

Palm Cooling Between Sets Reduces Perceived Exertion Without Enhancing Performance During High-Load Deadlifts

Original Research

Jeffrey Buxton, Johnny Aloï, Ryan Hersey, Hunter Presgrave, Stewart McClain, Nico Flati, Hayden Gerhart, Philip Prins

¹Department of Exercise Science, Grove City College, Grove City, PA, USA

Open Access



Published: October 27, 2025



Copyright, 2025 by the authors. Published by Pinnacle Science and the work is licensed under the Creative Commons Attribution 4.0 International License. To view a copy of this license, visit <http://creativecommons.org/licenses/by/4.0/>

Research in Strength and Performance:
2025, Volume 5 (Issue 1): 8

ISSN: 3069-0765

Abstract

Introduction: This study investigated the effects of inter-set palm cooling on performance, physiological, and perceptual responses during high-load deadlift exercise.

Methods: Twelve resistance-trained males (age: 20.6 ± 1.4 years) completed two randomized, counterbalanced experimental sessions involving repeated sets of hex bar deadlifts at 95% of their estimated 5-RM. During rest intervals, participants either sat passively without a device (no palm cooling; NPC) or held a commercially available palm cooling device (palm cooling; PC). Performance metrics (total volume, bar velocity, power, and force), physiological responses (heart rate, core and skin temperature), and perceptual measures (RPE, affect, thermal comfort, and perceived recovery) were recorded.

Results: No significant differences were observed between PC and NPC conditions for performance or physiological outcomes ($p > 0.05$). Although not statistically significant, PC resulted in greater total volume (+15%), partial (concentric-phase) power (+4%), and peak force (+5%). Perceptual responses differed significantly, with PC producing lower RPE ($p = 0.049$), higher affect ($p = 0.049$), and improved thermal comfort ($p = 0.002$), but unexpectedly lower perceived recovery between sets ($p = 0.001$).

Conclusions: PC did not significantly enhance performance or physiological recovery during high-load deadlifts but improved perceptual responses, supporting the hypothesis that PC may modulate central sensory feedback during exercise. These findings suggest PC may be especially useful during high-intensity resistance training in hot environments or for athletes sensitive to thermal strain.

Key Words: thermoregulation, resistance training, central sensory feedback.

Corresponding author: Jeffrey Buxton buxtonjd@gcc.edu

Introduction

Resistance training is a foundational component of athletic performance and general fitness, with benefits ranging from increased muscular strength and hypertrophy to improved metabolic health^{1, 2, 3} Maximizing performance during resistance training sessions often depends on the ability to sustain high force and power output across successive sets. However, fatigue accumulation and thermal discomfort can impair performance, particularly during high-intensity protocols which may increase energy consumption, and subsequently, heat generation up to 100-fold in working muscles.⁴



Thermoregulation plays a critical role in exercise performance. Research has shown that local skeletal muscle tissue exhibits an optimal working temperature range, with temperatures exceeding this range resulting in rapid decreases in contractile force capabilities.⁵ Additionally, elevated core and skin temperatures can negatively affect neuromuscular function, cardiovascular efficiency, and perceptual responses such as perceived exertion and thermal discomfort, resulting in diminished performance.^{6,7} Although several cooling strategies have shown benefits, such as cold water immersion, cooling vests, and localized cooling, most are impractical for use during training due to their invasiveness, time demands, or logistical constraints.⁸ In contrast, palm cooling (PC) is non-invasive, fast-acting, and can be applied during short rest intervals between sets, making it a practical alternative for athletes and practitioners. The palms contain specialized vascular structures known as arteriovenous anastomoses, where heat absorbed by circulating blood from working muscles can be extracted, thereby reducing the rate of heat accumulation in the active muscle tissue. Since temperature is a limiting factor of muscle function, delaying heat accumulation may improve muscle contractile force capabilities and ultimately performance.⁹

Palm cooling may influence both physiological and perceptual responses during resistance exercise. Mechanistically, cooling the palms can attenuate the rise in active muscle and core temperature and modulate thermal perception, thereby reducing central fatigue by altering afferent thermal signals and potentially preserving central motor drive.^{9,6} Additionally, psychophysiological factors such as thermal discomfort and perceived exertion are closely linked to motor unit recruitment and pacing behavior, suggesting that thermal interventions may indirectly influence performance through perceptual pathways.¹⁰ High-load resistance training elevates perceptual strain, such as perceived exertion, thermal discomfort, and affective valence, which can impair exercise tolerance and reduce adherence. By reducing perceptual strain, palm cooling may enhance the subjective experience of training, potentially improving performance indirectly by increasing comfort and reducing the psychological burden of effort.^{11,12}

Preliminary research suggests that PC may enhance endurance and anaerobic performance, delay fatigue, and improve physiological, metabolic and responses during resistance exercise.^{9,13,14,11,12} However, PC's effects on resistance training performance, particularly during high-load multi-set protocols, remain underexplored. Thus, this study aimed to investigate the effects of inter-set PC on performance, physiological, and perceptual responses during repeated sets of high-load deadlifts. It was hypothesized that PC would reduce perceptual strain and improve physiological and performance outcomes compared to a no-cooling control condition.

Scientific Methods

Experimental Design

A randomized, counterbalanced crossover design was employed to investigate the effects of inter-set palm cooling on performance during multiple sets of high-load deadlifts. Twelve participants completed one familiarization session followed by two experimental sessions conducted at the same time of day, each separated by at least seven days. During the familiarization session, participants were introduced to all procedures, completed anthropometric assessments (height, weight, and body composition), and performed a 1-repetition maximum (1-RM) test using a hexagonal barbell. This 1-RM was used to estimate each participant's 5-RM load. During each experimental session, participants performed a standardized dynamic warm-up and then completed as many sets as possible of five repetitions at 95% of their estimated 5-RM, using the hexagonal barbell, with three minutes of rest between sets. During rest periods, participants either sat passively without a device (non-palm cooling; NPC) or held a commercially available palm cooling device (palm cooling; PC). Performance and physiological outcomes were assessed throughout each session, including total training volume (sets × reps), bar velocity metrics (average and peak velocity, partial power, and peak force), heart rate, core and skin temperature, and perceptual measures [ratings of perceived exertion (RPE), affect, thermal comfort, and perceived recovery]. All procedures were approved by the institutional review board (IRB #127-2024), and written informed consent was obtained from all participants. Experimental sessions were conducted in the Exercise Science Laboratory at Grove City College.

Participants

Twelve resistance-trained, college-aged males with at least two years of consistent training experience and no known chronic disease volunteered to participate (Table 1). All participants were familiar with the hexagonal barbell deadlift and regularly performed it at high relative intensities (>85% 1-RM) at least once per week. Participants were excluded if they were involved in competitive weightlifting, had sustained an injury within the previous 12 months, were currently injured, or had a known cardiovascular, metabolic, or pulmonary disease. Participants were instructed to refrain from caffeine consumption for 24 hours and from vigorous physical activity for 48 hours prior to each testing session.

Additionally, participants were instructed to maintain their regular exercise and dietary habits throughout the study. All participants were familiarized to the study protocols and informed of the risks prior to providing written consent.

Table 1: Physical characteristics of the participants (N=12).

Variable	Mean \pm SD
Age (yr)	20.58 \pm 1.37
Height (cm)	182.78 \pm 9.33
Weight (kg)	93.35 \pm 18.17
BMI	27.27 \pm 5.89
Fat %	17.57 \pm 8.72
Fat mass (kg)	17.71 \pm 12.41
FFM (kg)	75.63 \pm 6.88
Muscle mass (kg)	71.91 \pm 6.52
Resting heart rate (bpm)	76.92 \pm 11.98
1RM deadlift (kg)	179.96 \pm 28.32
5RM deadlift load (kg)	148.78 \pm 23.44

yr = years; cm = centimeters; kg = kilograms; bpm = beats per minute

Protocol

Familiarization

During the familiarization session, following orientation to all experimental procedures and provision of written informed consent, participants completed anthropometric assessments for height (cm) using a stadiometer (Detect-Medic Balance scale, Detecto Scales, Inc., Brooklyn NY) and body mass (kg) and body composition (BMI (kg/m²), fat mass (% and kg), and fat free mass (kg) using a bioelectrical impedance analyzer (BIA) (TBF-310GS, Tanita Corporation of America, Arlington Heights, Illinois). Participants were then introduced to four perceptual scales: the OMNI-Resistance Exercise RPE Scale,¹⁵ the ASHRAE Thermal Comfort Scale,¹⁶ the Feeling Scale for affect,¹⁷ and the Perceived Recovery Status Scale.¹⁸ These were explained prior to testing to ensure consistent interpretation during experimental sessions. Participants then completed a standardized dynamic warm-up followed by a 1-repetition maximum (1-RM) hexagonal barbell deadlift protocol, following NSCA guidelines.¹⁹ Experimental session load was calculated using the equation: 1-RM \times 0.87 \times 0.95, where 0.87 represents the estimated load for 5-RM and 0.95 accounts for the intensity used during testing sessions.²⁰ Randomized counterbalancing was used to determine the assignment of palm cooling (PC) or no palm cooling (NPC) sessions.

Experimental Session

Before each session, participants were fitted with a heart rate monitor (Polar H10, Polar Electro, Kempele, Finland) at the xiphoid process and a core temperature sensor (CORE Sensor, greenTEG AG, Zürich, Switzerland), which was attached to the heart rate strap and positioned along the left anterior axillary line, prior to beginning the standardized warm-up. Following the warm-up, participants completed the deadlift protocol, which involved performing as many sets as possible of five repetitions at 95% of their estimated 5-RM, with three minutes of seated passive recovery between sets. The protocol was terminated when a participant was unable to complete five successful repetitions, defined as maintaining a neutral spine throughout the concentric and eccentric phases and achieving full knee lockout at the end of each concentric phase. During the PC condition, participants held a cylindrical palm cooling device (Charge Bar, AVA Cooling Technology, Sun Valley, ID, USA) with both bare hands continuously throughout each recovery period. The PC device was monitored continuously throughout each trial and maintained at a temperature of 7-15°C per manufacturer's recommendations. If the device exceeded 15°C, it was immediately replaced with one within the recommended temperature range. No placebo device was used in the NPC condition; participants rested without holding any object. The laboratory environment where all procedures were conducted was maintained at a thermoneutral temperature and humidity (~20°C & 40% relative humidity) for all trials.

RPE, affect, thermal comfort, HR, skin temperature (ST), and core temperature (CT) were recorded immediately post-set. HR, ST, CT, and perceived recovery (PR) were then recorded again prior to the start of the next set. Changes in HR (Δ HR), skin temperature (Δ ST), and core temperature (Δ CT) were calculated by subtracting pre-set values from immediately post-set values, and these deltas were used in analysis. During deadlift repetitions, a linear position transducer (TENDO Unit, Tendo Sports Machines, London, UK) was used to record average and peak bar velocity (m/s), peak force (N), and partial power (mean concentric-phase power, W). The average of each perceptual and

mechanical variable across all sets was calculated for each participant and used for analysis. Total session volume was recorded as the number of sets and successful repetitions completed.

Statistical Analysis

All statistical analyses were performed using SPSS version 29.0 (IBM, Amonk, NY, USA) and GraphPad Prism version 10.5.0 (Dotmatics, Boston, MA, USA). Statistical significance was set a priori at $p \leq 0.05$. Descriptive statistics were calculated for each variable. Paired-samples t-tests were used to compare outcome variables between conditions (PC vs. NPC). Normality was confirmed for all variables using the Shapiro-Wilk test. Effect sizes (Cohen's d) were calculated to aid interpretation, with thresholds of 0.2 (small), 0.5 (medium), and 0.8 (large).

Results

Performance Outcomes

No significant differences ($p > 0.05$) were observed between conditions for any performance variables (Table 2, Figure 1 & 2). Although not statistically significant, the PC condition resulted in ~15% greater total volume (mean difference: 5 repetitions), along with small increases in partial power (~4%) and peak force (~5%). All effect sizes were small ($d \leq 0.38$).

Table 2: Performance measures (total volume, average velocity, peak velocity, partial power, and peak force (N=12)).

Variable	PC	NPC	Δ	P-value (Effect size)
Total Volume (a.u.)	36.67 \pm 17.75	31.67 \pm 15.28	5.00	0.214 (0.38)
Avg. Velocity (m/s)	0.44 \pm 0.1	0.44 \pm 0.1	0.00	0.917 (0.03)
Peak Velocity (m/s)	0.83 \pm 0.2	0.83 \pm 0.17	0.00	0.937 (0.05)
Partial Power (W)	495.90 \pm 118.26	477.57 \pm 136.63	18.33	0.609 (0.15)
Peak Force (N)	1841.65 \pm 277.71	1750.45 \pm 325.34	91.20	0.251 (0.35)

PC = palm cooling; NPC = no palm cooling; a.u. = arbitrary units; m/s = meters per second; W = watts; N = newtons

Table 3: Average change during recovery periods, calculated as the difference between immediately post-set and pre-set values, for heart rate (Δ HR), core temperature (Δ CT), and skin temperature (Δ ST) (N = 12).

Variable	PC	NPC	Δ	P-value (Effect size)
ΔHR (bpm)	45.77 \pm 11.33	43.32 \pm 12.37	2.45	0.518 (0.04)
ΔCT ($^{\circ}$C)	0.25 \pm 0.83	0.01 \pm 0.04	0.24	0.96 (-0.02)
ΔST ($^{\circ}$C)	-0.09 \pm 0.22	-0.05 \pm 0.09	0.04	0.85 (-0.06)

PC = palm cooling; NPC = no palm cooling; HR = heart rate; bpm = beats per minute; $^{\circ}$ C = degrees Celsius.

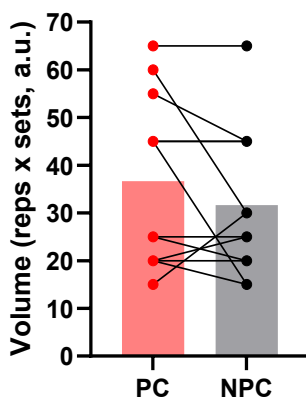


Figure 1. Total volume (reps x sets) performed during each condition. PC = palm cooling; NPC = no palm cooling; a.u. = arbitrary units.

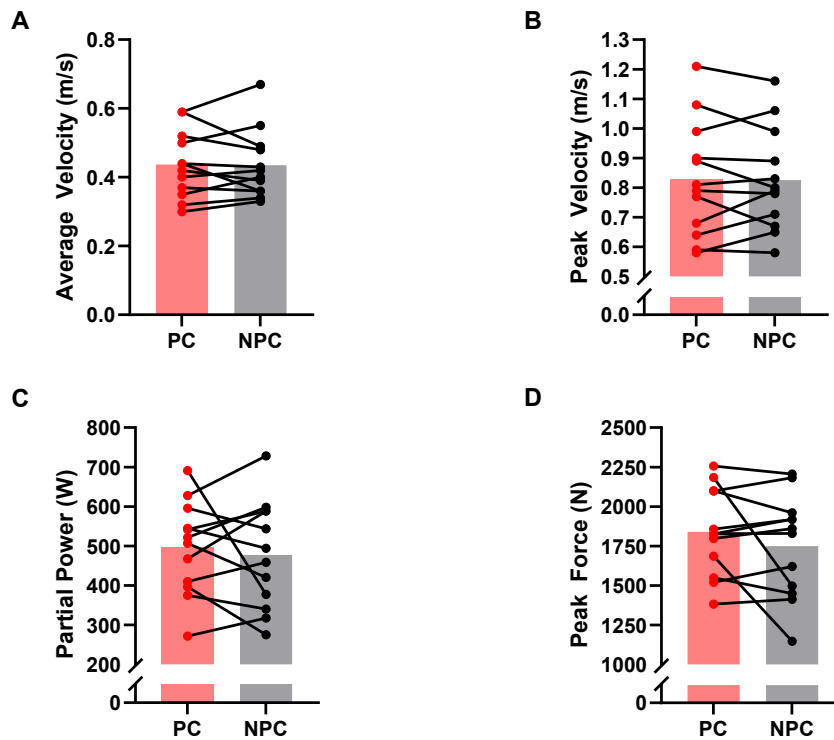


Figure 2. Average (A) and peak bar velocity (B), partial power (C), and peak force (D). PC = palm cooling; NPC = no palm cooling; m/s = meters per second; W = watts; N = Newtons.

Physiological outcomes

No significant differences ($p > 0.05$) were observed between conditions for changes in heart rate (HR), core temperature (CT), or skin temperature (ST) during the recovery periods (Table 3, Figure 3).

Table 3: Average change during recovery periods, calculated as the difference between immediately post-set and pre-set values, for heart rate (Δ HR), core temperature (Δ CT), and skin temperature (Δ ST) (N = 12).

Variable	PC	NPC	Δ	P-value (Effect size)
Δ HR (bpm)	45.77 \pm 11.33	43.32 \pm 12.37	2.45	0.518 (0.04)
Δ CT ($^{\circ}$ C)	0.25 \pm 0.83	0.01 \pm 0.04	0.24	0.96 (-0.02)
Δ ST ($^{\circ}$ C)	-0.09 \pm 0.22	-0.05 \pm 0.09	0.04	0.85 (-0.06)

PC = palm cooling; NPC = no palm cooling; HR = heart rate; bpm = beats per minute; $^{\circ}$ C = degrees Celsius.

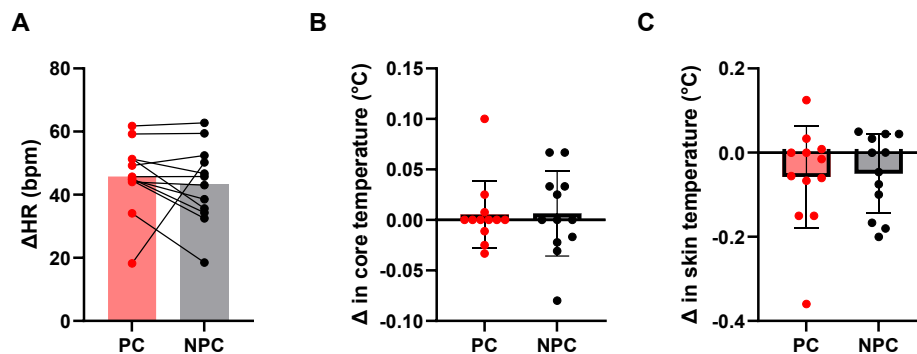


Figure 3. Average changes in heart rate (A), core temperature (B), and skin temperature (C) during recovery periods. HR = heart rate; PC = palm cooling; NPC = no palm cooling.

Perceptual Outcomes

Only perceptual measures [rating of perceived exertion (RPE), affect, thermal comfort (TC), and perceived recovery (PR)] differed significantly between conditions (Table 4, Figure 4). The PC condition resulted in significantly lower RPE, higher affect, and lower thermal comfort scores, indicating that participants felt cooler during PC than NPC. Interestingly, although PC improved thermal comfort and reduced RPE, it was also associated with significantly lower perceived recovery between sets. The effect sizes for differences between conditions in RPE and affect were moderate ($d=0.64$), while differences in TC and PR were large ($d \geq 1.14$).

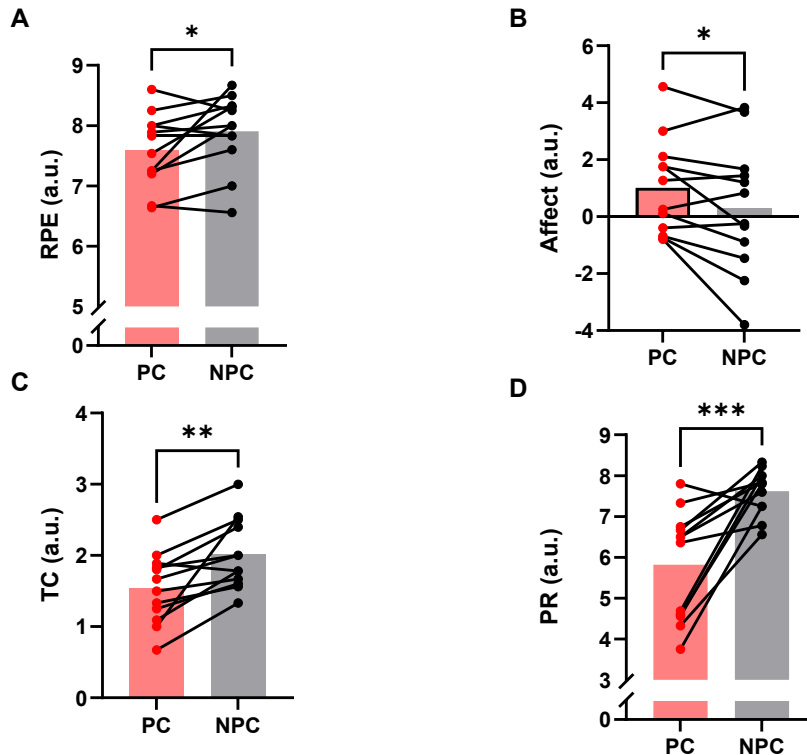


Figure 4. Perceptual measures: rating of perceived exertion (RPE; A), affect (B), thermal comfort (TC; C), and perceived recovery (PR; D). RPE = rating of perceived exertion; a.u. = arbitrary units; TC = thermal comfort; PR = perceived recovery; PC = palm cooling; NPC = no palm cooling. * $p < 0.05$, ** $p < 0.01$, *** $p \leq 0.001$.

Table 4: Perceptual measures: RPE, affect, thermal comfort (TC), and perceived recovery (PR) during experimental sessions (N = 12).

Variable	PC	NPC	Δ	P-value (Effect size)
RPE (a.u.)	7.59 ± 0.61	7.91 ± 0.61	0.32	0.049 (-0.64)
Affect (a.u.)	1.01 ± 1.69	0.31 ± 2.27	0.70	0.049 (0.64)
TC (a.u.)	1.54 ± 0.51	2.01 ± 0.50	0.47	0.002 (-1.14)
PR (a.u.)	5.82 ± 1.34	7.62 ± 0.56	1.80	0.001 (-1.30)

RPE = rating of perceived exertion; a.u. = arbitrary units; TC = thermal comfort; PR = perceived recovery; PC = palm cooling; NPC = no palm cooling.

Discussion

This study examined the impact of inter-set palm cooling on performance, physiological, and perceptual responses during repeated high-load deadlifts. It was hypothesized that palm cooling would enhance performance (i.e., total volume, bar velocity), improve physiological recovery (i.e., HR, core temperature), and reduce perceived exertion. However, these hypotheses were not supported for objective performance or physiological outcomes. Palm cooling did, however, yield significant improvements in perceptual responses, including lower RPE, more positive effects, and improved thermal comfort.

Notably, no significant differences in core or skin temperature were observed between the palm cooling and control conditions. This is consistent with the limited surface area involved in palm cooling and suggests that the intervention did not meaningfully alter whole-body heat content or deep body temperature. Despite this, participants reported significantly lower RPE, greater thermal comfort, and more positive affect, suggesting that perceptual benefits occurred independently of changes in core or skin temperature. These findings support the hypothesis that palm cooling may operate through modulation of central sensory feedback, particularly from arteriovenous anastomoses in the hands, rather than through traditional thermoregulatory pathways.^{21, 22} This dissociation between objective thermal strain and subjective perception highlights palm cooling's potential as a targeted perceptual aid during high-intensity resistance exercise.

These findings align with prior research suggesting that cooling interventions may more effectively improve perceptual responses, such as reduced exertion or enhanced comfort, than directly enhance neuromuscular output, particularly during short-duration, high-intensity resistance exercise.^{11, 12} The modest, non-significant increases in total volume (~15%, ES = 0.14) and power output (~4%) observed in the palm cooling condition may indicate a potential benefit that could become more pronounced over longer training periods or with larger sample sizes.¹⁴

Generally, cooling strategies result in improved comfort and reduced perceptions of effort during exercise resulting in the perception of being more recovered between exertional bouts than.²³ Occasionally this enhanced perception of recovery is different than one's actual state of physical recovery. Interestingly, despite lower RPE and improved thermal comfort, participants in the present study reported significantly lower perceived recovery in the PC condition. This counterintuitive result may reflect a dissociation between thermal comfort and neuromuscular readiness. One possibility is that the cooling intervention may have altered participants' sense of recovery or readiness between sets without improving actual neuromuscular status. Alternatively, the cooling sensation may have masked fatigue cues, leading to a mismatch between perceived and physiological recovery.²³ In other words, while palm cooling may have reduced discomfort, it could have disrupted internal cues typically used to assess recovery, resulting in lower PR scores.

This study adds to emerging evidence that localized palm cooling can influence perceptual responses during exercise, even in the absence of immediate measurable performance benefits.⁹ Current evidence shows mixed acute performance benefits with respect to resistance training, repeat sprint ability, and aerobic performance.^{11, 13, 14, 24, 25} The results of the present study suggest that acute performance benefits from PC should not be expected. However, improved thermal comfort and reduced exertion may help athletes tolerate higher training volumes throughout high intensity training blocks or maintain effort across longer sessions, particularly in hot environments. As such, PC could be a viable strategy employed by coaches, athletes, practitioners, etc. to mitigate thermal strain during training blocks, which over time may lead to significant performance enhancements. This is consistent with a series of experiments from Grahn et. al., who employed inter-set PC during resistance training over the course of several weeks which resulted in significant improvements in overall work volume and strength outcomes.²⁶

Future studies should first explore whether palm cooling improves long-term training adaptations when used consistently across multiple sessions. Furthermore, future work should also assess effects across different exercise modalities and populations, and clarify underlying mechanisms such as thermoregulation, cardiovascular strain, or neuromuscular recovery.

Limitations of this study include the small sample size, the use of a single exercise modality, and the relatively short duration of the protocol. Additionally, the cooling device's temperature range and application method may influence its effectiveness. The study did not assess long-term training adaptations or neuromuscular recovery, which could provide further insight into the utility of palm cooling in resistance training contexts. Finally, participants were not blinded to condition, and no placebo cooling device was used, which may have influenced perceptual outcomes.

Conclusions

While palm cooling did not significantly enhance performance, it improved perceptual responses, including lower RPE, greater thermal comfort, and more positive effects. Palm cooling may be especially useful during high-intensity resistance training in hot environments or for athletes sensitive to thermal strain.

Acknowledgements

The authors wish to thank all the participants who volunteered for the study.



Funding Sources: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. This work was supported internally by the Grove City College Exercise Science Department.

Conflicts of Interest: The authors declare no conflicts of interest

References

1. Kraemer WJ, Ratamess NA, French DN. Resistance training for health and performance. *Curr Sports Med Rep.* 2002;1(3):165–171.
2. Schoenfeld BJ, Ogborn D, Krieger JW. Effects of resistance training frequency on measures of muscle hypertrophy: A systematic review and meta-analysis. *Sports Med.* 2016;46(11):1689–1697.
3. Schoenfeld BJ, Ogborn D, Krieger JW. Dose-response relationship between weekly resistance training volume and increases in muscle mass: A systematic review and meta-analysis. *J Sports Sci.* 2017;35(11):1073–1082.
4. Westerblad H, Allen DG, Lännergren J. Muscle Fatigue: Lactic Acid or Inorganic Phosphate the Major Cause? *Physiology.* 2002;17(1):17–21. doi:10.1152/physiologyonline.2002.17.1.17.
5. Bennett AF. Thermal dependence of muscle function. *Am J Physiol.* 1984;247(2 Pt 2):R217–R229. doi:10.1152/ajpregu.1984.247.2.R217.
6. Wong BJ, Hollowed CG. Current concepts of active vasodilation in human skin. *Temperature.* 2016;3(3):308–329. doi:10.1080/23328940.2016.1188676.
7. Periard JD, Racinais S, Sawka MN. Adaptations and mechanisms of human heat acclimation: Applications for competitive athletes and sports. *Scand J Med Sci Sports.* 2021;31(4):636–648. doi:10.1111/sms.13883.
8. Cao VA, Grahn DA, Heller HC. Practical cooling strategies for exercise performance: A review of head, neck, and palm cooling. *J Therm Biol.* 2022;104:103146. doi:10.1016/j.jtherbio.2021.103146.
9. Grahn D, Cao V, Heller C. Heat extraction through the palm of one hand improves aerobic exercise endurance in a hot environment. *J Appl Physiol.* 2005;99(3):972–978. doi:10.1152/jappphysiol.00292.2005
10. Nybo L. Brain temperature and exercise performance. *Exp Physiol.* 2012;97(3):333–339. doi:10.1113/expphysiol.2011.063701.
11. McMahan G, Kennedy R. The effects of palm cooling on physiological and metabolic responses during resistance training. *J Strength Cond Res.* 2023;37(11):1–9.
12. Esteves GJ, Garcia RA, Azevedo PHS. Different cooling strategies applied during inter-set rest intervals in high-intensity resistance training. *Int J Exerc Sci.* 2021;14(2):295–303.
13. Wrabley E, Lagerquist B, Smith G, et al. The effects of palm cooling on repeat sprint ability following a fatigue-inducing protocol in collegiate female athletes. *Int J Exerc Sci.* 2025;18(3):415–426. doi:10.70252/KSSI2281.
14. Kwon YS, Robergs RA, Kravitz L, et al. Palm cooling delays fatigue during high-intensity bench press exercise. *Med Sci Sports Exerc.* 2010;42(8):1557–1565.
15. Robertson RJ, Goss FL, Rutkowski J, et al. Concurrent validation of the OMNI perceived exertion scale for resistance exercise. *Med Sci Sports Exerc.* 2003;35(2):333–341.
16. ASHRAE. *ASHRAE Handbook—Fundamentals.* American Society of Heating, Refrigerating and Air-Conditioning Engineers; 2025.
17. Nagle EF, Robertson RJ, Laroche DP, Connolly DA. Perceived exertion, affect, and self-efficacy in response to resistance exercise. *Percept Mot Skills.* 2017;124(1):139–157.
18. Laurent CM, Green JM, Bishop PA, et al. A practical approach to monitoring recovery: Development of a perceived recovery status scale. *J Strength Cond Res.* 2011;25(3):620–628. doi:10.1519/JSC.0b013e3181c69ec6
19. Baechle TR, Earle RW, eds. *Essentials of Strength Training and Conditioning.* 3rd ed. Human Kinetics; 2008.
20. Haff GG, Triplett NT, eds. *Essentials of Strength Training and Conditioning.* 4th ed. Human Kinetics; 2015.
21. Flavahan NA. Thermoregulation: The normal structure and function of the cutaneous vascular system. In: *Raynaud's Phenomenon.* Springer; 2014:37–55. doi:10.1007/978-1-4939-1526-2_4
22. Grodzinsky E, Sund Levander M. Thermoregulation of the human body. In: *Understanding Fever and Body Temperature.* Springer; 2019:49–65. doi:10.1007/978-3-030-21886-7_5.
23. Moore E, Fuller JT, Buckley JD, et al. 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 Med.* 2022;52(7):1667–1688. doi:10.1007/s40279-022-01644-9.
24. McMahan G. No Effect of Interset Palm Cooling on Acute Bench Press Performance, Neuromuscular or Metabolic Responses, Following Moderate-Intensity Resistance Exercise. *J Strength Cond Res.* 2024;38(7):1213–1220. doi:10.1519/JSC.0000000000004798.



25. Kenville R, Clauß M, Arup A, Ragert P, Maudrich T. No Effect of Intermittent Palm or Sole Cooling on Acute Training Volume during Resistance Exercise in Physically Active Adults: A Summary of Protocols. *Sports*. 2024; 12(10):281. <https://doi.org/10.3390/sports12100281>.
26. Grahn DA, Cao VH, Nguyen CM, Liu MT, Heller HC. Work volume and strength training responses to resistive exercise improve with periodic heat extraction from the palm. *J Strength Cond Res*. 2012;26(9):2558-2569. doi:10.1519/JSC.0b013e31823f8c1a.