

# METABOLIC PERFORMANCE CHANGES COMPARISON FOR PERSONAL PROTECTIVE EQUIPMENT FOR FIREFIGHTING GEAR, EXPLOSIVE ORDNANCE DISPOSAL GEAR, AND POLICE GEAR

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## INTRODUCTION

- Personal protective equipment (PPE) increases metabolic demands for professionals at rest and during exercise.
- There is very little research investigating the metabolic demands of wearing explosive ordinance disposal (EOD) equipment, however, there is a great deal of research on the demands of firefighting equipment and police equipment.
- How these demands compare between the different PPE needs to be investigated. Greater understanding of these demands and how they impact performance is one step towards learning how this equipment influences performance and fatigue of its operators.

## PURPOSE

- To compare metabolic demands between wearing firefighting PPE, EOD PPE, and police PPE.

## METHODS

- 17 recreationally trained college aged students (weight 88.5±15.6 kg, age 23±4.8 years, 12 male and 5 female, height 1.76±0.07m, Body Fat Percentage 20.5±10.1%, Mean ± SD) participated in this study.
- Subjects came in for 4 total testing visits. PPE was donned in the testing visits after the initial familiarization (FAM) visit, the options were firefighting PPE (turnout clothes, SCBA, Helmet (approximately 27kg)), EOD PPE (jacket, leggings, IGP, helmet (approximately 35kg)), and police PPE (tactical vest and duty belt with typical weight loadout).
- Subjects performed a Bruce treadmill protocol, during the FAM visit subjects completed a standard VO2 max protocol (Bruce protocol) on the treadmill. Subjects completed a modified Bruce protocol during the PPE visits (stages 1-3).
- Metabolic measurements were recorded during each stage of the test. Subjects self-reported their ratings of perceived exertion (RPE) during each stage (1-10 scale, 10 being hardest).
- PPE order was randomized with familiarization always being first.
- Metabolic data was analyzed for the time point of inflection of ventilation rate was determined as the ventilatory anaerobic threshold (VAT). Performed by the change in slope of ventilation escalating more so in one stage than the previous.
- Data was then analyzed for changes in performance between the different PPE and the familiarization visit utilizing ANOVA with LSD post hoc testing, significance was set at  $p < .05$ .

## RESULTS

- Heart rate and VO2 were significantly higher in a number of stages in the EOD equipment compared to the firefighting gear. This equipment was significantly higher for the imposed demands than the police and familiarization visit.
- EOD PPE and firefighting PPE were significantly more metabolically demanding than the familiarization visit for all metabolic metrics. The EOD PPE had greater glycolytic demands than the familiarization, but not significantly different than the fire fighting gear.
- The police gear was only significantly different than the familiarization in VAT. Otherwise the demands were not significantly different for the familiarization and the VAT time was similar to the other equipped visits.
- Subjects fatigued significantly earlier on the bomb suit trial than on the familiarization trial or in the police equipment trial the time to fatigue was not significantly different than the fire fighting gear.

Load	Familiarization	Bomb Suit	Fire Fighting Gear	Police Equipment
Stage 1 VO2 (mgO2/kg/min)	8.15±2.91	12.36±4.30*†	10.38±3.65*†	7.16±3.66
Stage 2 VO2	12.99±3.98	19.99±6.20*†	16.59±5.62*	13.31±6.42
Stage 3 VO2	19.01±5.73	30.18±15.19*†	26.28±11.29*†	20.14±8.42
VO2 Max	36.16±11.09	30.76±12.37	31.36±10.46	25.0±11.38*
RER stage 1 (VCO2/VO2)	0.84±.11	0.84±.07	0.92±.09*	0.99±.37*‡
RER stage 2	0.76±.06	0.84±.06*	0.82±.06*	0.82±.10
RER stage 3	0.85±.09	0.94±.09*	0.92±.13	0.90±.17
RER max	1.09±.09	1.03±.10*	1.08±.13	0.98±.21
VAT time (min)	12.3±2.1	8.9±2.2*	9.9±1.6*	9.8±1.7*
RPE stage 1 (1-10 AU)	1.24±1.09	3.44±1.93*†	2.16±1.28*	1.62±.97
RPE stage 2	2.24±1.60	5.2±2.28*†	3.48±2.04*	2.92±1.70
RPE stage 3	3.59±2.40	6.6±3.77*	5.11±3.08*	4.46±2.57
RPE max	7.94±2.16	8±1.83	6.76±4.09	5.4±3.3*‡
HR Stage 1 (BPM)	112.1±18.1	136.3±14.8*	124.8±19.5	113.9±18.6
HR Stage 2	127.5±18.8	162.2±9.5*†‡	144.8±19.1*†	128.7±20.4
HR Stage 3	147.8±22.2	181.3±55.1*†	170.2±15.7*†	152.3±19.3
HR Max	190.1±13.8	182.9±12.6	182.5±14.3	175.1±13.3*
Duration (min)	14.1±2.8	9.4±2.9*†	11.9±4.0	14.5±6.2
<b>Significance (P&lt;.05) to Familiarization *, to Police gear †, to Firefighting gear ‡</b>				

## CONCLUSIONS

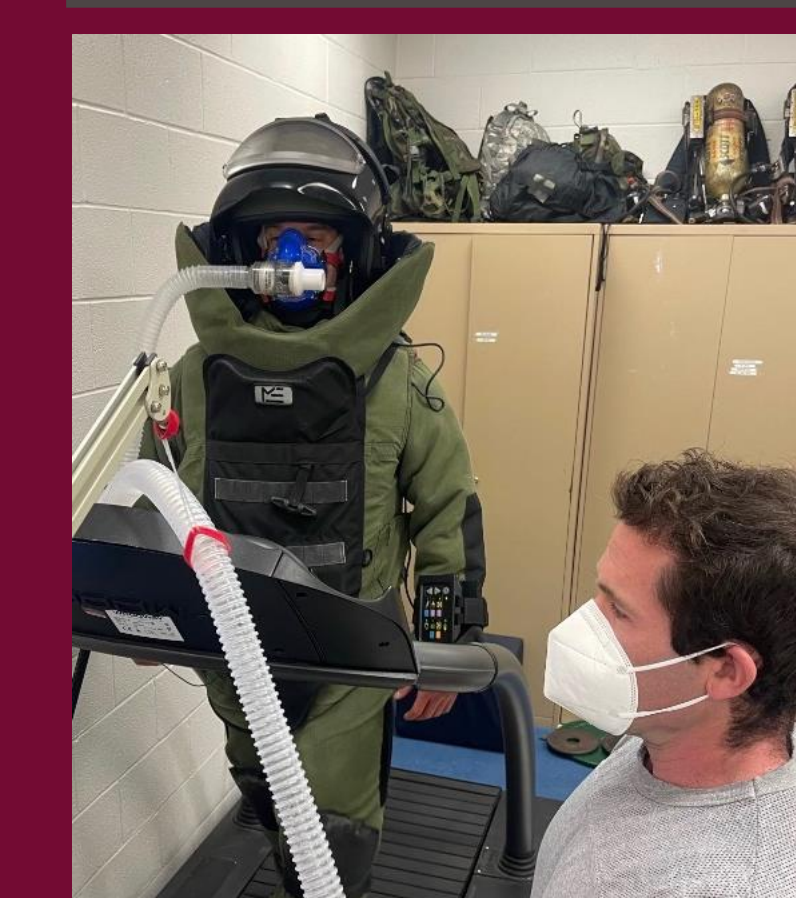
- The bomb suit had greater metabolic demands and was perceived as the more difficult load carriage than the firefighting gear though not significantly.
- The EOD equipment also caused fatigue to occur significantly earlier than the FAM and police gear trials showing that the greater demands in the gear precludes higher intensity operation in the equipment. The difference though significant do show relatively similar responses to performance when wearing either equipment compared to unencumbered performance.
- The police equipment was markedly easier and had a minimal detrimental effect on performance compared to the familiarization performance.
- The EOD equipment was perceived as being very difficult though the metabolic demands did not increase as commensurate with the ratings compared to the fire fighting equipment.
- VO2 max values were only truly achieved in the familiarization and in the heavier load carriages due to fatigue. The lower values in the police equipment is due to that equipment not eliciting fatigue that stopped any further performance.

## PRACTICAL APPLICATIONS

- Coaches that work with individuals that need to wear EOD equipment should understand that bomb disposal equipment is more demanding than firefighting gear but very similar and in turn program for the physical development of their clients appropriately. Using training recommendations for fire fighters can be useful for operations in the equipment, though EOD operations are performed at a lower intensity.
- Police gear does influence performance, but to nowhere near as great of a degree as the other equipment.

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