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Impact of police body armour and equipment on mobility

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ABSTRACT

Body armour is used widely by law enforcement and other agencies but has received mixed reviews. This study examined the influence of stab resistant body armour (SRBA) and mandated accessories on physiological responses to, and the performance of, simulated mobility tasks. Fifty-two males (37 ± 9.2 yr, 180.7 ± 6.1 cm, 90.2 ± 11.6 kg, VO_{2max} 50 ± 8.5 ml kg^{-1} min^{-1}, BMI 27.6 ± 3.1, mean $\pm$ SD) completed a running VO_{2max} test and task familiarisation. Two experimental sessions were completed ($\geq$4 days in between) in a randomised counterbalanced order, one while wearing SRBA and appointments (loaded) and one without additional load (unloaded). During each session participants performed five mobility tasks: a balance task, an acceleration task that simulated exiting a vehicle, chin-ups, a grappling task, and a manoeuvrability task. A 5-min treadmill run (zero-incline at 13 km·h^{-1}, running start) was then completed. One min after the run the five mobility tasks were repeated.

There was a significant decrease in performance during all tasks with loading ($p < 0.001$). Participants were off-balance longer; slower to complete the acceleration, grapple and mobility tasks; completed fewer chin-ups; and had greater physiological cost (↑ $\%HR_{max}$, ↑ $\%VO_{2max}$, ↑ RER) and perceptual effort (↑ RPE) during the 5-min run. Mean performance decreases ranged from 13 to 42% while loaded, with further decreases of 6–16% noted after the 5-min run. Unloaded task performance was no different between phases.

Wearing SRBA and appointments significantly reduced mobility during key task elements and resulted in greater physiological effort. These findings could have consequences for optimal function in the working environment and therefore officer and public safety.

1. Introduction

Law enforcement officers have traditionally worn and carried various protective and functional equipment required in the discharge of their duties (Hooper, 1999; Stubbs et al., 2008). For the New Zealand Police, the duty belt and mandated appointments (equipment currently consisting of a duty belt, radio, extendable baton, pepper spray, handcuffs, a personal protection kit and a torch) weigh approximately 3.5 kg (Stab Resistant Body Armour Introduction and Guidelines, 2007). Body armour (e.g. stab resistant body armour, SRBA) is used widely by law enforcement and other agencies internationally. In 2007, SRBA was introduced to all frontline New Zealand Police, purportedly in response to escalating crimes of violence, and to reduce officer fatalities (Stab Resistant Body Armour Introduction and Guidelines, 2007; Wallwork, 2010). While the SRBA (2.7–3.8 kg depending on size) provides protection from stabbing, blunt trauma, and small calibre bullets, it has been suggested that the SRBA and belt unit negatively affect police physical performance (Hooper, 1999; Stubbs et al., 2008).

Although there is a wealth of literature exploring the impact of added load (backpacks) on human performance (Knapik et al., 1996), few studies have been designed to assess the effect of body armour on task elements typically encountered in policing. Most research involves analysis of military based tasks using heavier specialised military body armour, finding that it adversely affects mobility, strength, speed, balance and physiological strain (Dorman and Havenith, 2009; Larsen et al., 2011; Ricciardi et al., 2008). The weight and rigidity of SRBA along the length of the torso may also hinder an individual's ability to move efficiently and correct loss of balance (Hooper, 1999; Stubbs et al., 2008). Anecdotal police reports and officer interviews within New Zealand and the United Kingdom suggest that SRBA and appointments restrict job related mobility during a number of work related tasks. Tasks cited were running, pursuing, rapidly exiting vehicles and scuffling or grappling with an offender. More mundane tasks, such as

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manoeuvring or lifting their body weight, carrying, climbing over objects, balancing, and changing a car wheel, were also reportedly affected (Bonneau and Brown, 1995; Collingwood et al., 2004; Hooper, 1999; Stubbs et al., 2008; Wallwork, 2010).

The purpose of this study was to explore and provide information on the influence that the wearing of SRBA and mandated appointments has on physiological markers of effort and performance during the completion of simulated mobility tasks. We hypothesised that wearing the SRBA and appointments would negatively impact all mobility tasks and increase the physiological effort of movement. Given that failure to complete critical tasks in police work could have potentially fatal consequences for police officers, their work colleagues, and the public they serve, this research is timely and necessary.

2. Methods

2.1. Participants

Fifty-three male participants were recruited from the New Zealand Southern Region District Police force with assistance from a Southern Region Police physical education officer. The demanding testing required that participants be physically active with no history of cardiovascular disease or neurological deficits, and free of musculoskeletal injury. Participants were asked to abide by test preparation guidelines and keep pre-testing physical activity, sleep patterns and diet consistent between test sessions.

2.2. Baseline session

Participants completed a 10–12 min incremental treadmill test to identify their maximal aerobic fitness (VO_{2max}), with oxygen uptake (VO_2), respiratory exchange ratio (RER) and heart rate (HR) recorded throughout. The test ended at volitional fatigue, or when all of the following criteria (Howley et al., 1995) were realised: (i) a plateau in VO_2 with increases in external work (ΔVO_2 <150 ml·min^{-1} at VO_{2peak}) (ii) RER >1.1, and (iii) HR reaching ± 10 b·min^{-1} of age-predicted maximum (220-age). Participants' age, height and body mass were recorded. Following the test, participants were fully familiarised with testing procedures and practiced all five mobility tasks (see Section 2.3) three times each while both loaded and unloaded. This familiarisation and practice ensured test consistency and suitable technique were achieved.

2.3. Mobility task sessions

Wearing exercise shoes and clothing, participants completed two identical experimental sessions in a randomised and counterbalanced order. One session was conducted carrying added load (loaded, fitted SRBA plus weight representative of a standard police duty belt and appointments, 7.65 kg ± 0.73, mean ± SD), while the other was completed without additional load (unloaded). Sessions were completed under the same conditions within an eighteen day period, with at least four days between sessions. It was not possible for all participants to complete their testing at the same time of day due to availability and shift work schedules.

During each session, participants completed five mobility tasks (initial phase) that were selected based on job task analyses from the literature (Bonneau and Brown, 1995; Hooper, 1999; Stubbs et al., 2008) and a review of the New Zealand Police Physical Competency Test (Handcock and Dempsey, 2011) to represent mobility challenges encountered during police work. Time between the tasks were standardised based on expected exertion (45 s after the lower exertion balance and acceleration tasks and 90 s after the higher exertion chin-ups, grapple and manoeuvrability tasks), but also to adhere to data recording and session time constraints. After the fifth mobility task, participants rested for 5 min (final 3 min seated) and were connected to a metabolic cart (Cosmed, CPET, Rome, Italy). They then completed a 5-min run on a zero grade treadmill at 13 km·h^{-1} commencing from a running start. While the amount of job related running for police is difficult to quantify, the treadmill run was an attempt to replicate a near maximal running effort that may present a worst-case policing scenario (Bonneau and Brown, 1995; Collingwood et al., 2004; Strating et al., 2010). The 13 km·h^{-1} treadmill speed was based on the mean running speeds attained during the run section of the New Zealand Police Physical Competency Test (Handcock and Dempsey, 2011). Measures of HR (Polar S-810i, Kempele, Finland), VO_2, and RER were recorded and averaged over the final min. A rating of perceived exertion (RPE) score (Borg 6–20) was recorded during the final 20 s of the run. On run completion, participants rested for 1 min before repeating the five mobility tasks with identical rest times (repeat phase). To avoid possible performance bias, participants were blinded to their initial phase results.

The mobility tasks were:

(1) a timed balance task, standing on a stabilometer platform with feet shoulder width apart. Initial balance was achieved and as soon as the participant's hands were released from supports the test began. The objective was to keep the platform balanced against lateral excursions (left and right edges out of contact with the ground) for 30 s. Time off-balance was recorded as the total time the platform was in contact with the ground.
(2) an acceleration task to simulate exiting a vehicle. Participants began this task sitting in a floor mounted car seat (Nissan Skyline GTS, seat bottom 30 cm high) with their feet flat on the ground. On "GO" they stood without arm assistance, pivoted 90° to the right and sprinted 2.85 m through a set of opto-reflective timing gates.
(3) as many successive standard chin-ups as possible (underhand grip). Upper body strength or strength endurance has been indicated as an important element in a number of police job task analyses (Bonneau and Brown, 1995; Collingwood et al., 2004; Handcock and Dempsey, 2011).
(4) a grapple task. On "GO", participants raised a cylindrical 'grappling bag' (G_{BAG}; weight 64.5 kg, length 155.25 cm, diameter 37.10 cm) to vertical position. Grasping the middle of the G_{BAG}, they then lifted the G_{BAG} 0.75 m onto a wooden platform (89 × 122 cm) demarcated into two target zones (each 45 × 56.7 cm) separated by a 70 mm high by 65 mm wide strip (Fig. 1). The G_{BAG} was then lifted and moved twice over the strip, touching the bag down in each target zone, before being lifted off the platform, tilted down and dragged 4.5 m until the distal end of the bag crossed a line and the timer was stopped.

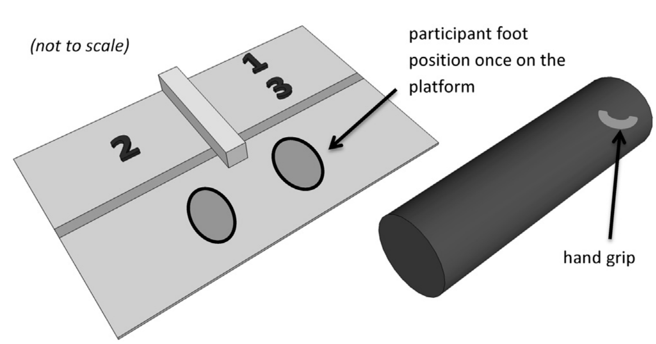

Fig. 1. Schematic diagram of the wooden platform and grappling bag (G_{BAG}) used for the grappling task. *Note.* The numbers in each target zone indicate where the G_{BAG} was sequentially touched down.