

ORIGINAL ARTICLE

Guarding and flow in the movements of people with chronic pain: A qualitative study of physiotherapists' observations

Amanda C. de C. Williams¹  | Raffaele Buono²  | Nicolas Gold³  |
Temitayo Olugbade⁴  | Nadia Bianchi-Berthouze⁴ 

¹Research Department of Clinical, Educational & Health Psychology, University College London, London, UK

²Department of Anthropology, University College London, London, UK

³Computer Science, University College London, London, UK

⁴UCL Interaction Centre (UCLIC), University College London, London, UK

Correspondence

Amanda C. de C. Williams, Research Department of Clinical, Educational & Health Psychology, University College London, Gower St, London WC1E 6BT, UK.

Email: amanda.williams@ucl.ac.uk

Abstract

Background: Among the adaptations of movement consistently associated with disability in chronic pain, guarding is common. Based on previous work, we sought to understand better the constituents of guarding; we also used the concept of flow to explore the description of un/naturalness that emerged from physiotherapists' descriptions of movement in chronic pain. The aim was to inform the design of technical systems to support people with chronic pain in everyday activities.

Methods: Sixteen physiotherapists, experts in chronic pain, were interviewed while repeatedly watching short video clips of people with chronic low back pain doing simple movements; physiotherapists described the movements, particularly in relation to guarding and flow. The transcribed interviews were analysed thematically to elaborate these constructs.

Results: Moderate agreement emerged on the extent of guarding in the videos, with good agreement that guarding conveyed caution about movement, distinct from biomechanical variables of stiffness or slow speed. Physiotherapists' comments on flow showed slightly better agreement, and described the overall movement in terms of restriction (where there was no flow or only some flow), of tempo of the entire movement, and as naturalness (distinguished from normality of movement).

Conclusions: These qualities of movement may be useful in designing technical systems to support self-management of chronic pain.

Significance: Drawing on the descriptions of movements of people with chronic low back pain provided by expert physiotherapists to standard stimuli, two key concepts were elaborated. Guarding was distinguished from stiffness (a physical limitation) or slowness as motivated by fear or worry about movement. Flow served to describe harmonious and continuous movement, even when adapted around restrictions of pain. Movement behaviours associated with pain are better understood in terms of their particular function than aggregated without reference to function.

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1 | INTRODUCTION

Pain can produce fear of movement – apprehension of harm or of increased pain under immediate threat – or anxiety about movement, where threat is uncertain (Elman & Borsook, 2018; Vlaeyen & Linton, 2000). Behaviours associated with fear and anxiety about movement (concepts used somewhat interchangeably in chronic pain) include verbal statements, non-language vocalization, posture, gesture, gait, functional limitations, and seeking health care or emotional support (Fordyce, 1996), each subject to contingencies whose manipulation enables behaviour change. Many ‘pain behaviour’ scales combine these into a single total, without questioning whether the topographically distinct movements constitute a unitary construct (Moore, 2014). After verbal and facial expression of pain, the most studied pain behaviour in humans is guarding (Main & Watson, 1996; Moore, 2014), a robust construct directly associated with anxiety (Olugbade, Bianchi-Berthouze, & Williams, 2019), and predicting future disability (Prkachin et al., 2007).

Movement characteristics between people with and without low back pain overlap but vary substantially (Knechtel et al., 2021; Laird et al., 2014; Laird et al., 2019) in speed, range, flexion-relaxation response, and lumbo-pelvic synchrony (Laird et al., 2018), inside and outside clinic settings (Gizzi et al., 2018; Roeser et al., 2019), but intervening to change them has produced mixed reports of change in pain and function (Farragher et al., 2019; Kent et al., 2015; Laird et al., 2012; van Dieën et al., 2019). Although physiotherapists routinely observe and interpret pain-related movement quality (Van Dijk, Smorenburg, Visser, Heerkens, & Nijhuis-van der Sanden, 2017), no adequate assessment instruments exist (Van Dijk et al., 2020).

Many people with chronic low back pain hold models of irreparable damage to spinal structures (Setchell et al., 2017; Shanbehzadeh et al., 2022), fostering protective movement patterns (Caneiro et al., 2017; Thomas & France, 2007). In acute and chronic pain, pain-related fear or anxiety is associated with disability (Zale et al., 2013), with smaller associations with specific parameters of spinal movement, such as reduced range, increased muscle activity (Christe et al., 2021), and functional limitation. In everyday clinical practice aiming to facilitate everyday activities in chronic pain, physiotherapists may focus on correcting movement and/or on correcting patients' misapprehensions (Caneiro et al., 2017). Most widely used cues to guarding among physiotherapists are smoothness, speed, pattern or sequencing of movement, and facial expression (Olugbade et al., 2018; Van Dijk, Smorenburg, Visser, Nijhuis-van der Sanden, & Heerkens, 2017). The concept of ‘flow’ (Nakamura & Csikszentmihalyi, 2002) was used to capture physiotherapists' descriptions of

‘naturalness’ of movement, and to achieve an inclusive and psychologically-informed description suitable for rehabilitation. Flow is described as awareness of movement without self-conscious control, where skills match challenge.

An important aim of this study was to contribute to development of computational models of movement qualities in chronic pain (Thiry et al., 2022; Wang et al., 2019), to support technology for everyday self-management. To identify the behavioural language that these models should draw upon, assumption-free qualitative methods were used to ask (1) what pain-experienced physiotherapists identified as guarding in standard movements by people with chronic pain, how they described it, and (2) whether they identified ‘flow’ and how they characterized it.

2 | METHODS

2.1 | Participants

The study was approved by the local research ethics committee (reference: 5095/001). Eighteen physiotherapists working with chronic pain patients were recruited by snowball sampling from clinical contacts of the first author. All were in senior positions, working full- or part-time in chronic pain. One did not respond to the invitation to participate. The remainder completed and returned consent forms, and individual interviews using Microsoft Teams were arranged at convenient times, recorded with their explicit consent. One of these recordings failed, leaving 16 participants. These 16 physiotherapists were offered no reimbursement but were provided with a summary of findings.

Mean time since qualification of physiotherapists was 21 years, range 10–33 years, working in chronic pain for a mean of 10 full-time years (adjusted for part-time work and career breaks), range 3–17 years. Twelve worked full-time in pain; the remaining four worked 50% or 60% of their time in pain.

2.2 | Material

During the interview, each physiotherapist was shown videos from the EmoPain dataset (Aung et al., 2016; and see Figure S1) of people with chronic musculoskeletal low back pain doing each of four movements: reaching forward with arms horizontal in standing position (reach-forward), bending down towards the toes in standing position (forward-bend), standing from sitting (sit-to-stand), and sitting from standing (stand-to-sit). All these

movements can be challenging for people with chronic low back pain, and are well represented in the physiotherapy literature. The videos, from 10 people with low back pain, were chosen from a larger set of 16 people all performing each movement twice: choice was based on showing both sexes, a range of ages, and as wide as possible variation in pain-affected movement. Most lasted less than 30s. The quality of the video was also considered, although, given the distance of the camera from the moving person, facial expression was always rather low resolution. This provided five videos of reach-forward, four of forward-bend, and six each of sit-to-stand and stand-to-sit. Videos were randomly assigned across physiotherapists, two for each of the four movements, so each physiotherapist commented on eight videos. In turn, each video was described by at least three and at most eight physiotherapists. Interview transcripts automatically generated by Microsoft Teams were checked and corrected by an independent researcher (RB) using the video soundtrack to obtain verbatim data.

2.3 | Procedure

After watching each video for the first time, the physiotherapist was then asked, How would you describe the movement? The videos were repeated while the physiotherapist described the movement to his or her satisfaction. Several further questions followed: Would you describe it as guarded, stiff, slow, etc.?; When do you notice the movement being different/abnormal? (the physiotherapist would say 'now' as the video ran); Did the movement have flow?; and What single piece of advice would you like to give the patient to help with this movement? This was repeated for each of the eight videos (two for each of the four movements) for each physiotherapist.

2.4 | Data management and analysis

The first author (AW), trained in clinical psychology, used framework analysis to analyse data on guarding and on flow. Framework analysis is related to thematic analysis, but is used deductively where overall themes are drawn from current theory, suiting elaboration of relatively homogeneous participant accounts (Gale et al., 2013; Smith & Firth, 2011). The processes mostly follow thematic analysis: developing codes through immersion in data; placing codes in categories; achieving meaning by iterative interpretation; with the additional step of indexing transcripts by categories against participants (Spencer et al., 2013).

Because of the risk of selectivity in coding and allocation to themes in any thematic analysis, a second author

(RB), trained in anthropology and unfamiliar with the participants or stimulus material, independently analysed data on flow for the same transcripts using thematic analysis inductively (Braun & Clarke, 2006). After analysis was complete, the two accounts were compared and discussed.

3 | RESULTS

Most interviews took around 1 h. One recording failed, so 16 were transcribed and analysed. Framework analysis addressed guarding and flow separately (albeit with some cross-referencing in codes), and for both, the framework analysis largely agreed with the independent thematic analysis with no marked differences, so the two versions were combined. The notable difference between the two methods, other than the overall epistemological difference of a deductive rather than inductive stance, is the cross-referencing of themes to participants. When inspected, this provided no evidence of uniqueness of particular themes to different groups of physiotherapists, so is not reported here. While it is unusual to analyse data by two similar methods independently, it confers at least as much rigour as sampling of sections of one researcher's analysis by another, as is recognized good practice in qualitative research (Braun & Clarke, 2006). Themes are illustrated below with quotations from participating physiotherapists, indicated by [PH + index number].

3.1 | Guarding

Guarding was not always judged as present or absent, but qualified by application to part of the movement or part of the body. Observations were coded as 0 for not guarded, 1 for partial guarding (part of body/part of movement), 2 for definite guarding, and 3 for marked guarding (emphasized by respondent). Between three and eight physiotherapists commented on guarding for each of the videos (see Figures 1 and 2), with five missing values where the question was erroneously not asked or answered. Agreement on guarding, using the categories above, was not high (see Figure 1), with four instances of complete agreement: three (with six, three, and two physiotherapists respectively) on no guarding, and one (four physiotherapists) on guarding.

3.1.1 | Guarding versus stiffness versus bracing

Although agreement was moderate at best, physiotherapists were highly consistent in describing guarding; no

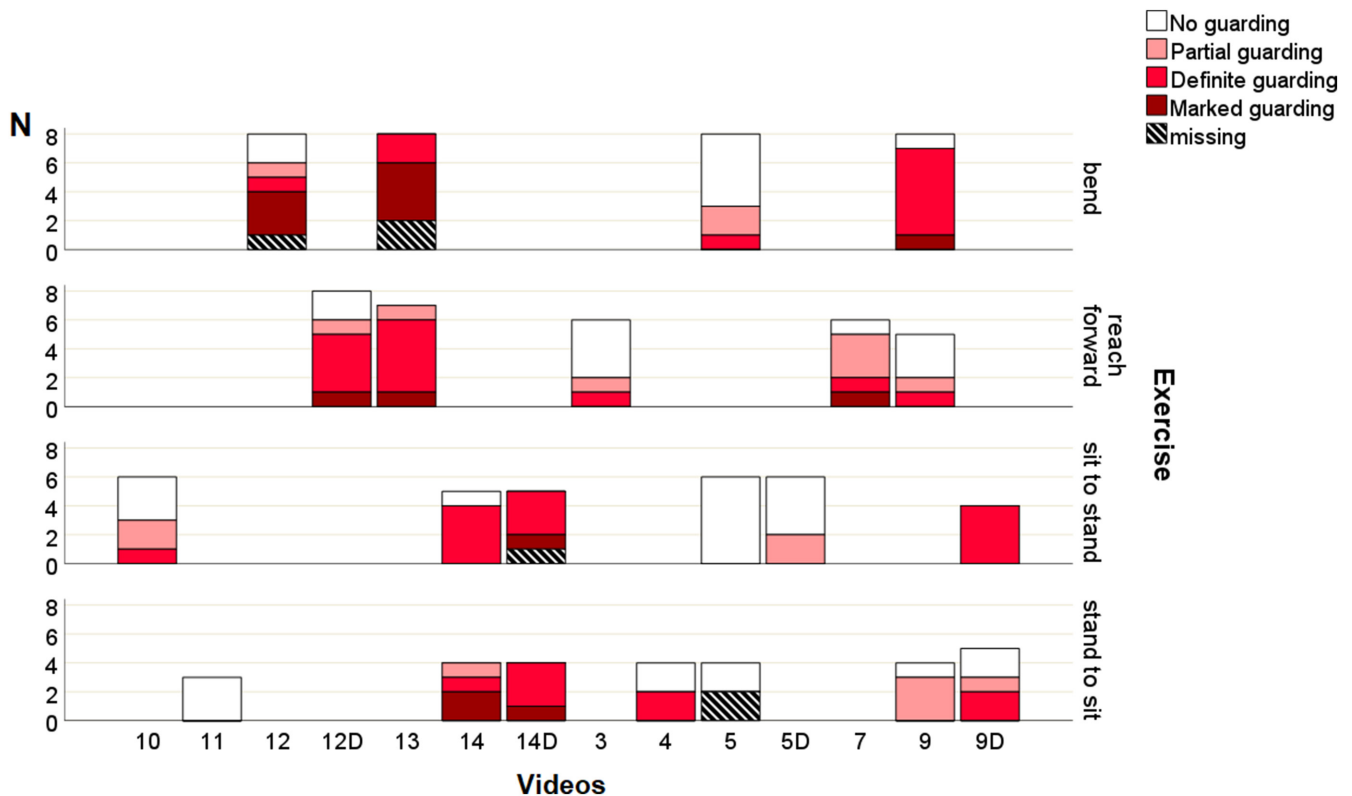


FIGURE 1 Physiotherapist dis/agreement on guarding. Key: ID number of person with pain + 'D' when movement was made more difficult, for example, by holding 2 kg weight in hands, or trying not to use hands when stand-to-sit or sit-to-stand.

constituent themes were extracted. However, guarding was clearly distinguished from stiffness, slowness, and bracing. Stiffness was described predominantly in biomechanical terms, as 'rigid' or 'wooden', and guarding more in terms of emotion. Bracing was rarely used, and almost entirely for taking weight through the hands placed on thighs when moving from/to standing to/from sitting.

3.1.2 | Emotional nature of guarding

Guarding descriptions included 'cautious', 'protective', 'fearful', and 'avoidant': 'Guarding... people look reluctant to do it: they're cautious and apprehensive about doing it' [PH10]. Comments on breath-holding as an indication of anxiety were common for all except one of the high-consensus guarded movements, with additional 'grimacing' or unspecified 'facial expression'. Physiotherapists often specified what part of body was being guarded, most often the spine: 'doing the movement ... as if she didn't want to move the lumbar spine' [PH5]. Compensatory strategies were also noted: 'trying to keep his lower back quite still by stretching forward his thoracic spine' [PH12]; 'it looks like he's quite cautious with the spine there—and that's why maybe he's compensating with his legs' [PH5]. They less often included terms such as 'stiff', tending to

emphasize the cautious nature of the movement over the physical restriction, although the two were related: 'Very stiff movement... but ... rather than him himself physically being stiff, it's the guarding that makes it look so stiff' [PH15]. The single sit-to-stand movement, agreed not to show guarding by all six physiotherapists who viewed it, was nevertheless described by all as departing from normal movement, but not indicating participant anxiety about the movement.

3.2 | Flow

The question 'Does this movement have flow?' was often answered 'yes' (coded 2) or 'no' (coded 0) with some qualifications: some flow, or flow for part but not all of the movement, or flow in some parts of the body but not others (all coded 1). Agreement was calculated: where two each of six physiotherapists were coded as answering 0, 1, and 2, agreement was 2/6; where four of six physiotherapists were coded as answering 0, and one each for 1 and 2, agreement was 4/6. Nine judgements were missing where participants gave no or unclear responses.

Agreement among physiotherapists on flow was not high (see Figure 2), although three cases, all *no flow*, showed consensus: a sit-to-stand and a stand-to-sit (four

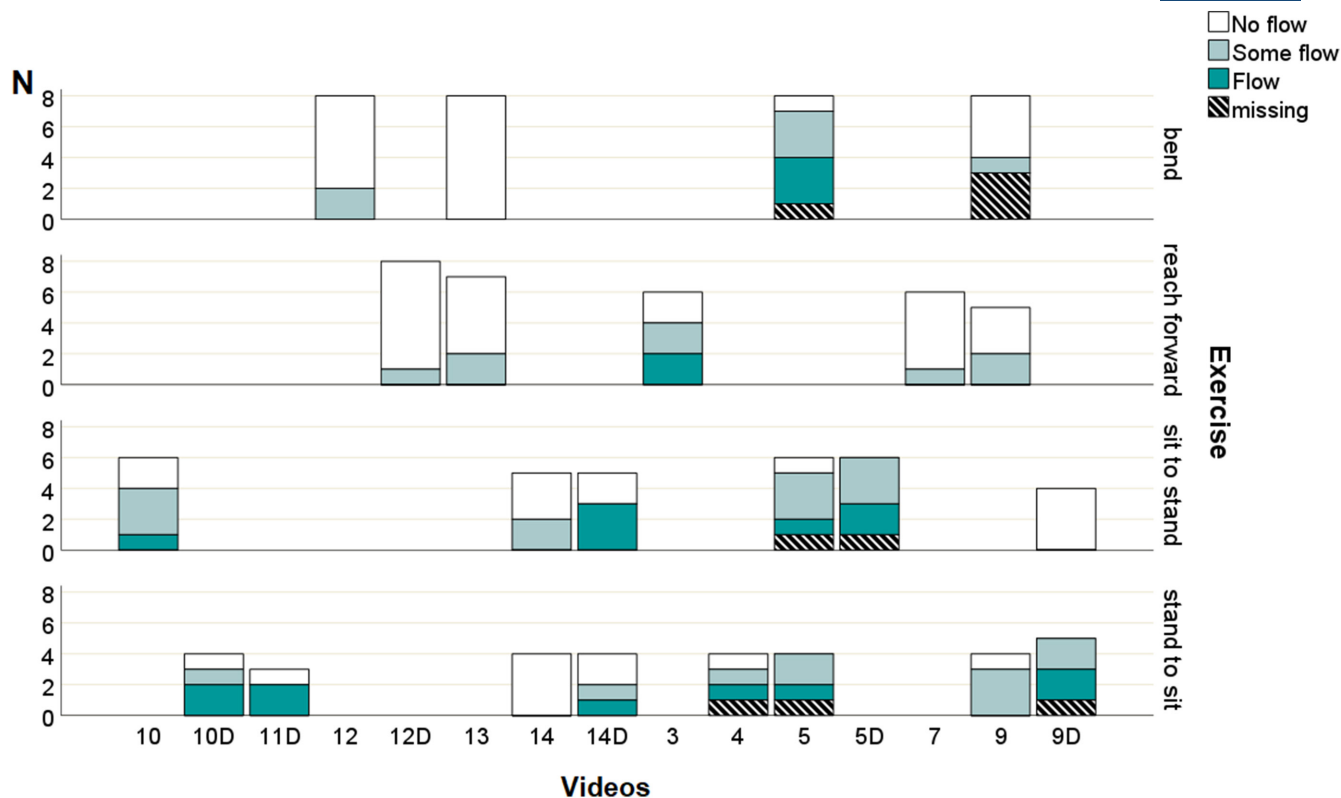


FIGURE 2 Physiotherapist dis/agreement on flow. Key: ID number of person with pain + 'D' when movement was made more difficult, for example, by holding 2 kg weight in hands, or trying not to use hands when stand-to-sit or sit-to-stand.

physiotherapists), and a forward-bend (eight physiotherapists). Overall agreement for reach-forward was 67%, for sit-to-stand 65%, for stand-to-sit 59%, and for forward-bend 74%. Since overall judgements were by different sets of physiotherapists for each video, further exploration of levels of agreement was not pursued.

Flow is represented here as a continuum from *no flow* through *some flow* (defined using participants' own qualifications: 'some', 'sort of', 'yes for age', 'first bits had flow then it stopped', 'going into flexion, yes, coming out less so') to *flow*, with two themes applied onto part of the continuum.

A first theme was contextualized movement: physiotherapists contextualized observed movements within an understanding of the particular person and the experimental setting, using cues in facial expressions (somewhat low video resolution), and frequently commenting on the lack of information from the person with pain. Rather than describing movement in terms of ab/normality, physiotherapists showed curiosity about personal-historical, medical, and pain characteristics, beliefs, and emotional context. Thus movements that were unconventional, or worked around physical limitations, could still have flow for that person and movement.

A second theme, restriction of movement, applied to judgements of *no flow* or *some flow*. Where there was *no*

flow, restricted movement often invoked stiffness: 'He keeps his back quite arched and quite rigid' [PH3]; 'Very limited movement throughout her spine, stiff in her neck, stiff in her shoulders, and stiff in her thoracic spine. Yeah, and lumbar spine' [PH16]. For *some flow*, comments often referred to constraints of age, build, fitness, actual or anticipated pain.

She almost keeps her back straight when she moves... If that's a problem or not, I don't know. Could be that she's doing it because it hurts when she moves her back – so she's keeping it still to avoid the pain. Could be that she's just really stiff through there. Could be that she's been told not to bend her back because it's a bad thing to do.

[PH6]

Poor flow was also associated with lack of balance or visible shift in balance during the movement, described in terms of 'things moving in isolation' [PH05] or 'moving in sections' [PH06] where only part of the body or movement had flow.

Related to restricted movement, and again occurring only for *no flow* or *some flow*, was the theme flow as tempo, to express the way in which elements of the overall

movement were related. Timing of movements was an important dimension, mostly without reference to normal speed, but with the focus rather on the tempo of the movement itself. Thus a movement performed slowly could still have flow, depending on its other qualities. Hesitation, uneven tempo, or effort, or in a few cases a movement performed fast and appearing 'jerky', decreased or destroyed flow.

Then there's initiation of trunk forward flexion, and then... that absolutely stops. You can see the brakes go juddering on and then the girdle just protracts and she reaches out. [PH10]

The last, but central, theme is flow as natural, occurring across judgements but mainly when physiotherapists judged a movement to have flow. Flow was described in aesthetic terms ('lovely'), or as not deliberate or consciously controlled: 'intuitive', 'happy', 'confident', 'comfortable'. These were coded as *natural movement*. Other descriptions referred to tempo ('smooth', 'fluid'), or, unlike other themes, normality of speed or range ('moving freely and able to reach up and move to a point that would be expected' [PH16]).

Naturalness of a movement took into account individual characteristics of the person with pain, including biomechanical restrictions. Qualifications to the judgement of flow were coded *but not perfect* (in the framework analysis): although the movement showed some difficulty, or a strategic adaptation, it still had a naturalness and ease.

OK, there's also a tiny bit of an area that he is trying to avoid as he does it, but on the whole it's a much more fluid movement.

[PH12]

But she's got a bit of a habit of doing it [using her hand]. She's very kind of flowing and smooth. It seems like this way of moving for her works really well.

[PH1]

Flow expressed confidence in achieving the movement, even idiosyncratically adapted. This confidence was not a self-conscious performance, but in-the-moment intuitively guided rather than controlled.

By contrast, non-natural movement (no or little flow) was described in terms of awareness, protection, guarding, attention to or conscious control of movement, or avoidance, albeit contextualized by age, physique, or condition. Impressions of the person with pain being 'not happy with this' or 'uncomfortable' were common.

I'd say the first bit seemed to have flow and then... the flow stopped... almost like she's sort of forgotten that first initial moment like she's sort of not thinking about it so much—she's just doing it. But then you see her mind sort of kicks in. It looks like she's starting to analyse what she's doing, and particularly now she's thinking it might be a problem.

[PH11]

4 | DISCUSSION

Both guarding and flow were identified by physiotherapists without difficulty, often as a continuum rather than categorically, but with reasonable confidence despite the lack of information from or about the individual in the video. Although estimated between-physiotherapist agreement on guarding was only moderate, their elaborations showed a high level of consistency, with attention particularly to signs of tension or apprehension. Guarding as reluctance or caution in movement – as an intention expressed through subtle rather than obvious qualities of movement, 'doing something to stop something' [PH10] – was clearly distinguished from stiffness, an inference about physical condition, and from slowness. This strongly supports the important emotional component of guarding, previously implicit rather than explicit.

Our findings suggest that combining different protective behaviours (including guarding and stiffness) in a single category, as in pain behaviour inventories (e.g. Cook et al., 2013), obscures meaningful differences in how people move with chronic pain. Descriptions of guarding here offer some leads for further research, although more granular information is required to identify behavioural expression of emotional aspects of guarding. Subtle avoidance may constitute safety behaviour (Sharpe et al., 2022), anxiety-reducing behaviour that prevents disconfirmation of a disabling belief and so maintains and even worsens anxiety (Meulders et al., 2016; Rachman et al., 2008; Thwaites & Freeston, 2005). In applying the concept to physical disorders, Sharpe et al. (2022) distinguished between safety precautions, reducing realistic threat to allow engagement with valued activities (Karsdorp & Vlaeyen, 2009), and safety behaviours, ineffective efforts to avoid overestimated threat, thereby reducing engagement. To some extent, physiotherapists in our study applied similar pragmatic judgements, addressing how well adaptations served people with pain in achieving the overall movement.

Flow was also identified by all physiotherapists, continuous rather than categorical, again with modest agreement

except in a few cases of no flow. Interestingly, a large scale study of physiotherapists' views on quality of movement of people with low back pain, reported a similar theme of fluency of movement among the complex and multiple dimensions of movement description, but associated fluency with normality and symmetry (Van Dijk, Smorenburg, Visser, Nijhuis-van der Sanden, & Heerkens, 2017), and less with the psychological concepts proffered by our sample. In our study, flow was not incompatible with guarding (and clearly not synonymous with absence of guarding), although the presence of guarding was usually associated with judgements of limited flow at best. Description of flow appeared to be close to those in the non-clinical literature (Nakamura & Csikszentmihalyi, 2002), neither over-controlled, as in guarded behaviour, nor uncontrolled. Flow was related to movement tempo by the absence of sudden changes in movement velocity: acceleration and deceleration in the movements occurred with seamless transitions between different parts of the body and of the movement. The movement could be slow yet still have flow. By contrast, stops, pauses, and hesitations disrupted flow, often serving to take more control of a movement, suggesting anxiety about completing it. Advice offered by physiotherapists often involved simplifying the movement (such as sitting down on or standing up from a higher seat) to try to find the point at which the person with pain was no longer apprehensive, an excellent example of reducing challenge to the just-manageable (Nakamura & Csikszentmihalyi, 2002). A further piece of advice involved conscious control of breathing to increase fluency of movement, hence physiotherapists' concern when they believed they observed restricted breathing.

Bodily expression has been relatively neglected in emotion recognition studies (Kleinsmith & Bianchi-Berthouze, 2012). In everyday settings, body affect recognition may be as good as recognition of facial emotional expression, with fear (in particular) automatically processed (Aviezer et al., 2012; De Gelder et al., 2015; Zhao et al., 2019), and likely to affect physiotherapists' judgements of a movement even without awareness. Here the emotional information inherent in movement was usefully conceptualized as flow. This was the first attempt to relate flow to movement with pain; not only did it make sense to physiotherapists, but it was not defined in terms of normality of movement.

The study had several limitations. The task required of physiotherapists was unusual in that they were unable to supplement observations with information about the person with pain. Nor could they fully use facial cues that they sought since the video resolution was inadequate for the purpose. Thus some judgements were conditional on assumptions about the target person's physical and psychological state that would, under

normal clinical conditions, be confirmed or disconfirmed by questioning or observation. Some physiotherapists opined that being observed and filmed, even at the distance used, might have exacerbated anxieties for the person with pain, and we cannot disconfirm the possibility. A further possible source of bias is that most participating physiotherapists were known to the interviewing author, and all were aware that she was a psychologist; this may have encouraged reporting of psychological factors in interview. Requiring quantitative judgements of guarding and flow would have allowed better calculation of dis/agreement. The decision not to do so, out of concern for the possible cost to physiotherapists' elaborations, represents a further limitation. Concerning analysis, the first author held views on pain behaviour that could have biased the themes extracted, but the use of framework analysis, plus separate thematic analysis by a naïve researcher, mitigated this to some extent.

This study confirmed for us the importance of integrating emotional state and beliefs into understanding movement, as experienced physiotherapists did. It also affirmed flow as a useful concept in describing desired qualities of movement, since neither limited mobility nor adjustment to pain (actual or anticipated) necessarily undermined flow where adaptations were harmoniously embodied and enacted. Flow is very likely related to 'fluency', the second most common movement quality named by a large sample of physical therapists in the Netherlands (Van Dijk, Smorenburg, Visser, Heerkens, & Nijhuis-van der Sanden, 2017; Van Dijk, Smorenburg, Visser, Nijhuis-van der Sanden, & Heerkens, 2017). Clinical research could usefully foster recognition of emotional barriers to movement, since the methods to address them are distinct from those to address musculoskeletal barriers; drawing on expert observation (as sampled here) to foster better understanding in less experienced physiotherapists, since all will deal daily with complaints of pain, even if it is not the main focus. Psychologically-informed physiotherapy practice is welcomed by patients (Wilson et al., 2016), and is at least as effective as traditional methods (Guerrero et al., 2018). We currently lack the datasets to develop these ideas further, and better datasets would include clearer facial expression and auditory information (particularly on breathing), both difficult to capture without affecting the target's behaviour. This information could support clinical treatment, particularly when used in the wild, away from the safety of the physiotherapist and clinic setting, thereby addressing the unrealized potential for technology to supplement physiotherapists' rehabilitative initiatives in chronic pain, and to take it into people's own environments (Sterling & Keefe, 2021).

The findings from our study contribute to informing technological contributions to assessing the needs of

people with pain in order to tailor support for a more active lifestyle. First, the distinctions between guarding and flow by physiotherapists point to the need for technology to assess and address them as separate constructs; this points to an issue about different types of behaviour that is important in establishing ground truths on which to train technologies. Second, experienced physiotherapists make affective evaluations in the individual's context, indicating the desirability of a multilayer technological approach to specifying individual needs. This multilayer approach could aim to capture multiple levels of abstraction, including the target individual's subjective state (e.g. anxiety about the intended activity), the observer's expert assessment of their movement (e.g. flow/no flow), and lower level observer judgement of physical (e.g. slow, hesitant) characteristics of the movement. This can be achieved using multitask and/or hierarchical learning strategies, such as in the studies of Wang et al. (2021), Lu et al. (2018), and Zhang and Provost (2019); all enable multiple 'views' of the same experience to be modelled jointly. New datasets will be needed to facilitate this as the few open datasets, such as the EmoPain dataset (Aung et al., 2016), while including a variety of relevant self and observer ratings (such as pain intensity, anxiety level, guarding, hesitation), does not have labels for 'flow'. Success in extending existing datasets with new observer annotations in the past, for example, for the extension of the EmoPain dataset (Olugbade, Bianchi-Berthouze, & Williams, 2019) and with the BoLD dataset (Luo et al., 2020), shows this to be a practical and less expensive alternative to creating new datasets. Overall, the current study adds to similar studies (e.g. Olugbade, Singh, et al., 2019) to deepen insight into the ways in which pain, fear of movement, and low-mood interfere with physical activity, studies that are valuable groundwork for informing (machine learning) problem formulation for chronic pain physical rehabilitation technology.

AUTHOR CONTRIBUTIONS

Amanda C de C. Williams: Conceptualisation, methodology, investigation, data curation, analysis, writing – original draft, funding acquisition. Raffaele Buono Data curation, analysis, reviewing final draft. Nicolas Gold: Conceptualisation, writing – reviewing and editing, funding acquisition. Temitayo Olugbade: Conceptualisation, data curation, writing – reviewing and editing. Nadia Berthouze: Conceptualisation, methodology, writing – reviewing and editing, funding acquisition.

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ORCID

Amanda C. de C. Williams  <https://orcid.org/0000-0003-3761-8704>

Raffaele Buono  <https://orcid.org/0000-0001-5187-0629>

Nicolas Gold  <https://orcid.org/0000-0002-2195-5995>

Temitayo Olugbade  <https://orcid.org/0000-0002-2838-6131>

Nadia Bianchi-Berthouze  <https://orcid.org/0000-0001-8921-0044>

REFERENCES

- Aung, M. S. H., Kaltwang, S., Romera-Paredes, B., Martinez, B., Singh, A., Cella, M., Valstar, M., Meng, H., Kemp, A., Shafizadeh, M., Elkins, A. C., Kanakam, N., de Rothschild, A., Tyler, N., Watson, P. J., Williams, A. C., Pantic, M., & Bianchi-Berthouze, N. (2016). The automatic detection of chronic pain-related expression: Requirements, challenges and a multimodal dataset. *IEEE Transactions on Affective Computing*, 7(4), 435–451. <https://doi.org/10.1109/TAFFC.2015.2462830>
- Aviezer, H., Trope, Y., & Todorov, A. (2012). Body cues, not facial expressions, discriminate between intense positive and negative emotions. *Science*, 30, 1225–1229. <https://doi.org/10.1126/science.1224313>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp0630a>
- Caneiro, J. P., O'Sullivan, P., Smith, A., Moseley, G. L., & Lipp, O. V. (2017). Implicit evaluations and physiological threat response in people with persistent low back pain and fear of bending. *Scandinavian Journal of Pain*, 17, 355–366. <https://doi.org/10.1016/j.sjpain.2017.09.012>
- Christe, G., Crombez, G., Edd, S., Opsommer, E., Jolles, B. M., & Favre, J. (2021). Relationship between psychological factors and spinal motor behaviour in low back pain: A systematic review and meta-analysis. *Pain*, 162(3), 672–686. <https://doi.org/10.1097/j.pain.0000000000002065>
- Cook, K. F., Keefe, F. J., Jensen, M. P., Roddey, T. S., Callahan, L. S., Revicki, D., Bamer, A. M., Kim, A. M., Chung, H., Salem, R., & Amtmann, D. (2013). Development and validation of a new self-report measure of pain behaviors. *Pain*, 154(12), 2867–2876. <https://doi.org/10.1016/j.pain.2013.08.024>
- De Gelder, B., de Borst, A. W., & Watson, R. (2015). The perception of emotion in body expressions. *Wiley Interdisciplinary Reviews Cognitive Science*, 6, 149–158. <https://doi.org/10.1002/wcs.1335>
- Elman, I., & Borsook, D. (2018). Threat response system: Parallel brain processes in pain Vis-à-Vis fear and anxiety. *Frontiers in Psychiatry*, 9, 29. <https://doi.org/10.3389/fpsyt.2018>
- Farragher, J. B., Pranata, A., Williams, G., El-Ansary, D., Parry, S. M., Kasza, J., & Bryant, A. (2019). Effects of lumbar extensor muscle strengthening and neuromuscular control retraining in disability in patients with chronic low back pain: A protocol for a randomised controlled trial. *BMJ Open*, 9, e028259. <https://doi.org/10.1136/bmjopen-2018-028259>
- Fordyce, W. E. (1996). *Behavioral methods for chronic pain and illness*. CV Mosby and Co. Reprinted in C. J. Main, F. J. Keefe, M. P. Jensen, J. W. S. Vlaeyen, & K. E. Vowles (Eds.), (2014), *Fordyce's behavioral methods for chronic pain and illness, republished with invited commentaries*. Philadelphia, USA: IASP Press/Wolters Kluwer.

- Gale, N. K., Heath, G., Cameron, E., Rashid, S., & Redwood, S. (2013). Using the framework method for the analysis of qualitative data in multi-disciplinary health research. *BMC Medical Research Methodology*, *13*, 117. <https://doi.org/10.1186/1471-2288-13-117>
- Gizzi, L., Röhrle, O., Petzke, F., & Falla, D. (2018). People with back pain show reduced movement complexity during their most active daily tasks. *European Journal of Pain*, *43*, 410–418. <https://doi.org/10.1002/ejp.1318>
- Guerrero, A. V. S., Maujean, A., Campbell, L., & Sterling, M. (2018). A systematic review and meta-analysis of the effectiveness of psychological interventions delivered by physiotherapists on pain, disability and psychological outcomes in musculoskeletal pain conditions. *Clinical Journal of Pain*, *34*(9), 838–857.
- Karsdorp, P. A., & Vlaeyen, J. W. S. (2009). Active avoidance but not activity pacing is associated with disability in fibromyalgia. *Pain*, *147*(1–3), 29–35. <https://doi.org/10.1016/j.pain.2009.07.019>
- Kent, P., Laird, R., & Haines, T. (2015). The effect of changing movement and posture using motion-sensor biofeedback, versus guidelines-based care, on the clinical outcomes of people with sub-acute or chronic low back pain – A multicentre, cluster-randomised, placebo-controlled, pilot trial. *BMC Musculoskeletal Disorders*, *16*, 31. <https://doi.org/10.1186/s12891-015-0591-5>
- Kleinsmith, A., & Bianchi-Berthouze, N. (2012). Affective body expression perception and recognition: A survey. *IEEE Transactions in Affective Computing*, *4*(1), 15–33. <https://doi.org/10.1109/T-AFFC.2012.16>
- Knechtle, D., Schmid, S., Suter, M., Riner, F., Moschini, G., Senteler, M., Schweinhardt, P., & Meier, M. L. (2021). Fear-avoidance beliefs are associated with reduced lumbar spine flexion during object lifting in pain-free adults. *Pain*, *162*(6), 1621–1631. <https://doi.org/10.1097/j.pain.0000000000002170>
- Laird, R. A., Gilbert, J., Kent, P., & Keating, J. L. (2014). Comparing lumbo-pelvic kinematics in people with and without back pain: A systematic review and meta-analysis. *BMC Musculoskeletal Disorders*, *15*, 229. <https://doi.org/10.1186/1471-2474-15-229>
- Laird, R. A., Keating, J. L., & Kent, P. (2018). Subgroups of lumbo-pelvic kinematics are present in people with and without persistent low back pain. *BMC Musculoskeletal Disorders*, *19*, 309. <https://doi.org/10.1186/s12891-018-2233-1>
- Laird, R. A., Keating, J. L., Ussing, K., Li, P., & Kent, P. (2019). Does movement matter in people with back pain? Investigating ‘atypical’ lumbo-pelvic kinematics in people with and without back pain using wireless movement sensors. *BMC Musculoskeletal Disorders*, *20*, 28. <https://doi.org/10.1186/s12891-018-2387-x>
- Laird, R. A., Kent, P., & Keating, J. L. (2012). Modifying patterns of movement in people with low back pain – Does it help? A systematic review. *BMC Musculoskeletal Disorders*, *13*, 169. <https://doi.org/10.1186/1471-2474-13-169>
- Lu, J., Shang, C., Yue, C., Morillo, R., Ware, S., Kamath, J., Bamis, A., Russell, A., Wang, B., & Bi, J. (2018). Joint modeling of heterogeneous sensing data for depression assessment via multi-task learning. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, *2*(1), 1–21.
- Luo, Y., Ye, J., Adams, R. B., Li, J., Newman, M. G., & Wang, J. Z. (2020). ARBEE: Towards automated recognition of bodily expression of emotion in the wild. *International Journal of Computer Vision*, *128*, 1–25.
- Main, C. J., & Watson, P. J. (1996). Guarded movements: Development of chronicity. *Journal of Musculoskeletal Pain*, *4*(4), 163–170. https://doi.org/10.1300/J094v04n04_16
- Meulders, A., Van Daele, T., Volders, S., & Vlaeyen, J. W. (2016). The use of safety-seeking behavior in exposure-based treatments for fear and anxiety: Benefit or burden? A meta-analytic review. *Clinical Psychology Review*, *45*, 144–156. <https://doi.org/10.1016/j.cpr.2016.02.002>
- Moore, J. (2014). Targeting behavior change in chronic pain treatment: A clinical perspective. In C. J. Main, F. J. Keefe, M. P. Jensen, J. W. S. Vlaeyen, & K. E. Vowles (Eds.), *Fordyce's behavioral methods for chronic pain and illness, republished with invited commentaries* (pp. 192–197). IASP Press/Wolters Kluwer.
- Nakamura, J., & Csikszentmihalyi, M. (2002). The concept of flow. In C. R. Snyder & S. J. Lopez (Eds.), *Handbook of positive psychology* (pp. 89–105). OUP.
- Olugbade, T., Bianchi-Berthouze, N., & Williams, A. C. (2019). The relationship between guarding, pain and emotion. *Pain Reports*, *4*, e770. <https://doi.org/10.1097/PR9.0000000000000770>
- Olugbade, T. A., Singh, A., Bianchi-Berthouze, N., Marquardt, N., Aung, M. S. H., & Williams, A. C. (2019). How can affect be detected and represented in technological support for physical rehabilitation? *ACM Transactions on Computer-Human Interaction (TOCHI)*, *26*(1), 1–29.
- Olugbade, T.O., Bianchi-Berthouze, N., Marquardt, N., & Williams, A.C.de C. (2018). Human observer and automatic assessment of movement related self-efficacy in chronic pain: from exercise to functional activity. *IEEE Transactions on Affective Computing*, *11*(2), 214–229. <https://doi.org/10.1109/TAFFC.2018.2798576>
- Prkachin, K. M., Schulz, I. Z., & Hughes, E. (2007). Pain behavior and the development of pain-related disability: The importance of guarding. *Clinical Journal of Pain*, *23*(3), 270–277. <https://doi.org/10.1097/AJP.0b013e3180308d28>
- Rachman, S., Radosky, A. S., & Shafran, R. (2008). Safety behaviour: A reconsideration. *Behaviour Research and Therapy*, *46*, 163–173. <https://doi.org/10.1016/j.brat.2007.11.008>
- Roeser, S., Hernandez, A., Ransone, K., Turner, C., Weber, M., Brunner, R., Atkins, B., & Gombatto, S. P. (2019). *Monitoring of lumbar spine posture and movement during daily activities in individuals with chronic low back pain: A case series. Poster presented at 2019 combined sections meeting.* American Physical Therapy Association.
- Setchell, J., Costa, N., Ferreira, M., Makovey, J., Nielsen, M., & Hodges, P. W. (2017). Individuals' explanations for their persistent or recurrent low back pain: A cross-sectional survey. *BMC Musculoskeletal Disorders*, *18*, 466. <https://doi.org/10.1186/s12891-017-1831-7>
- Shanbehzadeh, S., ShahAli, S., Takamjani, I. E., Vlaeyen, J. W. S., Salehi, R., & Jafari, H. (2022). Association of pain-related threat beliefs and disability with postural control and trunk motion in individuals with low back pain: A systematic review and meta-analysis. *European Spine Journal*, *31*, 1802–1820. <https://doi.org/10.1007/s00586-022-07261-4>
- Sharpe, L., Todd, J., Scott, A., Gatzounis, R., Menzies, R. E., & Meulders, A. (2022). Safety behaviours or safety precautions? The role of subtle avoidance in anxiety disorders in the context of chronic physical illness. *Clinical Psychology Review*, *92*, 102–126. <https://doi.org/10.1016/j.cpr.2022.102126>
- Smith, J., & Firth, J. (2011). Qualitative data analysis: Application of the framework approach. *Nurse Researcher*, *18*(2), 52–62. <https://doi.org/10.7748/nr2011.01.18.2.52.c8284>
- Spencer, L., Ritchie, J., Ormston, R., O'Connor, W., & Barnard, M. (2013). Analysis: Principles and processes. In J. Ritchie, J.

- Lewi, C. M. Nicholls, & R. Ormston (Eds.), *Qualitative research practice. A guide for social science students and researchers* (2nd ed., pp. 269–293). Sage.
- Sterling, M., & Keefe, F. J. (2021). Physical rehabilitation research and pain science. *Pain*, *162*(11), 2621–2624. <https://doi.org/10.1097/j.pain.0000000000002326>
- Thiry, P., Houry, M., Philippe, L., Nocent, O., Buisseret, F., Dierick, F., Slama, R., Bertucci, W., Thévenon, A., & Simoneau-Buessinger, E. (2022). Machine learning identifies chronic low back pain patients from an instrumented trunk bending and return test. *Sensors*, *22*(13), 5027. <https://doi.org/10.3390/s22135027>
- Thomas, J. S., & France, C. R. (2007). Pain-related fear is associated with avoidance of spinal motion during recovery from low back pain. *Spine*, *32*(16), E460–E466. <https://doi.org/10.1097/BRS.0b013e3180bc1f7b>
- Thwaites, R., & Freeston, M. (2005). Safety-seeking behaviours: Fact or function? How can we clinically differentiate between safety behaviours and adaptive coping strategies across anxiety disorders? *Behavioural and Cognitive Psychotherapy*, *33*, 177–188. <https://doi.org/10.1017/S1352465804001985>
- van Dieën, J. H., Reeves, N. P., Kawchuk, G., van Dillen, L. R., & Hodges, P. W. (2019). Motor control changes in low back pain: Divergence in presentations and mechanisms. *Journal of Orthopaedics and Sports Physical Therapy*, *49*, 370–379. <https://doi.org/10.2519/jospt.2019.7917>
- Van Dijk, M. J. H., Smorenburg, N. T. A., Heerkens, Y. F., Mollema, J., Kiers, H., Nijhuis-van der Sanden, M. W. G., & Visser, B. (2020). Assessment instruments of movement quality in patients with non-specific low back pain: A systematic review and selection of instruments. *Gait & Posture*, *76*, 346–357.
- Van Dijk, M. J. H., Smorenburg, N. T. A., Visser, B., Heerkens, Y. F., & Nijhuis-van der Sanden, M. W. G. (2017). How clinicians analyse movement quality in patients with non-specific low back pain: A cross-sectional survey study with Dutch allied health care professionals. *BMC Musculoskeletal Disorders*, *18*, 288. <https://doi.org/10.1186/s12891-017-1649-3>
- Van Dijk, M. J. H., Smorenburg, N. T. A., Visser, B., Nijhuis-van der Sanden, M. W. G., & Heerkens, Y. F. (2017). Description of movement quality in patients with low back pain: A qualitative study as a first step to a practical definition. *Physiotherapy Theory and Practice*, *33*(3), 227–237. <https://doi.org/10.1080/09593985.2017.1282998>
- Vlaeyen, J. W. S., & Linton, S. J. (2000). Fear-avoidance and its consequences in chronic musculoskeletal pain: A state of the art. *Pain*, *85*, 317–332. [https://doi.org/10.1016/S0304-3959\(99\)00242-0](https://doi.org/10.1016/S0304-3959(99)00242-0)
- Wang, C., Gao, Y., Mathur, A., Williams, A. C., Lane, N. D., & Bianchi-Berthouze, N. (2021). Leveraging activity recognition to enable protective behavior detection in continuous data. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, *5*(2), 1–27.
- Wang, C., Peng, M., Olugbade, T. A., Lane, N. D., Williams, A. C., & Bianchi-Berthouze, N. (2019). Learning temporal and bodily attention in protective movement detection. ACII 2019 8th International Conference on Affective Computing and Intelligent Interaction Workshops and Demos (ACIIW).
- Wilson, S., Chaloner, N., Osborn, M., & Gauntlett-Gilbert, J. (2016). Psychologically-informed physiotherapy for chronic pain: Patient experiences of treatment and therapeutic process. *Physiotherapy*, *103*(1), 98–105.
- Zale, E. L., Lange, K. L., Fields, S. A., & Ditte, J. W. (2013). The relationship between pain-related fear and disability: A meta-analysis. *Journal of Pain*, *14*(10), 1019–1030. <https://doi.org/10.1016/j.jpain.2013.05.005>
- Zhang, B., & Provost, E. M. (2019). Automatic recognition of self-reported and perceived emotions. In *Multimodal behavior analysis in the wild* (pp. 443–470). Academic Press.
- Zhao, N., Zhang, Z., Wang, Y., Wang, J., Li, B., Zhu, T., & Xiang, Y. (2019). See your mental state from your walk: Recognizing anxiety and depression through Kinect-recorded gait data. *PLoS One*, *14*(5), e0216591. <https://doi.org/10.1371/journal.pone.0216591>

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