IMPACT OF ON-DUTY ENDURANCE EXERCISE ON FIREFIGHTERS' NEUROMUSCULAR FUNCTION AND WORKING MEMORY

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BACKGROUND

- Overexertion-induced musculoskeletal injuries (22% slip/trip/fall) and sudden cardiac events are significant threats to firefighter safety and health.[1] Cardiorespiratory endurance is associated with a decreased risk of musculoskeletal injury and cardiovascular disease.[2,3] Firefighters must possess adequate cardiorespiratory levels to reduce these risks.
- The National Fire Protection Association recommends that firefighters perform on-duty exercise to enhance firefighter safety and health.[4] High-intensity interval training (HIIT) and continuous steady-state endurance exercise (CEE) are effective types of endurance training. However, on-duty exercise is often interrupted by emergency calls, thus requiring firefighters to perform rigorous occupational tasks and retain critical operational information in a fatigued state. Furthermore, fatigue has been associated with reduced working memory function.[5]
- Therefore, it is critical to determine the impact of on-duty exercise on the subsequent risk of injury and working memory.

AIM

- To evaluate the acute impact of on-duty endurance exercise on firefighters' subsequent neuromuscular function (NMF) and working memory (WM).

METHODS

- 18 male career structural firefighters (Age: 32.1±4.1 yr; Experience 7.2±4.2 yr; VO_{2peak}: 46.6±5.7 mL/kg/min) completed assessments of NMF and WM before and 10 min after high-intensity interval training (HIIT) and continuous endurance exercise (CEE). The 3 sessions were separated by 72 hr and the order of exercise sessions (HIIT/CEE) was randomized.
- Intensities were determined from a maximal graded exercise test. HIIT included 10 intervals of 45 s of work at 110% of the velocity associated with $\dot{V}O_{2peak}$ and 45 s of passive recovery. CEE included a 30 min bout at 10% below ventilatory threshold.
- Blood lactate and perceived exertion (RPE; 6-20) were recorded as descriptors of exercise intensity.
- Neuromuscular outcomes were assessed using dual force plates (VALD, INC). Peak force (N) and rate of force development (RFD) at 200 ms (N/s) were assessed during an isometric midthigh pull prior to and immediately post-exercise. Postural sway metrics (mean velocity: mm/s; total excursion: mm) were evaluated while wearing personal protective equipment during a 30 s bilateral stance with eyes open prior to and 10 min post-exercise.
- WM was assessed by written recall of 10 variables from simulated emergency radio communication prior to and 20 min post-exercise.
- Two-way repeated-measures ANOVA with post hoc tests evaluated changes across time points and conditions. Relative difference (RD), partial eta squared (η_p^2), and statistical power values are reported; minimal difference analyses were utilized for WM. Significance was set at p<0.05.

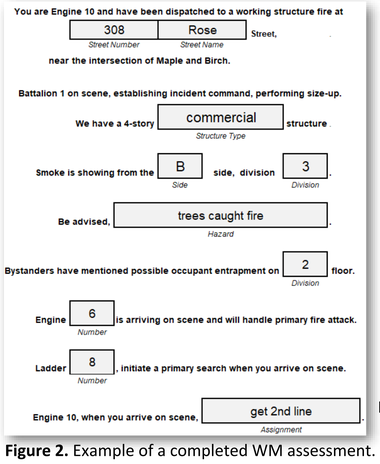

Figure 2. Example of a completed WM assessment.

Figure 3. Performance of the isometric mid-thigh pull on portable force plates.

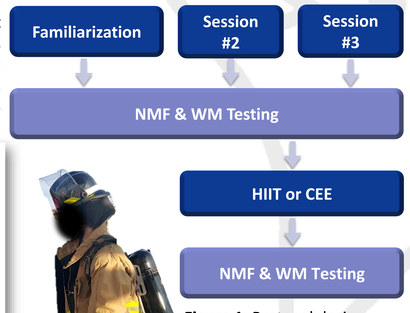

Figure 1. Protocol design.

FRRL Website

RESULTS

HIIT: Pace: 16.1 ± 1.7 km/h; Distance: 2.0 ± 0.2 km; Post lactate: 6.1 ± 1.8 mmol/L; Max RPE: 15.4 ± 3.1

HIIT yielded higher levels of blood lactate (p≤0.01), but similar RPE levels (p=0.08) compared to CEE.

CEE: Pace: 11.2 ± 1.2 km/h; Distance: 5.6 ± 0.6 km; Post lactate: 3.5 ± 1.2 mmol/L; Max RPE: 14.8 ± 2.2

NEUROMUSCULAR FUNCTION

Postural Sway

Mean Velocity (No effects)
- Condition ($F(1,17)=0.96$, $p=0.34$, $\eta_p^2=0.05$, Power=0.15)
- Time ($F(1,17)=4.08$, $p=0.06$, $\eta_p^2=0.19$, Power=0.48)
- Interaction ($F(1,17)=0.08$, $p=0.79$, $\eta_p^2=0.00$, Power=0.06)

Total Excursion (No effects)
- Condition ($F(1,17)=0.89$, $p=0.36$, $\eta_p^2=0.05$, Power=0.14)
- Time ($F(1,17)=4.09$, $p=0.06$, $\eta_p^2=0.19$, Power=0.48)
- Interaction ($F(1,17)=0.08$, $p=0.79$, $\eta_p^2=0.01$ Power=0.06)

- Peak force displayed an effect of time ($F(1,16)=23.85$, $p<0.01$, $\eta_p^2=0.60$, Power=0.99), with no effect of condition (p=0.14) or interaction (p=0.34).
- Peak force decrements were observed following completion of HIIT (RD=-4.4%, p<0.01) and CEE (RD=-6.1%, p<0.01).
- RFD yielded an effect of time ($F(1,16)=6.24$, $p=0.024$, $\eta_p^2=0.28$, Power=0.65), with no effect of condition (p=0.79) or interaction (p=0.70).
- Post hoc analyses did not specify RFD decrements following completion of HIIT ($t(1,16)=1.78$, p=0.10, RD=-4.3%) or CEE ($t(1,17)=1.61$, p=0.06, RD=-2.5%).

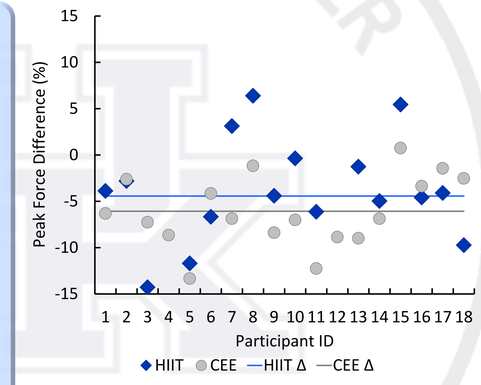

Figure 4. Relative change [(post-pre)/pre*100] in firefighters' peak force production capabilities between session baseline versus post-HIIT and post-CEE exercise, respectively.

WORKING MEMORY

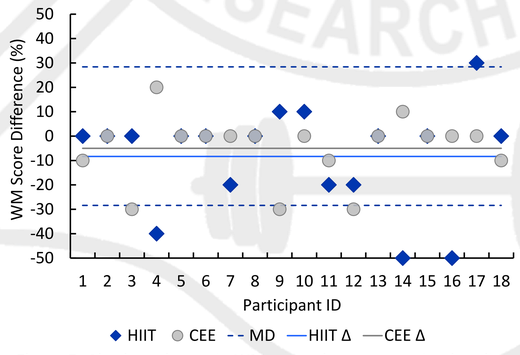

Figure 5. Absolute change in WM scores between session baseline versus post-HIIT and post-CEE exercise, respectively, compared to minimal difference (MD; = 28.4%).

- There was an effect of time on WM performance ($F(1,17)=8.58$, $p<0.01$, $\eta_p^2=0.34$, Power=0.79).
- CEE decreased WM (RD: -5.8±14.4%; $t(17)=1.88$, p=0.04; d=0.44)
- Post-HIIT displayed a non-significant decrease (RD: -7.3±23.0%; $t(17)=1.67$, p=0.06; d=0.39).
- There were no condition or interaction effects for WM (p≥0.07).

CONCLUSION

- Completion of HIIT and CEE yielded similar RPE scores and resulted in muscular fatigue.
- Post-exercise postural sway was not impacted following either endurance training bout.
- WM performance was reduced following CEE completion.

PRACTICAL APPLICATIONS

- Appropriately programmed **on-duty endurance exercise may not be detrimental** to subsequent static balance in recreationally trained structural firefighters.
- **Exercise participation is encouraged** to develop cardiorespiratory outcomes associated with health and occupational readiness.
- **Additional research is warranted** to further elucidate the impact of CEE **on occupational working memory**.

ACKNOWLEDGEMENTS

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