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RESEARCH ARTICLE

'We just make do': the use, comfort and functionality of personal protective equipment in the UK mounted police

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ABSTRACT

Police officers wear personal protective equipment (PPE) to reduce their risk of injury while on duty. Despite the unique policing activity of riding a horse, little is known about the PPE used by mounted officers. The aim of this research was to assess the use, comfort, and functionality of mounted police PPE. Twenty officers from three UK Mounted Sections were recruited. Semi-structured interviews and range of movement assessments were conducted. Interview data was analysed using reflexive thematic analysis. Three main themes were generated: *Functional requirements, Issues,* and *Areas for improvement*. Much of the PPE worn by mounted officers is not designed for the risks associated with horse riding. There was a sense that officers 'make do' with their current PPE provision, but increased protection from falls and mounted specific public order protection were identified as particular areas for improvement.

PRACTITIONER SUMMARY: We investigated the provision and perceptions of protective equipment used by UK mounted police. We show that much of the equipment is not designed for the risks associated with horse riding. Officers 'make do', but desire the risks of policing on horseback to be considered in their future equipment provision.

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Police; mounted police; equipment; protective equipment

Introduction

The United Kingdom (UK) has thirteen mounted police units who are often employed to situations that attract large crowds, such as sporting, music and demonstration events (Giacomantonio et al. 2015). The daily tasks for mounted officers often include horse riding (training), mounted patrols, horse care, and desk-based paperwork (Canetti et al. 2024; Giacomantonio et al. 2015). The physical nature of some of these tasks, which can include restraining offenders (Bonneau and Brown 1995; Orr et al. 2020) and mounting a horse from the ground (Orr et al. 2023), put officers at high risk of injury while at work. A review of injury data from an Australian state police force between 2014 and 2020 found that mounted officers most frequently report injuries caused by falls from height (15.9%) and repetitive tasks (10.6%), whereas non-mounted police most frequently report injuries from physical assault (21.3%) (Orr et al. 2023). Furthermore, mounted police reported more frequent injuries at different body sites to their non-mounted counterparts, with the lower back (13.9%), neck (7.3%), and shoulder (7.3%) most frequently injured in mounted officers, and the knee (13.9%), lower back (10%), and hands (8.2%) the most injured sites for non-mounted officers.

To reduce the risk of injury, officers wear personal protective equipment (PPE), which is defined as any equipment worn or held by a working person to reduce risks to their health and safety (UK Health and Safety Executive 2023). For police officers, this can include equipment like body armour, helmets, duty belts, tactical vests, and limb protection (Lewis et al. 2017). Despite the importance of PPE, there is a paucity of research on the function and comfort of protective equipment used by police, and no evidence on the equipment used by mounted officers (Hudson et al. 2024). The existing literature on police PPE, although limited, has highlighted the importance of fit, with ill-fitting body armour suggested to decrease mobility and reduce task efficiency for non-mounted patrol officers (Dempsey, Handcock, and Rehrer 2013; Lewinski et al. 2015; Ramstrand et al. 2016). Military research has also demonstrated negative physical

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consequences of ill-fitting protective equipment, including an increased severity of musculoskeletal pain and discomfort (Coltman et al. 2020). This, perhaps, highlights a need for PPE that fits mounted officers when they are both on and off horseback, to protect them from the specific risks related to their role.

As mounted police officers are considered a valuable resource for public engagement and public order (Giacomantonio et al. 2015), understanding the strengths and weaknesses of their current PPE provision can provide a foundation for the development of any future equipment that could help reduce officers risk of injury while on duty. Therefore, the aim of this research was to assess use, comfort, and functionality of mounted police officers' PPE.

Methods

Research design

Data collection was conducted in two phases. Firstly, a within subject design was employed to assess mounted officers' range of motion at the neck, shoulders and hips. This was done on and off horseback, with and without their on-duty equipment. The second phase involved semi-structured interviews to explore the types of protective equipment officers use, and their experiences of its fit, comfort and functionality.

Participants

Twenty police officers (9 males, 11 females) were recruited from three UK Mounted Sections using purposive sampling. All officers participated in the range of movement assessments (age: 42 ± 6 years, body mass: 75.5 ± 12.1 kg, height: 1.73 ± 0.98 m) and twelve of those also volunteered to be interviewed. Informed consent was obtained prior to data collection. The study received approval from the School of Human and Health Sciences Research and Integrity Ethics Committee at the University of Huddersfield (approval number: SREIC/2021/109).

Procedures

Interviews

Semi-structured interviews were conducted individually on one occasion, with each interview lasting 20–40 minutes. All interviews were conducted virtually using video communication software (Microsoft Teams) or telephone. The interviewer (JB) had experience of horse riding, but not policing. The interview guide was created and agreed by the research team prior to data collection, to ensure that questions reflected the research aim. Questions centred on better understanding the role of the mounted police, the current provision of protective equipment, its integration with other equipment (such as the saddle or other garments), and the perceived effect of movement, posture and comfort. Participants were asked the same fundamental questions but were free to explore their perceptions and experiences. Participants were asked to provide their body measurements and to bring their armour/equipment to the virtual interview to demonstrate the equipment and their interaction with it. This helped visually communicate answers to the researchers. Interviews were recorded and transcribed verbatim for analysis. All data was anonymised using participant numbers.

Range of motion assessment

The methods of Mitchell (2013) and Coltman et al. (2022) were modified to assess joint specific range of motion at the neck, shoulders, and hips (thoracolumbar spine). Seven movements were completed on and off horseback, while wearing on-duty equipment (riding boots, waterproof trousers, body armour, tactical vest/duty belt, coat, riding helmet; Figure 1) (additional mass = ~8.5 kg) compared to reference clothing (training clothes: riding boots, jodhpurs, t-shirt, jumper and riding hat). Officers wore their own equipment and used their own horse when completing the tasks on horseback. All officers wore similar on duty equipment, although twelve chose to carry equipment in a tactical vest, while the other eight carried equipment in a duty belt. All motions were performed three times with the mean calculated and used as the score.

Neck range of motion. Neck rotation and neck flexion off horseback were measured using the methods of Mitchell et al. (2013). See Mitchell (2013) for a full description and images of the off horseback measurement methods. Briefly, for neck rotation this involved placing a bubble inclinometer (Baseline, Fabrication Enterprises Inc., USA) on the back of helmet, with the participants bent forward at the waist and holding the back of a chair. Participants started with their head as far to the right as possible and then rotated as far to the left as possible while ensuring that the thoracic and lumbar spine did not rotate. For neck flexion, the bubble inclinometer was placed on top of the helmet with the participant sat on the chair. Flexion was measured from the participants head being as far forward as possible to being as far back as possible, without moving the trunk or shoulders.

Figure 1. Officers from different sections wearing their on-duty equipment. Image A shows an officer carrying equipment in a duty belt. Image B shows an officer carrying equipment in the tactical vest.

The same movements were modified for the neck range of motion measurements on horseback. For neck rotation on horseback, participants were asked to bend forward at the waist, gripping the saddle with both hands to ensure the torso did not rotate. For neck flexion on horseback, participants were asked to sit upright throughout the movement, with as little movement in the trunk and shoulders as possible (Figure 2).

Thoracolumbar spine range of motion. The standing thoracolumbar spine tasks were completed on a 480 mm raised box, with the participants foot tips positioned at the edge of the box. Participants were instructed to reach their hands down as far as possible while keeping their knees in full extension, holding the final position (the end of the range of motion) for 5 seconds. The distance from the floor to the middle finger on the right hand was measured while the participants held the final position. All measures were calculated as the distance reached relative to the floor while standing on the raised box, using a metre rule.

For the same measurements on horseback, participants were instructed to remain fully seated in the saddle throughout all movements, and the distance from the middle finger to the floor was measured using a stadiometer (Seca 217 Stadiometer, Seca GmbH & Co, Germany). For the forward flexion task, officers were instructed to reach forward down the side of the horse's neck, with measurement taken from the right side, unless there was a known musculoskeletal injury that could limit shoulder range of motion on the right side of the body. For the lateral flexion task, participants were instructed to sit upright in the saddle and to minimise hip flexion during the movement.

Shoulder range of motion. The methods described by Mitchell et al. (2013) were also used to measure shoulder range of motion off horseback. For shoulder forward flexion, backward extension, and abduction, the bubble inclinometer was placed on the upper arm, just above the elbow, with a ruler pointing from the inclinometer to the shoulder joint to ensure that the inclinometer followed the movement of the humerus. For all shoulder measurements, participants stood upright and were told to maintain an upright posture, ensuring no extension of the back, no arm/shoulder rotation, no elbow flexion. Participants started with their arms by their side and were asked to move their arms as far as they could in the sagittal plane for shoulder forward flexion and backward extension, and in the frontal plane for shoulder abduction.

Figure 2. An example of measuring neck flexion on horseback in the reference clothing condition using a bubble inclinometer.

The measures of should forward flexion, backward extension and abduction were identical on horseback, except for participants being seated in the saddle instead of standing. Participants were again instructed to maintain an upright posture throughout each motion ensuring no extension of the back, no arm/shoulder rotation, and no elbow flexion. All shoulder measurements on and off horseback were taken from the participants right side, unless there was a known musculoskeletal injury that could limit shoulder range of motion on the right side of the body.

Data analysis

Interview data

Braun and Clarke's approach to reflexive thematic analysis was used to analyse the interview data (Braun and Clarke 2006). This approach allowed for a non-linear, iterative and recursive analysis of the data. Transcribed data were coded in NVivo (version 14, Lumivero, Denver, USA). Themes and subthemes were developed based on the importance of what the data revealed about mounted officers' perceptions and experiences, not prevalence of the data item. Two members of the research team (SH & JB) met at different stages of the thematic analysis process to discuss the codes and themes. Themes could be adapted and updated during these verification meetings, which helped to ensure the credibility of the data (Tracy 2010).

Range of motion data

Mean ± standard (SD) deviation was calculated for the range of motion data. A paired-sample t-test was used to assess differences between the on-duty protective equipment and reference clothing for each thoracolumbar, neck, and shoulder flexion and rotation measurement on and off horseback. The alpha level was set at $p \leq 0.05$. All inferential statistical analysis was performed on IBM SPSS (version 22, IBM SPSS statistics, Chicago, USA).

Results

Interview data

The interviews lasted between 19 and 41 minutes (total = 210 minutes; mean = 26 ± 8 minutes) and the transcribed audio recordings resulted in 120 pages of data (mean pages per participant = 10 ± 3). The analysis revealed three main themes which described the experiences of the participants' use, comfort and functionality of PPE as a mounted police officer: Functional requirements; Issues; Areas for improvement. These main themes were supported by several sub-themes, which are schematically presented in figure 3. Direct anonymised quotes have been used in this results section to contextualise each theme.

Main theme 1: functional requirements

The main theme of Functional requirements reflected the participants experiences of how their PPE interacted with the horse and its functionality. This was

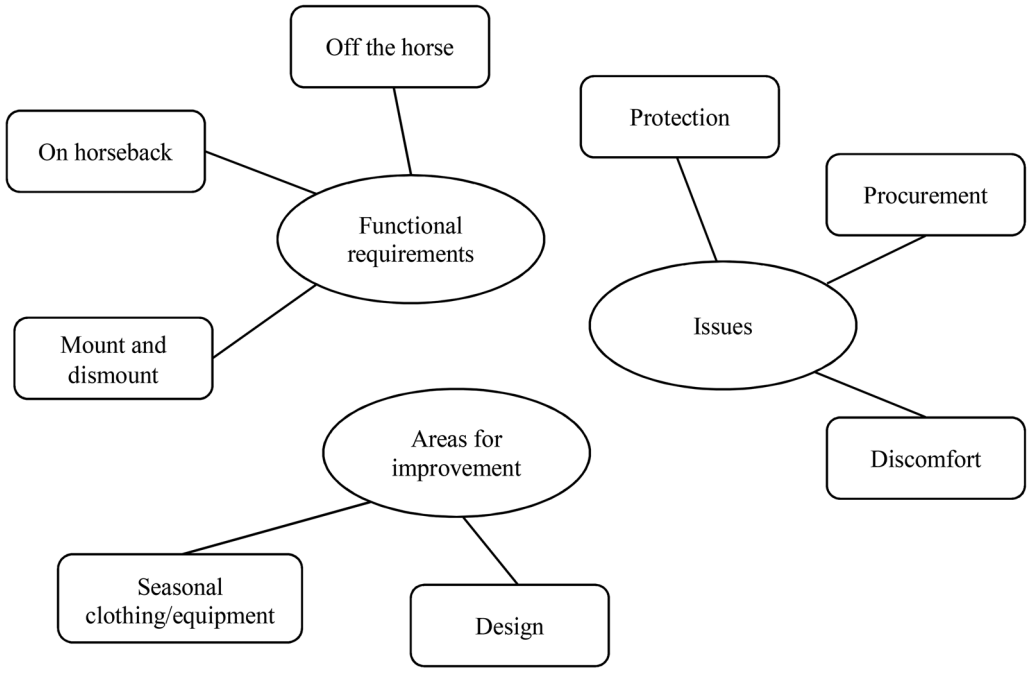

Figure 3. Schematic representation of the main themes (oval shapes) and sub-themes (rectangular shapes).

supported by three sub themes: Mount and dismount; Off the horse; On horseback.

Mount and dismount

PPE was described as being restrictive and the amount of PPE some officers wear meant mounting and dismounting the horse was challenging. The equipment often limited freedom of movement and some officers highlighted difficulty in mounting the horse from the ground when on patrol, particularly in winter when officers cited that wearing more layers can be restrictive.

> In winter, it's a nightmare, it's the last resort to get off the horse in winter. But operationally we have to. It's just adapting to it. Getting off, you know, it's fine, but it's the getting back on, you're not as agile as you would be without the equipment on. So how you get round that is you just, you use benches and walls to get on the horse out and about, rather than the usual way of getting on (P6).

Height was a common issue for some officers and mounting the horse appeared to be more of an issue for shorter officers when riding larger horses, with one officer commenting on the difficulty their shorter colleagues have in comparison to them 'You see, for me it's not an issue because I'm six foot three, but his actual rider is only five foot three, so she struggles' (P9).

On horseback

Officers mostly considered their PPE while on horseback, which includes training, patrol and public order tasks. The discussed PPE differed for each of these tasks. When training, officers commonly wore riding boots, jodhpurs, riding specific body protectors, and a riding hat. On patrol, officers mentioned wearing the same equipment as foot officers, exchanging their riding-specific body protectors for standard issue police body armour, with the addition of riding boots, jodhpurs and a riding hat. Officers were 'fitted' for this equipment when it was first issued, particularly the body armour, so they have the most appropriate 'off the shelf size' (e.g. small, medium, large). Equipment and clothing were also male and female specific, but no equipment was 'bespoke made to measure' for individual officers, with one officer stating that their long torso was an issue for body armour fit.

> When I went to the fitting, you have to pick the best of the bunch that fits you. But mine isn't long enough really, so it probably finishes under my ribs and then there's probably a ten inch gap from where my belt is (P1).

The on-patrol PPE allowed for individual choice regarding the use of a tactical vest or duty belt to hold equipment, which was often based on comfort, along with personal choice on the use of coats, jackets and general seasonal garments. During public events that are considered high-risk for disorder, officers wear protective pads on the shoulders, arms, and legs. They also have flameproof overalls and a specialised helmet for policing these high-risk events. While some officers referred to the helmet as a NATO helmet, one stated 'It's not a NATO helmet, I think it's called a hybrid helmet. We get them from a company in America' (P7).

Officers regularly spent 2–3 hours in the saddle during patrol activities, but this could extend to five hours for large public events. Most of the time on horseback was spent stationary or at walking pace, but emergency calls often required officers to ride at a trot. Cantering speeds and jumping were mostly just practised during training activities.

Off the horse

Whilst most of the officer's time was spent on the horse, there were situations where the officers might be required to dismount, such as when they were required to chase or detain offenders. The PPE was considered restrictive in these circumstances, but essential for protection when policing on foot.

> It's restrictive from the point of view if you're ever off your horse and running after someone, it's a lot of weight on you and I struggle when I'm running on my own feet with all the weight because I'm not a good runner (P3).

> …we are police officers at the end of the day and if we have to get off the horse and deal with somebody, then we almost turn into a foot officer anyway and we always have to have the capability of doing that (P4).

> It's harder to do your job and run after people if you've got all that stuff on. But you need it to keep warm and you need it to keep safe (P8).

Main theme 2: issues

Participants described numerous issues with their PPE and identified several barriers to its functionality and performance. The main theme of 'Issues' was supported by three sub themes: Protection; Discomfort; Procurement, which described the participants experiences of wearing their PPE whilst on duty.

Protection

Many of the officers described concerns about the limited protection offered by some of their PPE and whilst they acknowledged it offered protection from offenders, it failed to protect them from riding-specific incidents such as falls from the horse. Police issue body armour was a major concern for most officers who described how the equipment was standard issue and not designed specifically for horse-related activities. As such, participants felt that they were not properly protected from a fall and that their training body protector provided them with more protection in certain situations.

> You just need to be aware of the situations you get yourself into. Obviously, it doesn't offer any sort of protection if you fall off. There's no sort of protection there for falls or anything like that (P10).

Most officers accepted that their current PPE was designed to protect them from offenders and the public and were accepting of the limitations of their current equipment.

> In the Mounted Forces generally, we accept this pay off between the risk of a fall from height as opposed to the risk or vulnerability from a stab or a knife-based attack (P7).

> … the body armour is not designed for protection from fall, it's designed for stabbing and sharp objects basically. It's a ballistic nature isn't it, to protect us in that respect (P8).

Despite the concern about falls from some officers, there was an overall sense that they felt protected from the risks of dealing with members of the public.

> I probably feel safer when I've got the protective equipment on, on foot. If you came across somebody with a knife, it does afford you that protection from stab threats. If feel very safe if I am honest (P3).

Officers also noted feeling more protected on horseback compared to on foot, mostly due to the distance between themselves and the public when on horseback. Although some did acknowledge that there could be a risk to the lower limbs with limited protection in that area of their patrol uniform.

> I'm up on the horse, I feel quite safe without anything on the horse, my horse is massive. But I have to get off and wrestle with people. That's when I want the protective equipment (P3).

> When you're riding a horse, you tend to sit, you know, kind of almost six feet up in the air. So, the likelihood of being stabbed or attacked with a sharp weapon on a horse is minimal, whereas your legs would be far more exposed. But the kind of the risk assessment is you're more at risk when you get off a horse to deal with somebody and that's where it really comes into play (P7).

In addition to their usual patrol uniform, the participants explained how public order equipment (commonly known as riot gear) was worn during events with a high risk of disorder. The PPE worn in these circumstances benefitted from the addition of protective pads, which offered increased protection for the lower limbs, and many officers mentioned feeling better protected, but also more restricted, when wearing them. Some also noted that the public order protective equipment was not specific to mounted officers and not designed for horse riding, therefore, it hindered their ability to interact with the horse whilst in

the saddle. Some officers described this form of PPE as restricting, rigid and inflexible and detailed situations where they might be disconnected from their horse during these events and the difficulties remounting because of their PPE.

> …they've been designed for walking around, not mounted officers. So, whilst it offers a little bit of protection to your leg, it sort of impedes your riding because it pushed your leg further from the horse (P10).

Discomfort

Most participants reported experiencing discomfort from wearing their PPE with the most common being rubbing, restrictive movement and the weight of the equipment, both on patrol and public order, was stated to cause discomfort by most officers, which was accentuated when worn for long durations.

> I do find that it is very heavy. So, when I'm on board I get a bit of back ache from the body armour because I feel that the body armour is slightly too heavy, and I don't think it's suitable for us on the mounted (P11).

> If you're on for a while you sort of, your lower back, you know, it's your lower back will be like hurting a bit, that's pretty sort of common that, your lower back sort of hurting and you've just got to like twizzle around a bit and get off if you can (P10).

> It's quite heavy. It is a bit restrictive and like I said before because I've got a bit of a shoulder injury, it drags down on your shoulder and hurts quite a bit (P12).

The weight of the PPE was partly affected by the weather, with increased layers worn in cold conditions suggested to contribute to increased heaviness and restricted movement. The on-patrol uniform used in the range of movement assessments weighed ~ 8.5 kg. Some participants explained how this extra weight caused them back, neck and shoulder discomfort when worn on duty for long periods of time. However, some officers, mostly male, commented that they have little discomfort from the body armour when on the horse and one officer described discomfort due to heaviness as being more noticeable of foot compared to on horseback.

> For me, it's more noticeable on foot rather than on a horse. Before I joined the mounted police, I used to wear a tack vest and it used to really hang on my shoulders. Well since I've come to the Mounted, I don't get that because obviously I'm sat down on the horse, so you don't get it hanging off your shoulders a lot (P11).

> After a period of time I start to get a bit of back ache with it, just from carrying the extra weight. But for the length of deployments that we do, which are usually limited to about three hours, it's not too bad, but much beyond that and personally I start to feel I'm carrying additional weight (P7).

> If you're on for a while your lower back will be like hurting a bit, that's pretty common, your lower back sort of hurting. You've just got to like twizzle around a bit and get off if you can (P10).

There were also comments around accepting some discomfort to be protected and some participants seemed to feel it was 'part of the job' to experience discomfort.

> Yeah, I mean it's as comfortable as it can be, I think. If I had the choice of not wearing it, I wouldn't wear it. But obviously I have to wear it because it's got all my stuff on it, and I don't want to get injured by not wearing it. So, I'd rather be a little bit uncomfortable and be safe than not have it at all (P8).

Procurement

Several officers suggested that the current equipment provision was unlikely to improve due to financial restrictions in the police force nationally. There was a clear sense of 'just make do' with the current equipment, with nearly all officers stating that they have become accustomed to working with what they have, and making it work. Many believed the mounted police section of the police force was too small to necessitate the development of specific mounted police related PPE and their current equipment provision was attributable to a lack of investment in their division.

> Yeah, one of the issues that we have is there's only, across the country, there's only thirteen Forces now that still have Mounted Officers. So, if you added us altogether, there's probably two hundred and fifty officers. Now we all do our procurement either individually or regionally. So, from a manufacturer's point of view, you're having a limited run because you're only going to be asked to produce two hundred and fifty of them maximum, that's if you can get everyone in in the country to agree to replace their equipment (P7).

> I get that there is a lot of cost saving, but I just feel we should have the best protection going. I mean, we go out and do a job. We put ourselves at risk and they could at least give us the best kit and equipment available, I think, but it's not always the way (P8).

Main theme 3: areas for improvement

The third main theme was Areas for improvement, which consists of design and seasonal equipment/clothing as the two sub themes.

Design

This sub-theme was the biggest area of improvement suggested by most officers. Many commented on the potential benefit of including an element of protection from falls in the body armour. Some suggested that

their body armour would benefit from incorporating protection like that in commercially available equestrian body protectors and many felt more protected from falls whilst riding their horse in a training environment than out on patrol.

> The body protectors we've got, which we wear in training, are designed for a fall from height, but offer you no protection from a knife attack for example. So, if there was an opportunity to develop some sort of hybrid that perhaps covered both things (P7).

> … for me there could be a design whereby, have you seen these like air vests that people wear, that blow up when you come off. So, if something like that could be designed, even if it was just around the back of the vest, the back of the tack vest to give you some sort of cushioning to support your back or around the head and neck area to prevent rotational falls, when you fall from height, that could probably be linked into that current equipment that we're given, that current tack vest, but still leave the front pretty clear to keep all your other equipment (P8).

Officers commented that designing some elements of the equipment provision to be more specific to horse riding would improve their user experience. The public order equipment was often mentioned as an item that could be improved in this way, enabling greater contact between the rider and the horse to improve horse control and improving the design to reduce movement restriction in the upper body.

> Yeah, they are, the only thing I would say, if we could change, would be them, the pads, whether they could become more sort of flexible. They're quite rigid, they're very rigid plastic what we use (P2).

Making equipment lighter and the fit more customisable, particularly for the body armour, was frequently reported as an improvement for comfort and reducing potential shoulder and lower back pain. This improvement was also felt to aid officers when mounting and dismounting. Another area of improvement mentioned by some officers was their visibility on patrol, particularly in bad weather, poor visibility or after sunset. Officers described attaching bike lights to their uniform to aid visibility but were concerned that they are not visible enough when out on unlight roads. Integrable lights that could be attached to the body armour, or the horse, were suggested as improvements to their PPE.

> We struggle for sort of visibility. Because we're out in the dark a lot, we kind of, we're kind of at the stage where we're using cycle lights and we attach one to the front of our stab best and one to the back and it's just because we're a bit higher up, I think vehicles wonder what we are until they get sort of right upon us (P4).

Seasonal equipment/clothing

The participants PPE varied between seasons with extra clothing such as waterproof trousers, jackets and long riding boots being worn in colder, wetter weather. Many of these extra layers were not specific to the mounted police and many participants described how they often used garments designed for motorcycle officers and police on foot whilst out on patrol. Some officers commented on the benefit that they might get from being provided with thermal base layers, which might reduce the number of layers that officers need to wear during cold conditions. Another item of seasonal clothing item that was suggested could improve are the waterproof trousers that are issued. Many officers mentioned that they are very good at repelling water and keeping the officers dry, but some suggested that they are made for motorcycle police and that the material led to sliding in the saddle.

Range of motion assessments

All data range of motion data is presented in Table 1. On-duty protective equipment significantly reduced neck flexion on and off horseback and neck rotation off horseback. Shoulder forward flexion, backward flexion and abduction were also significantly reduced with on duty equipment on and off the horse. Thoracolumbar forward flexion was significantly reduced in the PPE conduction, but there was no effect on thoracolumbar lateral flexion.

Discussion

The aim of this research was to assess the use, comfort, and functionality of mounted police officers' protective

Table 1. Neck, shoulder, and thoracolumbar range of motion (mean ± SD) on and off horseback, with and without on-duty protective equipment.

	On horseback		Off the horse	
ROM task	On duty equipment	Reference clothing	On duty equipment	Reference clothing
Neck flexion (°)	112 ± 14[a]	121 ± 11[a]	111 ± 16[a]	119 ± 14[a]
Neck rotation (°)	123 ± 15	127 ± 17	137 ± 15[a]	150 ± 17[a]
Shoulder forward flexion (°)	149 ± 25[a]	163 ± 20[a]	151 ± 24[a]	170 ± 17[a]
Shoulder backward extension (°)	55 ± 11[a]	66 ± 14[a]	52 ± 12[a]	60 ± 11[a]
Shoulder abduction (°)	123 ± 27[a]	149 ± 24[a]	130 ± 28[a]	155 ± 21[a]
Thoracolumbar flexion (mm)	1048 ± 151[a]	975 ± 168[a]	509 ± 100[a]	473 ± 119[a]
Thoracolumbar lateral flexion (mm)	1206 ± 118	1186 ± 139	777 ± 246	753 ± 253

Lower values for the thoracolumbar spine represent a greater range of motion. Larger values for neck and shoulder angles represent a greater range of motion. [a]indicates a statistically significant difference between on-duty equipment and reference clothing ($p \leq 0.05$).

equipment. The interview analysis revealed three main themes that reflected the participants perceptions and experiences, including functional requirements, issues, and areas for improvement. These themes provide contextual evidence on the suitability of PPE for mounted officers in the UK. The range of motion assessments also provided objective data demonstrating increased movement restriction with the protective equipment and garments worn on patrol.

The findings revealed that mounted officers 'make do' with their current PPE, but also show a desire for the specific risks of policing on horseback to be considered in the provision of protective equipment. The mounted officers described wearing PPE during training, on patrol, and at public events, with the amount of PPE worn by officers increasing when the risk of disorder increases. This was expected as these are the most physically demanding activities for mounted officers (Canetti et al. 2024) and involve animal handling activities, which have been reported to cause 65% of injuries for mounted officers (Orr et al. 2023). For most training activities, the PPE appears to be specific for horse riding (e.g. riding helmet and body protectors), but these items were switched to standard issue police PPE when on patrol (e.g. body protectors switched to body armour). The mounted officers also wear other standard issue police equipment in public spaces, such as a tactical vest or duty belt to carry equipment, along with further non-mounted specific PPE when there was a high risk of disorder, such as exchanging equestrian riding helmets for public order helmets. As such, the amount of PPE designed specifically for horse-riding appears to decrease when the risk of disorder increases.

Mounted officers mentioned a need for PPE to function effectively when they dismount and interact with the public on foot and some officers described how this was when they felt most at risk of injury. This is unsurprising given that the latest UK Home office annual statistics for police officer assaults (2021–2022) show 41,000 assaults on officers in England and Wales, with 11,730 resulting in 'injury on a constable' (HomeOffice 2022). Although data for the number of assault injuries reported by mounted officers is limited, the findings from this study suggest that the officers felt safer from assault risks when on horseback, where they are 'almost six feet up in the air'. Indeed, injury data from Australia shows that only 1.3% of reported injuries by mounted officers are from physical assault, compared to 21% for non-mounted (Orr et al. 2023). This suggests that the addition of horse-riding specific PPE, that retains the current level of protection when dismounted, might be beneficial in reducing injuries for mounted officers.

While officers noted feeling safer from assault on horseback, protection from falls was considered a major issue with the current provision of PPE and was particularly notable for officers that had experienced a fall. Falls from height have been reported as the most common type of injury by Australian mounted officers (15.9% of all injuries from falls) (Orr et al. 2023), with equestrian injury data showing that most major injuries from horse riding occur in the upper body, particular at the head, thorax, and spine (Acton et al. 2020; Ball et al. 2007; Hasler et al. 2011). Similar data were reported by Orr et al. (2023) who found that mounted officers experienced the highest number of injuries in the lower back, neck and shoulders. The participants in this study identified several areas for improvement to their current PPE for reducing injury risk from falls. This included the incorporation of an airbag system in their body armour used in some commercially available products (such as those found in the motorcycle industry), or the inclusion of some of the protective elements of riding body protectors worn by the officers during training activities. Airbag systems (also known as air jackets, air vests, or airbag vets) have been used in equestrian activities for almost a decade (Ade, Stämpfli, and Schmitt 2016) and are designed to inflate when a lanyard attaching the vest to the saddle disengages, activating a CO_2 canister that inflates the vest. The inflated jackets are often designed to provide additional impact protection for the torso and neck. However, there is currently little evidence of reduced injury outcomes from horse falls when wearing an air jacket, compared to standard body protectors (Nylund et al. 2019). Therefore, it might be more beneficial for researchers and equipment manufacturers to focus on the modern foam materials and composite structures used in horse rising body protectors (Pacek and Rutkowski 2021), to see if these could be incorporated into police body armour. This might provide enhanced protection from falls whilst maintaining the current level of protection from stab and ballistic threats outlined by the UK Home Office Body Armour Standards (Payne, O'Rourke, and Malbon 2017).

The additional ~8.5 kg of PPE mass carried on patrol causes some discomfort, but it appears to be an acceptable trade-off for the increased protection that the equipment provides. This magnitude of additional mass from the uniform and protective equipment is consistent with load mass reported in other law enforcement research (Dulla et al. 2017; Ehnes et al. 2020; Marins et al. 2020). Many officers suggested that the discomfort caused by the additional mass is felt less in their mounted role compared to officers on foot. Many mounted officers also mentioned choosing

a tactical vest to hold appointments, rather than a duty belt, because it was more comfortable in a seated position. This is in line with research on vehicle police demonstrating that load bearing vests reduce discomfort in a seated position compared to duty belts (Filtness, Mitsopoulos-Rubens, and Rudin-Brown 2014). Although the mass of the equipment appears to be less of a comfort issue for mounted officers compared to other units, some officers suggested that they have difficulty remounting in winter, when they wear additional layers that can add mass and restrict movement. This is an issue because remounting from the ground is a requirement of the National Police Chief's Council (NPCC) Standard Equitation Course (SEC). A potential solution for reducing the overall mass of the uniform, without compromising protection, could be to improve the provision of thermal undergarments during the winter, which might prevent the need for heavy and restrictive fleece-lined coats.

In high-risk scenarios, the mounted police wear public order pads designed to provide additional protection to the shoulders, arms, and legs. This equipment also includes flameproof overalls and a public order helmet. We did not measure the additional mass of the public order protective equipment, but similar equipment has been reported to have a total mass of ~ 20 kg (Zwingmann et al. 2021). Officers expressed concerns about restricted movement and a reduced ability to control their horse when wearing their public order pads and public order helmet, which links to their concerns about fall risk. Given the significant increase in movement restriction for the shoulder and thoracolumbar joints when wearing the on-patrol uniform (consisting of body armour and a tactical vest/duty belt), it is likely that the public order pads lead to further movement restriction, although we were unable to test this. The issue might be addressed by the development of mounted specific public order pads, that allow for greater joint range of motion and provide an improved contact area between the rider's legs and the horse. Regarding the helmet, while there is a considerable amount of research on the protection afforded by equestrian helmets, little is known about the protection from mild traumatic brain injuries that the public order helmet would provide during fall incidents. However, the UK public order helmet does conform to the specification set by the Home office for protective headwear (Malbon and Croft 2004), which includes an impact velocity drop test at 6.61 $m \cdot s^{-1}$, which is slightly faster rate than the equivalent standard specification test for protective headgear used in horseback riding (6.00 $m \cdot s^{-1}$) (ASTM F1163-15).

There is a sense that officers 'just make do' with any PPE that they are provided. Although most officers noted one or more issues relating to protection and discomfort, many suggested that the costs of providing bespoke equipment for mounted officers is likely to be a limiting factor for its development. Giacomantonio et al. (2015) identified that mounted police do cost more than other police on an annual basis per officer, with the additional costs approximately equivalent to the cost of keeping a horse. However, Giacomantonio et al. (2015) also demonstrated that the costs of mounted police account for less than 0.4% of the total spend among forces with mounted sections. Furthermore, the cost of mounted police as an overall proportion of policing spends across all of England and Wales is only 0.002% of the total policing budget.

The range of motion assessments provide objective data showing that the on-duty protective equipment worn by mounted officers significantly reduced joint specific range of motion at the neck, shoulder and hips compared to the officers' training equipment (reference clothing condition) both on and off the horse. This finding was somewhat expected as both the design and weight of body armour has been shown to reduce joint specific range of motion in non-mounted police officers (Blackledge et al. 2009; Ramstrand et al. 2016; Schram et al. 2020). Physical interference from PPE during movement is likely to impede task performance and there appears to be a trade-off between performance and protection when wearing PPE (Hudson et al. 2024), with body armour negatively affecting jump height (Dempsey, Handcock, and Rehrer 2013; Zedler and Goldmann 2024), running speed (Ehnes et al. 2020; Lewinski et al. 2015), and agility (Marins et al. 2020; Orr et al. 2019) in non-mounted personnel. While this study found that wearing PPE restricted movement in the hips and upper body, further work is needed to quantify the potential effects of this restricted movement on the performance of tasks specific to the mounted police, such as mounting/dismounting, horse control, and responding to emergencies. For example, restricted movement of the neck could reduce the officer's ability to look in all directions while mounted. Restricted hip and shoulder movements could reduce the officer's ability to mount and dismount, while reducing their ability to reach down or perform hand signals while mounted.

The officers range of motion at the neck, shoulders and hips during the control condition (reference clothing, off horse) were within the expected range for healthy individuals without a known musculoskeletal injury (Mitchell 2013). Compared to the normative data presented by Mitchell (2013), officers were, on

average, in the 35th percentile for neck rotation, the 55th percentile for neck flexion, the 80th percentile for thoracolumbar lateral flexion, the 20th percentile for shoulder abduction, the 50th percentile for shoulder forward flexion, and the 97th percentile for shoulder backward flexion. The mounted officers on-duty equipment resulted in less movement restriction than has been previously reported with military PPE (Mitchell 2013), which supports previous research showing that military body armour restricts movement more than law enforcement armour (Orr, Schram, and Pope 2018) and provides further evidence to support the need for occupation and role specific PPE.

Although the findings of this study considerably improve our understanding of the PPE used by the UK Mounted Police, the results should be interpreted considering the study's limitations. Firstly, we were unable to measure joint specific range of motion range during dynamic or functional tasks specific to mounted policing, such as mounting/dismounting from the ground and horse control, which were highlighted by officers in this study as difficult tasks when wearing on-duty PPE. Secondly, we focused on static range of motion in the hips and upper body, but we did not include measures of motion in the lower limb (knees and ankles) which is likely to be effected by PPE when mounting from the ground and when riding (horse control). Further research is needed to explore the effect of PPE on task performance in the mounted police, which will provide practical data when considering uniform improvements to improve task performance and/or reduce the injury risks associated with policing on horseback.

Conclusion

Police officers from three UK mounted units provided insights and experiences of their protective equipment. This is the first study to investigate the provision and perceptions of the uniform and PPE worn by mounted officers. Much of the protective equipment worn on patrol is standard issue for police and not designed specifically for the risks associated with riding a horse riding. Officers 'make do' with their current provision of PPE but identified increased protection from falls as a particular area that they would like to see improved. There was also desire for the specific risks of policing on horseback to be considered in the provision of all protective equipment.

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References

Acton, A. S., C. E. Gaw, T. Chounthirath, and G. A. Smith. 2020. "Nonfatal Horse-Related Injuries Treated in Emergency Departments in the United States, 1990–2017." *The American Journal of Emergency Medicine 38* (6): 1062–1068. doi:10.1016/j.ajem.2019.158366.

Ade, N., R. Stämpfli, and K.-U. Schmitt. 2016. "Evaluating Airbag Safety Vests for Equestrian Sports." *Journal of Testing and Evaluation 44* (6): 2387–2395. doi:10.1520/JTE20140345.

Ball, C. G., J. E. Ball, A. W. Kirkpatrick, and R. H. Mulloy. 2007. "Equestrian Injuries: incidence, Injury Patterns, and Risk Factors for 10 Years of Major Traumatic Injuries." *American Journal of Surgery 193* (5): 636–640. doi:10.1016/j.amjsurg.2007.01.016.

Blackledge, C., D. Carruth, K. Babski-Reeves, D. Close, and M. Wilhelm. 2009. "Effects of Body Armor Design on Upper Body Range of Motion.". Proceedings of the Human Factors and Ergonomics Society Annual Meeting,

Bonneau, J., and J. Brown. 1995. "Physical Ability, Fitness and Police Work." *Journal of Clinical Forensic Medicine 2* (3): 157–164. doi:10.1016/1353-1131(95)90085-3.

Braun, V., and V. Clarke. 2006. "Using Thematic Analysis in Psychology." *Qualitative Research in Psychology 3* (2): 77–101. doi:10.1191/1478088706qp063oa.

Canetti, E. F., A. Gersbach-Seib, R. Moore, B. Schram, and R. Orr. 2024. "A Profile of Occupational Tasks Performed by Mounted Police Officers." *Work (Reading, Mass.)* 77 (4): 1235–1244. doi:10.3233/WOR-230283.

Coltman, C. E., B. R. Brisbine, R. H. Molloy, and J. R. Steele. 2022. "Can Smaller Body Armour Improve Thoracolumbar Range of Motion and Reduce Interference When Female Soldiers Perform Dynamic Tasks?" *Applied Ergonomics 98*: 103602. doi:10.1016/j.apergo.2021.103602.

Coltman, C. E., J. R. Steele, W. A. Spratford, and R. H. Molloy. 2020. "Are Female Soldiers Satisfied with the Fit and Function of Body Armour?" *Applied Ergonomics 89*: 103197. doi:10.1016/j.apergo.2020.103197.

Dempsey, P. C., P. J. Handcock, and N. J. Rehrer. 2013. "Impact of Police Body Armour and Equipment on Mobility." *Applied Ergonomics 44* (6): 957–961. doi:10.1016/j.apergo.2013.02.011.

Dulla, J., K. Baran, R. Pope, and R. Orr. 2017. "Duty Loads Carried by the LA Sheriff's Department Officers." *Journal of Science and Medicine in Sport 20*: S5–S6. doi:10.1016/j.jsams.2017.09.010.

Ehnes, C. M., M. P. Scarlett, S. J. Lemelin, M. K. Stickland, and S. R. Petersen. 2020. "The Effect of General Duty Police Ensemble on Graded Exercise and Simulated Work Performance." *Applied Physiology, Nutrition, and Metabolism=Physiologie Appliquee, Nutrition et Metabolisme 45* (3): 301–310. doi:10.1139/apnm-2019-0230.

Executive, H. a. S. 2023. "Personal Protective Equipment (PPE) at Work." https://www.hse.gov.uk/ppe/index.htm

Filtness, A., E. Mitsopoulos-Rubens, and C. M. Rudin-Brown. 2014. "Police Officer in-Vehicle Discomfort: appointments Carriage Method and Vehicle Seat Features." *Applied Ergonomics 45* (4): 1247–1256. doi:10.1016/j.apergo.2014.03.002.

Giacomantonio, C., B. Bradford, M. Davies, and R. Martin. 2015. "Making and Breaking Barriers.". *Assessing the Value of Mounted Police Units in the UK. Rand Corporation/ University of Oxford*: *Cambridge*.

Hasler, R. M., L. Gyssler, L. Benneker, L. Martinolli, A. Schötzau, H. Zimmermann, and A. K. Exadaktylos. 2011. "Protective and Risk Factors in Amateur Equestrians and Description of Injury Patterns: A Retrospective Data Analysis and a Case-Control Survey." *Journal of Trauma Management & Outcomes 5* (1): 4. doi:10.1186/1752-2897-5-4.

HomeOffice. 2022. "Annex: Statistics on the Number of Police Officers Assaulted in the Year Ending March 2022, England and Wales." https://www.gov.uk/government/statistics/police-workforce-england-and-wales-31-march-2022/annex-statistics-on-the-number-of-police-officers-assaulted-in-the-year-ending-march-2022-england-and-wales

Hudson, S., L. Ridland, J. Blackburn, L. Monchuk, and K. Ousey. 2024. "The Comfort and Functional Performance of Personal Protective Equipment for Police Officers: A Systematic Scoping Review." *Ergonomics* 67 (10): 1317–1337. doi:10.1080/00140139.2024.2302957.

Lewinski, W. J., J. L. Dysterheft, N. D. Dicks, and R. W. Pettitt. 2015. "The Influence of Officer Equipment and Protection on Short Sprinting Performance." *Applied Ergonomics 47*: 65–71. doi:10.1016/j.apergo.2014.08.017.

Lewis, E. A., J. Breeze, C. Malbon, and D. J. Carr. 2017. "Personal Armour Used by UK Armed Forces and UK Police Forces." In Ballistic Trauma: A Practical Guide. Cham: Springer International Publishing, 47–62.

Malbon, C., and J. Croft. 2004. *PSDB Protective Headwear Standard for UK Police (2004): Public Order Helmet*. Sandridge: Home Office Police Scientific Development Branch.

Marins, E. F., L. Cabistany, C. Bartel, J. Dawes, and F. B. Del Vecchio. 2020. "Effects of Personal Protective Equipment on the Performance of Federal Highway Policemen in Physical Fitness Tests." *Journal of Strength and Conditioning Research 34* (1): 11–19. doi:10.1519/JSC.0000000000003201.

Mitchell, K. B. 2013. *Standard Methodology for Assessment of Range of Motion While Wearing Body Armor*. Techincal Report (TR-13/033), United States Army. Natick Soldier Research, Development and Engineering Center, Natick, Massachusetts.

Nylund, L. E., P. J. Sinclair, P. L. Hitchens, and S. Cobley. 2019. "Do Riders Who Wear an Air Jacket in Equestrian Eventing Have Reduced Injury Risk in Falls? A Retrospective Data Analysis." *Journal of Science and Medicine in Sport 22* (9): 1010–1013. doi:10.1016/j.jsams.2019.05.012.

Orr, R., E. F. Canetti, R. Pope, R. G. Lockie, J. J. Dawes, and B. Schram. 2023. "Characterization of Injuries Suffered by Mounted and Non-Mounted Police Officers." *International Journal of Environmental Research and Public Health 20* (2): 1144. doi:10.3390/ijerph20021144.

Orr, R., B. Hinton, A. Wilson, R. Pope, and J. Dawes. 2020. "Investigating the Routine Dispatch Tasks Performed by Police Officers." *Safety 6* (4): 54. doi:10.3390/safety6040054.

Orr, R. M., F. Kukić, A. Čvorović, N. Koropanovski, R. Janković, J. Dawes, and R. Lockie. 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. doi:10.3390/ijerph16111947.

Orr, R., B. Schram, and R. Pope. 2018. "A Comparison of Military and Law Enforcement Body Armour." *International Journal of Environmental Research and Public Health 15* (2): 339. doi:10.3390/ijerph15020339.

Pacek, D., and J. Rutkowski. 2021. "The Composite Structure for Human Body Impact Protection." *Composite Structures 265*: 113763. doi:10.1016/j.compstruct.2021.113763.

Payne, T., S. O'Rourke, and C. Malbon. 2017. "Body Armour Standard (2017)." *Home Office*.

Ramstrand, N., R. Zügner, L. B. Larsen, and R. Tranberg. 2016. "Evaluation of Load Carriage Systems Used by Active Duty Police Officers: relative Effects on Walking Patterns and Perceived Comfort." *Applied Ergonomics* 53 Pt A: 36–43. doi:10.1016/j.apergo.2015.08.007.

Schram, B., R. Orr, B. Hinton, G. Norris, and R. Pope. 2020. "The Effects of Body Armour on Mobility and Postural Control of Police Officers." *Journal of Bodywork and Movement Therapies 24* (3): 190–194. doi:10.1016/j.jbmt.2020.03.001.

Tracy, S. J. 2010. "Qualitative Quality: Eight "Big-Tent" Criteria for Excellent Qualitative Research." *Qualitative Inquiry 16* (10): 837–851. doi:10.1177/1077800410383121.

Zedler, M., and J.-P. Goldmann. 2024. "Police-Specific Physical Performance of Men and Women with Different Body Heights." *The Police Journal 97* (1): 3–17. doi:10.1177/0032258X221126066.

Zwingmann, L., M. Hoppstock, J.-P. Goldmann, and P. Wahl. 2021. "The Effect of Physical Training Modality on Exercise Performance with Police-Related Personal Protective Equipment." *Applied Ergonomics 93*: 103371. doi:10.1016/j.apergo.2021.103371.