

Article

Physiological Recovery Following Repeated Firefighting Work in Recruit Firefighters

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Abstract

Firefighters often perform multiple consecutive bouts of high-intensity work in hot environments, which can lead to physiological fatigue and increased health risks. This study examined changes in core temperature, skin temperature, and heart rate during recovery periods following repeated bouts of work in recruit firefighters ($n = 10$) across a full day of outdoor training. Participants completed four work–rest cycles consisting of firefighting drills performed in full personal protective equipment (PPE), followed by passive recovery after PPE removal. Physiological measurements were recorded one minute prior to recovery and then at 5, 10, and 20 min throughout recovery. Skin temperature and heart rate decreased significantly ($p < 0.05$) within 5–10 min of recovery in most rounds. However, core temperature required at least 20 min to significantly decline ($p < 0.05$). These findings suggest that shorter recovery periods may be sufficient for heart rate and skin temperature to return to baseline, whereas longer recovery periods are needed for heat to dissipate from the core, especially as work intensity increases. Thus, standard rehabilitation protocols may be insufficient under more extreme working conditions and should be adjusted accordingly to ensure firefighter safety.

Keywords: core temperature; skin temperature; heart rate; rehabilitation; recruit firefighters; PPE; tactical athletes; first responders; heat illness; physiological strain

1. Introduction

Firefighting is a physically and thermally demanding emergency response occupation. Firefighters perform strenuous tasks such as carrying heavy hose lines, climbing stairs, breaching structures, and conducting search-and-rescue operations, often in hazardous environments with extreme heat, radiant energy, and humidity [1,2]. Thermal radiation, smoke, and metabolic heat production resulting from fire environments have been shown to increase the risk of heat strain and injury [3,4]. In addition, during strenuous firefighting activities and/or work in extreme conditions, firefighters are required to wear insulated, unbreathable personal protective equipment (PPE), which weighs between 45 and 75 pounds and further increases physical and thermal demands [1,5,6]. PPE is essential for protecting against fire and toxins; however, it restricts evaporative and convective heat loss from the body, thereby accelerating heat storage and increasing the work of the cardiovascular system [7,8].

Both core and skin temperature, as well as heart rate, have been shown to rise rapidly during firefighting tasks. Sandsund et al. (2024) demonstrated that core temperature and heart rate significantly increased in firefighters during a simulated smoke dive scenario in extremely



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hot conditions using a controlled heat chamber set at 110–272 °C (230–522 °F) without live fire or smoke [9]. Interestingly, core temperature continued to rise even after leaving the heat chamber, which demonstrates the importance of monitoring physiological responses during both work and recovery periods. Similarly, Hemmatjo et al. (2017) reported that 45–50 min of firefighting activities performed in warm environments (29–37 °C/84–99 °F) led to increases in heart rate and tympanic temperature, as well as impaired information processing performance, which suggests that heat stress may hinder both physiological and cognitive function [10].

These risks have led the National Fire Protection Association (NFPA) to establish formal guidelines for firefighter rehabilitation. Specifically, NFPA 1580 (Standard for Emergency Responder Occupational Health and Wellness) provides recommendations for rest, hydration, medical monitoring, and cooling [11]. According to NFPA 1580, firefighters shall undergo rehabilitation either after consuming a single self-contained breathing apparatus (SCBA) cylinder during intensive work or after 40 min of intensive work without SCBA. Following these working periods, the firefighters are recommended to spend a minimum of 20 min in rehabilitation, where they remove their PPE to allow heat dissipation, hydrate, and have their vital signs, including heart rate, temperature, and blood pressure, monitored before returning to duty.

Although previous literature has supported rehabilitation practices included in the NFPA guidelines to prevent heat-related illness among emergency responders [12], studies examining physiological recovery during realistic training scenarios are limited. The majority of studies in this area have focused on single heat exposures or controlled laboratory simulations, which may not provide a clear picture of the thermal challenges encountered in real-life situations [2,9]. For instance, in real-life firefighting emergencies, firefighters typically perform multiple consecutive bouts of high-intensity work followed by short recovery periods. Thompson et al. (2025) demonstrated that cognitive performance may be impaired immediately following heat exposure from live-fire training but can recover within 20 min [13]. It is important to determine how core temperature, skin temperature, and heart rate change during these recovery intervals to evaluate the adequacy of current NFPA guidelines and develop evidence-based work–rest strategies [4].

Thus, the purpose of this study was to determine changes in core temperature, skin temperature, and heart rate after 5, 10, and 20 min of recovery following repeated firefighting work bouts in recruit firefighters during a full day of outdoor training while wearing PPE. It was hypothesized that heart rate and skin temperature would decrease within the first 10 min of recovery, whereas core temperature would take longer to significantly decrease, especially in later rounds when cumulative physiological strain is higher.

2. Materials and Methods

2.1. Participants

Ten male firefighter recruits participated in this study during a scheduled outdoor firefighting training day. Participants were in the final week of a 12-week firefighter recruit training academy at the time of data collection. Therefore, all recruits had prior experience with training while wearing PPE and SCBA and were familiar with firefighting drills. The training activities during data collection constituted a physically demanding day at the academy. The mean age and BMI of the participants were 23.6 ± 4.8 years and 23.8 ± 3.8 , respectively. All participants were employed by a Fire Department in the Southeastern United States, which medically cleared them to perform the physical exertion required for firefighting training activities. Exclusion criteria included failure to meet departmental medical clearance requirements. All participation activities occurred as part of the Fire Academy's routine operational practices, except for wearing a chest strap to monitor

temperature and heart rate. Study procedures were approved by the institutional review board (IRBNet ID#2047457), and all participants signed informed consent to participate.

2.2. Study Design

This study utilized a repeated measures observational design to assess physiological recovery following firefighting drills. Data were collected on 20 November 2025, during a full day of firefighting training drills comprising multiple work–rest cycles. Participants completed multiple sessions of firefighting drills (i.e., chaos drill) in full PPE, followed by removal of the PPE for passive recovery periods. Thus, performing firefighting drills while wearing PPE is designated as the “WORKING” condition for this study, and recovering without PPE is designated as the “RECOVERY” condition.

The amount of PPE worn during the training activities differed across rounds. Round 1 was completed while wearing PPE, excluding the helmet and SCBA at first for physical training, then including them for skills testing. Round 2 was completed in full PPE without SCBA. Rounds 3 and 4 were completed in full PPE, including SCBA. The PPE configuration for each round was determined by the training objectives and was consistent across all participants.

After completing each work period and removing PPE, participants immediately began a passive recovery period. During recovery, participants mostly sat or stood in a shaded rehabilitation area but were also permitted to walk around. Participants were allowed to consume water and/or sports drinks ad libitum and food if desired. Most did not consume food, and if they did, it was a piece of candy. Structured physical activity was not performed during the recovery periods. Figure 1 displays the gear options worn during the RECOVERY and WORKING periods.



Figure 1. During the recovery period, participants wore a t-shirt, boots, and either shorts or shorts under PPE pants. During the working period, participants wore full PPE, which may or may not include the helmet and self-contained breathing apparatus.

Ambient temperatures on the day of data collection during the measured training period ranged from 61 to 85 °F (16–29 °C), with cooler weather in the morning that progressively increased throughout the day. The day was partly to mostly sunny with light wind and relative humidity ranging from 40% to 70%.

2.3. Physiological Measurements

2.3.1. Core and Skin Temperature

Core and skin temperatures were continuously monitored using the Calera Research Tool (<https://info.greenteg.com/calera-research/downloads/research-tool>, accessed on 15 July 2026, Calera Research, greenTEG AG, Rümlang, Switzerland). The validity and reliability of this device for estimating core temperature have been previously reported [14,15]. At the beginning of the day, monitors were placed on the participants. The temperature sensor monitor was attached to a soft elastic chest strap and positioned at the midline of the chest over the center of the sternum. The sensor remained in contact with the skin to continuously measure, record, and store skin and core temperatures at 1 min intervals in the Calera Research Tool software via Bluetooth. Core temperature was estimated using a proprietary algorithm embedded within the Calera Research Tool. The algorithm integrates skin temperature and individual physiological properties to estimate core temperature. The algorithm is proprietary; thus, the specific variables and weighting procedures used in the calculation are not publicly disclosed by the manufacturer.

2.3.2. Heart Rate

Heart rate was continuously measured with a Bluetooth heart rate monitor (Polar H9, Polar Electro, Kempele, Finland) attached to an elastic chest strap next to the temperature sensor. The heart rate monitor was connected to the Calera Research Tool to collect heart rate and temperature data synchronously. Heart rate data were recorded at 1 min intervals within the Calera Research Tool software. Placement of the heart rate and temperature monitors is shown in Figure 2.



Figure 2. The heart rate monitor was placed in the center of the chest at the sternum, and the temperature sensor was placed to the right of the heart rate monitor on an elastic strap.

2.4. Data Analysis

All data were recorded and stored using the Calera system for analysis. At the completion of each firefighting drill, physiological measurements were analyzed according to the following sequence:

1. End of work (WORKING): After completing the firefighting drill, core and skin temperature and heart rate measurements were recorded one minute before removing PPE for the recovery period (T_0).

2. Recovery period (RECOVERY): Temperature and heart rate measurements were recorded during passive recovery at time intervals including 5, 10, and 20 min after removing the PPE (T_5 , T_{10} , and T_{20} , respectively).
3. This was repeated for 4 WORKING/RECOVERY periods (rounds) throughout the day as shown in Table 1.

Table 1. Timeline and details of data collection throughout the testing day.

Round	Time of the Analyzed Recovery Period	Measures	Prior Work Actions (in PPE)
1	9:45–10:05 AM	Core temperature, skin temperature, and heart rate at 1 min prior to the recovery period (T_0), and then at 5 (T_5), 10 (T_{10}), and 20 (T_{20}) minutes during the recovery period	Physical training (~30 min; PPE without helmet or SCBA) Skills testing (~60 min intermittent activity; full PPE with SCBA)
2	11:45–12:05 PM		Training for the chaos drill (~75 min intermittent activity; full PPE without SCBA)
3	3:05–3:25 PM		Chaos drill: two-story structure search-and-rescue drill with blacked-out masks and high ambient noise; teams locate and extricate live volunteer victims (~60 min intermittent activity; full PPE with SCBA)
4	4:20–4:40		

2.5. Statistical Analysis

Prior to analysis, data for each variable were screened for outliers ($|z| > 3.0$). A series of linear mixed-effects model (LMEM) analyses was used to address the research aims and determine whether there were changes in thermoregulatory variables (skin temperature, core temperature, and heart rate) after different recovery periods. This approach was selected to account for the relatively large quantity of missing data points because LMEMs handle missing data, unlike traditional ANOVAs [16]. The first independent variable was time, with four levels: wearing PPE at the end of the firefighting drill (T_0) and at 5, 10, and 20 min of PPE-off recovery (T_5 , T_{10} , and T_{20}). The second independent variable was round, with four levels (1, 2, 3, and 4), each level corresponding to one of the active training/recovery cycles.

Individual subjects were specified as a correlated random effect to limit pseudo-replication of results. Both independent variables (time and round) were designated as repeated measures fixed factors. A heterogeneous compound symmetry covariance structure was selected for the repeated measures factors in all mixed-effects models.

Tests of fixed effects were generated along with Bonferroni-adjusted post hoc tests to maintain an alpha level of 0.05 for each analysis. In the event of a significant interaction effect, any significant main effects of time or round were not interpreted.

3. Results

Several participants were missing values for skin temperature (12 missing data points from three participants; ~6.8% of the missing total data points), core temperature (17 missing data points from two participants; ~9.7% of the missing total data points), and heart rate (26 missing data points from six participants; ~14.8% of the missing total data points). No outliers were identified. The residual values for each variable were normal according to visual inspection of Q-Q plots. Basic inferential statistical results for each variable are reported in the text of the associated subsection. Complete statistical results are reported in Table 2. Descriptive results for the main variables are reported in Table 3. Changes in these main variables over time are displayed graphically in Figure 3.

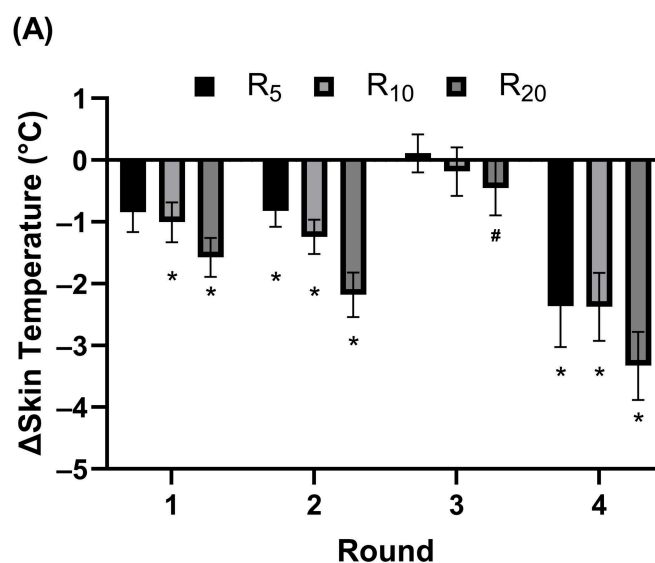
Table 2. Fixed effects results for linear mixed-effects model analysis for thermoregulatory variables.

Dependent Variable	Effect	df	F	p
Skin temperature	Time	3, 37.8	28.3	<0.001
	Round	3, 27.6	44.4	<0.001
	Time × Round	9, 29.0	3.2	0.009
Core Temperature	Time	3, 43.2	5.8	0.002
	Round	3, 37.3	11.6	<0.001
	Time × Round	9, 28.8	2.3	0.041
Heart Rate	Time	3, 65.3	40.2	<0.001
	Round	3, 63.8	44.3	<0.001
	Time × Round	9, 36.2	9.9	<0.001

Table 3. Descriptive results for thermoregulatory variables at each time point in each round. Results are presented as: mean (standard error).

Dependent Variable	Round	T ₀	T ₅	T ₁₀	T ₂₀
Skin temperature (°C)	1	34.81 (0.30)	33.97 (0.25)	33.81 (0.26) *	33.24 (0.25) *
	2	35.06 (0.25) †	34.23 (0.18) *	33.82 (0.23) *	32.88 (0.36) *
	3	36.05 (0.29) †	36.16 (0.25) †	35.86 (0.39) †	35.60 (0.45) #,†
	4	37.27 (0.35) †	34.91 (0.69) *	34.90 (0.54) *	33.94 (0.55) *
Core Temperature (°C)	1	38.16 (0.07)	38.00 (0.10)	37.88 (0.11)	38.01 (0.15)
	2	37.90 (0.08)	37.89 (0.07)	37.89 (0.09)	37.73 (0.09)
	3	37.85 (0.07) §	37.97 (0.09)	37.94 (0.10)	37.86 (0.07)
	4	38.83 (0.20) †	38.61 (0.19) †	38.40 (0.20)	37.95 (0.15) *,#
Heart Rate (bpm)	1	107.80 (4.41)	92.84 (3.49) *	92.30 (3.51) *	91.20 (3.18) *
	2	108.50 (4.58)	115.10 (4.89) §	102.73 (3.84)	96.00 (4.44) #
	3	137.90 (4.77) †	115.00 (5.42) *,§	99.00 (5.61) *	116.10 (4.61) *,†,‡
	4	155.40 (3.64) †	121.85 (4.58) *,§	110.59 (4.55) *,§	96.62 (2.92) *,#

Comparisons between time points at a given round: * = significantly different from the T₀ value; # = significantly different from the T₅ value. Comparisons between rounds at a given time point: † = significantly different than all previous rounds; § = significantly different than round 1; ‡ = significantly different than all other rounds.

**Figure 3.** Cont.

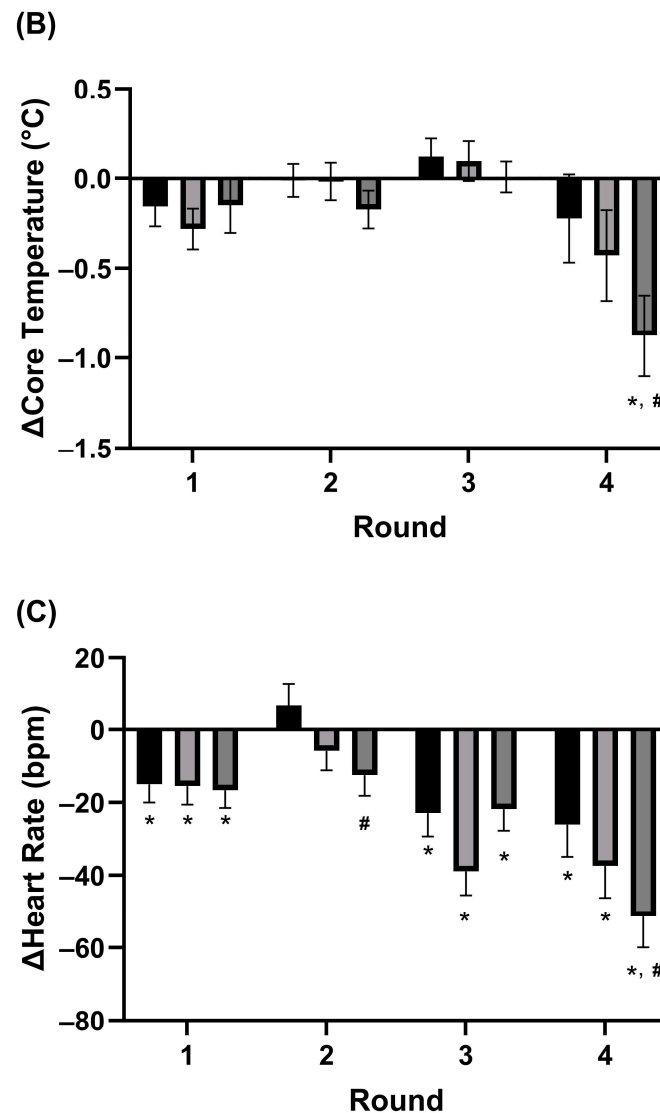


Figure 3. Clustered bar graph displaying change from T₀ at each time point in each round for (A) skin temperature, (B) core temperature, and (C) heart rate. Bars represent the estimated mean change from T₀, and whiskers represent the estimated standard error of the mean. * = significantly different than T₀ value; # = significantly different than T₅ value.

3.1. Skin Temperature

There was a significant interaction effect between time and round for skin temperature ($p = 0.009$). When comparing skin temperature across time points within each round, values were highest during T₀ for rounds 1, 2, and 4 and were significantly lower at T₅, T₁₀, and T₂₀. Skin temperature also decreased in round 2 from T₅ to T₁₀.

When comparing skin temperature across rounds at matched time points, values were higher at T₀ for rounds 3 and 4 than for rounds 1 and 2. Round 3 values were also higher than those in rounds 1 and 2 for T₅, T₁₀, and T₂₀. No other comparisons between time points were significant.

3.2. Core Temperature

There was a significant interaction effect between time and round for core temperature ($p = 0.041$). When comparing core temperature across time points within each round, the value was highest during T₀ for round 4 and was significantly lower at T₂₀ only. Core temperature also decreased in round 2 from T₅ to T₂₀.

When comparing core temperature across rounds at matched time points, values were highest for round 4 at T_0 and T_5 compared to all earlier time points. Core temperature was also higher for round 1 than for round 3 at T_0 . No other comparisons between time points were significant.

3.3. Heart Rate

There was a significant interaction effect between time and round for heart rate ($p < 0.001$). When comparing heart rate across time points within each round, values were highest during T_0 for rounds 1, 3, and 4, and were significantly lower at T_5 , T_{10} , and T_{20} . Heart rate also decreased in round 4 from T_5 to T_{20} .

When comparing heart rate across rounds at matched time points, at T_0 , heart rate was higher in rounds 3 and 4 than in all respective previous rounds. At T_5 , heart rate was higher in rounds 2, 3, and 4 than in round 1. Similarly, at T_{10} , heart rate was higher for round 4 than for round 1. At T_{20} , heart rate was higher in round 3 than in all other rounds. No other comparisons between time points were significant.

4. Discussion

The aim of this study was to determine the temperature and heart rate responses during four recovery periods throughout an outdoor training day in recruit firefighters. The first two recovery periods followed moderate-intensity activities, and the last two followed high-intensity activities. The results demonstrated that skin temperature and heart rate generally decreased within 10 min across multiple rounds of work/recovery. In contrast, a significant decrease in core temperature was observed only at T_{20} during round 4. Measurements were limited to the first 20 min of recovery; thus, the time required for complete core temperature recovery could not be determined. This may be due to differences in work intensity, PPE/SCBA use, and environmental conditions throughout the live training day, rather than cumulative physiological strain from working throughout the day alone. The independent contribution of each factor cannot be determined in the present study, as they changed concurrently across rounds due to the live training scenario.

As in other studies, this study demonstrated that heart rate and core and skin temperatures were elevated during the working period when PPE was on, indicating a burdened cardiovascular system engaged in maintaining thermal and systemic regulation [1,17,18]. Furthermore, the between-round post hoc tests demonstrated greater thermoregulatory strain in rounds 3 and 4, which coincided with the participants performing higher-intensity activities while wearing full PPE and SCBA. After removing PPE to passively recover, skin temperature and heart rate decreased significantly within 5–10 min in most rounds as heat dissipated from the skin. On the other hand, core temperature decreased more slowly, with a statistically significant decrease occurring only after 20 min in the final round. Heart rate and skin temperature can serve as indicators of recovery; however, they lack strict safety thresholds. Since skin temperature is associated with heat dissipation, higher skin temperatures result in a reduced gradient for heat loss from the core. Also, a heart rate that remains elevated during recovery indicates incomplete cardiovascular recovery [19,20]. Previous studies have also demonstrated delayed decreases and even continued increases in core temperature following firefighting tasks [9,21]. It is expected that core temperature will decrease more slowly than skin temperature, as core temperature reflects heat stored deeper in the body, while skin temperature reflects heat stored at the surface [22]. Although reductions were observed in most rounds, round 3 showed a different pattern in skin temperature, possibly due to variability in environmental conditions and/or because it was the first work/recovery period after lunch.

Recent research has shown that recovery from firefighting activity may be influenced by multiple physiological systems, including the autonomic nervous system. For instance, Ebersole et al. found that heart rate recovery and heart rate variability responses in firefighters depended on the exercise intensity, and although heart rate declined after 10 min of seated recovery, markers of autonomic recovery remained suppressed [23]. Mendelson et al. also found that the workload intensity, as well as individual fitness characteristics, may impact complete autonomic recovery [24]. Further, Marciniak et al. reported that elevated body temperature may interfere with autonomic recovery [25]. These findings align with the current study, as heart rate decreased rapidly during recovery while core temperature remained elevated for a much longer period, especially after the more physically challenging training rounds. Previous studies examining autonomic recovery in this population were conducted in controlled laboratory settings. The current study extends previous research by examining recovery during actual firefighting training drills performed while wearing PPE and, in later rounds, SCBA, which may better mirror the physiological demands of fireground operations. Therefore, these studies suggest that heart rate alone may not be a sufficient indicator of complete physiological recovery when making return-to-duty decisions.

As in the current study, Horn et al. demonstrated that core temperature continued to rise across repeated bouts of firefighting activity, even during recovery periods lasting more than 30 min [26]. Their findings suggest that the risk of heat strain may increase during later work periods due to the accumulation of thermal strain across repeated bouts of firefighting activity. Similarly, the present study found that core temperature recovered more slowly than heart rate and skin temperature, and it remained elevated following the more demanding training rounds. In the last (fourth) work period of this study, the average core temperature approached 38.8 °C (101.8 °F). Elevated core body temperatures to this degree are associated with impaired performance and reduced overall safety due to increased cardiovascular strain and the risk of heat-related illness [19,20]. For context, core temperatures of ~37.0–37.5 °C reflect a normal baseline, ~38.0 °C indicates mild hyperthermia, ≥38.5 °C indicates meaningful thermal strain, and ≥39.0 °C represents a high-risk range for heat-related illness [20]. Also, metabolic heat production from firefighting activities, reduced evaporative cooling from PPE, and dehydration from increased sweating can impair physical and cognitive performance to a greater degree when core body temperature is elevated [2,22,23], as observed during the last work period of our study. A significant reduction in core body temperature, which also coincided with a decrease in core temperature below 38.0 °C, was only observed after 20 min of recovery during the final round, likely due to a higher working core temperature in that round rather than a consistent cumulative heat-strain effect; however, the time required for complete thermal recovery could not be determined, as measurements were only taken during the first 20 min of recovery.

Sandsund et al. (2024) demonstrated that core temperature may continue to rise even after leaving a hot environment to recover [9]. This phenomenon may be detrimental, as prolonged heat stress exposure in firefighting simulations has been associated with impaired physiological and cognitive function [10,13]. Thus, monitoring core temperature, in addition to skin temperature and heart rate, is important to determine whether the firefighter is fully recovered.

Rehabilitation recommendations set by NFPA 1580 include initiating rehabilitation after using a single SCBA cylinder during intensive work or after 40 min of intensive work without SCBA, with a minimum recovery period of 20 min that includes removal of PPE, hydration, and monitoring of vital signs during recovery [11]. The recovery protocol used in this study implemented these NFPA guidelines, with participants removing PPE, passively

resting, consuming fluids, and recovering for at least 20 min. However, the findings of this study suggest that NFPA recommendations may not achieve full recovery when firefighters perform repeated and/or high-intensity work. Generally, the results showed that heart rate and skin temperature decreased significantly within 5–10 min of recovery. In the last work–rest round, core temperature decreased only after 20 min of rest, suggesting that the NFPA recovery duration may need to be extended under high-intensity conditions or elevated physiological heat load. Although in some cases, even 20 min of passive recovery was not enough to significantly reduce core temperature. Furthermore, other researchers have previously questioned whether the NFPA guidelines provide adequate recovery from fireground operations [18,27].

Previous studies have examined firefighter recovery following firefighting activity and support the current findings that thermal physiological recovery may remain incomplete during standard rehabilitation durations. For instance, Hostler et al. found that firefighters were unable to fully recover core temperature during a 20 min rehabilitation period that consisted of removing PPE and cooling interventions [28]. Colburn et al. also found that core temperatures remained elevated during recovery following live-fire activities [29]. Hostler et al. demonstrated that greater work performed before the rehabilitation period was associated with greater thermal strain and impaired subsequent work performance [30]. Further, Schlader et al. found that heat strain was greater on the second of two consecutive firefighting days despite appearing fully recovered before the second day's work [31].

The data from this study and previous studies suggest that the NFPA 1580 guidelines provide an appropriate standard for most operations; however, recovery may need to be reconsidered for high levels of physiological heat load or elevated core temperature. Safety officers should consider implementing the following suggestions: (1) extending recovery beyond 20 min when core temperature remains elevated, (2) adding active cooling strategies such as forearm immersion and/or cooling vests to help dissipate heat more quickly, and (3) adjusting recovery periods based on workload, environmental conditions, and individual responses [4,20]. These additional recovery strategies may potentially reduce the incidence of heat-related illness and sudden cardiac death, which have remained the primary cause of on-duty deaths among firefighters [18,32].

The small sample size in this study is a limitation, as it reduces generalizability. Also, core temperature was estimated using an algorithm rather than by direct measurement, which may introduce error. Additionally, participants were recruit firefighters, which may limit generalizability to active-duty, full-time experienced firefighters. Cardiorespiratory fitness was not assessed in this study. Because fitness has been shown to influence cardiovascular and autonomic recovery in firefighters, it may have contributed to variability in the recovery responses observed and could influence return-to-duty readiness [33]. Therefore, fitness should be examined in future firefighter rehabilitation studies. Environmental conditions, such as ambient temperature and humidity, were not controlled due to the field-based nature of the study, potentially introducing variability in physiological responses [14,15]. Future research should include larger samples of recruits and/or full-time firefighters and further evaluate recovery strategies under realistic operational conditions. Cognitive and physical performance outcomes should also be examined in conjunction with physiological recovery measures.

5. Conclusions

This study demonstrates that recovery from firefighting operations depends on the intensity of activity and the level of physiological heat load prior to recovery. The results suggest that heart rate and skin temperature decreased significantly within 10 min of recovery; however, complete physiological recovery could not be determined in the present

study. Further research is needed to identify evidence-based rehabilitation strategies for different working scenarios that enhance safety and improve operational effectiveness for firefighters.

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Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Augusta University (IRBnet #2047457 and 24 May 2023).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The original data presented in the study are openly available through Open Science Framework at the following link: <https://osf.io/jhkrq/overview> (accessed on 15 July 2026).

Conflicts of Interest: The authors declare no conflicts of interest.

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