EFFECT OF ON-DUTY CIRCUIT VS. HEAVY RESISTANCE TRAINING ON NEUROMUSCULAR FUNCTION IN STRUCTURAL FIREFIGHTERS

Jamal L. Thruston[1,2], Sarah N. Lanham[1,2], Mark R. Mason[1], Jackson Miller[1], Margaret A. Lewis[1,2], Abigayle R. Spong[1], Lance M Bollinger[1], Stuart Best[1], Nick Heebner[3], & Mark G. Abel[1,2]

[1]First Responder Research Laboratory, University of Kentucky, Lexington, KY; [2]Department of Kinesiology and Health Promotion, University of Kentucky, Lexington, KY;
[3]Sports Medicine Research Institute, University of Kentucky, Lexington, KY

ABSTRACT

Background: The National Fire Protection Association (NFPA) reports approximately 65,000 firefighter injuries annually; 21% of fireground injuries result from a slip/trip/fall and 40% are classified as a strain, sprain, or muscular pain.[1] Firefighters are recommended to perform on-duty resistance training to enhance occupational readiness and safety, however, it's unclear how exercise-induced fatigue may impact firefighters' ability to safely perform subsequent occupational tasks, as fatigue is considered a risk factor for slip/trip/fall-related injuries.[3] Heavy resistance and circuit training modalities are commonly utilized to meet these objectives and exercise sessions are often interrupted with emergency responses requiring that occupational tasks are performed in a fatigued state, potentially increasing injury risk. PURPOSE: The primary aim of this study was to compare the effects of circuit versus heavy resistance training fatigue on neuromuscular function in firefighters. METHODS: A convenience sample of 18 career structural firefighters (Age: 38.8±8.0 yr; Fat: 24.9±7.0%) were recruited from a local fire department. Participants completed 3 testing sessions, separated by at least 72 hr. During Session 1 anthropometrics and familiarization trials of the balance and neuromuscular function assessments were completed, which included single-leg drop landing (SLDL), postural sway (PS), and modified Functional Balance Test (mFBT). The mFBT required ambulation on a plank while maneuvering over and under standardized barriers. Sessions 2 and 3 were randomized, where participants completed either heavy resistance training (HRT; 5 repetition maximum (RM) load, 2 min recovery) or a circuit training (CT; 10RM load, 45 s recovery) session. Isometric midthigh pull (IMTP), long jump (LJ) lower body power, static and dynamic balance assessments were conducted pre- and 10 min post-exercise. Repeated measures ANOVA, effect sizes, and absolute and relative difference scores were used to analyze the effect of condition and time. Level of significance was set at p<0.05. RESULTS: IMTP, LJ, and LBP decreased following CT and HRT (p≤0.001, ES≥0.476). Bipedal PS mean velocity decrements were greater following CT compared to HRT (p=0.043). Despite not reaching significance, several additional balance variables exhibited large effect sizes reflecting greater potential decrements in neuromuscular function following CT. CONCLUSIONS: These findings suggest that on-duty resistance training reduces firefighters' strength and power immediately post-exercise and that CT may impact some measures of static balance greater than HRT, but not different than baseline. PRACTICAL APPLICATIONS: On-duty exercise is critical to enhance firefighter readiness and safety. Firefighters are recommended to exercise during low call volume to reduce the effects of post-exercise fatigue on risk of subsequent occupational injury.

BACKGROUND

Firefighters are recommended to perform on-duty resistance training to enhance occupational readiness and safety.[2] Heavy resistance and circuit training modalities are commonly utilized to meet these objectives.[4] *However, exercise sessions are often interrupted with emergency responses requiring that occupational tasks are performed in a fatigued state, potentially increasing risk of injury.*

AIM

To compare the effects of circuit versus heavy resistance training fatigue on neuromuscular function in firefighters.

METHODS

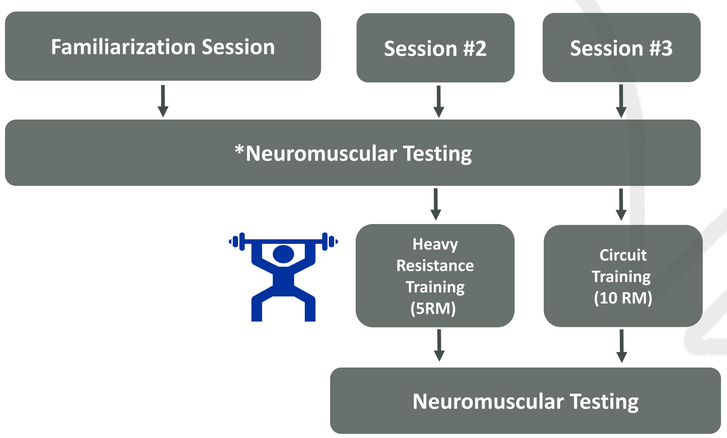

Figure 1. Procedural overview.

*Neuromuscular assessments included the modified Functional Balance Test (Figure 2) and postural sway outcomes using a force plate (Vald, Newstead, Australia).

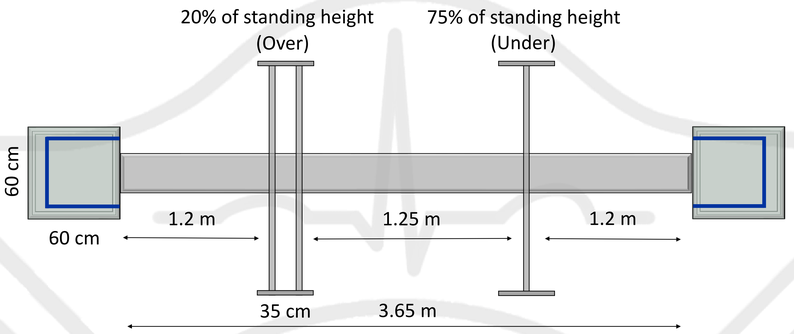

Figure 2. Schematic of the modified functional balance test.

RESULTS

Table 1. Comparison of circuit vs. heavy resistance training outcomes in firefighters (N=18). Values reflect relative difference scores within each condition.

Variable	†Circuit Training	†Heavy Resistance Training	‡Effect Size	‡Power
Strength & Power Performance				
Isometric Midthigh Pull*^	-6.5 ± 5.1	-2.7 ± 6.2	.340	.796
Long Jump*^	-7.4 ± 7.7	-3.1 ± 2.5	.294	.708
Lower Body Power*^	-14.8 ± 15.0	-6.7 ± 5.6	.294	.708
Single Leg Drop Landing (Dominant)				
Time to Stabilization	5.1 ± 43.4	7.6 ± 32.7	.004	.056
Peak Power (N=17)	-2.7 ± 10.5	3.8 ± 11.5	.126	.298
Postural Sway - Eyes Open				
Mean Velocity*	13.6 ± 30.6	0.2 ± 19.8	.219	.539
Mean Velocity – Anterior-Posterior*	13.0 ± 29.9	0.3 ± 20.8	.208	.514
Mean Velocity – Medial-Lateral	16.3 ± 37.3	0.7 ± 17.7	.162	.401
Excursion*	13.5 ± 30.5	0.2 ± 19.7	.214	.529
COP Range – Anterior-Posterior	18.5 ± 37.9	19.9 ± 39.1	.029	.103
COP Range – Medial-Lateral	42.0 ± 91.6	14.3 ± 54.1	.099	.251
Postural Sway - Eyes Closed				
Mean Velocity	11.1 ± 24.4	-3.2 ± 22.9	.163	.405
Mean Velocity – Anterior-Posterior	11.6 ± 25.3	-2.5 ± 23.7	.153	.379
Mean Velocity – Medial-Lateral*	10.9 ± 24.1	-10.4 ± 18.9	.243	.595
Excursion	11.1 ± 24.4	-3.2 ± 23.0	.162	.402
COP Range – Anterior-Posterior	26.2 ± 41.1	7.0 ± 41.0	.038	.121
COP Range – Medial-Lateral*	35.6 ± 59.6	-6.3 ± 34.5	.322	.763
Single-Leg Stand (Dominant)				
Mean Velocity	3.9 ± 25.3	-6.3 ± 16.7	.138	.344
Mean Velocity – Anterior-Posterior	6.8 ± 24.7	-4.7 ± 13.6	.201	.496
Mean Velocity – Medial-Lateral	2.2 ± 26.3	-7.4 ± 20.2	.102	.260
Excursion	3.9 ± 25.4	-6.2 ± 16.7	.137	.341
COP Range – Anterior-Posterior	28.3 ± 51.5	6.9 ± 27.1	.107	.270
COP Range – Medial-Lateral	6.8 ± 33.6	-2.1 ± 24.1	.137	.341
Modified Functional Balance Test (N=16)				
mFBT Time	6.0 ± 13.4	2.6 ± 7.9	.060	.150
mFBT Performance Index	5.2 ± 18.2	3.0 ± 14.2	.020	.082

Values reflect mean ± standard deviation. Rel Diff: Relative difference. Rel Diff = ((post-exercise value – pre-exercise value) / pre-exercise value) x 100. ‡partial eta squared and power describe condition x time interaction effects; *Significant condition x time effect ($p < 0.05$); ^Significant main effect of time ($p < 0.05$); COP: Center of Pressure; mFBT: modified Functional Balance Test; Partial eta squared: Small effect: 0.01-0.05; Medium effect: 0.06-0.13; Large effect: ≥ 0.14.

CONCLUSION

- Circuit and heavy resistance training decreased muscular power, however circuit training also induced decrements in strength immediately post-exercise.
- There was no impact of either resistance training stimulus on balance outcomes 10 minutes post-exercise.

PRACTICAL APPLICATIONS

- **On-duty exercise** is critical to enhance firefighter **readiness and safety.**
- Firefighters are recommended to train during **low call volume times** and **limit exposure to high volume circuit training to reduce the effects of post-exercise fatigue.**
- **Tactical strength & conditioning coaches** should utilize **periodization** when implementing circuit training, and must **consider the risks vs. rewards** as circuit training can create decrements in strength and power metrics post-exercise.

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