Introduction

Chronic pain is a common condition affecting up to 24% of adults across the world (Marris *et al*., 2019), with high levels of pain and pain-related diseases being reported as the leading cause of global disability and disease burden by the Global Burden of Disease Study 2016 (GBD, 2017; Mills *et al.,* 2019). Pain is classed as chronic if it persists past the normal tissue-healing time of three months and can significantly impact people's physical activity levels and participation in daily activities, as well has having psychological and emotional implications (Marris *et al.,* 2019). Although it may be precipitated by a single event such as a musculoskeletal injury, chronic pain is mediated by a range of physical, psychological, social and emotional factors (Mills *et al.,* 2019) and is often unrelated to the level of tissue damage. In chronic pain, the brain and nervous system have an increased ability to produce pain due to increased sensitivity in spinal and cortical nociceptive networks, a process often termed central sensitisation (Fletcher *et al.,* 2016). As well as living with the pain itself, there can be knock-on effects such as the development of maladaptive coping mechanisms and fear-avoidance behaviours. These can potentially be addressed through pain neuroscience education (PNE) with an aim to reconceptualise the pain experience (Louw *et al.*, 2011).

Chronic Pain and Fear Avoidance

Pain has been defined as 'an unpleasant sensory and emotional experience associated with actual or potential tissue damage' by the International Association for the Study of Pain (Merskey and Bogduk, 1994). The brain produces pain responses in reaction to danger signals it receives from sensors throughout the body. Activity of the neurones sending danger signals is termed nociception and can be produced by a variety of mechanical, chemical or temperature stimuli. However, not all nociceptive stimuli result in a pain response, this is dependent on how the brain analyses the information received and is influenced by emotional factors and past experiences. Many different areas of the brain are involved in pain expression and repetition of activity that occurs during a pain experience can form signal patterns (Butler and Moseley, 2013). Pain itself can be a useful adaptive response to protect the body and promote healing. In chronic pain, however, the increased sensitivity of the nervous system leads to longer-lasting, maladaptive changes. Patients may experience hyperalgesia – where noxious stimuli cause higher levels of pain – or allodynia – where a usually non-noxious stimulus such as light touch may become painful. Areas unrelated to the original site of damage may become involved, and the pain experience persists even though the initial injury may have healed. Repeated nociceptive stimulation can cause these changes to become more permanent within the central nervous system (van Griensven *et al.*, 2014).

There are a variety of risk factors for developing chronic pain, including socioeconomic background, employment status and health-related behaviours, along with clinical factors such as acute pain, multimorbidity, mental health or genetics. Personal attitudes and beliefs regarding pain can also influence the development and persistence of chronic pain and disability. This is in part due to passive coping strategies, such as taking medication, rather than more effective active strategies such as exercise therapy which results in lower levels of pain-related disability and less interaction with healthcare services (Mills *et al.,* 2019). Patients with lower pain self-efficacy are also more at risk of developing chronic pain and maladaptive behaviours. Low self-efficacy can involve fear of movement and activities, lack of motivation and less ability to successfully manage pain or related symptoms (Martinez-Calderon *et al.,* 2018). Conversely, patients with higher levels of self-efficacy are less likely to develop chronic pain, and those that do are more able to self-manage their

condition. Self-efficacy can act as a mediator between pain and disability, leading to fear-avoidance behaviours through the maintenance of unhelpful pain beliefs (Karasawa *et al.*, 2019).

Fear-avoidance beliefs are strongly linked to the chronic pain experience. To avoid painful experiences or activities, patients may begin catastrophising about potential pain-provoking situations and falsely believe this pain to be causing further tissue damage. These fears can result in avoidance behaviours such as kinesiophobia and hypervigilance (Fletcher *et al.*, 2016: Gatchel *et al*., 2016). This irrational fear of movement creates a downward spiral of reduced physical activity and deconditioning, lowered mood and increased pain-related disability, which can then result in a worsened pain experience. This leads to even less participation and reduced quality of life (Zale and Ditre, 2015). This process is described in Vlaeyen's fear-avoidance model of pain (Vlaeyen and Linton, 2000), which incorporates physical, psychological and social components and describes catastrophising as exacerbating fear, whereas confrontation can reduce it (Wittink and Michel, 2002). This has potential as an area of intervention in chronic pain management. Methods to measure pain-related fear-avoidance have been developed, including the Tampa Scale of Kinesiophobia (TSK) and the Fear-Avoidance Beliefs Questionnaire (FABQ). However, these do not relate avoidance behaviours with fear of pain specifically. The Fear-Avoidance Components Scale (FACS) has been more recently developed to address this shortcoming, with clinically relevant levels designed to support healthcare professionals in assessing and treating fear avoidance and disability (Gatchel *et al*. 2016). Addressing psychosocial factors such as fear avoidance specifically, rather than taking a biomedical approach to pain management, can lead to reduced disability, improved mood and better quality of life (Zale and Ditre, 2015).

Previous chronic pain treatments have involved various approaches, including joint manipulation, acupuncture, general exercise and pharmacological intervention. However, these tend to focus on physical structures, and are often passive rather than involving the patient actively in their own pain management. They have been found to have small effect sizes and could be said to neglect important aspects of chronic pain conditions, including pain cognition, behaviours and understanding (Rabiei *et al*., 2020). Chronic pain is a complex condition resulting from combined biological, psychological and social factors and, as such, requires a more comprehensive approach to treatment than previously provided (Zale and Ditre, 2015). Healthcare has experienced a move away from a traditional biomedical approach towards a biopsychosocial model, requiring chronic pain management and interventions to follow suit (Rabiei *et al*., 2020). These must take account of the wide range of factors that may be maintaining a patient's pain experience and impacting their quality of life. It is likely that a more person-centred approach to working with chronic pain patients will improve the chance of successful outcomes and the patient experience (SIGN, 2019). Current guidelines for chronic pain management recommend multidisciplinary pain management programmes and psychological intervention alongside other forms of physical therapy and potential pharmacological treatment. Although education strategies can provide benefits to chronic pain patients, there is limited clinically significant evidence to support improvements in pain intensity and disability. However, improvements may be seen in attitudes towards pain after a combined PNE programme (NICE, 2021; SIGN, 2019).

Pain Neuroscience Education

PNE is a cognition-based education intervention with a growing evidence base. It differs from other education models by focusing on the neurophysiology and neurobiology of pain along with contextual factors, rather than using biomechanical models (Louw *et al*., 2011). In doing so, it aims

to help patients view their pain as less threatening and develop more effect management strategies as a result (Watson *et al., 2019).* Previous educational strategies such as the back school approach tend to link pain to pathology and vulnerability of structures; however, this fails to address psychosocial barriers to rehabilitation (Moseley *et al.*, 2004). PNE also differs from alternative psychological therapies such as cognitive behavioural therapy (CBT) – which focuses on coping with the emotional response to pain (Marris *et al.*, 2019), and motivational interviewing – which is a more communicative approach encouraging patients to change behaviours by reducing uncertainty by providing information and support (Nijs *et al.*, 2020). Both approaches are widely accepted options in the treatment of chronic pain, and PNE also has the potential to be used in conjunction with these effectively.

The principle of "explaining pain" was first described by Moseley (2002) in a study investigating the effects of combined physiotherapy and education on lower back pain. This has led to the development of PNE as a more robust, structured intervention. Moseley *et al.* (2004) investigated this further by isolating the neurophysiology component of education. The information given in these education sessions was based on knowledge of pain neurophysiology from Wall and Melzack's *Textbook of Pain.* In a later systematic review evaluating the effectiveness of PNE, Louw *et al.* (2011) determined the common content of PNE sessions. These included pain neurophysiology, nociception and nociceptive pathways, neurons, synapses, action potential, spinal inhibition and facilitation, peripheral sensitisation, central sensitisation and neuroplasticity. There was no reference to anatomic models, and little discussion of emotional or behavioural aspects of pain in any session. Some of the studies reported using content from *Explain Pain* by Butler and Moseley to direct their sessions. PNE explores these areas using metaphors to help patients understand the processes behind their pain experience and reconceptualise their pain (Louw *et al.,* 2019). It is important that the reality of their experience is acknowledged, as a common misconception conveyed with pain education is that an individual's pain is "all in their head". This is not the case, and pain education should reassure patients that their experience of pain is real, even though the risk of tissue damage is not (Moseley and Butler, 2015).

Primary benefits of PNE are the reduction of fear-avoidance beliefs and behaviours and catastrophising. The maladaptive behaviours exhibited by many chronic pain sufferers stem from inaccurate knowledge and beliefs relating to pain, so by targeting these beliefs there is the potential to influence the behaviours as a result. Links have been found between increased knowledge of pain neurophysiology and reduced kinesiophobia and fear-avoidance beliefs. However, current evidence is less clear in relation to effects on pain and pain-related disability (Fletcher *et al.*, 2016; Watson *et al.*, 2019). Unlike other interventions such as pharmacological or manual therapies, PNE does not focus on pain reduction directly, though this may occur through reduced catastrophising and increased participation in other pain-influencing activities. For the most part though, the greater benefit seen through PNE is the improvements to a patient's quality of life. Watson *et al.* (2019) found that reductions in disability became progressively closer to clinical significance when measured in the medium term compared to short-term effects. This suggests that patients may take time to change their behaviour and engage more successfully with meaningful activities as they get better at managing their symptoms. Benefits may also be seen as kinesiophobia reduces and patients become more accepting of active treatments that promote recovery.

Some studies have investigated the use of PNE as a standalone intervention with varying results. While some have suggested it does lead to improvements in pain-related disability (Louw *et al.*, 2011; Fletcher *et al.*, 2016), others have been unable to show this with clinical significance and the benefits seem to be limited to altered beliefs and understanding, with some improvements to

participation (Moseley and Butler, 2015; Watson *et al.*, 2019). However, there is no harm from PNE interventions alone and these may still result in improved knowledge and understanding of pain, increased participation in other rehabilitative interventions, and reduced catastrophising and fear of pain. All of these can be considered benefits to a person showing maladaptive adaptations because of their pain experience (Moseley and Butler, 2015). Moseley and Butler (2015) highlight that 'explaining pain' was not initially intended as an individual treatment, and when combined with other biopsychosocial treatments it can offer clinically significant reductions in pain and disability.

PNE can be combined with a variety of different treatments. For example, PNE with cognition-targeted motor control training has been found to be superior to traditional care – back and neck education and general exercise therapy - for improving pain cognition and function, and reducing chronic spinal pain (Malfliet *et al*., 2018a). PNE can also be combined with psychological interventions such as motivational interviewing to provide complementary components to an education session, potentially improving outcomes. This could provide a strong base to progress to more active but still biopsychosocially driven pain management strategies (Nijs *et al.*, 2020). Combining PNE with traditional physiotherapy interventions for chronic pain has been found to be superior at reducing pain and disability compared with physiotherapy alone, although the same review was unable to determine whether it was more effective than combined CBT and physiotherapy (Marris *et al*., 2020). Combining PNE with other interventions is in line with current best-practice guidance recommending multimodal approaches to management. This may indicate an important role for physiotherapists, as professionals with both knowledge of pain neurophysiology and a movement-based approach to interventions (Louw *et al*., 2011). And, importantly, the addition of PNE to a physiotherapy programme or other current practice is not shown to have any negative effects.

The results of PNE are also dependant on delivery and, again, the evidence-base varies on this. When comparing two studies providing PNE based on *Explain Pain* (Butler and Moseley, 2013), it was found to have benefits for pain and disability when delivered face-to-face, but to be largely ineffective when only written material was used (Wang *et al.*, 2021). In contrast, another study found that using a metaphor-based storybook as an educational tool does show improvements for pain catastrophising and could be an effective precursor to more active rehabilitation (Gallagher *et al.*, 2013). This implies that written material can be useful in pain education, but the presentation of this is important when engaging people to change their beliefs. People are more inclined to read a book of metaphors explaining pain concepts than they are to read a book providing behavioural advice (Moseley and Butler, 2015). Nijs *et al.* (2011) describe a process incorporating an initial education session, homework with an educational booklet, then a second follow-up session to consolidate and begin exploring more active patient management. The literature also describes both individual and group delivery formats, although there is little evidence to support one being superior to the other and they are sometimes used in combination (Wood and Hendrick, 2018).

It is also important to consider how ready an individual may be to accept the information given during a PNE session, and how ready they are to change their beliefs or behaviours regarding their pain. The process of changing maladaptive behaviours can be described by the transtheoretical model of behaviour change. This model consists of five stages: precontemplation – the individual has no intention to change behaviour; contemplation – they are aware of the problem; preparation – they intend to change their behaviour; action – they attempt to do so; and maintenance – consolidation of new behaviour and relapse prevention (Jensen *et al.*, 2000). Those in different stages may respond better to different interventions and determining where a patient lies in this model can help direct their treatment to what is most appropriate and useful for them. For example,

someone in the precontemplation stage may believe their pain is a medical problem that needs 'fixed', and therefore have little motivation to actively engage with behavioural change (Dijkstra, 2005). The initial focus for such a person may therefore be developing their understanding of the pain process, rather than suggesting positive behavioural changes straight away and linking these to more active treatment. In this scenario PNE as an individual intervention could be clinically reasoned to be the most appropriate.

Looking Forward

A clear link is already established between chronic pain, fear-avoidance beliefs and behaviours and pain-related disability, and stronger evidence is emerging to support the use of PNE to manage these. Further research could consider the most effective delivery processes of PNE as there is currently little evidence to support either individual or group approaches (Wood and Hendrick, 2018). One study by Malfliet *et al*. (2018b) implemented a blended learning approach to PNE delivery, incorporating online and face-to-face learning, and was the first of its kind to do so. Further research evaluating this approach would be useful to determine benefits to time and cost-effectiveness. Many studies consider the effects of PNE in the short and medium term, but less evidence exists to show the long-term outcomes. It would be useful to determine long-term effectiveness, whether benefits of the intervention are retained, and factors that influence this. Future research could also compare PNE combined with other interventions to guide development of optimal interventions and dosage. This can then be integrated in current guidelines (Watson *et al.*, 2019).

There is also scope for PNE to be used as a preventative measure, as well as an intervention for existing chronic pain. By recognising at-risk populations and educating them regarding the pain process, this can reduce the likelihood of them developing chronic pain (Louw *et al.*, 2011). For example, Goudman *et al.* (2019) discuss the use of PNE pre-operatively for patients undergoing lumbar radiculopathy surgery. By educating these at-risk patients before the surgery takes place, they have more accurate expectations of their symptoms post-surgery and are less likely to catastrophise both before and after their hospital admission. The central nervous system is therefore better able to recover along with the healing tissues, avoiding added stress components and maladaptive coping mechanisms (Goudman *et al.*, 2019). It is likely that PNE could have a strong role to play in preventing development of chronic pain following episodes of acute pain, providing another area for valuable future research (Moseley and Butler, 2015).

Conclusion

Chronic pain is a widespread, complex condition that can significantly impact the quality of life of those experiencing it. This condition is influenced by a range of biopsychosocial factors and can lead to fear-avoidance beliefs and catastrophizing. This ultimately results in the development of maladaptive adaptations and fear-avoidance behaviours which create a downward spiral of pain and disability and can negatively impact rehabilitation. To manage the symptoms of chronic pain interventions must include strategies to target fear avoidance and misconceptions about pain. Although there are still many aspects requiring further research, this can be approached successfully using pain neuroscience education.

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