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The Relationship Between Physical Activity and Thermal Protective Clothing on Functional Balance in Firefighters

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Abstract

We investigated the relationship between baseline physical training and the use of firefighting thermal protective clothing (TPC) with breathing apparatus on functional balance. Twenty-three male firefighters performed a functional balance test under four gear/clothing conditions. Participants were divided into groups by physical training status, and task performance was analyzed. There was an effect of equipment and training status on performance with the group reporting both aerobic and resistance training performing better than the group reporting no physical training. In conclusion, firefighters walk more slowly as a strategy to maintain balance when wearing TPC, which may be suboptimal given the emergent nature of fire suppression. This result was most prominent in the group reporting no physical training.

Keywords

face mask; personal protective equipment; training; vision

Slips, trips, and falls are related to impaired balance and are common in physically demanding occupations. The incidence of fall-related injuries among firefighters has been reported to range from 25.5% to > 46% of all injuries (Heineman, Shy, & Checkoway, 1989; Karter & Molis, 2006). Two thirds of falls result in strains and sprains, while 8.6% lead to temporary disability; the median time away from work due to falls is 17 days (Heineman et al., 1989). The average compensation cost per claim is \$3,147 (Walton, Conrad, Furner, & Samo, 2003). These data suggest that occupational falls negatively influence firefighters' quality of life and are costly to society. During structural fire suppression and heavy rescue work, firefighters wear thermal protective clothing (TPC), also known as turnout gear or bunker gear, which typically includes heavy fire-resistant outer garments (pants, coat), safety

boots, gloves, a helmet, fire-resistant hood, and a self-contained breathing apparatus (SCBA). The SCBA provides breathable air in a contaminated environment and is used in conjunction with a full face mask. The total additional mass of the TPC ensemble ranges from 18 to 24 kg of which the majority is attributable to the SCBA alone. On the fire ground, firefighters who consistently use SCBA are 2.8–4.0 times more likely to sustain fall-related injuries compared with those who do not use SCBA in the same or a similar fire, respectively (Heineman et al., 1989). Furthermore, larger SCBA cylinders are associated with compromised gait characteristics among firefighters (Park, Hur, Rosengren, Horn, & Hsiao-Wecksler, 2010). The positive association between falls and SCBA use suggests that wearing these external devices disturbs the body's balance system. Two possible ways the SCBA may impair balance are reduced visibility and field of view from wearing the face mask and the additional mass attached to the body.

Previous studies have investigated the effect of wearing different combinations of TPC and other forms of protective equipment on balance performance. Protective eyewear can reduce visual fields and clarity and facemasks or respirators may impair visual sensory input, requiring the wearer to use compensating strategies to maintain or regain postural stability (Punakallio, Lusa, & Luukkonen, 2003; Seliga et al., 1991; Wade, Weimer, & David, 2004). While TPC appears to be associated with impaired balance, it is difficult to reconcile the conclusions of these studies due to the varied tests of balance, experimental conditions, and the evolution of TPC and SCBA design. One influential study showed that most TPC combinations impaired balance with the SCBA (Punakallio et al., 2003). In contrast, however, another study found that static balance improved when wearing protective clothing and SCBA, compared to regular clothing (Sobeih, Davis, Succop, Jetter, & Bhattacharya, 2006). In a third study, results varied regarding the effect of TPC on postural balance depending on the balance tests and/or variables analyzed (Kincl, Bhattacharya, Succop, & Clark, 2002).

It is unclear whether TPC/SCBA use impairs balance, and, if so, whether it is due to the added equipment mass, reduced visual input, or a combination of factors. It is also likely that other intrinsic and extrinsic factors related to the firefighter's health and fitness influence TPC performance. A recent study of simulated firefighting activities identified aspects of muscular strength, endurance, power, and abdominal strength related to performance but did not measure balance (Michaelides, Parpa, Henry, Thompson, & Brown, 2011). While the effects of physical training and performance on balance have been studied in athletes, it is unknown whether physical training mitigates the effects of TPC/SCBA on firefighters' balance (Cressey, West, Tiberio, Kraemer, & Maresh, 2007; Filipa, Byrnes, Paterno, Myer, & Hewett, 2010). Therefore, we investigated potential relationships between physical characteristics and physical activity patterns on firefighters' functional balance when wearing TPC and SCBA.

Method

The university's Institutional Review Board approved all study procedures. We conducted a crossover study of firefighters performing a functional balance test in regular clothing and in multiple permutations of TPC.

Participants

We obtained written informed consent from participants prior to data collection. Twenty-four male firefighters were recruited by flyer and agreed to participate. We excluded data for 1 participant due to a shuffling gait pattern (sliding/dragging) without a single leg support phase. Descriptive characteristics of the remaining 23 participants are shown in Table 1. We asked participants to complete a survey on demographics, medical history, and physical activity patterns to screen for conditions that could negatively affect balance. Exclusion criteria included current pain, dizziness, tremors, alcoholism, vestibular disorder, neurological disorder, diabetes, musculoskeletal injuries within the past month, and lower extremity surgeries within the past 6 months. Based on self-reported physical activity patterns, eligible participants were further divided into four groups, those who: (a) participated in regular resistance training at least once per week, (b) participated in regular aerobic (AEROBIC) training at least once per week, (c) participated in both resistance and aerobic training (COMBINATION), and (d) did not participate in any (NONE).

Procedures

We tested four clothing and equipment conditions (see Table 2 and Figure 1). Condition 1 (regular clothing and shoes) served as the control. Condition 2 included TPC without the SCBA to represent what firefighters typically wear for operations that do not involve interior fire suppression. Conditions 3 and 4 included TPC with SCBA. In Condition 3, participants carried the face mask suspended from a strap around their neck. In Condition 4, they wore the face mask. All participants used a carbon fiber SCBA from a single manufacturer (Mine Safety Appliance, Inc, Pittsburgh, PA). Participants provided and wore their own TPC; however, all TPC met the requirements of the National Fire Protection Association (NFPA) standard 1971 (NFPA, 2007).

To measure performance, we used a functional test developed specifically for investigating balance performance among firefighters (Punakallio, 2004; Punakallio et al., 2003). We asked participants to walk on a beam 2.45 m long, 0.09 m wide, and 0.07 m high, with the middle 0.50- m painted black to indicate a “turning area” (see Figure 1). Participants started on marked footprints at one end of the beam, walked forward to the middle turning area, turned 180° within this area, continued to walk backward toward the opposite end of the beam, and then placed their feet on marked footprints at the opposite end. They then immediately repeated the task from the opposite end to the starting point. Participants’ primary goal was to avoid errors defined as falling off the beam, touching the floor, turning outside the designated turning area, or letting the whole foot step outside the footprint. Their secondary goal was to complete the task as fast as possible. During each test, participants’ performance time and number of errors were recorded. With good-to-excellent within-day and between-day reliability (Punakallio, 2004), this test has been used to successfully distinguish balance abilities among different age groups and occupations (Punakallio et al., 2003), as well as to predict firefighters’ work ability (Punakallio, Lusa, & Luukkonen, 2004).

We asked participants to refrain from alcohol consumption for 24 hr prior to data collection. Their mass and height were measured prior to donning the TPC. After the test procedures

were explained and demonstrated, each participant performed three practice trials in regular clothing to become familiar with the test. A previous study using this test showed no further improvement in performance after the third trial (Punakallio, 2004). Participants then performed three functional balance tests under each of the four clothing and equipment conditions. The order of clothing and equipment conditions were counterbalanced during each session. In each condition, the total mass of the participant and equipment was measured to determine the additional equipment mass (see Table 2).

Statistical Analyses

All analyses were performed using the SPSS software (version 11.0 for Mac, SPSS Inc., Chicago, IL). Time and error data were not normally distributed. Therefore, a log transformation was performed for analysis. The average time to complete the task, the average sum of errors committed during the task, and a composite score of time + errors (each error = 1 s) were used as dependent variables in subsequent statistical analyses. We used a repeated measures analysis of variance to identify differences in each dependent variable. The within-group factor was equipment (four conditions). The between-group factor was self-reported training activity. We performed two-tailed Spearman correlations to examine potential relationships between the average time, sum of error, and composite score in Condition 4 and age, height, mass, and body mass index (BMI) variables. Statistical significance was set at $p = .05$. We used Tukey's test to identify differences in activity groups. Data are shown as means and standard deviations.

Results

Seven participants reported aerobic training only, 12 reported a combination of aerobic and resistance training, and 4 reported no regular training. No participant reported resistance training only. The total mass of the protective clothing was approximately 20 kg. There was an effect of equipment condition $F(3, 80) = 5.82, p = .05$, and physical activity pattern $F(2, 80) = 32.2, p < .001$, on time to complete the task. Post hoc analyses revealed multiple differences for groups and condition (see Table 3). Firefighters in the NONE group demonstrated the largest rise in time to complete the task as the clothing condition became more complex, while firefighters in the COMBINATION and AEROBIC groups maintained a nearly constant time to complete the task across conditions (see Figure 2).

There was an effect of equipment $F(3, 80) = 20.4, p < .001$, and activity pattern $F(2, 80) = 4.99, p = .04$, on the sum of errors made during the task (see Figure 2). The composite score of time + errors was similar to the time to complete the task, with a main effect of equipment $F(3, 80) = 12.0, p = .001$, and activity $F(2, 80) = 25.4, p < .001$. There was a significant interaction between equipment and activity for errors made during the trial $F(6, 80) = 14.2, p = .008$. When firefighters wore full TPC and SCBA (Condition 4), there was a trend toward significance for the correlation between the sum of errors and average time to complete the task ($r = .397, p = .061$). There were no significant correlations between balance performance and age, height, mass, or BMI.

Discussion

In the present study, we determined that (a) firefighters slow their gait during balance testing while wearing TPC compared to when they wear regular clothing, and (b) those who do not participate in regular physical training demonstrate the greatest degree of impairment while wearing TPC. As the complexity of TPC conditions increased, participants walked more slowly and committed more errors when compared with the regular clothing condition. The rise in the time required to complete tasks and the number of errors committed was most prominent in the NONE group after adding the SCBA face piece (Condition 4). The effect of condition on time suggests that slowing down was the chosen strategy to maintain balance under challenging circumstances. However, the slowing strategy seen in this laboratory study may not be possible at an actual incident, given the rapid nature of fire suppression activities that may lead to a slip or fall. Different from the NONE group, firefighters in the COMBINATION group were able to maintain balance and time to complete the task across all conditions. However, firefighters in the AEROBIC group did not differ from the NONE group, thus implying that resistance training may have a benefit of on performing a functional balance test.

Previous studies on firefighters' balance are difficult to reconcile (Kincl et al., 2002; Punakallio et al., 2003; Sobeih et al., 2006). The varied results may be explained partly by the lack of randomization in the order of clothing conditions and the wide variety of TPC and SCBA available for study (Punakallio et al., 2003; Sobeih et al., 2006). These factors make it difficult to determine the effect of wearing TPC on balance ability due to the high motor learning effect of balance tests (Punakallio, 2004; Rhine, Pasanen, Miilunpalo, & Oja 2001). Furthermore, some studies used static postural tests to measure firefighters' balance while wearing TPC (Kincl et al., 2002; Sobeih et al., 2006). The type of balance tests used will have a great impact on the outcome and interpretation. Static balance may be improved through training and practice, but it does not reflect the dynamic nature of fire suppression activities that require the firefighter to maintain balance on slippery and uneven surfaces or when walking while carrying a load. The present study adds to the current knowledge by using a counter-balanced presentation of the experimental conditions during a functional test to assess balance, while considering participant morphometrics and physical training patterns.

Firefighters in the COMBINATION group demonstrated superior balance ability, as they made fewer errors during the task and demonstrated a more consistent time in completing the task across conditions. In response to a perturbation, such as a slip for example, the body must adjust the center of mass within the support base to maintain balance. Successful recovery strategies require muscle recruitment to produce the desired force within a short time interval (Cham & Redfern, 2002; Chambers & Cham, 2007). In older populations, lower extremity strength (Lord, Ward, Williams, & Anstey, 1994; Pijnappels, van der Burg, Reeves, & van Dieen, 2008), rate of force development (Pijnappels, Bobbert, & van Dieen, 2005), and fast response time (van den Bogert, Pavol, & Grabiner, 2002) have been identified as important factors in preventing falls. Muscular strength and endurance are also related to better performance in specific firefighting ability tests (Michaelides, Parpa, Thompson, & Brown, 2008). Because resistance training increases maximal force

production, rate of force development, and neural drive of human skeletal muscles (Aagaard, Simonsen, Andersen, Magnusson, & Dyhre-Poulsen, 2002), one or more of these factors may explain why resistance-trained firefighters demonstrated superior balance performance. More recently, a study of 90 firefighters demonstrated that fitness variables, such as abdominal strength, power (measured with a step test), push-ups, resting heart rate, and body fat contributed significantly to the predictive power of performance on an abilities test when wearing TPC/SCBA (Michaelides et al., 2011). In contrast, a study by Punakallio, Hirvonen, and Gronqvist (2005) showed that muscular capacity was not associated with the risk of slip-related falls among male firefighters (Punakallio et al., 2005). However, this study used (a) isometric trunk and knee extension to indicate muscular strength, and (b) the number of sit-ups and squats performed within 60 s to reflect muscular endurance. These tests did not include reaction time or rate of force development components and, therefore, may not correspond well to balance recovery strategies.

In the present study, there was a trend toward a positive correlation between time to complete the task and errors committed during the task in the most challenging condition (Condition 4), potentially indicating that participants who made more errors also took a longer time to complete the test. However, unlike the study by Michaelides et al. (2011) in which higher body fat was associated with unsatisfactory performance on a firefighting abilities test, we find no relationship between balance and physical characteristics including age, height, mass, and BMI. Using similar testing procedures, Punakallio et al. (2003) also failed to identify a difference in balance ability between younger (33–38 years) and older (age 43–56 years) firefighters, although a trend toward significance was reported in that study. In another study by Punakallio (2003) in which participants were divided into three groups, age difference was observed between the youngest (< 40 years) and the oldest group (> 49 years) but not between the youngest and the middle (40–49 years) groups. The age range of our participants was relatively narrow (19–43 years), which may not have allowed us to detect any age-related difference in balance performance. Among construction workers, high BMI is associated with more frequent falls (Chau et al., 2004). Although there was a wide range of BMI in our study (19.0–42.2 kg/m²), 79.2% of participants were classified as overweight (BMI ≥ 25), obese, or morbidly obese, which is becoming typical in the fire service and is associated with line-of-duty injuries (Poston, Jitnarin, Haddock, Jahnke, & Tuley, 2011; Soteriades, Hauser, Kawachi, Christiani, & Kales, 2008). However, we did not identify an association between BMI and functional balance performance in firefighters, potentially due to the low number of normal-weight participants.

Although we recruited participants from multiple fire departments, our cohort was primarily volunteer firefighters and may not be representative of firefighters across the United States. TPC worn by the participants came from all major manufacturers and could not be standardized. However, while there were variations in thermal performance and moisture barriers, the differences were minimized by ensuring all components of the TPC ensemble met the NFPA 1971 standard for protective ensembles for structural firefighting. Fitness standards for this cohort were voluntary and annual fitness-for-duty/physical exams were not required. In addition, the differences in resistance-trained participants were based on self-reported data and not direct measurements of strength or power. Similarly, the high BMI in the AEROBIC group may indicate the training programs were not particularly vigorous or

effective. The self-report data for exercise practices have limitations that may bias the results. Future studies examining the relationship between balance and fitness should directly assess aerobic capacity, muscular strength, and muscular power.

We chose to modify the analysis to include separate analyses of time to complete the task and errors committed during the task (Punakallio et al., 2003). With these data, the time analysis and composite time + errors analysis yielded similar information, while the errors analysis differed from the composite. This indicates that future investigations should consider these variables separately to better understand the compensation strategy participants chose and its result on functional balance.

We instructed the participants to optimize their performance by committing as few errors as possible and performing the task as quickly as possible. While different from previous studies, the speed-accuracy trade off created with this instruction set is relevant to fire-service operations. Fire suppression and rescue operations are fast paced, but firefighters are expected to operate safely at all times. For example, firefighters will not run during fire ground operations unless trying to escape an imminently life-threatening situation. Instead, the firefighter will work purposefully while avoiding slip and trip hazards. The slowing strategy displayed in this study may be applicable in these situations.

It is unclear what an operationally relevant time or number of errors is acceptable on this test of functional balance. Future studies should directly measure strength, aerobic fitness, agility, and coordination to stratify participants, as these factors may also influence performance on functional balance tests. We were limited by the relatively small number of participants in the present study, making it difficult to recommend specific policy changes or fitness programs for the fire service. We estimate that 10 participants per group would be required in a follow-up study to have 80% statistical power to identify a 3.5-s difference in time to complete the task and to identify a difference of three errors committed during the task.

In conclusion, the present study demonstrates that firefighters wearing TPC slow down during a functional balance test to maintain good balance. The additional mass and visual obstruction caused by wearing SCBA do not cause any change in balance among firefighters who participate in regular resistance training, but they impair balance among those who do not engage in resistance training. Future studies are required to determine what aspect of resistance training may account for this effect.

References

1. Aagaard P, Simonsen EB, Andersen JL, Magnusson P, Dyhre-Poulsen P. Increased rate of force development and neural drive of human skeletal muscle following resistance training. *Journal of Applied Physiology*. 2002; 93:1318–1326. [PubMed: 12235031]
2. Cham R, Redfern MS. Changes in gait when anticipating slippery floors. *Gait & Posture*. 2002; 15:159–171. doi: S0966636201001503 [pii]. [PubMed: 11869910]
3. Chambers AJ, Cham R. Slip-related muscle activation patterns in the stance leg during walking. *Gait & Posture*. 2007; 25:565–572. doi: S0966-6362(06)00131-7 [pii]10.1016/j.gaitpost.2006.06.007. [PubMed: 16876417]

4. Chau N, Gauchard GC, Siegfried C, Benamghar L, Dangelzer JL, Français M, Mur JM. Relationships of job, age, and life conditions with the causes and severity of occupational injuries in construction workers. *International Archives of Occupational Environmental Health*. 2004; 77:60–66. [PubMed: 12942333]
5. Cressey EM, West CA, Tiberio DP, Kraemer WJ, Maresh CM. The effects of ten weeks of lowerbody unstable surface training on markers of athletic performance. *Journal of Strength and Conditioning Research*. 2007; 21:561–567. doi: R-19845 [pii]10.1519/R-19845.1. [PubMed: 17530966]
6. Filipa A, Byrnes R, Paterno MV, Myer GD, Hewett TE. Neuromuscular training improves performance on the star excursion balance test in young female athletes. *Journal of Orthopaedic & Sports Physical Therapy*. 2010; 40:551–558. doi: 2475 [pii]10.2519/jospt.2010.3325. [PubMed: 20710094]
7. Heineman E, Shy C, Checkoway H. Injuries on the fireground: Risk factors for traumatic injuries among professional fire fighters. *American Journal of Industrial Medicine*. 1989; 15:267–282. [PubMed: 2929616]
8. Karter M Jr, Molis J. Firefighter injuries for 2005. *NFPA Journal*. 2006; 100(6):76–85. Kincl LD, Bhattacharya A, Succop PA, Clark CS. Postural sway measurements: A potential safety monitoring technique for workers wearing personal protective equipment. *Applied Occupational and Environmental Hygiene*. 2002; 17:256–266. [PubMed: 11942669]
9. Lord SR, Ward JA, Williams P, Anstey KJ. Physiological factors associated with falls in older community dwelling women. *Journal of the American Geriatrics Society*. 1994; 42:1110–1117. [PubMed: 7930338]
10. Michaelides MA, Parpa KM, Henry LJ, Thompson GB, Brown BS. Assessment of physical fitness aspects and their relationship to firefighters' job abilities. *Journal of Strength and Conditioning Research*. 2011; 25:956–965. [PubMed: 20703167] Michaelides MA, Parpa KM, Thompson J, Brown B. Predicting performance on a firefighter's ability test from fitness parameters. *Research Quarterly for Exercise and Sport*. 2008; 79:468–475. [PubMed: 19177948]
11. Park K, Hur P, Rosengren KS, Horn GP, Hsiao-Wecksler ET. Effect of load carriage on gait due to firefighting air bottle configuration. *Ergonomics*. 2010; 53:882–891. [PubMed: 20582769]
12. Pijnappels M, Bobbert MF, van Dieen JH. Control of support limb muscles in recovery after tripping in young and older subjects. *Experimental Brain Research*. 2005; 160:326–333. [PubMed: 15322782]
13. Pijnappels M, van der Burg PJ, Reeves ND, van Dieen JH. Identification of elderly fallers by muscle strength measures. *European Journal of Applied Physiology*. 2008; 102:585–592. [PubMed: 18071745]
14. Poston WS, Jitnarin N, Haddock CK, Jahnke SA, Tuley BC. Obesity and injury-related absenteeism in a population-based firefighter cohort. *Obesity (Silver Spring)*. 2011; 19:2076–2081. [PubMed: 21633400]
15. Punakallio A. Balance abilities of different-aged workers in physically demanding jobs. *Journal of Occupational Rehabilitation*. 2003; 13:33–43. [PubMed: 12611029]
16. Punakallio A. Trial-to-trial reproducibility and test-retest stability of two dynamic balance tests among male firefighters. *International Journal of Sports Medicine*. 2004; 25:163–169. [PubMed: 15088238]
17. Punakallio A, Hirvonen M, Gronqvist R. Slip and fall risk among firefighters in relation to balance, muscular capacities and age. *Safety Science*. 2005; 43:455–468.
18. Punakallio A, Lusa S, Luukkonen R. Protective equipment affects balance abilities differently in younger and older firefighters. *Aviation Space and Environmental Medicine*. 2003; 74:1151–1156.
19. Punakallio A, Lusa S, Luukkonen R. Functional, postural and perceived balance for predicting the work ability of firefighters. *International Archives of Occupational and Environmental Health*. 2004; 77:482–490. [PubMed: 15558300]
20. Rinne MB, Pasanen ME, Miilunpalo SI, Oja P. Test-retest reproducibility and inter-rater reliability of a motor skill test battery for adults. *International Journal of Sports Medicine*. 2001; 22:192–200. [PubMed: 11354522]

21. Seliga R, Bhattacharya A, Succop P, Wickstrom R, Smith D, Willeke K. Effect of work load and respirator wear on postural stability, heart rate, and perceived exertion. *American Industrial Hygiene Association Journal*. 1991; 52:417–422. [PubMed: 1951051]
22. Sobeih TM, Davis KG, Succop PA, Jetter WA, Bhattacharya A. Postural balance changes in on-duty firefighters: Effect of gear and long work shifts. *Journal of Occupational and Environmental Medicine*. 2006; 48:68–75. doi: 00043764-200601000-00009 [pii]. [PubMed: 16404212]
23. Soteriades ES, Hauser R, Kawachi I, Christiani DC, Kales SN. Obesity and risk of job disability in male firefighters. *Occupational Medicine (London)*. 2008; 58:245–250.
24. van den Bogert AJ, Pavol MJ, Grabiner MD. Response time is more important than walking speed for the ability of older adults to avoid a fall after a trip. *Journal of Biomechanics*. 2002; 35:199–205. doi: S0021929001001981 [pii]. [PubMed: 11784538]
25. Wade LR, Weimar WH, Davis J. Effect of personal protective eyewear on postural stability. *Ergonomics*. 2004; 47:1614–1623. doi: WUB3VWE8CAW3R46K [pii]10.1080 / 00140130410001724246. [PubMed: 15545235]
26. Walton SM, Conrad KM, Furner SE, Samo DG. Cause, type, and workers' compensation costs of injury to fire fighters. *American Journal of Industrial Medicine*. 2003; 43:454–458. [PubMed: 12645102]

Figure 1.

A participant performs the functional balance test on a beam while wearing thermal protective clothing and a self-contained breathing apparatus (SCBA). Photo demonstrates the procedure only. More than 2 m of space was provided around the beam during actual testing.

Figure 2.

Average time (top panel), errors committed (middle panel), and composite score of time + errors (bottom panel) for firefighters completing the balance tests. Physical activity status shown as squares (aerobic only), circles (aerobic and resistance), and triangles (none). Condition 1: regular clothing; Condition 2: thermal protective clothing (TPC); Condition 3: TPC with a self-contained breathing apparatus (SCBA), facemask carried; Condition 4: TPC with SCBA, facemask worn.

Table 1

Physical characteristics of 23 participants

	All (<i>n</i> = 23)		Aerobic training (<i>n</i> = 7)		Combination training (<i>n</i> = 12)		No training (<i>n</i> = 4)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Age (years)	28.2	6.7	32.3	8.4	27.0	5.0	25.0	5.0
Height (cm)	177.0	1.2	172.0	19.0	181.0	6.0	174.0	3.0
Mass (kg)	91.3	21.2	98.7	23.1	88.9	18.8	85.4	27.1
BMI (kg×m ⁻²)	29.3	6.4	33.6	6.1	27.1	5.2	28.0	8.0

Note. *M* = mean; *SD* = standard deviation; BMI = body mass index; there were no differences between groups for any variable.

Table 2

Clothing/equipment conditions and associated mass

Cond.	Clothing and equipment	Mass (kg) ^a	
		<i>M</i>	<i>SD</i>
1	Participant's Clothing and shoes	1.3	0.6 ^{a,b}
2	TPC, including helmet, gloves, & boots	10.9	1.4 ^{b,c}
3	TPC, including helmet, gloves, boots, & SCBA with face mask carried	20.4	1.7 ^{a,c}
4	TPC, including helmet, gloves, boots, & SCBA with face mask worn	20.4	1.7

Note. Cond. = condition; *M* = mean; *SD* = standard deviation; TPC = Thermal protective clothing; SCBA = self-contained breathing apparatus; analysis of variance revealed significant difference in mass ($p < .001$).

^aSignificantly different from Condition 2.

^bSignificantly different from Condition 3.

^cSignificantly different from Condition 1.

Table 3

Point estimates and 95% confidence intervals for post hoc comparisons

	Time (s)		Errors committed		Composite (time + errors)	
	Diff.	95% CI of diff.	Diff.	95% CI of diff.	Diff.	95% CI of diff.
Aerobic vs. combination						
Condition 1	-1.7	-10.34-6.9	-0.9	-5.05-3.25	-2.7	-13.51-8.11
Condition 2	-1.3	-9.94-7.3	-0.4	-4.55-3.75	-1.7	-12.51-9.11
Condition 3	-3.4	-12.04-5.2	-2.2	-6.35-1.95	-5.5	-16.31-5.31
Condition 4	-1.6	-10.24-7.04	-3.3	-7.45-0.84	-4.9	-15.71-5.91
Aerobic vs. no training						
Condition 1	6.1	-5.29-17.49	-1.2	-6.67-4.27	4.8	-9.45-19.05
Condition 2	7.4	-3.99-18.79	-0.9	-6.37-4.57	6.5	-7.75-20.75
Condition 3	8.0	-3.39-19.39	-1.4	-6.87-4.07	6.7	-7.55-20.95
Condition 4	13.6*	2.21-24.99	4.6	-0.87-10.07	18.2*	3.95-32.45
Combination vs. no training						
Condition 1	7.8	-2.69-18.29	-0.3	-5.34-4.74	7.5	-5.62-20.63
Condition 2	8.7	-1.79-19.19	-0.5	-5.54-4.54	8.2	-4.93-21.33
Condition 3	11.4*	0.91-21.89	0.8	-4.24-5.84	12.2*	-0.927-25.33
Condition 4	15.2*	4.71-25.69	7.9*	2.87-12.94	23.1*	9.97-36.23

Note. CI = confidence interval.

* $p < .05$.