant changes (effect sizes d = 1.77 for 5 min and d = 6.37 for 10 min in *m.* flexor carpi radialis muscle), with the 5-minute protocol showing greater relative perfusion improvements compared to baseline (4).

When combined with heat, these effects are amplified—showing significant improvements in tissue perfusion, pain tolerance, and muscle properties in athletes exposed to intense workloads, such as MMA fighters (7). Studies on contrast compression therapy in similar athlete populations indicate that benefits may extend systemically, improving both targeted and opposite limbs (28).

Data from O'Riordan *et al*. (4) demonstrated that different compression garments (socks, shorts, tights) affect muscle blood flow differently. The highest mean blood flow was recorded under tights (> 0.4 mL/min/100 g) compared to control (~ 0.2 mL/min/100 g), $p < 0.05$–0.01. These results highlight that dynamic and lower-body–intensive sports, such as basketball, benefit most from full-limb compression garments that maximize venous return and oxygenation. In endurance sports like running and cycling, compression garments do not consistently enhance VO_2 max or lactate threshold but still improve post-exercise recovery through reduced soreness and faster lactate clearance (29,30).

Sex-Based Differences

Sex-based physiological differences can also influence the effectiveness of heated compression therapy. Research suggests that both males and females experience thermoregulatory changes after heat exposure—such as reduced skin temperature, lower heart rate, and improved sweat rate—but adaptation speed can differ between sexes. In an analysis by Kelly *et al*., female participants had a 12–15% slower rate of heat acclimation, and they needed approximately 5–6 days longer to achieve stable heat balance compared to males (31). In contrast, men demonstrated a reduction in mean skin temperature (~0.5 °C) and a 4–6% decrease in heart rate during repeated heat therapy trials, showing that they have faster vascular adaptation.

In endurance contexts, men tend to show greater increases in blood flow after post-exercise heating, while women demonstrate more efficient sweating responses in specific regions, indicating distinct thermoregulatory mechanisms. Findings by Kirby *et al*. showed that males exhibited an average 18–22% increase in limb blood flow during post-exercise sauna sessions, compared to 11–13% in females, while women had 10–12% higher sweat rates in regions such as the forearms and upper back (32). This demonstrates pathways for thermoregulation that differ depending on sex, with men showing better vascular dilation and women having higher cooling efficiency during heat recovery. Compression garments also interact differently with male and female physiology due to differences in muscle mass, fat distribution, and surface-area-to-mass ratio (33). Females typically produce less metabolic heat and sweat, affecting their responsiveness to heated compression. Males, however, tend to experience stronger improvements in venous return and muscle perfusion. Collectively, these findings suggest that sex-based physiological factors should be considered when tailoring heated compression therapy for optimal recovery and performance outcomes (Table 1).

Table 1. Summary and analysis of major studies included this review

Author (Year) - (Reference #)	Age Group	Gender	Study participants	Sample Size	Intervention	Outcomes
(1)	Mixed younger and middle-agedathletes (20–40)	Mixed	General athletes	N/A	Compression	Improved sprint & agility, mixed endurance results
(4)	Younger athletes (20–30)	Male	Basketball players	n = 22	Compression	↑ Venous return, ↑ blood flow, improved recovery

Continued Table 1. Summary and analysis of major studies included this review

Author (Year) - (Reference #)	Age Group	Gender	Study participants	Sample Size	Intervention	Outcomes
(5)	Younger and recreational athletes (18–35)	Mixed	Physically active	n = 12	Local heat therapy	↑ Skeletal muscle function, ↑ flexibility
(7)	Younger and athletes (18–35)	Male	MMA fighters	n = 12	Heated compression	↑ Tissue perfusion, ↑ pain tolerance, ↓ soreness
(10)	Elite younger athletes (20–30)	Mixed	Strength sports athletes	n = 28	Dynamic compression	↑Pressure-to-pain threshold, ↓ fatigue
(15)	Older recreational athletes (65+)	Mixed	General population	N/A	Heat therapy	Characterized heat vulnerability, ↑ cardiovascular strain
(17)	Older recreational athletes (55–70)	Mixed	General population	n = 16	Heat therapy	↓ Blood pressure, ↑ endothelial function
(20)	Older recreational athletes (60+)	Mixed	General population	n = 18	Heat therapy	↑ Skeletal muscle blood flow during exercise
(28)	Younger athletes (20–30)	Male	MMA fighters	n = 15	Contrast Compression	↑ Ipsilateral and contralateral perfusion
(36)	Mixed younger and middle-aged recreational athletes (20–40)	Mixed	General population	n = 24	Pneumatic compression	↑ Skin blood flow, ↑ vascular reactivity
(41)	Younger athletes (18-24)	Male	Baseball and Golf players	n = 21	Compression	↑ Fastball accuracy; ↑ golf accuracy; ↑ perceived comfort

DISCUSSION

The reviewed literature demonstrates that both heat and compression therapies improve recovery outcomes, and when combined, their effects are complementary and more effective than using either one alone. Heat therapy has been shown to promote vasodilation, which raises muscle temperature, enhances blood flow, and increases enzymatic activity, accelerating metabolic waste clearance, which is needed for muscle repair. Compression garments benefit recovery by applying external pressure that reduces pooling of blood, enhances venous return, and supports blood flow during and after physical activity. Systematic reviews emphasize that compression improves peripheral circulation and reduces vibrations in muscles. Studies have shown that compression and heating together speed up clearance of lactate, reduce fatigue symptoms, and improve tolerance to increased training loads. Heated compression also enhances perceptions of comfort and shortens recovery time compared to using either therapy alone.

Some important physiological changes that are caused by compression garments, as shown in Figure 3, include increases in skin temperature and reductions in muscle oscillation, even though overall blood markers stay the same. This indicates that the main benefits of compression are perceptual and muscular, as it reduces soreness, improves sensory feedback, and helps athletes process limb position and movement accuracy. The lack of significant changes in heart rate, respiratory rate, or blood pressure further confirms that the effects are mostly localized.

Some key physiological and perceptual outcomes of compression garments include the following: compression garments may not consistently enhance physical performance, they reduce muscle soreness and muscle oscillations, helping athletes recover faster between training sessions. Additionally, skin temperature increases at the area of the garment, though core temperature and heart rate are unaffected, suggesting

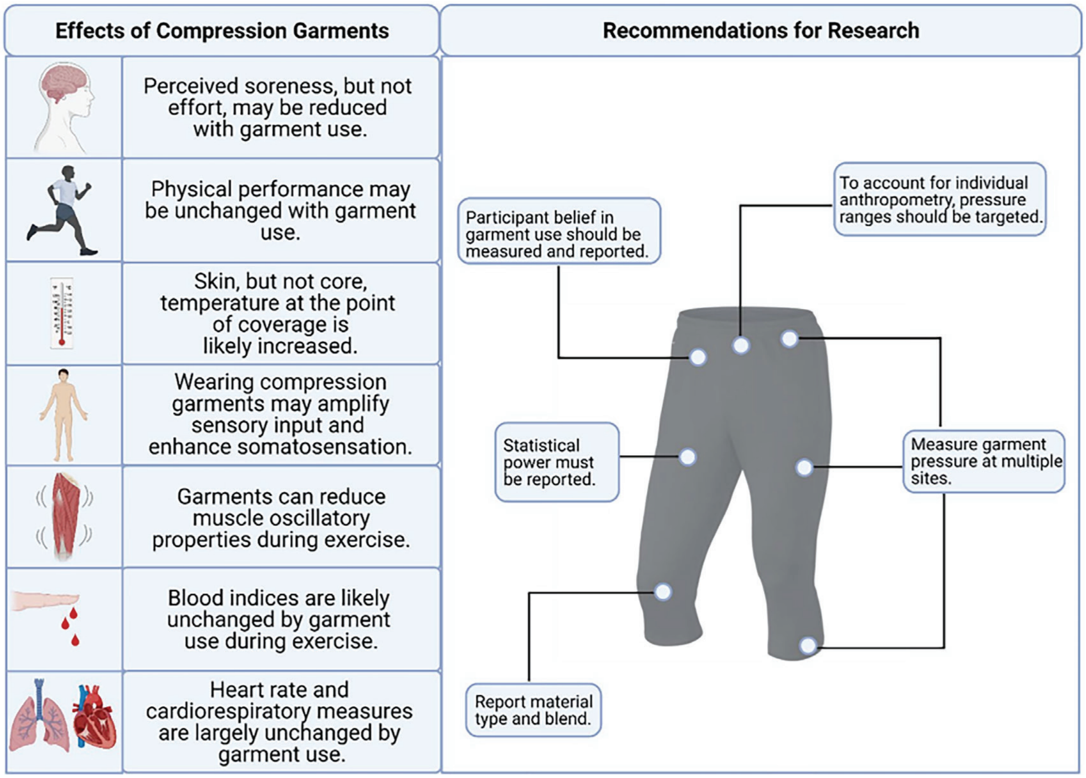

Figure 3. Research recommendations and a summary of key findings relating to the use of compression garments. Adapted from Weakley *et al*. (40) under CC BY 4.0 license.

that the thermal effects are localized rather than systemic. These garments can also improve somatosensory feedback, helping athletes perceive limb position and movement more accurately during recovery. However, blood and respiratory measures are unchanged, showing that the benefits are more muscular and perceptual rather than cardiovascular.

Age-specific differences are also clear across studies. Research shows that as younger athletes possess more responsive vascular systems, they tend to benefit more from the vasodilation caused by heat therapy and the circulatory support caused by compression therapy. On the other side, older athletes, who face reduced endothelial function and slower blood flow, can benefit from heated compression in ways that combat stiffness, vascular decline, and hypertension.

However, findings from studies are inconsistent, as not all trials show significant improvements in performance, as they instead focus on recovery benefits from heated compression therapy. Many studies report that there are improvements in pain perception for the participants, such as reduced soreness and faster recovery, without concrete corresponding increases in competition-level performance. This highlights a gap: while heated compression supports performance indirectly by enhancing recovery, direct evidence linking it to improved results in competitive settings is limited and requires further investigation.

Overall, the results suggest that heated compression therapy is most beneficial for enhancing post-exercise recovery by improving circulation, accelerating the clearance of fatigue-inducing metabolites, reducing soreness, and stabilizing the cardiovascular system. While younger athletes experience rapid performance recovery due to their efficient vascular responses, older athletes benefit from reduced stiffness, improved vascular health, and enhanced comfort. Evidence from the literature consistently supports heated compression therapy as an innovative recovery method, however several studies state the need for standardized protocols and age-specific trials to strengthen these results.

Moving forward, future research should aim to address these gaps. Studies should include diverse age groups, use standardized protocols for temperature and compression, and be conducted in both laboratory and real-world athletic settings. More long-term investigations would also help clarify whether heated compression not only helps with short-term recovery but also contributes to adaptations in muscle function and vascular health over time. Ultimately, this will allow heated compression therapy to transition from a promising recovery tool into a validated and widely applicable method for athletes across different sports and age groups.

Limitations

The overall research suggests that the combination of heat and compression is more effective than either method alone, but there are several important limitations to consider. One major issue is the lack of studies that directly compare results between younger and older athletes. While general patterns hint that younger individuals show faster vascular responses and older athletes benefit from stiffness reduction, these findings are indirect and highlight a need for more age-specific investigations.

Another significant limitation is the heterogeneity in the studies. Different temperature levels, compression pressures, treatment durations, and application methods make it challenging to compare outcomes across studies. Some papers focus on static compression, while others use dynamic compression, which makes the synthesis of data more challenging, and leads to limited consensus on the most effective technique. Similarly, there is potential heterogeneity in the types of products tested—commercially available compression garments and heat wraps have a different design, fit, and thermal regulation, which can affect outcomes and reduce comparability across studies.

Although this review conceptually groups ages into younger (16–35), middle-aged (36–54), and ≥55 years, primary studies used heterogeneous age cut-offs (e.g. 18–35, 20–40, 55–70, ≥60). Age labels in the Results section therefore reflect the original study definitions, and cross-study comparisons should be interpreted with caution.

Many existing studies are also limited by small sample sizes, which restricts the statistical reliability of their findings and makes it difficult to apply results to the general athletic population. Furthermore, the lack of standardized measures is a challenge. While some studies show changes in blood flow, others focus on soreness, pressure to pain thresholds, or recovery time, creating inconsistency that does not allow for accurate direct comparison and analysis.

Another point to consider is that this review does not use a formal risk-of-bias assessment for the included studies. Risk-of-bias tools are often used in systematic reviews to evaluate methodologies and identify potential issues such as randomization errors or sample imbalances. While this paper did not include such an assessment, the studies reviewed were selected based on specific inclusion and exclusion criteria, ensuring that the evidence gathered was current, peer-reviewed, and relevant to the research question. Therefore, although potential bias in individual studies cannot be fully avoided, the dataset still provides a valid and up-to-date view of the role of heated compression therapy in athletic recovery and performance.

Finally, most studies emphasize immediate or short-term recovery outcomes, such as acute improvements in blood flow, reduced soreness, or faster metabolite clearance. Only a fraction of the investigations examine whether these benefits translate into long-term benefits, such as vascular health improvements or injury prevention. Without direct evidence, the complete value of heated compression therapy remains uncertain.

Controlled laboratory settings also introduce some limitations. While these controlled environments standardize and improve the reliability of data collection, they do not fully capture the complex conditions of real-world sport. Outdoor environments have additional factors such as humidity, different temperatures, weather, and varying exercise intensity that could increase or decrease the effect of heated compression therapy. As a result, translating laboratory findings into practical recommendations for athletes needs validation in real-world settings.

Risk of Bias

While the studies reviewed provide crucial information about the physiological and recovery benefits of heated compression therapy, several limitations and potential biases should be acknowledged. Across the literature that was included, randomization and blinding were applied inconsistently, especially in studies such as Kużdżał *et al.* and Sands *et al*., which relied on athlete self-reports and lacked blind control groups. Sample sizes also varied considerably across studies, ranging from pilot studies with fewer than 15 participants to systematic reviews combining over 50 trials, which introduces heterogeneity in reliability and comparability. In addition, there were differences in measurements when it came to pressure-to-pain thresholds, vascular flow, and thermal adaptation, as different methodologies and time intervals were used. Laboratory-based trials had high internal validity, meaning they could demonstrate more precise physiological changes (e.g., blood flow, temperature, PPT), while field studies offered stronger ecological validity but higher variability. Based on these factors, the overall quality of evidence can be rated as Moderate according to a GRADE-style assessment. Future research using standardized trial durations, larger and more diverse sample groups, and consistent blinding procedures will help improve the reliability of findings.

CONCLUSION

Heated compression therapy emerges as a promising method for improving circulation, enhancing recovery, and supporting athletic performance. By combining two well-established recovery strategies: heat and compression, this approach has the potential to optimize muscle temperature, promote efficient blood flow, and reduce post-exercise soreness. For athletes, these combined effects can increase recovery speed, improve comfort, and make their bodies ready for high-intensity training or competition.

The evidence reviewed suggests that the benefits of heated compression may not be the same across all populations. Younger athletes tend to experience quicker circulatory responses and performance enhancements, while older athletes may find more benefit from stiffness reduction, vascular support, and long-term comfort. This shows that heated therapy has the potential to have different but complementary purposes across the lifespan of athletes.

Despite its promising aspects, limitations remain. Current research is weighed down by inconsistent protocols for temperature, compression levels, and treatment duration, as well as a lack of studies directly comparing different age groups. Many findings also come from controlled laboratory settings, which do not always capture the complex environment of real-world training and competition. To establish the role of heated compression therapy in sports medicine, future research must utilize standardized methods, involve diverse athlete populations, and measure outcomes in practical athletic environments.

In conclusion, heated compression therapy holds strong potential as both a performance enhancer and a recovery tool. Its dual effect to support immediate recovery and promote long-term vascular health makes it an innovative tool for athletes at all levels. With continued research and refinement, it may become a central part of recovery practices in modern sports.

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CONFLICT OF INTEREST

The author(s) declare no conflicts of interest related to this work.

AUTHOR CONTRIBUTIONS

Arslan Maharramli: conceptualization, methodology, validation, data curation, investigation, writing, review and editing, visualization, project administration. Konstantinos Mantzios: conceptualization, methodology, validation, data curation, investigation, review and editing, visualization, supervision.

ABBREVIATIONS

FVC	Forearm vascular conductance ($ml \cdot min^{-1} \cdot 100\ mmHg^{-1}$)
MMA	Mixed Martial Arts
HCT	Combined Heated Compression Therapy
PPT	Pressure-to-pain threshold
PU	Perfusion units
VAS	Visual Analogue Scale (0–10 scale)
VO_2 max	Maximal oxygen uptake
Vp-p	Volts peak-to-peak

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