A Global Investigation into the Back Pain Attitudes and Beliefs of Human Factors and Ergonomics Specialists

BY

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THESIS

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ABSTRACT

Background: Lower back pain (LBP) is highly prevalent within working contexts globally and evidently has a negative impact on the well-being and performance of workers. Unhelpful attitudes and beliefs about back pain, through complex interactions, contribute to the persistence of LBP and related disability. Professionals have the potential to transmit their own views to others through belief-driven advice and recommendations. The attitudes and beliefs of human factors and ergonomics (HFE) specialists are currently unknown but have the potential to influence the attitudes, beliefs, and behaviours of workers and other company stakeholders. This study aimed to address this gap through an investigation into the back pain related attitudes and beliefs of global HFE specialists, including the International Ergonomics Association's (IEA) Council. **Method:** The validated Back Pain Attitudes Questionnaire (Back-PAQ) was used to assess attitudes and beliefs about back pain. Data were collected at the International Ergonomics Association's 22nd Triennial Congress held in Jeju, South Korea, and via email through IEA federated and affiliated societies. Descriptive statistics and frequency results were used to explore the attitudes and beliefs of global HFE specialists, and inferential statistics were used to determine any differences related to role and in terms of years of experience. The attitudes and beliefs of the IEA Council were subsequently compared to the rest of the sample. **Results:** 158 questionnaires were returned, 38 of which were from the IEA Council, providing data from HFE specialists across 27 countries. Unhelpful beliefs relating to the need for protective mechanisms and the special nature and impact of back pain were frequently identified. Conversely, the sample held positive beliefs around the relationship between pain and injury, back pain prognosis, and the need to remain active during pain episodes. The attitudes and beliefs of HFE specialists in this study were, however, highly variable with several contradictions identified. **Conclusions:** While some positive beliefs were identified, the negative and contradictory beliefs held may undermine advancements in HFE research, education, and practice and have the potential to perpetuate similar attitudes and beliefs in others. Further research is necessary to develop tailored interventions that address these unhelpful beliefs in specific contexts. Such efforts may improve the implementation of evidence-based prevention efforts in the workplace.

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LIST OF ABBREVIATIONS

HFE – Human factors and ergonomics

IEA – International Ergonomics Association

LBP – Lower back pain

ACE – Activity-Centred Ergonomics

Back-PAQ – Back Pain Attitudes Questionnaire

BBQ – Back Beliefs Questionnaire

MSD – Musculoskeletal disorder

ILO – International Labour Organisation

ISO – International Standards Organisation

FEES – Federation of European Ergonomic Societies

ULAERGO – La Unión LatinoAmericana de Ergonomía/the Latin American Ergonomics Union

ACED – Asian Council on Ergonomics and Design

SEANES – The South East Asian Network of Ergonomics Societies

IEA2024 – International Ergonomics Association's 22nd Triennial Congress

PhD – Doctor of Philosophy

HSE – Health and Safety Executive

OSHA – Occupational Safety and Health Administration

OHSAS – Occupational Health and Safety Advisory Services

CHAPTER 1: INTRODUCTION AND REVIEW OF LITERATURE

Introduction

"A group of scientists believe that our back pain epidemic is being caused not by something physically wrong with our spines but something culturally wrong with our beliefs: how we think about our backs and how we think about back pain. A cultural illness. A society-wide sickness of how we think and speak" (Mannix, 2023, p. 61).

To define an appropriate research question, it is first necessary to establish a clear gap in the literature that has scientific relevance and importance. Lower back pain (LBP) and related disability remain a significant problem within working contexts despite prevention efforts (De Kok et al., 2019; Oakman et al., 2019a; Chen et al., 2023). The scientific discipline of human factors and ergonomics (HFE) purports to use a systems approach to optimise work environments for human well-being and performance. The adoption of such an approach may be hindered by the back pain beliefs held by HFE specialists, which may reflect a traditional biomedical view. The continued persistence of LBP and related disability in the workplace, despite HFE guidance, suggests that this is an important area requiring continued scientific research. Therefore, this chapter explores the relevant literature, provides a problem statement based on the identified gaps, and outlines the research questions that the study aims to answer.

Initially, the chapter frames a broad understanding of LBP, providing some background and context around the global prevalence and impact of LBP and related disability both generally and within working contexts. The section that follows explores how our understanding of LBP aetiology has evolved over time and expanded beyond the traditional biomedical view.

The subsequent section develops an understanding of attitudes and beliefs in the context of LBP, their role in the persistence of LBP and related disability, some commonly held unhelpful beliefs about back pain, as well as the tools available to

assess them. The literature relating to professionals' attitudes and beliefs about back pain is also explored, explaining why these matter.

The final section of the review examines the discipline and practice of HFE, including: the origins and historical development of HFE, the need and advocacy for a holistic systems approach within HFE, and the current risk management practices for musculoskeletal disorders (MSDs). The chapter ends with a statement of the problem identified through the literature review and outlines the research questions aimed at addressing this problem.

1. Review of Literature

1.1 Lower back pain

LBP is a musculoskeletal symptom characterised by pain, discomfort, or stiffness that typically occurs in the lumbosacral region between the lower rib margins and the buttocks (Atlas & Deyo, 2001; Hartvigsen et al., 2018; Knezevic et al., 2021). Depending on the duration of the LBP episode, it may be categorised as acute, subacute, or chronic (Atlas & Deyo, 2001; Tagliaferri et al., 2020). Acute episodes subside within six weeks and subacute episodes within 12 weeks (Atlas & Deyo, 2001; Krismer & van Tulder, 2007; Urits et al., 2019; Tagliaferri et al., 2020). LBP is classified as chronic when it persists for more than 12 weeks (Atlas & Deyo, 2001; Krismer & van Tulder, 2007; Urits et al., 2019; Tagliaferri et al., 2020).

LBP is highly prevalent globally with negative implications evident in populations of varying socioeconomic backgrounds (Vos et al., 2016; Hartvigsen et al., 2018; Cieza et al., 2020; Wu et al., 2020; Ferreira et al., 2023). According to Global Burden of Disease Studies, an estimated 568.4 million people had LBP in 2019 (Chen et al., 2022), rising to 619 million in 2020 (Ferreira et al., 2023). The prevalence of LBP has increased over the last three decades and is projected to rise further (Cieza et al., 2019; Ferreira et al., 2023), with an estimated 843 million cases expected by the year 2050 (Ferreira et al., 2023). LBP is the leading cause of disability globally, accounting for an estimated 63.7 billion years lived with disability (Hartvigsen et al., 2018; Buchbinder et al., 2018; Chen et al., 2022). The high prevalence and disabling nature

of LBP demonstrate the need to intensify research efforts to reduce this burden (Hartvigsen et al., 2018; Buchbinder et al., 2018).

LBP negatively impacts the quality of life of those affected from both a social and economic standpoint (Hoy et al., 2014; Vos et al., 2016; Cieza et al., 2020). The direct (medical) and indirect (productivity loss and absenteeism) costs associated with LBP are significant for individuals and society at large (Hartvigsen et al., 2018). In a review paper including high-income countries, the average annual direct costs of LBP ranged from €2.3 to €2.6 billion, while indirect costs ranged from €0.24 to €8.15 billion (Fatoye et al., 2023a). A similar review based on low- and middle-income countries revealed that the total annual economic costs of LBP were approximately US$2.2 billion (Fatoye et al., 2023b). Furthermore, LBP presents a large burden to healthcare systems in all income settings, with those in low- and middle-income contexts poorly equipped to manage the influx of cases (Ferreira et al., 2023).

LBP in the workforce is a significant contributor to the global burden, representing the most common musculoskeletal problem reported in the workplace (De Kok et al., 2019; Oakman et al., 2019a; Chen et al., 2023). Additionally, working-age adults (25 – 65 years) experience the highest prevalence of LBP and related disability (Vos et al., 2016; Hartvigsen et al., 2018; Cieza et al., 2020; Ferreira et al., 2023; Chen et al., 2023). Across occupational settings, LBP is commonly reported, including among construction workers (Adhikari et al., 2021), office workers (Campos-Fumero et al., 2017), and healthcare providers (Wong et al., 2021; Rezaei et al., 2021).

LBP negatively impacts workers' well-being and their ability to perform tasks, thus affecting performance and productivity (Philips et al., 2008; Fan & Straube, 2016; Chen et al., 2023). Work absence, productivity loss, and premature retirement are most frequently associated with LBP, highlighting its significant impact on the working population (Hoy et al., 2014; Cieza et al., 2020). Work absences and limited productivity also collectively contribute to billions of dollars in annual economic losses, which have negative implications for the economy (Chen et al., 2023). For example, in 2019, occupational LBP resulted in an estimated 216.1 billion dollars in economic losses globally (Chen et al., 2023). Given the prevalence and impact of LBP among the workforce, investigating evidence-based strategies to prevent and manage LBP in

the workplace, and the factors that influence their implementation, remains a salient research objective in the 21st century.

Classifications of LBP exist based on the presence or absence of a clear underlying pathology. Specific LBP, which accounts for a small proportion of LBP cases, refers to pain that occurs due to damage to the spinal tissues or nerves (Krismer & van Tulder, 2007; Hartvigsen et al., 2018). Two broad types of specific LBP are recognised: LBP due to a serious pathology and LBP with significant neurological deficits (Atlas & Deyo, 2001; O'Sullivan et al., 2018; Hartvigsen et al., 2018). LBP cases associated with serious pathology account for 1-2% of cases and include spinal malignancy, infections, vertebral fractures, axial spondyloarthritis, and cauda equina syndrome (Atlas & Deyo, 2001; O'Sullivan et al., 2018; Hartvigsen et al., 2018). LBP cases with significant neurological deficits account for 5-10% of cases and include radicular pain, radiculopathy, spinal stenosis, and, in some cases, intervertebral disc herniation (Atlas & Deyo, 2001; O'Sullivan et al., 2018; Hartvigsen et al., 2018). Most LBP cases (approximately 90%) are non-specific in nature and occur without an identifiable pathoanatomical cause (Atlas & Deyo, 2001; Krismer & van Tulder, 2007; Maher et al., 2017; Hartvigsen et al., 2018; Lund et al., 2020). Given that most presentations of LBP are non-specific and lack an identifiable pathoanatomical cause, understanding LBP requires conceptual models that extend beyond traditional biomedical reasoning.

1.1.1 Evolution of conceptual models of LBP

Perspectives on LBP have developed over time from the traditional biomedical view to one that appreciates LBP as a complex and multidimensional condition (O'Sullivan et al., 2016; Hartvigsen et al., 2018; Hush, 2020). The following section explores the evolution of these perspectives, outlining the transition from a reductionist to a more comprehensive understanding.

The biomedical model

The biomedical model underpins the traditional approach used to understand health, illness, and pain (Wade & Halligan, 2017; Rocca & Anjum, 2020). This model originated within Western medicine based on the assumption that pain and illness occur solely due to physical and biological factors that can be identified and treated within the body (Engel, 1977; Wade & Halligan, 2017; Rocca & Anjum, 2020).

Reductionist approaches subsequently emerged in practice, viewing the mind and body as separate and unrelated entities (Engel, 1977; Wade & Halligan, 2017; Rocca & Anjum, 2020). The biomedical model of illness and pain was highly influential in Western medicine and remains the dominant view (Rocca & Anjum, 2020), influencing both clinical practice (O'Sullivan et al., 2016) and pain management (Wade & Halligan, 2017).

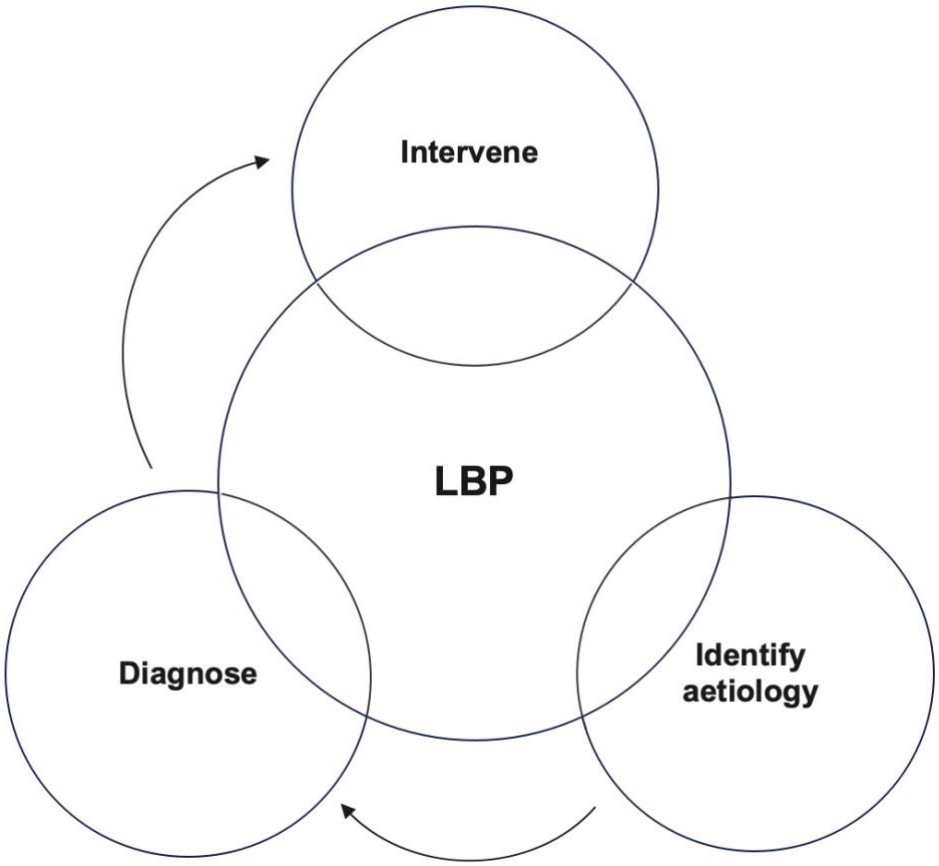

Figure 1. The biomedical model in relation to LBP

From a biomedical perspective, LBP is conceptualised structurally and occurs due to underlying damage to the spinal structures and soft tissues (Vlaeyen & Crombez, 1999; Quintner et al., 2008; O'Sullivan, 2012). Biomedical treatments involve finding, diagnosing, and treating the biological source of the pain, as depicted in Figure 1 (Mescouto et al., 2022). The prevention of LBP was also shaped by the biomedical framework, focusing on reducing exposure to the activities and tasks associated with damage, including lifting, loading, and awkward postures (McGill, 1997; Pope et al., 2002; De Bruin et al., 2024). The biomedical model ultimately framed many of the

strategies utilised to prevent, manage, and treat LBP (Foster et al., 2018; Buchbinder et al., 2018; Mescouto et al., 2022; De Bruin et al., 2024).

Despite the popularity of the biomedical model, the associated approaches failed to reduce the burden of LBP, with the outcomes and prevalence worsening over time (Hush, 2020; Foster et al., 2018; Buchbinder et al., 2018). In most cases, an underlying pathoanatomical cause could not be found (Atlas & Deyo, 2001; Krismer & van Tulder, 2007; Maher, 2017; Hartvigsen et al., 2018), which limited the application of the biomedical model and elicited the need for a different approach (Hush, 2020). This led to a shift whereby newer models and more comprehensive approaches were developed to address these shortcomings (O'Sullivan et al., 2016; Hush, 2020; Lund et al., 2020; Mescouto et al., 2022).

Contemporary models

The biopsychosocial model was developed by George Engel in 1977 who argued that pain and illness occur due to a combination of biological, psychological, and social factors (Engel, 1977). The biopsychosocial model emphasised the need to address nociceptive drivers of pain alongside the multiple other contributing factors (Moseley & Butler, 2015). Waddell (1987, 1992) promoted the shift from a biomedical to a biopsychosocial approach to LBP in clinical practice due to the failure of biomedically-focused approaches to prevent and treat most cases of LBP. The biopsychosocial model presents multiple biological, psychological, and social factors that contribute to the development and persistence of LBP, as illustrated in Figure 2. This model provided a framework to understand LBP as a complex and multidimensional phenomenon (Wade & Halligan, 2017; Lund et al., 2020).

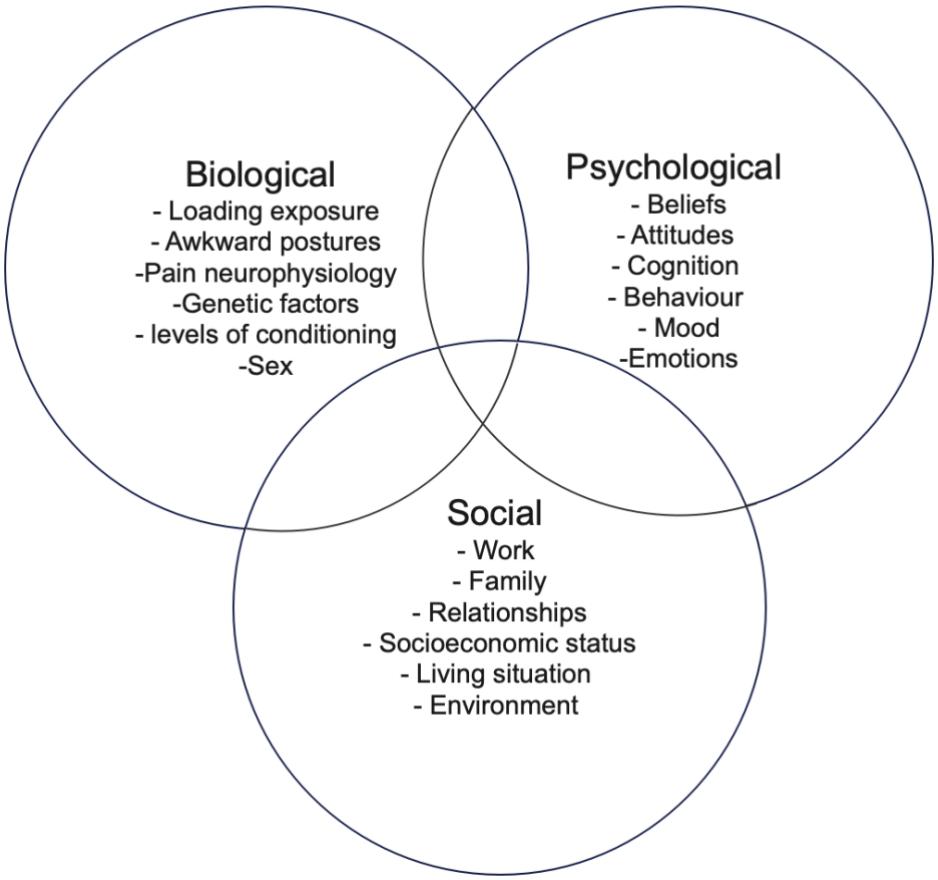

Figure 2. The biopsychosocial model of LBP (adapted from Mescouto et al., 2022)

The biopsychosocial model was an important stepping stone that advanced our understanding of health, illness, and pain. However, this model was critiqued for its fragmented implementation in practice (Stilwell & Harman, 2019; Rocca & Anjum, 2020; Mescouto et al., 2022). Waddell (1987) argued that the biological, psychological, and social elements of the biopsychosocial model interact to shape LBP experience and therefore should not be considered in isolation. In many cases, a more reductionist approach is taken where these factors are viewed as separate and unrelated, with some (typically biological) given far more attention (Stilwell & Harman, 2019; Rocca & Anjum, 2020; Mescouto et al., 2022). The separation of the biological, psychological, and social elements allows a biological or physical focus to persist (Stilwell & Harman, 2019). Moreover, if the focus is not heavily biological then it is heavily psychological, with statements like ‘pain is all in the mind’ emerging (Stilwell & Harman, 2019).

Researchers note that the fragmented implementation of the biopsychosocial model is not what Engel intended (Wade & Halligan, 2017; Stilwell & Harman, 2019; Rocca & Anjum, 2020). The biopsychosocial model was intended to be a systems model that acknowledged the interactions between different components (Engel, 1977; Wade & Halligan, 2017). However, science and medicine typically understand complex phenomena through the ontological perspective of 'mereological composition' (Rocca & Anjum, 2020). Mereological composition relates to an understanding of how different components constitute a whole (Rocca & Anjum, 2020). Mereological composition here reflects the view that complex phenomena can be understood by breaking up the whole and investigating different parts in isolation (Rocca & Anjum, 2020). When trying to understand LBP, this view argues that LBP causation can be understood by looking at the physical, psychological, and social factors in isolation, which is often how the biopsychosocial model is implemented (Stilwell & Harman, 2019; Rocca & Anjum, 2020; Mescouto et al., 2022).

However, complex phenomena require a whole systems view, as first introduced within general systems theory (von Bertalanffy, 1950). The notion of 'genuine complexity' opposes that of mereological composition as it argues that the behaviour of the whole is shaped by the interactions between different component parts (Rocca & Anjum, 2020). From this perspective, the whole is greater than the sum of its component parts as opposed to merely being equal to the sum of its parts (von Bertalanffy, 1950; Rocca & Anjum, 2020). The behaviour of components and of the whole system consequently cannot be understood without considering interactions, because these interactions change both the components and the whole system (von Bertalanffy, 1950; Rocca & Anjum, 2020). Within this view, it is imperative to understand the interactions between the physical, psychological, and social elements, as these shape pain experience (Stilwell & Harman, 2019). Focusing on isolated components risks overlooking the interactions that shape pain experience, potentially limiting the effectiveness of prevention and treatment efforts (Stilwell & Harman, 2019). The differences between ontological perspectives and how these translate into practice can be seen in Figure 3 (Rocca & Anjum, 2020).

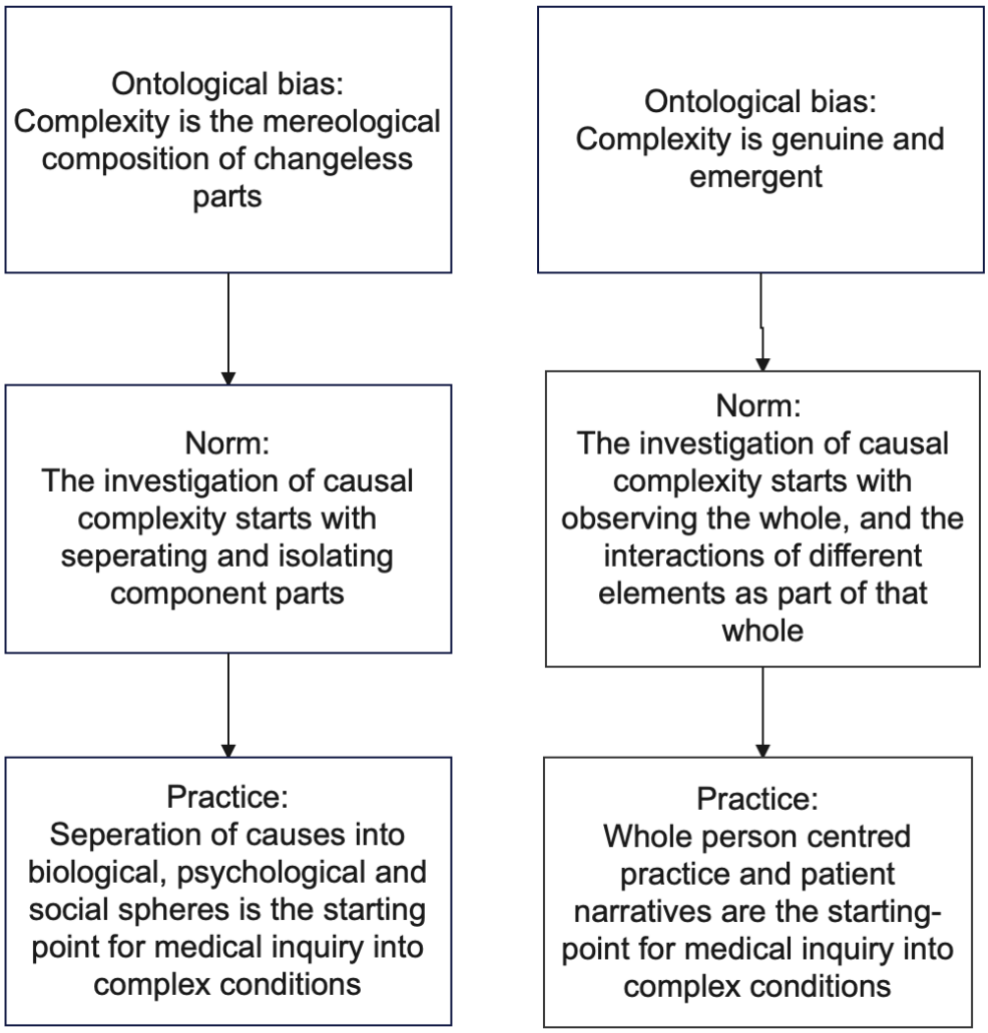

Figure 3. Comparison between 'mereological composition' and 'genuine complexity' (adapted from Rocca & Anjum, 2020)

The biopsychosocial model was critical as it challenged the reductionist tendencies of the biomedical model and provided a new framework for understanding pain (Wade & Halligan, 2017; Stilwell & Harman, 2019; Mescouto et al., 2022). However, widespread misconceptions about back pain still exist as individuals continue to subscribe to the biomedical model or a reductionist version of the biopsychosocial model (Stilwell & Harman, 2019; Lund et al., 2020; Mescouto et al., 2022).

Other conceptualisations have emphasised the importance of understanding dynamic interactions by framing LBP as an emergent, multidimensional phenomenon (O'Sullivan, 2012; O'Sullivan et al., 2016, 2018). Within this view, the body responds to perceived threats through neuro-immune-endocrine system interactions that create certain pathways for pain (O'Sullivan et al., 2016; O'Sullivan et al., 2018). Such

interactions are influenced by an interplay of physical, psychological, social, and other contextual factors, as depicted in Figure 4 (O'Sullivan et al., 2016). The frequent presentation of LBP as non-specific further supports the view that pain arises from interactions between various systems within the body (O'Sullivan et al., 2016, 2018).

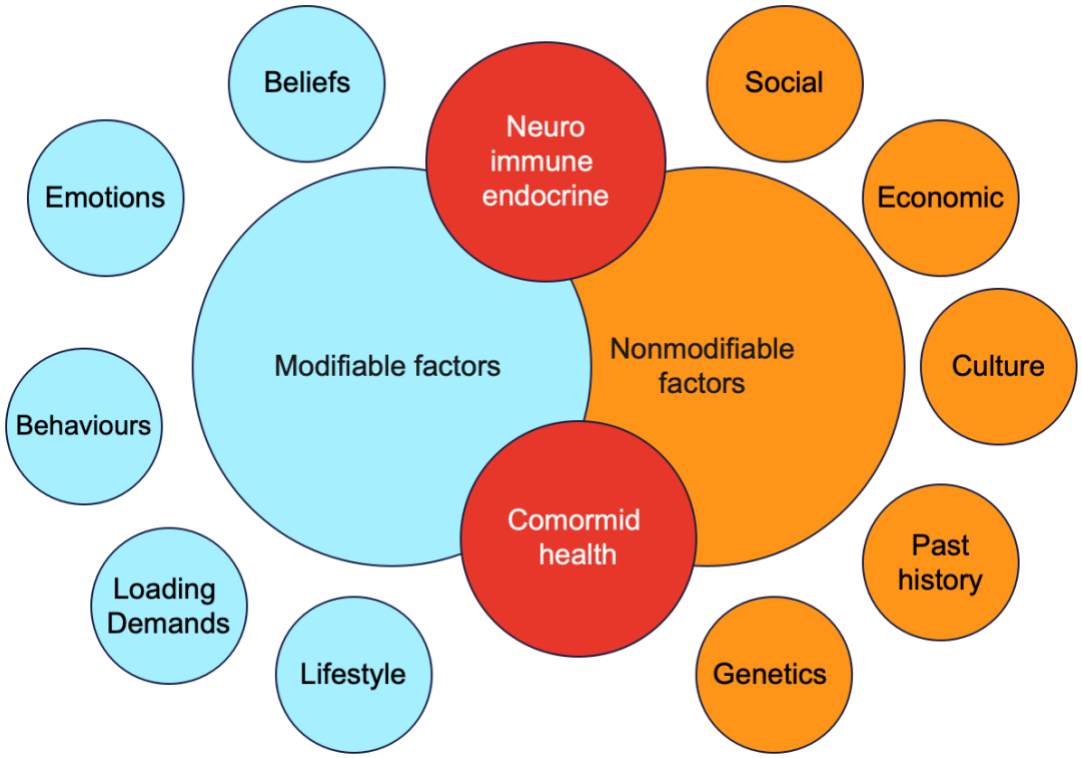

Figure 4. Multidimensional nature of LBP experience (adapted from O'Sullivan et al., 2016)

The enactive approach to pain was also developed to address the shortfalls of the biopsychosocial model (Stilwell & Harman, 2019). This approach recognises humans in context and proposes that humans can be viewed as open systems that are shaped by the environment and shape the environment in return (Varela et al., 1991, 2017; Stilwell & Harman, 2019). Additionally, the enactive approach aligns with the view that pain occurs due to the interactions between different systems within the body and that these interactions are shaped by the context in which humans exist and perform their tasks (Stilwell & Harman, 2019; Stilwell & Coninx, 2021). As such, perceived threat, experience, and memory all shape the experience of pain and are formed by the interactions with others (Stilwell & Harman, 2019).

The following quote was adapted from an interview with Evan Thompson and attempts to explain the enactive view of pain: “Saying that pain is in the brain is like saying flight is in a bird’s wings. A brain is needed to have pain and wings are needed to fly – but to understand pain or flight, one needs to consider the whole picture and the relational nature between things like a person (with a body/brain) and their social/environmental context; or the bird and the atmosphere. It follows that the experience of pain will not be found in the blood, brain or other bodily tissues. The tissues in the body or the networks in the brain are not the key to pain – instead they are pieces of a larger system that is adapting and striving to sustain into the future. This always involves the environment that we shape and that shapes us.” (Stilwell & Harman, 2019, p. 655).

Stilwell & Harman (2019) proposed that people in pain should be viewed as non-linear systems that cannot be understood by separating and looking at components (biological, psychological, and social) in isolation. Rather, this approach recognises pain as an emergent outcome of a sense-making process that occurs throughout the entire body, shaped by the context in which the person in pain exists (Stilwell & Harman, 2019). The enactive approach appreciates the human as a whole and how the interactions within the environment enact or create experiences of pain (Stilwell & Coninx, 2021). Finally, “when considering an enactive approach to pain, we move away from it being just *in the brain* or *in the back* – to it being a process that emerges or unfolds through a whole person that is inseparable from the world” (Stilwell & Harman, 2019, p. 654).

Most of the aforementioned models and associated approaches were developed from a treatment perspective by physiotherapists and other medical professionals. Within the field of HFE, authors were also attempting to advance the knowledge and understanding of LBP and its development in the workplace. For example, Marras (2012) emphasised the need to adopt a systems-based framework to understand LBP risk. This systems-based framework outlined the importance of recognising how the interactions between the musculoskeletal, cognitive, and physiological systems within the body, and the humans’ interactions with their environment, shape LBP risk (Marras, 2012; Marras et al., 2016). Similarly, Marras & Hancock (2014) argued that all human responses are shaped by their perception of their environment and as such,

human responses must be understood with respect to the context in which they occur (Marras & Hancock, 2014).

These contemporary models and associated approaches align more with the 'genuine complexity' ontology and oppose the dualist and reductionist perspectives, emphasising the need to acknowledge the interactions between different factors, rather than focusing on components in isolation. As such, cognitive/psychological factors are just as important as physical factors due to their role in shaping these interactions and associated outcomes. Consequently, attitudes and beliefs towards back pain may shape the experience of LBP and are therefore important to consider.

1.2 Attitudes and beliefs

Beliefs are mental representations of what a person considers to be true (Rainville et al., 2011). Shaped by perceptions, observations, reasoning, or communications, beliefs are often developed without formal verification (Rainville et al., 2011). In the context of LBP, beliefs refer to individuals' preconceived ideas about the integrity of the back, as well as the causes and consequences of pain (Rainville et al., 2011; Bunzli et al., 2017; Suhail & Poulter, 2022). Attitudes, defined as "the way in which a person views or evaluates something" (Vargas-Sánchez et al., 2016, p. 58), are informed by underlying beliefs, feelings, and values, and predispose individuals to respond in a certain way (Jeffrey & Foster, 2012).

Attitudes and beliefs about back pain are important factors to consider when trying to understand the LBP experience (Linton, 2005; Main et al., 2010; Linton & Shaw, 2011; Darlow, 2016; Bunzli et al., 2017; Caneiro et al., 2021). The following section examines how attitudes and beliefs about back pain are formed, their influence on pain, as well as commonly reported unhelpful beliefs. It also explores the role that professionals play in shaping these beliefs.

The common-sense model describes the formation of beliefs and associated responses to health threats (Leventhal et al., 1992, 2016), which was later used to understand the formation and impact of back pain beliefs (Bunzli et al., 2017; Caneiro et al., 2021). The common-sense model proposes that individuals form cognitive

representations to make sense of specific threats, which in turn shape their responses to those threats (Leventhal et al., 2016). Such representations are based on a set of underlying beliefs around the identity, causes, consequences, duration, and the ability to control said threat, as shown in Figure 5 (Leventhal et al., 2016; Bunzli et al., 2017; Caneiro et al., 2021).

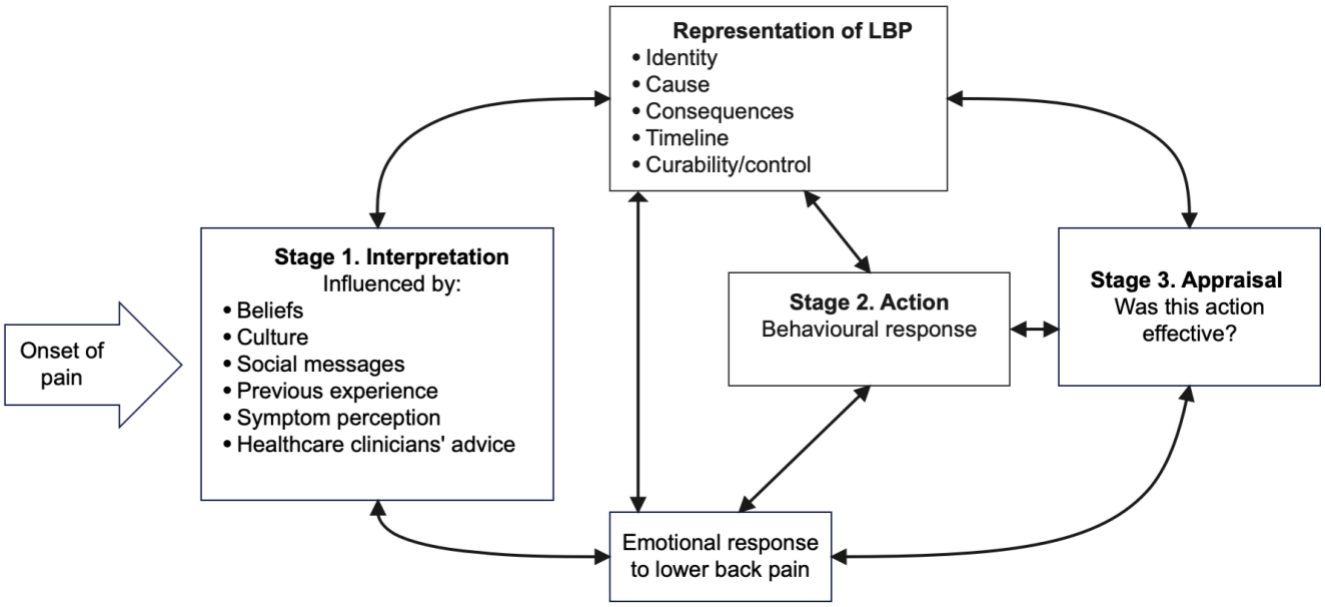

Figure 5. The common-sense model (adapted from Vlaeyen & Linton, 2000 and Caneiro et al., 2021)

Individuals may form cognitive representations based on experience, observations, interactions with professionals, and social messages (Leventhal et al., 2016; Bunzli et al., 2017; Caneiro et al., 2021). Beliefs and associated attitudes about back pain can therefore stem from various sources, including the media, the community, messages in the workplace, and from professionals providing advice about LBP (Vlaeyen & Crombez, 1999; Rainville et al., 2011; Darlow et al., 2012; Darlow, 2016; Suhail & Poulter, 2022). Other factors such as education level, culture, training, and previous experiences of pain may also influence the formation of these beliefs (Suhail & Poulter, 2022).

The aforementioned cognitive representations and underlying beliefs can therefore occur before the onset of pain, and shape how individuals interpret and respond when

pain is experienced (Caneiro et al., 2021). Such cognitive representations not only guide behaviour but also influence the complex processes that shape pain experience.

1.2.1 How attitudes and beliefs influence pain: top-down and bottom-up mechanisms

According to contemporary frameworks, pain is a subjective and multidimensional experience that serves as a protective mechanism to prevent tissue damage and promote survival (Tracey & Mantyh, 2007; Moseley & Butler, 2015; Tagliaferri et al., 2020). Pain then occurs in response to perceived or actual threat (Moseley, 2003; O' Sullivan et al., 2016; Tagliaferri et al., 2020). Dynamic contextual factors, including attitudes and beliefs, shape how the body perceives and responds to these threats (Tracey & Mantyh, 2007; Moseley & Butler, 2015; O'Sullivan et al., 2016; Stilwell & Harman, 2019; Tagliaferri et al., 2020), and can influence pain experience through both top-down and bottom-up processes.

Pain modulation and pain perception (top-down approach)

From a contemporary perspective, pain occurs due to the interaction between biological and psychological systems within the body, which are influenced by the social environment (Engel, 1977; Gatchel et al., 2007). Within this framework, the neuromatrix model of pain offers a neurophysiological explanation for how such factors influence pain (Melzack, 1999). The psychological model of pain perception further elaborates on how different cognitive and emotional factors can act to modulate pain through top-down processes. The aforementioned models are used to describe how attitudes and beliefs about back pain can influence pain perception.

The neuromatrix model of pain suggests that, due to the plasticity of the central nervous system, pain occurs as a multidimensional output that is influenced by sensory, cognitive, and emotional inputs (Melzack, 1999, 2001). Pain signals can therefore be modulated and altered by a variety of factors, including context, pain memories, beliefs, emotions, mood, and expectations (Melzack, 2001; Tracey & Mantyh, 2007; Tagliaferri et al., 2020). As such, the model moved away from the traditional view of pain as a purely sensory experience associated with tissue damage (Melzack, 1999, 2001; Trout, 2004).

In the psychological model of pain perception proposed by Linton & Shaw (2011), pain is shaped by both sensory input as well as cognitive and emotional processes. When noxious stimuli are experienced, cognitive and emotional processes are required to interpret what they mean, as depicted in Figure 6 (Linton & Shaw, 2011). This interpretation is based on past experience as well as beliefs about the meaning of pain (Linton, 2005; Linton & Shaw, 2011). Such interpretations influence the perception of threat associated with pain as well as the subsequent emotional and behavioural responses (Darlow et al., 2015; Bunzli et al., 2017).

When the brain interprets a high level of threat to the body, it may produce a heightened perception of pain as a protective response (Moseley & Butler, 2015). Pain therefore serves as an adaptive output of the brain rather than a direct depiction of tissue damage (Moseley, 2003; Tracey & Mantyh, 2007; Moseley & Butler, 2015; Tagliaferri et al., 2020). Negative attitudes and beliefs about back pain are associated with higher levels of threat perception (Darlow et al., 2015; Bunzli et al., 2017) and may influence the perceived intensity of pain (Vlaeyen & Crombez, 1999; Bunzli et al., 2017).

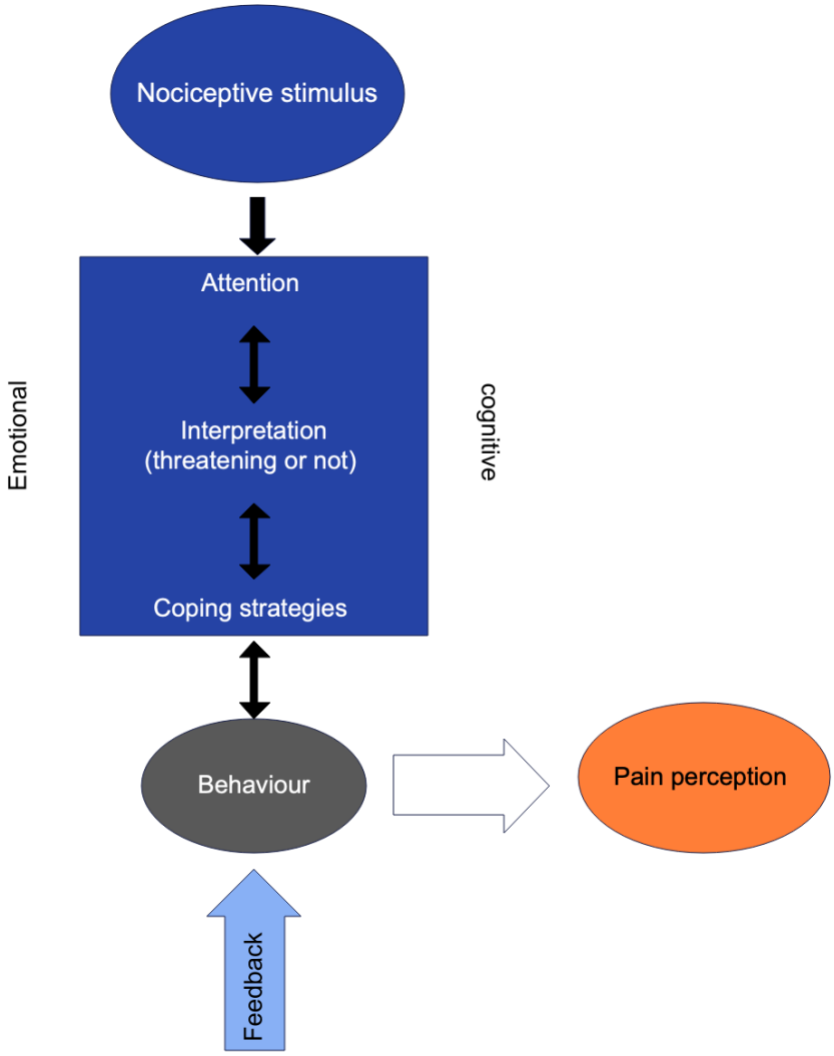

Figure 6. Psychological model of pain perception (adapted from Linton & Shaw, 2011)

The neuromatrix model and the psychological model of pain perception offer insight into how pain is modulated by various factors, including attitudes and beliefs.

Pain sensitivity (bottom-up approach)

Pain experience is not only shaped by the top-down evaluation of certain stimuli but can also be altered through changes in the biochemical environment (bottom-up). Negative attitudes and beliefs can trigger stress responses which, through biochemical changes, can enhance pain sensitivity.

Stress responses are often triggered when individuals perceive high levels of threat or danger (Latremoliere & Woolf, 2009; Moseley & Butler, 2015). The stress response is associated with the release of 'stress hormones' including corticosteroids and

catecholamines, which initiate inflammatory responses (Black, 2002; Barsotti et al., 2021; Tong et al., 2023). Such inflammatory responses result in the upregulation of proinflammatory cytokines (Black, 2002; Barsotti et al., 2020; Tong et al., 2023), which can act to increase pain sensitivity in several ways (Sommer & Kress, 2004; Latremoliere & Woolf, 2009). Firstly, proinflammatory cytokines sensitise nociceptors within tissues (Latremoliere & Woolf, 2009; Kress, 2010; Izzo et al., 2015), thus lowering the stimulus/loading required to cause pain (Marras, 2012; Marras et al., 2016). Secondly, proinflammatory cytokines can induce swelling, which may increase the hydrostatic pressure on nearby nerves and trigger a pain response (Marras et al., 2016). Lastly, proinflammatory cytokines can also stimulate nerve and blood vessel growth within the intervertebral disc (which is typically avascular and aneural), thereby creating new pathways for pain (Izzo et al., 2015; Marras et al., 2016).

An upregulation of proinflammatory cytokines also occurs in states of heightened biomechanical loading (Yang et al., 2011), which can be elevated by mental stress through associated increases in muscle coactivation (Splittstoesser et al., 2012). Biomechanical and biochemical changes are further influenced by individual differences in personality (Marras et al., 2000; Splittstoesser et al., 2012), highlighting how psychological, physiological, and biomechanical interactions can influence pain sensitivity.

Neuroplastic changes to the central nervous system can lead to central sensitisation, whereby heightened pain experiences persist in the absence of painful stimuli (Latremoliere & Woolf, 2009; Marras, 2012). As such, pain can become established in the brain through central processes (Marras, 2012). It is crucial to break patterns of pain reinforcement early, before they are established centrally (Marras, 2012). In individuals who are sensitised, regular day-to-day activities and previously manageable loads can induce pain responses in the absence of threat or damage to the tissue (Latremoliere & Woolf, 2009; Marras, 2012).

Taken together, the top-down and bottom-up processes show the dynamic interactions between biomechanical, physiological, and cognitive systems and how these shape pain experience. Attitudes and beliefs, which are socially and culturally constructed, influence how sensory information is perceived (including noxious stimuli, which may

be perceived as painful). Figure 7 illustrates how attitudes and beliefs may influence pain experience, using a model adapted from Marras & Hancock (2014).

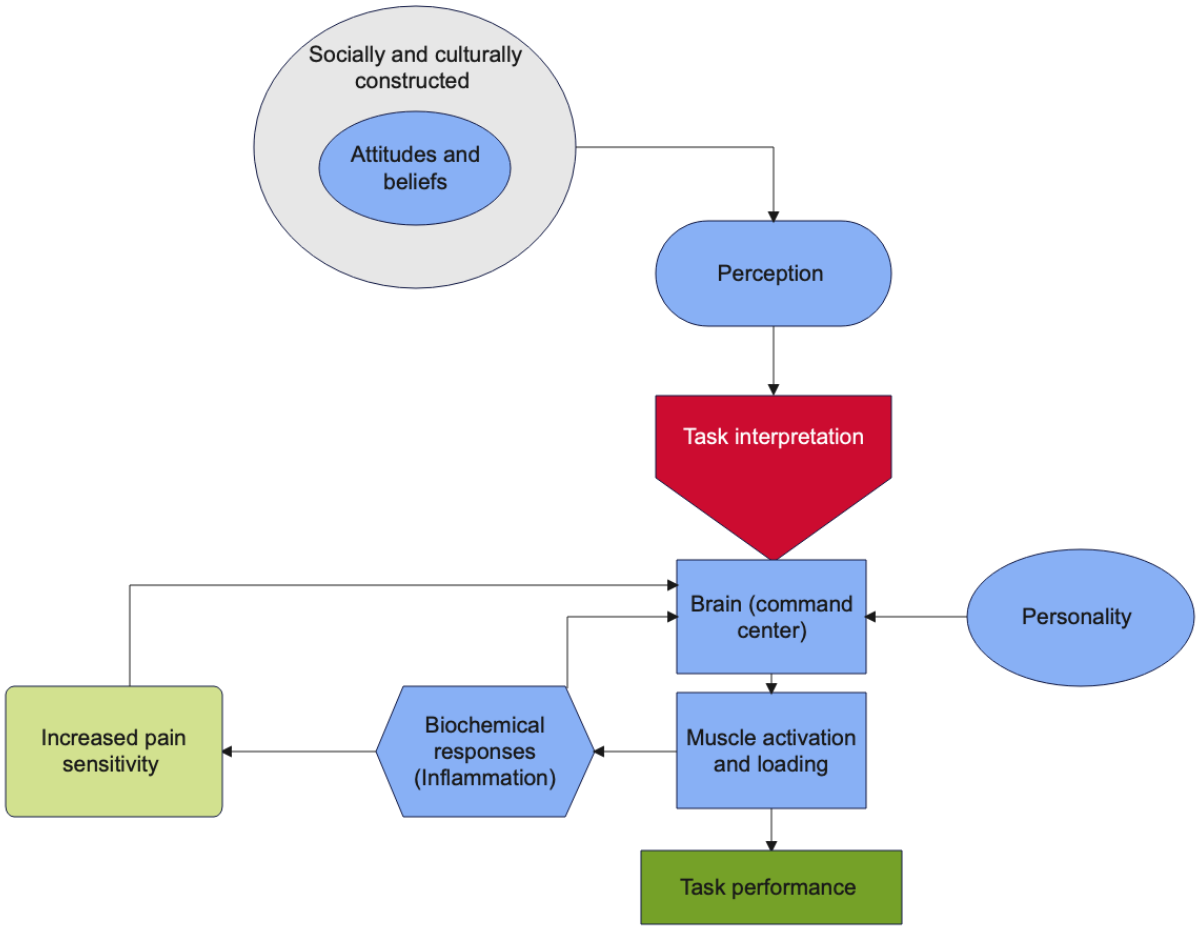

Figure 7. Role of attitudes and beliefs in pain experience (adapted from Marras & Hancock, 2014)

Negative and/or painful perceptions can influence task demands, muscle activity, and loading (Marras et al., 2001, 2004; Marras & Hancock, 2014). Increases in muscle activation and loading, as well as psychosocial stress, can result in changes to the biochemical environment through the upregulation of proinflammatory cytokines which can act to increase sensitivity to pain (Marras, 2012; Yang et al., 2011; Splittstoesser et al., 2012; Marras & Hancock, 2014). This demonstrates how attitudes and beliefs can influence pain experience through dynamic interactions.

1.2.2 Psychological and behavioural consequences of maladaptive beliefs

Having explored how attitudes and beliefs influence pain through both top-down and bottom-up processes, it is equally important to consider how these beliefs shape individuals' thoughts, emotions, and behaviours in response to pain. Unhelpful attitudes and beliefs are associated with catastrophising, fear-avoidance, poor self-efficacy, psychological distress, poor expectations of recovery, and reliance on passive coping strategies (Feuerstein & Beattie, 1995; Darlow, 2016; Suhail & Poulter, 2022). These psychological and behavioural responses, driven by maladaptive beliefs, are associated with persistent pain and disability (Feuerstein & Beattie, 1995; Darlow, 2016; Bunzli et al., 2017; Ng et al., 2017; Caneiro et al., 2021; Estee et al., 2024). The following section explores the psychological and behavioural consequences of unhelpful attitudes and beliefs.

Catastrophising

Catastrophising refers to unhelpful or negative thoughts about what causes LBP, and what the consequences of LBP might be (Darlow, 2016; Bunzli et al., 2017; Caneiro et al., 2021). Unhelpful beliefs that associate pain with serious injury often lead to catastrophising, which can be understood as a negative appraisal of pain (Vlaeyen & Crombez, 1999; Main et al., 2010). Negative appraisals of pain may prompt fearful emotional responses and avoidant behavioural responses that increase disability, promote distress, and heighten pain experience through various mechanisms (Bunzli et al., 2017). Catastrophising is associated with psychological distress and can influence pain through increased sympathetic arousal, which causes anxiety and tonic changes in muscle activity (Ciccone & Grzesiak, 1984; Vlaeyen & Crombez, 1999). The responses that stem from catastrophic thinking influence how the brain regulates pain signals (pain modulation) due to heightened emotional responses and greater attention, which in turn contribute to enhanced pain perception (Weissmen-Fogel et al., 2008; Main et al., 2010).

Fear-avoidance

Unhelpful beliefs are often associated with fear-avoidant behaviours (Rainville et al., 2011; Darlow et al., 2014a, 2014b, 2015; Darlow, 2016; Bunzli et al., 2017; O'Sullivan et al., 2020). The term 'fear-avoidance' refers to a fear of pain that results in the avoidance of movements or activities that are perceived to be threatening (Lethem et

al., 1983; Bunzli et al., 2017). Fear-avoidant beliefs and behaviours are linked with poor outcomes for LBP, including increased pain intensity, disability, extended recovery (Vlaeyen & Crombez, 1999; Rainville et al., 2011; Jakobsen et al., 2025), as well as long-term sick leave (Trinderup et al., 2018). High levels of pain-related fear and avoidance behaviours may occur due to biomedical beliefs about the causes of LBP (Vlaeyen & Crombez, 1999; Bunzli et al., 2017).

Individuals' beliefs about back pain determine the willingness to perform or avoid various activities, thus influencing the level of disability associated with LBP (Rainville et al., 2011). Activity avoidance can have detrimental consequences, including physical, psychological, and social changes associated with greater disability (Lethem et al., 1983; Vlaeyen & Crombez, 1999; Vlaeyen & Linton, 2000; Bunzli et al., 2017). These changes may further contribute to a vicious cycle of pain and disability, as shown in Figure 8 (Vlaeyen & Linton, 2000; Bunzli et al., 2017). Individuals who confront or resume normal daily activities despite experiencing pain often exhibit reduced fear and tend to recover faster than those who avoid activities perceived as dangerous (Vlaeyen & Crombez, 1999; Bunzli et al., 2017). It is therefore crucial to address the negative beliefs and representations of LBP that drive fear-avoidance, including the exposure to threatening information, if we wish to reduce pain persistence and related disability (Bunzli et al., 2017; Caneiro et al., 2021).

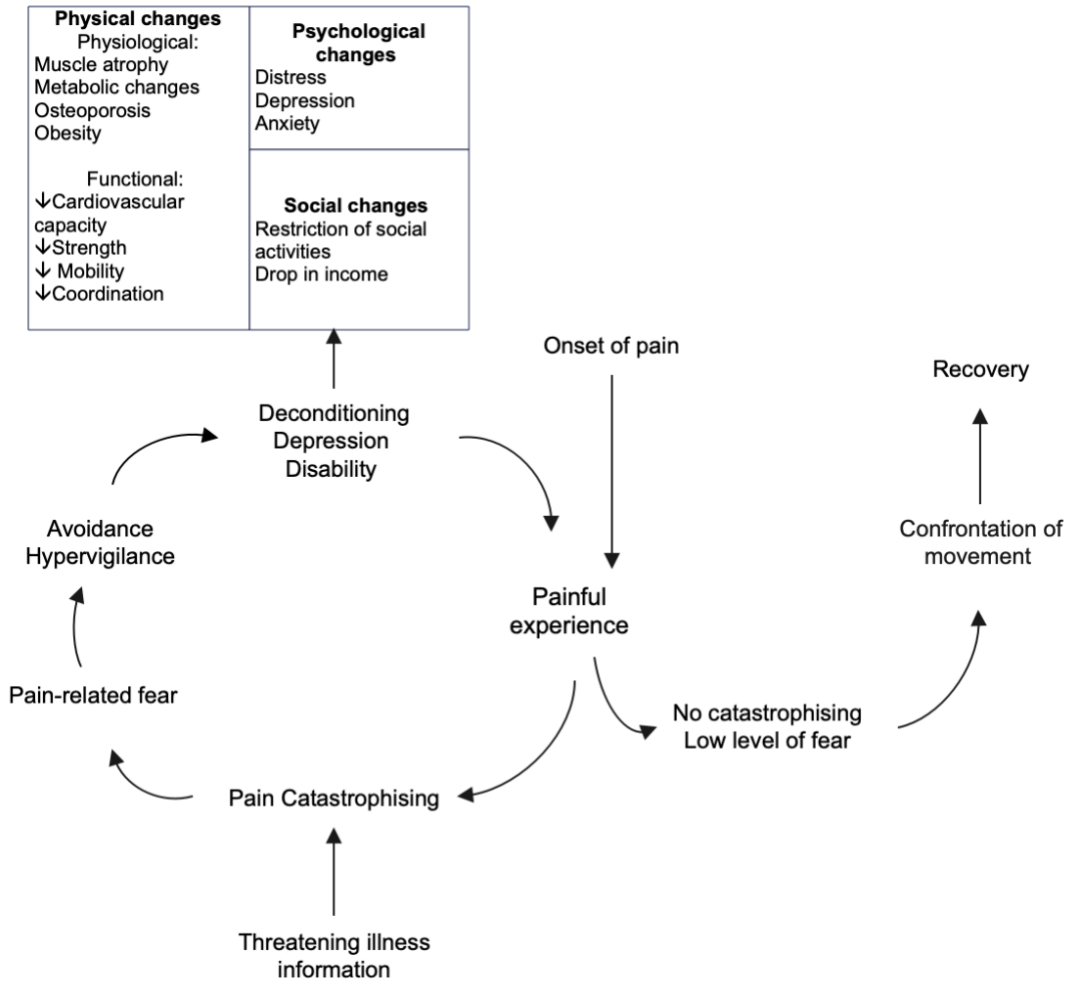

Figure 8. Fear-avoidance model (adapted from Vlaeyen & Linton, 2000 and Roquelaure, 2018)

Self-efficacy

Self-efficacy refers to an individual's perceived ability to cope while in pain (Darlow, 2016). Negative attitudes and beliefs may contribute to poor self-efficacy by decreasing individuals' confidence in their ability to participate in daily activities and work (Darlow et al., 2015). Reduced self-efficacy is associated with poor outcomes and may further enhance experiences of pain and disability through decreased pain tolerance levels and lower activity levels (Main et al., 2010; Darlow et al., 2015; Darlow, 2016). An overreliance on poor coping strategies, including the overuse of medications, is often associated with a lack of self-efficacy (Main et al., 2010). The negative implications of poor-self efficacy emphasise the need to address the underlying unhelpful beliefs that drive it.

Attention to pain

Research shows that the amount of attention given to pain influences pain perception (Main et al., 2010; Linton & Shaw, 2011; Garland, 2012; Stilwell & Harman, 2019). The level of threat associated with a painful experience influences how much attention is given to it, and how individuals respond to it (Quevedo & Coghill, 2007; Main et al., 2010; Linton & Shaw, 2011). Heightened attention to pain can be linked to fear, anxiety, and avoidance (Linton & Shaw, 2011). From this perspective, attentional responses can act to increase pain as a mechanism to protect the body (Linton & Shaw, 2011).

Negative beliefs about the back may cause individuals to pay more attention to their backs and be in a constant state of awareness regarding their movements (hypervigilance), which may alter experiences of pain (Main et al., 2010; Linton & Shaw, 2011). Hypervigilance often occurs in states of heightened anxiety, stress, or fear and is associated with increased pain intensity and the transition from acute to chronic LBP (Vlaeyen & Linton, 2000; Main et al., 2010; Zhang et al., 2025).

Psychological distress

Negative attitudes and beliefs can lead to states of psychological distress through interacting psychological and behavioural responses (Vlaeyen & Crombez, 1999; Darlow, 2016; Bunzli et al., 2017; Caneiro et al., 2021). Pain-related fear, catastrophising, fear-avoidant behaviours, and poor self-efficacy may all contribute to increased distress (Campbell et al., 2013). Psychological distress, mediated by cognitive processes (e.g., fear, worry, and anxiety), can trigger stress responses (Tracey & Mantyh, 2007; Main et al., 2010; Barsotti et al., 2020). Stress responses increase pain through bottom-up mechanisms, as discussed in the previous section (Tracey & Mantyh, 2007; Main et al., 2010; Barsotti et al., 2020).

Poor expectations

Individuals with and without LBP can hold beliefs and have expectations regarding LBP prognosis and recovery (Darlow et al., 2015). Poor expectations about recovery are typically associated with a failure to return to work, and the transition from acute to chronic LBP (Iles et al., 2008, 2009; Main et al., 2010; Ramond et al., 2011). It is

therefore important to understand the beliefs that drive poor expectations as they play an important role in the progression of LBP.

The previously discussed psychological factors are interrelated and interact with one another to influence pain and disability (Vlaeyen & Crombez, 1999; Campbell et al., 2013; Darlow, 2016). Negative attitudes and beliefs (including beliefs relating to the identity, causes, consequences, timeline, and ability to control LBP) give rise to catastrophising, pain-related fear, avoidance, and psychological distress (Vlaeyen & Crombez, 1999; Bunzli et al., 2017). Interacting psychological factors such as these may enhance pain perception and reinforce the individuals' pre-existing negative beliefs (Bunzli et al., 2017).

1.2.3 Common unhelpful attitudes and beliefs

The previous section established how attitudes and beliefs are formed and their role in shaping pain experience through complex pain processes. Negative beliefs about back pain are associated with persistent pain and disability (Nicholas et al., 2011; Urquhart et al., 2008; Ng et al., 2017; Bunzli et al., 2017; Caneiro et al., 2021; Estee et al., 2024) and are therefore important to understand and address.

Unhelpful attitudes and beliefs about the back and back pain have been frequently reported in the literature (Darlow et al., 2014a; Darlow, 2016; Pierobon et al., 2020; O'Sullivan et al., 2020; Christe et al., 2021a). Studies have shown that unhelpful beliefs about back pain are common among individuals with LBP (Darlow et al., 2015; Bunzli et al., 2015), among individuals without LBP (Darlow et al., 2014a; Pierobon et al., 2020; Christe et al., 2021a), and among professionals (Darlow et al., 2012; Nolan et al., 2018, 2019; Christe et al., 2021b). Table 1 summarises the commonly held unhelpful beliefs alongside evidence-based statements. The unhelpful beliefs presented in Table 1 are further explored in the following section.

Table 1. Common unhelpful beliefs about back pain and corresponding evidence-based statements

Commonly held unhelpful beliefs	**Corresponding evidence-based statements that promote helpful beliefs**	**Supporting references**
LBP is common because the back is weak, vulnerable, and easy to injure	The spine is a robust, stable, and flexible structure and few LBP cases are associated with a serious pathology	Hartvigsen et al. (2018) Slater et al. (2019) Atlas & Deyo. (2001) Maher et al. (2017) Hartvigsen et al. (2018) Galbusera & Bassani (2019) O'Sullivan et al. (2020)
Everyday movement and loading of the spine cause wear and tear of the spinal structures and result in tissue damage	Graded movement and spinal loading are safe and promote resilience	Foster et al. (2018) O'Sullivan et al. (2020) Owen et al. (2021) O'Sullivan et al. (2020) De Bruin et al. (2024)
LBP is always a serious and dangerous medical condition	Most LBP cases are not associated with serious or threatening pathologies	Atlas & Deyo (2001) Krismer & van Tulder (2007) Maher et al. (2017) Hartvigsen et al. (2018)
Lifting without bending the knees is dangerous for the back	There is no universally safe lifting technique for every individual in every situation	van Dieën et al. (1999) Straker (2003) Saraceni et al. (2020) Washmuth et al. (2022)
Good posture is required to protect the back and prevent LBP	Poor posture cannot independently cause LBP. Sitting and standing posture are highly variable with and without pain (i.e. individuals can have poor posture without pain and individuals can have good posture with pain)	Laird et al. (2016) Claus et al. (2016) Slater et al. (2019) Korakakis et al. (2019) Swain et al. (2020) O'Sullivan et al. (2020)
Sitting is bad for the back	Sitting is not independently causative of LBP and is not inherently dangerous for the back	Claus et al. (2008) Roffey et al. (2010a) Slater et al. (2019)
Persistent LBP is always a sign of underlying tissue damage	Negative attitudes and behaviours (negative mindset, fear avoidance, poor coping strategies) have a more significant association with persistent LBP than underlying damage does	Iles et al. (2008) Urquhart et al. (2008) Ng et al. (2017) Estee et al. (2024) Bunzli et al. (2017) O'Sullivan et al. (2020) Caneiro et al. (2021) Jakobsen et al. (2025)

Pain during exercise indicates harm and is a warning sign to stop or alter the activity	Incremental exercise is safe for the spine and should be encouraged, especially when LBP is non-specific	Foster et al. (2018) Lin et al. (2020) Owen et al. (2021) Belavy et al. (2017) O'Sullivan et al. (2020)
A healthcare professional is always required to diagnose and treat LBP	Self-management (education and remaining active) is the first line of treatment for acute and persistent non-specific LBP	Delitto et al. (2012) Foster et al. (2018) Lin et al. (2020) O'Sullivan et al. (2020)
Imaging is required to diagnose LBP	Imaging is not recommended for most LBP cases. Misinterpretations are common, often leading to expensive and harmful care	Deyo et al. (2009) Maher et al. (2017) Foster et al. (2018) Brinjikji et al. (2015) Lemmers et al. (2019) Ferrari (2016) O'Sullivan et al. (2020)
Biomedically focused treatments including injections, spinal surgery, and strong medications, are useful and important for treating LBP	Biomedically focused treatments for LBP are not usually effective and are not recommended in most cases. Effective LBP care should focus on education, mindset, and physical and mental well-being	Deyo et al. (2009) Delitto et al. (2012) Foster et al. (2018) Harris et al. (2018) Buchbinder et al. (2018) O'Sullivan et al. (2018) Lin et al. (2020) Caneiro et al. (2021)

Vulnerability and need for protection

Individuals often believe that the spine is weak, vulnerable, and easily injured (Darlow et al., 2013, 2014b, 2015; Darlow, 2016; O'Sullivan et al., 2020). The back is commonly thought to be poorly designed for everyday activities such as sitting, bending, and lifting (Darlow et al., 2015; Darlow, 2016; O'Sullivan et al., 2020). Unhelpful beliefs relating to the back's vulnerability often stem from the biomedical understanding of LBP that is prevalent in society (Bunzli et al., 2017; Lund et al., 2020). When pain is viewed as synonymous with injury, the high prevalence of LBP is associated with a poorly designed back that is easy to injure (Darlow et al., 2015; Darlow, 2016; Bunzli et al., 2017).

Attitudes and beliefs about the need to protect the back are also widespread due to this perceived vulnerability (Darlow, 2016; Bunzli et al., 2017; Nolan et al., 2018). Individuals often believe that the back requires protective mechanisms, including good posture, strong muscles, and specific lifting techniques to avoid injury (Darlow et al.,

2014b, 2015; Darlow, 2016; Pierobon et al., 2020). Protective beliefs similarly stem from a biomedical viewpoint, whereby protective strategies are required to avoid injury (Darlow, 2016), and LBP is attributed to a failure to effectively protect the back (Darlow et al., 2015).

LBP is often associated with adopting an incorrect posture while sitting, standing, and lifting (Slater et al., 2019; O'Sullivan et al., 2020; Maier et al., 2024). Individuals and professionals largely subscribe to the belief that maintaining a neutral posture (no excessive lordosis or kyphosis) is necessary to prevent LBP (Slater et al., 2019; Korakakis et al., 2019; Maier et al., 2024). Such protective beliefs may be reinforced by ergonomic interventions and advice that promote the maintenance of a neutral posture while performing occupational tasks (O'Sullivan et al., 2016; Slater et al., 2019). Protective advice and interventions are common despite the evidence that suggests that they are ineffective at preventing or reducing LBP (Hartvigsen et al., 2005; Bigos et al., 2009; Driessen et al., 2010, 2011; Verbeek et al., 2011; Hogan et al., 2014).

Limited and inconsistent evidence is available to support a causal relationship between posture and pain, which has contributed to discourse and debate within the literature (O'Sullivan et al., 2012; Slater et al., 2019; Swain et al., 2020; Korakakis et al., 2019). While there is evidence to suggest that prolonged sitting and prolonged static postures are risk factors for LBP (Parreira et al., 2018; Dong et al., 2022), there is limited evidence to support that there is one universally correct posture that protects against LBP (Slater et al., 2019). Posture is highly variable when both sitting and standing (Claus et al., 2016; Schmidt et al., 2018). For example, Laird et al. (2016) found that there was no significant difference in lumbar lordosis between individuals with and without LBP. Pain-free individuals do not necessarily maintain a 'correct' or neutral posture: many asymptomatic individuals flex their spines while sitting (Claus et al., 2016). If pain-free or asymptomatic individuals also display poor posture or slumping, this leads us to question the traditional idea that specific postures cause pain (Claus et al., 2016). Rather, due to the complex and multifactorial nature of LBP, it is essential to consider the combination of various risk factors (Lis et al., 2007).

The evidence suggesting that poor sitting and standing postures independently cause LBP is limited (Lis et al., 2007; Roffey et al., 2010b; Slater et al., 2019). Furthermore, the evidence shows that education or advice based on correcting posture is ineffective at preventing LBP (Demoulin et al., 2012; Steffens et al., 2016). Greater success has been seen when promoting movement and postural changes throughout the day (Waongenngarm et al., 2021; Soares et al., 2023). Advice or messaging around posture can induce fear and worry among individuals, particularly if they find it difficult or uncomfortable to maintain specific postures (Slater et al., 2019; Maier et al., 2024). The advocacy for movement and postural changes reduces the risk of pain and discomfort by minimizing exposure to static or prolonged postures and, along with other health benefits, promotes confidence to move rather than fear (Slater et al., 2019).

In a similar light, beliefs around safe lifting technique and safe lifting posture are common (Nolan et al., 2018, 2019; Smith & Thompson, 2020). Most professionals believe that lifting with the knees (squat lifting) is safer for the back (Nolan et al., 2018, 2019; Smith & Thompson, 2020; Washmuth et al., 2022). Beliefs that squat lifting is safer are associated with negative perceptions overall, as these lifting beliefs stem from biomechanical or structural explanations of back pain (Nolan et al., 2018, 2019; Smith & Thompson, 2020). Those who believe that squat lifting is the safer technique argue that the back is less likely to be injured when it is in a neutral position (Nolan et al., 2018, 2019).

Advice on squat lifting is based on biomechanical principles that emphasise the need to keep the load close to the body to reduce the moment arm and, consequently, the load on the lower back (Anderson & Chaffin, 1986). However, recent studies have shown that spinal loading is similar between squat and stoop lifting styles (van der Have et al., 2019), with compression forces often lower during stoop (von Arx et al., 2019). Evidence also suggests that stoop lifting is less demanding physiologically and is often preferred by workers (Straker, 2003; Washmuth et al., 2022). For example, Saraceni et al. (2021) found that manual workers with no previous LBP history and more than five years of experience adopted stoop lifting strategies during a 100 lift-task. Lifting advice and training that favours squat lifting persists despite evidence that there is no universally safe lifting technique for every individual and situation (Straker,

2003; van der Have, 2019; Von Arx et al., 2021; Saraceni et al., 2020; Washmuth et al., 2022). Furthermore, training individuals to adopt a specific lifting technique is not an effective strategy to prevent LBP (Martimo et al., 2008; Bigos et al., 2009; Verbeek et al., 2011, 2012; Kuijer et al., 2014; Denis et al., 2020). The current evidence leads us to question the traditional views around safe lifting posture.

Unhelpful beliefs that the back is vulnerable and needs protection can lead to the avoidance of certain activities or movements perceived as dangerous (Bunzli et al., 2017; Darlow et al., 2015; O'Sullivan et al., 2020) and promote catastrophic thinking associated with persistent pain and disability (Vlaeyen & Crombez, 1999; Bunzli et al., 2017). Furthermore, unhelpful psychological responses, including high levels of pain-related fear, are associated with altered movement patterns and increased muscle activity in individuals experiencing pain (Geisser et al., 2004; Christe et al., 2021d).

Special nature and impact of LBP

Individuals frequently hold negative attitudes and beliefs about the special nature and impact of LBP (Darlow et al., 2014a; Pierobon et al., 2020; Christe et al., 2021a). LBP is often considered a serious disorder that is unique in its nature and impact, requiring attention from healthcare professionals to diagnose and treat (Vlaeyen & Crombez, 1999; Darlow et al., 2014a, 2015; O'Sullivan et al., 2020). Such beliefs persist despite the fact that most people will experience an acute episode of LBP that is unrelated to damage at some point in their lives, suggesting that LBP is a common and largely non-threatening condition (Foster et al., 2018; Buchbinder et al., 2018; Hartvigsen et al., 2018; O'Sullivan et al., 2020).

Unhelpful beliefs relating to the special nature and impact of LBP largely stem from a biomedical view that pain reflects tissue damage (O'Sullivan et al., 2016; Lund et al., 2020). Once individuals understand a problem through a biomedical lens, they will instinctively search for a biomedical solution (Rocca & Anjum, 2020). Beliefs that attribute LBP to a specific spinal pathology are associated with increased healthcare seeking, low-value care, and poor outcomes (Bunzli et al., 2017; Buchbinder et al., 2018; O'Keeffe et al., 2019; Caneiro et al., 2021).

When individuals seek medical attention for LBP, they hold certain expectations regarding what the treatment process should look like (Darlow et al., 2015; Bunzli et al., 2017). These expectations often follow a linear diagnosis, treatment, cure model based on biomedical assumptions (Bunzli et al., 2017). However, due to the complexity of LBP and the prevalence of non-specific LBP, this process is rarely possible (Bunzli et al., 2017), often leaving the patients confused and frustrated (Lim et al., 2019). Confusing clinical experiences often create an unpredictable and threatening representation of LBP, leaving patients feeling like they lack control over their pain (Bunzli et al., 2017; Caneiro et al., 2021).

A biomedical understanding of LBP causality promotes the use of non-evidence-based treatments, including opioids, spinal injections, and surgery (Buchbinder et al., 2018; Foster et al., 2018; O'Sullivan et al., 2020). Misconceptions about the causes of LBP are associated with harmful and ineffective care that frequently enhances disability (Buchbinder et al., 2018). Initiatives are needed to address these widespread negative beliefs to promote evidence-based care and reduce the prevalence of disabling LBP (Buchbinder et al., 2018). The evidence-based guidelines for the management and treatment of LBP are often poorly adopted in practice (Foster et al., 2018). The guidelines for both acute and subacute non-specific LBP recommend non-pharmacological treatments, including education, exercise, the resumption of normal activities, and reassurance that an episode of LBP is likely to recover quickly (Oliveira et al., 2018; Foster et al., 2018; O'Sullivan et al., 2020; Lin et al., 2020).

Despite the evidence and guidelines that exist to guide the care of patients experiencing LBP, biomedically focused interventions are still the norm in many places (Oliveira et al., 2018; Foster et al., 2018; Kamper et al., 2019). Clinicians reported several barriers to providing evidence-based care for LBP, explaining the persistence of these fragmented models (Hall et al., 2019; Walker et al., 2025). Barriers likewise exist that hinder evidence-based advice regarding the prevention of LBP (Whysall et al., 2004; Oakman et al., 2019b). Such barriers are crucial to overcome to prevent the spread of misinformation to individuals regarding the causes and consequences of LBP.

Pain and Injury

Negative attitudes and beliefs exist regarding the relationship between pain and injury (Darlow et al., 2015; Darlow, 2016). Individuals often believe that back pain signals a damaged or injured back (Darlow et al., 2015; Darlow, 2016; Bunzli et al., 2017). Biomedical beliefs that back pain reflects tissue damage are common among individuals experiencing LBP (Darlow et al., 2015; Bunzli et al., 2015; Darlow, 2016). Such biomedical beliefs may lead to unhelpful emotional and behavioural responses, including poor coping strategies (Bunzli et al., 2017; Caneiro et al., 2021). These beliefs reduce individuals' confidence to move or cope while they are in pain (reduced self-efficacy), due to the belief that moving will worsen their condition (Darlow, 2016; Bunzli et al., 2017). When pain is associated with injury, individuals are more likely to become stressed over their condition, develop pain-related fear, and catastrophise, contributing to a worsened pain experience (Bunzli et al., 2017).

Physical Activity and Pain

Negative beliefs that activity and vigorous exercise should be avoided while experiencing LBP are common (Darlow et al., 2014a, 2015; O'Sullivan et al., 2020). When the back is viewed as vulnerable and back pain is viewed as a sign of damage, unhelpful beliefs often emerge about engaging in exercise (Darlow et al., 2015). People often feel that activities and movements can worsen damage and pain and should therefore be avoided while experiencing LBP (Darlow et al., 2015; Bunzli et al., 2017; O'Sullivan et al., 2020). The evidence and guidelines for LBP promote the resumption of physical activity during LBP episodes (Foster et al., 2018) and demonstrate that exercise is an effective strategy to prevent and reduce the impact of LBP (Bigos et al., 2009; Steffens et al., 2016; Foster et al., 2018; De Campos et al., 2021). Unhelpful beliefs that activity and exercise should be avoided during LBP episodes should be addressed as these are associated with increased disability and pain (Vlaeyen & Linton, 2000; Caneiro et al., 2021).

Prognosis and Recovery

Beliefs exist around the prognosis of LBP and the likelihood of recovery (Darlow et al., 2015; O'Sullivan et al., 2020). Individuals are often uncertain about the prognosis of LBP (Darlow et al., 2015). Furthermore, Darlow et al. (2015) found that unhelpful beliefs about prognosis were reported among individuals with chronic pain. Individuals

also reported fears that LBP can recur at any time (Darlow et al., 2015). Negative attitudes and beliefs about prognosis and recovery are likely to lead to poor expectations for recovery (Main et al., 2010), which are associated with poorer outcomes (Iles et al., 2009).

1.2.4 Professionals' attitudes and beliefs

The sense-making process and formation of beliefs or representations of LBP often occur in a participatory manner through interactions with others, including with professionals (Bunzli et al., 2017; Stilwell & Harman, 2019; Caneiro et al., 2021). Attitudes and beliefs about back pain are often influenced by the advice and recommendations provided by professionals who prevent and treat LBP (Darlow et al., 2012, 2013; Gardner et al., 2017; Caneiro et al., 2021; Suhail & Poulter, 2022). The nature of advice provided, and the language used while providing this advice, has a profound influence on the way individuals view their backs and how they assign meaning to their pain (Darlow et al., 2013; Bunzli et al., 2017; Stewart & Loftus, 2018; Linskens et al., 2023). Evidence suggests that addressing the beliefs of professionals may be beneficial to avoid the downstream transmission of negative beliefs (Suhail & Poulter, 2022).

According to several studies, the advice provided by professionals reflects their attitudes, beliefs, and treatment orientation (Darlow et al., 2012; Gardner et al., 2017; Christe et al., 2021b; Caneiro et al., 2021; Leysen et al., 2021). In this way, professionals transmit their own beliefs and attitudes to patients through advice and recommendations that reflect their own views (Darlow et al., 2013; Gardner et al., 2017; Christe et al., 2021). Negative beliefs are associated with advice that does not align with the evidence and guidelines (e.g., rest and avoid activity) (Darlow et al., 2012; Gardner et al., 2017). This type of advice influences individuals' long-term relationship with activity, often causing anxiety when certain 'dangerous' activities are used or needed in daily life (Darlow et al., 2013). Therefore, the advice given by professionals plays an important role in how individuals make sense of and respond to their pain (Bunzli et al., 2017; Caneiro et al., 2021).

Professionals with a biopsychosocial treatment orientation tend to have more helpful beliefs and provide advice that aligns with the evidence-based guidelines (Bishop et

al., 2008; Hartvigsen et al., 2018; Gardner et al., 2017; Foster et al., 2018; Leysen et al., 2021). Research has also shown that evidence-based education has a positive influence on attitudes and beliefs (Latimer et al., 2004; Christe et al., 2021c) as well as on advice (Leysen et al., 2021). Helpful beliefs are associated with the provision of advice to stay active and resume daily activities (Christe et al., 2021b; Leysen et al., 2021). When professionals provide reassurance about movement, advise their patients to continue moving, and recommend avoiding bed rest, patients' attitudes and beliefs can be influenced in a way that promotes confidence and reduces anxiety or fear (Darlow et al., 2013).

Negative or threatening language used while providing advice is associated with increased anxiety, fear, and negative beliefs (Stewart & Loftus, 2018; Linskens et al., 2023). Professionals should therefore be mindful of their own beliefs, the nature of the advice provided, and the language used while providing this advice (Darlow et al., 2013; Stewart & Loftus, 2018; Christe et al., 2021b; Caneiro et al., 2021). Furthermore, investigating and addressing the beliefs of the professionals providing advice to individuals about LBP is paramount to ensure that unhelpful beliefs and misconceptions are effectively targeted (Buchbinder et al., 2018; Suhail & Poulter, 2022).

1.2.5 Measuring attitudes and beliefs

Several tools are available to measure back pain beliefs, including the Back Beliefs Questionnaire (BBQ), the Fear-Avoidance Beliefs Questionnaire (FABQ), and the Back Pain Attitudes Questionnaire (Back-PAQ). This section outlines the development of these tools.

Back Beliefs Questionnaire

The Back Beliefs Questionnaire (BBQ) was developed in 1996 to measure workers' attitudes and beliefs about lower back troubles (Symonds et al., 1996). The BBQ largely focuses on the perceived consequences of lower back troubles, and the relationship between back pain, and work (Symonds et al., 1996). The initial study found an association between negative beliefs and work loss (Symonds et al., 1996). Furthermore, this study emphasised the need for interventions targeting workers'

beliefs to reduce instances of excessive work loss due to back troubles (Symonds et al., 1996).

The Fear Avoidance Beliefs Questionnaire

The Fear Avoidance Beliefs Questionnaire (FABQ) was developed by Gordon Waddell and his team in 1993 to assess levels of fear avoidance beliefs (Waddell et al., 1993). Theories related to fear-avoidance were used to develop this questionnaire following the emergence of the biopsychosocial model (Waddell et al., 1993). The items in this questionnaire are primarily addressed to patients with LBP and ask questions relating to the relationship between physical activity, work, and LBP (Waddell et al., 1993).

The Back Pain Attitudes Questionnaire

The Back Pain Attitudes Questionnaire (Back-PAQ) was developed, through interviews with people experiencing acute and chronic LBP, to measure levels of attitudes and beliefs in both general and practitioner populations (Darlow et al., 2014b). The Back-PAQ has been used in various contexts, including with general populations, physiotherapists, and manual handling advisors, and has been widely published (Darlow et al., 2014a; Nolan et al., 2018, 2019; Pierobon et al., 2020; Christe et al., 2021a, 2021b).

The Back-PAQ has been used to investigate attitudes and beliefs about back pain in the New Zealand (Darlow et al., 2014a), Argentina (Pierobon et al., 2020), and French-speaking Swiss (Christe et al., 2021a) general populations. These studies assessed the back pain beliefs of the general public, including adults over the age of 18 (Darlow et al., 2014a; Pierobon et al., 2020; Christe et al., 2021a). Non-probability-based sampling strategies were used in two studies to recruit participants from the general population in Argentina and the French-speaking part of Switzerland through social networks (Pierobon et al., 2020; Christe et al., 2021a). The study conducted in New Zealand (Darlow et al., 2014a) randomly selected participants from the electoral roll (Darlow et al., 2014).

The general populations investigated in these studies frequently demonstrated unhelpful beliefs, as indicated by high Back-PAQ scores. The Back-PAQ provides a score between 35 and 170, with higher scores reflecting more unhelpful beliefs

(Darlow et al., 2014a). The mean scores reported for general populations are as follows: Argentine (111.7 ± 12.8) and French-speaking Swiss (113 ± 10.6) (Pierobon et al., 2020; Christe et al., 2021a). Negative attitudes and beliefs, particularly relating to the vulnerability and need to protect the back as well as the unique nature and impact of back pain, were common among general populations (Darlow et al., 2014a; Pierobon et al., 2020; Christe et al., 2021a). Some positive beliefs were also identified relating to the role of psychological factors in pain experience and recovery and the importance of remaining physically active (Darlow et al., 2014a; Pierobon et al., 2020; Christe et al., 2021a). There was, however, uncertainty regarding the levels of physical activity that are safe during episodes of pain (Darlow et al., 2014a; Pierobon et al., 2020).

The Back-PAQ has also been used to investigate the back pain attitudes and beliefs of practitioners, including manual handling advisors (Nolan et al., 2018, 2019) and physiotherapists (Nolan et al., 2018, 2019; Christe et al., 2021b). One study assessed the beliefs of physiotherapists and determined the association between their beliefs and clinical decisions (Christe et al., 2021b). Other studies investigated physiotherapists' and manual handling advisors' beliefs about back pain and perceptions regarding safe lifting posture (Nolan et al., 2018, 2019). The studies conducted with physiotherapists and manual handling advisors from various countries employed non-probability convenience sampling strategies to recruit participants (Nolan et al., 2018, 2019). On the other hand, Christe et al. (2021b) assessed the LBP beliefs of physiotherapists in the French-speaking part of Switzerland using a non-probability-based snowball sampling strategy.

Professionals and practitioners demonstrated varying attitudes and beliefs about back pain, as reflected by their Back-PAQ mean scores: French-speaking Swiss physiotherapists (82.7 ± 17.2), physiotherapists from different countries (67.4 ± 18.6) and manual handling advisors from different countries (101.3 ± 15.9) (Christe et al., 2021b; Nolan et al., 2018).

Unhelpful beliefs about the vulnerability, need for protection, and the unique nature of LBP were prevalent among physiotherapists and manual handling advisors (Nolan et al., 2018, 2019; Christe et al., 2021b). Interestingly, Christe et al. (2021b) found that

fewer years of physiotherapy experience were associated with more helpful beliefs. The back pain beliefs of French-speaking Swiss physiotherapists were more helpful than those of the French-speaking Swiss general population but within both groups there were unhelpful beliefs that should be addressed (Christe et al., 2021a, 2021b). The attitudes and beliefs of physiotherapists were more positive than those demonstrated by manual handling advisors; however, all groups exhibited unhelpful protective beliefs that negatively impacted advice and recommendations (Nolan et al., 2018, 2019; Christe et al., 2021b).

1.3 Human Factors and Ergonomics

The previous section outlined the role that attitudes and beliefs play in influencing LBP and related disability, as well as how professionals contribute to shaping these beliefs. Investigations into the back pain attitudes and beliefs of professionals have largely focused on healthcare practitioners who manage and treat LBP (Darlow et al., 2012; Darlow et al., 2013; Gardner et al., 2017; Nolan et al., 2018, 2019; Christe et al., 2021b). However, Nolan et al. (2018, 2019) emphasised the importance of understanding the beliefs of manual handling advisors who provide advice regarding LBP prevention in the workplace.

HFE is the scientific discipline and profession concerned with the optimisation of the work environment for performance and well-being (Dul et al., 2012). HFE specialists may contribute to the prevention of LBP in the workplace through workplace guidelines, risk assessment, advice/recommendations, and interventions (Whysall et al., 2004; Hartvigsen et al., 2005; Bigos et al., 2009; Macdonald & Oakman, 2022; De Bruin et al., 2024), yet little is currently known about their back pain beliefs. HFE is primarily involved in and concerned with prevention, but HFE specialists are often consulted after a problem arises (Whysall et al., 2004) and may implement interventions to reduce LBP intensity (Driessen et al., 2010) or prevent disability (Sormunen et al., 2022). The involvement of HFE specialists in prevention efforts highlights their potential to influence the beliefs of workers at risk of or already experiencing LBP.

HFE has developed over time from a largely partitioned and reductionist discipline to one that advocates for a holistic systems approach. Despite this shift, reductionist tools and methods remain prevalent in some areas of practice (Macdonald & Oakman, 2022, 2024; De Bruin et al., 2024), with potentially negative impacts on workers' beliefs. The following section outlines the historical development of HFE and its evolution into a systems discipline. Lastly, the section explores current risk assessment practices for musculoskeletal disorders (MSDs) like LBP in the workplace.

1.3.1 Origins and historical development of HFE

HFE as a scientific discipline and profession has developed significantly over the last several decades and continues to evolve as the nature of work and technology changes (Koningsveld, 2019). The term "Ergonomy" was coined in 1857 by a Polish scientist, W.B. Jastrezbowski, combining the Greek words 'ergon' and 'nomos' to reflect the 'science of labour' (Zionchenko & Munipov, 2004; Karwowski, 2005). This represented one of the first known attempts at understanding humans at work. HFE evolved differently around the globe and, while the primary outcomes of optimising performance and well-being remained the same, different traditions emerged (Thatcher et al., 2019).

The historical development of HFE followed two broad trajectories. In the United States, the United Kingdom, and some parts of Europe, HFE developed with roots in positivism and empiricism (Zionchenko & Munipov, 2004; Dekker et al., 2013; Kroemer, 2017; Thatcher et al., 2019). This was the dominant paradigm for decades with an emphasis on experimental and laboratory-based studies (Wilkin, 2010; Dekker et al., 2013). On the other hand, the development of HFE in France and other French-speaking regions emerged slightly differently with a greater alignment with constructivism and interpretivism, valuing an understanding of work as it occurred in context (Filliettaz et al., 2015). The historical development and philosophical underpinning of a discipline and profession tend to influence its current practice despite potential advancements (Rocca & Anjum, 2020), emphasising the need to explore the evolution of HFE.

In the 19th and 20th centuries, American engineers began trying to understand human performance at work (Zionchenko & Munipov, 2004). This early research played a

critical role in the development of HFE in this context. In the late 1800s and early 1900s, American Engineer Fredrick Taylor produced some of the earliest scientific research that aimed to optimise work and enhance performance (Björkman, 1996; Zionchenko & Munipov, 2004). Taylor's work was based on scientific principles and was influential within traditional HFE (Björkman, 1996). Frank Gilbreth, another American engineer, built on the work of Fredrick Taylor and was one of the prominent researchers who developed the concept of time and motion analysis to enhance worker efficiency while also placing emphasis on worker well-being (Sanders & McCormick, 1993; Zionchenko & Munipov, 2004). These are two examples of early contributions that established the foundation upon which traditional HFE principles were developed, many of which are still prevalent today.

The need to understand and optimise human performance grew significantly in the early 1900s due to the industrial and wartime climate. The First World War saw a rise in military industry and labour intensification, leading to an increase in work-related injuries and worker fatigue (Zionchenko & Munipov, 2004). Consequently, Britain developed the Health of Munition Workers Committee in 1915, which was later reorganised post-war into the Industrial Health Board, which aimed to enforce laws around safety and health in workplaces (Zionchenko & Munipov, 2004; Boff, 2006). In other regions of the world, researchers in the 1920s developed psychotechnics, which applied principles of psychology to human activity and developed the initial concept of fitting the man to the machine, another well-known HFE approach (Zionchenko & Munipov, 2004; Kroemer, 2017).

Human factors and ergonomics emerged as distinct disciplines in response to industrial and wartime demands as Western nations began their search for economic growth and productivity (Dempsey et al., 2006; Koningsveld, 2019). Human factors emerged in the United States during World War Two, primarily drawing from the disciplines of psychology and engineering (Wilson, 2000; Wilson & Sharples, 2015). The development of human factors, or human factors engineering, was necessary as the rapid development of technology heightened the need to understand cognitive factors and how humans interact with tools and technologies (De Winter & Hancock, 2021). There were significant problems emerging with the equipment utilised during this time that required a better understanding, and design, of human-machine

interactions (Jefferson, 2005). The goal of human factors was to design machines and tasks that align with human capabilities (Chapanis, 1959). Human factors primarily focused on the cognitive factors and mental processes that influenced task performance and equipment use (Wilson, 2000; Dempsey et al., 2006; De Winter & Hancock, 2021).

On the other hand, the broad discipline of ergonomics emerged in the United Kingdom and Europe with interest in aspects of human performance drawing from disciplines including anatomy, physiology, industrial medicine and hygiene, and design engineering (Wilson, 2000; Wilson & Sharples, 2015). In Europe, the development of ergonomics emerged due to its applications to industrial processes and interest in improving well-being and manufacturing productivity (Jefferson, 2005). Ergonomics traditionally focused on the physical aspects of people and their working environment (Wilson, 2000; Dempsey et al., 2006) and aimed to understand and improve the interactions between the worker and their physical environment (Dempsey et al., 2006). Ergonomics became associated with workspace design, focusing on matching the design of tools and tasks to the capabilities of the human (Kroemer, 2017).

Despite their different origins, both disciplines aimed to enhance performance and well-being within working contexts through the understanding of human characteristics and work system interactions (Dempsey et al., 2006). During this time, mainstream HFE followed a linear model paradigm rooted in positivism (Wilkin, 2010; Dekker et al., 2013). Within this paradigm, associated approaches focused on the measurement of different aspects of human performance and behaviour, and the alteration of specific components to improve quantifiable outcomes (Wilkin, 2010).

The positivist focus within mainstream HFE in the 20th century was questioned by some researchers, including Paul Branton (Hignett & Wilson, 2004). Branton questioned the traditional positivist approach to ergonomics in Britain, arguing for the importance of understanding workers' perceptions, values, and views (Oborne, 2000; Hignett & Wilson, 2004). The person-centred approach to ergonomics, developed by Branton, moved away from a mechanistic view of humans and emphasised the importance of understanding the role of human emotion on behaviour and performance (Oborne, 2000; Hignett & Wilson, 2004). Branton's work highlighted the

need to understand the whole person from a physical, psychological, and social perspective (Oborne, 2000), representing a shift towards a more holistic approach.

HFE developed slightly differently in other countries, like France, with the emergence of alternative approaches, some of which did not align with the traditional positivist paradigm prevalent within mainstream HFE. France developed their own approach to HFE, known as activity-centred ergonomics (ACE), which later spread to South America and some parts of North and West Asia (Daniellou & Rabardel, 2005). While the evolution of HFE in France was closely related to that seen throughout the rest of Europe, the French approach was grounded in an understanding of human activity as it occurred in context rather than in the laboratory (Barcellini et al., 2025). The foundational development of ACE emerged in the 1950s and 1960s, questioning the traditional Taylorian-Fordist models (Barcellini et al., 2025).

ACE emerged in French-speaking countries based on the work done by pioneers including Alain Wisner (Wisner, 1995), Jacques Leplat (Leplat, 1990; Leplat, 1994) and Pierre Rabardel (Rabardel & Beguin, 2005), with a few unique key characteristics (Barcellini et al., 2025). A central component of ACE is the understanding and analysis of activity (Daniellou & Rabardel, 2005; Barcellini et al., 2025). ACE aims to transform activity through a humanistic and emancipatory approach that focuses on promoting development through increasing workers' autonomy over their work situation (Daniellou & Rabardel, 2005; Barcellini et al., 2025). Within ACE, the understanding of activity is not separated from the social or political context in which it occurs (Daniellou & Rabardel, 2005; Barcellini et al., 2025). ACE and its foundations valued a more qualitative, contextual understanding of work that embraced the complexity of activity as it occurred in the real world (Barcellini et al., 2025).

Other researchers including Jean-Marie Faverge, and Ivar Oddone heavily influenced the development of ACE, with an emphasis on understanding activity from the perspective of the worker (Daniellou, 2005; Barcellini et al., 2025). These researchers highlighted that workers' responses were influenced by the work situation (Daniellou, 2005; Barcellini et al., 2025). Further, Oddone and his team emphasised that work cannot be understood by separating it from the social and economic climate in which it occurred and without an understanding of workers' experiences (Barcellini et al.,

2025). Such research promoted the development of work (and workers) through the active involvement of stakeholders to co-construct meaningful solutions (Barcellini et al., 2025). Values around participation and worker involvement formed the basis of ACE and spread beyond France to other regions, including South America (Brunoro et al., 2020), and some parts of Asia (Daniellou & Rabardel, 2005; Barcellini et al., 2025).

ACE continued to develop based on these foundations and emerged as an approach that values an understanding of work as it occurs in context (Daniellou, 2005; Barcellini et al., 2025). The origins and development of HFE in France and similar regions shaped how these HFE specialists were educated and trained, therefore influencing the nature of their interactions with workers (Barcellini et al., 2025).

1.3.2 Role of the International Ergonomics Association

The formation of the International Ergonomics Association (IEA) marked a crucial starting point for the development of global HFE (Caple, 2012). The IEA was formed in 1959 during the meeting of the European Productivity Agency to advance the science and practice of ergonomics (Kuorinka, 2000; Koningsveld, 2019). The formation of the IEA united the global HFE community and allowed for the development of HFE as we know it today. In 1976, the IEA became the association of federated HFE societies worldwide, bringing together many national HFE societies (Koningsveld, 2019). The role of the IEA is to share and develop HFE research, education, and practice globally (Caple, 2012).

After 1976, the number of federated societies collaborating with the IEA steadily increased (Koningsveld, 2019). While most of the early IEA members were predominantly from developed countries, membership expanded in the later years to include developing countries (Caple, 2012). The IEA promoted global collaboration and allowed for the unification of both disciplines, contributing to the recognition of HFE as a unique and globally recognised discipline and profession (Koningsveld, 2019).

Through the collaboration and unification of HFE across different regions, knowledge and theoretical practices were shared (Kuorinka, 2000; Koningsveld, 2019). IEA

Congresses facilitated the exchange of diverse HFE approaches on a global platform, resulting in the cross-pollination of different schools of thought within HFE (Caple, 2012; Koningsveld, 2019). The shared understanding of different HFE practices globally played a vital role in the shift away from reductionism within mainstream HFE towards a discipline that values a holistic systems approach (Dul et al., 2012; Koningsveld, 2019).

The technological revolution in the 1980s altered the structure of many work systems and increased the need to understand the evolving demands placed on workers (Boff, 2006; Koningsveld, 2019). The changes occurring due to rapid advancements in technology challenged traditional HFE approaches and prompted the need to adapt HFE to acknowledge increasingly complex digital work systems (Carayon et al., 2006; Dul et al., 2012; Karwowski, 2012; Koningsveld, 2019). Through the global collaboration of various HFE experts, newer approaches emerged to address the limitations of traditional ergonomics, including macroergonomics and participatory ergonomics.

Macroergonomics is an approach or subdiscipline that was developed to understand and design sociotechnical systems using a whole-systems perspective, in order to improve performance and well-being (Kleiner, 2006; Walker, 2008; Hendrick, 2012; Holden et al., 2015). Adopting principles of sociotechnical systems theory, macroergonomics typically focuses on broader work system design through an understanding of social, technical, and environmental interactions (Kleiner, 2006). As work systems became more complex, there was a growing need to understand the broader organisational and environmental context that influences human-technology interactions (Kleiner, 2006). Macroergonomics was developed to address the shortcomings of traditional HFE approaches that focused on components (physical/cognitive) in isolation (Kleiner, 2006; Holden et al., 2015). Through the introduction of a systems approach, macroergonomics recognises the interactions between these components as well as the influence of the broader organisational and environmental context (Kleiner, 2006; Holden et al., 2015).

Researchers in Britain, namely Eric Trist, Ken Bamforth, and Fred Emery developed sociotechnical systems theory in the 1950s to explain the complex interaction between

social (humans) and technical (tools, machines, buildings) subsystems within the work environment (Waterson, 2005). Sociotechnical systems theory proposes that both the technical and social aspects of the work system must be balanced to achieve effective performance (Waterson, 2005). This implies purposeful interactions between humans and the tools/technologies utilised to bring about the given inputs and outputs within a system (Sanders & McCormick, 1993; Wilson, 2000). Therefore, efficiency within sociotechnical systems depends on the joint optimisation of the social and technical subsystems (Hendrick, 2012). Joint optimisation, as depicted in Figure 9, requires the consideration of all system components in order to balance these interactions, thereby promoting system efficiency (Hendrick, 2012; Waterson, 2005).

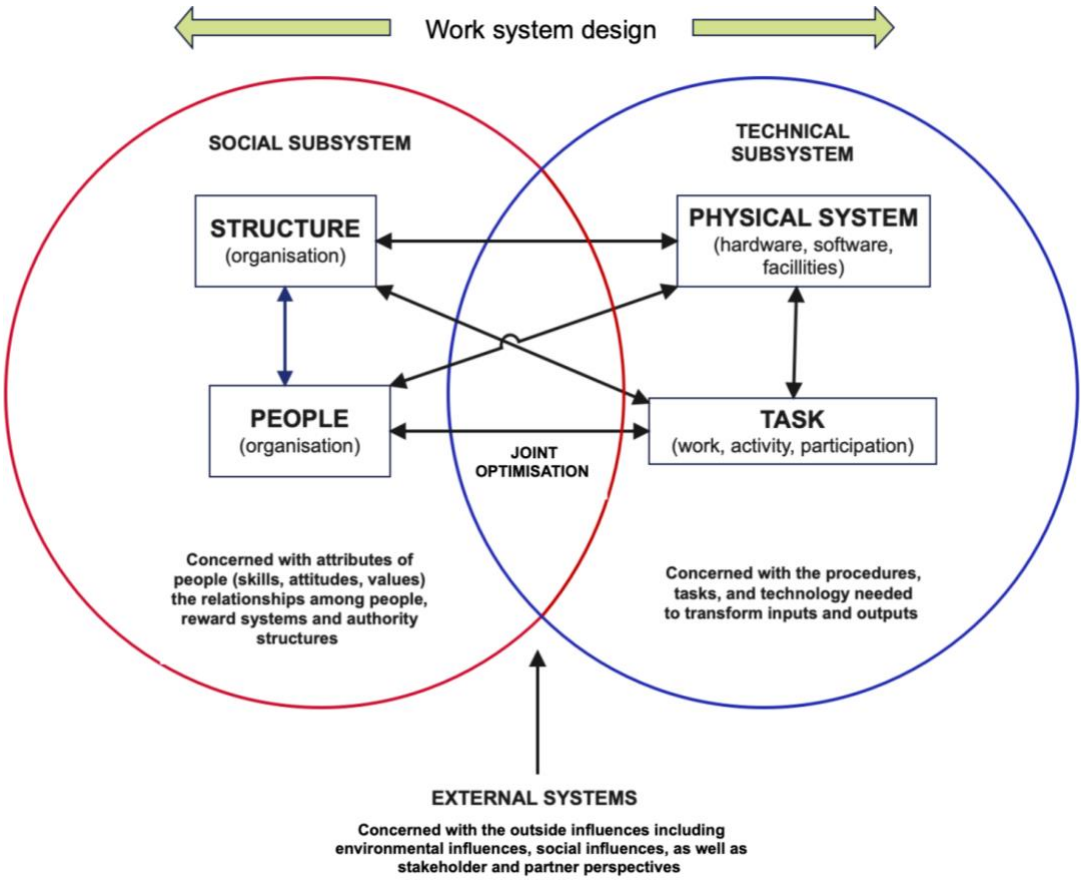

Figure 9. Sociotechnical systems theory (adapted from Bostrom & Heinen, 1977 and Trancossi et al., 2021)

Within HFE, the system of focus is made up of the workers and their interactions with the physical, social, and organisational environment (Wilson, 2000; Carayon, 2006; Dul et al., 2012). Work systems have technical components (the physical workplace

made up of the buildings, equipment, tools, and technology used, as well as the organisational structure that governs it), and social components (the people within the system) (Dul et al., 2012; Wilson, 2000). HFE aims to promote the dual outcome of performance and well-being (Dul et al., 2012). Such efforts require the joint optimisation of the social and technical elements of the system (Walker et al., 2008), indicating the utility of adopting the principles of sociotechnical systems theory within HFE.

Participatory ergonomics was introduced in the 1980s to promote the involvement of workers and other stakeholders in the design and management of work systems (Koningsveld, 2019). Hancock (1997) noted that control over one's working conditions altered the way individuals responded to their work by promoting a sense of freedom, often leading to a reduction in work-related stress. This participatory approach aligned more with the French ideology that involved workers in the design and management of their work systems (Barcellini et al., 2025). The adoption of both macroergonomics and participatory ergonomics marked a gradual shift towards a more holistic systems-oriented approach within HFE.

In 2000, the IEA presented the new definition of HFE as "the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimise human well-being and overall system performance." (IEA, 2000). This definition included the identification of specific HFE domains, including physical ergonomics, cognitive ergonomics, and organisational ergonomics; and at this time, these domains were still largely separate (Wilson, 2000). Cognitive ergonomics focuses on how mental processes (memory, decision making, perception, work stress, etc) influence the interactions between workers and the other elements of the system (IEA, 2024c; Koningsveld, 2019). Physical ergonomics focuses on the physical aspects of working environments, including the influence of anatomical, anthropometric, physiological, and biomechanical factors on work performance. Lastly, organisational ergonomics (or macroergonomics) focuses on optimising sociotechnical system design with an interest in the broader organisational structure and the processes and policies that influence performance and well-being (IEA, 2024c;

Koningsveld, 2019). The distinction between these domains was prominent in early HFE, with a vast influence on global practice (Wilson, 2014).

In addition to shaping the global HFE climate, the IEA has been responsible for developing HFE education programmes, HFE certification boards, and ergonomic guidelines (Kuorinka, 2000; Caple, 2012; Koningsveld, 2019). The IEA has also built global relationships with important organisations, including the International Labour Organisation (ILO) as well as the International Organisation for Standardisation (ISO) (Kuorinka, 2000; Caple, 2012; Koningsveld, 2019). Due to global differences in the development of HFE, methodologies, practices, and areas of application may vary, but the core outcomes remain the same (Caple, 2012; Koningsveld, 2019).

The IEA endorses and supports the certification of HFE professionals through certification systems around the world (Smith, 2012; IEA, 2024a). To become a certified HFE professional endorsed by the IEA, there are certain criteria and competencies that must be met (Smith, 2012; IEA, 2024a). Many regions do not have IEA endorsed certification systems but still practice HFE. The regions with IEA endorsed certification systems are as follows: Argentina, Australia, Brazil, Canada, Europe, Japan, New Zealand, South Africa, the United States of America, and Malaysia (IEA, 2024a). The regions with IEA recognised certification systems include the United Kingdom and Mexico (IEA, 2024a). Not all HFE researchers and practitioners are certified professionals, and for this reason, the term HFE specialist was chosen when referring to individuals who research, teach, and practice HFE in this study.

1.3.3 Understanding complexity: the need for a systems approach

Researchers within HFE have argued that dealing with work systems that involve both humans and technology cannot avoid embracing complexity (Karwowski, 2012; Dekker et al., 2013). In the early 2000s, the traditional separation of physical, cognitive, and organisational domains within HFE was questioned (Wilson, 2000; Carayon, 2006; Kleiner, 2006; Wilson, 2014). HFE researchers increasingly started to recognise the interrelatedness of the aforementioned domains and the need to take an approach that acknowledges the interactions between the human (physical and cognitive) and their environment (physical and organisational) (Wilson, 2000; Carayon, 2006; Dul et

al., 2012). As such, the IEA commissioned white paper titled ‘The Future of Ergonomics’ positioned HFE as a holistic systems discipline (Dul et al., 2012). This section outlines the need for such an approach within HFE.

Complex systems, including work systems, display certain characteristics, most importantly: they are open systems that require an understanding of holism and emergence (von Bertalanffy, 1950, 2008; Meadows, 2009; Wilson, 2014). These characteristics were first outlined within general systems theory (von Bertalanffy, 1950) and later applied to HFE to describe the complexity of modern work systems (Rasmussen, 1997; Karwowski, 2012; Wilson, 2014). The openness of complex systems indicates a reciprocal relationship between the system and its environment, emphasising their ability to adapt based on external changes (Cilliers, 1998). Furthermore, complex system outcomes are shaped by non-linear interactions and therefore cannot be understood through an understanding of component parts (von Bertalanffy, 1950; Cilliers, 1998). These dynamic and non-linear interactions often lead to unintended emergent outcomes (von Bertalanffy, 1950; Cilliers, 1998). Such characteristics challenged the effectiveness of traditional reductionist approaches within HFE (Karwowski, 2012; Dekker et al., 2013; Wilson, 2014).

Within the paradigm of complexity, humans can be viewed as complex systems that operate within environments that have their own complexity (Meadows, 2009). Humans are essentially a set of interacting subsystems (the nervous system, the muscular system, the circulatory system, etc) working together to achieve specific goals (von Bertalanffy, 1950, 2008; Meadows, 2009). The human body possesses different cells, tissues, organs, and systems that interact in dynamic and non-linear ways, giving rise to emergent properties and behaviours (Pol et al., 2019; Mazzocchi, 2025). Humans have autonomy and the capacity to adapt and respond to changes in their environment (open systems), further emphasising their complexity (Mazzocchi, 2025). Therefore, humans exhibit the characteristics of complex systems as they adapt, self-organise, and respond in non-linear ways to environmental and task demands (Pol et al., 2019; Mazzocchi, 2025). When multiple individuals interact, under a specific organisational structure and other constraints, with tools and technology, the complexity of the given system increases (Karwowski, 2012).

Simon (1962, p. 468) proposed that complex systems are ‘composed of interrelated subsystems, each of the latter being, in turn, hierarchic in structure until we reach some lowest level of the elemental subsystem’. This is often referred to as the nested systems approach, which has been adapted by other disciplines (Bronfenbrenner, 1977, 1994). Work systems are often conceptualised as hierarchical nested systems (Thatcher et al., 2020). The nested systems approach proposes that smaller systems (micro) display less complexity and are embedded in larger systems (meso and macro) that display increasing complexity, as depicted by Figure 10 (Thatcher et al., 2020). Due to this hierarchical structure, the most internal (micro) subsystem is governed by various interactions across system levels (Bronfenbrenner, 1977, 1994).

Modern work systems consist of multiple interacting human-machine subsystems that, together with their environments, form a larger sociotechnical system designed to achieve shared goals (Sanders & McCormick, 1993; Karwowski, 2012). From a nested systems perspective: individuals and their interactions with their tools and tasks make up a system (with goals, interactions, and outcomes), this individual forms part of a team of individuals which creates another system (with goals, interactions, and outcomes), and this system forms part of a broader organisation (larger socio-technical system with its own goals, interactions and outcomes) that forms part of a larger societal and environmental context (another broader system), as depicted in Figure 10 (Thatcher & Yeow, 2016).

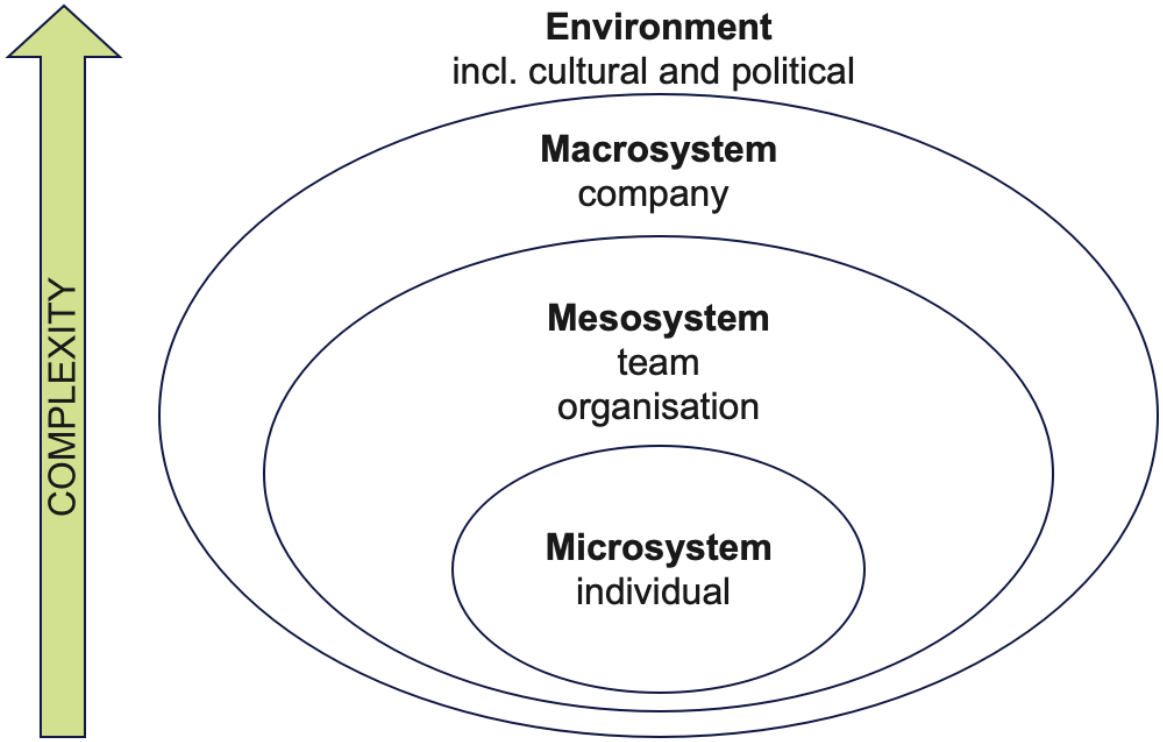

Figure 10. Example of hierarchical nested work systems (adapted from Bronfenbrenner, 1977 and Thatcher & Yeow, 2016).

Within the hierarchical nested systems framework, micro level system behaviour and outcomes cannot be understood without understanding the interactions across system levels that shape these outcomes (Waterson, 2009; Wilson, 2014; Thatcher & Yeow, 2016). Work systems often involve people interacting at various levels, each bringing their own goals, values, and beliefs into the system, contributing to the systems' overall complexity (Waterson, 2009). As depicted in Figure 10, individuals' interactions at a micro level occur within and are shaped by the larger system (Waterson, 2009; Thatcher & Yeow, 2016). The complex nature of modern work systems emphasises the importance of the conceptual shift towards a holistic systems approach within HFE. Such an approach is essential throughout all areas of HFE application, even those historically addressed at a micro level (Carayon et al., 2015).

1.3.4 Advancements and practical challenges of systems HFE

The broader shift towards a systems approach within HFE is recognised by international guidelines (IEA & ILO, 2021; IEA, 2021). The IEA & ILO released a jointly

prepared document titled ‘Principles and Guidelines for Human Factors and Ergonomics (HF/E) Design and Management of Work Systems’ to guide high-quality HFE practice (IEA & ILO, 2021). The HFE principles and guidelines recognise that dynamic interactions influence the functioning of work systems, and advocate for the use of a systems approach within HFE (IEA & ILO, 2021). The HFE principles and guidelines do still present the domains (physical, cognitive, and organisational) as “three primary interrelated spheres of investigation and intervention” (IEA & ILO, 2021, p. 36) but state that these domains cannot be viewed in isolation but rather understood through a holistic, systems perspective.

The separation of these domains is questionable: the mind and body cannot be separated, and the human cannot be isolated from the organisational environment in which they operate (Wilson, 2014; Marras & Hancock, 2014). No task is solely cognitive or solely physical; in any given working context, both cognitive and physical characteristics, as well as the broader organisational context, determine human behaviour and influence the performance and well-being of the worker (Wilson, 2014; Marras & Hancock, 2014). According to the IEA, “Such a division is not in accordance with the characteristics of the profession: A concentration on one of these aspects, without consideration of the other aspects, is not HFE” (IEA, 2021, p. 4).

The IEA has also released a document titled ‘Core Competencies in Human Factors and Ergonomics (HFE) – Professional Knowledge and Skills’ (IEA, 2021) that defines the core knowledge and skills required to practice HFE (IEA, 2021). The IEA core competencies provide the basis required for certifying HFE professionals, which should likewise be reflected in educational programmes (IEA, 2021). The adoption of a holistic systems approach within HFE is prevalent throughout the IEA core competencies document (IEA, 2021). The IEA core competencies state that knowledge of all HFE domains is required and necessary to adopt a holistic systems approach to work system design and management in all instances, including when implementing recommendations (IEA, 2021).

Despite this shift, traditional reductionist approaches persist, and many HFE tools and methods focus on examining components in isolation (Wilson, 2014; Salmon et al., 2017; Bernardes et al., 2021; Koirala & Nepal, 2022; Macdonald & Oakman, 2022; De

Bruin et al., 2024; Nwosu et al., 2024; IEA, 2024d). For example, risk management practices for MSDs still tend to have a predominant biomechanical focus (Wilson, 2014; Macdonald & Oakman, 2015, 2022, 2024; De Bruin et al., 2024). Wilson (2014, p. 6) states that “it is tempting to be hard-nosed and suggest that any study, investigation, analysis or development which does not take a systems view is in fact, not E/HF at all… So, a musculoskeletal disorders (MSD) investigation or improvement which does not account for psychological/emotional/social influences, on MSD causation or success of solutions, is not properly E/HF.” (Wilson, 2014, p. 6). As such, efforts to shift HFE practice may still be required.

1.3.5 Risk management for MSDs

HFE specialists contribute to the prevention of work-related MSDs, including LBP, through risk assessment and management (Macdonald & Oakman, 2022). Risk management frameworks involve the identification and reduction of risks identified in the workplace (Macdonald & Oakman, 2022; Bazaluk et al., 2023). The identification process involves the observation and analysis of tasks, as well as interviews and conversations with workers (Kee, 2021; Oakman et al., 2022; Bazaluk et al., 2023). Oakman et al., (2022) noted that although observational hazard identification tools are commonly used in risk management practices, they are limited in their ability to assess psychosocial hazards. Certain tools and methods are then used to assess risk (Kee, 2021; Macdonald & Oakman, 2022; Oakman et al., 2022; Bazaluk et al., 2023), many of which assess physical risks (Oakman et al., 2022; De Bruin et al., 2024; IEA2024d). After risks are identified, measures are put in place to reduce or control these risks (Oakman et al., 2022). Risks are usually controlled in the following order of effectiveness: elimination of the risk, substitution of the risk, engineering controls, administrative controls, and protective equipment (OSHA, 2023). This framework addresses risk at a micro level, whereby the risks are isolated, and measures are put in place to eliminate or reduce the exposure to these isolated risks, typically without considering the interactions between different risk factors or how these interactions may be influenced by broader system factors (Carayon et al., 2015).

Many of the traditional risk assessment tools designed to reduce MSDs, including LBP, were based on biomechanical models (Pope et al., 2002; McGill, 1997; Marras, 2012). The biomechanical basis for many MSD/LBP risk assessment practices stemmed from

the biomedical viewpoint that injury and pain can be prevented through an understanding of the physical factors that cause injury (Marras, 2012; De Bruin et al., 2024). Traditionally, MSDs were understood through a mechanistic framework, whereby tissue damage occurs from sudden or cumulative trauma associated with the handling of loads (McGill, 1997). In the case of LBP, biomechanical models informed prevention strategies that aimed to reduce the incidence of lower back injuries through an understanding of the mechanical tolerance of the spinal tissues and the loading required to exceed that threshold (McGill, 1997; Marras, 2012).

Cumulative injury models were also developed to reflect the dynamic nature of tissue tolerance and proposed that injury and pain occur from cumulative exposure to mechanical loading through awkward postures, physical exertion, or lifting which decreases tissue tolerance to the point where injury can occur (McGill, 1997; Rainville et al., 2011). As such, biomechanical risk factors are well understood and accounted for within risk assessment practices (Marras, 2000, 2012; Macdonald & Oakman, 2022; Oakman et al., 2022). However, these initial models, upon which many MSD tools were based, were too simple to encompass the dynamic nature of tissue tolerance and loading (Marras, 2012).

Simple load-tolerance models evolved to include the various factors that influence tissue tolerance, including genetic factors, age, cumulative exposure, as well as strength and conditioning (Marras, 2012). Additionally, researchers noted that pain tolerance is influenced by various factors, including inflammation, and tends to decrease before tissue tolerance, as illustrated in Figure 11 (Marras et al., 2000; Marras, 2012). Furthermore, spinal loading is influenced by factors such as mental demand, environmental factors, and individual characteristics (Marras et al., 2000; Marras, 2012). The complex relationship between tissue loading, tissue tolerance, and pain tolerance meant that simple tools that viewed tissue tolerance as static and aimed to prevent LBP through an understanding of biomechanical factors alone were insufficient (Marras, 2012).

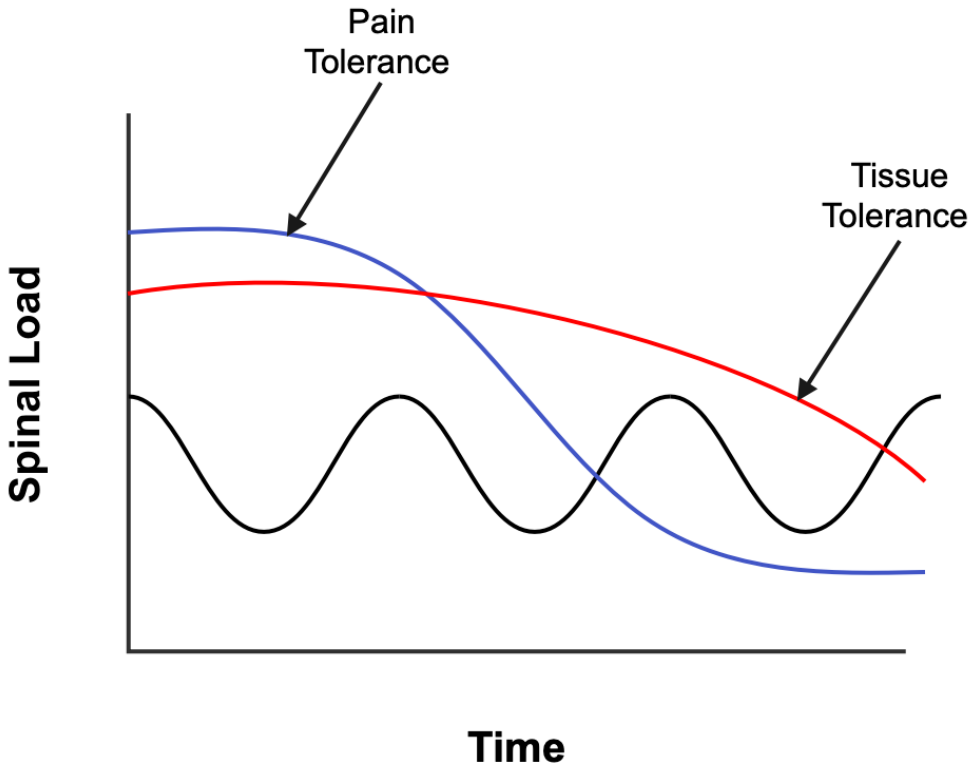

Figure 11. Pain tolerance and tissue tolerance (adapted from Marras, 2012)

Further, the evidence that physical factors independently cause LBP is weak (Rainville et al., 2011; Macdonald & Oakman, 2022; De Bruin et al., 2024), emphasising the need for a holistic systems approach. Studies have shown that occupational sitting (Roffey et al., 2010a), lifting (Wai et al., 2010a), bending (Wai et al., 2010b), twisting (Wai et al., 2010b), walking (Roffey et al., 2010c), standing (Roffey et al., 2010c), pushing (Roffey et al., 2010e), pulling (Roffey et al., 2010e), carrying (Wai et al., 2010c) and awkward postures (Roffey et al., 2010b) do not independently cause LBP.

The risk of work-related MSD development is complex and shaped by the interaction between a variety of factors, including biomechanical, psychosocial, organisational, and individual factors (Roquelaure, 2016; Oakman et al., 2023; Oakman & Macdonald, 2022, 2024). Evidence suggests the role that psychosocial hazards play in the development of work-related MSDs (Hauke et al., 2011; Macdonald & Oakman, 2015; Oakman et al., 2023), yet these are typically overlooked in many risk management frameworks (Macdonald & Oakman, 2022, 2024; Oakman et al., 2023). Psychosocial hazards are aspects of the job or work situation that may cause a stress response leading to physical or psychological harm (SafeWork, 2021). Stress responses can

influence the development of MSDs through physiological pathways (Hauke et al., 2011; Roquelaure, 2018), some of which are illustrated in Figure 12. The evidence of stress-related mechanisms highlights the influence of psychosocial factors in the development of MSDs (Hauke et al., 2011; Roquelaure, 2018).

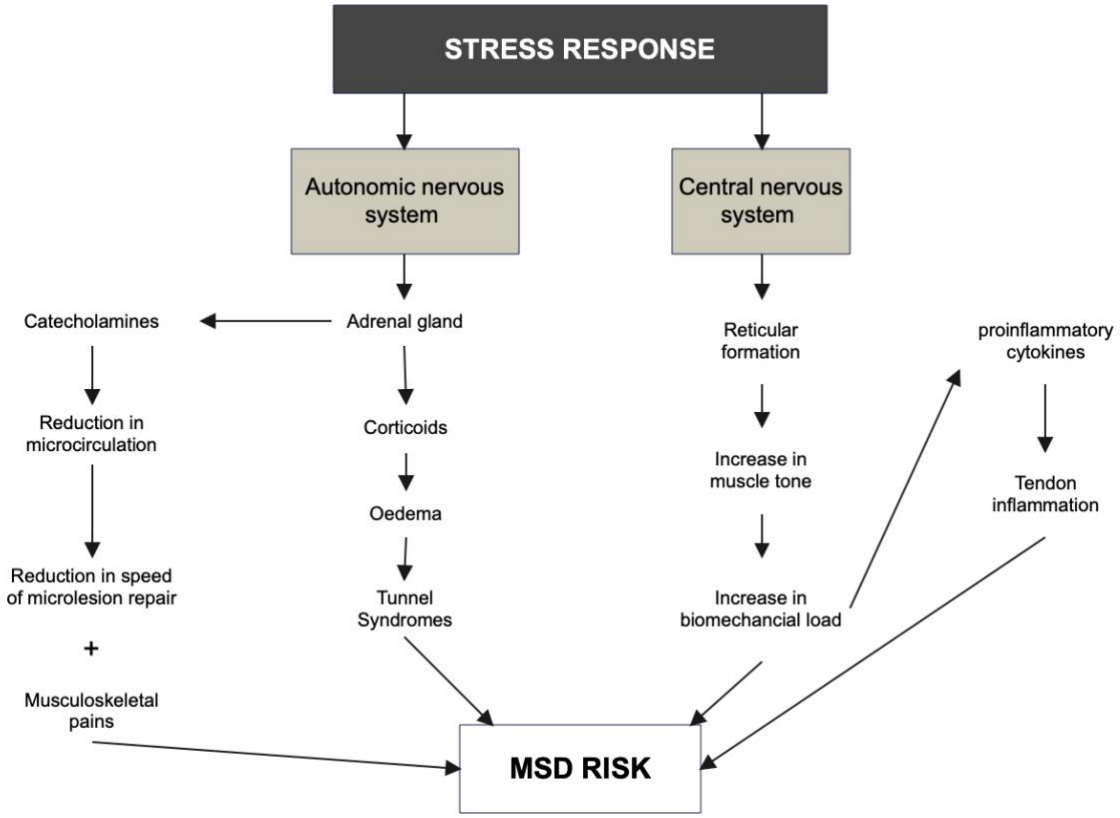

Figure 12. Impact of stress responses on MSD risk (adapted from Macdonald & Oakman, 2024)

Most intervention strategies fail to account for the complexity of work-related MSDs and focus on addressing physical risk factors alone or in isolation (Oakman et al., 2019a; Macdonald & Oakman, 2022; De Bruin et al., 2024; Nwosu et al., 2024). MSD risk management requires a shift towards a more holistic systems approach that accounts for all the relevant risk factors and the interaction between these factors (Oakman et al., 2019a; Macdonald & Oakman, 2022). It is paramount that HFE tools and methods reflect the nature of the problem: it makes little sense to address a complex problem with a reductionist approach (Walker et al., 2010). The need for a more comprehensive approach is highlighted by the continued prevalence of work-related MSDs (Ferreira et al., 2021; De Kok et al., 2019; Oakman et al., 2019a). Newer

risk assessment tools have been developed that address MSDs using a holistic systems framework (Oakman & Macdonald, 2019; Goode et al, 2019), but how well these are utilised in practice remains unknown.

A multidimensional model of MSDs was developed in France (Roquelaure, 2016). French ergonomists typically promote a more holistic, systems-based approach that is participatory in nature, aiming to understand how the constraints that occur at multiple levels of the system shape MSD risk (Lanfranchi & Duveau, 2008; Roquelaure, 2016). The multidimensional model, as shown in Figure 13, considers the interactions between biomechanical and psychosocial factors, while also taking into consideration how these interactions are influenced by organisational factors, as well as the economic, social, and political environment (Roquelaure, 2016). A more integrated model of MSDs that looks at the interactions occurring at multiple levels of the system is reflective of the ACE approach, as it aims to understand work and activity as they occur in context (Barcellini et al., 2025). Such an approach should be more widely adopted in practice due to its alignment with HFE's systems values.

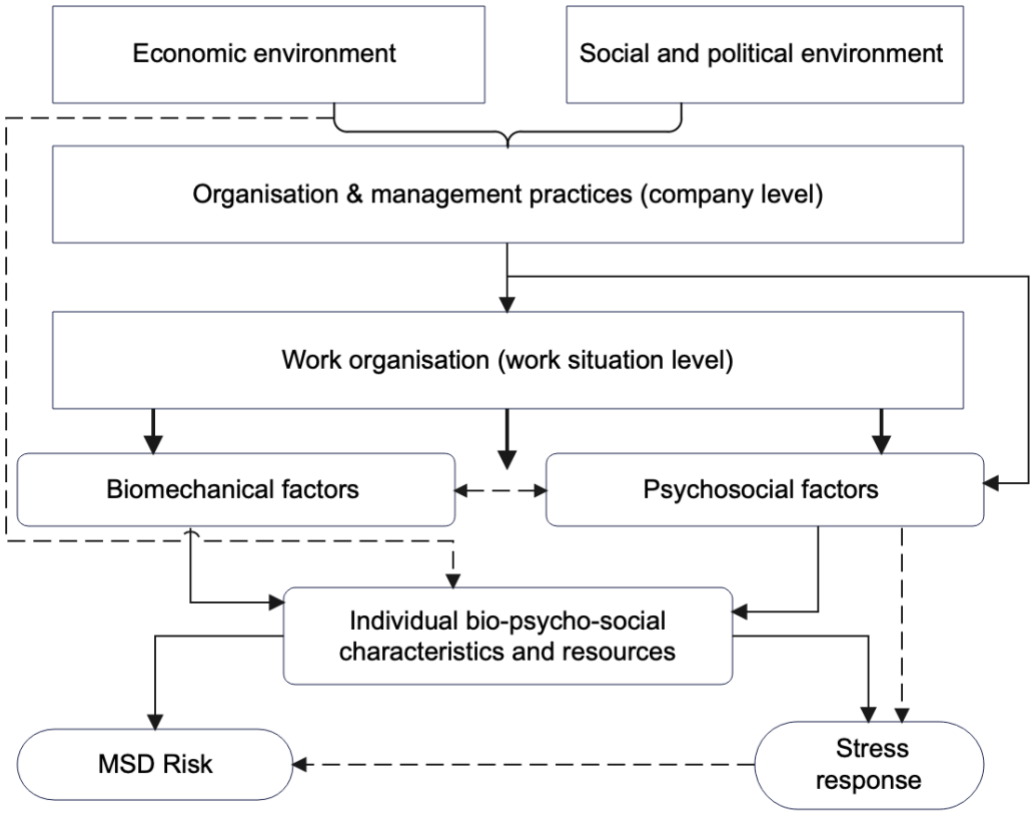

Figure 13. Integrated model of MSD development (adapted from Roquelaure, 2016)

Despite the current evidence, interventions and prevention strategies for LBP in the workplace tend to focus on reducing exposure to isolated biomechanical risk factors, including lifting, loading, awkward postures, and forceful exertions (Martimo et al., 2008; Bigos et al., 2009; Driessen et al., 2010, 2011; Verbeek et al., 2011, 2012; Hartvigsen et al., 2005; Sormunen et al., 2022). Psychosocial factors, if addressed at all, are often only briefly mentioned or addressed in isolation (Driessen et al., 2010, 2011; Sormunen et al., 2022). Biomechanical strategies to reduce or prevent LBP have been largely unsuccessful (Bigos et al., 2009; Driessen et al., 2010, 2011; Verbeek et al., 2011; Hartvigsen et al., 2005; Hogan et al., 2014; Sormunen et al., 2022), primarily due to their reductionist nature. The failure of traditional approaches to reduce the prevalence of LBP highlights the limited utility of looking at physical factors in isolation (Macdonald & Oakman, 2022). Reductionist approaches to understanding MSD risk are outdated but remain prevalent within modern HFE (Macdonald & Oakman, 2022), with potentially harmful impacts on workers' beliefs and behaviours (O'Sullivan et al., 2016; De Bruin et al., 2024).

The gap between evidence and practice for MSDs like LBP in the workplace reflects the need for research investigating the attitudes and beliefs of HFE specialists. The choice to implement biomechanically focused interventions and advice despite evidence and guidelines may be influenced by HFE specialists' back pain attitudes and beliefs, as seen in other professionals (Gardner et al., 2017; Nolan et al., 2018; Christe et al., 2021b). Furthermore, addressing widespread misconceptions about LBP is essential to reducing its global burden (Buchbinder et al., 2018), further reflecting the need to investigate HFE specialists' back pain attitudes and beliefs.

1.4 Problem statement

LBP is highly prevalent within working populations with vast negative implications for workers. LBP is complex and multifactorial, indicating that it emerges from the interaction between a variety of factors. Attitudes and beliefs about back pain influence these interactions and alter behaviour and pain experience. HFE specialists work closely with individuals in working contexts, where LBP and associated disability are common, and have the potential to influence workers' attitudes and beliefs about back pain. Risk management within HFE largely adopts a reductionist approach despite

current evidence, with associated attitudes and beliefs potentially reflecting this reductionist view. How HFE specialists choose to intervene in cases of musculoskeletal pain (how they communicate with workers, the choice of risk assessment tools, interventions and advice) is likely shaped by their attitudes and beliefs about back pain. Despite important interactions between workers and HFE specialists, there are currently no studies that investigate their back pain attitudes and beliefs. Therefore, the purpose of this study is to investigate the attitudes and beliefs about back pain held by HFE specialists on a global scale.

Research questions

What are the attitudes and beliefs about back pain among human factors and ergonomics (HFE) specialists globally?

Do the back pain attitudes and beliefs of HFE specialists in different roles (researchers/academics, practitioners, students), and countries differ?

Are back pain attitudes and beliefs influenced by HFE experience?

Is there a difference between the back pain attitudes and beliefs of general HFE specialists and the members of the International Ergonomics Association (IEA) Council?

CHAPTER 2: METHODOLOGY

The following chapter provides an overview of the research methodology employed to explore the attitudes and beliefs of global HFE specialists regarding back pain. More specifically, this chapter details the study design, study setting, participant characteristics, data collection tools, ethical considerations, procedures followed, and data analysis methods used.

2.1 Study design

The study explored the back pain attitudes and beliefs of HFE specialists on a global scale using an explorative cross-sectional questionnaire-based design. This approach was appropriate to answer the established research questions as it allowed for the exploration of HFE specialists' attitudes and beliefs about back pain using a validated and standardised questionnaire. Such an approach provided a subjective understanding of HFE specialists' attitudes and beliefs regarding back pain, including insights into specific trends in attitudes and beliefs at the time of the study.

2.2 Study setting

The study primarily took place at the International Ergonomics Association's 22nd Triennial Congress (IEA2024) held in Jeju, South Korea. Participant recruitment after the conference took place online via email.

2.3 Participants

The participants of this study consisted of HFE specialists who attended IEA2024 as well as members of the International Ergonomics Association's (IEA) federated and affiliated societies. Both platforms provided access to HFE specialists from various countries.

2.3.1 HFE specialists

As previously stated, the term HFE specialist was chosen as the study did not require participants to have professional certification. Firstly, because not all countries/regions have recognised certification bodies (according to the IEA, there are nine endorsed certification bodies around the world), and secondly, to allow for the investigation of

HFE practitioners, researchers/academics, and students (studying towards a master's level degree or higher).

The attitudes and beliefs of HFE practitioners were investigated due to their likely impact on HFE practice, including the advice provided to workers, and their potential to shape the beliefs, perceptions, and behaviour of workers and other stakeholders. The attitudes and beliefs of researchers/academics were explored due to their prospective influence on the provision of HFE education, and their likely role in shaping the attitudes, beliefs, and behaviours of those with a future career in HFE. The attitudes and beliefs of students were examined because they will likely become future researchers, educators, and practitioners and therefore have the capacity to alter future HFE practice and the attitudes, beliefs, and behaviour of future workers.

2.3.2 The IEA Council

A subset of participants included in this study were members of the IEA Council. The IEA Council is the governing body of the IEA (IEA, 2024b) and is responsible for making decisions regarding global HFE research, education and practice (Caple, 2012), indicating the importance of their beliefs. According to the IEA website (IEA, 2024b), the IEA Council is made up of representatives from different national and federated societies from around the world (presidents, vice-presidents or their nominees), and representatives from IEA networks, including the Federation of European Ergonomic Societies (FEES), ErgoAfrica, the Latin American Ergonomics/Union La Unión LatinoAmericana de Ergonomía (ULAERGO), BRICSplus, the Asian Council on Ergonomics and Design (ACED), and the South East Asian Network of Ergonomics Societies (SEANES).

2.3.3 Inclusion and exclusion criteria

This study included HFE specialists, which as defined above, included practitioners, researchers/academics (those who research and/or teach HFE at a tertiary level), and students studying towards a Master's or Doctor of Philosophy (PhD) specialising in HFE. HFE specialists who were not proficient in English were excluded from this study as the questionnaire was provided in English. The limited timeframe and global scope of this thesis meant that providing validated translations in multiple languages was not feasible.

2.3.4 Population and sample size

The population size for this study was unknown as there are no sources reporting the exact number of global HFE specialists proficient in English. The sample size calculation was therefore based on an unknown population size. With the population size unknown, the estimated minimum sample size was 377 based on the Raosoft sample size calculator (http://www.raosoft.com/samplesize.html).

2.3.5 Sampling strategy

The sampling strategy used for this study was non-probability based, including both convenience sampling and voluntary response sampling, as there was no feasible way to randomly select HFE specialists to participate in this study. The IEA Council members were recruited on a voluntary basis at the council meeting that took place in the days preceding IEA2024, affording all IEA Council members in attendance the opportunity to participate. Conference attendees were recruited in person at the conference during breaks between sessions and at social gatherings, and online attendees were recruited via email. Furthermore, access to federated and affiliated IEA societies was permitted, and all societies were contacted and invited to participate. The societies' decision to distribute the questionnaire to their members was voluntary.

2.4 Tools

The validated 34-item Back Pain Attitudes Questionnaire (Back-PAQ) was used alongside a list of demographic questions to collect data for this study.

2.4.1 Back Pain Attitudes Questionnaire

The validated and standardised 34-item Back-PAQ (Darlow et al., 2014b) was used to explore the back pain attitudes and beliefs of HFE specialists in this study. The questionnaire was developed to measure the back pain beliefs of both general and practitioner populations, indicating that it would be appropriate to use with HFE specialists (Darlow et al., 2014b). The Back-PAQ demonstrated excellent internal consistency and test-retest reliability (Moran et al., 2017) and was chosen over other instruments as it focuses on practitioners' own beliefs rather than their perceptions of others' beliefs (Darlow et al., 2014b). It was also selected due to its use in research

conducted with other professional groups, such as physiotherapists and manual handling advisors (Nolan et al., 2018, 2019; Christe et al., 2021b).

The Back-PAQ consists of 34 items scored on a five-point Likert scale. Item scores range from one to five ('false' = one, 'possibly false' = two, 'unsure' = three, 'possibly true' = four, 'true' = five). Most items are scored in a forward direction, with 11 reverse-scored items (1, 2, 3, 15, 16, 17, 27, 28, 29, 30, 31). After correcting reverse-scored items, the Back-PAQ provides a score between 34 and 170, with higher scores reflecting more unhelpful beliefs about back pain.

The 34 item Back-PAQ consists of six broad themes, namely: 'the vulnerability of the back' (vulnerability), 'the need for protective mechanisms for the back' (protection), 'the relationship between pain and injury' (pain-injury), 'the unique nature and impact of back pain' (special pain), 'the importance of engaging in physical activity while experiencing back pain' (activity) and 'the prognosis of back pain' (prognosis) (Darlow et al., 2014b; Christe et al., 2021b). Each item of the Back-PAQ correlates with one theme and these are as follows: vulnerability (items 1, 2, 3, 4, 5, 6, 9, 12, and 14), protection (items 7, 8, 10, 11, and 21), pain-injury (13, 15, 16, 17, 22, 29, 30, and 31), special pain (items 18, 19, 20, 23, and 24), physical activity (25, 26, and 27), and prognosis (28, 32, 33, and 34) (Appendix A) (Darlow et al., 2014b).

2.4.2 Demographic questions

A list of demographic questions was provided alongside the 34-item Back-PAQ to obtain relevant information needed for sample description and to allow for comparison. The demographic information included questions about the individuals' country of operation, years of HFE experience, and role (researcher/academic, practitioner, and/or student [Master's/PhD]). Participants were able to select more than one role if applicable.

2.5 Ethical considerations

Prior to the commencement of data collection for this study, ethical approval was granted by the Human Research Ethics Committee at Rhodes University in South Africa (reference number: 2024-7839-8829) (Appendix F). Participation in this study was completely voluntary, and informed consent was obtained from each participant

before the completion of the questionnaire. Each participant received a randomised participant number associated with their questionnaire and demographic information to ensure anonymity. Minimal risk was associated with this study. The only risks identified included a possible brief disruption of activities to complete the questionnaire. Benefits included contributing to an under-researched area.

2.6 Procedures

The IEA Council was the first group of HFE specialists recruited to participate in this study. The IEA Council members were recruited at the associated IEA2024 council meeting, which took place in Jeju, South Korea in August of 2024 before the start of the formal conference. At the IEA Council meeting, the purpose of the study was explained to the Council members in attendance during one of the breaks. The IEA Council members who were willing to participate in this study were provided with a letter of information and were able to ask any questions about the study. Verbal consent was obtained from the IEA Council members who were interested in participating before the questionnaire and demographic questions were distributed. Those who were willing to participate in the study were then asked to complete and return the questionnaire and demographic questions during the course of the day. The questionnaire pack, which included the demographic questions, had a blank page at the top with a unique participant number to protect the participants' anonymity.

Conference attendees were recruited during IEA2024, which took place from the 25th to the 29th of August. Conference attendees were approached and recruited during breaks between sessions and during lunch. Those who were willing to participate were able to complete an online version of the 34-item Back-PAQ and demographic questions on the Zoho Survey platform (https://www.zoho.com/survey/). The first page of the online version of the questionnaire provided the necessary information about the study and included an option to provide consent. Those who did not provide consent to participate in the study were not able to proceed to the questionnaire. Participants were given the option to either complete the questionnaire using an ipad provided by the researcher or were given a card with a QR code that directed them to the questionnaire to be completed in their own time. This card included the contact details of the researcher in case the participants had any further questions about the study. The conference took place both in person and online, those attending the

conference online were emailed a link to the online questionnaire along with an explanation of the purpose of the study.

Due to the low response rate at the IEA2024 conference and interest from some IEA Council members to extend the questionnaire to their societies, recruitment was extended to include members of IEA federated and affiliated societies after receiving ethical amendment. Members of national HFE federated and affiliated societies of the IEA were emailed, and the purpose of the study was explained. Those societies interested in participating forwarded the relevant information about the study to their members along with a link to the online questionnaire on the Zoho Survey platform. Societies were contacted in October 2024 and in January 2025.

2.7 Data analysis

This section outlines how the data were processed and analysed using both descriptive and inferential statistics.

2.7.1 Statistical software

The descriptive statistics were calculated using Microsoft Excel, while the graphs were created and the statistical tests were conducted using R Statistical Software Version 4.3.3 (R Core Team, 2025). Different R Statistical Software packages were used to create the graphs and conduct specific statistical tests. Table 14 summarises the packages used and their associated references.

2.7.2 Data processing

Prior to data analysis, the questionnaires were checked and unanswered questions were flagged. Questionnaires with fewer than 17 completed item responses were excluded from the calculation of total scores, as stipulated by Darlow et al. (2014b), but were still used when calculation descriptive statistics and frequency results per item. For the IEA Council who completed hard copies of the questionnaire, the responses were transferred into an Excel spreadsheet manually. For those who completed the online version of the questionnaire, the responses were downloaded as an Excel spreadsheet from the Zoho Survey website. The questionnaires were then scored, providing a score between one and five for each item using the find and replace Excel function. After raw scores were provided, a second spreadsheet was

created, and reverse-scored items were corrected, prior to the calculation of total scores. A Quantile-Quantile plot was used to check normality (Figure 21). The data processing followed the guidelines put forward by Darlow et al. (2014b).

2.7.3 Descriptive statistics and frequency results

Descriptive statistics (mean, standard deviation, mode, and coefficient of variation), frequency results, and confidence intervals were calculated for each item of the Back-PAQ. The confidence intervals for proportions were calculated using the Wilson method in R (R Core Team, 2025). The percentages of true, possibly true, false, and possibly false responses were calculated and used to create frequency graphs. Red and orange colours were used to depict negative beliefs, while green and light green were used to depict positive beliefs. The descriptive statistics and frequency results were calculated using raw scores before the correction for question direction. In the table displaying the descriptive statistics and frequency results, the percentages of true and possibly true responses were combined to facilitate interpretation and to allow for comparison with similar studies (Darlow et al., 2014a; Pierobon et al., 2020). Thereafter, item mean and standard deviation were used to create a table of the top ten most helpful and unhelpful beliefs about back pain.

Thereafter, summed scores were calculated for each theme, using corrected items, to provide a score for each theme. Completed responses for each item within these themes was required. Descriptive statistics were then calculated for each summed theme score to provide an overview of the attitudes and beliefs held within each theme. Boxplots were then created for each theme of the Back-PAQ, and for all responses, using mean item scores (ranging from one to five). The theme boxplots illustrate the trends of attitudes and beliefs across each theme of the Back-PAQ, showing the range of beliefs as well as the outliers within each theme.

2.7.4 Inferential statistics

Further statistical analyses were then conducted to assess the differences between the attitudes and beliefs of those with different roles (researchers/academics vs practitioners vs students vs multiple roles), to compare the attitudes and beliefs of the IEA Council with the rest of the sample, and to determine if HFE experience influences back pain attitudes and beliefs. Initially, one of the aims was to compare attitudes and

beliefs of HFE specialists across countries; however, there were not enough participants from each country to proceed with this analysis. All statistical tests and assumption checks were conducted using R Statistical Software Version 4.3.3 (R Core Team, 2025)

Role

The Kruskal-Wallis test was used to determine if there were differences in the overall back pain attitudes and beliefs of HFE specialists across different roles. Four roles were included in this analysis: researchers/academics, practitioners, students (including both Master's and PhD students), and those who selected multiple roles. Only participants with completed questionnaires, and those who selected one or more role were included in this analysis. The Kruskal-Wallis test was used because the data for each group failed to meet the assumptions of the one-way ANOVA (particularly normality and equal variance of each group). These assumptions were checked visually using a box plot (see Figure 17). The test was conducted with a significance level of 0.05 and the hypotheses for this statistical analysis were as follows:

Null hypothesis: There is no difference in the median Back-PAQ total scores of HFE specialists across different roles.

$$H0: M1 = M2$$

Alternative hypothesis: There is a difference in the median Back-PAQ total scores of HFE specialists across different roles.

$$H1: M1 \neq M2$$

After performing the Kruskal-Wallis test, the Dunn's post-hoc test with the Bonferroni correction was performed to determine where the significant differences were.

Council vs regular HFE specialists

The Welch two-sample t-test was used to determine if there was a significant difference between the back pain attitudes and beliefs of the IEA Council and the regular HFE specialists who responded to the questionnaire. Only participants with completed questionnaires were included in this analysis. The Welch two sample t-test was used for the following reasons: the assumptions of normality were checked

visually using a box plot and double checked using the Shapiro-Wilk test and it was established that both samples followed a normal distribution. While both samples displayed normality, the assumption of equal variance was tested visually and double checked using the Levene's test and this assumption was not met. Because both samples displayed normality, but the assumption of equal variance was not met and the samples differed in size, the most appropriate test to use was the Welch two sample t-test. While there is some controversy around running parametric tests for Likert data, many researchers state that this can be done particularly when using Likert total scores, if the assumptions are met (Sullivan & Artino, 2013). Several similar studies adopted this approach (Darlow et al., 2014; Nolan et al., 2018; Christe et al., 2021a, 2021b). The hypotheses and results from the assumption checks can be found in Appendix H.

The significance level for the Welch two sample t-test was 0.05 and the hypotheses were as follows:

Null hypothesis: There is no difference in the mean Back-PAQ total scores of the IEA Council and those of regular HFE specialists.

$$H_0: \bar{x}_1 = \bar{x}_2$$

Alternative hypothesis: There is a difference in the mean Back-PAQ total scores of the IEA Council and those of regular HFE specialists.

$$H_A: \bar{x}_1 \neq \bar{x}_2$$

Years of experience

As per the initial research questions proposed, one aim was to determine whether there was a relationship between years of experience and attitudes and beliefs about back pain, specifically aiming to determine if attitudes and beliefs about back pain are significantly influenced by HFE experience. The assumptions of the linear regression model and Pearson's correlation coefficient were tested using a scatterplot, and the assumptions were not met (a linear relationship was not demonstrated between the two variables). The assumptions of the Spearman's rank correlation coefficient test were also assessed using a scatterplot and the assumption of a monotonic relationship

between the two variables was not met. For these reasons, further statistical tests were not run.

CHAPTER 3: RESULTS

The purpose of this thesis was to investigate the back pain attitudes and beliefs of HFE specialists on a global scale. As stipulated in the previous chapter, an exploratory cross-sectional questionnaire-based design was adopted to achieve this aim. Furthermore, the Back Pain Attitudes Questionnaire (Back-PAQ) was used to gain a subjective understanding of the attitudes and beliefs that global HFE specialists hold about back pain. This chapter presents the findings of this study. The first subsection describes the response rate for the study, after which the demographic characteristics of the sample are presented. The descriptive statistics and frequency results are then displayed for each item of the Back-PAQ, and different themes are subsequently explored. Finally, this chapter reports the results of the analyses of HFE specialists' attitudes and beliefs across different roles, the comparison between the International Ergonomics Association's (IEA) Council and the rest of the sample, and presents the scatterplot examining Back-PAQ total score and HFE experience.

3.1 Response rate

The response rate from HFE specialists during both the International Ergonomics Association's 22nd Triennial Congress (IEA2024) and from federated and affiliated IEA societies was low, based on the minimum sample size calculated. According to the response analytics provided by the Zoho Survey platform, 495 people opened the questionnaire/visited the survey site and were able to read the information letter and gain an understanding of the study's purpose. Of those 495 people, six people did not provide consent to participate in the study, and 350 people left the survey site without providing consent. 139 people provided consent and initiated the questionnaire. 16 of those 139 people who consented to participate in the study did not complete anything further, and 13 people only completed the demographic information. The remaining 110 completed the demographic information and started completing the questionnaire. Of those 110, there were nine people who did not finish the questionnaire, seven of whom had fewer than 17 valid responses that could not be used for the calculation of total scores. Therefore, 101 participants had fully completed questionnaires that were used for all analyses.

The response rate from the IEA Council was higher. 38 out of 50 IEA Council members completed the questionnaire, providing a response rate of 76%. Of those 38 responses, 32 were fully completed, and six were partial but could still be used where fully completed questionnaires were not required (they all had more than 17 valid item responses, five with only one missing item response, and one with four missing item responses). Combining both the general HFE specialists and the IEA Council formed the entire sample of HFE specialists for this study, providing a total sample size of 148.

3.2 Participant characteristics

The demographic characteristics of this sample are presented in Table 2. Data were collected from HFE specialists from 27 countries. The highest percentage of respondents were practitioners (45.27%), closely followed by researchers/academics (44.59%). The smallest percentage of respondents were students (18.25%). HFE specialists were able to select multiple roles if applicable, providing a reason why the sum of these percentages is greater than 100. The participants in this study demonstrated a wide range in HFE experience, from 0 to 60 years. Overall, the mean years of experience within the sample was 18.14 ± 13.85.

Table 2. Demographic characteristics of the sample

Respondent characteristic	n (%)*
Country of operation	
Australia	37 (25.00)
South Africa	27 (18.24)
France	13 (8.78)
Republic of Korea	10 (6.76)
Philippines & Japan	6 (4.05)
United Kingdom	5 (3.38)
Germany, Canada, China & Brazil	4 (2.70)
India, Israel & Switzerland	3 (2.03)
United States of America, Malaysia & Columbia	2 (1.35)
Ecuador, Peru, Algeria, Argentina, Taiwan, Finland, Singapore, Italy, New Zealand, Hong Kong & Chile	1 (0.68)
Not stated	2 (1.35)
Role†	
Researcher/academic	66 (44.59)
Practitioner	67 (45.27)
PhD student	12 (8.11)
Master's student	15 (10.14)
Years of experience* (mean ± SD)	18.14 ± 13.85

*Unless otherwise stated

†Total equals more than 100% as respondents were able to select more than one role

Countries with the same number of respondents were included in the same line of the table

3.3 Descriptive statistics

For the entire sample, the mean total score for participants with at least 17 valid responses was 102.53 ± 19.73 (CV: 19.25%). The mean total score for participants with complete questionnaires was 102.29 ± 19.72 (CV: 19.27%). The high standard deviation and coefficient of variation show that there was variability in the total scores within the sample. Furthermore, total scores in the sample ranged from 54 to 146. Descriptive statistics were calculated for questionnaire items and themes for the entire sample, and the results are as follows:

3.3.1 Descriptive statistics for items

The descriptive statistics and frequency results were calculated for each item of the Back-PAQ. These findings are presented in Table 3

Table 3. Descriptive statistics and frequency results for each item of the Back-PAQ for the entire sample

Item	Theme	Mean (± SD)*	Percentage True † (95% CI)	Mode*	n
1. Your back is one of the strongest parts of your body	Vulnerability	3.65 (± 1.34)	65.31 (57.31 – 72.52)	5	147
2. Your back is well designed for the way you use it in daily life	Vulnerability	3.55 (± 1.43)	61.49 (53.45 – 68.94)	5	148
3. Bending your back is good for it	Vulnerability	3.30 (± 1.50)	56.85 (48.74 – 64.61)	4	146
4. Sitting is bad for your back	Vulnerability	3.23 (± 1.42)	54.42 (46.36 – 62.26)	4	147
5. Lifting without bending the knees is not safe for your back	Vulnerability	3.66 (± 1.49)	63.51 (55.51 – 70.84)	5	148
6. It is easy to injure your back	Vulnerability	3.62 (± 1.46)	66.22 (58.27 – 73.34)	5	148
7. It is important to have strong muscles to support your back	Protection	4.67 (± 0.75)	94.44 (89.42 – 97.16)	5	144

8. Good posture is important to protect your back	Protection	4.54 (± 0.81)	92.36 (86.84 – 95.68)	5	144
9. If you overuse your back, it will wear out	Vulnerability	3.51 (± 1.45)	61.81 (53.66 – 69.33)	5	144
10. If an activity or movement causes back pain, you should avoid it in the future	Protection	2.96 (± 1.42)	41.67 (33.93 – 48.83)	2	144
11. You could injure your back if you are not careful	Protection	4.22 (± 1.09)	83.33 (76.40 – 88.54)	5	144
12. You can injure your back and only become aware of the injury sometime later	Vulnerability	4.24 (± 1.12)	85.42 (78.73 – 90.25)	5	144
13. Back pain means that you have injured your back	Pain-injury	2.45 (± 1.37)	31.21 (24.14 – 39.27)	1	141
14. A twinge in your back can be the first sign of a serious injury	Vulnerability	3.38 (± 1.32)	62.86 (54.61 – 70.42)	4	140
15. Thoughts and feelings can influence the intensity of back pain	Pain-injury	4.35 (± 1.00)	85.82 (79.11 – 90.63)	5	141
16. Stress in your life (financial, work, relationship) can make back pain worse	Pain-injury	4.55 (± 0.82)	92.91 (87.44 – 96.10)	5	141
17. When you have back pain, you can do things which increase your pain without harming your back	Pain-injury	3.65 (± 1.36)	60.00 (51.72 – 67.74)	5	140
18. Having back pain makes it difficult to enjoy life	Special pain	4.34 (± 1.03)	87.86 (81.41 – 92.28)	5	140
19. It is worse to have pain in your back than in your arms or legs	Special pain	3.43 (± 1.44)	53.90 (45.68 – 61.92)	5	141
20. It is hard to understand what back pain is like if you have never had it yourself	Special pain	3.96 (± 1.17)	80.14 (72.80 – 85.89)	4	141
21. If your back hurts, you should take it easy until the pain goes away	Protection	2.95 (± 1.39)	46.81 (38.77 – 55.02)	4	141

22. If you ignore back pain you may cause damage to your back	Pain-injury	4.06 (± 1.20)	78.72 (71.25 – 84.67)	5	141
23. It is important to see a health professional when you have back pain	Special pain	4.18 (± 1.07)	83.57 (76.55 – 88.80)	5	140
24. To effectively treat back pain you have to know exactly what is wrong	Special pain	3.69 (± 1.48)	65.71 (57.53 – 73.06)	5	140
25. If you have back pain you should avoid exercise	Activity	1.79 (± 1.16)	12.06 (7.67 – 18.46)	1	141
26. If you have back pain the risks of vigorous exercise outweigh the benefits	Activity	3.03 (± 1.39)	40.00 (32.26 – 48.28)	3	140
27. If you have back pain you should try to stay active	Activity	4.21 (± 1.17)	81.56 (74.35 – 87.09)	5	141
28. Most back pain settles quickly, at least enough to get on with normal activities	Prognosis	3.63 (± 1.25)	61.87 (53.58 – 69.52)	4	139
29. Worrying about your back can delay recovery from back pain	Pain-injury	3.63 (± 1.28)	62.59 (54.31 – 70.19)	4	139
30. Focusing on things other than your back helps to recover from back pain	Pain-injury	3.45 (± 1.26)	58.27 (49.96 – 66.14)	4	139
31. Expecting your back pain to get better helps you to recover from back pain	Pain-injury	3.63 (± 1.23)	64.75 (56.51 – 72.20)	4	139
32. Once you have back pain there is always a weakness	Prognosis	2.54 (± 1.31)	32.37 (25.17 – 40.54)	1	139
33. There is a high chance than an episode of back pain will not resolve	Prognosis	2.47 (± 1.24)	28.06 (21.26 – 36.04)	1	139
34. Once you have a back problem, there is not a lot you can do about it	Prognosis	1.53 (± 0.98)	7.19 (3.95 – 12.74)	1	139

* 1.00='False', 3.00 = 'Unsure', '5.00' = True; this table represents raw scores not adjusted for question direction.

† Combined 'true' and 'possibly true' responses

Grey blocks represent reverse-scored items

Table 3

Table 3 provides an overview of the beliefs demonstrated by the sample through combined true and possibly true responses. This approach facilitated interpretation and allowed for comparison with other studies, as stated in the previous chapter (Darlow et al., 2014a; Pierobon et al., 2020). A more detailed overview of responses is provided in subsequent figures.

The sample displayed some negative attitudes and beliefs about the back and back pain. Most of the sample believed that strong muscles (94.44%; *item 7*) and good posture (92.36%; *item 8*) are required to support and protect the back. Most of the sample also believed that special care is required to avoid injury (83.33%; *item 11*), reporting that you can injure your back without being aware of it until later (85.42%; *item 12*). Furthermore, 87.86% of the sample subscribed to the belief that back pain makes life difficult to enjoy (*item 18*), and 80.14% believed that back pain is difficult to understand without firsthand experience (*item 20*). Most of the sample also reported that back pain requires the attention of a healthcare professional (83.57%; *item 23*) and similarly reported that ignoring back pain may result in damage (78.72%; *item 22*).

The sample did display some positive beliefs about back pain. Most of the sample agreed that back pain intensity can be influenced by thoughts, feelings (85.82%; *item 15*), and stress (92.91%; *item 16*). A small proportion subscribed to the negative belief that exercise should be avoided while experiencing back pain (12.06%; *item 25*), and most agreed that staying active is important while experiencing back pain (81.56%; *item 27)*. Furthermore, only a small proportion of the sample subscribed to the negative belief that not much can be done about a back problem once it is experienced (7.19%; *item 34*) and that an episode of back pain is not likely to resolve (28.06%; *item 33*).

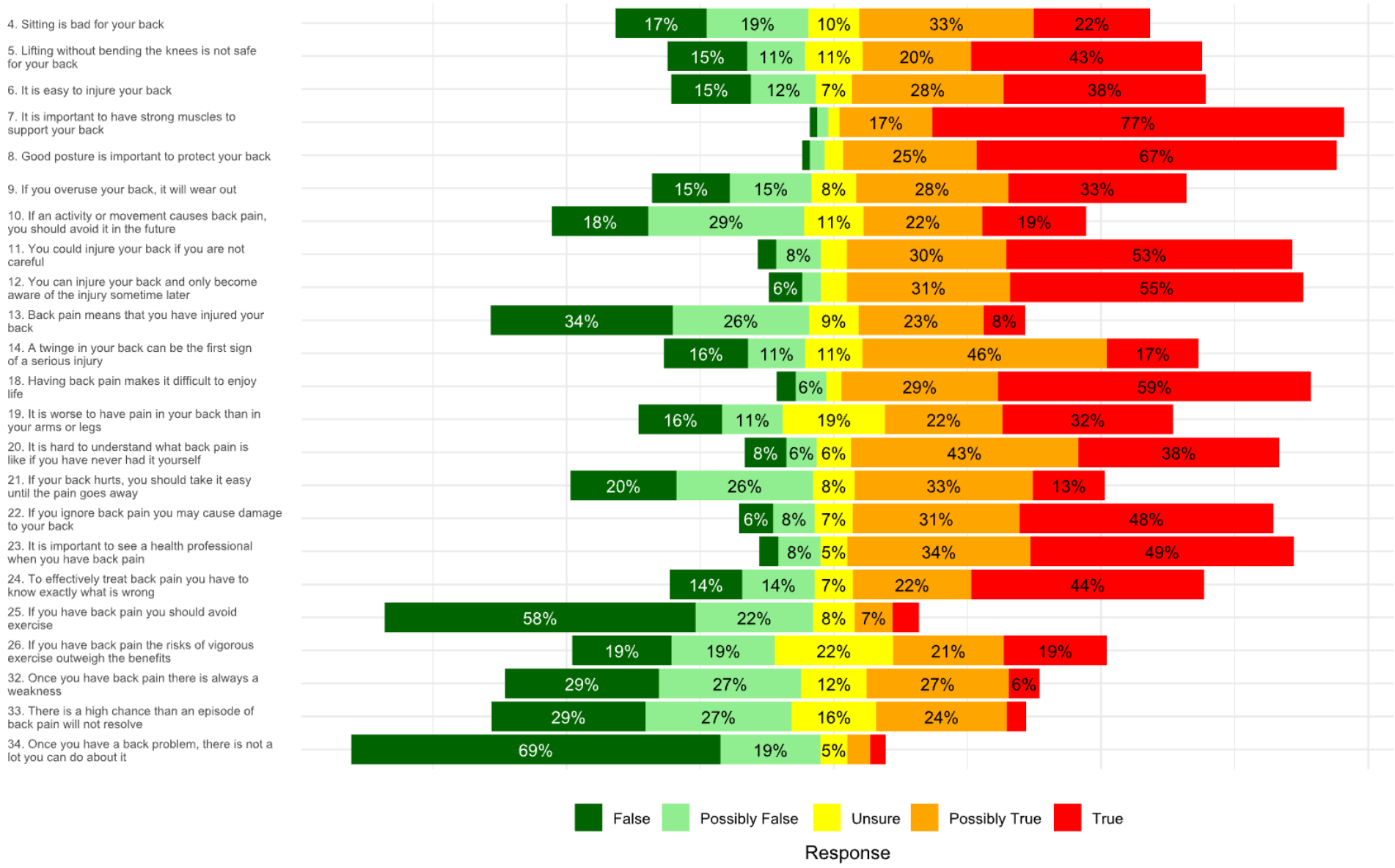

Figure 14. Frequency results for forward-scored items of the Back-PAQ

Figure 14 shows the frequency results for each forward-scored item of the Back-PAQ, providing a visual representation of the positive and negative beliefs held by the sample. In Figure 14, true and possibly true responses (shown in red and yellow) reflect negative attitudes and beliefs about back pain. Overall, this figure shows that the prevalence of negative attitudes and beliefs among the sample was widespread. Negative attitudes and beliefs about back pain were more common among the sample than positive ones across the forward-scored items, although some items had more variable responses.

The sample displayed some negative beliefs about the back and back pain. Some negative beliefs were held with more confidence or certainty, reflected by a larger proportion of true responses. A large proportion of the sample answered true when asked if strong muscles (77%; *item 7*) and good posture (67%; *item 8*) are required to support and protect the back, with 17% and 25% answering possibly true respectively. A large proportion of the sample also answered true (59%; *item 18*) when asked if back pain makes it difficult to enjoy life, with 29% answering possibly true. 55% of the sample answered true and 31% of the sample answered possibly true when asked if you could injure your back without being aware of the injury until later (*item 12*). A large proportion of the sample reported that care should be taken to avoid injuring the back (53% true), with 30% answering possibly true (*item 11*). Almost half of the sample also confidently believed that a healthcare professional is needed when back pain is experienced (49%), with 34% less confidently subscribing to this belief (*item 23*).

Some beliefs were held with less confidence, with a larger prevalence of possibly true responses. While for some items negative beliefs were held with less confidence, these are still problematic. Less confidence was shown when asked if a twinge in the back represents the first sign of serious injury as 46% of the sample answered possibly true and 17% answered true (*item 14*). Less certainty was also evident when asked if back pain is difficult to understand without firsthand experience, with 43% answering possibly true and 38% answering true (*item 20*).

The sample also displayed some positive beliefs about back pain as depicted in Figure 14. A large proportion of the sample answered false (58%) when asked if exercise should be avoided when experiencing back pain, and 22% answered possibly false

(*item 25*). 69% confidently disagreed that there is not a lot that you can do once you have a back problem and 19% less confidently disagreed with this statement (*item 34*).

For some items, responses were more spread showing more varied beliefs. Responses varied when asked if a painful movement should be avoided in the future (*item 10)*, if taking it easy is important until pain goes away (*item 21*) and if the risks of vigorous physical activity outweigh the benefits (*item 26*).

For most of the items, a small percentage of the sample provided unsure responses. The two items with the highest percentage of unsure responses were items 19 and 26. 19% of the sample answered unsure when asked if back pain is worse than pain in the extremities (*item 19*) and 22% answered unsure when asked if the risks of vigorous activity outweigh the benefits (*item 26*).

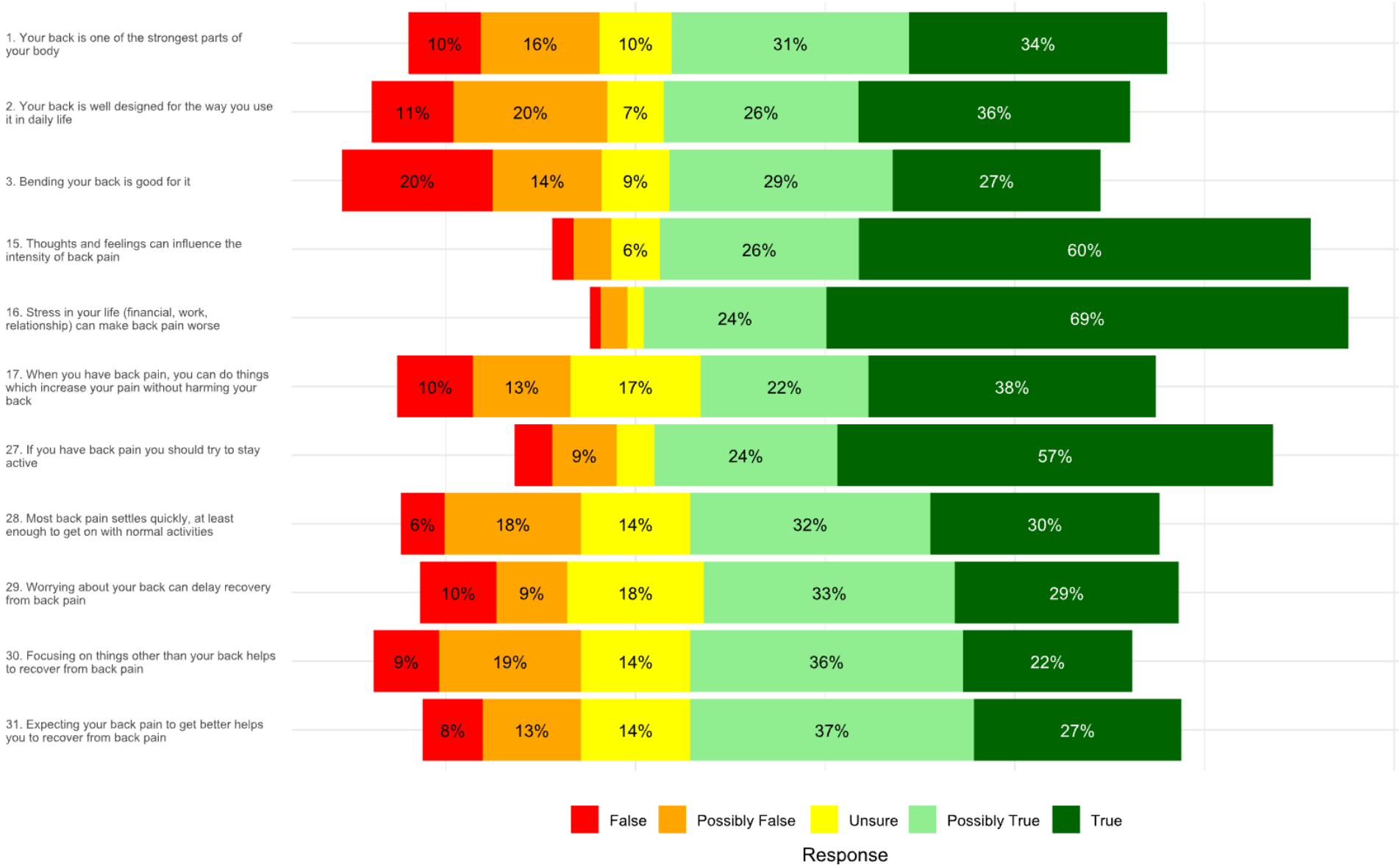

Figure 15. Frequency results for reverse-scored items of the Back-PAQ

Figure 15 shows the frequency results for each reverse-scored item of the Back-PAQ. This figure provides a visual representation of the positive and negative beliefs across reverse-scored items. Within these items, the positive attitudes and beliefs are represented by possibly true and true responses (shown in light green and green), and the negative attitudes and beliefs are represented by false and possibly false responses (shown in red and orange).

Positive attitudes and beliefs about back pain were common across reverse-scored items. 69% of the sample confidently believed that stress can worsen back pain experience, and 24% of the sample less confidently subscribed to this belief (*item 16*). 60% answered true and 26% answered possibly true when asked if thoughts and feelings can influence back pain intensity (*item 15*). Furthermore, 57% of the sample strongly believed that staying active during back pain episodes is important, with 24% less firmly subscribing to this belief (*item 27)*.

Some items had a larger frequency of possibly true responses, showing that these positive beliefs were held with less certainty. 36% answered possibly true when asked if focusing on other things helps back pain recovery, while only 22% firmly held this belief (*item 30*). Furthermore, 37% answered possibly true when asked if expecting the back to get better improves back pain recovery, and fewer (27%) answered possibly true (*item 31*).

A summary of the most widely held positive beliefs and the most widely held negative beliefs is provided in Table 4.

Table 4. Summary of most negative and most positive beliefs about back pain

Theme	Item		Mean (±SD) item score †
Ten most negative beliefs about back pain			
Protection	7	It is important to have strong muscles to support your back	4.67 (± 0.75)
Protection	8	Good posture is important to protect your back	4.54 (± 0.81)
Special pain	18	Having back pain makes it difficult to enjoy life	4.34 (± 1.03)
Vulnerability	12	You can injure your back and only become aware of the injury sometime later	4.24 (± 1.12)
Protection	11	You could injure your back if you are not careful	4.22 (± 1.09)
Special pain	23	It is important to see a health professional when you have back pain	4.18 (± 1.07)
Pain-injury	22	If you ignore back pain you may cause damage to your back	4.06 (± 1.20)
Special pain	20	It is hard to understand what back pain is like if you have never had it yourself	3.96 (± 1.17)
Special pain	24	To effectively treat back pain you have to know exactly what is wrong	3.69 (± 1.48)
Vulnerability	5	Lifting without bending the knees is not safe for the back	3.66 (± 1.49)
Ten most positive beliefs about back pain			
Pain-injury	16*	Stress in your life (financial, work, relationship) can make back pain worse	1.43 (± 0.79)
Prognosis	34	Once you have a back problem, there is not a lot you can do about it	1.53 (± 0.98)
Pain-injury	15*	Thoughts and feelings can influence the intensity of back pain	1.63 (± 0.98)
Activity	27*	If you have back pain you should try to stay active	1.77 (± 1.16)
Activity	25	If you have back pain you should avoid exercise	1.79 (± 1.16)
Pain-injury	17*	When you have back pain, you can do things which increase your pain without harming your back	2.35 (± 1.36)
Vulnerability	1*	Your back is one of the strongest parts of your body	2.35 (± 1.34)
Pain-injury	31*	Expecting your back pain to get better helps you to recover from back pain	2.37 (± 1.23)
Pain-injury	29	Worrying about your back can delay recovery from back pain	2.37 (± 1.28)
Prognosis	28	Most back pain settles quickly, at least enough to get on with normal activities	2.44 (± 1.27)

*Reverse-scored items; † corrected for question direction

Table 4 depicts the top ten most helpful and unhelpful beliefs demonstrated by the global HFE specialists in this study. The unhelpful beliefs held by HFE specialists in this study came from the themes relating to the need to protect the back, the vulnerability of the back and the special nature and impact of back pain. To summarise, this sample of HFE specialists believed that the back requires special care including good posture, strong muscles and the use of a specific lifting technique to avoid injury. Participants also believed that back pain required diagnosis and treatment from a healthcare professional, reporting that ignoring it may cause damage. Back pain was also perceived to be unique in both its nature and impact.

The results revealed that the HFE specialists in the study held positive beliefs relating to the relationship between pain and injury, the need to remain physically active while experiencing back pain, and the prognosis of back pain. The sample of HFE specialists believed that stress, thoughts, feelings, and expectations can influence back pain intensity, and that it is important to remain active and continue exercising while experiencing back pain. The sample also believed that the back is strong and that back pain mostly settles quickly.

3.3.2 Descriptive statistics for themes

Descriptive statistics were calculated for each theme of the Back-PAQ. The Back-PAQ consists of six main themes. These themes relate to the vulnerability of the back, the need to protect the back from injury, the relationship between pain and injury, the special nature and impact of back pain, the need to engage in physical activity while experiencing back pain, and the prognosis of back pain. The descriptive statistics for each summed theme score are provided in Table 5 while a visual representation of the trends across each theme based on item score is presented in Figure 16.

Table 5. Mean summed theme scores for the Back-PAQ

Theme	Mean theme score (±SD; range)	n
Vulnerability (range: 9 – 45)	29.13 (± 6.89; 12 – 42)	137
Protection (range: 5 – 25)	19.38 (± 3.55; 9 – 25)	141
Pain-injury (range: 8 – 40)	19.17 (± 5.79; 8 – 37)	138
Special pain (range: 5 – 25)	19.65 (± 4.06; 7 – 25)	139
Activity (range: 3 – 15)	6.60 (± 2.95; 3 – 15)	140
Prognosis (range: 4 – 20)	8.96 (± 3.25; 4 – 20)	139

These scores are corrected for question direction; n = number of participants

Higher scores indicate more unhelpful beliefs

Table 5 demonstrates the mean, standard deviation, and range for each summed theme score. The sample displayed high theme scores in the ‘vulnerability’ (29.13 ± 6.89), ‘protection’ (19.38 ± 3.55), and ‘special pain’ (19.65 ± 4.06) themes. Lower theme scores were demonstrated within the ‘activity’ (6.60 ± 2.95), ‘prognosis’ (8.96 ± 3.25), and ‘pain-injury’ (19.65 ± 4.06) themes.

The ranges provide the lowest and the highest theme scores demonstrated by the participants in the study, which can be compared to the minimum and maximum possible theme scores. The ranges provided indicate, alongside the standard deviations, that there was a fair amount of variability in beliefs within the sample across all themes.

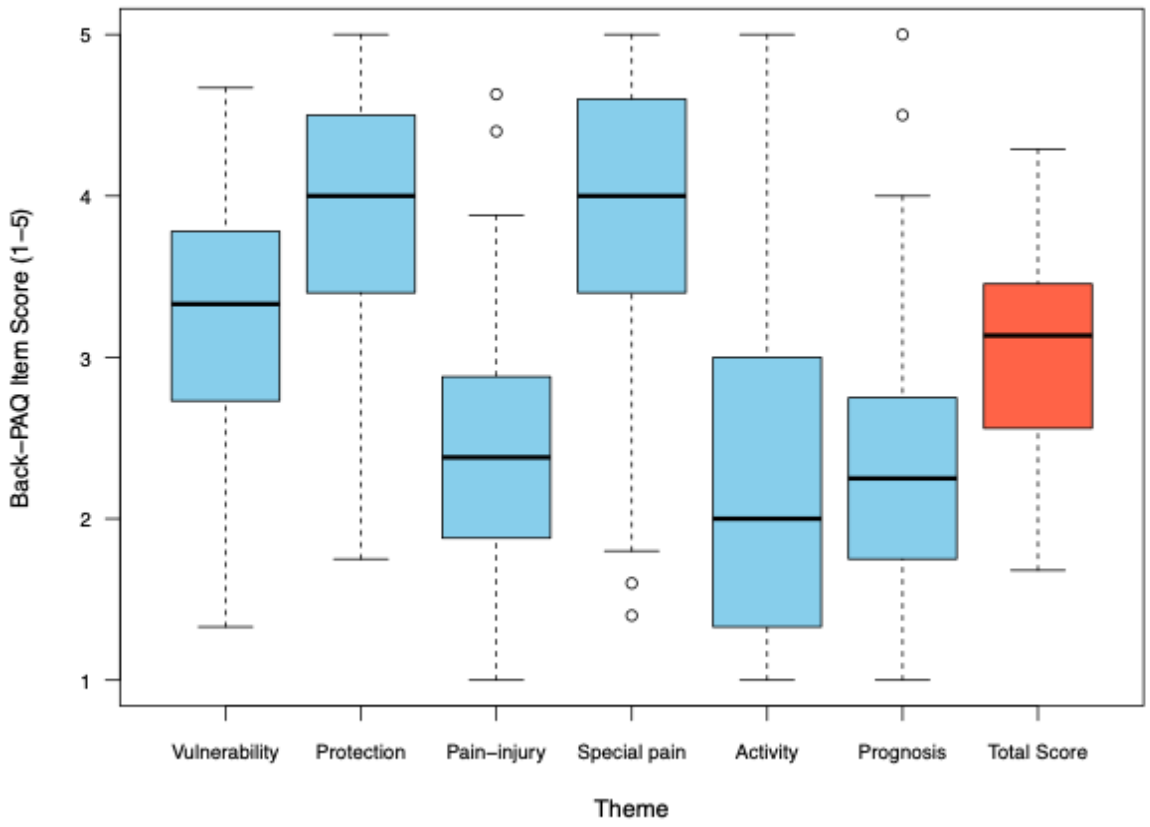

Figure 16. Back-PAQ total and theme scores

Boxplots are depicted in Figure 16, showing the median, upper quartile, lower quartile, range, and outliers for each theme of the Back-PAQ, based on the mean item score (from one to five). Figure 16 shows that the most negative attitudes and beliefs were found in the ‘protection’ theme, the ‘special pain’ theme, and the ‘vulnerability’ theme. The graph also illustrates that more positive beliefs were held within the ‘activity’, ‘pain-injury’ and ‘prognosis’ themes. However, as depicted by the interquartile ranges and whiskers of the plots, there was a large amount of variability within the responses within each theme, particularly for the ‘activity’ theme. The figure also shows some outliers within the ‘pain-injury’ theme, the ‘special pain’ theme, and the ‘prognosis’ theme, showing that some participants displayed either far more negative or positive attitudes and beliefs in those themes compared to the rest of the sample.

The box plot for ‘total score’ was moderate, with a slight negative skew. The positioning of the ‘total score’ box plot can be explained by the variability across and within themes.

3.4 Statistical analyses

3.4.1 Role

The Kruskal-Wallis test was conducted to determine whether there were differences in the median back pain attitudes and beliefs of HFE specialists across different roles. The assumptions for the Kruskal-Wallis test were checked using a box plot, and similar distributional shapes were demonstrated, as shown in Figure 17. The median total Back-PAQ score for practitioners was 99 (32.25), while for researchers/academics it was 112 (26.75), for students it was 104 (28.50), and for those with multiple roles it was 107 (32.00). The results for the Kruskal-Wallis test are as follows: $H(3) = 8.61$, $p = 0.035$. Because the p value was less than 0.05, the null hypothesis was rejected, and the alternative hypothesis was accepted. Therefore, these findings show that there was a significant difference in the back pain attitudes and beliefs of HFE specialists across roles, based on median total score. The Dunn’s post-hoc test with the Bonferroni correction was conducted to determine where the differences were (Table 6).

Table 6. Dunn's post-hoc test with the Bonferroni correction

	Multiple	Practitioner	Researcher/academic
Practitioner	1.000	-	-
Researcher/academic	1.000	0.022	-
Student	1.000	0.820	1.000

The results from the Dunn’s post-hoc test in Table 6 show that a significant difference was found between the median back pain attitudes and beliefs of researchers/academics and practitioners. As shown in Table 6, no other significant differences were found.

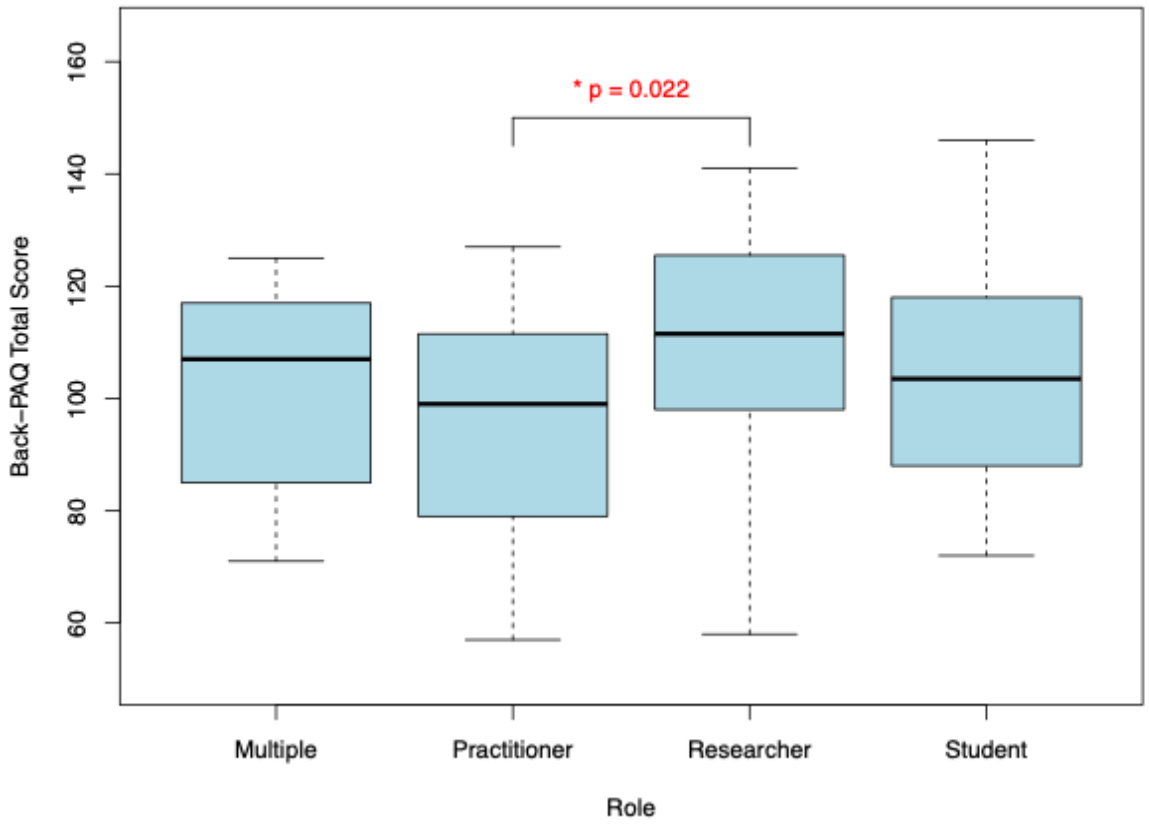

Figure 17. Comparison of Back-PAQ scores across roles

Figure 17 illustrates box plots for each role (median, lower quartile, upper quartile, and range). The p value for the Dunn's post hoc test is presented in Figure 17 in red, depicting the significant difference in median back pain attitudes and beliefs between practitioners and researchers/academics. As it appears in Figure 17, the distributional shapes for each group differ slightly but were still similar enough to run the Kruskal-Wallis and Dunn's post hoc test without violating the assumptions of the test. As illustrated in Figure 17, the median for the 'researcher' group was higher than that of the 'practitioner' group, showing a higher prevalence of unhelpful beliefs among researchers and academics. There 'researcher' group did, however, demonstrate a larger range in scores than the 'practitioner' group.

3.4.2 IEA Council vs regular HFE specialists

The Welch two sample t-test was used to determine if there was a difference between the back pain attitudes and beliefs (based on mean total Back-PAQ score) of those who form part of the IEA Council (n = 32) and the regular HFE specialists (n = 101) in this study. The results of the Welch two sample t-test are as follows: t (63.75) = 3.15, p = 0.002. The p value for the Welch two sample t-test was less than 0.05. The null hypothesis was therefore rejected, and the alternative hypothesis was accepted. These findings suggest a significant difference between the mean total Back-PAQ scores of the IEA Council and the regular HFE specialists who participated in this study, indicating a difference in overall attitudes and beliefs about back pain. The mean total score of the IEA council was higher (110.66 ± 16.20) than the mean total score of the regular HFE specialists (99.64 ± 20.06), reflecting a greater prevalence of unhelpful beliefs within the IEA Council.

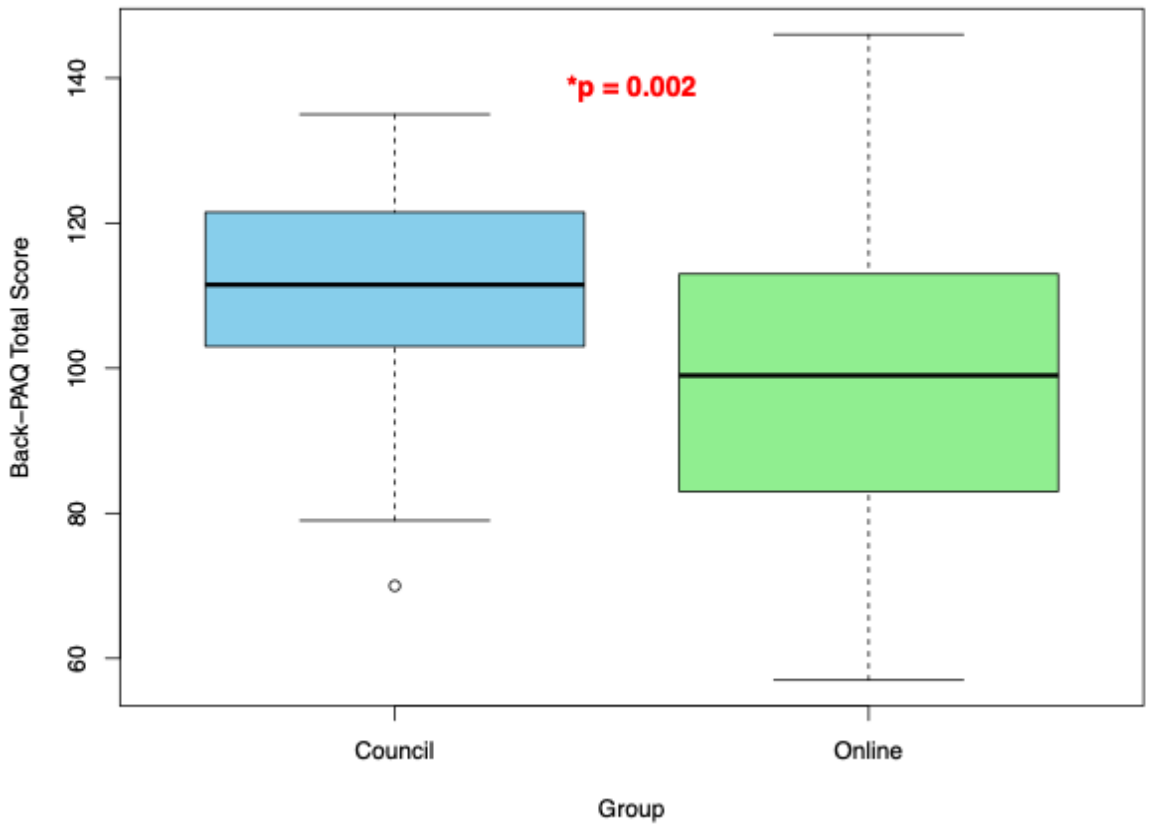

Figure 18. IEA Council and regular HFE specialists

Figure 18 illustrates the box plots (upper quartile, lower quartile, range, and outliers) for the IEA Council and for regular HFE specialists. The p value in red demonstrates that a significant difference was found between the mean total Back-PAQ score of the IEA Council and the regular HFE specialists in this study.

3.4.3 Years of experience

A scatterplot was used to visually assess the assumptions needed to statistically determine if years of HFE experience influence back pain attitudes and beliefs (reflected by total Back-PAQ score) as shown in Figure 19. The scatterplot determined that there was no clear linear or monotonic relationship between Back-PAQ total score and years of experience. Consequently, the statistical tests were not conducted, and no meaningful association was observed in this sample.

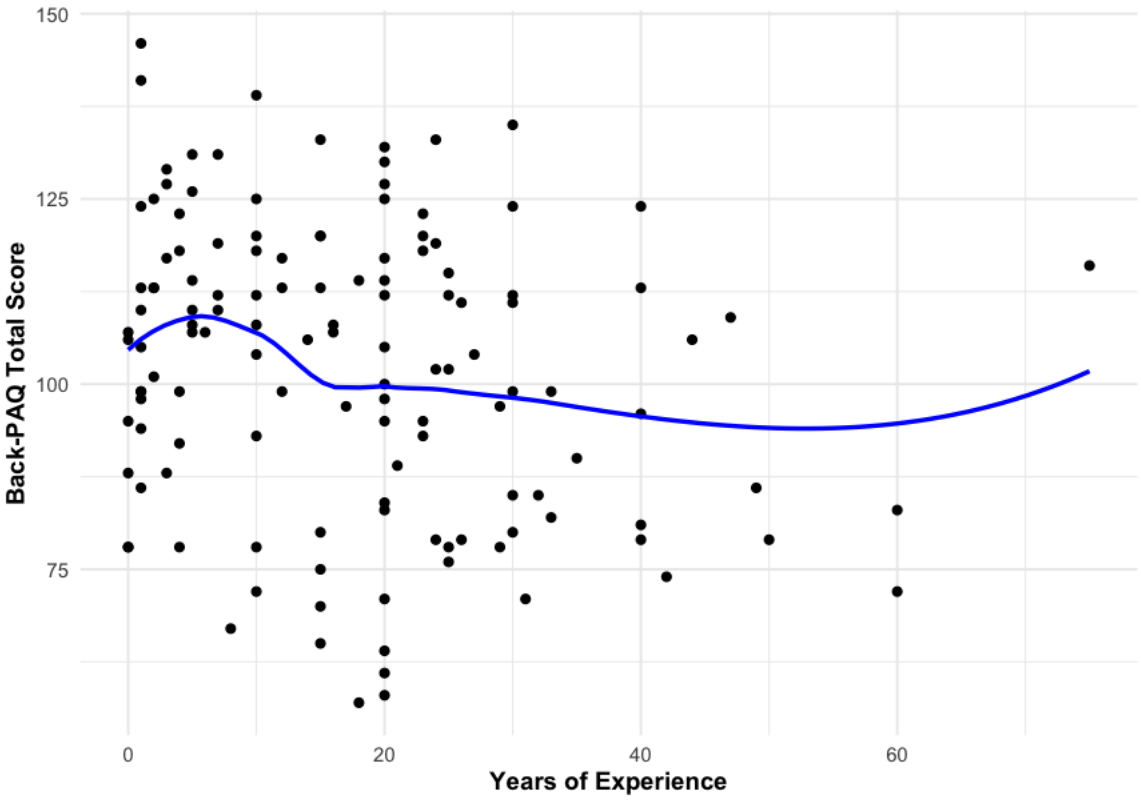

Figure 19. Relationship between Back-PAQ score and years of experience

Figure 19 illustrates the relationship between HFE experience and Back-PAQ total score, with a LOESS (locally estimated scatterplot smoothing) line. There was no clear visual association between HFE experience and back pain beliefs in this sample.

CHAPTER 4: DISCUSSION

The aim of this study was to explore back pain attitudes and beliefs of HFE specialists on a global scale. The purpose of this chapter is to discuss the findings of this study and contextualise these findings in terms of the broader literature. This chapter starts with a summary of the main findings, followed by an interpretations and implications section, and ends with a discussion on the strengths and the limitations of the study.

4.1 Summary of Main Findings

The sample of global HFE specialists demonstrated highly variable and inconsistent attitudes and beliefs about back pain. Within this sample, there were some unanimous positive and negative beliefs, but for many items, the responses were highly variable. The mean Back-PAQ score for the sample was 102.53 ± 19.73. The high standard deviation reflects the variability of beliefs across the sample. Overall, some of the frequently identified unhelpful beliefs within the sample raise concerns regarding how LBP is understood within HFE. The most prevalent negative attitudes and beliefs were related to the need to protect the back and the special nature and impact of back pain. The sample held some unhelpful and contradictory attitudes and beliefs relating to the vulnerability of the back. Contrastingly, the sample held some positive beliefs regarding the relationship between pain and injury, the need to remain physically active, and back pain prognosis. Some of the attitudes and beliefs found within this sample aligned with general populations (Darlow et al., 2014a; Pierobon et al., 2020; Christe et al., 2021a) and manual handling advisors (Nolan et al., 2018, 2019), but were more unhelpful than physiotherapists overall (Nolan et al., 2018, 2019; Christe et al., 2021b).

The back pain attitudes and beliefs in this study displayed both intra- and interindividual variability. Intraindividual variability was demonstrated as individual participants possessed both positive and negative beliefs across items. Interindividual variability was evident through the varied responses to specific items, with some responses reflecting positive beliefs, some reflecting negative beliefs, and some showing uncertainty. Furthermore, total scores ranged from 54 to 146, showing that some participants held largely positive beliefs while others held largely negative beliefs. The observed interindividual variability likely reflects the diverse backgrounds

of HFE specialists across different countries in this study, where differences in HFE practice (Koningsveld, 2019), as well as broader cultural and socioeconomic factors, may have influenced attitudes and beliefs (Suman et al., 2017; Buchbinder et al., 2018; Suhail & Poulter, 2022).

In terms of role, the results showed that there was a significant difference between the back pain attitudes and beliefs of researchers/academics and practitioners. Figure 17 shows a trend towards more negative beliefs among researchers/academics, with this group also demonstrating a greater range in scores. A significant difference was also found between the attitudes and beliefs of the IEA Council and the rest of the sample. Figure 18 shows that the IEA Council had higher scores overall but less variability in the scores than regular HFE specialists. The mean total score for the IEA Council (110.66 ± 16.20) was also higher than the mean total score for regular HFE specialists (99.64 ± 20.06), showing a higher prevalence of negative beliefs within the IEA Council. Furthermore, the results showed that there was no clear or consistent pattern between Back-PAQ total score and years of experience (Figure 19), suggesting that attitudes and beliefs were not visibly associated with HFE experience. Inferential analyses were not conducted, as the data failed to meet the assumptions of the appropriate tests. The potential reasons for these findings will be explored in a later section.

4.2 Interpretations and implications

This section explores the findings of this study by analysing the back pain attitudes and beliefs held by the sample of HFE specialists, interpreting their meaning, and situating them within the broader literature. The implications section then discusses the potential impact that the attitudes and beliefs identified may have on HFE practice, research, and education, including a discussion around how these beliefs might influence workers and play a role in shaping LBP risk in the workplace.

4.2.1 Back-PAQ total score

In this study, the back pain attitudes and beliefs were measured using the validated Back Pain Attitudes Questionnaire (Back-PAQ). Total scores were calculated from this

questionnaire providing a score between 34 – 170, with higher scores indicating more unhelpful beliefs.

Attitudes and beliefs about back pain have been previously explored using the Back-PAQ in various contexts (Darlow et al., 2014a; Nolan et al., 2018, 2019; Pierobon et al., 2020; Christe et al., 2021a, 2021b, 2021c) due to their role in the development and persistence of LBP and related disability (Urquhart et al., 2008; Linton & Shaw, 2011; Deliitto et al., 2012; Darlow, 2016; Bunzli et al., 2017; Ng et al., 2017; Estee et al., 2024). Back pain attitudes and beliefs have been investigated in both general populations (Darlow et al., 2014a; Pierobon et al., 2020; Christe et al., 2021a) and professional groups (Nolan et al., 2018, 2019; Christe et al., 2021b). This section compares the attitudes and beliefs of HFE specialists with the beliefs found in general population and professional groups based on the total Back-PAQ score to provide a general comparison with existing studies.

Attitudes and beliefs about back pain were assessed with the New Zealand (Darlow et al., 2014a), Argentine (Pierobon et al., 2020), and French-speaking Swiss (Christe et al., 2021a) general populations. The term ‘general population’ represents samples that include the general public rather than professionals. Back pain attitudes and beliefs have also frequently been explored among healthcare professionals involved in the management and treatment of LBP (Darlow et al., 2012; Gardner et al., 2017; Nolan et al., 2018, 2019; Christe et al., 2021b, 2021c), as well as among professionals who are involved in LBP prevention (Nolan et al., 2018, 2019).

The professionals included in this comparison are physiotherapists and manual handling advisors (Nolan et al., 2018, 2019; Christe et al., 2021b). Physiotherapists’ beliefs have been assessed due to the important role they play in managing LBP, particularly when it is non-specific, chronic, and disabling (Gardner et al., 2017; Nolan et al., 2018, 2019; Christe et al., 2021b). Manual handling advisors’ beliefs have been explored as they give advice, guidance, and training in manual handling contexts (OHSAS, n.d.), where LBP is common, and often provide advice regarding the risks associated with LBP (Nolan et al., 2018). Professionals’ recommendations and advice often reflect their own beliefs rather than the evidence-based clinical guidelines (Darlow et al., 2012; Gardner et al., 2017; Nolan et al., 2018, 2019; Christe et al.,

2021b; Caneiro et al., 2021), which can negatively influence the beliefs and behaviours of those receiving the advice (Darlow et al., 2012; Bunzli et al., 2017; Caneiro et al., 2021).

Table 7 depicts the mean Back-PAQ total score across several studies, including this one, to provide a general comparison of overall attitudes and beliefs about back pain. The HFE specialists in this study held more positive beliefs, as reflected by a lower Back-PAQ score, than the Argentine (Pierobon et al., 2020) and French-speaking Swiss (Christe et al., 2021a) general populations, as shown in Table 7. The mean total score for the New Zealand general population was not stated in the study and therefore could not be included in this comparison (Darlow et al., 2014a). The HFE specialists in this study demonstrated a tendency towards more negative beliefs compared to French-speaking Swiss physiotherapists (Christe et al., 2021b) and physiotherapists from multiple countries (Nolan et al., 2018), and held beliefs more aligned with manual handling advisors (Nolan et al., 2018).

Table 7. Comparing the Back-PAQ total scores across several studies

	Current study	General populations		Professionals		
Sample	HFE specialists	Argentine	French-speaking Swiss	French-speaking Swiss physiotherapists	Physiotherapists	Manual Handling advisors
Reference		Pierobon et al. (2020)	Christe et al. (2021a)	Christe et al. (2021b)	Nolan et al. (2018)	Nolan et al. (2019)
Country	Multiple countries	Argentina	Switzerland	Switzerland	Multiple countries	Multiple countries
Sample size	141	1092	1129	288	255	160
Back-PAQ score	**102.53 ± 19.73**	**111.7 ± 12.8**	**113 ± 10.6**	**82.7 ± 17.2**	**67.4 ± 18.6**	**101.3 ± 15.9**

The sample of HFE specialists demonstrated a tendency towards more helpful beliefs when compared with both the Argentine (Pierobon et al., 2020) and French-speaking Swiss (Christe et al., 2021a) general populations overall. However, HFE specialists

did display a higher standard deviation, suggesting that some HFE specialists may have held beliefs that were more comparable to or more negative than those observed in previous general population studies. While not all HFE specialists are directly involved in MSD risk management, according to the IEA Core competencies document, HFE specialists are expected to have a minimum understanding of all HFE areas (IEA, 2021). Basic HFE training, which should cover physical, cognitive, and organisational aspects of HFE (Bridger, 2012; Oakman et al., 2020; IEA, 2021), should therefore provide HFE specialists with knowledge about MSDs, including LBP, from a holistic perspective. However, there are several challenges that hinder HFE educational programmes at a tertiary level, which may result in gaps and inconsistencies in the education offered to HFE specialists (Oakman et al., 2020), providing a potential reason why some HFE specialists may hold similar or more unhelpful beliefs than these general populations. HFE educational programmes are frequently hindered by structural issues, low visibility and misunderstanding of HFE, global inconsistencies, content challenges, identity dilution with other disciplines, and accessibility, all of which hinder their sustainability (Oakman et al., 2020).

As depicted in Table 7, the HFE specialists in this study held more negative beliefs than both the French-speaking Swiss physiotherapists (Christe et al., 2021b) and physiotherapists from multiple countries (Nolan et al., 2018). This was a somewhat concerning finding because both HFE specialists and physiotherapists are trusted professionals who may interact with individuals at risk of or already experiencing LBP, with the potential to influence individuals' attitudes and beliefs about the back (Nolan et al., 2018, 2019; Caneiro et al., 2021; De Bruin et al., 2024). The higher prevalence of helpful beliefs among physiotherapists may be due to more tailored LBP education that is increasingly advocating for a biopsychosocial approach (Christe et al., 2021b, 2021c).

The Back-PAQ total score of the HFE specialists in this study was more aligned with the sample of manual handling advisors, as shown in Table 7 (Nolan et al., 2018), reflecting similar beliefs. Manual handling advisors provide advice, training, and expertise in manual handling contexts, typically drawing on ergonomic principles (Nolan et al., 2018, 2019; OHSAS, n.d.). In contrast, HFE specialists adopt a holistic systems approach to the design and management of work systems (IEA & ILO, 2021;

IEA, 2021), which may include, but is not limited to, assessing MSD risk and providing advice and recommendations to reduce this risk (Macdonald & Oakman, 2022). As such, while manual handling advisors have a narrower focus, both professionals can provide advice to workers to prevent musculoskeletal problems in the workplace.

Similar attitudes and beliefs between these groups are not entirely unexpected given the shared focus on preventing MSDs, although the scope and approach taken by these professional groups do differ. Contemporary HFE risk management frameworks have conceptually evolved beyond reductionist approaches (Oakman & Macdonald, 2019; Macdonald & Oakman, 2024), while manual handling guidelines (e.g., HSE, 2020; ILO, n.d.) and the advice provided by manual handling advisors remain rooted in biomechanical principles (Nolan et al., 2019). However, risk management practices and methods within HFE still have a predominant biomechanical focus despite the conceptual shift (Macdonald & Oakman, 2022, 2024), providing a potential reason for similar views. It is also important to note that given the broad scope of HFE (Caple, 2012) and the tendency for practitioners to work within specific domains of practice (Wilson, 2012; IEA & ILO, 2021; IEA, 2024c), it is plausible that not all the HFE practitioners in this study address LBP or musculoskeletal issues in their work and therefore may not influence workers' beliefs about back pain.

Unhelpful beliefs about the back and biomechanical explanations of back pain persist (Nolan et al., 2019) despite the evidence to support the complex and multifactorial nature of MSD development (Hauke et al., 2011; Macdonald & Oakman, 2022, 2024; Roquelaure, 2018). Manual handling advice tends to focus too heavily on physical risk factors, which can have a negative impact on workers' attitudes and beliefs about the back (Nolan et al., 2018, 2019). Physical advice and biomechanical explanations promote the view that the back is vulnerable, easy to injure, and that pain is associated with injury caused by the physical aspects of their jobs (Nolan et al., 2018, 2019), rather than a combination of interacting physical, psychosocial, and individual risk factors (Hauke et al., 2011; Roquelaure, 2016, 2018). The current biomechanical focus of manual handling advice may need to evolve to align with current evidence, as it may have potentially harmful impacts on workers' beliefs (Nolan et al., 2019). It is likely that a similar shift is required within HFE (Macdonald & Oakman, 2022).

The HFE specialists in this study displayed the highest standard deviation across all studies included in Table 7. The highly variable back pain attitudes and beliefs in this study may have occurred due to the broad range of countries from which the participants were recruited. The data in this study were collected from HFE specialists from 27 countries, where socioeconomic and cultural factors (Suman et al., 2017; Buchbinder et al., 2018; Suhail & Poulter, 2022), as well as global differences in HFE education and practice (Caple, 2012; Koningsveld, 2019), may have influenced attitudes and beliefs about back pain. HFE education and practice differ globally due to several reasons, including differences in the origin and development of HFE (Caple, 2012; Koningsveld, 2019; Barcellini et al., 2025), financial constraints (Caple, 2012; Bridger, 2012), and local needs (Bridger, 2012; Caple, 2012). Due to the low response rate, we were unable to determine how much of the variability in total score could be explained by the differences in country of operation. Some of the variation in total Back-PAQ score may have also occurred due to individual factors, including age and current experience of LBP (Christe et al., 2021b); however, these were not obtained in this study.

4.2.2 Themes of attitudes and beliefs

The following section explores the back pain attitudes and beliefs demonstrated by HFE specialists within each theme of the Back-PAQ. This section discusses the combined true and possibly true responses for the items within each theme, taken from Table 3, and provides a more in-depth understanding of the back pain attitudes and beliefs held by the HFE specialists in this study, including how they compare with existing studies.

Vulnerability

The sample of HFE specialists demonstrated some contradictory beliefs relating to the vulnerability of the back. A large proportion of the sample believed that the back is both strong (65.31%) and well designed for daily use (61.49%), yet also believe that the back is easy to injure (66.22%). Similar contradictory beliefs that the back is both strong and easy to injure were also demonstrated by the New Zealand, Argentine, and French-speaking Swiss general populations (Darlow et al., 2014a; Pierobon et al., 2020; Christe et al., 2021a), but were not widely reported among French-speaking Swiss physiotherapists (Christe et al., 2021b).

Unhelpful beliefs that the back is prone to injury are associated with the persistent messaging that the back needs protection (Darlow et al., 2013, 2015). Threatening messages that promote the view that the back is easy to injure can prompt people to understand back pain as a sign of injury or tissue damage (Bunzli et al., 2015; Darlow, 2016). Such beliefs are associated with greater levels of pain-related fear as well as other negative emotional and behavioural responses to pain (Bunzli et al., 2015, 2017; Caneiro et al., 2021).

Threatening messages can alter workers' perceptions and responses to their tasks, which may result in biochemical changes associated with enhanced pain sensitivity (Marras & Hancock, 2014). Furthermore, fear and distress from threatening messages can elicit stress responses (Bunzli et al., 2017), which, through physiological mechanisms, may contribute to increased MSD risk (Hauke et al., 2011; Roquelaure, 2018; Macdonald & Oakman, 2022). Such responses may increase the intensity of pain and the likelihood of developing persistent and disabling LBP (Urquhart et al., 2008; Ng et al., 2017; Caneiro et al., 2021; Estee et al., 2024). As such, addressing the unhelpful beliefs about the vulnerability of the back among HFE specialists is crucial to ensure that such beliefs are not reflected in the advice provided to workers.

HFE specialists should be cognisant of how messages that the back is easy to injure may be perceived by workers and how these messages may influence workers' beliefs and responses at work. HFE specialists may promote messages that the back is easy to injure unintentionally by using threatening language (Stewart & Loftus, 2018) or advice that focuses on what workers should avoid doing (Darlow et al., 2013). If the back is viewed as easy to injure, individuals may become fearful and experience distress when participating in tasks or activities that load the spine (Darlow et al., 2013, 2015).

A large proportion of the sample reported that stoop lifting is unsafe for the back (63.51%), but that bending the back is good for it (56.85%). This finding is also somewhat contradictory but may reflect the view that lifting loads in a stooped posture is not safe, but bending is fine. The belief that stoop lifting is not safe for the back was more widely reported among both the New Zealand (93.5%) and Argentine (87.3%)

general populations (Darlow et al., 2014a; Pierobon et al., 2020), as well as among a sample of physiotherapists (76%) and manual handling advisors (91%) (Nolan et al., 2018). Conversely, this belief was less commonly held among French-speaking Swiss physiotherapists, reported by just over half of this sample (Christe et al., 2021b). These findings suggest that while beliefs regarding safe lifting techniques vary across different groups, they remain important to address.

The unhelpful beliefs around safe lifting technique persist in this sample and in other professional groups (Nolan et al., 2018). As discussed in the review, the notion of a single, universally safe lifting technique is not well supported by evidence (von Arx et al., 2021; Straker, 2003; van der Have et al., 2019; Washmuth et al., 2022). Rather, safe lifting depends on multiple interacting factors that should be considered before offering advice (von Arx et al., 2021; Straker, 2003; van der Have et al., 2019; Washmuth et al., 2022). Furthermore, research provides limited support for lifting technique training as an effective preventative strategy for LBP (Martimo et al., 2008; Bigos et al., 2009; Verbeek et al., 2011, 2012; Kuijer et al., 2014). Moreover, such training may unintentionally reinforce unhelpful attitudes and beliefs about the vulnerability and need to protect the back (Nolan et al., 2019). These findings suggest that advice that favours a single safe lifting technique may need to evolve to align with current evidence (Nolan et al., 2019; Washmuth et al., 2022).

Just over half of the sample held the unhelpful belief that sitting is not good for the back (54.42%), despite evidence that sitting is not independently causative of LBP (Roffey et al., 2010a; O'Sullivan et al., 2013; Slater et al., 2019). Interestingly, this belief was less commonly reported by the New Zealand general population (42.7%), the Argentine general population (43.2%), and French-speaking Swiss physiotherapists (Darlow et al., 2014a; Pierobon et al., 2020; Christe et al., 2021b).

The variability in responses to the item related to sitting reflects the need to emphasise the current evidence around the relationship between sitting and LBP in this sample of HFE specialists. While prolonged sitting is recognised as a risk factor for LBP (Parreira et al., 2018), sitting is not inherently dangerous for the back (Slater et al., 2019). HFE specialists should therefore promote the benefits of active breaks throughout the day (Waongenngarm et al., 2021; Soares et al., 2023) without

advocating to workers that sitting is ‘bad’ for the back (Slater et al., 2019). These beliefs are unhelpful and may promote behaviours and responses that worsen the condition (Darlow et al., 2015; Slater et al., 2019). LBP is complex and influenced by many factors (O’Sullivan et al., 2016; Hartvigsen et al., 2018; Perreira et al., 2018), and threatening messages around sitting may promote fear and anxiety in workers who have more sedentary jobs (Slater et al., 2019).

A large proportion of the sample subscribed to the belief that overusing the back will lead to wear and tear (61.81%), a common back pain myth (Darlow, 2016; O’Sullivan et al., 2020). Most of the sample also believed that the back could become injured, with the impacts of the injury only becoming apparent later (85.42%). Due to the complexity of pain mechanisms, it is common for pain to occur in the absence of injury (Marras et al., 2016), as it does in non-specific LBP cases (Hartvigsen et al., 2018). The belief that you can injure your back without noticing is a scary concept that may promote constant vigilance (Darlow et al., 2015). Such beliefs are associated with increased threat perception, which may trigger unhelpful emotional and behavioural responses to pain (Darlow et al., 2015; Darlow, 2016; Bunzli et al., 2017)

A large proportion of the sample also believed that a twinge in the back may represent the initial sign of a serious injury (62.86%). The aforementioned belief reflects a biomedical understanding of LBP whereby a twinge (which may be only slightly painful if at all) is associated with the development of a serious injury; a problematic belief considering the large prevalence of non-specific LBP (Hartvigsen et al., 2018; O’Sullivan et al., 2020). Biomedical beliefs, like this one, reflect the need to educate HFE specialists regarding the current evidence and best practice for LBP (Hartvigsen, 2018; O’Sullivan et al., 2020). When noxious stimuli are associated with the start of a serious injury, perceptions of threat may increase, contributing to enhanced pain perception (Linton & Shaw, 2011; Moseley & Butler, 2015).

Unhelpful, inconsistent, and contradictory beliefs relating to the vulnerability of the back were frequently identified in the sample. Inconsistent and contradictory advice may have a negative impact on individuals’ representations of LBP, potentially leading to greater pain experience and disability (Bunzli et al., 2017; Caneiro et al., 2021). When the back is viewed as vulnerable and susceptible to injury, any experience of

pain may be perceived as a threat (Darlow et al., 2015). Vulnerability beliefs may reduce individuals' confidence and willingness to participate in work and daily activities, increasing the risk of disability (Darlow, 2016; Bunzli et al., 2017; Caneiro et al., 2021). Vulnerability beliefs should be addressed among HFE specialists to ensure that positive workplace messages are shared that promote confidence and self-efficacy in workers.

Protection

The sample displayed unhelpful beliefs relating to the need to protect the back from injury. Most of the sample believed that strong muscles (94.44%) and good posture (92.36%) are required for protection. Beliefs that special care is required to avoid injury are associated with beliefs that the back is easy to injure (Liew & Darlow, 2024), which were also frequently identified in this sample. Beliefs about the importance of good posture were also widely held by the New Zealand (98.7%) and Argentine (97.4%) general population (Darlow et al., 2014a; Pierobon et al., 2020), as well as by the French-speaking Swiss general population (Christe et al., 2021a) and French-speaking Swiss physiotherapists (Christe et al., 2021b). These findings demonstrate a need to develop widespread interventions to target protective beliefs.

As discussed in the review, there is limited evidence to support that poor posture independently causes LBP due to its highly variable nature (Claus et al., 2016; Schmidt et al., 2018; Slater et al., 2019; Korakakis et al., 2019). The advice that may stem from these types of beliefs (i.e., that certain postures are dangerous) may cause fear, anxiety, and lead to hypervigilance (Slater et al., 2019; Wernli et al., 2022), which may have negative impacts on individuals' pain experiences (Darlow, 2016; Caneiro et al., 2021). Due to the association between static postures and LBP (Parreira et al., 2018), it may be useful to encourage activity breaks, movement, and the exploration of different postures rather than strictly advising workers to maintain a neutral posture (Slater et al., 2019). HFE specialists should be mindful of how protective advice may be perceived by workers and focus on providing advice to workers using non-threatening language (Stewart & Loftus, 2018).

Most of the sample felt that care should be taken to avoid injury (83.33%). However, less than half believed that painful movements should be avoided (41.67%) and that

taking it easy is important until pain subsides (46.81%). These beliefs emphasise the need to move with care, a view similarly demonstrated by other professional populations (Nolan et al., 2018, 2019).

It is crucial, particularly within working contexts like manual materials handling, where strict protective mechanisms are often enforced, that advice promotes messages to "trust the back" rather than to "protect the back" (Nolan et al., 2019). Messages that the back requires protection may also reinforce existing beliefs that the back is vulnerable and easy to injure (Darlow et al., 2013). Protective advice can increase negative feelings associated with pain, including vigilance, worry, and guilt (Darlow et al., 2013). Advice to move cautiously may also reinforce negative beliefs and result in guarded movements (O'Sullivan et al., 2018; Nolan et al., 2019; Wernli et al., 2022), particularly if workers are already experiencing pain (Geisser et al., 2004). It is therefore crucial to alter protective beliefs among professionals to ensure that these beliefs do not translate into threatening protective advice.

Beliefs that the back requires special protection are still widespread, as seen within HFE specialists and other professional groups (Nolan et al., 2018, 2019; Christe et al., 2021b). Protective beliefs persist despite the lack of evidence that LBP is caused solely by physical factors, including lifting (Straker et al., 2003; Wai et al., 2010a; Saraceni et al., 2020), loading (De Bruin et al., 2024), and awkward postures (Roffey et al., 2010b) and despite the prevalence of non-specific LBP (Maher et al., 2017; Hartvigsen et al., 2018). Ergonomic risk assessment practices still rely on reductionist approaches that focus heavily on physical risk factors in isolation (Macdonald & Oakman, 2022, 2024), despite their limited effectiveness (Hartvigsen et al., 2005; Bigos et al., 2009; Driessen et al., 2010). The beliefs relating to vulnerability and protection within this sample of HFE specialists may not be entirely surprising considering the tendency to focus on physical factors within HFE practice (Macdonald & Oakman, 2022, 2024). The protective beliefs demonstrated by the sample reflect the need to educate HFE specialists on how protective advice might be perceived by workers and the impact this may have on workers' responses.

Pain-injury

The sample held mostly positive beliefs regarding the relationship between pain and injury. There was, however, a fair amount of variability within this theme, both within and across items. Attitudes and beliefs that relate to the relationship between pain and injury are extremely important due to the complex and multifactorial nature of LBP (O'Sullivan et al., 2016; Hartvigsen et al., 2018). Furthermore, pain science recognises the role of multiple interacting factors in pain perception and experience (Tracey & Mantyh, 2007; Latremoliere & Woolf, 2009; Moseley & Butler, 2015). Most LBP cases are non-specific in nature and emerge without an identifiable pathoanatomical cause, indicating that back pain mostly occurs without damage to the tissues (Atlas & Deyo, 2001; Krismer & van Tulder, 2007; Maher et al., 2017; Hartvigsen et al., 2018; Lund et al., 2020). An understanding of the complexity of LBP is therefore extremely important for HFE specialists involved in risk assessment, as this may influence how they choose to intervene and provide advice.

A small proportion of the sample reported that back pain reflects injury (31.21%), showing that most of the HFE specialists understand that pain is not always an accurate depiction of tissue damage. Within the New Zealand general population, the negative belief relating to back pain and injury was more widely held (56.5%), but within the Argentine general population, this belief was less widely held (26.5%) (Darlow et al., 2014a; Pierobon et al., 2020). These findings show an interesting difference in belief trends in different countries. The negative belief relating to pain and injury was also less widely held by French-speaking Swiss physiotherapists (6.6%), aligning with the finding that physiotherapists' beliefs were more helpful than HFE specialists overall.

Most of the sample displayed positive beliefs relating to the influence of psychological factors on pain experience, 85.82% of the sample agreed that thoughts and feelings can influence back pain intensity, and 92.91% of the sample agreed that stress can worsen back pain. The positive beliefs regarding the impact of psychological factors were less common among the New Zealand general population (Darlow et al., 2014) and more common among French-speaking Swiss physiotherapists (Christe et al., 2021b). These positive beliefs regarding the impact of psychological factors align with

the current evidence for LBP (Hartvigsen et al., 2018) and are likely to have a positive impact on the way that HFE specialists interact with workers, their choice of intervention, and the nature of the education provided to students.

Furthermore, a large proportion of the sample reported that it is possible to increase pain without harming the back (60.00%), yet most of the sample believed that ignoring back pain may cause damage (78.72%). This somewhat contradictory belief reflects that there may be a lingering concern that the source of the pain might be pathoanatomical and therefore should not be ignored. The beliefs that ignoring back pain may cause damage could be counteracted by educating the public and professionals about the prevalence of non-specific LBP, emphasising that most cases of LBP do not have a pathoanatomical cause (Hartvigsen et al., 2018). There may also be a need to educate HFE specialists on the red flag symptoms for LBP (e.g., fever, numbness, tingling, trauma and/or unexplained weight loss), although these should be interpreted with caution as individuals can have red flag symptoms in the absence of a serious pathology (Hartvigsen et al., 2018). Educating workers on the prevalence of non-specific LBP may also reduce the fear, stress, and negative thoughts associated with pain episodes (Darlow et al., 2015; O'Sullivan et al., 2016).

The sample of HFE specialists held largely positive beliefs regarding the impact of psychological factors on recovery. A large proportion of the sample reported that worrying can delay recovery (62.59%), and that expecting pain to get better (64.75%), and focusing on other things (58.27%) can improve recovery. Positive beliefs relating to the impact of psychological factors on recovery were less common among the New Zealand (Darlow et al., 2014a), Argentine (Pierobon et al., 2020), and French-speaking Swiss (Christe et al., 2021a) general populations, but were similar among French-speaking Swiss physiotherapists (Christe et al., 2021b). The positive beliefs relating to the impact of psychological factors on recovery should be widely emphasised among the general public and professionals due to their importance in influencing back pain outcomes (Iles et al., 2009; Main et al., 2010; Caneiro et al., 2021).

The previously discussed positive beliefs show that most HFE specialists are aware of the impact of psychological factors on pain experience and recovery. There is,

however, still a need to ensure that HFE specialists within different contexts are aligned regarding the relationship between pain and injury. While many of the HFE specialists in this study demonstrated an understanding of the multifactorial nature of LBP, protective beliefs persist. The persistence of protective beliefs may be due to the biomechanical history of ergonomics (Pope et al., 2002) and the tendency to focus on the physical factors within practice (Whysall et al., 2004; Macdonald & Oakman, 2022), despite advocating for a holistic systems approach. While the role of the HFE specialist is to promote well-being and performance by reducing the risk of injury, it is crucial to be reflective and aware of how protective advice may influence workers' perceptions and behaviours in the workplace.

Special nature and impact of pain

The HFE specialists in this study displayed predominantly negative beliefs about the special nature and impact of back pain. The HFE specialists in this study believed that back pain is unique in nature and impact, requiring special attention from a healthcare professional to diagnose and treat. These beliefs, which do not align with the current evidence and best practice for LBP (Foster et al., 2018), were also frequently identified within general populations (Darlow et al., 2014a; Pierobon et al., 2020; Christe et al., 2021a).

Most of the sample held unhelpful beliefs that back pain is unique in nature and impact: most believed that back pain makes life difficult to enjoy (87.86%), half believed that it is worse than pain in the extremities (53.90%), and most believed that it is difficult to understand without firsthand experience (80.14%). These beliefs are somewhat contradictory because while only half believe that back pain is worse than other types of pain, most believe that it is hard to understand without experiencing it. While most might not view it as worse, it is viewed as unique and different from other types of pain. Individuals often view LBP as unique, as it is perceived to reflect damage to one of the most important and central structures of the body that is needed for everyday life (Darlow, 2016). Such beliefs may lead people to catastrophise and worry when it is experienced (Bunzli et al., 2017; Darlow, 2016). These beliefs are problematic as most people will experience LBP at some point but only few cases reflect an underlying pathology or damage to the tissues (Atlas & Deyo, 2001; Hartvigsen et al., 2018).

The belief that back pain negatively impacts the ability to enjoy life is common (Darlow et al, 2014a) and promotes low pain self-efficacy (Darlow, 2016). Society does not typically cope well with pain (Buchbinder et al., 2018). According to Mannix (2023, p. 66): “Indeed, our society as a whole does not handle pain very well. We avoid it at all costs. We hide from it with drugs. We *fear* it. That may be why we’re so bad at handling what is a normal part of life”. There is a general need for society to learn to better manage and cope with pain (Buchbinder et al., 2018). The tendency to catastrophise LBP stems from society's deep-rooted culture that views pain as a reflection of damage rather than a normal part of the human experience (Moseley & Butler, 2015; Buchbinder et al., 2018; Mannix, 2023; Pate, 2025). For example, Moseley & Butler (2015, p. 808) state that “pain is unavoidable – suffering is not”, further emphasising the need to change the way society understands and manages pain (Moseley & Butler, 2015; Buchbinder et al., 2018).

Most of the sample also believed that a healthcare professional must be consulted when experiencing back pain (83.57%), and a large proportion believed that effective treatment requires a diagnosis (65.71%). Such beliefs contradict the current evidence and best practice for LBP which highlight that most LBP cases are non-specific and are therefore best approached using self-management techniques, including exercise and education (Delitto et al., 2012; Foster et al., 2018). Beliefs relating to the need for healthcare interventions were common among general populations (Darlow et al., 2014a; Pierobon et al., 2020; Christe et al., 2021a) but less widely held by French-speaking Swiss physiotherapists (Christe et al., 2021b).

In this sample, widely held beliefs regarding the need for medical intervention may translate to an overreliance on passive low-value treatments commonly provided for LBP in healthcare settings (Foster et al., 2018; Buchbinder et al., 2018). The tendency for HFE specialists to align with beliefs that emphasise the need for medical intervention may be influenced by the fact that ruling out a specific pathology is beyond the scope of HFE (Kocks et al., 2024). Additionally, HFE specialists are required to report employees who are experiencing work-related pain for further medical surveillance or evaluation by a healthcare professional (Kocks et al., 2024), providing another potential reason why HFE specialists’ beliefs align with the need for medical intervention.

HFE specialists are, however, well positioned to influence communication and workplace culture towards LBP, ensuring that workers' expectations are managed before they enter healthcare settings (Buchbinder et al., 2018). HFE specialists and other stakeholders should therefore promote positive back pain messages in the workplace and educate workers about the evidence-based guidelines to prevent workers from entering clinical pathways with misconceptions or biomedical care expectations (Bunzli et al., 2017; Buchbinder et al., 2018; Lim et al., 2019). Positive health messages should focus on debunking common myths and misconceptions about back pain and encourage open lines of communication where workers can report their pain and receive the necessary support (Buchbinder et al., 2018). In this way, HFE specialists can contribute to the prevention of LBP persistence and related disability that is frequently exacerbated by unhelpful clinical experiences and non-evidence-based care (Bunzli et al., 2017; Buchbinder et al., 2018; Lim et al., 2019; Caneiro et al., 2021). Such an approach to prevent LBP-related disability is in accordance with global public health challenges for LBP (Buchbinder et al., 2018).

Activity participation

The sample of HFE specialists displayed positive beliefs about engaging in physical activity while experiencing back pain, although there was less agreement around the levels of physical activity that are appropriate. A very small proportion of the sample believed that exercise should be avoided during back pain episodes (12.06%), and most agreed that it is important to stay active (81.56%). The beliefs around activity held by the HFE specialists in this study align with the current evidence and best practice for LBP (Foster et al., 2018).

Despite the consensus around the importance of remaining physically active, the responses for the item relating to the risks of vigorous activity were more varied. This finding suggests that there is some discourse around the levels of physical activity that are appropriate during back pain episodes. Similar views regarding the importance of physical activity, alongside uncertainty about the levels of activity that are safe, were found in general population studies (Darlow et al., 2014a; Pierobon et al., 2020; Christe et al., 2021b). Manual handling advisors likewise advocated for the need to remain active, but carefully (Nolan et al., 2019). As such, there may be a need for

guidelines and recommendations relating to how to stay active during episodes of back pain (Nolan et al., 2019).

Prognosis

The sample of HFE specialists displayed positive beliefs about back pain prognosis. A large proportion of the sample believed that back pain episodes typically resolve quickly (61.87%), and few believed they are unlikely to resolve (28.08%). The responses to these items were, however, more varied. Furthermore, a small proportion of participants reported that a weakness will persist after an episode of back pain (32.37%) and that there is not much that can be done about a back problem (7.19%). Similar positive beliefs regarding prognosis were demonstrated by some general populations (Darlow et al., 2014a; Christe et al., 2021b) and tended to be more positive among physiotherapists (Nolan et al., 2019; Christe et al., 2021b). Such beliefs reflect the current LBP evidence (Foster et al., 2018).

The largely positive beliefs about the favourable prognosis of LBP are encouraging, but the variability in some responses suggests that these positive views should be emphasised. Uncertainty about prognosis can influence how HFE specialists communicate with workers, potentially shaping their expectations and recovery trajectories. Given that pessimistic beliefs about back pain prognosis contribute to unnecessary care-seeking and greater disability (Buchbinder et al., 2018), ensuring that HFE specialists hold and promote positive messages about prognosis is crucial in working contexts where LBP-related disability commonly impacts workers (Hartvigsen et al., 2018).

Comparison of theme scores with other studies

The different scores across each theme can be used to further compare the attitudes and beliefs of the HFE specialists in this study with other professionals. Table 8 reveals that the attitudes and beliefs of HFE specialists in this study were more unhelpful than those of physiotherapists across all themes (Nolan et al., 2019), as illustrated by the higher theme scores. On the other hand, the attitudes and beliefs of HFE specialists were more aligned with those demonstrated by manual handling advisors across themes (Nolan et al., 2019). As previously discussed, similar beliefs among HFE specialists and manual handling advisors are not entirely surprising because both

professional groups focus on the prevention of musculoskeletal problems in the workplace (Nolan et al., 2018, 2019). These findings show that while a holistic approach may be advocated for within HFE, such an approach may not be as widely adopted in practice (Macdonald & Oakman, 2015, 2022; De Bruin et al., 2024).

Table 8. Mean theme score and standard deviation compared with physiotherapists and manual handling advisors from Nolan et al. (2019)

	Mean theme score (± SD)		
Theme	**Current study HFE specialists**	**Manual Handling advisors**	**Physiotherapists**
Vulnerability **(Range: 9 – 45)**	29.12 (± 6.88)	30.7 (± 6.14)	18.6 (± 7.59)
Protection **(Range: 5 – 25)**	19.38 (± 3.55)	19.5 (± 2.94)	13.6 (± 4.66)
Pain-injury **(Range: 8 – 40)**	19.17 (± 5.79)	17.8 (± 4.22)	11.2 (± 3.49)
Nature-impact **(Range: 5 – 25)**	19.65 (± 4.06)	18.5 (± 4.06)	14.2 (± 1.42)
Activity **(Range: 3 – 15)**	6.60 (± 2.95)	5.63 (± 1.75)	4.25 (± 1.42)
Prognosis **(Range: 4 – 20)**	8.96 (± 3.25)	9.10 (± 2.78)	5.55 (± 2.12)

The prevalence of negative beliefs among those involved in providing advice about LBP in the workplace highlights the need to educate HFE specialists and manual handling advisors on the current evidence and best practice for LBP, along with other workplace stakeholders (Nolan et al., 2019). In some cases, workplace management may only implement physical recommendations (Whysall et al., 2004), potentially because they are more tangible and easier to implement than psychosocial recommendations (Oakman et al., 2019b). Management may also lack the knowledge necessary to deal with stress-related or psychosocial problems because such issues are not viewed as a priority (Oakman et al., 2019b). This highlights the need to convince all workplace stakeholders of the value of adopting a holistic systems approach (Roquelaure, 2016; Macdonald & Oakman, 2022).

While HFE advocates for a holistic systems approach (IEA & ILO, 2021; IEA, 2021), implementing this approach in practice is difficult without the buy-in of company stakeholders who may perceive and expect HFE to deal with biomechanical risk factors (Macdonald & Oakman, 2022). Until such a time that the beliefs of all company stakeholders are aligned, implementing a holistic approach that acknowledges all relevant risk factors, and the interactions between them, will be challenged (Macdonald & Oakman, 2015; Roquelaure, 2016; Nolan et al., 2019). Overall, a shift in workplace culture and messaging is required that promotes the multifactorial nature of MSDs like LBP (Oakman et al., 2019b). Such a shift may require public health campaigns that target the well-established biomedical beliefs held by society at large (Buchbinder et al., 2018; Nolan et al., 2019).

Contradictory attitudes and beliefs

The HFE specialists in this study demonstrated positive, negative, and contradictory beliefs about back pain, which have been explored. Many of the beliefs demonstrated by the HFE specialists in this study did not align with one another within the sample of HFE specialists (Figure 20). It is important to explore possible reasons for these misalignments in beliefs, as they may shape how MSDs like LBP are handled in practice and could lead to inconsistent or contradictory messages being communicated to workers.

Some of the attitudes and beliefs, including beliefs that the back is easy to injure, require protection (good posture, strong muscles, lifting technique and special care), and beliefs that back pain requires diagnosis and treatment from a healthcare professional, reflect a biomedical understanding of back pain as depicted in red (Figure 20). Negative beliefs were then paired with positive beliefs that contradicted the traditional biomedical view and acknowledged the role of psychological factors in pain experience and recovery, reflecting a more biopsychosocial understanding (Figure 20).

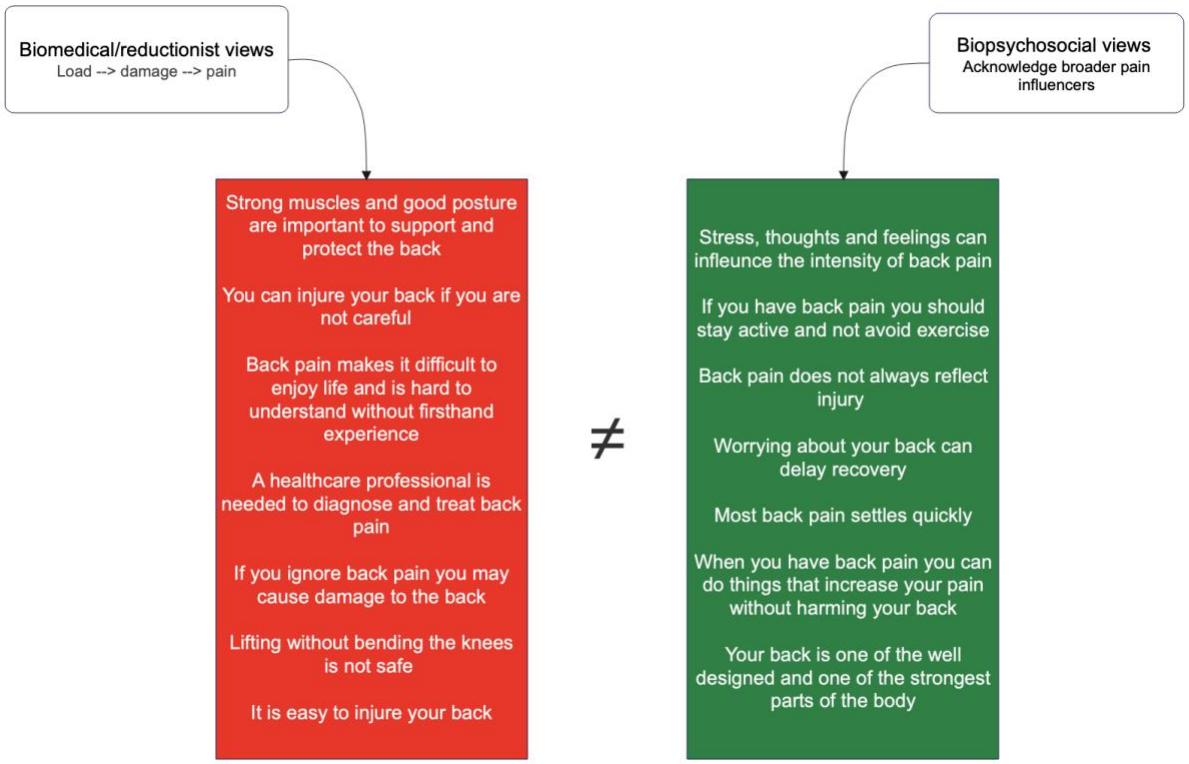

Figure 20. Misalignment between unhelpful and helpful beliefs

The illustrated contradictory beliefs show that the HFE specialists in this study may understand the biopsychosocial model but apply it in a fragmented manner. The fragmented application of the biopsychosocial model is common within clinical practice and acknowledges the biological, psychological and social factors without considering how these interact with one another (Stilwell & Harman, 2019; Rocca & Anjum, 2020; Mescouto et al., 2022). Within HFE, this fragmented application may be in part due to the philosophical underpinning (ontology) or foundation of traditional HFE, which was largely reductionist (Wilkin, 2010; Dekker et al., 2013; Thatcher et al., 2019). These findings suggest that although HFE specialists acknowledge the range of different factors that influence LBP, they still tend to default to biomechanically oriented beliefs. Such contradictions indicate that the challenge may not lie in their theoretical understanding of the biopsychosocial model or related holistic systems approaches, but rather in translating these frameworks into practice. This challenge is reflected by the ongoing biomechanical emphasis that continues to dominate MSD practice (Macdonald & Oakman, 2022, 2024).

The role of HFE specialists in preventing MSDs and injuries may contribute to a tendency to align with protective beliefs, as MSD prevention strategies are often biomechanical (Macdonald & Oakman, 2022; De Bruin et al., 2024). Biomechanical risk factors are often associated with increased risk of LBP onset (Maher et al., 2017; Parreira et al., 2018; Hartvigsen et al., 2018) and are associated with increased risk of injury (Roquelaure, 2018). However, these physical risk factors interact with psychosocial risk factors and cannot be controlled or viewed in isolation (Hauke et al., 2011; Macdonald & Oakman, 2015, 2022; Roquelaure, 2018). Furthermore, psychological factors are associated with persistent pain and disability and are crucial to consider when reducing risk in the workplace (Nicholas et al., 2011; De Bruin et al., 2024). Ultimately, there needs to be a careful balance in ensuring that physical risk factors in the workplace are reduced while also ensuring that the measures to limit exposure to physical risk factors do not have a negative impact on workers perceptions, responses and behaviours.

It is unlikely that HFE specialists can prevent workers from experiencing any kind of back pain due to the multifactorial risk factors both at work and beyond that contribute to LBP onset (O'Sullivan et al., 2018; Parreira et al., 2018; Roquelaure, 2018). HFE specialists can, however, play a preventative role by positively influencing how workers respond to experiences of LBP, thereby reducing the risk of developing persistent pain and disability (Bunzli et al., 2017; O'Sullivan et al., 2018; Roquelaure, 2018; Caneiro et al., 2021). HFE specialists therefore need to be aware of language use (Stewart & Loftus, 2018; Caneiro et al., 2021) and how advice and recommendations relating to physical risk factors are communicated to workers.

4.2.3 Role

This study aimed to determine if there were differences in back pain attitudes and beliefs across HFE specialists with different roles, looking specifically at researchers/academics, practitioners, students (both Master's and PhD) ,and those with multiple roles. A significant difference was found between the attitudes and beliefs of researchers/academics and those of practitioners (based on median total Back-PAQ score). Figure 17 demonstrates that the group of researchers and academics had higher total Back-PAQ scores than practitioners, indicating the prevalence of more unhelpful beliefs overall.

The tendency towards more unhelpful beliefs among researchers and academics is surprising in light of the typical evidence-practice gap for LBP (Foster et al., 2018). Due to the tendency to value an outdated biomedical model of care within LBP treatment (Foster et al., 2018; Buchbinder et al., 2018), as well as the inclination to focus on physical factors during risk management in HFE (Macdonald & Oakman, 2015, 2022), it was expected that the attitudes and beliefs of researchers and academics would be more positive. There was some expectation that HFE researchers and academics would have greater exposure to the current evidence and best practice for LBP through research and education, translating into more positive beliefs. However, evidence within physiotherapy shows that those with greater exposure to individuals experiencing LBP in practice settings have a better understanding of the LBP evidence and more helpful beliefs (Christe et al., 2021b). The attitudes and beliefs of researchers/academics may have been influenced by educational context in which they were trained or the current context in which they teach. If content historically emphasised biomechanical or structural explanations of LBP, and challenges and constraints are in place limiting curriculum development, this may have contributed to more unhelpful beliefs compared with those who engage with workers experiencing pain in practical settings.

HFE practitioners are often only consulted after the problem has occurred (Whysall et al., 2004) and may also be exposed to workers experiencing LBP, potentially translating to a better understanding of the guidelines. Some practitioners have voiced that they understand the complexity of musculoskeletal disorders but are faced with several barriers to implementing this approach in practice (Whysall et al., 2004). These are possible reasons why practitioners demonstrated more helpful beliefs than researchers/academics overall. It is, however, important to note that researchers/academics, practitioners, and students all demonstrated variability in the total Back-PAQ score, reflecting the need to address beliefs and attitudes across all roles.

4.2.4 Years of experience

This study initially aimed to determine if experience within HFE influences attitudes and beliefs about back pain. The results from this study showed that there was no

clear or consistent relationship between attitudes and beliefs and years of experience within HFE, as illustrated in Figure 19. This finding did not align with the study conducted with French-speaking Swiss physiotherapists (Christe et al., 2021b), where experience within physiotherapy was significantly associated with Back-PAQ total score (Christe et al., 2021b). In another study, Nolan et al. (2018) found no significant association between years of manual handling and physiotherapy experience and choice of lifting technique but did not look for an association between years of experience and Back-PAQ score. It is unclear why there was no clear visible pattern or association between years of HFE experience and total Back-PAQ score, although this may have been due to the variability in country of operation. Future studies should look at the impact of HFE experience on attitudes and beliefs about back pain in samples of HFE specialists from the same country.

4.2.5 IEA Council

This study investigated the back pain attitudes and beliefs of the IEA Council as a subset of HFE specialists included in this study. The IEA represents the global network of federated HFE societies and is responsible for developing and sharing HFE research, education, and practice globally (Caple, 2012; Koningsveld, 2019). The IEA Council is the governing body of the IEA and plays an important role in shaping the global HFE climate. A significant difference was found between the attitudes and beliefs of the IEA Council and those of general HFE specialists in this study. The results also showed that the IEA Council had a higher mean total score (110.66 ± 16.20) than the general HFE specialists (99.64 ± 20.06) in this study, indicating the prevalence of more unhelpful beliefs within the Council overall.

The higher prevalence of unhelpful beliefs about back pain within the IEA Council was a surprising yet important finding. It is crucial that the governing body of the IEA holds evidence-based attitudes and beliefs about back pain. The attitudes and beliefs of the IEA Council may have a downstream influence on the beliefs of different professionals within the societies and organisations led by IEA Council members. Furthermore, these unhelpful attitudes and beliefs may also feed into the education and practice of HFE in different countries, translating to a leniency towards educational programmes and practices that are reductionist in nature. The IEA, as the global network of HFE specialists, has strong relationships and influence with other international

organisations that inform workplace guidelines, policy documents, and workplace standards (Caple, 2012), all of which should promote a holistic systems approach. The prevalence of unhelpful beliefs among the IEA Council reflects the need to address commonly held misconceptions about back pain within this influential group of HFE specialists to ensure that the IEA are promoting HFE research, education, and practice that reflects the current evidence and best practice for LBP.

The IEA Council is involved in formulating the HFE guidelines (IEA & ILO, 2021) and the HFE core competencies (IEA, 2021), both of which emphasise the need to take a holistic, systems approach in the design and management of work systems. The involvement in creating these core HFE guideline and competency documents should mean that the IEA Council is more aware of the current evidence and best practices for MSDs, including LBP, and should therefore hold more positive views about the back. It is important to note that these IEA documents (IEA, 2021; IEA & ILO, 2021) are formulated by collaborative working groups, with some members of the IEA Council provide contributions to their formulation and refinement. The extent to which the HFE community adheres to the HFE guidelines and core competencies may therefore need to be investigated, as the beliefs of the HFE specialists in this study did not always reflect a holistic systems approach.

The reasons why unhelpful beliefs persist among HFE specialists, including members of the IEA Council, despite advocating for a holistic systems approach, remain unclear. Understanding and addressing the sources of these beliefs should be a key research focus of the IEA going forward to ensure that HFE specialists are exposed to evidence-based information. Addressing the unhelpful attitudes and beliefs among HFE specialists may be a crucial first step towards promoting an integrated systems approach across all applications of HFE. In addition, HFE tools and frameworks designed to assess MSD risk from a holistic systems perspective should be both taught and advocated for within practice (Oakman & Macdonald, 2019).

4.2.6 Implications

The back pain attitudes and beliefs demonstrated by the HFE specialists in this study have various potential implications for HFE practice, education and research. This section starts by discussing the potential implications of the beliefs found on HFE

practice, particularly relating to how these beliefs might influence the interactions with and the advice and management recommendations provided to workers. The following subsection focuses on the potential implications of these beliefs for HFE research and education.

Implications for HFE practice

While back pain attitudes and beliefs have not yet been investigated with HFE specialists, evidence suggests that attitudes and beliefs about back pain influence clinical decisions and advice in several other professional groups (Darlow et al., 2012; Gardner et al., 2017; Nolan et al., 2018; Christe et al., 2021b; Caneiro et al., 2021). The back pain attitudes and beliefs of HFE specialists may therefore be instrumental in influencing HFE practice, including their interactions with workers and their choice of recommendations and interventions. Through these interactions and interventions, HFE specialists may influence workers' beliefs, perceptions, and responses, and therefore their risk of developing persistent and disabling LBP in the workplace. Using a systems perspective, this section considers how HFE specialists' attitudes and beliefs may influence the design and management of work systems and, in turn, shape the environments in which workers carry out their tasks.

The role that HFE specialists play in influencing workers' perceptions and responses to their tasks can be understood through a systems lens: human responses at work are shaped by interactions between physical, cognitive, and physiological subsystems within the body, and these interactions are influenced by the environmental context in which they exist (Marras & Hancock, 2014). Ultimately, "humans respond according to how they interpret the conditions under which they must labor" (Marras & Hancock, 2014, p. 56). How workers perceive, interpret, and respond to their tasks is influenced by the context in which those tasks occur (Marras & Hancock, 2014), and this context can be shaped by the interventions and recommendations provided by HFE specialists.

When HFE specialists interact with or provide recommendations to workers, the nature of these recommendations may shape workers' beliefs about back pain, thereby influencing how workers perceive and respond to their tasks. If workers are exposed to messages regarding biomechanical risks that are delivered in a threatening or

cautionary manner, these may develop or reinforce beliefs that the back is weak, vulnerable, or easy to injure. According to the common-sense Model, these beliefs inform how individuals make sense of risk, influencing both their behavioural responses to tasks they perceive as dangerous and their interpretations of pain (Bunzli et al., 2017; Stilwell & Harman, 2019; Caneiro et al., 2021). In the context of HFE practice, this means that the way risks are communicated may unintentionally promote fear, overprotection, or reduced confidence in movement, despite the intention to prevent injury.

Attitudes and beliefs, which are socially and culturally constructed, can influence the perception and interpretation of the task, and ultimately influence psychological, physiological, and biomechanical interactions that give rise to pain (Figure 7). Negative or threatening perceptions influence responses to specific tasks (Geisser et al., 2004; Marras & Hancock, 2014), leading to increased muscle activity and biomechanical loading. Unhelpful beliefs are also associated with heightened stress responses (Caneiro et al., 2021). Both biomechanical changes and psychological distress contribute to elevated proinflammatory cytokine levels, which, as previously discussed, can alter pain sensitivity (Marras, 2012; Marras & Hancock, 2014). Heightened pain during tasks then reinforces previously established negative beliefs and leads to a cycle of persistent pain and disability (Bunzli et al., 2017; Caneiro et al., 2021).

While the pathways that exist between negative attitudes and beliefs and LBP onset are not as well understood, they should be investigated further due to the impact that attitudes and beliefs have on stress responses which, through psychological, biomechanical and physiological interactions, may increase LBP risk (Marras, 2012; Hauke et al., 2011; Roquelaure**,** 2018; Macdonald & Oakman, 2022).

It is likely that the way HFE specialists choose to intervene within a system reflects their attitudes and beliefs about the back, as it has among other professionals (Darlow et al., 2012; Gardner et al., 2017; Nolan et al., 2018; Christe et al., 2021b). In this light, HFE specialists with protective beliefs may provide recommendations that focus more on the reduction of physical risks. Physically focused risk assessment is a common practice within HFE despite evidence advocating for a holistic systems approach

(Macdonald & Oakman, 2022, 2024; De Bruin et al., 2024), which may in part be due to HFE specialists' tendency to hold protective beliefs.

It is important to note that the positive beliefs held by the sample relating to the role of psychological factors and the importance of activity may not translate to workers when combined with negative protective beliefs. Workers are not likely to understand the different underlying mechanisms and interactions between risk factors and may focus on biomechanical advice, particularly if it is communicated in a cautionary or threatening way. As a result, workers may form or reinforce unhelpful beliefs about the vulnerability and need to protect the back. This highlights the need for HFE specialists to understand how different risk factors influence one another and communicate risk clearly, using non-threatening language to promote more helpful beliefs among workers.

Implications for HFE research and education

The unhelpful beliefs identified within HFE researchers and academics have potentially negative implications for the education provided to HFE students, as well as the nature of the LBP research conducted in HFE. HFE research and education may need to move beyond traditional, reductionist methods and adopt a more holistic perspective. The utility of lab-based research within HFE may be limited and should evolve to align with the systems values of HFE (Wilson, 2014). Shifting focus within HFE research could lead to the development of more holistic methodologies and tools that can be adopted in HFE practice. The nature of HFE research should be investigated to determine if it aligns with the holistic systems approach advocated for within HFE.

The attitudes and beliefs of HFE students should be addressed to ensure that the future generation of HFE specialists holds beliefs that align with the current evidence and best practice for LBP. Studies have shown that students' beliefs can change through tailored education (Christe et al., 2021c) and can therefore be an important point of intervention to alter the beliefs of future HFE specialists while they're still in training. The nature of current HFE education and training may also be negatively influencing HFE specialists' attitudes and beliefs, but further research investigating the nature of HFE education is required.

4.3 Strengths and limitations

The following section will outline the strengths and limitations of this study.

4.3.1 Strengths

This study represents the first investigation into back pain attitudes and beliefs of HFE specialists regarding back pain. The findings from this thesis therefore provided valuable insights into the global trends of attitudes and beliefs held by this sample of HFE specialists. This research also contributed to the public health challenge that emphasised the need to develop strategies to address modifiable risk factors for disabling LBP (Buchbinder et al., 2018) by identifying unhelpful beliefs among HFE specialists that can be targeted in future interventions. Through this investigation, valuable insights were gained about the back pain attitudes and beliefs of the IEA Council, an influential group of HFE specialists who are responsible for shaping the global HFE climate.

This study aimed to provide initial insights into the back pain attitudes and beliefs of HFE specialists due to the important interactions that they have with workers in contexts where LBP and related disability are prevalent. The negative beliefs identified within this study further emphasise the need to address negative beliefs within HFE specialists, as they could have a downstream positive influence on workers' beliefs (Suhail & Poulter, 2022).

Participation in this research may have also promoted reflection among participating HFE specialists around the complexity of LBP and demonstrated the potential influence that personal beliefs and attitudes have on the interactions with workers and the way HFE is taught and practiced globally. This study demonstrated that potential pathways exist between the current state of HFE education, research, and practice, negative attitudes and beliefs about the back, and the risk of developing persistent and disabling LBP in the workplace. However, this should be investigated further.

4.3.2 Limitations

This study was not without limitations. One notable limitation of this study was the low response rate, both from IEA2024 attendees and members of IEA federated and

affiliated societies. The exact reasons for the low response rate in this study are unknown. However, possible reasons include: the limited time available for data collection at IEA2024, and the exclusion based on English proficiency. The conference took place over four days and had a busy schedule with many parallel sessions occurring concurrently. This meant that there was limited time available during the conference for recruitment and to get buy-in from potential participants. In addition, the questionnaire, demographic information, and study details were provided in English, which reduced the number of HFE specialists eligible to participate. The study may have benefited from more widespread promotion to all attendees via the conference organisers.

The low response rate of this study challenges the generalisability of the study's findings. As such, it is difficult to make inferences regarding the extent to which the findings of this study apply to the broader population of global HFE specialists. Furthermore, due to the low response rate, there were not enough participants from each country to answer one of the initially established research questions. This study therefore could not provide insights into the differences in attitudes and beliefs about back pain across different countries of operation, or the extent to which the variability in attitudes and beliefs occurred due to countries of operation.

Another limitation of this study was introduced due to the inability to determine the exact population size of global HFE specialists who are proficient in English, which meant that the sample size calculation was an estimate. Such an approach may have over- or underestimated the required sample size, further limiting the generalisability of the study's findings. Therefore, the attitudes and beliefs about back pain found in this study may not accurately represent the beliefs of others in the discipline and profession.

Furthermore, the non-probability based sampling strategy utilised in this study may have introduced selection bias and self-selection bias. Ultimately, the participants recruited may not have been an accurate representation of the population, and due to the voluntary nature of the study, some participants may have been more inclined to participate than others based on their interests or the perceived importance of the

study. The sampling strategy adopted further limits the generalisability of the study's findings.

A limitation of this study was the omission of a demographic question relating to LBP expertise. This question would have allowed for statistical analysis relating to the correlation between LBP expertise and attitudes and beliefs about back pain. This would also have provided us with an understanding of the number of HFE specialists in this study who were likely to influence the beliefs and attitudes and workers.

Furthermore, attitudes and beliefs about back pain are not static and have the potential to change over time. This study therefore provided a snapshot of the attitudes and beliefs held by HFE specialists at the time that the study was conducted. However, the fluid nature of attitudes and beliefs about back pain means that they can be altered in a more positive manner, particularly when exposed to positive and evidence-based information. Furthermore, due to the limited nature of the questionnaire (only 34-likert scale items), the study would have benefited from open ended questions or semi-structured interviews to gain a more in-depth understanding of the attitudes and beliefs of HFE specialists.

The final limitation of this study was the omission of some demographic questions (including age, sex, and past/current/no experience with LBP). This demographic information may have provided insight into individual factors that could influence attitudes and beliefs about back pain among the HFE specialists in this study.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

The aim of this study was to investigate the back pain related attitudes and beliefs of global HFE specialists. The beliefs and attitudes of HFE specialists in this study were highly variable and inconsistent with some positive and some negative beliefs frequently identified. The HFE specialists in this study held unhelpful beliefs about the need to protect the back, the special nature and impact of back pain, and some contradictory beliefs regarding the back's vulnerability. The sample of HFE specialists believed that the back is easy to injure and therefore requires special care, including strong muscles and good posture, to avoid injury. Furthermore, intervention from a healthcare professional was perceived as necessary to diagnose and treat back pain. These beliefs do not align with the current evidence and best practice for back pain, with potential negative implications for the advice provided to and interventions provided with workers, as well as HFE education and research relating to lower back pain (LBP).

The HFE specialists did, however, hold positive beliefs regarding the relationship between pain and injury, the need to remain physically active while experiencing back pain, and the prognosis of back pain. The HFE specialists believed that stress, thoughts, and feelings can influence pain intensity and that poor expectations and worrying can negatively influence recovery. Staying active through exercise during pain episodes was perceived as important, despite some uncertainty regarding the appropriate intensity of exercise. These beliefs align with the current evidence and best practice for LBP and are likely to have positive implications for the choice of interventions, advice, and management recommendations for workers in occupations where the risk of experiencing LBP is high.

Despite the prevalence of some positive beliefs identified within the sample, the unhelpful beliefs relating to protection, vulnerability, and the special nature and impact of pain still persist. Such beliefs may hinder the provision of evidence-based interventions for LBP in the workplace. The persistence of unhelpful biomedical beliefs alongside positive beliefs suggests that although biopsychosocial concepts are

understood by HFE specialists, they are not consistently translated into practice. Such contradictions reflect the need for clearer strategies to translate the holistic systems approach endorsed by HFE into consistent and evidence-based MSD practice.

Unhelpful attitudes and beliefs about back pain were more prevalent among the IEA Council as well as among HFE researchers and academics, reflecting the need to investigate HFE education programmes and current trends in HFE research relating to musculoskeletal disorders (MSDs) to determine if the research and education reflect the holistic systems approach advocated for by the IEA. Furthermore, HFE specialists need to be aware of their own potential biases and acknowledge the impact that their own perceptions and beliefs may have on their interactions with others.

The following quote nicely sums up the need for HFE specialists to understand their attitudes and beliefs about back pain, as well as their potential biases, and how these may influence HFE research, education, and practice: “Ever since the Industrial Revolution, Western society has benefited from science, logic and reductionism over intuition and holism. Psychologically and politically, we would much rather assume that the cause of the problem is ‘out there’ rather than ‘in here’. It’s almost irresistible to blame something or someone else, to shift responsibility away from ourselves and to look for the control knob, the product, the pill, the technical fix that will make a problem go away” (Meadows, 2008, p.4).

As such, it is easier to adopt solutions to LBP that address the physical aspects of a task, as these can be easily measured, quantified, and controlled, than it is to try and understand workers’ perceptions and how these perceptions are influenced by the external context that HFE specialists often play a role in shaping. It is easier to address the risky physical components than it is to consider that the way we speak, think, and behave may be contributing to the problem. It is easier to look for a quick fix: alter the design of a workplace, replace a piece of equipment, lecture a worker about their posture and how many hours a day they spend sitting, or change their lifting technique than it is to consider that the way we interact with them as trusted professionals may influence their fears, their behaviour, their motivations at work and most importantly, their pain and disability.

Overall, this study provided a good starting point for research relating to the back pain attitudes and beliefs of HFE specialists globally and demonstrated the need for further investigation. Future studies should focus on investigating the attitudes and beliefs of HFE specialists in different countries, using validated translations of the Back Pain Attitudes Questionnaire (Back-PAQ). Such investigations are necessary to understand how these beliefs differ in various contexts. Furthermore, studies that investigate attitudes and beliefs about back pain using professionals' first language are ideal, as there is a smaller chance of misinterpreting the items. For languages where a translation is not yet available, research should focus on developing and validating translated versions of the questionnaire.

Future studies should also focus on exploring the degree to which HFE specialists' attitudes and beliefs about back pain influence the advice, recommendations, and choice of risk assessment practices within workplaces. Subsequent studies should investigate the association between HFE specialists and workers' attitudes and beliefs regarding back pain to determine the degree to which HFE specialists' beliefs align with those of workers. It would also be beneficial to focus these studies on HFE specialists who are involved in the prevention and management of MSDs in the workplace. In addition, more detailed investigations into the beliefs of workers and other company stakeholders may be necessary to shift the broader workplace culture to one that understands the complex and multifactorial nature of LBP.

The present research brought to light that some HFE specialists demonstrate potentially harmful attitudes and beliefs the back that need to be addressed. Therefore, context-specific interventions are needed to positively alter these beliefs. Future research may focus on developing and testing belief change interventions for HFE specialists. Such interventional studies may involve investigations and alterations to the education provided to HFE specialists, and the promotion of evidence-based practices for LBP.

The findings from this study suggest the need to investigate the degree to which current MSD practice, including widely used risk assessment tools and methodologies, align with the holistic systems approach advocated for within HFE. More comprehensive frameworks for MSDs have been developed (Roquelaure, 2016;

Oakman & Macdonald, 2019), but future research is required to determine if these are effectively utilised in HFE practice.

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APPENDICES

Appendix A: Copy of 34-item Back-PAQ

Back Pain Attitudes Questionnaire

Please answer all questions # Mark your answers like this ✓ If you make a mistake, do this then tick the correct response ✗

THESE QUESTIONS ARE ABOUT YOUR OWN BACK

	Please rate each statement as	False	Possibly False	Unsure	Possibly True	True
1	Your back is one of the strongest parts of your body					
2	Your back is well designed for the way you use it in daily life					
3	Bending your back is good for it					
4	Sitting is bad for your back					
5	Lifting without bending the knees is not safe for your back					
6	It is easy to injure your back					

THESE QUESTIONS ARE ABOUT LOOKING AFTER YOUR OWN BACK

	Please rate each statement as	False	Possibly False	Unsure	Possibly True	True
7	It is important to have strong muscles to support your back					
8	Good posture is important to protect your back					
9	If you overuse your back, it will wear out					
10	If an activity or movement causes back pain, you should avoid it in the future					
11	You could injure your back if you are not careful					
12	You can injure your back and only become aware of the injury sometime later					

THESE QUESTIONS ARE ABOUT BACK PAIN IN GENERAL

	Please rate each statement as	False	Possibly False	Unsure	Possibly True	True
13	Back pain means that you have injured your back					
14	A twinge in your back can be the first sign of a serious injury					
15	Thoughts and feelings can influence the intensity of back pain					
16	Stress in your life (financial, work, relationship) can make back pain worse					

→ *Go to next page, question* 17

This questionnaire is taken from: Darlow B, Perry M, Mathieson F, Stanley J, Melloh M, Marsh R, Baxter D, Dowell A (2013) The Development of the Back Pain Attitudes Questionnaire (Back-PAQ). *BMJ Open*.

Back Pain Attitudes Questionnaire

THESE QUESTIONS ARE ABOUT BACK PAIN IN GENERAL

	Please rate each statement as	False	Possibly False	Unsure	Possibly True	True
17	When you have back pain, you can do things which increase your pain without harming the back					
18	Having back pain makes it difficult to enjoy life					
19	It is worse to have pain in your back than your arms or legs					
20	It is hard to understand what back pain is like if you have never had it yourself					

THESE QUESTIONS ARE ABOUT WHAT YOU SHOULD DO IF YOU HAVE BACK PAIN

	Please rate each statement as:	False	Possibly False	Unsure	Possibly True	True
21	If your back hurts, you should take it easy until the pain goes away					
22	If you ignore back pain, you may cause damage to your back					
23	It is important to see a health professional when you have back pain					
24	To effectively treat back pain you need to know exactly what is wrong					
25	If you have back pain you should avoid exercise					
26	When you have back pain the risks of vigorous exercise outweigh the benefits					
27	If you have back pain you should try to stay active					

THESE QUESTIONS ARE ABOUT RECOVERING FROM BACK PAIN

	Please rate each statement as:	False	Possibly False	Unsure	Possibly True	True
28	Most back pain settles quickly, at least enough to get on with normal activities					
29	Worrying about your back can delay recovery from back pain					
30	Focussing on things other than your back helps you to recover from back pain					
31	Expecting your back pain to get better helps you to recover from back pain					
32	Once you have had back pain there is always a weakness					
33	There is a high chance that an episode of back pain will not resolve					
34	Once you have a back problem, there is not a lot you can do about it					

This questionnaire is taken from: Darlow B, Perry M, Mathieson F, Stanley J, Melloh M, Marsh R, Baxter D, Dowell A (2013) The Development of the Back Pain Attitudes Questionnaire (Back-PAQ). *BMJ Open*.

Demographic Questions:

Demographic information:

Please complete the following demographic information alongside the questionnaire for comparative purposes:

Country of operation:

Role [select all that are applicable]:

Researcher/academic ☐

Practitioner ☐

Educator ☐

Student:

Masters ☐

PhD ☐

Committee member ☐

Years of experience: _____

Appendix B: Letter of information

LETTER OF INFORMATION TO PARTICIPANTS

Dear _____ Date: __/__/__

Thank you for volunteering to participate in this Masters project. Your help and participation are greatly appreciated. This letter aims to inform you of the nature and procedure for this Masters project titled:

A GLOBAL INVESTIGATION INTO THE BACK PAIN ATTITUDES AND BELIEFS OF HUMAN FACTORS AND ERGONOMICS SPECIALISTS

It is advised that you read through this document carefully and thoroughly before signing the informed consent form. If there are any questions, queries, or concerns regarding the study, please contact me (contact information at the end of the document).

AIMS OF THE STUDY

The purpose of this study is to investigate the back pain attitudes and beliefs of Human Factors and Ergonomics specialists globally, and to compare the attitudes and beliefs of Human Factors and Ergonomics specialists from different countries, and with different roles and years of experience. Back pain beliefs and attitudes will be recorded using the 34-item back-pain attitudes questionnaire and demographic information will be recorded for comparative purposes.

PROCEDURES

Those participating in this study will be required to complete the 34-item back-pain attitudes questionnaire as well as a list of demographic questions. This questionnaire is standardised and validated for use in research. The questionnaire will be distributed to the participants at the International Ergonomics Associations 22nd Triennial

Congress held in Jeju, South Korea. The purpose of the research will be explained and those that wish to participate will receive a letter of information, and a copy of the 34-item back-PAQ. If the participants still wish to participate, they will need to return the completed questionnaire. The questionnaire and consent form will be separated to protect the identity of participants. An online version of the 34-item Back Pain Attitudes Questionnaire and demographic questions will be created for those attending the conference online, which will include both information on the study and an option to provide consent.

RISKS

There are low risks associated with this study. There is the potential risk that daily activities will be briefly disrupted when the questionnaire is completed. However, this questionnaire is short and straightforward and should not take too long to complete. Another risk is that participants will rethink their attitudes and beliefs about the back while answering this questionnaire. This will be mitigated as participants will receive information on positive, evidence-based beliefs at the end of the study with the feedback on the results of the study.

BENEFITS

The benefits of the study include contributing to the current understanding of the back pain attitudes and beliefs of Human Factors and Ergonomics specialists globally. The research to investigate the attitudes and beliefs of Human Factors and Ergonomics specialists is extremely limited and non-existent globally. Participants would therefore be contributing to an important and under-researched area.

OTHER

Your participation in this research is completely voluntary and you are free to withdraw from the study if you feel unable or unwilling to complete the questionnaire. All information collected during this study will be kept confidential and codes will be used in lieu of any names. Also, the findings of this research may be referenced in future studies for the purposes of thorough exploration of this area.

Thank you in advance for your interest in this research. I have provided my contact details below, should you have any questions please feel free to contact me.

Yours sincerely:

Abigail Du Plessis

Abigaildup@icloud.com

Supervisor

Andrew Todd

a.todd@ru.ac.za

Appendix C: Information provided on the Zoho Survey platform

Abigail Du Plessis from the Department of Human Kinetics and Ergonomics at Rhodes University in South Africa has requested your permission to participate in the research project titled 'A global investigation into the back pain attitudes and beliefs of Human Factors and Ergonomics specialists'.

Rhodes University has given ethical clearance to this research project (2024-7839-8829) and you may request to see the clearance certificate by contacting the Ethics Coordinator (ethics-committee@ru.ac.za)

The purpose of this research project is to investigate the back pain attitudes and beliefs of Human Factors and Ergonomics specialists on a global scale and compare the attitudes and beliefs of Human Factors and Ergonomics Specialists in different countries, with different roles and years of experience.

Please take this survey if you are a Human Factors and Ergonomics specialist (This includes practitioners, academics/researchers and students (Masters/PhD) within the field of Human Factors and Ergonomics). Participation requires proficiency in English to understand and answer the questionnaire.

By participating in this research project, you will be contributing towards an increased understanding of the back pain attitudes and beliefs of Human Factors and Ergonomics specialists on a global scale.

Your participation in this project will involve completing the 34-item Back Pain Attitudes Questionnaire and a short list of demographic questions. The Back Pain Attitudes Questionnaire will include questions surrounding attitudes and beliefs about the back and back pain. This questionnaire is taken from: Darlow B, Perry M, Mathieson F, Stanley J, Melloh M, Marsh R, Baxter GD, Dowell A. (2014). The development and exploratory analysis of the Back Pain Attitudes Questionnaire (Back-PAQ). BMJ Open, 4(5).

Your participation is entirely voluntary and should you not wish to participate, close this window now and do not provide consent below.

You will not be compensated for participating in this research project.

The following risks are associated with your participation: Time will be allocated to completing this questionnaire which may briefly disrupt personal activities. Completing this questionnaire may also result in participants rethinking their attitudes and beliefs about the back. Should you experience any of the above, please contact the researchers involved (details will be stipulated below).

The research results of this project will be published in the form of an academic paper. However, confidentiality and anonymity of records will be maintained, and your name and identity will not be revealed or linked to the results of this survey in any way.

In terms of the Protection of Personal Information Act (No. 4 of 2013) you have the right to request the Researcher to provide you with a detailed explanation of exactly how confidentiality and anonymity of the data you provide will be achieved. You may also request to know exactly how your personal information will be stored securely, and for how long it will be stored.

Data collected from you for this research project will not be used for any further study.

In terms of the POPI Act, you possess the right to receive feedback after the research project has been completed. Should you wish to receive feedback, there will be a link to provide your email address (your personal information will NOT be linked to your responses).

Any further questions that you have regarding the nature of the research and/or your participation in it will be answered by Abigail Du Plessis, G20d4206@campus.ru.ac.za.

Appendix D: Letter requesting permission to conduct research

ACCESS LETTER REQUESTING PERMISSION TO CONDUCT RESEARCH

Rhodes University
Drostdy Road,
Grahamstown,
6139

The President
International Ergonomics Association
Rio de Janeiro
Brazil

9 July 2024

Dear Mr Orlando Gomes

REQUEST FOR PERMISSION TO CONDUCT RESEARCH

I am a registered Master's student in the Department of Human Kinetics and Ergonomics at Rhodes University. My supervisor is Andrew Todd.

The proposed topic of my research is: "A global investigation into the back pain attitudes and beliefs Human Factors and Ergonomics specialists". The objectives of the study are:

(a) To investigate the back pain attitudes and beliefs of Human Factors and Ergonomics specialists on a global scale.
(b) To compare the back pain attitudes and beliefs of Human Factors and Ergonomics specialists in different countries, and in terms of years of experience.

I am hereby seeking your consent to conduct the following research at the International Ergonomics Associations 22nd Triennial congress in Jeju, South Korea in August 2024. To assist you in reaching a decision, I have attached to this letter:

(a) A copy of an ethical clearance certificate issued by the University
(b) A copy the research instruments which I intend on using in my research
(c) A copy of the letter of information that will be provided to participants

Should you require any further information, please do not hesitate to contact me or my supervisor. Our contact details are as follows:

Abigail Du Plessis:
Email: abigaildup@icloud.com
Cellphone number: +27 652339582

Andrew Todd:
Email: a.todd@ru.ac.za
Cellphone number: +27 832770795

Upon completion of the study, I undertake to provide you with feedback

Your permission to conduct this study will be greatly appreciated.

Yours sincerely,

Abigail Du Plessis

Abigail Gillian Du Plessis

Appendix E: Gatekeeper permission letter

IEA
International Ergonomics & Human Factors Association

Rio de Janeiro, 9 July 2024

Ms Abigail Du Plessis
Department of Human Kinetics and Ergonomics
Rhodes University

Dear Ms Du Plessis,

GATEKEEPER PERMISSION TO CONDUCT RESEARCH AT THE INTERNATIONAL ERGONOMICS ASSOCIATIONS' 22ND TRIENNIAL CONGRESS

Name of research proposal: *A global investigation into the back pain attitudes and beliefs of Human Factors and Ergonomics specialists.*

This letter serves to confirm that you have been granted permission to conduct your proposed research titled "a global investigation into the back pain attitudes and beliefs of Human Factors and Ergonomics specialists" at the International Ergonomics Associations' 22nd Triennial Congress in Jeju, South Korea as requested. In my capacity as the International Ergonomics Association's President, I do not have any objection should you wish to survey Human Factors and Ergonomics specialists attending the International Ergonomics Associations' 22nd Triennial Congress in August 2024.
Sincerely,

José Orlando Gomes, Ph.D., CPE.
President of International Human Factors and Ergonomics Association (IEA)
Polytechnic School's Associate Dean for International Affairs to BRICS Countries,
Graduate Program in Informatics & Polytechnic School, Federal University of Rio de Janeiro.
Rio de Janeiro, Brazil
President@iea.cc

Appendix F: Final ethical approval letter

RHODES UNIVERSITY
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RU 120 1904-2024

Rhodes University Human Research Ethics Committee
Main Admin Building, Drostdy Road, Makhanda, 6139, South Africa
PO Box 94, Makhanda, 6140, South Africa
t: +27 (0) 46 603 7314
e: ethics-committee@ru.ac.za
https://www.ru.ac.za/researchgateway/ethics/
NHREC Registration number: RC-241114-045

22 July 2024

Ms Abigail Du Plessis

Email: g20d4206@campus.ru.ac.za abigaildup@icloud.com

Review Reference: 2024-7839-8829

Dear Ms Du Plessis,

Title: A global investigation into the back pain attitudes and beliefs of Human Factors and Ergonomics specialists.

Researcher: Ms Abigail Du Plessis

Supervisor(s): Mr Andrew Todd

This letter confirms that the above research proposal has been reviewed and **APPROVED** by the Rhodes University Human Research Ethics Committee (RU-HREC). Your Approval number is: 2024-7839-8829

Approval has been granted for 1 year. An annual progress report will be required in order to renew approval for an additional period. You will receive an email notifying you when the annual report is due.

Please ensure that the ethical standards committee is notified should any substantive change(s) be made, for whatever reason, during the research process. This includes changes in investigators. Please also ensure that a brief report is submitted to the ethics committee on the completion of the research. The purpose of this report is to indicate whether the research was conducted successfully, if any aspects could not be completed, or if any problems arose that the ethical standards committee should be aware of. If a thesis or dissertation arising from this research is submitted to the library's electronic theses and dissertations (ETD) repository, please notify the committee of the date of submission and/or any reference or cataloguing number allocated.

Sincerely,

Janet Hayward

Dr Janet Hayward

Chair: Rhodes University Human Research Ethics Committee, RU-HREC

cc: Ethics Coordinator

Appendix G: Ethical amendment letter

Rhodes University Human Research Ethics Committee
Main Admin Building, Drostdy Road, Makhanda, 6139, South Africa
PO Box 94, Makhanda, 6140, South Africa
t: +27 (0) 46 603 7314
e: ethics-committee@ru.ac.za
https://www.ru.ac.za/researchgateway/ethics/
NHREC Registration number: RC-241114-045

27 September 2024

Ms Abigail Du Plessis
Department of Human Kinetics and Ergonomics
Rhodes University

Dear Ms Du Plessis,

Re: A global investigation into the back pain attitudes and beliefs of Human Factors and Ergonomics specialists.

This letter confirms that the RU-HREC has reviewed the proposed changes to your research protocol and approved the following amendment:

Inclusion of participants who are members of societies affiliated with the International Ergonomics Association. They will be recruited with the assistance of Society Presidents but will participate in their individual capacity.

Approval number: 2024-7839-8829

Sincerely,

Janet Hayward

Dr Janet Hayward
Chair of Rhodes University Human Research Ethics Committee

Appendix H: Hypotheses and results from normality tests

IEA Council vs regular HFE specialists

IEA Council (n = 32)

Regular HFE specialists (n = 101)

Shapiro-Wilk test

The Shapiro-Wilk test was used to establish if the two samples of interest (the IEA Council and Regular HFE specialists) were normally distributed. The significance level for this test was 0.05.

IEA Council:

Null hypothesis: The sample (the IEA Council) follows a normal distribution.

Alternative hypothesis: The sample (the IEA Council) does not follow a normal distribution.

Regular HFE specialists:

Null hypothesis: The sample (regular HFE specialists) follows a normal distribution.

Alternative hypothesis: The sample (regular HFE specialists) does not follow a normal distribution.

	IEA Council	Regular HFE specialists
p-value	0.101	0.2215
w statistic	0.94457	0.98303

IEA Council:

The p-value demonstrated above was greater than 0.05, indicating that we fail to reject the null hypothesis. Therefore, there was insufficient evidence to suggest that the sample deviates from normality. The W statistic is close to one (0.94), indicating that the data is close to a normal distribution.

Regular HFE specialists:

The p-value demonstrated by the sample of regular HFE specialists was greater than 0.05, indicating that we fail to reject the null hypothesis. Therefore, there was insufficient evidence to suggest that the sample of regular HFE specialists' deviates from normality. The w statistic is close to one (0.98), indicating that the data is close to a normal distribution.

Levene's test

The Levene's test was used to determine if the two sample groups of interest (IEA Council and Regular HFE specialists) displayed equal variance. The significance level for this test was 0.05

Null hypothesis: The IEA Council and regular HFE specialists display equal variance.

H0: $\sigma_1^2 = \sigma_2^2$

Alternative hypothesis: The IEA Council and regular HFE specialists do not display equal variance.

H1: $\sigma_1^2 \neq \sigma_2^2$

The results from the Levene's test of equal variance are as follows:

The p-value (0.03) was less than 0.05, indicating that we reject the null hypothesis and accept the alternative hypothesis. We can therefore conclude that the IEA Council and regular HFE specialists do not display equal variance.

	IEA Council v regular HFE specialists
p-value	0.03038
F value	4.7909

Appendix I: Supplementary figures and tables

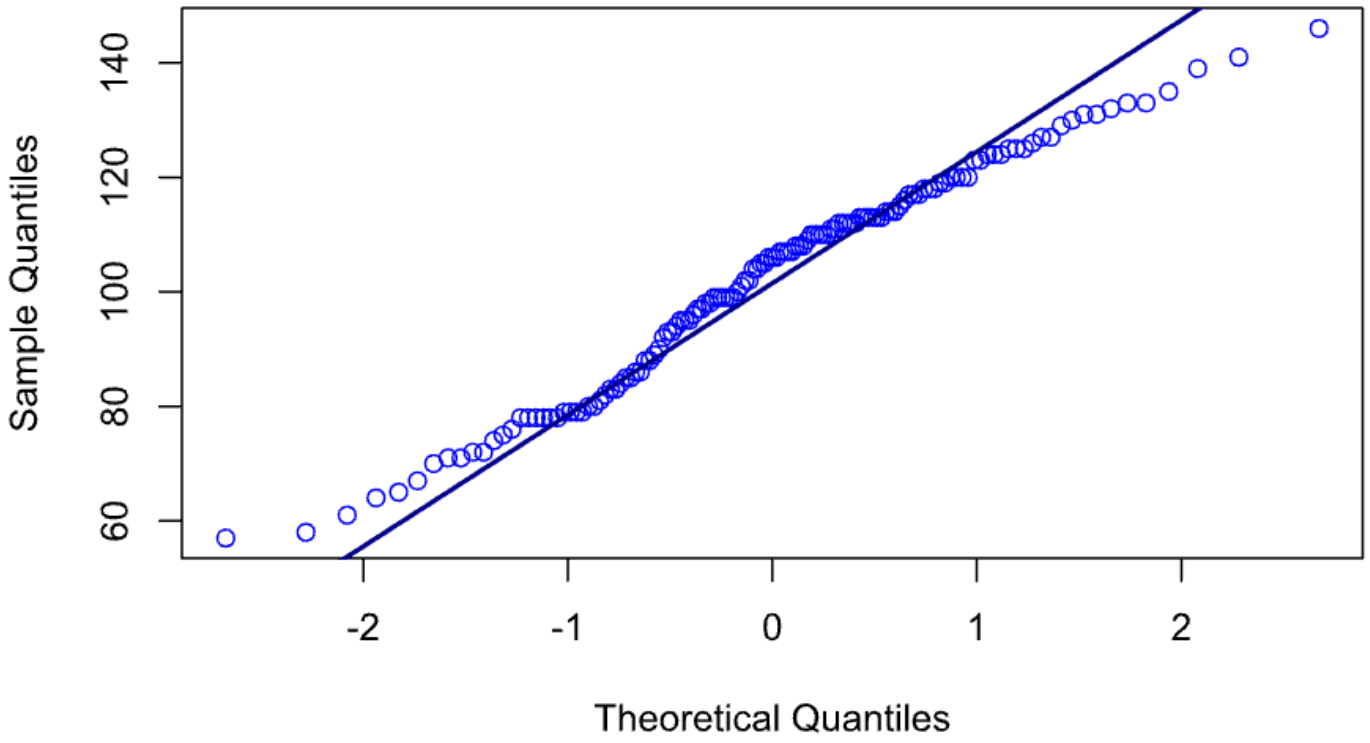

Figure 21. Quantile-Quantile plot for the entire sample

Entire sample

Table 9. Detailed overview of responses for each item of the Back-PAQ for the entire sample

Item	True	Possibly true	Unsure	Possibly false	False	n
1.	50	46	14	23	14	147
2.	53	38	11	30	16	148
3	40	43	13	21	29	146
4	32	48	14	28	25	147
5	64	30	16	16	22	148
6	56	42	10	18	22	148
7	111	25	3	3	2	144
8	97	36	5	4	2	144
9	48	41	12	22	21	144
10	28	32	16	42	26	144
11	77	43	7	12	5	144
12	79	44	7	5	9	144
13	11	33	13	36	48	141
14	24	64	15	15	22	140
15	84	37	9	7	4	141
16	97	34	3	5	2	141
17	53	31	24	18	14	140

18	82	41	4	8	5	140
19	45	31	27	16	22	141
20	53	60	9	8	11	141
21	19	47	11	36	28	141
22	67	44	10	11	9	141
23	69	48	7	11	5	140
24	61	31	10	19	19	140
25	7	10	11	31	82	141
26	27	29	31	27	26	140
27	81	34	7	12	7	141
28	42	44	20	25	8	139
29	41	46	25	13	14	139
30	31	50	20	26	12	139
31	38	52	20	18	11	139
32	8	37	17	37	40	139
33	5	34	22	38	40	139
34	4	6	7	26	96	139

Raw scores not corrected for question direction

Table 10. Percentages of each response for each item of the Back-PAQ for the entire sample

Item	True	Possibly true	Unsure	Possibly false	False	n
1.	34.01	31.29	9.52	15.65	9.52	147
2.	35.81	25.68	7.43	20.27	10.81	148
3	27.40	29.45	8.90	14.38	19.86	146
4	21.77	32.65	9.52	19.05	17.01	147
5	43.24	20.27	10.81	10.81	14.86	148
6	37.84	28.38	6.76	12.16	14.86	148
7	77.08	17.36	2.08	2.08	1.39	144
8	67.36	25.00	3.47	2.78	1.39	144
9	33.33	28.47	8.33	15.28	14.58	144
10	19.44	22.22	11.11	29.17	18.06	144
11	53.47	29.86	4.86	8.33	3.47	144
12	54.86	30.56	4.86	3.47	6.25	144
13	7.80	23.40	9.22	25.53	34.04	141
14	17.14	45.71	10.71	10.71	15.71	140
15	59.57	26.24	6.38	4.96	2.84	141
16	68.79	24.11	2.13	3.55	1.42	141
17	37.86	22.14	17.14	12.86	10.00	140
18	58.57	29.29	2.86	5.71	3.57	140

19	31.91	21.99	19.15	11.35	15.60	141
20	37.59	42.55	6.38	5.67	7.80	141
21	13.48	33.33	7.80	25.53	19.86	141
22	47.52	31.21	7.09	7.80	6.38	141
23	49.29	34.29	5.00	7.86	3.57	140
24	43.57	22.14	7.14	13.57	13.57	140
25	4.96	7.09	7.80	21.99	58.16	141
26	19.29	20.71	22.14	19.29	18.57	140
27	57.45	24.11	4.96	8.51	4.96	141
28	30.22	31.65	14.39	17.99	5.76	139
29	29.50	33.09	17.99	9.35	10.07	139
30	22.30	35.97	14.39	18.71	8.63	139
31	27.34	37.41	14.39	12.95	7.91	139
32	5.76	26.62	12.23	26.62	28.78	139
33	3.60	24.46	15.83	27.34	28.78	139
34	2.88	4.32	5.04	18.71	69.06	139

Raw scores not corrected for question direction

Table 11. Detailed overview of responses for each item of the Back-PAQ for the IEA Council

Item	True	Possibly true	Unsure	Possibly False	False	n
1	13	9	3	9	3	37
2	10	11	1	13	3	38
3	8	8	4	6	10	36
4	8	10	4	8	7	37
5	16	8	8	2	4	38
6	14	11	3	5	5	38
7	29	8	0	1	0	38
8	27	9	2	0	0	38
9	16	9	6	6	1	38
10	12	11	6	7	2	38
11	22	12	1	2	1	38
12	18	15	3	0	2	38
13	3	17	3	7	8	38
14	6	19	6	5	1	37
15	17	15	3	2	1	38
16	23	13	0	2	0	38
17	8	7	6	9	7	37
18	25	8	1	2	1	37

19	11	11	7	5	4	38
20	12	17	2	4	3	38
21	4	15	3	7	9	38
22	24	10	3	1	0	38
23	23	9	1	4	0	37
24	22	6	1	4	4	37
25	1	5	7	9	16	38
26	9	8	8	7	5	37
27	18	12	1	4	3	38
28	9	10	7	8	4	38
29	7	14	6	6	5	38
30	3	13	4	15	3	38
31	6	15	8	7	2	38
32	2	18	6	8	4	38
33	2	12	8	8	8	38
34	0	4	1	13	20	38

Raw scores not adjusted for question direction

Table 12. Percentage of each response for each item of the Back-PAQ for the IEA Council

Item	True	Possibly true	Unsure	Possibly False	False	n
1	35.14	24.32	8.11	24.32	8.11	37
2	26.32	28.95	2.63	34.21	7.89	38
3	22.22	22.22	11.11	16.67	27.78	36
4	21.62	27.03	10.81	21.62	18.92	37
5	42.11	21.05	21.05	5.26	10.53	38
6	36.84	23.68	7.89	13.16	13.16	38
7	76.32	28.95	0.00	2.63	0.00	38
8	71.05	31.58	5.26	0.00	0.00	38
9	42.11	39.47	15.79	15.79	2.63	38
10	31.58	44.74	15.79	18.42	5.26	38
11	57.89	51.35	2.63	5.26	2.63	38
12	47.37	39.47	7.89	0.00	5.26	38
13	7.89	44.74	7.89	18.42	21.05	38
14	16.22	51.35	16.22	13.51	2.70	37
15	44.74	39.47	7.89	5.26	2.63	38
16	60.53	34.21	0.00	5.26	0.00	38
17	21.62	18.92	16.22	24.32	18.92	37
18	67.57	21.62	2.70	5.41	2.70	37

19	28.95	28.95	18.42	13.16	10.53	38
20	31.58	44.74	5.26	10.53	7.89	38
21	10.53	39.47	7.89	18.42	23.68	38
22	63.16	26.32	7.89	2.63	0.00	38
23	62.16	24.32	2.70	10.81	0.00	37
24	59.46	16.22	2.70	10.81	10.81	37
25	2.63	13.16	18.42	23.68	42.11	38
26	24.32	21.62	21.62	18.92	13.51	37
27	47.37	31.58	2.63	10.53	7.89	38
28	23.68	26.32	18.42	21.05	10.53	38
29	18.42	36.84	15.79	15.79	13.16	38
30	7.89	34.21	10.53	39.47	7.89	38
31	15.79	39.47	21.05	18.42	5.26	38
32	5.26	47.37	15.79	21.05	10.53	38
33	5.26	31.58	21.05	21.05	21.05	38
34	0.00	10.58	2.63	34.21	52.63	38

Raw scores not corrected for question direction

Table 13. Descriptive statistics and frequency results for each item of the Back-PAQ for the IEA Council

Item	Theme	Mean (±SD) *	Percentage True/possibly true†	Mode*	n
1.	Vulnerability	3.54 (±1.41)	59.46	5	37
2.	Vulnerability	3.32 (±1.40)	55.26	2	38
3.	Vulnerability	2.94 (±1.57)	44.44	1	36
4.	Vulnerability	3.11 (±1.47)	48.65	4	37
5.	Vulnerability	3.79 (±1.34)	63.16	5	38
6.	Vulnerability	3.63 (±1.44)	65.79	5	38
7.	Protection	4.71 (±0.61)	97.37	5	38
8.	Protection	4.66 (±0.58)	94.74	5	38
9.	Vulnerability	3.87 (±1.21)	65.79	5	38
10.	Protection	3.63 (±1.26)	60.53	5	38
11.	Protection	4.37 (±0.97)	89.47	5	38
12.	Vulnerability	4.24 (±1.00)	86.84	5	38
13.	Pain-injury	3.00 (±1.36)	52.63	4	38
14.	Vulnerability	3.65 (±1.01)	67.57	4	38
15.	Pain-injury	4.18 (±0.98)	84.21	5	38
16.	Pain-injury	4.50 (±0.76)	94.74	5	38
17.	Pain-injury	3.00 (±1.45)	40.54	2	37
18.	Special pain	4.51 (±0.90)	89.19	5	38

19.	Special pain	3.58 (±1.31)	57.89	4	38
20.	Special pain	3.82 (±1.23)	76.32	4	38
21.	Protection	2.95 (±1.41)	50.00	4	38
22.	Pain-injury	4.50 (±0.76)	89.47	5	38
23.	Special pain	4.38 (±0.98)	86.49	5	37
24.	Special pain	4.03 (±1.44)	75.68	5	37
25.	Activity	2.11 (±1.18)	15.79	1	38
26.	Activity	3.24 (±1.38)	45.95	5	37
27.	Activity	4.00 (±1.29)	78.95	5	38
28.	Prognosis	3.32 (±1.34)	50.00	4	38
29.	Pain-injury	3.32 (±1.32)	55.26	4	38
30.	Pain-injury	2.95 (±1.18)	42.11	2	38
31.	Pain-injury	3.42 (±1.13)	55.26	4	38
32.	Prognosis	3.11 (±1.16)	52.63	4	38
33.	Prognosis	2.79 (±1.26)	36.84	4	38
34.	Prognosis	1.71 (±0.96)	10.53	1	38

* 1.00='False', 3.00 = 'Unsure', '5.00' = True; this table represents raw scores not adjusted for question direction.

† Combined 'true' and 'possibly true' responses.

Appendix J: R packages

Table 14. Summary of R statistical software packages used

R package	Uses	Reference
FSA package	Used for Levene's test of equal variances	Ogle et al. (2025)
Car package	Used for the Dunn's post-hoc test	Fox & Weisberg (2019)
Ggplot2 package	Used for scatterplot and quantile-quantile plot	Wickham (2016)
Ggstatsplot package	Used to create frequency graphs	Patil (2021)
Ggstats package	Used to create frequency graphs	Larmarange (2025)
Dplyr package	Used for data cleaning and manipulation	Wickham et al. (2023)

Appendix K: R code and statistical outputs

Code for confidence intervals for each item

```
prop.test(96, 147, correct = FALSE)
prop.test(91, 148, correct = FALSE)
prop.test(83, 146, correct = FALSE)
prop.test(80, 147, correct = FALSE)
prop.test(94, 148, correct = FALSE)
prop.test(98, 148, correct = FALSE)
prop.test(136, 144, correct = FALSE)
prop.test(133, 144, correct = FALSE)
prop.test(89, 144, correct = FALSE)
prop.test(60, 144, correct = FALSE)
prop.test(120, 144, correct = FALSE)
prop.test(123, 144, correct = FALSE)
prop.test(44, 141, correct = FALSE)
prop.test(88, 140, correct = FALSE)
prop.test(121, 141, correct = FALSE)
prop.test(131, 141, correct = FALSE)
prop.test(84, 140, correct = FALSE)
prop.test(123, 140, correct = FALSE)
prop.test(76, 141, correct = FALSE)
prop.test(113, 141, correct = FALSE)
prop.test(66, 141, correct = FALSE)
prop.test(111, 141, correct = FALSE)
prop.test(117, 140, correct = FALSE)
prop.test(92, 140, correct = FALSE)
prop.test(17, 141, correct = FALSE)
prop.test(56, 140, correct = FALSE)
prop.test(115, 141, correct = FALSE)
prop.test(86, 139, correct = FALSE)
prop.test(87, 139, correct = FALSE)
prop.test(81, 139, correct = FALSE)
prop.test(90, 139, correct = FALSE)
prop.test(45, 139, correct = FALSE)
prop.test(39, 139, correct = FALSE)
```

```
prop.test(10, 139, correct = FALSE)
```

Statistical analyses per Role:

Code for Kruskal-Wallis test and Dunn's post-hoc test

```
## roleoriginal <- read.table("Entiresamplerole.txt", sep = ";", header
= TRUE)
## kruskal.test(Total.score ~ Role, data = roleoriginal)
## install.packages("FSA")
## library (FSA)
##  dunnTest(Total.score  ~  Role,  data  =  roleoriginal,  method  =
"bonferroni")
```

Results for Kruskal-Wallis test:

Researcher (n = 44)

Practitioner (n = 47)

Student (n = 22)

Multiple (n = 17)

```
        Kruskal-Wallis rank sum test

data:  Total.score by Role
Kruskal-Wallis chi-squared = 8.6127, df = 3, p-value = 0.03491
```

Dunn (1964) Kruskal-Wallis multiple comparison

p-values adjusted with the Bonferroni method.

```
                Comparison          Z     P.unadj       P.adj
1   Multiple - Practitioner  1.1456507 0.251939721 1.00000000
2     Multiple - Researcher -0.9929856 0.320716978 1.00000000
3 Practitioner - Researcher -2.9078913 0.003638748 0.02183249
4        Multiple - Student -0.1854559 0.852871493 1.00000000
5    Practitioner - Student -1.4884815 0.136623958 0.81974375
6      Researcher - Student  0.8566302 0.391649273 1.00000000
```

Statistical analyses for Council vs regular HFE specialists:

R code for IEA Council vs regular HFE specialists

```
## councilcorrected <- read.table("councilcorrectedforR.txt", sep = ";", header = TRUE)

## onlinecorrected <- read.table("onlinesamplecorrectedforR.txt", sep = ";", header = TRUE)

## councilcorrected$Group <- "Council"
## onlinecorrected$Group <- "Online"

## combined_data <- rbind(councilcorrected, onlinecorrected)

## shapiro.test(councilcorrected$Total.score)
## shapiro.test(onlinecorrected$Total.score)

## library(car)
## leveneTest(Total.score ~ Group, data = combined_data)
## t.test(Total.score ~ Group, data = combined_data, var.equal = FALSE)
```

Results:

Shapiro-Wilk normality test for Council

```
        Shapiro-Wilk normality test

data:  councilcorrected$Total.score
W = 0.94457, p-value = 0.101
```

Shapiro-Wilk normality test for regular HFE specialists

```
        Shapiro-Wilk normality test

data:  onlinecorrected$Total.score
W = 0.98303, p-value = 0.2215
```

Results from Levene's test

```
Levene's Test for Homogeneity of Variance (center = median)
       Df F value  Pr(>F)
group   1  4.7909 0.03038 *
      131
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Results from Welch two sample t test

```
        Welch Two Sample t-test

data:  Total.score by Group
t = 3.1548, df = 63.75, p-value = 0.002451
alternative hypothesis: true difference in means between group Council and group Online is not equal to 0
95 percent confidence interval:
  4.038585 17.986787
sample estimates:
mean in group Council  mean in group Online
            110.65625              99.64356
```

The full code, including data transformation and graph creation may be requested from the researcher

Appendix L: Turnitin report

My Submissions

Part 1 | Part 2 | Part 3 | Part 4 | Part 5

Title	Start Date	Due Date	Post Date	Marks Available
September - December 2025 - Part 1	1 Sept 2025 - 00:00	31 Dec 2025 - 15:07	1 Sept 2025 - 01:00	100

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The end. Thank you for reading.