THE EFFECT OF CARDIOVASCULAR FATIGUE ON TRUNK MUSCLE ACTIVATION AND SPINE POSTURES DURING FIREFIGHTING TASKS

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INTRODUCTION

The Candidate Physical Ability Test (CPAT) is used to assess the physical fitness of firefighter candidates. The test is comprised of eight tasks which simulate real firefighting duties and demands. These tasks, whether executed during the CPAT or during a real firefighting scenario, are often performed in a cardiovascularly fatigued state. Given that cardiovascular fatigue is a large component of both the CPAT and real firefighting scenarios, it is important to understand the effect of such fatigue on firefighting tasks. Therefore the primary purpose of this study was to examine the effect of fatigue on trunk muscle activation patterns and three-dimensional spine postures during three standard CPAT tasks.

The secondary purposes of this study were to examine the effect of gender and CPAT experience (previous completion of the complete CPAT protocol) during the same standard CPAT tasks.

METHODS

Ten individuals (five male, five female) from a university population were recruited for the current study. Participants were free of any low back pain in the twelve months prior to the collection. Five of the ten participants had previous CPAT experience.

The three CPAT tasks chosen for examination were the ceiling breach and pull (ceilingBP), designed to simulate breaking or pulling down part of a ceiling; the forcible entry (forceE), designed to simulate entry through a wall or door; and the mannequin drag (mDrag), designed to simulate moving a victim. The ceilingBP involved pushing up three times on a 27.3 kg ceiling hinged door and pulling down five times on an 3.6 kg ceiling latch; with the complete cycle repeated four times. The forceE involved repetitively striking a mechanized target with a 4.5 kg sledgehammer until the target moved a given distance (generally 5-10 hits). The mDrag involved dragging a 75 kg mannequin 10.7 m followed by a 180° turn and another 10.7 m drag.

Each participant performed all three tasks (presented in random order) with as much rest in between as required by the participant while wearing a 22.7 kg CPAT regulation weight vest which is a requirement of the protocol. Each participant then completed the official CPAT fatiguing protocol which consisted of stair climbing at a rate of 60 steps/minute while wearing the 22.7 kg weight vest plus an additional 11.3 kg on the shoulders (total of 34 kg) for 3 minutes. Immediately following the fatigue protocol and the removal of the additional 11.3 kg, the participants repeated the three CPAT tasks (in the same order presented for that participant prior to fatigue) without any rest given in between.

During the tasks (both prior to and following fatigue) muscle activation and spine postures were monitored. Surface electrodes were adhered to the skin bilaterally over the
internal oblique, external oblique, lumbar erector spinae, and thoracic erector spinae. Spine posture was monitored using the Lumbar Motion Monitor (AcuPath Industrial, Biomec Inc., Cleveland, OH, USA). Variables examined included average and peak muscle activation, and average and peak spine angles, velocities, and accelerations in all three axes (flexion/extension, lateral bend, and axial twist).

RESULTS AND DISCUSSION

Individuals showed lower average muscle activation in all four abdominal muscles during the three tasks following the fatigue protocol as compared to before (Figure 1a, p<0.05), while no differences in average back extensor activation were observed following the fatigue protocol. In addition, individuals showed increased average and peak spinal flexion following the fatigue protocol as compared to before (Figure 1b, p<0.05).

The reduced abdominal activation post fatigue may be indicative of the increased challenge of breathing. It has been shown that during a challenged breathing scenario, some individuals change their abdominal activation patterns to preferentially assist in breathing rather than to stabilize their spine (McGill et al., 1995). The cardiovascular fatigue in the current study may have induced a similar phenomenon. Since abdominal activation is cyclic in nature during a challenged breathing task, the average activation would likely be lower if compared to a static activation in the abdominals in order to maintain stability of the spine. Further, the increase in spinal flexion that was observed post fatigue may place individuals at an increased risk of spinal injury. When an individual becomes cardiovascularly fatigued, generally quality of form is lost. Poor form, combined with reduced abdominal activation and thus likely reduced spine stability, may increase the risk of injury to the individual.

SUMMARY/CONCLUSIONS

Cardiovascular fatigue is very common in firefighting scenarios. The current study demonstrated that such fatigue results in reduced abdominal activation, and increased spinal flexion, likely increasing an individual’s risk of spine injury.

REFERENCES


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