

## Development of a patient-reported outcome measure for neck pain in military aircrew

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# BMJ Open Development of a patient-reported outcome measure for neck pain in military aircrew: qualitative interviews to inform design and content

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## ABSTRACT

**Introduction** The prevalence of flight-related neck pain is 70% in UK fast jet pilots; much higher than the general population. The Aircrew Conditioning Programme and direct access physiotherapy exist to minimise the impact on military capability, but a population specific patient-reported outcome measure (PROM) is required to investigate the effectiveness of these. We aimed to explore the experiences of flight-related neck pain to inform the content validity and development of a population specific PROM.

**Methods** Qualitative semistructured interviews combining phenomenological and grounded theory methods, reported using Consolidated criteria for Reporting Qualitative research guidelines. A purposive sample of 10 fast jet pilots with neck pain was recruited. Concept elicitation interviews were audio recorded, transcribed verbatim along with field notes. Data analysis involved subject and methodological expertise used a concept elicitation approach.

**Results** Participants included 10 male fast jet pilots, age 34.7 years. Identified themes included: (1) physical symptoms associated with flying activities; (2) occupational effects revealed modifications of flying, or 'suboptimal' performance owing to neck pain; (3) psychological effects revealed feelings or worry and (4) social and activity effects showed impact on out of work time.

**Conclusion** Population-specific occupational, psychological and social factors should be considered alongside physical symptoms when managing neck pain in military aircrew. Findings support the development of a PROM specifically designed for military aircrew with neck pain.

## INTRODUCTION

Flight-related neck pain is a common musculoskeletal problem for military pilots, with prevalence reported as 66% for all Royal Air Force (RAF) aircrew, and 70% for UK fast jet pilots.<sup>1</sup> One-year estimates for Danish helicopter pilots were 43%–48%, relative to 26% in the general population.<sup>2</sup> Neck pain incidence is consistently higher relative to the general population despite several neck

## Strengths and limitations of this study

- Findings provide fast jet pilots' perspective on the implications of neck pain to inform content validity of a population-specific patient-reported outcome measure.
- The study design and methods are informed and reported in line with published guidance (Consolidated criteria for Reporting Qualitative research, concept elicitation).
- The sample included only male participants from one military squadron.
- Further research is required to enable cognitive debriefing of the derived domains.

pain risk factors, such as age, physical inactivity and female gender, being lower among military groups.<sup>3</sup>

UK Defence Rehabilitation services have taken steps to address this issue and mitigate known under reporting of neck pain among aircrew.<sup>4</sup> The Aircrew Conditioning Programme (ACP),<sup>5</sup> which includes exercises which target the neck, has been introduced due to evidence supporting targeted strength training as a preventative strategy,<sup>4 6</sup> and direct access to physiotherapy services are now available to aircrew. However, in the absence of a population-specific outcome measure the effectiveness of these interventions remains unclear and is identified as a UK Defence Rehabilitation research priority.<sup>7</sup>

Patient-reported outcome measures (PROM) facilitate healthcare service quality improvement, and are integral to evidence-based practice. PROM can be disease specific (eg, Neck Disability Index (NDI)) or generic (eg, Numerical Pain Rating Scale), where disease-specific measures are more sensitive to change in a single patient with regional specific musculoskeletal dysfunction.<sup>8</sup> This supports their use for investigating the effectiveness of interventions such as conditioning

programmes.<sup>9</sup> The NDI is the most widely used and validated disease-specific neck PROM,<sup>10</sup> although its applicability to military aircrew, with unique psychological and physical occupational requirements is unknown. This refers to the content validity of a psychometric measure, and considers the relevance of a PROM to the population of interest. The COnsensus-based Standards for the selection of health Measurement Instruments (COSMIN) checklist, a well-established PROM quality assessment tool, requires that 'age, gender, disease characteristics, country and setting' are well matched.<sup>11</sup> In addition to demographic and disease-related differences, the occupational and ergonomic demands vary greatly between the general and military populations.<sup>12</sup> Poor head postures, continuous vibration, repetitive movements, sustained static postures and neck loading from combat flying equipment are all unique military risk factors.<sup>12</sup> Beyond the physical factors, psychological factors such as working on military operations creates a further set of population-specific risk factors.<sup>13 14</sup> Military culture may influence healthcare attitudes and beliefs, with evidence indicating that pilots were reluctant to provide accurate information<sup>15</sup> and seek treatment for neck pain.<sup>4</sup> These factors may alter the psychometric properties of PROM by affecting how individuals approach tasks and score questionnaire items.<sup>16</sup> It is evident that the COSMIN content validity requirements would not be met by an existing PROM and is needed to evaluate effectiveness of the ACP or changes in aircrew neck complaints over time.

Across the military aircrew populations, neck pain in fast jet pilots poses a greater flight safety risk to due to higher pain prevalence,<sup>1</sup> and pilots flying solo. Training and airframe costs are also relatively higher, which increases the price of pilot hours lost to neck pain.<sup>17</sup> This qualitative study, therefore, aimed to explore the psychological, social and occupation factors of flight related neck pain in fast jet aircrew during their career to inform the design and content validity of a new population-specific PROM.

### Theoretical framework

The study followed the concept elicitation format for a new PROM; the methodological orientation combined phenomenological and grounded theory approaches, adapted to consider prior knowledge to inform the study design and topic guide.<sup>6</sup> This included review of existing literature which has critiqued the content validity of the NDI and developed a population-specific tool for whiplash associated disorders (WAD)<sup>18 19</sup> (grounded theory) and exploring fast jet pilot participants' own experiences and perceptions of neck pain (phenomenology). In line with the study aims, this allowed us to acquire an in depth understanding of the experiences of neck pain from individual fast jet pilots. The study was reported using the Consolidated Criteria for Reporting Qualitative Studies (online supplemental file 1).<sup>20</sup>

### Design and setting

Qualitative semistructured interviews of the experiences of neck pain in fast jet pilots (Typhoon flying squadron) were conducted at RAF Akrotiri, Cyprus between 17 July 2018 and 25 July 2018.

### Interviews

Semistructured interviews were used to maximise the insight of neck pain in fast jet pilots across the biopsychosocial framework. This allowed us to explore in depth past and current experiences of neck pain, attitudes and beliefs about neck pain, associated occupational factors and impact on function and performance within and outside work.

### Interview procedure and topic guide

Semistructured interviews were conducted by a musculoskeletal physiotherapist (AD) with 10 years musculoskeletal physiotherapy experience, and 7 years working with RAF fast jet pilots. Participants were unknown to the researcher and no prior relationship was established. Interviews lasted between 15 and 50 min and were recorded using a digital voice recorder. Participants were encouraged to talk for as long as was needed. No one else was present.

The topic guide (box 1) was developed by the research team (AD, ES and NRH) in accordance with published guidance<sup>6</sup> (1) a disease model for neck pain in the general population,<sup>21</sup> modified to acknowledge population specific differences (2) a proposed endpoint model for a new PROM for military aircrew (figure 1), and the hypothesised conceptual framework (figure 2A). The derived topic guide incorporated existing evidence and review of items in existing PROM. This included previous work, which critiqued the content validity of the NDI, and informed the development of a population specific tool for WAD.<sup>18 19</sup> (online supplemental file 2) The topic guide was piloted with fast jet pilots without a history of neck pain in advance of the main data collection to assess the feasibility, including clarity of questions and timing of the interview.

### Participants

#### Sampling and recruitment

Purposive sampling<sup>22</sup> was used to recruit fast jet aircrew across a range of characteristics, including age, gender, flying experience, fast jet flying hours and neck pain presentations. The sample size was predetermined at ten participants, as this was deemed sufficient to reach concept saturation.<sup>6 23</sup> Inclusion criteria were: member of Typhoon flying squadron, qualified fast jet pilot, fully operational flight status at enrolment or lost operational flight status due to flying related neck pain (no other reason). Exclusion criteria included: no previous occurrences of flight-related neck pain. A participant information sheet was distributed by email to potentially eligible pilots; all those approached agreed to participate in the study.

## Box 1 Topic guide was developed by the research team and piloted in advance of the main data collection

### Starting instructions:

- ▶ Thanks so much for agreeing to take part in this research. Introductions.
- ▶ As you may have seen on the participant information sheet, the reason for this research is to try and collect information that will help create a neck pain questionnaire that is relevant to the specific needs of military aircrew. These questionnaires are useful to help us evaluate the physiotherapy services that are currently being provided to military aircrew, with the aim of hopefully building and improving on them.
- ▶ You are free to stop the interview and withdraw your consent to participate in this research at any point, if you decide this during the interview then please let me know. This will in no way affect your onward service career. Also, if you decide after the interview that you don't want your information to be used in the research this is also fine, as long as you notify me within a week of completion of this interview. After this point the information you have given will have been processed and won't be able to be distinguished from those given by other individuals.
- ▶ Just to reassure you—as stated in the information sheet and consent form none of the answers or information that you give will be identifiable to you. The interview will be coded as opposed to being stored against your name. Once the data and information from the interview has been used, the recordings will be wiped from the recording device.
- ▶ Are there any questions before we start?

### Main Body of Questions

First, I'm keen to try and gain a bit of information about your past experiences of neck pain. Thinking back to the last time you had issues with you neck, what sort of problems or physical symptoms did you experience?

- ▶ Are there any further problems/symptoms that you can think of? (pain at rest, pain during or after flying, stiffness, decreased range of motion, headaches, thoracic pain/stiffness).

When you get issues with your neck, what aspects of your daily life does it tend to affect or interfere with?

- ▶ Can you tell me a bit more about how your neck pain affects you at work  
Flying performance, concentration when flying, desk based work/flight planning/concentration.  
Would you be able to give the pain you typically experience (when flying, when forming combat manoeuvres/when flight planning) a score out of 10?  
How about social activities and sport?  
Military fitness test/running/weight lifting?  
Would you be able to give the pain you typically experience a score out of 10?  
Does your neck pain impact on home life at all?  
Sleep and subsequent feeling of fatigue?  
Does it ever affect you when driving?  
Would you be able to give the pain you typically experience a score out of 10?
- ▶ Is there anything it stops you doing/activities you have to avoid?  
When you get neck pain, are there any thoughts, feeling or concerns that you experience associated with it?
- ▶ Does it worry you at all?

Continued

## Box 1 Continued

Do you know what it is specifically that worries you? (long-term career implications, fear of ongoing pain/symptoms, affect on family life).

- ▶ Does it ever make you feel angry or frustrated?  
Equipment concerns/budget and funding restrictions.

### Conclusions

Is there anything else that you feel is important that we haven't talked about?

At the beginning of each interview, the participant information sheet was discussed and questions were answered. Confidentiality and the concept of voluntary participation was explained, including the process of withdrawal. All subjects provided written informed consent before participating.

### Patient and public involvement

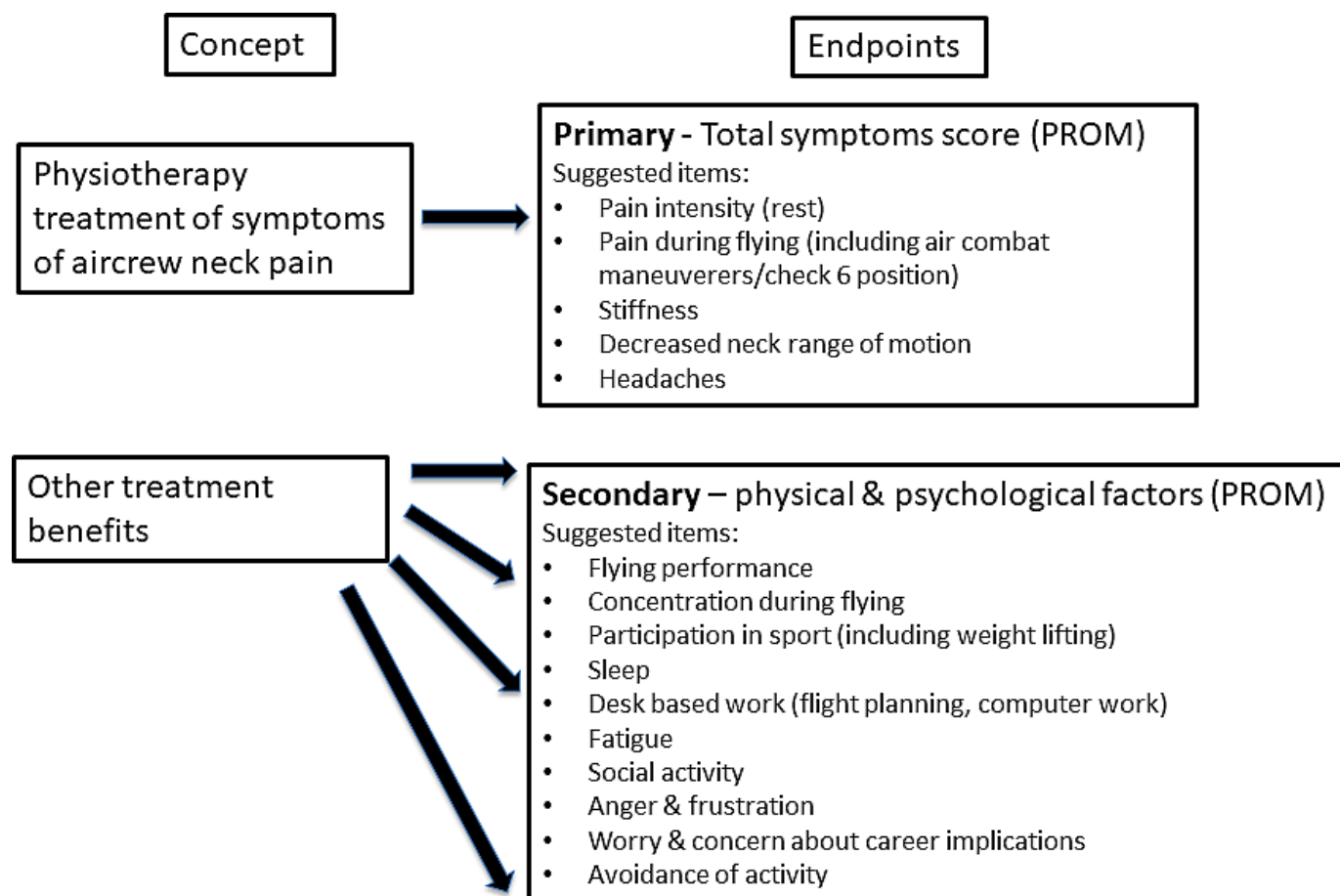
The study design and methods were informed by our experience of working with practitioners and military aircrew and more specifically fast jet pilots. They actively contributed to the research question and to establish the need for this research. Findings of the study will be shared with key stakeholders.

### Data analysis

Data were analysed according to a recommended process of coding and data analysis,<sup>6</sup> combined with guidance on thematic analysis.<sup>24</sup> An initial coding framework was created from the topic guide, hypothesised conceptual framework and data from pilot testing.<sup>6</sup> The lead researcher (AD) listened to, scored and assigned codes to themes that featured in interview transcripts and documented all modifications to the initial framework, which was expanded and restructured continuously as new data emerged.<sup>6</sup> A saturation table compiled during data analysis revealed that concept saturation was reached (table 1). Once all transcripts had been processed, a coding dictionary was developed detailing all participant quotes according to each code. This enabled comparison of grouped data and an initial check of coding consistency.<sup>24</sup> Inductive analysis informed further modifications in coding terminology and theme allocation, ensuring the coding framework and dictionary were a true reflection of participant data and not imposed by previous knowledge.<sup>6</sup>

Coinvestigators (NRH and ES) assisted with data analysis and interpretation to enhance the credibility of study findings. ES, a highly experienced musculoskeletal physiotherapist and researcher, checked coding and theme allocation by matching patient quotes to themes and codes in accordance with previous guidance.<sup>25</sup> Consensus was achieved regarding theme and subtheme coding. Reflexivity was used throughout and a revised conceptual framework (figure 2B), or thematic map generated for further analysis and interpretation by the research team.<sup>6 24</sup>





**Figure 1** Proposed endpoint model for a new neck specific PROM for military aircrew. PROM, patient-reported outcome measure.

## RESULTS

The sample comprised 10 male RAF fast jet pilots, with mean age 34.7 years (range 29–41 years), and a wide range of flying experience (median 1850 hours, range 650–3000 hours), fast jet flying hours (median 1200 hours, range 300–2400 hours) and incidence of neck pain during their military flying career (median 3.5, range 1–100 incidents).

Findings support significant modifications to the hypothesised conceptual framework (figure 2A) when compared with the revised conceptual framework that was developed following data collection. (figure 2B).

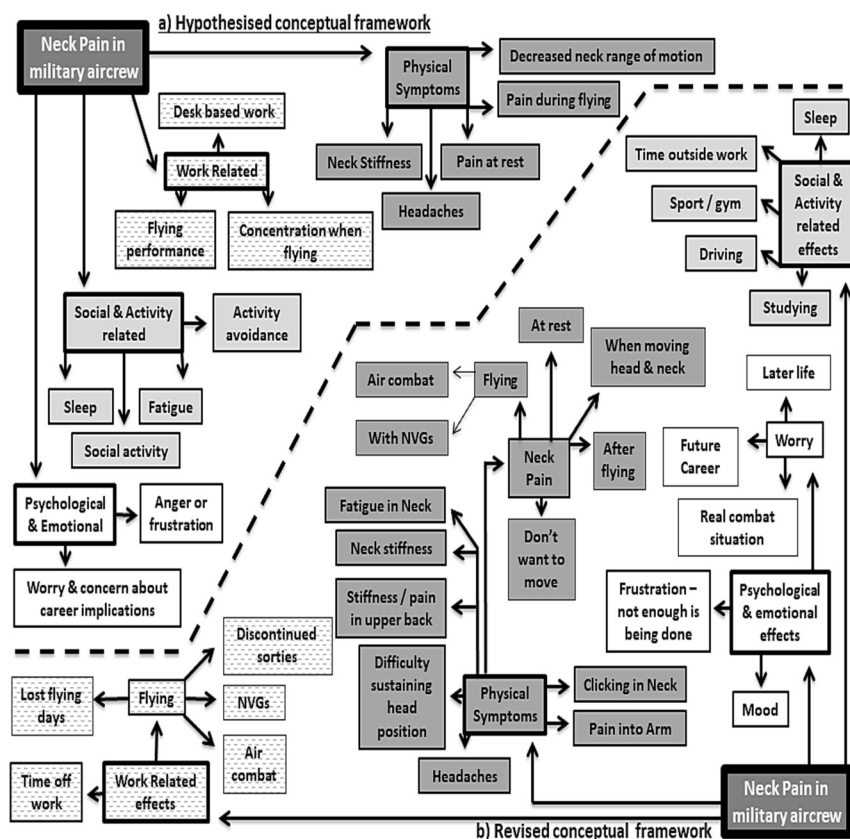
Figure 3A–D illustrates these according to our four derived themes (1) physical symptoms, (2) work-related effects, (3) psychological and emotional effects and (4) social and activity-related effects. Collectively, this includes 13 new subthemes, with 7 modified (work related, flying, physical symptoms, neck pain, social and activity related, psychological and emotional, and worry) and 4 discarded (decreased neck range of motion, desk-based work, fatigue and activity avoidance) as no data were collected to support their inclusion. Only four themes remain unchanged across the two frameworks (headaches, pain at rest, neck stiffness and sleep).

Each theme and subtheme are presented with codes in the form of quotes labelled according to participant (P) number in table 2.

### Theme A: physical symptoms

When compared with the hypothesised framework, six new subthemes emerged within this theme; with five pain related (when moving, when flying, not wanting to move, after flying and at rest), with pain when flying further subgrouped to include air combat and use of night-vision goggles (NVG). ‘Headaches’ and ‘pain at rest’ are the only consistent subthemes across the two frameworks.

Most participants had experienced pain when moving their head and neck, with rotation the most provocative movement. Pain was associated with air combat flying where head position and the application of gravitational force during flying manoeuvres were contributing factors. Some reported pain with NVG flying, especially ‘long duration use’ or ‘long sorties’. Difficulty sustaining the required head position against gravitational force resistance was reported with the neck being ‘close to the limit of its strength’ and sometimes associated with pain.



**Figure 2** (A) Hypothesised conceptual framework for a neck specific PROM for military aircrew (top left). (B) Revised conceptual framework for a neck specific PROM for military aircrew (bottom right). Thirteen new subthemes were included in the revised conceptual framework, with seven modified (work related, flying, physical symptoms, neck pain, social and activity related, psychological and emotional, and worry) and four discarded (decreased neck range of motion, desk-based work, fatigue and activity avoidance). PROM, patient-reported outcome measure.

Pain duration varied from ‘a couple of days’ to ‘a week and a half’ with participants describing delayed onset of pain to one or 2 days postflying; a comparison made with that experienced with delayed-onset muscle soreness or fatigue. ‘Fatigue’ or ‘tiredness’ in the neck was widely reported, with contributing factors being long duration sorties, weight of the helmet and NVGs, poor neck positioning and acceleration/gravitational force. Some participants described ‘neck stiffness’ and used the term interchangeably with reduced neck movement. The term ‘decreased neck range of motion’ did not reflect the language used by participants and was therefore discarded (figure 2B).

Some described thoracic spine symptoms, describing both tightness and pain in the ‘upper back’ or ‘between the shoulder blades’. Further descriptions included ‘pain in the back of my head’, and it ‘sort of feels like the same muscle’ (P2) as the neck were also used, therefore ‘headaches’ was retained as a subtheme in the revised conceptual framework (figure 2B). Radiating arm symptoms associated with previous acute neck pain episodes, and neck clicking leading to an acute onset of pain were also described. Pain-related fear avoidance was raised and associated with previous acute pain episodes. Some participants described previous episodes of constant symptoms that were present at rest (table 1).

### Theme B: work-related effects

Factors in this theme were modified significantly from the hypothesised framework, with ‘flying performance’ subdivided to include four subthemes and retention of ‘time off work’. Both ‘concentration’ and ‘desk-based work’ were removed as no data were yielded to support inclusion.

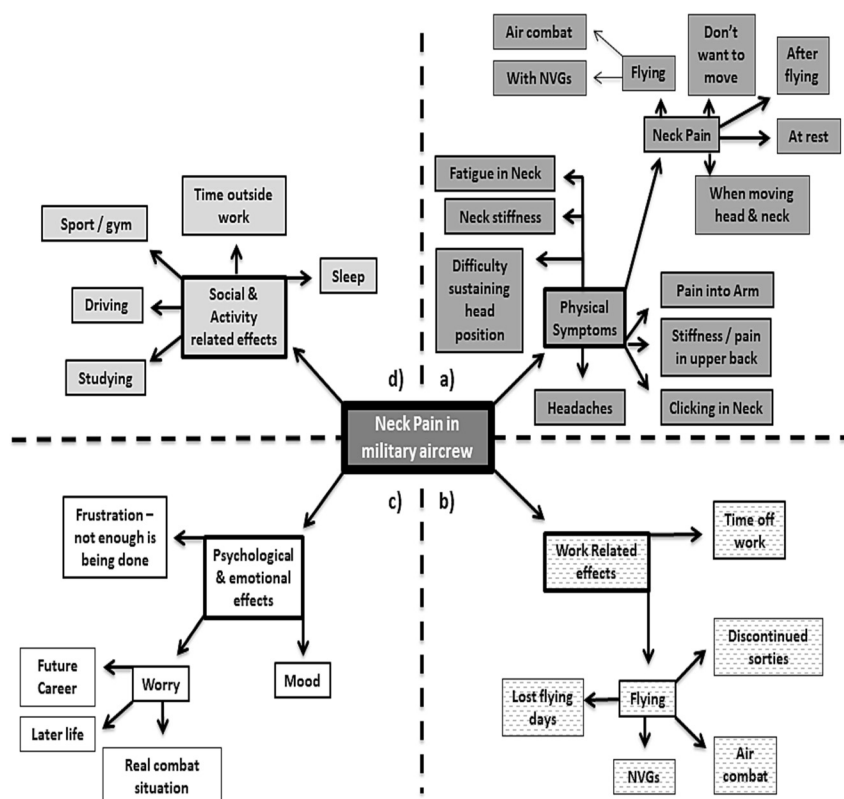
Many participants admitted limiting their air combat flying to avoid neck pain/injury, specifically restricting manoeuvres and gravitational force, or avoiding certain head positions. Some participants discussed how NVG use was affected, ‘flipping them up’ or removing them to avoid neck pain. Some participants referred to occasions when they stopped flying early due to neck pain, or were unable to fly or took time off work. The secondary effects and impact on operational output was expanded on by some of the senior aircrew (table 1).

Subthemes within this theme were modified from the hypothesised framework, with ‘worry’ being divided into three subcategories, and ‘anger or frustration’ revised to ‘frustration’. ‘Mood’ was included as a new subtheme.

Concern about the quality of life implications of ongoing neck and back problems were raised by some participants. Others expressed worry about neck pain affecting their flying career, with both short-term and long-term concerns reflected. Some pointed to concerns

**Table 1** Saturation table compiled during data analysis revealed that concept saturation was reached

Theme	Subthemes	Interview no									
		1	2	3	4	5	6	7	8	9	10
Physical symptoms	1.Neck stiffness/reduced freedom of neck movement		✓								
	2a. Moving head and neck—causes pain	✓									
	2b. Moving head and neck—don't want to due to pain			✓							
	3.Headaches		✓								
	4.Fatigue in neck	✓									
	5.Stiffness or pain in upper back/between shoulder blades	✓									
	6.Difficulty sustaining optimal head position		✓								
	7a. Pain while flying—using NVGs	✓									
	7b. Pain while flying—air combat			✓							
	8.Pain after flying			✓							
Work-related effects	9.Pain down into arm				✓						
	10.Clicking in neck					✓					
	1a. Affects flying—during air combat	✓									
	1b. Affects flying—takes off NVGs			✓							
	2.Discontinued sorties			✓							
	3.Lost flying days		✓								
	4.Time off work				✓						
	1.Sleep (quality or duration)	✓									
	2.Time outside work (socialising, time at home)			✓							
	3.Studying at home	✓									
Social and activity-related effects	4.Participation in sport/gym			✓							
	5.Driving	✓									
	1.Worry about effects in later life	✓									
	2.Worry neck would limit performance in real combat situation									✓	
	3.Worry about future career			✓							
Psychological and Emotional effects	4.Feels that not enough is being done to tackle the problem	✓									
	5.Pain effects mood			✓							
	No of new codes appearing in each interview	10	4	9	2	1	0	0	0	1	0
	% of total new codes (total=27)	37	15	33	7	4	0	0	0	4	0
	NVGs, night-vision goggles.										



**Figure 3** Revised conceptual framework for a neck specific PROM for military aircrew. PROM, patient-reported outcome measure. NVG, night-vision goggles

that neck pain would pose a risk in a real time combat situation. Participants also expressed frustrations that not enough is being done to tackle the issue of neck pain in aircrew with neck symptoms reportedly having an adverse effect mood (table 1).

Three new categories were added to this theme (sport/ gym, driving and studying), while ‘fatigue’ was removed and ‘sleep’ remained unchanged. ‘Social activity’ and ‘activity avoidance’ were encompassed in ‘time outside work’.

Neck pain impacting sleep duration and quality was discussed. The impact of neck pain on time outside work was mentioned, with consequential avoidance of home or social activity. Limiting or stopping sport or weight training was discussed during an acute neck pain episode. Other activities which were impacted by neck pain included driving and home computer use (table 1).

## DISCUSSION

This is the first qualitative study of military aircrew that used in-depth semistructured interviews to investigate flying-related neck pain in fast jet pilots. The study was designed to inform the design and content validity of a pilot specific PROM, focusing on their experiences of occupation related neck pain rather than any current neck pain.<sup>23</sup> Previous studies involving fast jet pilots used self-administered questionnaires with content analysis and quantitative data processing methods, where prior theory and the researcher’s perspective are used

to interpret concepts.<sup>4 15 26</sup> This study used participants words and phrases in ‘ground up’ concept generation, ensuring data accurately reflects participants perspective,<sup>23</sup> whereas previous work has examined pilot’s neck pain experience, with a focus on physical symptoms.<sup>4 15 26</sup> This study additionally examined occupational, psychological and social effects to reflect the wider impact of neck pain on health and function.

## Physical symptoms

Most emergent physical symptoms related to pilot’s experience of neck pain, with some expanding on the circumstances of pain onset. Consistent with a recent literature review,<sup>27</sup> the ‘check six’ position during air combat flying was cited as a cause of neck pain or injury. This requires pilots to adopt combined end range neck extension, lateral flexion and rotation under Gz, placing considerable biomechanical strain on musculoskeletal tissues and structures.<sup>28</sup> NVG use adds to head mounted load particularly when worn for prolonged periods, thereby increasing this strain.<sup>28</sup> Our findings also mirror previous studies where NVG use was linked to in-flight neck pain.<sup>12 14</sup>

Postflight pain onset was also reported which is consistent with a previous fast jet survey.<sup>15</sup> Participants also discussed pain related fear of movement, as previously found in an experimental study of rotary pilots.<sup>13</sup> Fear avoidance is thought to provide a protective mechanism against further injury or pain amplification in the acute injury phase.<sup>29</sup> However, persistent maladaptive behaviours may cause functional activity restriction,<sup>30</sup>



**Table 2** Themes, subthemes and codes

Theme	Subtheme	Codes (participant quotes)
Physical Symptoms	Neck pain	when moving ‘I remember it being painful to move my head, mainly side to side’ (P1) ‘Yeah if I move it that way, then the muscle will pull in my top-left shoulder, so I can’t really do that. Chin-to-chest, I feel it in the same place’ (P4) when flying (air combat & NVGs) ‘So, a burning pain associated with applying Gz (gravitational force) whilst having my neck in certain positions...’ (P9) Participants noted pain with NVG (night vision goggles) flying, especially ‘long duration use’, or on ‘long sorties’ (P1). don’t want to move ‘I don’t know whether I just couldn’t move my neck or I didn’t want to, because I knew that I was going to get dealt another jab of pain’ (P6) after flying ‘...it’s probably akin to having DOMS (delayed onset muscle soreness)...a day or two later you will feel it in the deep muscles as opposed to the external ones’ (P5) at rest ‘Yeah, I was lying on my back... because I could get in a position where I wouldn’t have the tingling—or the pain to the end of the fingers’. (P4)
	Fatigue in neck	‘I do get quite tired, at the base of my neck... That is quite fatiguing actually, to wear the goggles for a long time, fatiguing on the neck’ (P10)
	Neck stiffness	‘Yes that’s usually after I’ve done some sort of combat, ... and come back and put heat strips on....just to stretch it off, just to try and stop it being stiff ...When I haven’t been doing combat... your range of movement is a lot better’. (P5)
	Stiffness or pain in upper back	‘I would say it’s nowhere near as acute or painful as the actual pain in the neck’. (P1) ‘Upper shoulder, across the top of my shoulder. Neck, no not particularly if I’m honest. But for me, it’s across that bit between your shoulder blades, maybe a bit higher’. (P10)
	Difficulty sustaining head position	‘So, a burning pain associated with applying Gz (gravitational force) whilst having my neck in certain positions, and then an inability to hold my neck in that position against Gz’. (P10) ‘One participant described the neck as being ‘close to the limit if it’s strength’, meaning it was ‘hard to sustain the head position that I want’ (P2)
	Headaches	‘...pain in the back of my head’, and it ‘sort of feels like the same muscle’ (P2)
	Pain in arm	‘That was just tightness down my Traps, all the way to my, well pain in my Traps, down to my elbow really, and restricted movement in my neck’. (P4) ‘Yeah, I was lying on my back... because I could get in a position where I wouldn’t have the tingling—or the pain to the end of the fingers.’ (P4)
	Clicking in neck	‘On the Hawk where I had the one with the nice click, and a lot of pain, that was when someone was demonstrating a BFM (basic fighter manoeuvres) turn...’ (P5)

Continued

**Table 2** Continued

Theme	Subtheme	Codes (participant quotes)
Work-related effects	Flying	‘My performance in Typhoon is sub-optimal in a particular skill set, so air combat, because of the way I guard against neck injury’. (P2) ‘I’m acutely aware when I’m wearing goggles that I will always try and limit manoeuvring... I pull as little Gz as absolutely possible...’. (P1) ‘...if I’m wearing the electric hat, then I’m a lot more reticent to actually put my neck into the position that you need to’. (P5)
	air combat	‘I’ll go for protracted periods where they’ll either be up or more likely I’ll just take them off...which of course, is bad, because that’s the only way you’re going to spot anybody shooting you...’. (P10)
	NVGs	‘Recently we probably did about 45 minutes of combat, we refuelled twice, and, on the last iteration of sustained 7G for about 2 or 3 minutes, my neck was just... It was hurting at that point, so I called off the fight’ (P4)
	discontinued sorties	‘We’re so tight on available bodies...that it has a humongous impact on the flying programme...If you take one person out, particularly a supervisor...the entire squadron’s effort for the remainder of the week can just fall over’. (P3)
Time off work	lost flying days	‘...he told me to look right and as he then loaded six G on the jet... I lost a week and a half of flying straight out of that. Then the recent one...that was threedays off, which was fairly quick’ (P5) ‘Obviously, yeah, when I was on my back, yeah, nothing was happening at that point. It was...so I wasn’t working’. (P4)
	Worry	‘Long-term, yeah, I am massively worried about long-term impact on my neck and back, I guess... Yeah, just quality of life, sort of thing, like having ongoing neck and back issues for the remainder of my life’. (P3) ‘Yeah, how long can I sustain that for? How long can I sustain this role if this is what it’s doing to me? How long can I sustain being a fast jet pilot through this discomfort?’. (P4) ‘Maybe I’m one of those people that just will always get neck pain, so maybe I shouldn’t fly the Typhoon anymore’, you know, long-term health. I did have concerns about that’. (P9)
	Frustration	‘Because if I’m in a position where I think, I’m not going to pull as much Gz, because I want my neck to survive, I may not actually survive the thing that I’m doing, because I might be in a real situation’. (P9) ‘Yeah, I firmly believe that the RAF needs to do more. I’ve got a lot of issues with the way we do things... I do have with regards to the RAF allocating you time and effort to be able to try and prevent injuries’. (P1). ‘It probably makes me a bit grumpy sometimes’. (P3)
Psychological and emotional effects	Mood	Continued

Table 2 Continued

Theme	Subtheme	Codes (participant quotes)
Social and activity-related effects	Sleep	'It does affect my sleep. It makes it hard to sleep for a long duration... I just end up thrashing around and almost waking myself up every half an hour' (P3)
	Time outside work	'Particularly when it's in one of your bad bits where, I don't know, you just don't want to do stuff, like I will just have to go and lie down..... I just say to my wife, Sorry... I need a good lie down,' (P3)
		'So actually, the last thing you want to do at the weekend is go out somewhere and you're socialising... sitting there with a heat pack on your neck'. (P5)
		'Yeah, you can't go and, I do a lot of road cycling and the last thing you want to do is kind of hunch over with your neck down'. (P5)
	Sport/gym	'Yeah, so looking that way it's hurting, and maybe that's not checking the left as well as I could do'. (P4)
	Driving	'I mainly notice this once at home, when I've... Because I'm doing a lot of studying at the moment'. (P1)
	Studying	

changes in muscle performance<sup>29 31</sup> and transition to chronic or persistent spinal pain.

Neck fatigue was widely reported in this study, but no previous studies having recognised this as a symptom or differentiated this from neck pain. Previous authors have examined neck neuromuscular fatigue as possible injury risk factor, and compared cumulative effects of low with high gravitational force exposures in fast jet aircrew.<sup>14</sup> In addition, symptoms distal to the neck were reported in this study, with radicular arm symptoms associated with an acute neck pain which is consistent with a previous fast jet survey.<sup>15</sup> Symptoms of stiffness and pain in the upper back were also reported, although not reflected in any previous military aircrew literature. While previously neck pain was widely considered in isolation interest in the relationship (neurophysiological and biomechanical) between the cervical and thoracic regions has gained momentum.<sup>32-34</sup> These findings reflect the strength of the concept elicitation interview format that was used in this study, designed to capture patient's perceptions of their condition to inform content validity and PROM development.<sup>6</sup>

### Work-related effects

Most work-related effects involved limitation or modification of flying. Days lost from flying or discontinuation of sorties due to neck pain was both reported and is in keeping with a previous fast jet survey that suggested 42% of pilots had been temporarily unfit to fly in their career.<sup>4</sup> Secondary impacts of lost flying time were also revealed, with senior pilots discussing implications for achieving key performance indicators. Participants also described modifications of flying technique due to neck pain, again these impacts are previously unreported. NVG removal to relieve neck pain was widely reported, with pilots acknowledging that this poses a significant flight safety risk. Similarly, participants discussed adapting their methods of flying combat manoeuvres, some raising concerns that reduced flying performance could prove fatal in a real-time scenario.

### Psychological and emotional effects

Worrying due to neck pain was discussed by participants, specifically mentioning impact on future career, later life and performance in a real combat scenario. Effects on mood, with being 'grumpy' raised by one pilot with a history of recurrent neck pain, is encompassed by items on three of six most common neck related PROM.<sup>10</sup> Responses were similar to that of the Copenhagen Neck Functional Disability Scale (CNFDS) item 'disruption of future'. The interdependence of psychological and emotional functioning and general well-being is well recognised<sup>35</sup> particularly as the NDI does not represent these domains.<sup>36</sup> Findings demonstrate the significance of these dimensions to neck pain complaints in military aircrew, and therefore should be reflected in a new population specific PROM.

## Social and activity-related effects

The social and activity related problems discussed by the participants largely reflect items found in six common neck-related PROM featured in recent literature review<sup>10</sup> (online supplemental file 2). Sleep and driving were both cited; these feature in four and three of these questionnaires, respectively.<sup>10</sup> Limitations of sport or gym activities was reported in relation to acute pain, which is a population relevant aspect of the 'recreational activities' item included in four PROM.<sup>10</sup> Impact on time outside work was discussed which relates to items on the CNFDS, including family relationships and going out with others.<sup>37</sup>

## Strengths and limitations

Several factors may have influenced data collection, analysis and interpretation and affected the trustworthiness of findings. The sample consisted of only males as no female pilots were available at the time of data collection. Despite meeting qualitative interviewing competencies,<sup>6</sup> the primary researcher (AD) was a relative novice as a qualitative interviewer. Concept saturation was reached in this study but this was assessed retrospectively, whereas assessment throughout data collection is recommended and would have improved methodology.<sup>6</sup> Data coding was conducted by the primary researcher (AD) and cross checked by another researcher (ES) after completion. While time constraints limited the extent of member checking and transcript validation inductive analysis ensured the coding framework and dictionary were a true reflection of participant data.<sup>6</sup>

## Implications for practice and future research

Findings can be used to inform the current practice of physiotherapists working with military aircrew with neck pain. In the absence of a population-specific measure, clinicians should ensure biopsychosocial impact factors of flying are assessed during the patient history taking. Further qualitative research is required to build on these findings and develop a population-specific PROM; cognitive interviewing would test the range and interpretation of concepts and refine the new PROM items.<sup>38</sup> Once a PROM has been developed and validated for fast jet aircrew, it would require revalidation in other military aircrew groups. A population-specific measure would enable investigation of the effectiveness of the ACP, and daily physiotherapy practice to mitigate against neck pain in this unique population.

## CONCLUSION

Flight-related neck pain has a broad impact on the lives of fast jet pilots, including physical symptoms, occupational, psychological and social effects. Physical symptoms were largely associated with neck pain, but other clinically relevant factors included symptoms in other body regions and fear avoidance patterns. Occupational factors included modifications and restrictions of flying, some of which may have flight safety implications. Psychological effects

expanded on feelings of worry, including impact on future quality of life. Social and activity factors reflected items in existing PROM. Further qualitative research is required to develop and validate a population specific PROM for military aircrew.

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**Supplementary file 1. COREC 32-Item Checklist**

No. Item	Guide questions/description	Reported on Page #, line #
Domain 1: Research team and reflexivity		
1. Inter viewer/facilitator	Which author/s conducted the interview?	4, 125
2. Credentials	What were the researcher's credentials?	4, 128
3. Occupation	What was their occupation at the time of the study?	4, 125
4. Gender	Was the researcher male or female?	1, 5
5. Experience and training	What experience or training did the researcher have?	4, 125-126
6. Relationship with participants established	Was a relationship established prior to study commencement?	4, 127
7. Participant knowledge of the interviewer	What did the participants know about the researcher?	4, 125-127
8. Interviewer characteristics	What characteristics were reported about the inter viewer/facilitator?	4, 125-127
Domain 2: study design		
9. Methodological orientation and theory	What methodological orientation was stated to underpin the study?	4, 109-110
10. Sampling	How were participants selected?	7, 141
11. Method of approach	How were participants approached?	7, 147-148
12. Sample size	How many participants were in the study?	7, 143
13. Non-participation	How many people refused to participate or dropped out? Reasons?	7, 147-148
14. Setting of data collection	Where was the data collected?	4, 118
15. Presence of non-participants	Was anyone else present besides the participants and researchers?	4, 128-129
16. Description of sample	What are the important characteristics of the sample?	9, 189-192
17. Interview guide	Were questions, prompts, guides provided by the authors?	6
18. Repeat interviews	Were repeat interviews carried out?	No
19. Audio/visual recording	Did the research use audio or visual recording to collect the data?	4, 128
20. Field notes	Were field notes made during and/or after the interview?	2, 40
21. Duration	What was the duration of the interviews	4, 127
22. Data saturation	Was data saturation discussed?	7, 170-171 & Table 2
23. Transcripts returned	Were transcripts returned to participants correction?	No
Domain 3: analysis and findings		
24. Number of data coders	How many data coders coded the data?	7-8, 167-182
25. Description of the coding tree	Did authors provide a description of the coding tree?	7-8, 167-182
26. Derivation of themes	Were themes identified in advance or derived from the data?	7, 169-182
27. Software	What software, if applicable, was used to manage the data?	n/a
28. Participant checking	Did participants provide feedback on the findings?	No
29. Quotations presented	Were participant quotations presented to illustrate the themes/findings? Was each quotation identified?	10, Table 3
30. Data and findings consistency	Was there consistency between the data presented and the findings?	9, 204-205 & Table 3
31. Clarity of major themes	Were major themes clearly presented in the findings?	Page 9-13 & Table 3
32. Clarity of minor themes	Is there a description of diverse cases or discussion of minor themes?	Page 9-13 & Table 3

**Supplementary file 2. Neck pain patient reported outcome measures**

Item activity	NDI	NPDS	NPQ	NBQ	CNFDS	WDQ
Pain intensity	✓	✓	✓	✓ over past week		✓
Personal care	✓	✓			✓ getting dressed in same time ✓ bend over sink to brush teeth without pain	✓
Lifting	✓				✓ objects from 2-4kg	
Reading	✓		✓+ TV		✓	
Headaches	✓				✓	
Concentration	✓	✓			✓	✓
Work	✓	✓	✓+ housework	✓ inside & out home over past week		✓+ home/study duties
Driving	✓	✓	✓			✓ or using public transport
Sleeping	✓	✓	✓		✓	✓
Recreation	✓	✓		✓ +social & family over past week	✓ leisure with family	✓ non sporting leisure activities
Average pain		✓				
Worst pain		✓				
Standing		✓				
Walking		✓				
Social activities		✓	✓		✓ going out with others	✓
Personal relationships		✓			✓ with family	
Outlook on life		✓				
Emotions		✓				
Neck stiffness		✓				
Turning head		✓				
Looking up & down		✓				
Working overhead		✓				
Pain pills helpful		✓				
Pins & needles in arms at night			✓			
Symptom duration			✓			
Carrying			✓			
Diff since last NPQ			✓			
Daily activities				✓ housework, washing, dressing, lifting, reading, driving over past week	✓ as before with pain & ✓ without help from others	
Anxious				✓ tense, uptight, irritable, difficulty concentrating/relaxing over past week		✓
Depression/sadness				✓ down in dumps, sad, in low spirits, pessimistic, unhappy over past week		✓
Self control of pain				✓ over past week		
More time at home					✓	
More time in bed					✓	
Disruption of future					✓	
Tiredness/fatigue						✓
Sport						✓
Anger						✓

Abbreviations: NDI= Neck Disability Index, NPDS = Neck Pain and Disability Questionnaire, NPQ = Northwick Park Neck Pain Questionnaire, NBQ = Neck Bournemouth Questionnaire, CNFDS = Copenhagen Neck Functional Disability Scale, WDQ = Whiplash Disability Questionnaire