Measuring, Analyzing and Retraining Movement using Occupationally Valid Evaluations (M.O.V.E.)

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KEY FINDINGS

- Monitoring physiologic responses that identify fitness and system stress is possible with applied technologies designed to meet the rigours of firefighting.
- Technology-enabled evaluation of occupational tasks have the potential to identify injury risk during field and simulated firefighting tasks.

BACKGROUND

- Firefighters (FF) incur high rates of cardiovascular and musculoskeletal stress during training and fire suppression tasks.
- It is challenging to understand these risks in a contextually valid manner that includes full equipment and actual job tasks.

OBJECTIVES

- Test whether a wearable technology (Zephyr BioHarness) can monitor FF physiologic changes and fitness levels.
- Identify relevance and validity of a musculoskeletal risk assessment tool (OWAS) and video analysis software (Dartfish) in assessing firefighting tasks.

PHASE 1 (PHYSIOLOGIC MONITORING): METHODS

Our development work established that the Zephyr BioHarness is a reliable and valid device in the general population.12

Part 1 – Fitness Testing3

- Participants: n = 49 Hamilton FF (46M, 3F; Mean age = 33.7 (SD = 9.0)); n = 40 healthy controls (20M, 20F; Mean age = 39.0 (SD = 11.0)).
- The Zephyr BioHarness device monitored heart rate and respiratory rate and quantified aerobic capacity (VO2 max) levels during a submaximal fitness test.
- Data analyses: Wilcoxon rank sum tests (differences between groups). Standardized response mean (SRM; magnitude of difference between groups). Regression analyses (age and gender effects on aerobic capacity).

Part 2 – Simulated Firefighting Tasks4

- The Zephyr BioHarness monitored the same cohort of FF physiologic responses during a simulated hose drag and stair climb with a high-risk pack.
- Data analyses: Pearson correlation coefficients (fitness parameters vs. task completion times). Regression Models (factors predicting task completion times).

PHASE 1: RESULTS

- The VO2 max levels among FF and the general population did not vary significantly (median difference = 4.20; SRM = 0.48).
- Age had a statistically significant impact on FF VO2 max levels (p < 0.001).
- No gender effect was detected in the FF (p = 0.300).
- Near maximal heart rates of ≥88% of heart-rate maximum were recorded during the two tasks (See Table 1).
- Higher aerobic capacity levels were associated with faster task completions times with correlation coefficients of ≥0.30.
- Age, sex, resting heart rate and upper body/lower body strength levels have similar and predictive values in task completion times (Model F = 0.24-0.25; SE = 13.10-13.55).

PHASE 1: CONCLUSION

- Zephyr is a wearable device designed specifically to meet the demands of firefighter tasks. It could take reliable and responsive measurement of fitness while assessing submaximal fitness in firefighters.11

PHASE 2 (ERGONOMIC ASSESSMENT): METHODS

- Physiotherapists and a kinesiologist assessed videos of firefighting tasks (n=25) using the Ovako Working Postures Assessment System (OWAS).
- Data analyses: Reliability statistics (Cohen’s kappa with quadratic weighting).

PHASE 2: RESULTS

- Simple, static posture (Fig. 1) showed very good OWAS inter-rater reliability (Fig. 2).
- Complex, dynamic postures (Fig. 1) had poor to moderate OWAS inter-rater reliability (Fig. 2).

PHASE 2: CONCLUSION

- OWAS measured gross movements related to anatomical regions which may have limited the specificity of the assessment particular during complex movements.
- Combining video from multiple planes (i.e., sagittal and frontal) was associated with higher reliability, however, this may not always be feasible in applied contexts.
- Training on assessment of firefighter tasks analysis will be needed to improve reliability.
- Video analysis may be a way to improve reliability and precision for MOVE analyses.

PHASE 3 (KINEMATIC ANALYSIS): METHODS

- Dartfish movement analysis software was adapted to measure firefighters’ movements and postures from video-based inputs.
- Technology-Enabled Analysis of Movement and Feedback (TEAM-Feedback) integrates ergonomic principles with annotation features of Dartfish.
- Kinematic analysis includes measuring angles during dynamic and static postures, as well as horizontal and vertical displacement of anatomical segments.

PHASE 3: RESULTS

- TEAM-Feedback can be refined and disseminated using features of Dartfish including Dartfish TV and/or the Dartfish App.
- This information can be used to identify group level or individual risks and to re-train task performance.
- TEAM-Feedback Examples (Fig. 3 & 4):