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

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3 1 **Development of a patient reported outcome measure for neck pain in military aircrew: qualitative**
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5 2 **interviews to inform design and content**
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38 **ABSTRACT**

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

45 **Methods:** Qualitative semi structured interviews combining phenomenological and grounded theory
46 methods, reported using COREQ guidelines. Purposive sample of 10 fast jet pilots with neck pain were
47 recruited. Concept elicitation interviews were audio recorded, transcribed verbatim along with field
48 notes. Data analysis involved subject and methodological expertise used a concept elicitation
49 approach.

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

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

58 **Key words:** Aircrew, Neck pain, Patient-reported outcome measure (PROM); Qualitative

59 **ARTICLE SUMMARY**

61 **Strengths and limitations of this study**

- 62 • Findings provide fast jet pilots' perspective on the implications of neck pain to inform content
63 validity of a population specific PROM
- 64 • The study design and methods are informed and reported in line with published guidance
65 (COREQ, concept elicitation)
- 66 • The sample included only male participants from one military squadron
- 67 • Further research is required to enable cognitive debriefing of the derived domains

68 INTRODUCTION

69

70 Flight related neck pain is a common musculoskeletal problem for military pilots, with
71 prevalence reported as 66% for all Royal Air Force (RAF) aircrew, and 70% for UK fast jet pilots. [1] One-
72 year estimates for Danish helicopter pilots were 43-48%, relative to 26% in the general population.[2]
73 Neck pain incidence is consistently higher relative to the general population despite several neck pain
74 risk factors, such as age, physical inactivity and female gender, being lower amongst military groups.[3]

75 UK Defence Rehabilitation services have taken steps to address this issue and mitigate known
76 under reporting of neck pain amongst aircrew.[4] The Aircrew Conditioning Program (ACP)[5] has been
77 introduced due to evidence supporting targeted strength training as a preventative strategy, [4, 6] and
78 direct access to physiotherapy services are now available to aircrew. However, in the absence of a
79 population specific outcome measure the effectiveness of these interventions remains unknown.

80 Patient reported outcome measures (PROM) facilitate healthcare service quality
81 improvement, and are integral to evidence-based practice. PROM can be disease specific or generic,
82 where disease specific measures are more sensitive to change in a single patient with regional specific
83 musculoskeletal dysfunction. [7] This supports their use for investigating the effectiveness of
84 interventions such as conditioning programmes. [8]

85 The Neck Pain Disability Index (NDI) is the most widely used validated neck specific PROM, [9]
86 although its applicability to military aircrew is unknown. Content validity is the psychometric measure
87 that considers the relevance of a PROM to the population of interest. The COSMIN checklist, a well-
88 established PROM quality assessment tool, requires that 'age, gender, disease characteristics, country
89 and setting' are well matched.[10] In addition to demographic and disease related differences, the
90 occupational and ergonomic demands vary greatly between the general and military populations. Poor
91 head postures, continuous vibration, repetitive movements, sustained static postures and neck loading
92 from combat flying equipment, are all unique military risk factors. [11]

93 Beyond the physical factors, psychological factors such as working on military operations
94 creates a further set of population-specific risk factors.[12, 13] Military culture may influence
95 healthcare attitudes and beliefs, with evidence indicating that pilots were reluctant to provide
96 accurate information [14] and seek treatment for neck pain. [4] These factors may alter the
97 psychometric properties of PROM by affecting how individuals approach tasks and score questionnaire
98 items. [15] It is evident that the COSMIN content validity requirements would not be met by an existing
99 PROM.

100 Across the military aircrew populations, neck pain in fast jet pilots poses a greater flight safety
101 risk to due to higher pain prevalence, [1] and pilots flying solo. Training and airframe costs are also
102 relatively higher, which increases the price of pilot hours lost to neck pain. [16] This study therefore

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2
3 103 aimed to explore the psychological, social and occupation factors of flight related neck pain in fast jet
4 104 aircrew to inform the content validity of a new population specific PROM.

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6 105

8 106 **DESIGN & METHODS**

10 107 **Theoretical framework**

11 108 The study followed the concept elicitation format for new PROM; the methodological orientation
12 109 combined phenomenological and grounded theory approaches adapted to consider prior knowledge
13 110 to inform the study design and topic guide. [6] In line with the study aims this allowed us to acquire an
14 111 in depth understanding of the experiences of neck pain from individual fast jet pilots. The study was
15 112 reported using the Consolidated Criteria for Reporting Qualitative Studies (Supplementary file 1). [17]

16 113

18 114 **Design and setting**

19 115 Qualitative semi structured interviews of the experiences of neck pain in fast jet pilots (Typhoon flying
20 116 squadron) were conducted at RAF Akrotiri, Cyprus between 17th and 25th July 2018.

21 117 *Interviews*

22 118 Semi structured interviews were used to maximise the insight of neck pain in fast jet pilots across the
23 119 biopsychosocial framework. This allowed us to explore in depth past and current experiences of neck
24 120 pain, attitudes and beliefs about neck pain, associated occupational factors and impact on function
25 121 and performance within and outside work.

26 122 *Interview procedure and topic guide*

27 123 Semi structured interviews were conducted by a musculoskeletal physiotherapist (AD) (BSc Hons, PG
28 124 Dip) with ten years musculoskeletal physiotherapy experience, and seven years working with RAF fast
29 125 jet pilots. Participants were unknown to the researcher and no prior relationship was established.
30 126 Interviews lasted between 15 and 50 minutes and were recorded using digital voice recorder. No one
31 127 else was present.

32 128 The topic guide (Table 1) was developed by the research team (AD, ES, NH) in accordance with
33 129 published guidance [6] i) a disease model for neck pain in the general population, [18] modified to
34 130 acknowledge population specific differences ii) a proposed endpoint model for a new PROM for
35 131 military aircrew (Figure 1), and the hypothesised conceptual framework (Figure 2a). The derived topic
36 132 guide incorporated existing evidence and review of items in existing PROM. This included previous
37 133 work, which critiqued the content validity of the NDI, and informed the development of a population
38 134 specific tool for WAD. [19, 20] The topic guide was 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 and 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

Firstly, 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 ROM, 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?
 - 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?

135

136 **Table 1 – Topic guide**

137 **Participants**

138 *Sampling and recruitment*

139 Purposive sampling [21] was utilised to recruit fast jet aircrew across a range of characteristics,
140 including age, gender, flying experience, fast jet flying hours and neck pain presentations. The sample
141 size was predetermined at ten participants, as this was deemed sufficient to reach concept saturation.
142 [6, 22] Inclusion criteria were: member of Typhoon flying squadron, qualified fast jet pilot, fully
143 operational flight status at enrolment, or lost operational flight status due to flying related neck pain
144 (no other reason). Exclusion criteria included: no previous occurrences of flight related neck pain. A
145 participant information sheet was distributed by email to potentially eligible pilots; all those
146 approached agreed to participate in the study.

147

148 *Ethical approval*

149 The study protocol was approved in advance by the Ministry of Defence Research Ethics
150 Committee (reference 844/MODREQ/18, 29 June 2018), and the University of Birmingham Ethics
151 Committee. At the beginning of each interview, the participant information sheet was discussed and
152 questions were answered. Confidentiality and the concept of voluntary participation was explained,
153 including the process of withdrawal. All subjects provided written informed consent before
154 participating.

155

156 **Patient and public involvement**

157

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

161

162 **Data analysis**

163 Data was analysed according to a recommended process of coding and data analysis, [6]
164 combined with guidance on thematic analysis. [23]

165 An initial coding framework was created from the topic guide, hypothesised conceptual
166 framework and data from pilot testing. [6] The lead research (AD) assigned codes to themes that
167 featured in interview transcripts and documented all modifications to the initial framework, which
168 was expanded and restructured continuously as new data emerged. [6] A saturation table compiled
169 during data analysis revealed that concept saturation was reached (Table 2). Once all transcripts had
170 been processed, a coding dictionary was developed detailing all participant quotes according to each

1
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3 171 code. This enabled comparison of grouped data and an initial check of coding consistency. [23]
4
5 172 Inductive analysis informed further modifications in coding terminology and theme allocation,
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7 173 ensuring the coding framework and dictionary were a true reflection of participant data and not
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9 174 imposed by previous knowledge.[6]

10 175 Co-investigators (NH and ES) assisted with data analysis and interpretation to enhance the
11
12 176 credibility of study findings. ES, a highly experienced musculoskeletal physiotherapy and researcher
13
14 177 checked coding and theme allocation by matching patient quotes to themes and codes in accordance
15
16 178 with previous guidance.[24] Reflexivity was used throughout and a revised conceptual framework
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18 179 (figure 2b), or thematic map generated for further analysis and interpretation by the research team.
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Theme	Sub-themes	Interview Number									
		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 whilst flying – using NVGs	✓									
	7b. Pain whilst flying – air combat			✓							
	8. Pain after flying			✓							
9. Pain down into arm				✓							
10. Clicking in neck					✓						
Work related effects	1a. Affects flying – during air combat	✓									
	1b. Affects flying – takes off NVGs			✓							
	2. Discontinued sorties			✓							
	3. Lost flying days		✓								
4. Time off work				✓							
Social & Activity related effects	1. Sleep (quality or duration)	✓									
	2. Time outside work (socialising, time at home)			✓							
	3. Studying at home	✓									
	4. Participation in sport/gym			✓							
	5. Driving	✓									
Psychological & Emotional effects	1. Worry about effects in later life	✓									
	2. Worry neck would limit performance in real combat situation									✓	
	3. Worry about future career			✓							
	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

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206 **Table 2 – Saturation table**

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208

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210 **RESULTS**

211 The sample comprised ten male RAF fast jet pilots, with mean age 34.7 years (range 29-41
212 years), and a wide range of flying experience (median 1850 hours, range 650-3000 hours), fast jet
213 flying hours (median 1200 hours, range 300-2400 hours) and neck pain prevalence (median 3.5, range
214 1-100 incidents).

215
216 Findings support significant modifications to the hypothesised conceptual framework (Figure 2a)
217 when compared to the revised conceptual framework that was developed following data collection.
218 (Figure 2b).

219
220 Figure 3 (a-d) illustrates these according to our derived themes. Collectively this includes
221 thirteen new sub-themes, with seven modified and four discarded as no data was collected to support
222 their inclusion. Only four themes remain unchanged across the two frameworks (headaches, pain at
223 rest, neck stiffness, and sleep). We therefore propose the following themes for the revised framework;
224 (a) physical symptoms, (b) work related effects, (c) psychological and emotional effects and (d) social
225 and activity related effects.

226 Each theme and subtheme are presented with codes in the form of quotes labelled according
227 to participant (P) number in table 3.

228

Theme	Sub theme		Codes (participant quotes)
Physical Symptoms	Neck pain	when moving	<i>'I remember it being painful to move my head, mainly side to side' (P1)</i> <i>'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)</i>
		when flying (air combat & NVGs)	<i>'So, a burning pain associated with applying Gz (gravitational force) whilst having my neck in certain positions...' (P9)</i> <i>Participants noted pain with NVG (night vision goggles) flying, especially 'long duration use', or on 'long sorties' (P1).</i>
		don't want to move	<i>'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)</i>
		after flying	<i>'...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)</i>
		at rest	<i>'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)</i>

	<i>Fatigue in neck</i>		<i>'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)</i>
	<i>Neck stiffness</i>		<i>'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)</i>
	<i>Stiffness or pain in upper back</i>		<i>'I would say it's nowhere near as acute or painful as the actual pain in the neck'. (P1)</i> <i>'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)</i>
	<i>Difficulty sustaining head position</i>		<i>'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)</i> <i>'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)</i>
	<i>Headaches</i>		<i>...'pain in the back of my head', and it 'sort of feels like the same muscle' (P2)</i>
	<i>Pain in arm</i>		<i>'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)</i> <i>'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)</i>
	<i>Clicking in neck</i>		<i>'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)</i>
Work related effects	Flying	<i>air combat</i>	<i>'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> <i>'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)</i> <i>'...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)</i>
		<i>NVGs</i>	<i>'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)</i>
		<i>discontinued sorties</i>	<i>'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)</i> <i>'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</i>

			<i>squadron's effort for the remainder of the week can just fall over'. (P3)</i>
		<i>lost flying days</i>	<i>'...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 three days off, which was fairly quick' (P5)</i>
		<i>Time off work</i>	<i>'Obviously, yeah, when I was on my back, yeah, nothing was happening at that point. It was...so I wasn't working'. (P4)</i>
Psychological & Emotional effects	Worry	<i>effects in later life</i>	<i>'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)</i>
		<i>future career</i>	<i>'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)</i>
		<i>real combat situation</i>	<i>'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)</i>
		<i>Frustration</i>	<i>'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).</i>
		<i>Mood</i>	<i>'It probably makes me a bit grumpy sometimes'. (P3)</i>
	Social & Activity related effects	<i>Sleep</i>	
<i>Time outside work</i>			<i>'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)</i>
			<i>'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)</i>
<i>Sport/gym</i>			<i>'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)</i>
<i>Driving</i>			<i>'Yeah, so looking that way it's hurting, and maybe that's not checking the left as well as I could do'. (P4)</i>
	<i>Studying</i>		<i>'I mainly notice this once at home, when I've... Because I'm doing a lot of studying at the moment'. (P1)</i>

229

230 **Table 3. Themes, subthemes and codes**

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1
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3 233 Theme A: Physical Symptoms
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5 234 When compared to the hypothesised framework, six new sub-themes emerged within this
6 235 theme; with five pain-related (when moving, when flying, not wanting to move, after flying, and at
7 236 rest), with pain when flying further sub-grouped to include air combat and use of night-vision goggles
8 237 (NVG). 'Headaches' and 'pain at rest' are the only consistent sub-themes across the two frameworks.

9
10 238 Most participants had experienced pain when moving their head and neck, with rotation the
11 239 most provocative movement. Pain was associated with air combat flying where head position and the
12 240 application of gravitational force during flying manoeuvres were contributing factors. Some reported
13 241 pain with NVG flying, especially 'long duration use', or 'long sorties'. Difficulty sustaining the required
14 242 head position against gravitational force resistance was reported with the neck being 'close to the
15 243 limit of its strength' and sometimes associated with pain.

16 244 Pain duration varied from 'a couple of days' to 'a week and a half' with participants describing
17 245 delayed onset of pain to one or two days post flying; a comparison made with that experienced with
18 246 delayed onset muscle soreness (DOMS), or fatigue. 'Fatigue' or 'tiredness' in the neck was widely
19 247 reported, with contributing factors being long duration sorties, weight of the helmet and NVGs, poor
20 248 neck positioning and acceleration/gravitational force. Some participants described 'neck stiffness'
21 249 and used the term interchangeably with reduced neck movement. The term 'decreased neck range of
22 250 motion' did not reflect the language used by participants and was therefore discarded (figure 2b).

23 251 Some described thoracic spine symptoms, describing both tightness and pain in the 'upper
24 252 back' or 'between the shoulder blades'. Further descriptions included 'pain in the back of my head',
25 253 and it 'sort of feels like the same muscle' (P2) as the neck were also used, therefore 'headaches' was
26 254 retained as a sub-theme in the revised conceptual framework (figure 2b). Radiating arm symptoms
27 255 associated with previous acute neck pain episodes, and neck clicking leading to an acute onset of pain
28 256 were also described. Pain related fear avoidance was raised and associated with previous acute pain
29 257 episodes. Some participants described previous episodes of constant symptoms that were present at
30 258 rest. (Table 2)

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35 260 Theme B: Work related effects
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37 261 Factors in this theme were modified significantly from the hypothesised framework, with
38 262 'flying performance' sub divided to include four sub-themes and retention of 'time off work'. Both
39 263 'concentration' and 'desk-based work' were removed as no data was yielded to support inclusion.

40 264 Many participants admitted limiting their air combat flying to avoid neck pain/injury,
41 265 specifically restricting manoeuvres and gravitational force, or avoiding certain head positions. Some
42 266 participants discussed how NVG use was affected, 'flipping them up' or removing them to avoid neck
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3 267 pain. Some participants referred to occasions when they stopped flying early due to neck pain, or were
4
5 268 unable to fly or took time off work. The secondary effects and impact on operational output was
6
7 269 expanded on by some of the senior aircrew. (Table 2)
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9 270

10 271 Theme C: Psychological & Emotional effects

11 272 Sub-themes within this theme were modified from the hypothesised framework, with 'worry'
12
13 273 being divided into three sub-categories, and 'anger or frustration' revised to 'frustration'. 'Mood' was
14
15 274 included as a new sub-theme.

16 275 Concern about the quality of life implications of ongoing neck and back problems were raised
17
18 276 by some participants. Others expressed worry about neck pain affecting their flying career, with both
19
20 277 short and long-term concerns reflected. Some pointed to concerns that neck pain would pose a risk in
21
22 278 a real time combat situation. Participants also expressed frustrations that not enough is being done
23
24 279 to tackle the issue of neck pain in aircrew with neck symptoms reportedly having an adverse effect
25
26 280 mood. (Table 2)
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28 281

28 282 Theme D: Social & Activity related effects

29
30 283 Three new categories were added to this theme (sport/gym, driving and studying), whilst
31
32 284 'fatigue' was removed and 'sleep' remained unchanged. 'Social activity' and 'activity avoidance' were
33
34 285 encompassed in 'time outside work'.

35 286 Neck pain impacting sleep duration and quality was discussed. The impact of neck pain on
36
37 287 time outside work was mentioned, with consequential avoidance of home or social activity. Limiting
38
39 288 or stopping sport or weight training was discussed during an acute neck pain episode. Other activities
40
41 289 which were impacted by neck pain included driving and home computer use. (Table 2)
42
43 290
44 291

45 292 **DISCUSSION**

46 293
47
48 294 This is the first qualitative study of military aircrew that used in-depth semi structured
49
50 295 interviews to investigate flying related neck pain in fast jet pilots. The study was designed to inform
51
52 296 the content validity of a pilot specific PROM. [22] Previous studies involving fast jet pilots used self-
53
54 297 administered questionnaires with content analysis and quantitative data processing methods, where
55
56 298 prior theory and the researcher's perspective are used to interpret concepts.[4, 14, 25] This study
57
58 299 used participants words and phrases in 'ground up' concept generation, ensuring data accurately
59
60 300 reflects participants perspective.[22] Furthermore previous work examined pilot's neck pain

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3 301 experience, with a focus on physical symptoms. [4, 14, 25] This study additionally examined
4
5 302 occupational, psychological and social effects to reflect the wider impact of neck pain on health and
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7 303 function.
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9 304

10 305 **Physical Symptoms**

11 306 Most emergent physical symptoms related to pilot's experience of neck pain, with some
12
13 307 expanding on the circumstances of pain onset. Consistent with a recent literature review,[26] the
14
15 308 'check six' position during air combat flying was cited as a cause of neck pain or injury. This requires
16
17 309 pilots to adopt combined end range neck extension, lateral flexion and rotation under Gz, placing
18
19 310 considerable biomechanical strain on musculoskeletal tissues and structures.[27] NVG use adds to
20
21 311 head mounted load, thereby increasing this strain.[27] Our findings also mirror previous studies where
22
23 312 NVG use was linked to in-flight neck pain.[11, 13]

24 313 Post flight pain onset was also reported which is consistent with a previous fast jet survey.[14]
25
26 314 Participants also discussed pain related fear of movement, as previously found in an experimental
27
28 315 study of rotary pilots.[12] Fear avoidance is thought to provide a protective mechanism against further
29
30 316 injury or pain amplification in the acute injury phase.[28] However, persistent maladaptive behaviours
31
32 317 may cause functional activity restriction,[29] changes in muscle performance, [28, 30] and transition
33
34 318 to chronic or persistent spinal pain.

35 319 Neck fatigue was widely reported in this study, but no previous studies having recognised this
36
37 320 as a symptom or differentiated this from neck pain. Previous authors have examined neck
38
39 321 neuromuscular fatigue as possible injury risk factor, and compared cumulative effects of low with high
40
41 322 gravitational force exposures in fast jet aircrew.[13] In addition, symptoms distal to the neck were
42
43 323 reported in this study, with radicular arm symptoms associated with an acute neck pain which is
44
45 324 consistent with a previous fast jet survey.[14] Symptoms of stiffness and pain in the upper back were
46
47 325 also reported, although not reflected in any previous military aircrew literature. Whilst previously neck
48
49 326 pain was widely considered in isolation interest in the relationship (neurophysiological and
50
51 327 biomechanical) between the cervical and thoracic regions has gained momentum.[31-33] These
52
53 328 findings reflect the strength of the concept elicitation interview format that was used in this study,
54
55 329 designed to capture patient's perceptions of their condition to inform content validity and PROM
56
57 330 development. [6]

58 331

59 332 **Work related effects**

60 333 Most work related effects involved limitation or modification of flying. Days lost from flying
334 or discontinuation of sorties due to neck pain was both reported and is in keeping with a previous fast

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3 335 jet survey that suggested 42% of pilots had been temporarily unfit to fly in their career.[4] Secondary
4 336 impacts of lost flying time were also revealed, with senior pilots discussing implications for achieving
5 337 key performance indicators. Participants also described modifications of flying technique due to neck
6 338 pain, again these impacts are previously unreported. NVG removal to relieve neck pain was widely
7 339 reported, with pilots acknowledging that this poses a significant flight safety risk. Similarly,
8 340 participants discussed adapting their methods of flying combat manoeuvres, some raising concerns
9 341 that reduced flying performance could prove fatal in a real-time scenario.

342

343 **Psychological & emotional effects**

344 Worrying due to neck pain was discussed by participants, specifically mentioning impact on
345 future career, later life, and performance in a real combat scenario. Effects on mood, or being
346 'grumpy' was raised, this being encompassed by items on three of six most common neck related
347 PROM.[9] Responses were similar to that of the Copenhagen Neck Functional Disability Scale (CNFDS)
348 item 'disruption of future'. The interdependence of psychological and emotional functioning and
349 general wellbeing is well recognised.[34] Findings demonstrate the significance of these dimension to
350 neck pain complaints in military aircrew, and therefore should be reflected in a new population
351 specific PROM.

352

353 **Social & activity related effects**

354 The social and activity related problems discussed by the participants largely reflect items
355 found in six common neck related PROM featured in recent literature review.[9] (Supplementary file
356 2) Sleep and driving were both cited; these feature in four and three of these questionnaires
357 respectively.[9] Limitations of sport or gym activities was reported in relation to acute pain, which is
358 a population relevant aspect of the 'recreational activities' item included in four PROM.[9] Impact on
359 time outside work was discussed which relates to items on the CNFDS, including family relationships
360 and going out with others.[35]

361

362 **Strengths and limitations**

363 Several factors may have influenced data collection, analysis and interpretation and affected
364 the trustworthiness of findings. The sample consisted of only males as no female pilots were available
365 at the time of data collection. Despite meeting qualitative interviewing competencies,[6] the primary
366 researcher (AD) was a relative novice as a qualitative interviewer. Concept saturation was reached in
367 this study but this was assessed retrospectively, whereas assessment throughout data collection is
368 recommended and would have improved methodology.[6] Data coding was conducted by the primary

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3 369 researcher (AD) and cross checked by another researcher (ES) after completion. Time constraints
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5 370 limited the extent of member checking and transcript validation. [6]

6 371

8 372 **Implications for practice and future research**

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10 373 Findings can be used to inform the current practice of physiotherapists working with military
11 374 aircrew with neck pain. In the absence of a population specific measure, clinicians should ensure
12
13 375 biopsychosocial impact factors of flying are assessed during patient history taking.

14
15 376 Further qualitative research is required to build on these findings and develop a population specific
16 377 PROM; cognitive interviewing would test the range and interpretation of concepts and refine the new
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18 378 PROM items.[36] Once a PROM has been developed and validated for fast jet aircrew, it would require
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20 379 re-validation in other military aircrew groups. A population specific measure would enable
21
22 380 investigation of the effectiveness of the ACP, and daily physiotherapy practice to mitigate against neck
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24 381 pain in this unique population.

25 382

26 383 **CONCLUSION**

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28 384 Flight related neck pain has a broad impact on the lives of fast jet pilots, including physical
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30 385 symptoms, occupational, psychological and social effects. Physical symptoms were largely associated
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32 386 with neck pain, but other clinically relevant factors included symptoms in other body regions and fear
33
34 387 avoidance patterns. Occupational factors included modifications and restrictions of flying, some of
35
36 388 which may have flight safety implications. Psychological effects expanded on feelings of worry,
37
38 389 including impact on future quality of life. Social and activity factors reflected items in existing PROM.
39
40 390 Further qualitative research is required to develop and validate a population specific PROM for
41
42 391 military aircrew.

43 392

44 393

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46
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48
49 396 discussed their thoughts and experiences.

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51
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53 399

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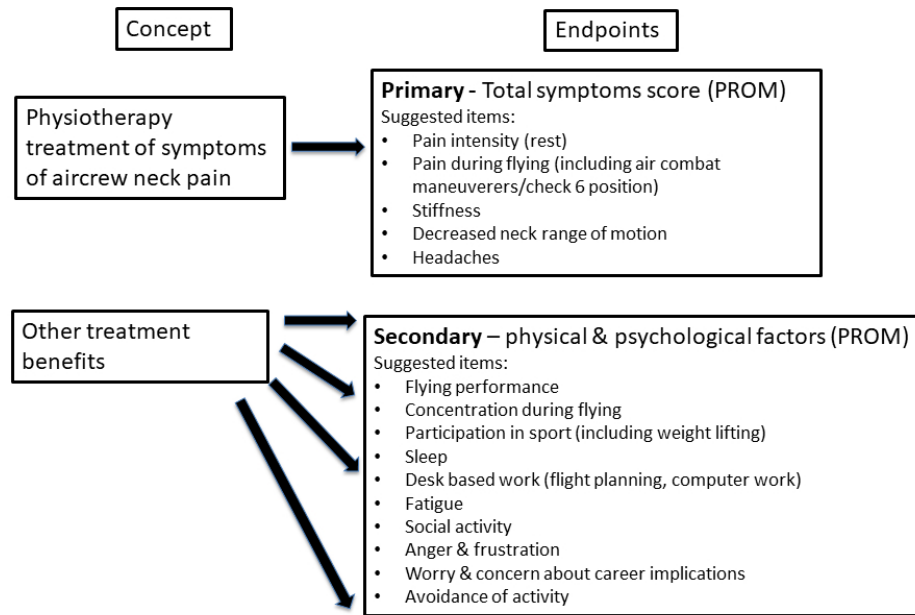
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15 507 **FIGURE LEGENDS**

16
17 508 **Figure 1 Proposed endpoint model for a new neck specific PROM for military aircrew**

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19 509 **Figure 2 a) Hypothesised b) Revised conceptual framework for a neck specific PROM for military**
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21 510 **aircrew**

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24 511 **Figure 3 - Revised conceptual framework for a neck specific PROM for military aircrew**

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31 Figure 1 Proposed endpoint model for a new neck specific PROM for military aircrew

32 81x60mm (300 x 300 DPI)

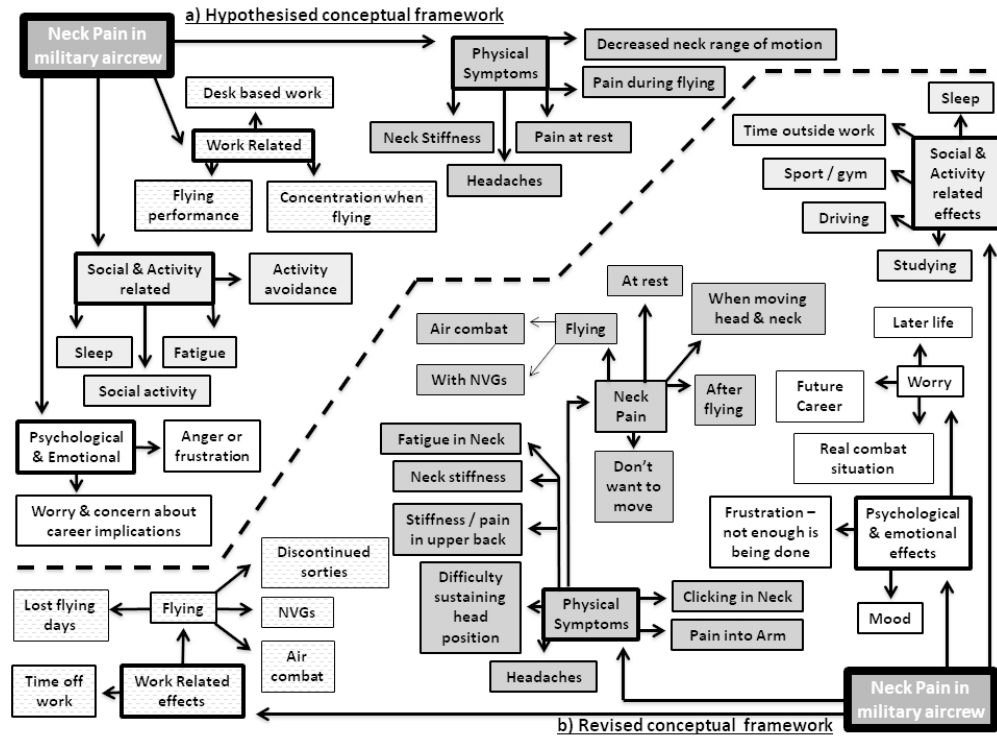


Figure 2 a) Hypothesised b) Revised conceptual framework for a neck specific PROM for military aircrew

81x60mm (300 x 300 DPI)

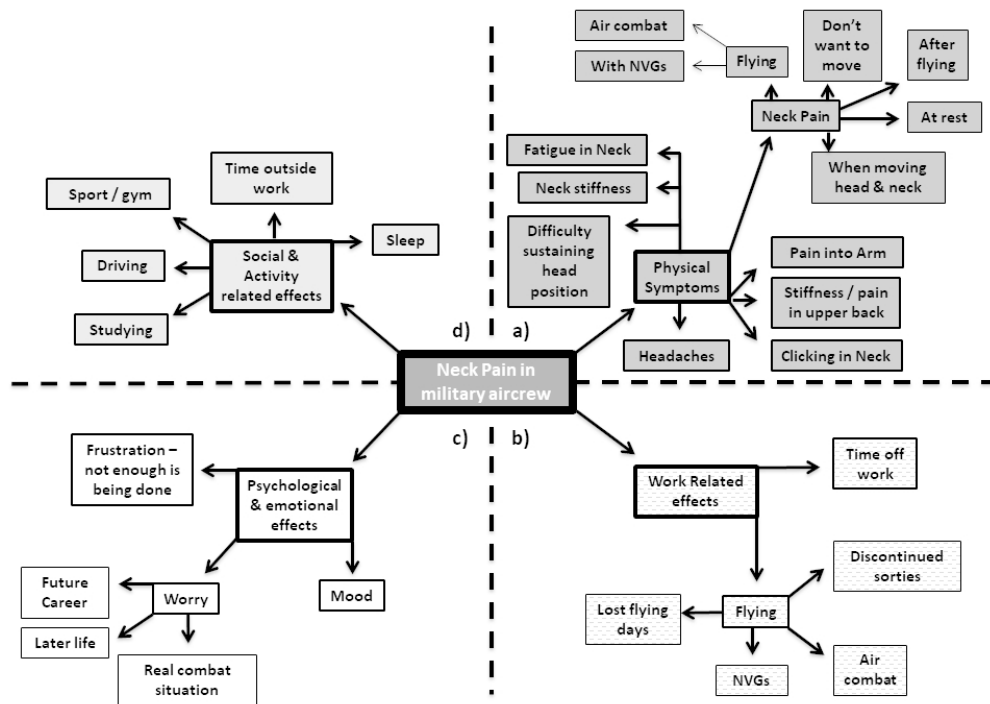


Figure 3 Revised conceptual framework for a neck specific PROM for military aircrew

81x60mm (300 x 300 DPI)

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 interviewer/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		✓

1	Self control of pain				✓ over past week		
2	More time at home					✓	
3	More time in bed					✓	
4	Disruption of future					✓	
5							
6	Tiredness/fatigue						✓
7	Sport						✓
8	Anger						✓
9							

10
11
12 Abbreviations: NDI= Neck Disability Index, NPDS = Neck Pain and Disability Questionnaire, NPQ =
13 Northwick Park Neck Pain Questionnaire, NBQ = Neck Bournemouth Questionnaire, CNFDS =
14 Copenhagen Neck Functional Disability Scale, WDQ = Whiplash Disability Questionnaire
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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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Primary Subject Heading:	Occupational and environmental medicine
Secondary Subject Heading:	Rehabilitation medicine, Qualitative research, Patient-centred medicine
Keywords:	REHABILITATION MEDICINE, AVIATION MEDICINE, Musculoskeletal disorders < ORTHOPAEDIC & TRAUMA SURGERY

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3 1 **Development of a patient reported outcome measure for neck pain in military aircrew: qualitative**
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5 2 **interviews to inform design and content**
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38 **ABSTRACT**

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

45 **Methods:** Qualitative semi structured interviews combining phenomenological and grounded theory
46 methods, reported using COREQ guidelines. Purposive sample of 10 fast jet pilots with neck pain were
47 recruited. Concept elicitation interviews were audio recorded, transcribed verbatim along with field
48 notes. Data analysis involved subject and methodological expertise used a concept elicitation
49 approach.

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

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

58 **Key words:** Aircrew, Neck pain, Patient-reported outcome measure (PROM); Qualitative

60 **ARTICLE SUMMARY**

61 **Strengths and limitations of this study**

- 62 • Findings provide fast jet pilots' perspective on the implications of neck pain to inform content
63 validity of a population specific PROM
- 64 • The study design and methods are informed and reported in line with published guidance
65 (COREQ, concept elicitation)
- 66 • The sample included only male participants from one military squadron
- 67 • Further research is required to enable cognitive debriefing of the derived domains

68 INTRODUCTION

69

70 Flight related neck pain is a common musculoskeletal problem for military pilots, with
71 prevalence reported as 66% for all Royal Air Force (RAF) aircrew, and 70% for UK fast jet pilots. [1] One-
72 year estimates for Danish helicopter pilots were 43-48%, relative to 26% in the general population.[2]
73 Neck pain incidence is consistently higher relative to the general population despite several neck pain
74 risk factors, such as age, physical inactivity and female gender, being lower amongst military groups.[3]

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

82 Patient reported outcome measures (PROM) facilitate healthcare service quality
83 improvement, and are integral to evidence-based practice. PROM can be disease specific or generic,
84 where disease specific measures are more sensitive to change in a single patient with regional specific
85 musculoskeletal dysfunction. [8] This supports their use for investigating the effectiveness of
86 interventions such as conditioning programmes. [9] The Neck Pain Disability Index (NDI) is the most
87 widely used validated neck specific PROM, [10] although its applicability to military aircrew is
88 unknown. Content validity is the psychometric measure that considers the relevance of a PROM to the
89 population of interest. The COSMIN checklist, a well-established PROM quality assessment tool,
90 requires that 'age, gender, disease characteristics, country and setting' are well matched.[11] In
91 addition to demographic and disease related differences, the occupational and ergonomic demands
92 vary greatly between the general and military populations. [12] Poor head postures, continuous
93 vibration, repetitive movements, sustained static postures and neck loading from combat flying
94 equipment, are all unique military risk factors. [12] Beyond the physical factors, psychological factors
95 such as working on military operations creates a further set of population-specific risk factors.[13, 14]
96 Military culture may influence healthcare attitudes and beliefs, with evidence indicating that pilots
97 were reluctant to provide accurate information [15] and seek treatment for neck pain. [4] These factors
98 may alter the psychometric properties of PROM by affecting how individuals approach tasks and score
99 questionnaire items. [16] It is evident that the COSMIN content validity requirements would not be
100 met by an existing PROM.

101 Across the military aircrew populations, neck pain in fast jet pilots poses a greater flight safety
102 risk to due to higher pain prevalence, [1] and pilots flying solo. Training and airframe costs are also

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3 103 relatively higher, which increases the price of pilot hours lost to neck pain. [17] This qualitative study
4 104 therefore aimed to explore the psychological, social and occupation factors of flight related neck pain
5 105 in fast jet aircrew during their career to inform the design and content validity of a new population
6 106 specific PROM.
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11 108 **DESIGN & METHODS**

12 109 **Theoretical framework**

13 110 The study followed the concept elicitation format for new PROM; the methodological
14 111 orientation combined phenomenological and grounded theory approaches adapted to consider prior
15 112 knowledge to inform the study design and topic guide. [6] In line with the study aims this allowed us
16 113 to acquire an in depth understanding of the experiences of neck pain from individual fast jet pilots.
17 114 The study was reported using the Consolidated Criteria for Reporting Qualitative Studies
18 115 (Supplementary file 1). [18]
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25 116

26 117 **Design and setting**

27 118 Qualitative semi structured interviews of the experiences of neck pain in fast jet pilots
28 119 (Typhoon flying squadron) were conducted at RAF Akrotiri, Cyprus between 17th and 25th July 2018.

29 120 *Interviews*

30 121 Semi structured interviews were used to maximise the insight of neck pain in fast jet pilots
31 122 across the biopsychosocial framework. This allowed us to explore in depth past and current
32 123 experiences of neck pain, attitudes and beliefs about neck pain, associated occupational factors and
33 124 impact on function and performance within and outside work.
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40 125 *Interview procedure and topic guide*

41 126 Semi structured interviews were conducted by a musculoskeletal physiotherapist (AD) (BSc
42 127 Hons, PG Dip) with ten years musculoskeletal physiotherapy experience, and seven years working with
43 128 RAF fast jet pilots. Participants were unknown to the researcher and no prior relationship was
44 129 established. Interviews lasted between 15 and 50 minutes and were recorded using a digital voice
45 130 recorder. Participants were encouraged to talk for as long as was needed. No-one else was present.
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50 131 The topic guide (Table 1) was developed by the research team (AD, ES, NH) in accordance with
51 132 published guidance [6] i) a disease model for neck pain in the general population, [19] modified to
52 133 acknowledge population specific differences ii) a proposed endpoint model for a new PROM for
53 134 military aircrew (Figure 1), and the hypothesised conceptual framework (Figure 2a). The derived topic
54 135 guide incorporated existing evidence and review of items in existing PROM. This included previous
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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 and 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

Firstly, 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 ROM, 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?
 - 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?

136 **Table 1** – Topic guide was developed by the research team and piloted in advance of the main data
137 collection.

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3 138 work, which critiqued the content validity of the NDI, and informed the development of a population
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5 139 specific tool for WAD. [20, 21] (Supplementary file 2) The topic guide was piloted in advance of the
6
7 140 main data collection.

8 141

10 142 **Participants**

12 143 *Sampling and recruitment*

14 144 Purposive sampling [22] was utilised to recruit fast jet aircrew across a range of characteristics,
15 145 including age, gender, flying experience, fast jet flying hours and neck pain presentations. The sample
16 146 size was predetermined at ten participants, as this was deemed sufficient to reach concept saturation.
17 147 [6, 23] Inclusion criteria were: member of Typhoon flying squadron, qualified fast jet pilot, fully
18 148 operational flight status at enrolment, or lost operational flight status due to flying related neck pain
19 149 (no other reason). Exclusion criteria included: no previous occurrences of flight related neck pain. A
20 150 participant information sheet was distributed by email to potentially eligible pilots; all those
21 151 approached agreed to participate in the study.

27 152

29 153 *Ethical approval*

30 154 The study protocol was approved in advance by the Ministry of Defence Research Ethics
31 155 Committee (reference 844/MODREQ/18, 29 June 2018), and the University of Birmingham Ethics
32 156 Committee. At the beginning of each interview, the participant information sheet was discussed and
33 157 questions were answered. Confidentiality and the concept of voluntary participation was explained,
34 158 including the process of withdrawal. All subjects provided written informed consent before
35 159 participating.

40 160

42 161 **Patient and public involvement**

44 162 The study design and methods were informed by our experience of working with practitioners
45 163 and military aircrew and more specifically fast jet pilots. They actively contributed to the research
46 164 question and to establish the need for this research. Findings of the study will be shared with key
47 165 stakeholders.

50 166

52 167 **Data analysis**

54 168 Data was analysed according to a recommended process of coding and data analysis, [6]
55 169 combined with guidance on thematic analysis. [24] An initial coding framework was created from the
56 170 topic guide, hypothesised conceptual framework and data from pilot testing. [6] The lead researcher
57 171 (AD) listened to, scored and assigned codes to themes that featured in interview transcripts and

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3 172 documented all modifications to the initial framework, which was expanded and restructured
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5 173 continuously as new data emerged. [6] A saturation table compiled during data analysis revealed that
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7 174 concept saturation was reached (Table 2). Once all transcripts had been processed, a coding dictionary
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9 175 was developed detailing all participant quotes according to each code. This enabled comparison of
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11 176 grouped data and an initial check of coding consistency. [24] Inductive analysis informed further
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13 177 modifications in coding terminology and theme allocation, ensuring the coding framework and
14
15 178 dictionary were a true reflection of participant data and not imposed by previous knowledge.[6]

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17 179 Co-investigators (NH and ES) assisted with data analysis and interpretation to enhance the
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19 180 credibility of study findings. ES, a highly experienced musculoskeletal physiotherapist and researcher
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21 181 checked coding and theme allocation by matching patient quotes to themes and codes in accordance
22
23 182 with previous guidance.[25] Consensus was achieved regarding theme and subtheme coding.
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25 183 Reflexivity was used throughout and a revised conceptual framework (figure 2b), or thematic map
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27 184 generated for further analysis and interpretation by the research team. [6, 24]
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Theme	Sub-themes	Interview Number									
		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 whilst flying – using NVGs	✓									
	7b. Pain whilst flying – air combat			✓							
	8. Pain after flying			✓							
	9. Pain down into arm				✓						
10. Clicking in neck					✓						
Work related effects	1a. Affects flying – during air combat	✓									
	1b. Affects flying – takes off NVGs			✓							
	2. Discontinued sorties			✓							
	3. Lost flying days		✓								
Social & Activity related effects	4. Time off work				✓						
	1. Sleep (quality or duration)	✓									
	2. Time outside work (socialising, time at home)			✓							
	3. Studying at home	✓									
	4. Participation in sport/gym			✓							
5. Driving	✓										
Psychological & Emotional effects	1. Worry about effects in later life	✓									
	2. Worry neck would limit performance in real combat situation									✓	
	3. Worry about future career			✓							
	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

208

209 **Table 2** – Saturation table compiled during data analysis revealed that concept saturation was
 210 reached.

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212 **RESULTS**

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

217 Findings support significant modifications to the hypothesised conceptual framework (Figure
 218 2a) when compared to the revised conceptual framework that was developed following data
 219 collection. (Figure 2b).

220 Figure 3 (a-d) illustrates these according to our derived themes. Collectively this includes
 221 thirteen new sub-themes, with seven modified (work related, flying, physical symptoms, neck pain,
 222 social and activity related, psychological and emotional, and worry) and four discarded (decreased
 223 neck range of motion, desk-based work, fatigue and activity avoidance) as no data was collected to
 224 support their inclusion. Only four themes remain unchanged across the two frameworks (headaches,
 225 pain at rest, neck stiffness, and sleep). We therefore propose the following themes for the revised
 226 framework; (a) physical symptoms, (b) work related effects, (c) psychological and emotional effects
 227 and (d) social and activity related effects.

228 Each theme and subtheme are presented with codes in the form of quotes labelled according
 229 to participant (P) number in table 3.

230

Theme	Sub theme		Codes (participant quotes)
Physical Symptoms	Neck pain	when moving	<i>'I remember it being painful to move my head, mainly side to side' (P1)</i> <i>'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)</i>
		when flying (air combat & NVGs)	<i>'So, a burning pain associated with applying Gz (gravitational force) whilst having my neck in certain positions...' (P9)</i> <i>Participants noted pain with NVG (night vision goggles) flying, especially 'long duration use', or on 'long sorties' (P1).</i>
	don't want to move	<i>'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)</i>	
	after flying	<i>'...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)</i>	

		<i>at rest</i>	<i>'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)</i>
	<i>Fatigue in neck</i>		<i>'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)</i>
	<i>Neck stiffness</i>		<i>'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)</i>
	<i>Stiffness or pain in upper back</i>		<i>'I would say it's nowhere near as acute or painful as the actual pain in the neck'. (P1)</i> <i>'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)</i>
	<i>Difficulty sustaining head position</i>		<i>'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)</i> <i>'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)</i>
	<i>Headaches</i>		<i>... 'pain in the back of my head', and it 'sort of feels like the same muscle' (P2)</i>
	<i>Pain in arm</i>		<i>'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)</i> <i>'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)</i>
	<i>Clicking in neck</i>		<i>'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)</i>
<i>Work related effects</i>	<i>Flying</i>	<i>air combat</i>	<i>'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> <i>'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)</i> <i>'...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)</i>
		<i>NVGs</i>	<i>'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)</i>
		<i>discontinued sorties</i>	<i>'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)</i>

			<i>'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)</i>
		<i>lost flying days</i>	<i>'...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 three days off, which was fairly quick' (P5)</i>
	<i>Time off work</i>		<i>'Obviously, yeah, when I was on my back, yeah, nothing was happening at that point. It was...so I wasn't working'. (P4)</i>
Psychological & Emotional effects	Worry	<i>effects in later life</i>	<i>'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)</i>
		<i>future career</i>	<i>'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)</i> <i>'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)</i>
		<i>real combat situation</i>	<i>'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)</i>
	<i>Frustration</i>		<i>'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).</i>
	<i>Mood</i>		<i>'It probably makes me a bit grumpy sometimes'. (P3)</i>
	Social & Activity related effects	<i>Sleep</i>	
<i>Time outside work</i>			<i>'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)</i> <i>'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)</i>
<i>Sport/gym</i>			<i>'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)</i>
<i>Driving</i>			<i>'Yeah, so looking that way it's hurting, and maybe that's not checking the left as well as I could do'. (P4)</i>
<i>Studying</i>			<i>'I mainly notice this once at home, when I've... Because I'm doing a lot of studying at the moment'. (P1)</i>

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232 **Table 3. Themes, subthemes and codes**

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5 235 Theme A: Physical Symptoms

6 236 When compared to the hypothesised framework, six new sub-themes emerged within this
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8 237 theme; with five pain-related (when moving, when flying, not wanting to move, after flying, and at
9
10 238 rest), with pain when flying further sub-grouped to include air combat and use of night-vision goggles
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12 239 (NVG). 'Headaches' and 'pain at rest' are the only consistent sub-themes across the two frameworks.

13 240 Most participants had experienced pain when moving their head and neck, with rotation the
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15 241 most provocative movement. Pain was associated with air combat flying where head position and the
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17 242 application of gravitational force during flying manoeuvres were contributing factors. Some reported
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19 243 pain with NVG flying, especially 'long duration use', or 'long sorties'. Difficulty sustaining the required
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21 244 head position against gravitational force resistance was reported with the neck being 'close to the
22
23 245 limit of its strength' and sometimes associated with pain.

24 246 Pain duration varied from 'a couple of days' to 'a week and a half' with participants describing
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26 247 delayed onset of pain to one or two days post flying; a comparison made with that experienced with
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28 248 delayed onset muscle soreness (DOMS), or fatigue. 'Fatigue' or 'tiredness' in the neck was widely
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30 249 reported, with contributing factors being long duration sorties, weight of the helmet and NVGs, poor
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32 250 neck positioning and acceleration/gravitational force. Some participants described 'neck stiffness'
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34 251 and used the term interchangeably with reduced neck movement. The term 'decreased neck range of
35
36 252 motion' did not reflect the language used by participants and was therefore discarded (figure 2b).

37 253 Some described thoracic spine symptoms, describing both tightness and pain in the 'upper
38
39 254 back' or 'between the shoulder blades'. Further descriptions included 'pain in the back of my head',
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41 255 and it 'sort of feels like the same muscle' (P2) as the neck were also used, therefore 'headaches' was
42
43 256 retained as a sub-theme in the revised conceptual framework (figure 2b). Radiating arm symptoms
44
45 257 associated with previous acute neck pain episodes, and neck clicking leading to an acute onset of pain
46
47 258 were also described. Pain related fear avoidance was raised and associated with previous acute pain
48
49 259 episodes. Some participants described previous episodes of constant symptoms that were present at
50
51 260 rest. (Table 2)

52 261

53 262 Theme B: Work related effects

54 263 Factors in this theme were modified significantly from the hypothesised framework, with
55
56 264 'flying performance' sub divided to include four sub-themes and retention of 'time off work'. Both
57
58 265 'concentration' and 'desk-based work' were removed as no data was yielded to support inclusion.

59 266 Many participants admitted limiting their air combat flying to avoid neck pain/injury,
60
267 specifically restricting manoeuvres and gravitational force, or avoiding certain head positions. Some

1
2
3 268 participants discussed how NVG use was affected, 'flipping them up' or removing them to avoid neck
4
5 269 pain. Some participants referred to occasions when they stopped flying early due to neck pain, or were
6
7 270 unable to fly or took time off work. The secondary effects and impact on operational output was
8
9 271 expanded on by some of the senior aircrew. (Table 2)

10 272

11 273 Theme C: Psychological & Emotional effects

12
13 274 Sub-themes within this theme were modified from the hypothesised framework, with 'worry'
14
15 275 being divided into three sub-categories, and 'anger or frustration' revised to 'frustration'. 'Mood' was
16
17 276 included as a new sub-theme.

18 277 Concern about the quality of life implications of ongoing neck and back problems were raised
19
20 278 by some participants. Others expressed worry about neck pain affecting their flying career, with both
21
22 279 short and long-term concerns reflected. Some pointed to concerns that neck pain would pose a risk in
23
24 280 a real time combat situation. Participants also expressed frustrations that not enough is being done
25
26 281 to tackle the issue of neck pain in aircrew with neck symptoms reportedly having an adverse effect
27
28 282 mood. (Table 2)

28 283

30 284 Theme D: Social & Activity related effects

31
32 285 Three new categories were added to this theme (sport/gym, driving and studying), whilst
33
34 286 'fatigue' was removed and 'sleep' remained unchanged. 'Social activity' and 'activity avoidance' were
35
36 287 encompassed in 'time outside work'.

37 288 Neck pain impacting sleep duration and quality was discussed. The impact of neck pain on
38
39 289 time outside work was mentioned, with consequential avoidance of home or social activity. Limiting
40
41 290 or stopping sport or weight training was discussed during an acute neck pain episode. Other activities
42
43 291 which were impacted by neck pain included driving and home computer use. (Table 2)

43 292

45 293 **DISCUSSION**

46 294

47
48 295 This is the first qualitative study of military aircrew that used in-depth semi structured
49
50 296 interviews to investigate flying related neck pain in fast jet pilots. The study was designed to inform
51
52 297 the design and content validity of a pilot specific PROM, focusing on their experiences of occupation
53
54 298 related neck pain rather than any current neck pain. [23] Previous studies involving fast jet pilots used
55
56 299 self-administered questionnaires with content analysis and quantitative data processing methods,
57
58 300 where prior theory and the researcher's perspective are used to interpret concepts.[4, 15, 26] This
59
60 301 study used participants words and phrases in 'ground up' concept generation, ensuring data

1
2
3 302 accurately reflects participants perspective,[23] whereas previous work has examined pilot's neck
4 pain experience, with a focus on physical symptoms. [4, 15, 26] This study additionally examined
5 303 occupational, psychological and social effects to reflect the wider impact of neck pain on health and
6 304 function.
7
8 305
9

10 306

11 307 **Physical Symptoms**

12
13 308 Most emergent physical symptoms related to pilot's experience of neck pain, with some
14 expanding on the circumstances of pain onset. Consistent with a recent literature review,[27] the
15 309 'check six' position during air combat flying was cited as a cause of neck pain or injury. This requires
16 310 pilots to adopt combined end range neck extension, lateral flexion and rotation under Gz, placing
17 311 considerable biomechanical strain on musculoskeletal tissues and structures.[28] NVG use adds to
18 312 head mounted load particularly when worn for prolonged periods, thereby increasing this strain.[28]
19 313 Our findings also mirror previous studies where NVG use was linked to in-flight neck pain.[12, 14]
20 314

21 315 Post flight pain onset was also reported which is consistent with a previous fast jet survey.[15]
22 316 Participants also discussed pain related fear of movement, as previously found in an experimental
23 317 study of rotary pilots.[13] Fear avoidance is thought to provide a protective mechanism against further
24 318 injury or pain amplification in the acute injury phase.[29] However, persistent maladaptive behaviours
25 319 may cause functional activity restriction,[30] changes in muscle performance, [29, 31] and transition
26 320 to chronic or persistent spinal pain.

27 321 Neck fatigue was widely reported in this study, but no previous studies having recognised this
28 322 as a symptom or differentiated this from neck pain. Previous authors have examined neck
29 323 neuromuscular fatigue as possible injury risk factor, and compared cumulative effects of low with high
30 324 gravitational force exposures in fast jet aircrew.[14] In addition, symptoms distal to the neck were
31 325 reported in this study, with radicular arm symptoms associated with an acute neck pain which is
32 326 consistent with a previous fast jet survey.[15] Symptoms of stiffness and pain in the upper back were
33 327 also reported, although not reflected in any previous military aircrew literature. Whilst previously neck
34 328 pain was widely considered in isolation interest in the relationship (neurophysiological and
35 329 biomechanical) between the cervical and thoracic regions has gained momentum.[32-34] These
36 330 findings reflect the strength of the concept elicitation interview format that was used in this study,
37 331 designed to capture patient's perceptions of their condition to inform content validity and PROM
38 332 development. [6]
39

40 333

41 334 **Work related effects**

1
2
3 335 Most work related effects involved limitation or modification of flying. Days lost from flying
4
5 336 or discontinuation of sorties due to neck pain was both reported and is in keeping with a previous fast
6
7 337 jet survey that suggested 42% of pilots had been temporarily unfit to fly in their career.[4] Secondary
8
9 338 impacts of lost flying time were also revealed, with senior pilots discussing implications for achieving
10
11 339 key performance indicators. Participants also described modifications of flying technique due to neck
12
13 340 pain, again these impacts are previously unreported. NVG removal to relieve neck pain was widely
14
15 341 reported, with pilots acknowledging that this poses a significant flight safety risk. Similarly,
16
17 342 participants discussed adapting their methods of flying combat manoeuvres, some raising concerns
18
19 343 that reduced flying performance could prove fatal in a real-time scenario.

20 345 **Psychological & emotional effects**

21
22 346 Worrying due to neck pain was discussed by participants, specifically mentioning impact on
23
24 347 future career, later life, and performance in a real combat scenario. Effects on mood, with being
25
26 348 'grumpy' raised by one pilot with a history of recurrent neck pain, is encompassed by items on three
27
28 349 of six most common neck related PROM.[10] Responses were similar to that of the Copenhagen Neck
29
30 350 Functional Disability Scale (CNFDS) item 'disruption of future'. The interdependence of psychological
31
32 351 and emotional functioning and general wellbeing is well recognised[35] particularly as the NDI does
33
34 352 not represent these domains. [36] Findings demonstrate the significance of these dimensions to neck
35
36 353 pain complaints in military aircrew, and therefore should be reflected in a new population specific
37
38 354 PROM.

38 356 **Social & activity related effects**

39
40 357 The social and activity related problems discussed by the participants largely reflect items
41
42 358 found in six common neck related PROM featured in recent literature review.[10] (Supplementary file
43
44 359 2) Sleep and driving were both cited; these feature in four and three of these questionnaires
45
46 360 respectively.[10] Limitations of sport or gym activities was reported in relation to acute pain, which is
47
48 361 a population relevant aspect of the 'recreational activities' item included in four PROM.[10] Impact on
49
50 362 time outside work was discussed which relates to items on the CNFDS, including family relationships
51
52 363 and going out with others.[37]

53 365 **Strengths and limitations**

54
55 366 Several factors may have influenced data collection, analysis and interpretation and affected
56
57 367 the trustworthiness of findings. The sample consisted of only males as no female pilots were available
58
59 368 at the time of data collection. Despite meeting qualitative interviewing competencies,[6] the primary
60

1
2
3 369 researcher (AD) was a relative novice as a qualitative interviewer. Concept saturation was reached in
4
5 370 this study but this was assessed retrospectively, whereas assessment throughout data collection is
6
7 371 recommended and would have improved methodology.[6] Data coding was conducted by the primary
8
9 372 researcher (AD) and cross checked by another researcher (ES) after completion. Whilst time
10
11 373 constraints limited the extent of member checking and transcript validation inductive analysis ensured
12
13 374 the coding framework and dictionary were a true reflection of participant data. [6]
14

15 375

15 376 **Implications for practice and future research**

16 377 Findings can be used to inform the current practice of physiotherapists working with military
17
18 378 aircrew with neck pain. In the absence of a population specific measure, clinicians should ensure
19
20 379 biopsychosocial impact factors of flying are assessed during patient history taking. Further qualitative
21
22 380 research is required to build on these findings and develop a population specific PROM; cognitive
23
24 381 interviewing would test the range and interpretation of concepts and refine the new PROM items.[38]
25
26 382 Once a PROM has been developed and validated for fast jet aircrew, it would require re-validation in
27
28 383 other military aircrew groups. A population specific measure would enable investigation of the
29
30 384 effectiveness of the ACP, and daily physiotherapy practice to mitigate against neck pain in this unique
31
32 385 population.

33 386

33 387 **CONCLUSION**

34
35 388 Flight related neck pain has a broad impact on the lives of fast jet pilots, including physical
36
37 389 symptoms, occupational, psychological and social effects. Physical symptoms were largely associated
38
39 390 with neck pain, but other clinically relevant factors included symptoms in other body regions and fear
40
41 391 avoidance patterns. Occupational factors included modifications and restrictions of flying, some of
42
43 392 which may have flight safety implications. Psychological effects expanded on feelings of worry,
44
45 393 including impact on future quality of life. Social and activity factors reflected items in existing PROM.
46
47 394 Further qualitative research is required to develop and validate a population specific PROM for
48
49 395 military aircrew.

50 396

51 397

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58
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3 4034
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6 405 AD and NH conceived the idea for the study. AD conducted the interviews with ES cross-checking
7
8 406 them. AD and NH analysed the data. AD and NH wrote the first draft. All authors reviewed and
9
10 407 provided additional review comments. All authors provided their full approval prior to submission.

11 408

12
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15 410 None declared.

16 411

17
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21
22 414 Deanery both provided funds towards this study.

23 415

24 416

25
26 417 **Data availability statement**27
28 418 All data relevant to the study are included in the article or uploaded as supplementary information.29
30 419 Any queries related to this article should be directed to the corresponding author.

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4 518 *respondent understanding Value in Health, 2011b. 14(8): p. 978-988.*
5 519

7
8 520 **FIGURE LEGENDS**

9
10 521 **Figure 1** Proposed endpoint model for a new neck specific PROM for military aircrew.

11 522

12
13 523 **Figure 2 a)** Hypothesised conceptual framework for a neck specific PROM for military aircrew in the
14 524 top left corner. **b)** Revised conceptual framework for a neck specific PROM for military aircrew in the
15 525 bottom right corner. Thirteen new sub-themes were included in the revised conceptual framework,
16 526 with seven modified (work related, flying, physical symptoms, neck pain, social and activity related,
17 527 psychological and emotional, and worry) and four discarded (decreased neck range of motion, desk-
18 528 based work, fatigue and activity avoidance).

19 529

20 530 **Figure 3** Revised conceptual framework for a neck specific PROM for military aircrew.

21 531

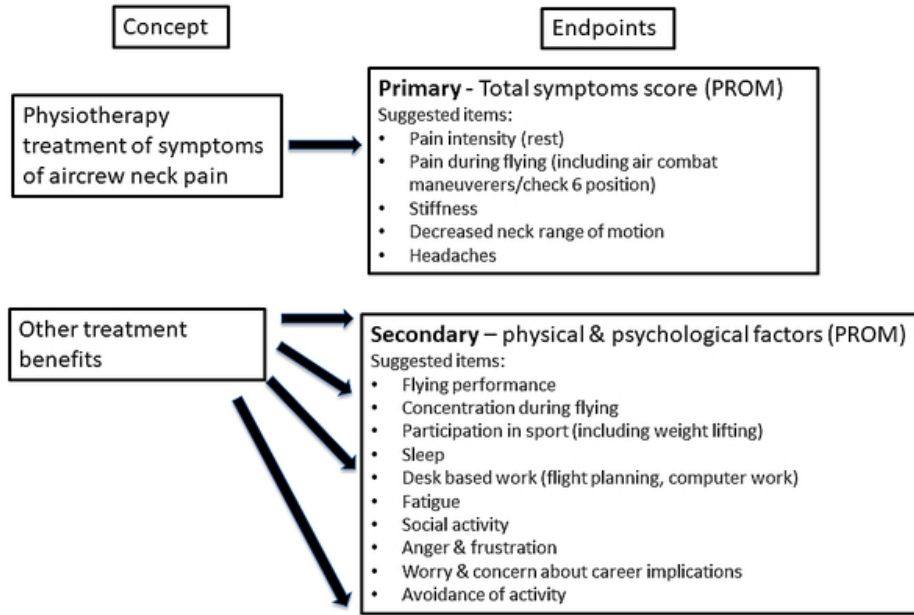


Figure 1 Proposed endpoint model for a new neck specific PROM for military aircrew

27x20mm (600 x 600 DPI)

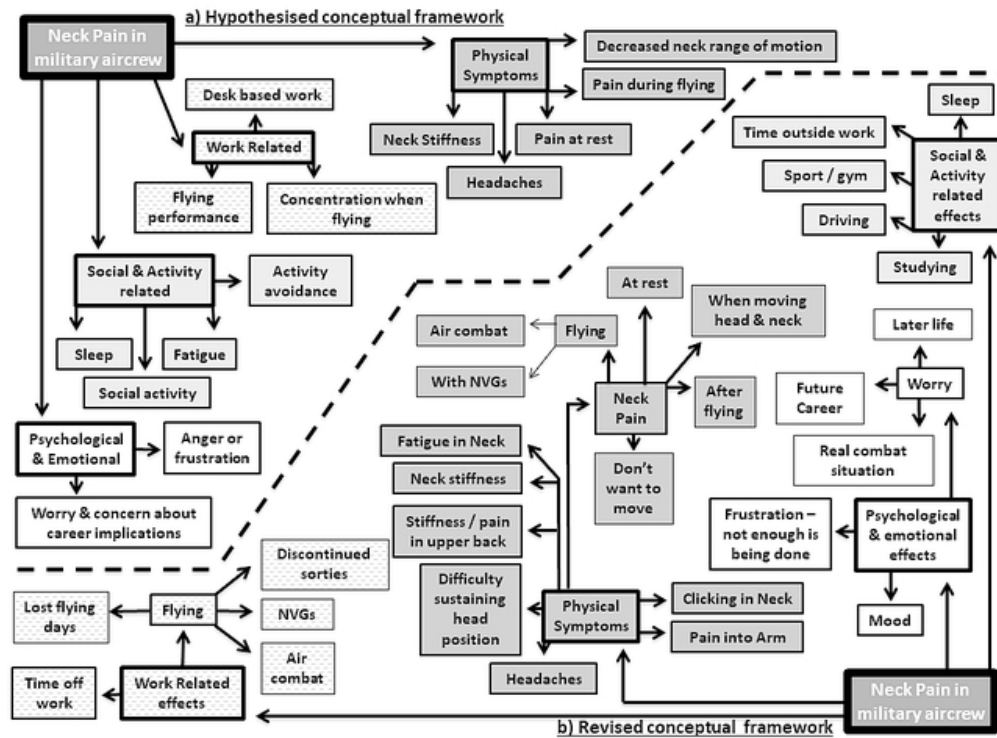


Figure 2 a) Hypothesised conceptual framework for a neck specific PROM for military aircrew in the top left corner. b) Revised conceptual framework for a neck specific PROM for military aircrew in the bottom right corner. [Thirteen new sub-themes were included in the revised conceptual framework, with 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)]

27x20mm (600 x 600 DPI)

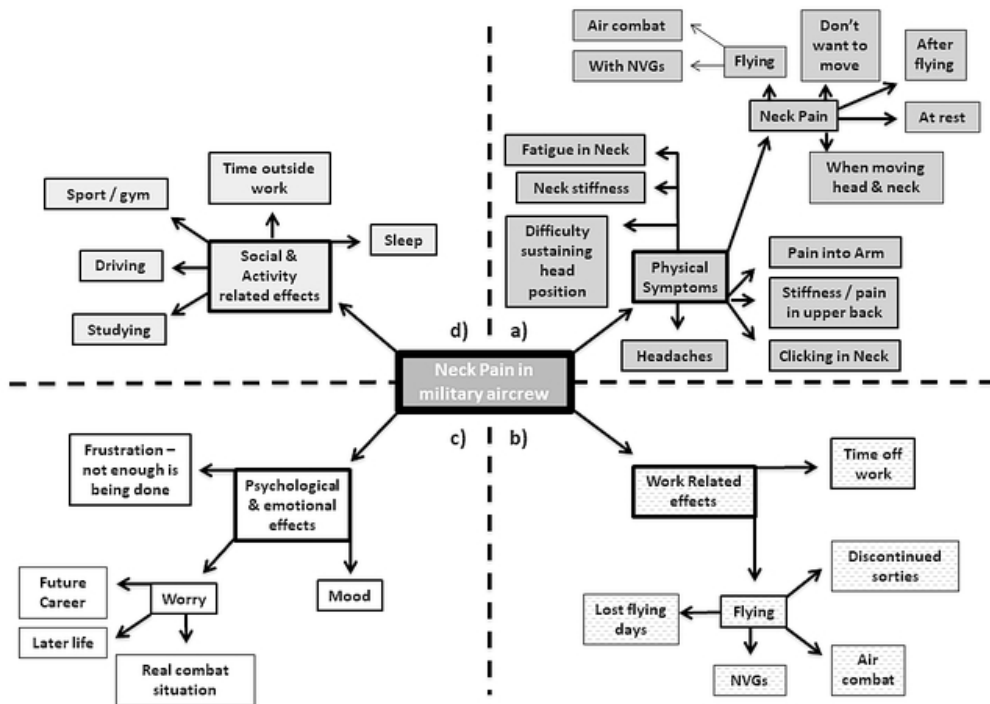


Figure 3 Revised conceptual framework for a neck specific PROM for military aircrew

27x20mm (600 x 600 DPI)

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 interviewer/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

BMJ Open

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3 1 **Development of a patient reported outcome measure for neck pain in military aircrew: qualitative**
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5 2 **interviews to inform design and content**
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9
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39 ABSTRACT

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

46 **Methods:** Qualitative semi structured interviews combining phenomenological and grounded theory
47 methods, reported using COREQ guidelines. Purposive sample of 10 fast jet pilots with neck pain were
48 recruited. Concept elicitation interviews were audio recorded, transcribed verbatim along with field
49 notes. Data analysis involved subject and methodological expertise used a concept elicitation
50 approach.

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

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

58
59 **Key words:** Aircrew, Neck pain, Patient-reported outcome measure (PROM); Qualitative

61 ARTICLE SUMMARY

62 Strengths and limitations of this study

- 63 • Findings provide fast jet pilots' perspective on the implications of neck pain to inform content
64 validity of a population specific PROM
- 65 • The study design and methods are informed and reported in line with published guidance
66 (COREQ, concept elicitation)
- 67 • The sample included only male participants from one military squadron
- 68 • Further research is required to enable cognitive debriefing of the derived domains

69 INTRODUCTION

70

71 Flight related neck pain is a common musculoskeletal problem for military pilots, with
72 prevalence reported as 66% for all Royal Air Force (RAF) aircrew, and 70% for UK fast jet pilots. [1] One-
73 year estimates for Danish helicopter pilots were 43-48%, relative to 26% in the general population.[2]
74 Neck pain incidence is consistently higher relative to the general population despite several neck pain
75 risk factors, such as age, physical inactivity and female gender, being lower amongst military groups.[3]

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

83 Patient reported outcome measures (PROM) facilitate healthcare service quality
84 improvement, and are integral to evidence-based practice. PROM can be disease specific [e.g. Neck
85 Pain Disability Index (NDI)] or generic (e.g. Numerical Pain Rating Scale), where disease specific
86 measures are more sensitive to change in a single patient with regional specific musculoskeletal
87 dysfunction. [8] This supports their use for investigating the effectiveness of interventions such as
88 conditioning programmes. [9] The NDI is the most widely used and validated disease specific neck
89 PROM, [10] although its applicability to military aircrew, with unique psychological and physical
90 occupational requirements is unknown. This refers to the content validity of a psychometric measure,
91 and considers the relevance of a PROM to the population of interest. The COSMIN checklist, a well-
92 established PROM quality assessment tool, requires that 'age, gender, disease characteristics, country
93 and setting' are well matched.[11] In addition to demographic and disease related differences, the
94 occupational and ergonomic demands vary greatly between the general and military populations. [12]
95 Poor head postures, continuous vibration, repetitive movements, sustained static postures and neck
96 loading from combat flying equipment, are all unique military risk factors. [12] Beyond the physical
97 factors, psychological factors such as working on military operations creates a further set of
98 population-specific risk factors.[13, 14] Military culture may influence healthcare attitudes and beliefs,
99 with evidence indicating that pilots were reluctant to provide accurate information [15] and seek
100 treatment for neck pain. [4] These factors may alter the psychometric properties of PROM by affecting
101 how individuals approach tasks and score questionnaire items. [16] It is evident that the COSMIN
102 content validity requirements would not be met by an existing PROM and is needed to evaluate
103 effectiveness of the ACP or changes in aircrew neck complaints over time.

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3 104 Across the military aircrew populations, neck pain in fast jet pilots poses a greater flight safety
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5 105 risk to due to higher pain prevalence, [1] and pilots flying solo. Training and airframe costs are also
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7 106 relatively higher, which increases the price of pilot hours lost to neck pain. [17] This qualitative study
8
9 107 therefore aimed to explore the psychological, social and occupation factors of flight related neck pain
10
11 108 in fast jet aircrew during their career to inform the design and content validity of a new population
12
13 109 specific PROM.

13 110

15 111 **DESIGN & METHODS**

16 112 **Theoretical framework**

18 113 The study followed the concept elicitation format for new PROM; the methodological
19
20 114 orientation combined phenomenological and grounded theory approaches adapted to consider prior
21
22 115 knowledge to inform the study design and topic guide. [6] This included review of existing literature
23
24 116 which has critiqued the content validity of the NDI and developed a population specific tool for
25
26 117 whiplash associated disorders [18, 19] (grounded theory) and exploring fast jet pilot participants own
27
28 118 experiences and perceptions of neck pain (phenomenology). In line with the study aims this allowed
29
30 119 us to acquire an in depth understanding of the experiences of neck pain from individual fast jet pilots.
31
32 120 The study was reported using the Consolidated Criteria for Reporting Qualitative Studies
33
34 121 (Supplementary file 1). [20]

33 122

35 123 **Design and setting**

36 124 Qualitative semi structured interviews of the experiences of neck pain in fast jet pilots
37
38 125 (Typhoon flying squadron) were conducted at RAF Akrotiri, Cyprus between 17th and 25th July 2018.

40 126 *Interviews*

41 127 Semi structured interviews were used to maximise the insight of neck pain in fast jet pilots
42
43 128 across the biopsychosocial framework. This allowed us to explore in depth past and current
44
45 129 experiences of neck pain, attitudes and beliefs about neck pain, associated occupational factors and
46
47 130 impact on function and performance within and outside work.

48 131 *Interview procedure and topic guide*

50 132 Semi structured interviews were conducted by a musculoskeletal physiotherapist (AD) (BSc
51
52 133 Hons, PG Dip) with ten years musculoskeletal physiotherapy experience, and seven years working with
53
54 134 RAF fast jet pilots. Participants were unknown to the researcher and no prior relationship was
55
56 135 established. Interviews lasted between 15 and 50 minutes and were recorded using a digital voice
57
58 136 recorder. Participants were encouraged to talk for as long as was needed. No-one else was present.

59 137 The topic guide (Table 1) was developed by the research team (AD, ES, NH) in accordance with
60
61 138 published guidance [6] i) a disease model for neck pain in the general population, [21] modified to

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 and 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

Firstly, 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 ROM, 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?
 - 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?

139 acknowledge population specific differences ii) a proposed endpoint model for a new PROM for
 140 military aircrew (Figure 1), and the hypothesised conceptual framework (Figure 2a). The derived topic
 141 guide incorporated existing evidence and review of items in existing PROM. This included previous

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142 **Table 1** – Topic guide was developed by the research team and piloted in advance of the main data
143 collection.

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3 144 work, which critiqued the content validity of the NDI, and informed the development of a population
4
5 145 specific tool for WAD. [18, 19] (Supplementary file 2) The topic guide was piloted with fast jet pilots
6
7 146 without a history of neck pain in advance of the main data collection to assess the feasibility, including
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9 147 clarity of questions and timing of the interview.
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11 148

12 149 **Participants**

13 150 *Sampling and recruitment*

14 151 Purposive sampling [22] was utilised to recruit fast jet aircrew across a range of characteristics,
15
16 152 including age, gender, flying experience, fast jet flying hours and neck pain presentations. The sample
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18 153 size was predetermined at ten participants, as this was deemed sufficient to reach concept saturation.
19
20 154 [6, 23] Inclusion criteria were: member of Typhoon flying squadron, qualified fast jet pilot, fully
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22 155 operational flight status at enrolment, or lost operational flight status due to flying related neck pain
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24 156 (no other reason). Exclusion criteria included: no previous occurrences of flight related neck pain. A
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26 157 participant information sheet was distributed by email to potentially eligible pilots; all those
27
28 158 approached agreed to participate in the study.
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30 159

31 160 *Ethical approval*

32 161 The study protocol was approved in advance by the Ministry of Defence Research Ethics
33
34 162 Committee (reference 844/MODREQ/18, 29 June 2018), and the University of Birmingham Ethics
35
36 163 Committee. At the beginning of each interview, the participant information sheet was discussed and
37
38 164 questions were answered. Confidentiality and the concept of voluntary participation was explained,
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40 165 including the process of withdrawal. All subjects provided written informed consent before
41
42 166 participating.
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44 168 **Patient and public involvement**

45 169 The study design and methods were informed by our experience of working with practitioners
46
47 170 and military aircrew and more specifically fast jet pilots. They actively contributed to the research
48
49 171 question and to establish the need for this research. Findings of the study will be shared with key
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51 172 stakeholders.
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54 174 **Data analysis**

55 175 Data was analysed according to a recommended process of coding and data analysis, [6]
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57 176 combined with guidance on thematic analysis. [24] An initial coding framework was created from the
58
59 177 topic guide, hypothesised conceptual framework and data from pilot testing. [6] The lead researcher
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3 178 (AD) listened to, scored and assigned codes to themes that featured in interview transcripts and
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5 179 documented all modifications to the initial framework, which was expanded and restructured
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7 180 continuously as new data emerged. [6] A saturation table compiled during data analysis revealed that
8
9 181 concept saturation was reached (Table 2). Once all transcripts had been processed, a coding dictionary
10
11 182 was developed detailing all participant quotes according to each code. This enabled comparison of
12
13 183 grouped data and an initial check of coding consistency. [24] Inductive analysis informed further
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15 184 modifications in coding terminology and theme allocation, ensuring the coding framework and
16
17 185 dictionary were a true reflection of participant data and not imposed by previous knowledge.[6]

18
19 186 Co-investigators (NH and ES) assisted with data analysis and interpretation to enhance the
20
21 187 credibility of study findings. ES, a highly experienced musculoskeletal physiotherapist and researcher
22
23 188 checked coding and theme allocation by matching patient quotes to themes and codes in accordance
24
25 189 with previous guidance.[25] Consensus was achieved regarding theme and subtheme coding.
26
27 190 Reflexivity was used throughout and a revised conceptual framework (figure 2b), or thematic map
28
29 191 generated for further analysis and interpretation by the research team. [6, 24]

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Theme	Sub-themes	Interview Number									
		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 whilst flying – using NVGs	✓									
	7b. Pain whilst flying – air combat			✓							
	8. Pain after flying			✓							
9. Pain down into arm				✓							
10. Clicking in neck					✓						
Work related effects	1a. Affects flying – during air combat	✓									
	1b. Affects flying – takes off NVGs			✓							
	2. Discontinued sorties			✓							
	3. Lost flying days		✓								
4. Time off work				✓							
Social & Activity related effects	1. Sleep (quality or duration)	✓									
	2. Time outside work (socialising, time at home)			✓							
	3. Studying at home	✓									
	4. Participation in sport/gym			✓							
	5. Driving	✓									
Psychological & Emotional effects	1. Worry about effects in later life	✓									
	2. Worry neck would limit performance in real combat situation									✓	
	3. Worry about future career			✓							
	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

215

216 **Table 2** – Saturation table compiled during data analysis revealed that concept saturation was
 217 reached.

218

219 RESULTS

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

224 Findings support significant modifications to the hypothesised conceptual framework (Figure
 225 2a) when compared to the revised conceptual framework that was developed following data
 226 collection. (Figure 2b).

227 Figure 3 (a-d) illustrates these according to our derived themes. Collectively this includes
 228 thirteen new sub-themes, with seven modified (work related, flying, physical symptoms, neck pain,
 229 social and activity related, psychological and emotional, and worry) and four discarded (decreased
 230 neck range of motion, desk-based work, fatigue and activity avoidance) as no data was collected to
 231 support their inclusion. Only four themes remain unchanged across the two frameworks (headaches,
 232 pain at rest, neck stiffness, and sleep). We therefore propose the following themes for the revised
 233 framework; (a) physical symptoms, (b) work related effects, (c) psychological and emotional effects
 234 and (d) social and activity related effects.

235 Each theme and subtheme are presented with codes in the form of quotes labelled according
 236 to participant (P) number in table 3.

237

Theme	Sub theme		Codes (participant quotes)
Physical Symptoms	Neck pain	when moving	<i>'I remember it being painful to move my head, mainly side to side' (P1)</i> <i>'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)</i>
		when flying (air combat & NVGs)	<i>'So, a burning pain associated with applying Gz (gravitational force) whilst having my neck in certain positions...' (P9)</i> <i>Participants noted pain with NVG (night vision goggles) flying, especially 'long duration use', or on 'long sorties' (P1).</i>
		don't want to move	<i>'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)</i>

		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)
Work related effects	Flying	air combat	'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)
		NVGs	'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)
		discontinued sorties	'Recently we probably did about 45 minutes of combat, we refuelled twice, and, on the last iteration of sustained 7G for

			<p>about 2 or 3 minutes, my neck was just... It was hurting at that point, so I called off the fight' (P4)</p> <p>'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)</p>
		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 three days off, which was fairly quick' (P5)
		Time off work	'Obviously, yeah, when I was on my back, yeah, nothing was happening at that point. It was...so I wasn't working'. (P4)
Psychological & Emotional effects	Worry	effects in later life	'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)
		future career	'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)
		real combat situation	'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)
		Frustration	'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).
		Mood	'It probably makes me a bit grumpy sometimes'. (P3)
Social & 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)
	Sport/gym		'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)
	Driving		'Yeah, so looking that way it's hurting, and maybe that's not checking the left as well as I could do'. (P4)
	Studying		'I mainly notice this once at home, when I've... Because I'm doing a lot of studying at the moment'. (P1)

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3 **239 Table 3. Themes, subthemes and codes**
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8 242 Theme A: Physical Symptoms
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10 243 When compared to the hypothesised framework, six new sub-themes emerged within this
11 244 theme; with five pain-related (when moving, when flying, not wanting to move, after flying, and at
12 245 rest), with pain when flying further sub-grouped to include air combat and use of night-vision goggles
13 246 (NVG). 'Headaches' and 'pain at rest' are the only consistent sub-themes across the two frameworks.

14
15 247 Most participants had experienced pain when moving their head and neck, with rotation the
16 248 most provocative movement. Pain was associated with air combat flying where head position and the
17 249 application of gravitational force during flying manoeuvres were contributing factors. Some reported
18 250 pain with NVG flying, especially 'long duration use', or 'long sorties'. Difficulty sustaining the required
19 251 head position against gravitational force resistance was reported with the neck being 'close to the
20 252 limit of its strength' and sometimes associated with pain.

21
22 253 Pain duration varied from 'a couple of days' to 'a week and a half' with participants describing
23 254 delayed onset of pain to one or two days post flying; a comparison made with that experienced with
24 255 delayed onset muscle soreness (DOMS), or fatigue. 'Fatigue' or 'tiredness' in the neck was widely
25 256 reported, with contributing factors being long duration sorties, weight of the helmet and NVGs, poor
26 257 neck positioning and acceleration/gravitational force. Some participants described 'neck stiffness'
27 258 and used the term interchangeably with reduced neck movement. The term 'decreased neck range of
28 259 motion' did not reflect the language used by participants and was therefore discarded (figure 2b).

29
30 260 Some described thoracic spine symptoms, describing both tightness and pain in the 'upper
31 261 back' or 'between the shoulder blades'. Further descriptions included 'pain in the back of my head',
32 262 and it 'sort of feels like the same muscle' (P2) as the neck were also used, therefore 'headaches' was
33 263 retained as a sub-theme in the revised conceptual framework (figure 2b). Radiating arm symptoms
34 264 associated with previous acute neck pain episodes, and neck clicking leading to an acute onset of pain
35 265 were also described. Pain related fear avoidance was raised and associated with previous acute pain
36 266 episodes. Some participants described previous episodes of constant symptoms that were present at
37 267 rest. (Table 2)

38 268

39
40 269 Theme B: Work related effects
41

42 270 Factors in this theme were modified significantly from the hypothesised framework, with
43 271 'flying performance' sub divided to include four sub-themes and retention of 'time off work'. Both
44 272 'concentration' and 'desk-based work' were removed as no data was yielded to support inclusion.

1
2
3 273 Many participants admitted limiting their air combat flying to avoid neck pain/injury,
4 274 specifically restricting manoeuvres and gravitational force, or avoiding certain head positions. Some
5 275 participants discussed how NVG use was affected, 'flipping them up' or removing them to avoid neck
6 276 pain. Some participants referred to occasions when they stopped flying early due to neck pain, or were
7 277 unable to fly or took time off work. The secondary effects and impact on operational output was
8 278 expanded on by some of the senior aircrew. (Table 2)

13 279

15 280 Theme C: Psychological & Emotional effects

16 281 Sub-themes within this theme were modified from the hypothesised framework, with 'worry'
17 282 being divided into three sub-categories, and 'anger or frustration' revised to 'frustration'. 'Mood' was
18 283 included as a new sub-theme.

19 284 Concern about the quality of life implications of ongoing neck and back problems were raised
20 285 by some participants. Others expressed worry about neck pain affecting their flying career, with both
21 286 short and long-term concerns reflected. Some pointed to concerns that neck pain would pose a risk in
22 287 a real time combat situation. Participants also expressed frustrations that not enough is being done
23 288 to tackle the issue of neck pain in aircrew with neck symptoms reportedly having an adverse effect
24 289 mood. (Table 2)

31 290

33 291 Theme D: Social & Activity related effects

34 292 Three new categories were added to this theme (sport/gym, driving and studying), whilst
35 293 'fatigue' was removed and 'sleep' remained unchanged. 'Social activity' and 'activity avoidance' were
36 294 encompassed in 'time outside work'.

37 295 Neck pain impacting sleep duration and quality was discussed. The impact of neck pain on
38 296 time outside work was mentioned, with consequential avoidance of home or social activity. Limiting
39 297 or stopping sport or weight training was discussed during an acute neck pain episode. Other activities
40 298 which were impacted by neck pain included driving and home computer use. (Table 2)

46 299

48 300 **DISCUSSION**

50 301

51 302 This is the first qualitative study of military aircrew that used in-depth semi structured
52 303 interviews to investigate flying related neck pain in fast jet pilots. The study was designed to inform
53 304 the design and content validity of a pilot specific PROM, focusing on their experiences of occupation
54 305 related neck pain rather than any current neck pain. [23] Previous studies involving fast jet pilots used
55 306 self-administered questionnaires with content analysis and quantitative data processing methods,

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2
3 307 where prior theory and the researcher's perspective are used to interpret concepts.[4, 15, 26] This
4
5 308 study used participants words and phrases in 'ground up' concept generation, ensuring data
6
7 309 accurately reflects participants perspective,[23] whereas previous work has examined pilot's neck
8
9 310 pain experience, with a focus on physical symptoms. [4, 15, 26] This study additionally examined
10
11 311 occupational, psychological and social effects to reflect the wider impact of neck pain on health and
12
13 312 function.

13 313

15 314 **Physical Symptoms**

16 315 Most emergent physical symptoms related to pilot's experience of neck pain, with some
17
18 316 expanding on the circumstances of pain onset. Consistent with a recent literature review,[27] the
19
20 317 'check six' position during air combat flying was cited as a cause of neck pain or injury. This requires
21
22 318 pilots to adopt combined end range neck extension, lateral flexion and rotation under Gz, placing
23
24 319 considerable biomechanical strain on musculoskeletal tissues and structures.[28] NVG use adds to
25
26 320 head mounted load particularly when worn for prolonged periods, thereby increasing this strain.[28]
27
28 321 Our findings also mirror previous studies where NVG use was linked to in-flight neck pain.[12, 14]

29 322 Post flight pain onset was also reported which is consistent with a previous fast jet survey.[15]
30
31 323 Participants also discussed pain related fear of movement, as previously found in an experimental
32
33 324 study of rotary pilots.[13] Fear avoidance is thought to provide a protective mechanism against further
34
35 325 injury or pain amplification in the acute injury phase.[29] However, persistent maladaptive behaviours
36
37 326 may cause functional activity restriction,[30] changes in muscle performance, [29, 31] and transition
38
39 327 to chronic or persistent spinal pain.

40 328 Neck fatigue was widely reported in this study, but no previous studies having recognised this
41
42 329 as a symptom or differentiated this from neck pain. Previous authors have examined neck
43
44 330 neuromuscular fatigue as possible injury risk factor, and compared cumulative effects of low with high
45
46 331 gravitational force exposures in fast jet aircrew.[14] In addition, symptoms distal to the neck were
47
48 332 reported in this study, with radicular arm symptoms associated with an acute neck pain which is
49
50 333 consistent with a previous fast jet survey.[15] Symptoms of stiffness and pain in the upper back were
51
52 334 also reported, although not reflected in any previous military aircrew literature. Whilst previously neck
53
54 335 pain was widely considered in isolation interest in the relationship (neurophysiological and
55
56 336 biomechanical) between the cervical and thoracic regions has gained momentum.[32-34] These
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58 337 findings reflect the strength of the concept elicitation interview format that was used in this study,
59
60 338 designed to capture patient's perceptions of their condition to inform content validity and PROM
339 development. [6]

340

1
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3 341 **Work related effects**

4
5 342 Most work related effects involved limitation or modification of flying. Days lost from flying
6 343 or discontinuation of sorties due to neck pain was both reported and is in keeping with a previous fast
7
8 344 jet survey that suggested 42% of pilots had been temporarily unfit to fly in their career.[4] Secondary
9
10 345 impacts of lost flying time were also revealed, with senior pilots discussing implications for achieving
11 346 key performance indicators. Participants also described modifications of flying technique due to neck
12
13 347 pain, again these impacts are previously unreported. NVG removal to relieve neck pain was widely
14
15 348 reported, with pilots acknowledging that this poses a significant flight safety risk. Similarly,
16
17 349 participants discussed adapting their methods of flying combat manoeuvres, some raising concerns
18 350 that reduced flying performance could prove fatal in a real-time scenario.

19
20 351

21 352 **Psychological & emotional effects**

22
23 353 Worrying due to neck pain was discussed by participants, specifically mentioning impact on
24
25 354 future career, later life, and performance in a real combat scenario. Effects on mood, with being
26
27 355 'grumpy' raised by one pilot with a history of recurrent neck pain, is encompassed by items on three
28
29 356 of six most common neck related PROM.[10] Responses were similar to that of the Copenhagen Neck
30 357 Functional Disability Scale (CNFDS) item 'disruption of future'. The interdependence of psychological
31 358 and emotional functioning and general wellbeing is well recognised[35] particularly as the NDI does
32
33 359 not represent these domains. [36] Findings demonstrate the significance of these dimensions to neck
34
35 360 pain complaints in military aircrew, and therefore should be reflected in a new population specific
36
37 361 PROM.

38 362

39
40 363 **Social & activity related effects**

41
42 364 The social and activity related problems discussed by the participants largely reflect items
43
44 365 found in six common neck related PROM featured in recent literature review.[10] (Supplementary file
45
46 366 2) Sleep and driving were both cited; these feature in four and three of these questionnaires
47
48 367 respectively.[10] Limitations of sport or gym activities was reported in relation to acute pain, which is
49
50 368 a population relevant aspect of the 'recreational activities' item included in four PROM.[10] Impact on
51
52 369 time outside work was discussed which relates to items on the CNFDS, including family relationships
53
54 370 and going out with others.[37]

55 371

56 372 **Strengths and limitations**

57 373 Several factors may have influenced data collection, analysis and interpretation and affected
58
59 374 the trustworthiness of findings. The sample consisted of only males as no female pilots were available
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3 375 at the time of data collection. Despite meeting qualitative interviewing competencies,[6] the primary
4
5 376 researcher (AD) was a relative novice as a qualitative interviewer. Concept saturation was reached in
6
7 377 this study but this was assessed retrospectively, whereas assessment throughout data collection is
8
9 378 recommended and would have improved methodology.[6] Data coding was conducted by the primary
10
11 379 researcher (AD) and cross checked by another researcher (ES) after completion. Whilst time
12
13 380 constraints limited the extent of member checking and transcript validation inductive analysis ensured
14
15 381 the coding framework and dictionary were a true reflection of participant data. [6]

16 382

17 383 **Implications for practice and future research**

18 384 Findings can be used to inform the current practice of physiotherapists working with military
19
20 385 aircrew with neck pain. In the absence of a population specific measure, clinicians should ensure
21
22 386 biopsychosocial impact factors of flying are assessed during patient history taking. Further qualitative
23
24 387 research is required to build on these findings and develop a population specific PROM; cognitive
25
26 388 interviewing would test the range and interpretation of concepts and refine the new PROM items.[38]
27
28 389 Once a PROM has been developed and validated for fast jet aircrew, it would require re-validation in
29
30 390 other military aircrew groups. A population specific measure would enable investigation of the
31
32 391 effectiveness of the ACP, and daily physiotherapy practice to mitigate against neck pain in this unique
33
34 392 population.

35 393

36 394 **CONCLUSION**

37 395 Flight related neck pain has a broad impact on the lives of fast jet pilots, including physical
38
39 396 symptoms, occupational, psychological and social effects. Physical symptoms were largely associated
40
41 397 with neck pain, but other clinically relevant factors included symptoms in other body regions and fear
42
43 398 avoidance patterns. Occupational factors included modifications and restrictions of flying, some of
44
45 399 which may have flight safety implications. Psychological effects expanded on feelings of worry,
46
47 400 including impact on future quality of life. Social and activity factors reflected items in existing PROM.
48
49 401 Further qualitative research is required to develop and validate a population specific PROM for
50
51 402 military aircrew.

52 403

53 404

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56
57 407 discussed their thoughts and experiences.

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4 409 Defence Academic Deanery, who both provided funds towards this study.

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7
8 411 **Contributors**

9
10 412 AD and NH conceived the idea for the study. AD conducted the interviews with ES cross-checking
11 413 them. AD and NH analysed the data. AD and NH wrote the first draft. All authors reviewed and
12 414 provided additional review comments. All authors provided their full approval prior to submission.

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14 415

15
16 416 **Competing Interests**

17
18 417 None declared.

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20 418

21
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24 421 Deanery both provided funds towards this study.

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30 424 **Data availability statement**

31 425 All data relevant to the study are included in the article or uploaded as supplementary information.

32
33 426 Any queries related to this article should be directed to the corresponding author.
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8 527 **FIGURE LEGENDS**

9
10 528 **Figure 1** Proposed endpoint model for a new neck specific PROM for military aircrew.
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12 529

13 530 **Figure 2 a)** Hypothesised conceptual framework for a neck specific PROM for military aircrew in the
14 top left corner. **b)** Revised conceptual framework for a neck specific PROM for military aircrew in the
15 531 bottom right corner. Thirteen new sub-themes were included in the revised conceptual framework,
16 532 with seven modified (work related, flying, physical symptoms, neck pain, social and activity related,
17 533 psychological and emotional, and worry) and four discarded (decreased neck range of motion, desk-
18 534 based work, fatigue and activity avoidance).
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25 537 **Figure 3** Revised conceptual framework for a neck specific PROM for military aircrew.
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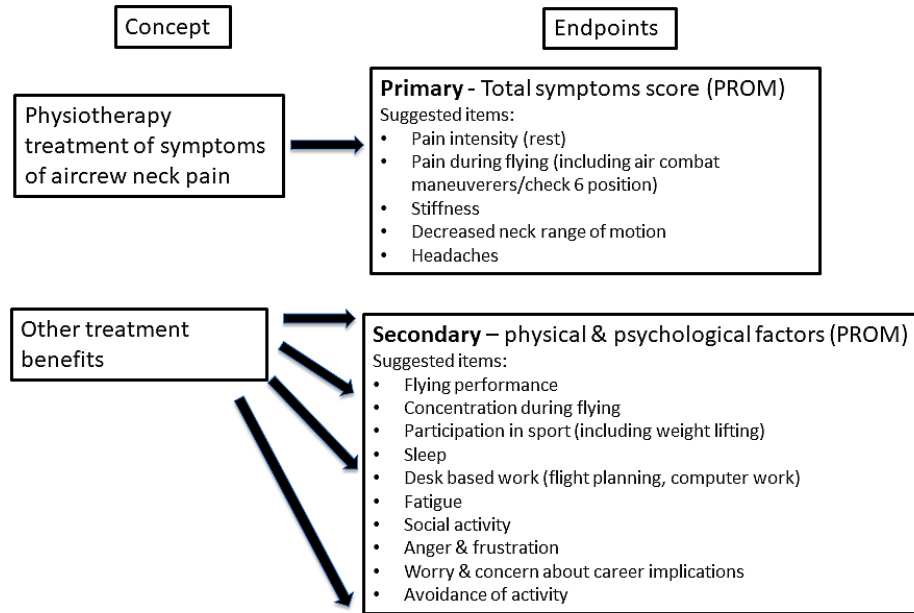


Figure 1 Proposed endpoint model for a new neck specific PROM for military aircrew

27x20mm (900 x 900 DPI)

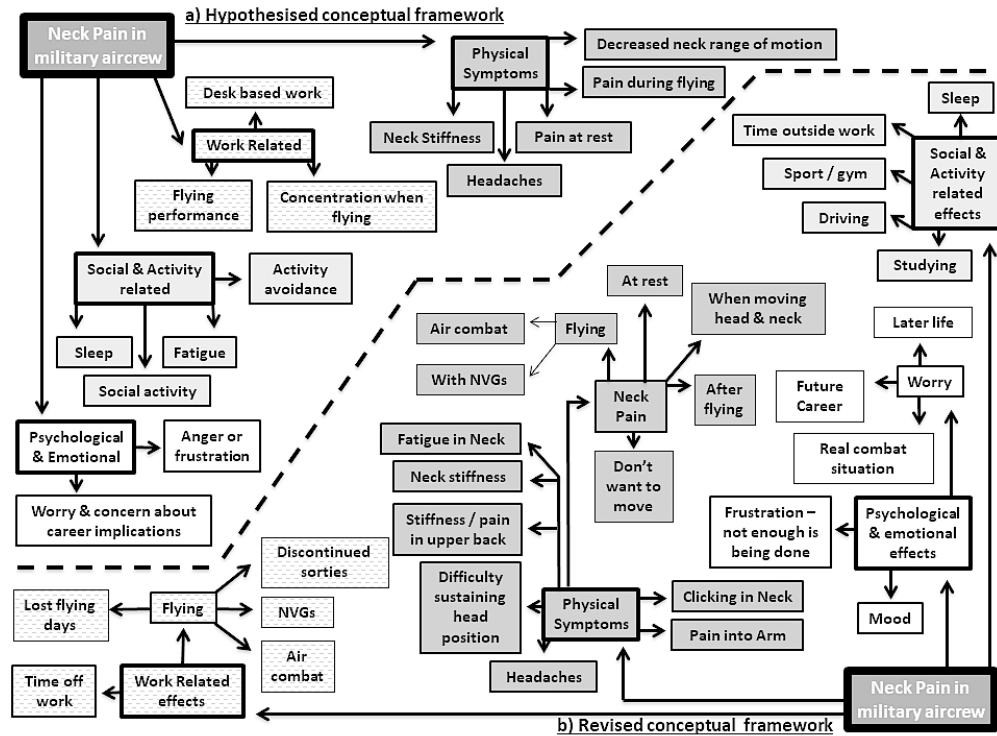


Figure 2 a) Hypothesised conceptual framework for a neck specific PROM for military aircrew in the top left corner. b) Revised conceptual framework for a neck specific PROM for military aircrew in the bottom right corner. [Thirteen new sub-themes were included in the revised conceptual framework, with 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)]

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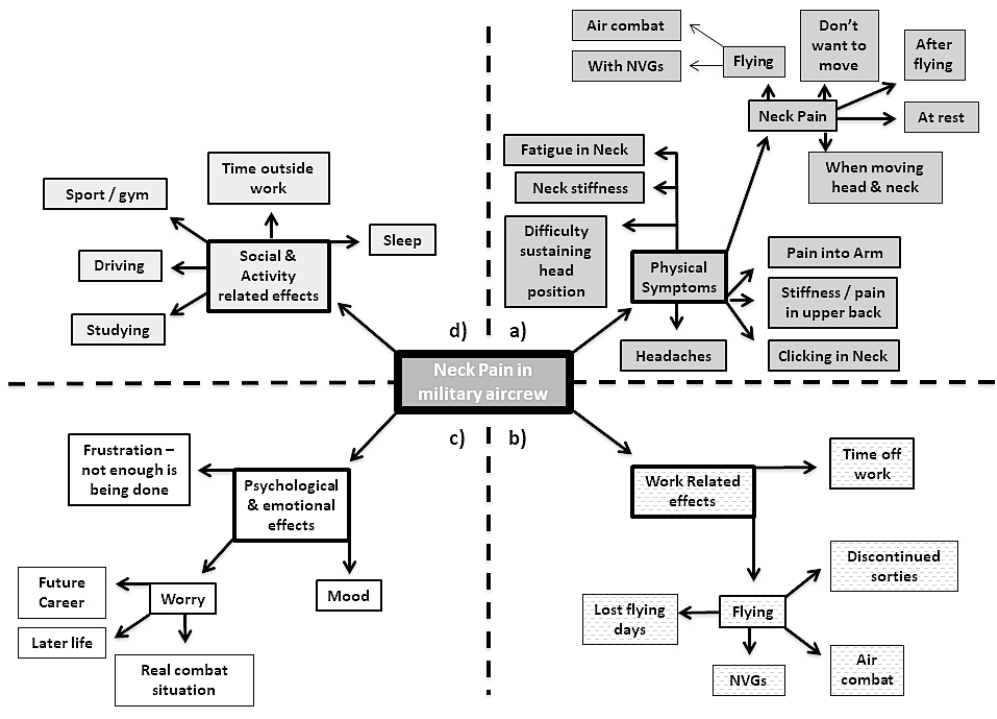


Figure 3 Revised conceptual framework for a neck specific PROM for military aircrew

27x20mm (900 x 900 DPI)

Supplementary file 1. COREC 32-Item Checklist

No. Item	Guide questions/description	Reported on Page #, line #
Domain 1: Research team and reflexivity		
1. Interviewer/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 interviewer/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