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Sex-Specific Differences in Fit Between Two Different Types of Body Armour: A Pilot Study

[1]**Claire Buttner**[1], [1]**Sharne-Louise Tiller**[2], [1]**Nash Vollenweider**[3], [1] [2]**Elisa Canetti**[4], [1] [2]**Ben Schram**[5], [3] [4]**Jay Dawes**[6], [5]**Robert Lockie**[7], [1] [2]**Robin Orr**[8]

[1]*Faculty of Health Sciences and Medicine, Bond University, Gold Coast, QLD, Australia*

[2]*Tactical Research Unit, Bond University, Gold Coast, QLD, Australia*

[3]*School of Kinesiology, Applied Health, and Recreation, Oklahoma State University, Stillwater, OK, USA*

[4]*Tactical Fitness and Nutrition Lab, Oklahoma State University, Stillwater, OK, USA*

[5]*Department of Kinesiology, California State University, Fullerton, Fullerton, CA, USA*

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Abstract: *Introduction*. Body armour, whilst improving wearer survivability, can negatively impact physical performance and increase injury risk. These impacts may differ between male and female personnel due to the generic design of armour systems. The aim of this study was to assess sex-specific differences in comfort when wearing military (MBA) and law enforcement (LEBA) body armour. *Methods*. Using a prospective, within-subjects, repeated measures, randomized cross-over design, 10 police officers (female=6: male=4) wore each set of body armour. After completing a variety of tasks, officers provided feedback on a subjective mannequin sketch and provided free text comments. *Results*. The heavier MBA received more negative comments than LEBA. The majority of negative comments by female officers referred to: (a) discomfort around the throat and shoulders, particularly when seated (six comments), (b) the vest compressing the utility belt or holster (six comments); (c) compression of the stomach and back (two comments); (d) restrictions in breathing and range of motion (four comments), (e) reduced ability to perform tasks (two comments); and (f) ill-fitting design (two comments). In comparison, male officers reported: (a) discomfort around the shoulders and abdomen (five comments), particularly when seated (three of the five comments); and (b) hip discomfort (e.g., pinching) (two comments). *Conclusion*. Comfort and fit of body armour should not be considered the same between males and females. Industries need to consider these sex-specific differences in their research and design. Agencies should investigate potential differences between sexes and between systems when purchasing such systems.

Keywords: law enforcement, police, military, personal protective equipment, ballistic vest.

1 clare.buttner@student.bond.edu.au
2 sharne-louise.tiller@student.bond.edu.au
3 nash.vollenweider@student.bond.edu.au
4 ecanetti@bond.edu.au • https://orcid.org/0000-0002-8358-398X
5 bschram@bond.edu.au • https://orcid.org/0000-0002-1865-0488
6 jay.dawes@okstate.edu • https://orcid.org/0000-0002-2668-8873
7 rlockie@fullerton.edu • https://orcid.org/0000-0002-7038-0294
8 Corresponding author: rorr@bond.edu.au • https://orcid.org/0000-0001-8297-8288 • Phone: +61 07 55 95 44 48

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INTRODUCTION

Body armour is an effective means of reducing wearer fatality risk when they are exposed to violent situations (Dempsey et al., 2013; Habersaat et al., 2015; Schram et al., 2018; Tomes et al., 2017). Previous literature by Orr et al. (2018) and Dempsey et al. (2013) have identified the donning of such protective clothing to extend beyond the traditional military environment, noting its increased use in law enforcement. This increased use by law enforcement has been attributed to a rise in violent crimes and incidents which police officers are exposed to (Dempsey et al., 2013; Schram et al., 2018; Tomes et al., 2017).

The total weight of body armour systems, when added to the wearer's overall occupational load, can vary greatly. For example, total worn military loads can weigh up to 45 kg if not heavier (Orr et al., 2015), whilst the total worn loads of law enforcement officers (LEO) are generally lighter, ranging from 10 kg for general duties officers (Baran et al., 2018) to 22+ kg for specialist police (Carlton et al., 2014). Furthermore, while military personnel may wear these loads intermittently, they can be worn daily by LEOs across the duration of their career. Unfortunately, while the wearing of body armour is designed to reduce occupational injury and fatality risks, it is concomitantly known to increase injuries and reduce performance (Kukic et al., 2020; Schram et al., 2018; Schram et al., 2020; Schram et al., 2019; Tomes et al., 2017). In both male and female personnel, body armour, and its associated imparted load, can cause injury (Fargo & Konitzer, 2007; Knapik et al., 2017), diminish the mobility of the carrier (Carlton et al., 2014; Dempsey et al., 2013; Joseph et al., 2018; Orr, Kukić et al., 2019), reduce operational capability (Dempsey et al., 2013), and result in poorer physical performance (Dempsey et al., 2013; Joseph et al., 2018; Wiley et al., 2020).

An increase in the number of serving females within police forces and military units (Toma et al., 2016), highlights the importance of considering body armour differences between sexes. Research suggests that body armour is typically designed for the male physique (Coltman et al., 2022) and thus does not account for sex-specific anthropometric differences (e.g., breast tissue) (Coltman, Brisbine, Molloy et al., 2021; Niemczyk et al., 2020) and subsequent second-order effects (e.g., wearing of a bra, creating another layer of material between the wearer and the body armour) (Coltman, Brisbine, & Steele, 2021). The above examples of the impact of the use of body armour in performance, and differences in physique and clothing (breast tissue and wearing a bra) suggest that sex-specific differences would exist in body armour fit and as such may bear consideration in body armour design and implementation.

Therefore, the aims of this study were to explore whether subjective differences existed between male and female personnel comfort when wearing body armour. Furthermore, the study sought to explore if the type of body armour worn would influence these findings. It was hypothesized that there would be differences between male and female officers in levels of comfort and discomfort when wearing body armour.

METHODS

Participants

A sample of convenience of 10 eligible police officers (females n = 6, mean height = 167.97 ± 3.67 cm, mean mass = 65.30 ± 10.57 kg: males n = 4, mean height = 82.15 ± 6.98 cm, mean weight = 85.55 ± 9.96 kg) volunteered to participate in the study. The inclusion criteria for officers were that they: a) were currently a serving law enforcement officer; b) had no musculoskeletal injury or impairment that may affect any of the tasks; and c) could attend both days of data collection. There were no exclusion criteria. All officers that participated in the study volunteered while off-duty, and each participant provided written informed consent to participate prior to any testing. Ethics approval to conduct the study was granted by the Bond University Human Research Ethics Committee (protocol number 15803).

Measurements and Procedures

The current study was concurrent to, and using, the same officers and tasks as previously published in a study comparing military and law enforcement body armour (Orr et al., 2018). The focus of this study, however, was to specifically investigate differences in subjective comfort between the two sexes when wearing body armour. The study's aims were addressed through use of a prospective, within-subjects, repeated measures, randomized cross-over study design. One of two body armour vests (Law Enforcement Body Armour (LEBA) (2.1 kg) or Military Body Armour (MBA) (6.4 kg)) provided by Australian Defence Apparel were allocated to officers through use of a randomized, counterbalanced approach. For the duration of the first testing period each officer wore their allocated vest (LEBA or MBA). The systems were of a unisex design. All officers then changed to their alternative vest for a corresponding test period on the second day. Use of this counterbalanced study design allowed for each officer to act as their own control, whilst further managing any task learning affects that may have occurred. Throughout each testing period, the officers were required to complete multiple occupationally orientated tasks (Table 1), with the testing standardized across both days to mitigate possible diurnal variations.

Table 1. *Schedule for Each Day of Testing*

Time	Activity
08.30	Briefing and vest allocation
	Initial anthropometric measures*
09.40	Illinois Agility Test
10.10	Vehicle exit and 5 m sprint
10.30	10 m sprint to simulated victim and 10 m recovery drag
11.00	Functional Movement Screen
11.30	Lunch (with allocated vests still worn)
12.00	Subjective assessments

*Officers' height measures were taken on the first day only.

Prior to the body armour being fitted, all officers were weighed, first in station wear (or equivalent), and directly after they had been fitted with their allocated unisex body armour. A digital scale (Wedderburn WM204 Professional Weight Scale, Sydney, Australia) was used to measure both the individual's unloaded and loaded weight. Each participant's height was measured (Ecomed Seca Measuring Rod, Hamburg, Germany) directly after initial body mass measurements had been recorded and before the officers wore their body armour. Body armour was worn over the officer's station wear (or equivalent) to provide, and more accurately ascertain, the impact of the different body armour types when worn overtly (as is common practice) with standard work attire.

Subjective Data

After all tasks had been completed and after a minimum of 30 minutes sitting, officers were asked to indicate areas of discomfort from wearing the vests using a mannequin sketch (Figure 1). Officers were required to write a comment and identify and rate any discomfort imparted by the armour system on a scale from 0 to 10, where 0 was no discomfort and 10 was of most discomfort. This method, used to capture subjective feedback from tactical participants in regards to discomfort associated with clothing wear, has been reported in the wider literature (Orr, Simas et al., 2019). Officers could also make positive comments which would be noted. A space for free comments was also allocated at the bottom and rear of the charts. The officers were asked to provide any feedback they felt appropriate regarding their armour system, be it negative, neutral, or positive.

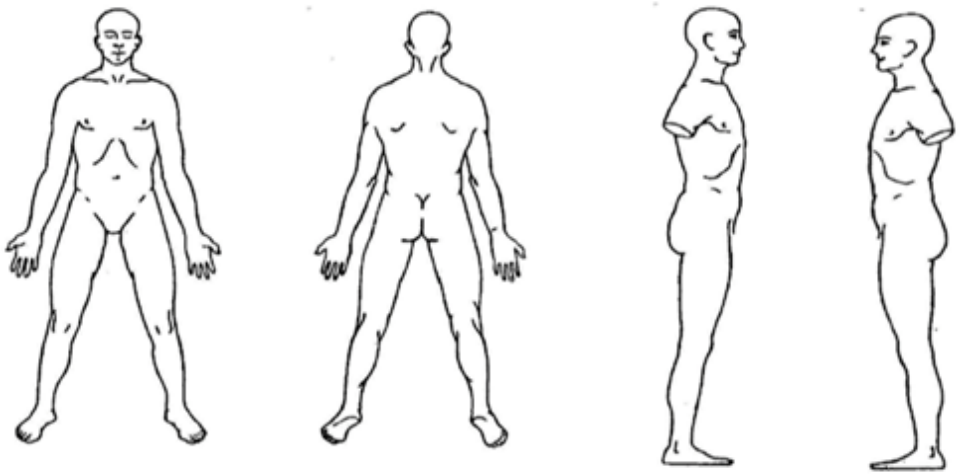


Figure 1. *Mannequin Sketch to Mark Any Areas of Discomfort*

Statistical Analysis

Demographic information was compared using an independent samples t-test with relative loads calculated based on the individual's body mass. Body charts and comments spaces were visually inspected after completion with any queries (e.g., writing legibility,

bodily sites marked on mannequin figure clarity, etc.) clarified with the participant. All the provided information placed on the mannequin figures was collated, transposed, and consolidated on single mannequin figure representations with comments, sex and body armour type identified. Free texts were collected, collated, and categorized as positive, negative, or neutral. Emerging themes were identified and reported.

RESULTS

Participant demographics are outlined in Table 2. Male officers were significantly taller ($p = 0.001$) and had significantly more body mass than female officers ($p = 0.006$). Total female loads with body armour were significantly lighter for both MBA ($p = 0.008$) and LEBA ($p = 0.008$) in comparison to their male counterparts. The difference in weight carried for the female and male officers were not significant. The difference in weight carried, when expressed as a percentage of body weight, was significantly greater for female when compared to male officers.

Table 2. *Demographic Details of Study Officers (Mean ± SD).*

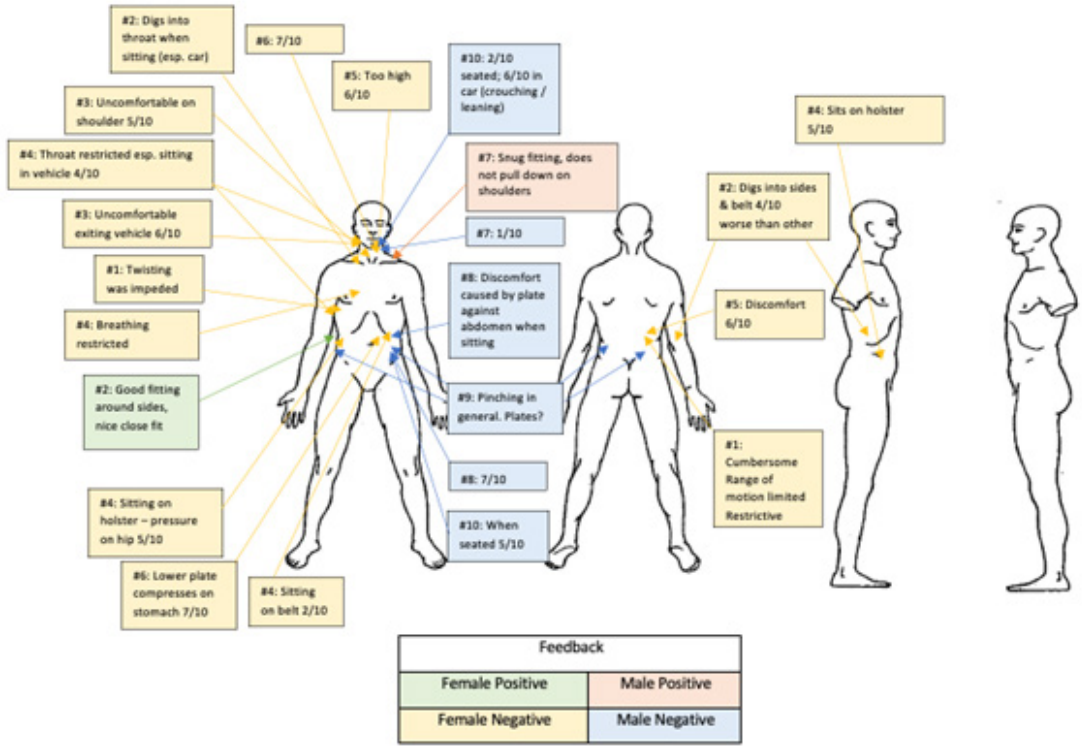
Measure	Females	Males
Height (cm)	168.0 ± 3.7	182.2 ± 7.0*
Body mass (kg)	65.3 ± 10.6	85.6 ± 10.0*
Body mass with LEBA (kg)	67.3 ± 10.5	87.7 ± 10.0*
Body mass with MBA (kg)	71.6 ± 10.9	92.2 ± 10.0*
% of body weight carried LEBA (%)	3.2 ± 0.7	2.5 ± 0.3
% of body weight carried MBA (%)	9.8 ± 1.3	7.8 ± 1.0*
Mean difference in weight carried (kg)	4.3 ± 0.5	4.5 ± 0.5
Mean difference in weight carried (% of body weight) (%)	6.6 ± 0.8	5.3 ± 0.9*

LEBA = Law Enforcement Body Armour, MBA = Military Body Armour, * = significant difference $p < 0.05$.

Subjectively, LEBA appeared to be the preferred type of body armour, when compared with the MBA, for both sexes. The LEBA received more positive and less negative feedback overall than the MBA (Figures 2 and 3). Both armour types received limited neutral feedback. The main areas of discomfort for the female officers for both armour styles were the neck, shoulder, chest, and hip regions. For the male officers it was the neck, shoulder, and abdomen.

When the free text comments, both on the mannequin and in the comments section, were combined there were a total of 49 comments from the six female officers (mean comments = 8.17 comments per officer) and 25 comments from the four male officers (mean = 6.25 comments per officer). Female officers recorded three positive comments, 22 negative comments, and one neutral comment for the MBA, and 18 positive comments, four negative comments, and one neutral comment for the LEBA. Male officers recorded four positive comments, seven negative comments, and one neutral comment for the MBA and 12 positive comments, one negative comment, and no neutral comments for the LEBA. Most positive free text comments regarding the LEBA from female officers referred to

comfort (eight comments), design/functionality (e.g., pockets, wide panels, plastic clips) (four comments), ability to complete tasks (three comments), weight (two comments), and heat dissipation (one comment) of the body armour. Similarly, male officers referred to the design (eight comments), comfort (three comments), and heat dissipation (one comment) of the LEBA. Negative comments reported by female officers in relation to wearing the LEBA, referred to vest length in relation to the trunk (two comments), incorrect fit (e.g., loose shoulder straps) (one comment), and heat discomfort (one comment). One male participant provided negative feedback regarding discomfort around the shoulders and neck for the LEBA. One neutral comment from a female participant, concerning the LEBA, referred to the lack of use for the vest in current position.

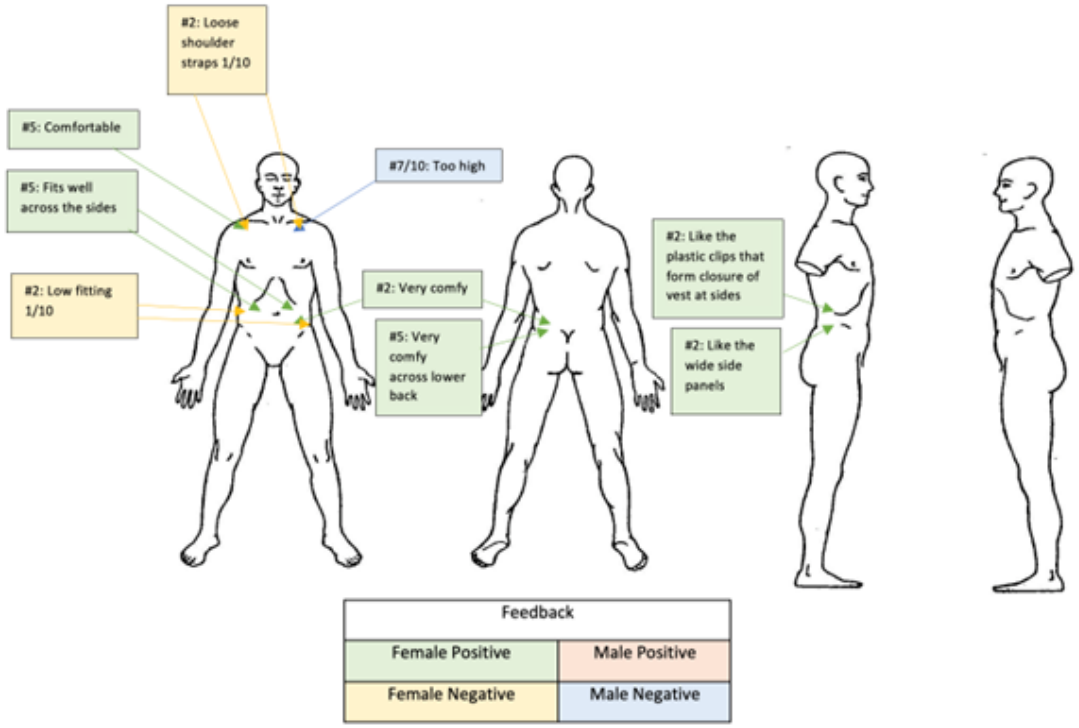


Legend: # signifies participant number; scores out of 10 signify discomfort level, with 10 being the highest discomfort and 0 no discomfort.

Figure 2. *Male and Female Subjective Feedback on Military Body Armour*

Positive comments received by female officers for the MBA referred to ease of use, fit and design (three comments), while male officers referred to comfort and design (three comments). One male officer also found the MBA to be comfortably fitting around the shoulders (one comment). The majority of negative comments regarding the MBA by female officers referred to: (a) discomfort around the throat and shoulders, particularly when seated (six comments), (b) the vest compressing the utility belt or holster (six comments); (c) compression of the stomach and back (two comments); (d) restrictions in breathing and range of motion (four comments), (e) reduced ability to perform tasks (two comments); and (f) ill-fitting design (two comments). One neutral comment was noted, from a female participant, referring to the fit of the vest across the chest. In comparison, nega-

tive feedback, concerning the MBA, from male officers referred to: (a) discomfort around the shoulders and abdomen (five comments), particularly when seated (three of the five comments); and (b) hip discomfort (e.g., pinching) (two comments). One male participant provided neutral feedback for the MBA regarding vest weight.



Legend: # signifies participant number; scores out of 10 signify discomfort level, with 10 being the highest discomfort and 0 no discomfort.

Figure 3. *Male and Female Subjective Feedback on Law Enforcement Body Armour*

DISCUSSION

The aim of this study was to explore whether subjective differences in reported comfort existed between male and female personnel when wearing different body armour systems. It was hypothesized that there would be differences between male and female officers in levels of comfort and discomfort when wearing body armour. This hypothesis was proved true. Females reported greater subjective concerns than males regarding body armour fit, with more negative feedback received from both sexes when wearing the MBA. Areas of most discomfort reported by female officers include the neck, shoulder, chest, and hip, whilst male officers reported areas of discomfort at the neck, shoulder, and abdomen.

Discomfort regarding the length of body armour reported in male officers were due to the vest's length finishing at the mid-abdominal region. As, typically, the armour is only needed to protect vital organs, the edges of armour vests may protrude into the abdomen of male officers, especially when sitting. Conversely, female participants reported discomfort on the hip where, due to the length of the vest on their generally shorter stature (Coltman et al., 2022), the body armour rested; especially in a seated position (Knapik et al., 2017;

Toma et al., 2016). Toma et al. (2016) corroborated findings of this study regarding the discomfort caused of armour length in the neck, shoulder, and hip regions, particularly by female personnel. This is of note as participants in the study by Toma et al. (2016) reported that even the smallest size available in armour vest was reported to be too long or too wide. This added size led to comfort impacts on the neck, shoulder, and hip regions among female personnel serving within the national defence system (Toma et al., 2016). In a similar result to this study, reports of discomfort were greater in female participants, whereby 85% of the officers reported the smallest size of a body armour vest to be too long or wide (Toma et al., 2016).

A potential reason for the greater frequency of reported discomfort in the upper trunk region by female officers wearing body armour may be due to a lack of customisation to account for anthropometric differences such as breast tissue. In a study of Australian Defence Force female soldiers, Coltman et al. (2021) documented that while 63% (n = 61) of female personnel reported discomfort when wearing body armour, 22% (n = 21) of these female soldiers reported a lack of integration between armour vest and bra as being of concern. These findings are supported by Malbon et al. (2020) in a study of 1765 female police officers wearing various bra types. The results demonstrated that 67% of officers reported the wearing of body armour to be uncomfortable or very uncomfortable. Furthermore, the female officers found running and self-defence activities, two common police activities, to be the cause of most discomfort, leading to the suggestion that bra type and breast support may be critical in comfort when wearing body armour (Malbon et al., 2020). This finding of discomfort due to the wearing of a bra, underneath body armour, bears consideration beyond just the comfort during activities (Malbon et al., 2020). Second order effects, such as friction between the body armour and the bra may not only cause discomfort but potentially a thermal effect (Coltman, Brisbine, & Steele, 2021). This supposition is strengthened by 17% of female participants within this study, noting heat dissipation to be a negative factor. Thus, potential differences in thermal burden caused by bra-body armour system integration warrants further investigation.

The leading concerns raised in the comments in this study were in relation to, or a consequence of, poor body armour fit. While relationships between fit and discomfort are intuitive, it should be noted that poor body armour fit has not only been associated with discomfort but with leading to musculoskeletal pain (Coltman et al., 2020; Larsen et al., 2018). In a study of Swedish police officers, a statistically significant association between discomfort from wearing mandatory body armour and multi-site musculoskeletal pain was found [OR 2.69 (95% CI 2.11–3.42)] (Larsen et al., 2018). Thus, discomfort expressed by officers in relation to poor body armour fit warrants attention. In this study, there were a notable number of instances (50% of officers) in which fit of the equipment when sitting was noted (female officers = 3: male officers = 2). Considering these findings in context, whereby the officers in this study sat for a relatively short period as opposed to the potentially long hours sitting at a desk or in a vehicle over a career span, the potential for lower back pathologies, already associated with seated body armour wear are of concern (Benyamina Douma et al., 2018). Additionally, there is the potential increased risk of meralgia paraesthetica, a condition attributed to body armour resting on the thighs and compressing the lateral femoral cutaneous nerve (Fargo & Konitzer, 2007; Knapik et al., 2017).

Considering the association between discomfort and injury, differences in discomfort between body armour systems and the sexes are of interest. Differences between the types

of system worn were noted with the MBA generally the least preferred, receiving more negative comments, fewer positive comments, and higher ratings of discomfort. Several reasons for this notable difference exist and could include the heavier total weight of the MBA and that all participants were police officers, as opposed to military personnel, hence preferring the LEBA over the MBA. Regardless, the notable differences in number and severity rating of discomfort between the two types of body armour, highlight that systems may elicit different levels of injury risk. Consequently, industry should consider subjective discomfort in their research and design processes, and organisations should also consider this prior to their body armour purchases. This is especially the case when considering body armour for the female form, highlighted in this study where five of the six female officers (83%) reported discomfort scores for the MBA and five reported positive comfort scores for the LEBA. In addition, there were differences in discomfort ratings and severity scores between female and male officers, which appear to be greater in the MBA than LEBA. As such, scaled down male armour may not be best practice for female officers and future armour design and sizing, catering for the female form, is recommended (Coltman et al., 2020).

Limitations

A notable limitation of this study is the sample size. Considering this, sample sizes akin to this study are common in these populations and reported in previous literature (Carlton et al., 2014; Orr et al., 2018; Schram et al., 2018; Schram et al., 2020; Schram et al., 2019). Furthermore, given the criticality of individual fit failure, gaining insights into individual concerns is of importance if the impact of body armour systems on individual officers is to be explored.

CONCLUSIONS

The results of this study highlight similarities and, more importantly, differences in bodily sites of discomfort, a potential injury risk indicator, between female and male officers when wearing body armour. In addition, these differences may be exacerbated or ameliorated by different body armour systems. Thus, industries need to consider these sex-specific differences in their research and design, while agencies need to investigate potential differences between sexes and between systems when purchasing such systems. Individual officers should be aware that different systems, and potentially different system weights, may increase or decrease levels of discomfort when worn. Finally, the impacts of anthropometric differences between the sexes in relation to body armour comfort should be considered when assessing personnel wearing their body armour.

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REFERENCES

Baran, K., Dulla, J., Orr, R. M., Dawes, J., & Pope, R. R. (2018). Duty loads carried by LA Sheriff's Department deputies. *Journal of Australian Strength and Conditioning*, *26*(5), 34–38.

Benyamina Douma, N., Côté, C., & Lacasse, A. (2018). Occupational and ergonomic factors associated with low back pain among car-patrol police officers. *Clinical Journal of Pain*, *34*(10), 960–966. https://doi.org/10.1097/ajp.0000000000000617

Carlton, S. D., Carbone, P. D., Stierli, M., & Orr, R. M. (2014). The impact of occupational load carriage on the mobility of the tactical police officer. *Journal of Australian Strength and Conditioning*, *21*(1), 32–37.

Coltman, C. E., Brisbine, B. R., Molloy, R. H., Ball, N. B., Spratford, W. A., & Steele, J. R. (2021). Identifying problems that female soldiers experience with current-issue body armour. *Applied Ergonomics*, *94*, 103384. https://doi.org/10.1016/j.apergo.2021.103384

Coltman, C. E., Brisbine, B. R., Molloy, R. H., & Steele, J. R. (2022). Can smaller body armour improve thoracolumbar range of motion and reduce interference when female soldiers perform dynamic tasks? *Applied Ergonomics*, *98*, 103602. https://doi.org/10.1016/j.apergo.2021.103602

Coltman, C. E., Brisbine, B. R., & Steele, J. R. (2021). Bra-body armour integration, breast discomfort and breast injury associated with wearing body armour. *Ergonomics*, *64*(12), 1623–1633. https://doi.org/10.1080/00140139.2021.1951849

Coltman, C. E., Steele, J. R., Spratford, W. A., & Molloy, R. H. (2020). Are female soldiers satisfied with the fit and function of body armour? *Applied Ergonomics*, *89*, 103197. https://doi.org/10.1016/j.apergo.2020.103197

Dempsey, P. C., Handcock, P. J., & Rehrer, N. J. (2013). Impact of police body armour and equipment on mobility. *Applied Ergonomics*, *44*(6), 957–961. https://doi.org/10.1016/j.apergo.2013.02.011

Fargo, M. V., & Konitzer, L. N. (2007). Meralgia paresthetica due to body armor wear in US soldiers serving in Iraq: A case report and review of the literature. *Military Medicine*, *172*(6), 663–665. https://doi.org/10.7205/milmed.172.6.663

Habersaat, S. A., Geiger, A. M., Abdellaoui, S., & Wolf, J. M. (2015). Health in police officers: Role of risk factor clusters and police divisions. *Social Science & Medecine*, *143*, 213–222. https://doi.org/10.1016/j.socscimed.2015.08.043

Joseph, A., Wiley, A., Orr, R., Schram, B., & Dawes, J. J. (2018). The impact of load carriage on measures of power and agility in tactical occupations: A critical review. *International Journal of Environmental Research and Public Health*, *15*(1), 88. https://doi.org/10.3390/ijerph15010088

Knapik, J. J., Reynolds, K., Orr, R., & Pope, R. (2017). Load carriage-related paresthesias (Part 2): Meralgia paresthetica. *Journal of Special Operations Medicine*, *17*(1), 94–100. https://doi.org/10.55460/6krp-71df

Kukic, F., Koropanovski, N., Jankovic, R., Cvorovic, A., Dawes, J., Lockie, R., Orr, R. M., & Dopsaj, M. (2020). Association of sex-related differences in body composition to change of direction speed in police officers while carrying load. *International Journal of Morphology*, *38*(3), 731–736. http://dx.doi.org/10.4067/S0717-95022020000300731

Larsen, L. B., Andersson, E. E., Tranberg, R., & Ramstrand, N. (2018). Multi-site musculoskeletal pain in Swedish police: Associations with discomfort from wearing mandatory equipment and prolonged sitting. *International Archives of Occupational and Environmental Health*, *91*(4), 425–433. https://doi.org/10.1007/s00420-018-1292-9

Malbon, C., Knock, C., Critchley, R., & Carr, D. J. (2020). The effect of breast size and bra type on comfort for UK female police officers wearing body armour. *Applied Ergonomics*, *84*, 103012. https://doi.org/10.1016/j.apergo.2019.103012

Niemczyk, S. E., Arnold, L., & Wang, L. (2020). Incompatible functions: Problems of protection and comfort identified by female police officers required to wear ballistic vests over bras. *International Journal of Fashion Design, Technology and Education*, *13*(2), 165–172. https://doi.org/10.1080/17543266.2020.1758800

Orr, R. M., Kukić, F., Čvorović, A., Koropanovski, N., Janković, R., Dawes, J., & Lockie, R. (2019). Associations between fitness measures and change of direction speeds with and without occupational loads in female police officers. *International Journal of Environmental Research and Public Health*, *16*(11), 1947. https://doi.org/10.3390/ijerph16111947

Orr, R. M., Pope, R., Coyle, J., & Johnston, V. (2015). Occupational loads carried by Australian soldiers on military operations. *Journal of Health, Safety and Environment*, *31*(1), 451–467.

Orr, R. M., Schram, B., & Pope, R. (2018). A comparison of military and law enforcement body armour. *International Journal of Environmental Research and Public Health*, *15*(2), 339. https://doi.org/10.3390/ijerph15020339

Orr, R. M., Simas, V., Canetti, E., Maupin, D., & Schram, B. (2019). Impact of various clothing variations on firefighter mobility: A pilot study. *Safety*, *5*(4), 78. https://doi.org/10.3390/safety5040078

Schram, B., Hinton, B., Orr, R., Pope, R., & Norris, G. (2018). The perceived effects and comfort of various body armour systems on police officers while performing occupational tasks. *Annals of Occupational and Environmental Medicine*, *30*, 15. https://doi.org/10.1186/s40557-018-0228-x

Schram, B., Orr, R., Hinton, B., Norris, G., & Pope, R. (2020). The effects of body armour on mobility and postural control of police officers. *Journal of Bodywork and Movement Therapies*, *24*(3), 190–194. https://doi.org/10.1016/j.jbmt.2020.03.001

Schram, B., Orr, R., Hinton, B., Pope, R., & Norris, G. (2019). The effects of body armour on the power development and agility of police officers. *Ergonomics*, *62*(10), 1349–1356. https://doi.org/10.1080/00140139.2019.1648878

Toma, D., Niculescu, C., Sălişteanu, A., Luca, D., Popescu, G., Popescu, A., Lăzăroaie, C., Său, C., & Istrate, M. (2016). Improved fit and performance of female bulletproof vests. *The 6th International Conference on Advanced Materials and Systems – ICAMS 2016*, Bucharest, Romania.

Tomes, C., Orr, R. M., & Pope, R. (2017). The impact of body armor on physical performance of law enforcement personnel: A systematic review. *Annals of Occupational and Environmental Medicine*, *29*, 14. https://doi.org/10.1186/s40557-017-0169-9

Wiley, A., Joseph, A., Orr, R., Schram, B., Kornhauser, C. L., Holmes, R. J., & Dawes, J. J. (2020). The impact of external loads carried by police officers on vertical jump performance. *International Journal of Exercise Science*, *13*(6), 1179–1189.