Towards an Understanding of Physical Activity in People with Chronic Low Back Pain

by

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Declaration

I declare that this doctoral thesis is entirely my own work. My submission as a whole is not substantially the same as any that I have previously made or currently am making, whether in published or unpublished form for a degree, diploma, or similar qualification at any university or similar institution.

Signature: ______________________
DEREK GRIFFIN
Abstract

Physical activity (PA) is well recognised as an essential component of a healthy lifestyle and is commonly recommended as part of a multimodal management approach for people with chronic low back pain (CLBP). However, to date there is limited evidence of how best to promote PA in people with CLBP. Knowledge of the correlates and determinants of PA in this patient group is necessary to facilitate and promote PA in patients’ everyday lives. The main aim of this thesis was to determine the physical and psychological correlates of objectively measured PA in people with CLBP. This doctoral thesis examined the correlates of PA and sedentary activity in people with CLBP using a mixed methods approach.

Initially, a systematic review was undertaken to examine the common assumption that patients with CLBP are less active than healthy individuals. There was no consistent evidence supporting this hypothesis for adults or adolescents. For older adults, there was evidence that they are less active than healthy control based on self-reported levels of PA.

The ActivPAL™ activity monitor has previously been validated as a measure of postural PA in people with CLBP. To further examine this monitor, a study was designed to determine if the ActivPAL™ can also accurately measure the intensity of PA in this patient group. The findings were positive and suggest that the ActivPAL™ “counts” function may be useful, from which one can accurately determine PA intensity especially during locomotor activity.

A study designed to examine the correlates of free-living PA and sedentary activity in people with CLBP revealed an important role of depression and elevated body mass index (BMI) respectively. Moreover, given the heterogeneity of people with CLBP, the comparative PA and sedentary activity profile of patients with and without a neuropathic pain (NeuP) component was examined. The findings are in line with previous findings which suggest that patients with a NeuP component are more disabled and have poorer psychological functioning. However, there was no significant difference in the level of PA or sedentary activity between the groups.

Finally, to add perspective and aid in the interpretation of the quantitative findings of this thesis, a qualitative study was undertaken to explore the perceptions and attitudes towards PA among patients with CLBP. The results, while highlighting a number of important barriers and motivations for PA, support recent experimental evidence which suggests that a decision to engage in or avoid activity is partly dependent on the motivational context of the activity. When patients are intrinsically motivated by non-pain goals, they are more likely to persist with an activity.

In summary, only depression and BMI were associated with objectively measured free-living PA and sedentary activity respectively. From a qualitative perspective, a number of potential barriers and motivations for PA were indentified although it was clear from the results that choosing to engage in or avoid activity was highly task- and context-specific.
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## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AEM</td>
<td>Avoidance-Endurance Model</td>
</tr>
<tr>
<td>ANOVA</td>
<td>Analysis of Variance</td>
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<tr>
<td>BMI</td>
<td>Body Mass Index</td>
</tr>
<tr>
<td>CI</td>
<td>Confidence Interval</td>
</tr>
<tr>
<td>CLBP</td>
<td>Chronic Low Back Pain</td>
</tr>
<tr>
<td>cm</td>
<td>Centimetres</td>
</tr>
<tr>
<td>CPAQ</td>
<td>Chronic pain Acceptance Questionnaire</td>
</tr>
<tr>
<td>CS</td>
<td>Central Sensitization</td>
</tr>
<tr>
<td>DLW</td>
<td>Doubly Labeled Water</td>
</tr>
<tr>
<td>EE</td>
<td>Energy Expenditure</td>
</tr>
<tr>
<td>F</td>
<td>Female</td>
</tr>
<tr>
<td>FABs</td>
<td>Fear-avoidance Beliefs</td>
</tr>
<tr>
<td>FAM</td>
<td>Fear-Avoidance Model</td>
</tr>
<tr>
<td>HADS</td>
<td>Hospital Anxiety and Depression Scale</td>
</tr>
<tr>
<td>hrs</td>
<td>Hours</td>
</tr>
<tr>
<td>IC</td>
<td>Indirect Calorimetry</td>
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<tr>
<td>ICC</td>
<td>Intraclass Correlation Coefficient</td>
</tr>
<tr>
<td>I²</td>
<td>Heterogeneity Statistic</td>
</tr>
<tr>
<td>LBP</td>
<td>Low Back Pain</td>
</tr>
<tr>
<td>LoA</td>
<td>Limits of Agreement</td>
</tr>
<tr>
<td>LPA</td>
<td>Light Intensity Physical Activity</td>
</tr>
<tr>
<td>M</td>
<td>Male</td>
</tr>
<tr>
<td>m.s⁻¹</td>
<td>metres per second</td>
</tr>
<tr>
<td>MET</td>
<td>Metabolic Equivalent</td>
</tr>
<tr>
<td>MVPA</td>
<td>Moderate-Vigorous Physical Activity</td>
</tr>
<tr>
<td>NA</td>
<td>Not applicable</td>
</tr>
<tr>
<td>no/n</td>
<td>Number</td>
</tr>
<tr>
<td>NOS</td>
<td>Newcastle Ottawa Scale</td>
</tr>
<tr>
<td>NRS</td>
<td>Numerical Rating Scale</td>
</tr>
<tr>
<td>NeuP</td>
<td>Neuropathic Pain</td>
</tr>
<tr>
<td>NSLBP</td>
<td>Non-specific Low Back Pain</td>
</tr>
<tr>
<td>ODI</td>
<td>Oswestry Disability Index</td>
</tr>
<tr>
<td>PA</td>
<td>Physical Activity</td>
</tr>
<tr>
<td>PAL</td>
<td>Physical Activity Level</td>
</tr>
<tr>
<td>PCA</td>
<td>Power and Calibration</td>
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<tr>
<td>PCS</td>
<td>Pain Catastrophizing Scale</td>
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<tr>
<td>PD-Q</td>
<td>PainDETECT Questionnaire</td>
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<tr>
<td>PI</td>
<td>Principle Investigator</td>
</tr>
<tr>
<td>POAM-P</td>
<td>Patterns of Activity Measure-Pain</td>
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<tr>
<td>PSEQ</td>
<td>Pain Self-efficacy Questionnaire</td>
</tr>
<tr>
<td>Q-Q</td>
<td>Quartile-Quartile</td>
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<tr>
<td>r</td>
<td>Pearson’s Correlation Coefficient</td>
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<tr>
<td>R²</td>
<td>Coefficient of Determination</td>
</tr>
<tr>
<td>RMR</td>
<td>Resting Metabolic Rate</td>
</tr>
<tr>
<td>ROI</td>
<td>Republic of Ireland</td>
</tr>
<tr>
<td>ROC</td>
<td>Receiver Operating Characteristic</td>
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SBx: Sensor Box
SD: Standard Deviation
SMD: Standardised Mean Difference
SPSS: Statistical Package for the Social Sciences
β: Beta Correlation Coefficient
ρ: Spearmann’s Rho Correlation Coefficient
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For Nan & Kathleen
CHAPTER ONE

General Introduction
1.1. Chronic Pain: An Irish Perspective

Chronic pain is defined as pain that persists beyond the healing phase following an injury (Apkarian et al. 2009). In the Republic of Ireland (ROI), it is estimated that between 19% and 35% of the population experience some form of chronic pain (Breivik et al. 2006; Raftery et al. 2011) with a total annual cost of €5.34 billion (Raftery et al. 2012). Although low back pain (LBP) is the most common site of pain reported, multiple pain sites are common (Kamaleri et al. 2009; Natvig et al. 2010; Raftery et al. 2011). For example, Raftery and colleagues (Raftery et al. 2011) showed that 47.2% of people with chronic pain in the ROI experienced pain in the lower back with approximately 80% of people with chronic pain reporting at least two pain sites. Chronic pain remains an intractable and poorly understood condition with no dominant physical or psychological risk factor sufficient to explain its development (Apkarian et al. 2009).

1.2. Low Back Pain

Low back pain refers to pain between the 12th rib and the inferior gluteal fold with or without leg pain (Airaksinen et al. 2006). A large number of interventions have been proposed, although there does not appear to be a specific treatment that is superior to another (Artus et al. 2010). Low back pain is a prevalent condition across the lifespan with as many as 84% of individuals experiencing LBP during their lifetime (Balague et al. 2011). Low back pain poses significant challenges for clinicians and patients alike and is associated with high direct and indirect individual and societal costs (Whitehurst et al. 2012).

Low back pain is a heterogeneous condition, with patients experiencing varying degrees of pain, disability and psychological co-morbidities including anxiety, depression and fear. The majority of LBP (85%) is described as “non-specific” (Fairbank et al. 2011). This refers to LBP for which a definitive cause is unknown. It is increasingly acknowledged that diagnostic imaging lacks both diagnostic (Shambrook et al. 2011) and predictive validity (McNee et al. 2011).
in patients with LBP. This is in most part due to a high prevalence of imaging “abnormalities” among asymptomatic individuals (Deyo et al. 2009). The connection therefore, between such radiographic findings and LBP is merely speculative.

It is common for people with LBP to report specific aggravating and easing activities or postures in relation to their pain. The mechanical nature of the pain in this group is characteristic of “nociceptive pain”, which is the primary pain mechanism underlying most non-specific LBP (NSLBP) presentations (O’Sullivan, 2005; Smart et al. 2012a). Among people with LBP, clinical presentations with “neuropathic pain” (NeuP) or “central sensitization” (CS) as the primary underlying pain mechanism are less common. Neuropathic pain or CS are characterised by a less predictable pain pattern and more widespread pain in the absence of any clear or consistent mechanical nature to the pain, especially in the presence of CS (Smart et al. 2012b; Smart et al. 2012c). The presence of NeuP or CS is associated with higher levels of pain, disability and psychological co-morbidities (Smart et al. 2011; Beith et al. 2011). In a recent large UK study examining patients with LBP in primary care, NeuP or CS was the dominant pain mechanism for approximately 16% of the sample (Beith et al. 2011). However, among patients with chronic low back pain (CLBP) specifically, the prevalence may be as high as 54% (Kaki et al. 2005).

1.3. Bio-psychosocial Model of Low Back Pain

Recent advances in pain neurophysiology have increased our understanding of the complexity and multidimensional nature of chronic pain. The traditional view of pain as an “input” from injured tissues has changed; pain is now viewed as a complex “output” of the brain and is essentially the brain’s “opinion of an organism’s state of health” (Burton, 2011). The degree of pain that a patient experiences is dependent on a multitude of factors including physical factors (posture, strength, endurance, motor control), psychosocial factors (mood, catastrophizing, fear, anxiety), cognitive factors (beliefs, previous pain experiences), lifestyle factors (physical activity, sleep, stress), personal factors (work) and neurophysiological factors (pain physiology) (O’Sullivan,
The multidimensional nature of chronic pain is illustrated in figure 1.1. Recent studies have confirmed the powerful role of emotion (Wiech & Tracey, 2009), expectation (Bingel et al. 2011) and attitudes and beliefs (Briggs et al. 2010) in the modulation of pain. Moreover, psychological factors are believed to play a pivotal role in the transition from acute to CLBP (Chou & Shekelle, 2010). There is a consensus in the literature that LBP needs to be managed within a bio-psychosocial framework where consideration is given to the physical, cognitive, psychological, social, environmental and cultural factors that may interact to influence the degree of pain a patient experiences (Edwards & Jones, 2013).

Figure 1.1: Bio-psyhosocial Model of Pain
1.4. Management of Chronic Pain in the Republic of Ireland

Treatment facilities in the ROI for the management of chronic pain including CLBP are not in line with internationally recommended standards (Fullen et al. 2006). The number of multidisciplinary pain management clinics is insufficient considering the high prevalence of chronic pain in the ROI. In addition to multidisciplinary treatment facilities, patients may receive treatment at unidisciplinary pain clinics which are usually led by the Anaesthetist or Pain Medicine Consultant. It is generally believed that patients who are referred to secondary care or those who attend a specialist-led pain clinic experience more complex and intractable chronic pain requiring more complex intervention (Nicholas, 2004). This sub-group of patients, which forms the basis of this thesis, may be distinctively different from patients seen by other healthcare professionals such as general practitioners and physiotherapists in hospital outpatient departments or in private practice settings. In this regard it is important that research acknowledges that patients with CLBP are a highly variable group with varying degrees of pain severity and functional limitations.

1.5. Physical Activity & Low Back Pain

Physical activity (PA) is defined as “any bodily movement produced by skeletal muscle that results in energy expenditure (EE)” (Caspersen et al. 1985). Physical inactivity has been described as the “greatest public health problem of the 21st century” (Blair, 2009). There is unequivocal evidence supporting the role of PA in the primary and secondary prevention of chronic disease including cardiovascular disease, diabetes mellitus and cancer (Warburton et al. 2006). Physical activity is well recognised as an essential component of a healthy lifestyle and is universally recommended in international LBP management guidelines (Koes et al. 2010). Disuse is an assumed consequence of LBP, whereby patients become less physically active as a result of their pain or fear of pain/re-injury (Vlaeyen & Linton, 2000). This is believed to lead to a vicious cycle of lower levels of PA and increasing pain, ultimately promoting chronicity. As a result, the assessment of PA among patients with CLBP has become an important research topic. This increase in
research activity has been coupled with an increasing availability of novel devices that provide an objective measure of PA in free-living environments. Aside from its obvious health-related benefits, PA is an important measurement domain in people with CLBP for three main reasons:

1) There is evidence that physical inactivity is a risk factor for the development of CLBP (Nilsen et al. 2011) and therefore, promoting PA among individuals with CLBP may be important as part of a multidimensional management approach.

2) Exercise and PA play a role in the modulation of pain and can reduce pain intensity (Hoffman et al. 2005; McLoughlin et al. 2011; Sluka et al. 2013).

3) Physical activity is effective in combating some of the common co-morbidities commonly experienced by people with CLBP e.g. depression, anxiety, sleep disturbance and obesity (Powell et al. 2011).

1.6. Rationale for the Thesis

Physical activity or exercise forms an important component of most management approaches to LBP and is increasingly used as a means of reducing pain and disability. For example, there is evidence that aerobic exercise is effective at reducing pain perception in a number of chronic pain conditions including CLBP and fibromyalgia in both experimental (Hofmann et al. 2005) and clinical settings (van Middelkoop et al. 2011; Hooten et al. 2012). The increased effectiveness of PA over more passive interventions has been established; although as a standalone treatment the effect size is generally low to moderate (van Middelkoop et al. 2011).

Epidemiological data which shows a strong, negative association between lower levels of PA and the prevalence of chronic pain (including CLBP) further supports the use of PA as an intervention in people with CLBP. For example, adults aged 20 to 64 who engage in recreational PA two to three
times a week have a 12% lower prevalence of chronic pain (Landmark et al. 2011).

In addition to the physical effects of exercise or PA, there is strong evidence that PA is effective in improving mood and reducing the severity of depression in both non-pain populations (Robertson et al. 2012) and in people with a chronic illness including chronic pain (Herring et al. 2012). This is important as depression is commonly reported in people with persistent musculoskeletal pain and is positively and negatively associated with both pain intensity and treatment outcome respectively (Linton & Bergbom, 2011; Linton et al. 2011).

In summary, PA is safe, requires little or no equipment and may positively impact on both the physical aspects of pain as well as the psychological co-morbidities that often accompany it. Therefore, promoting PA in people with CLBP should be an integral part of the management process.

While many studies have established the importance of PA in people with CLBP, there is less evidence on how best to promote or implement PA interventions in the clinical setting. A necessary first step is to determine the correlates or determinants of PA among people with CLBP. An understanding of the correlates of PA would enable the clinician to tailor rehabilitation programmes to individual patients with the ultimate aim of increasing their level of PA. Recent developments in the measurement of free-living PA using objective measures such as accelerometers have made such studies possible. The correlates of PA in people with CLBP are likely many and complex. The use of quantitative methods only may fail to capture this complexity. As research on the correlates of PA in people with CLBP is in its infancy and explorative, qualitative research may provide useful additional information, which may be helpful in designing future quantitative studies.

Therefore, the main focus of this thesis was to examine the correlates of free-living PA (measured using an activity monitor) using a mixed methodology design.
1.7. Outline & Aims of Thesis

**Aim 1:** To review the cognitive behavioural models that have been proposed to influence disability and PA in patients with CLBP and to provide an overview of the methods of measuring PA (Chapter Two).

Considering the complexity of PA behaviour, the selection of potential correlates or determinants is primarily based on existing behavioural theories or models (Bauman et al. 2012). In Chapter Two, the models that have been specifically proposed to explain disability and PA for people with chronic pain will be reviewed. This will provide the theoretical basis for the selection of potential correlates that are used in the cross-sectional study presented in Chapter Five.

A better understanding of the correlates of PA in people with CLBP is only possible with the accurate assessment of PA. In Chapter Two, the reader will be introduced to the various methods of measuring PA and their methodological considerations. Specifically, the ActivPAL™ activity monitor will be discussed in detail as a suitable and clinically-relevant measure of PA in people with CLBP.

**Aim 2:** To determine if individuals with CLBP have an altered level and/or pattern of PA compared to healthy individuals (Chapter Three).

A decrease in one’s habitual level of PA is commonly assumed in patients with CLBP and is central to the fear-avoidance model (FAM) (Vlaeyen & Linton, 2000). The aim of Chapter Three is to examine the evidence to support this claim. Specifically, the systematic review provides an overview of studies conducted to date which have directly compared the level and/or pattern of PA of people with CLBP compared to healthy individuals.

**Aim 3:** To determine the criterion validity of the ActivPAL™ activity monitor as a measure of PA intensity in people with CLBP (Chapter Four).
The ActivPAL™ activity monitor is a motion sensor that has been validated in patients with CLBP as a measure of postural PA. However, the ActivPAL™ activity monitor also provides information on the intensity of PA (METs or metabolic equivalent); although this outcome has not been previously validated in people with LBP. Activity intensity may be a useful outcome when examining the correlates of PA in people with CLBP as it is possible that different relationships exist between the different dimensions of PA (duration, frequency, intensity and volume) and the proposed correlate variables. In Chapter Four, the criterion validity of the ActivPAL™ activity monitor as a measure of energy expenditure (EE) among people with CLBP is examined. Actual PA intensity was measured using indirect calorimetry while the patient performed a number of treadmill-based walking tasks and tasks designed to replicate activities of daily living under laboratory conditions.

**Aim 4:** To examine the correlates (physical & psychological) of free-living PA in people with CLBP (Chapter Five-Part One).

The aim of the cross-sectional study presented in Chapter Five-Part One is to examine the relationship between a number of physical and psychological factors and objectively measured free living PA and sedentary activity in patients with CLBP who attend a specialist-led pain clinic. A number of potential correlates are examined, based on a number of cognitive-behavioural models of disability and PA as presented in Chapter Two.

**Aim 5:** To compare the PA and sedentary activity profile of people with CLBP with and without a NeuP component (Chapter Five-Part Two).

As mentioned previously, NeuP is a challenging problem to manage and is associated with higher levels of pain and disability and a lower quality of life. With regards to LBP, the PA literature to date has focused primarily on patients with NSLBP. Based on the broader literature in the area, one may hypothesise that patients with a neuropathic component to their LBP will exhibit lower levels of PA compared to individuals without a NeuP component. In Chapter Five-Part
Two, the PA and sedentary activity profile of patients with CLBP with and without a NeuP component are compared in an attempt to address this question. We are not currently aware of any studies to date that have addressed this question, which may ultimately have important clinical implications.

**Aim 6: To explore the perceptions, attitudes and beliefs towards PA among patients with CLBP (Chapter Six).**

Currently, little is known about the personal beliefs and attitudes towards PA among patients with CLBP. Qualitative data has the potential to enrich quantitative findings and allows researchers to explore issues that are difficult to measure quantitatively. The aim of Chapter Six is to explore the correlates of PA among individuals with CLBP from a qualitative perspective. Using a semi-structured interview methodology, various topics relating to PA are explored including the impact of pain on levels of PA; barriers to and motivations for PA and pattern(s) of PA.
CHAPTER TWO
2.1. Background

Physical activity is a complex human behaviour. Many studies to date have examined the correlates and determinants of PA in healthy individuals across the lifespan and have highlighted the influence of a number of factors across multiple domains including personal, psychological, environmental and social domains (Bauman et al. 2012). However, understanding the correlates and determinants of PA in clinical populations is also of considerable importance, given the increased potential for lower activity levels as a result of their condition (van den Berg-Emons et al. 2010). While many of the correlates identified for healthy populations are also likely to be relevant to clinical populations, correlates or determinants specific to people with chronic disease including chronic pain may be of importance. In this chapter, we will introduce the reader to the main cognitive-behavioural models that have been proposed to explain PA and disability in people with chronic pain. This will form the basis for the selection of potential correlates of free-living PA in the cross sectional study presented in Chapter Five of this thesis. Physical activity research in people with chronic pain is currently in its infancy and therefore, such theoretical models are a useful starting point in the selection of potential correlates or determinants for research purposes. The reader will also be introduced to important conceptual differences between PA and disability and how both of these concepts may potentially inform PA research in people with chronic pain. Finally, in this chapter, a useful overview of different methods of measuring PA and their associated methodological considerations is provided. The ActivPAL™ activity monitor will be discussed as a suitable and simple method of measuring free-living PA in people with CLBP.

2.2 Physical Activity versus Exercise

“Physical activity” is defined as “any bodily movement produced by skeletal muscles that results in EE” (Caspersen et al. 1985). The term “exercise” is not synonymous with “PA”. Exercise is a specific form of PA that is planned, structured, repetitive and aims to enhance physical fitness and overall
health (Caspersen et al. 1985). Various domains of PA exist and include occupational, household and leisure-time PA.

2.3. Disability versus Physical Activity

Disability is defined as any restriction or lack of ability to perform an activity within the range considered normal for a human being (WHO, 1980). In this regard, disability is a measure of an individual’s self-reported capacity to perform a specific activity or task. In contrast, PA refers to actual behaviour and is a measure of what a patient actually does on a daily basis. Among patients with acute and sub-acute LBP, the correlation between PA and disability is weak and non-significant (Lin et al. 2011). This illustrates that both constructs are conceptually distinct. In patients with CLBP however, there is a moderate, negative relationship between PA and disability (Lin et al. 2011). While there may be a direct relationship between PA and disability in this group, it is also possible that other “unknown” variables affect both disability and PA and may explain this relationship. This relationship is important as it suggests that many of the factors that are related to disability in people with chronic pain may also be relevant to PA. This is illustrated in figure 2.1.

2.4. Explanatory Models of Physical Activity & Disability

Various cognitive-behavioural and psychological models have been proposed to explain disability and PA behaviour among patients with chronic pain. The most widely accepted model is the Fear-Avoidance Model (FAM) (Vlaeyen & Linton, 2000), although the Avoidance-Endurance Model (AEM) (Hasenbring et al. 2001) has in recent times, gained empirical support. Models of disability including the Self-efficacy Model (Bandura, 1986) and the Acceptance and Commitment Model (McCracken & Vowles, 2006) are more recent models in the chronic pain literature. However, it is likely that there is significant overlap between these various models and no single model is likely to explain complex human behaviours such as PA. The moderate relationship between disability and PA in patients with CLBP means that many of the factors
associated with disability may also be relevant when examining PA (see figure 2.1).

2.4.1 Models of Physical Activity

2.4.1.1. The Fear-Avoidance Model (FAM)

Although acute pain is adaptive and designed to promote healing, a number of patients may misinterpret their pain as a sign of serious disease or illness (De Peuter et al. 2009). This concept known as catastrophizing, results in pain-related fear. According to the FAM in chronic pain (Vlaeyen & Linton, 2000), disuse or decreased PA levels results from fear of pain and subsequent fear and avoidance of activities that are known or believed to exacerbate pain (Leeuw et al. 2007). This reduction in PA levels is believed to lead to decreased muscle strength and endurance and is believed to play a pivotal role in the development and maintenance of CLBP.

The association of fear-avoidance beliefs (FABs) and disability is well established and supported in the literature (Wideman et al. 2009; Vlaeyen & Linton, 2012; Crombez et al. 2012). However, whether or not FABs lead to a reduced level of PA is less clear. According to the FAM, patients who are fearful will ultimately avoid activity resulting in reduced aerobic fitness, decreased muscle strength and reduced flexibility i.e. deconditioning. However, the degree of deconditioning does not appear to be associated with the level of FABs (Smeets et al. 2009). This finding casts doubt on the proposed causative role of FABs in determining PA levels as outlined in the FAM. Furthermore, other studies have failed to show a relationship between PA and level of FABs (Bousema et al. 2006; Ryan et al. 2010; Helmus et al. 2012). Importantly, other studies have provided conflicting findings. A recent study has shown a significant independent relationship between fear of movement and PA levels in patients with CLBP (Alschuler et al. 2011). However, this study measured PA over a very short timeframe and this may not be representative of participants’
Figure 2.1: The Association between Physical Activity and Disability in Chronic Pain.
“habitual” level of PA. The majority of studies to date have been cross-sectional in nature where causality cannot be determined. In this regard, prospective, longitudinal studies are required.

Pain catastrophizing defined as “a negative, cognitive orientation to pain” (Ruscheweyh et al. 2011) is another central component of the FAM. It has consistently been associated with pain intensity, functional disability and poorer outcome among patients with chronic pain (Smeets et al. 2006; Quartana et al. 2009; Cassidy et al. 2012; Burns et al. 2012). However, the association between catastrophizing and PA levels is less well investigated and is debated. Cross-sectional data indicates that patients with CLBP and a high level of catastrophizing are less active than those with a lower level of catastrophizing (Elfving et al. 2007). Interestingly, Verbunt et al. (2005) found catastrophizing to be significantly associated with perceived activity decline and not actual PA levels in patients with sub-acute LBP. Similar to FABs, some studies have failed to show a relationship between pain catastrophizing and objectively-measured free-living PA (Alschuler et al. 2011; Helmus et al. 2012). There is emerging evidence that pain catastrophizing is a dynamic construct that is influenced by pain intensity (Wade et al. 2012). This questions the validity or appropriateness of measuring pain catastrophizing at one point in time and may make any relationship between pain catastrophizing and PA difficult to establish.

Overall, the association between FABs, pain catastrophizing and PA levels is inconclusive. There are a number of possible reasons for these findings. It is possible that patients with CLBP avoid specific movements or activities without reducing their overall activity levels (Leeuw et al. 2007). Fear-avoidance behaviour is likely to be both context and task specific which is difficult to measure. It is also possible that the relationship between fear-avoidance variables and PA is non-linear.

2.4.1.2. The Avoidance-Endurance Model (AEM)

The AEM offers a complementary explanation to the FAM for the development and maintenance of CLBP (Hasenbring et al. 2001). According to
this model, in addition to patients who fear their pain, a sub-group of patients exists who give little or no attention to their pain and therefore persist with activity despite pain. “Avoiders” are characterised by avoidance of movements or activities and report higher levels of FABs and catastrophizing thoughts compared to other groups (Hasenbring & Verbunt, 2010). For this group, disability is believed to result from physical inactivity and physical deconditioning. In contrast and in accordance with the AEM, “persisters” continue to engage in PA despite pain, often to the point of significantly exacerbating their pain (Hasenbring & Verbunt, 2010). These patients may have a comparable or a higher level of PA compared to healthy individuals (Hasenbring et al. 2001) and may develop pain due to overload of soft-tissue structure and bone (Hasenbring et al. 2009). Disability for this group of patients is believed to result from ongoing pain due to the activity persistence. Heneweer et al. (2009) showed that both high and low levels of PA were associated with a greater prevalence of CLBP.

There is mounting evidence to support the existence of various activity patterns in patients with CLBP (Huijnen et al. 2011a; Hasenbring et al. 2012). Huijnen et al. (2011a) found that “persisters” reported higher pain and disability levels compared to “adaptive copers”. “Persisters” however were not more active than “avoiders”. This may reflect the context-specific nature of avoidance behaviour which does not necessarily result in an overt reduction in overall activity levels. An alternative explanation is that patients who persist with activity despite pain may be eventually forced to rest due to increasing pain levels (Hasenbring & Verbunt, 2010).

Persistence behaviour appears highly complex and has been explored further in a recent study (Kindermans et al. 2011). The authors concluded that various forms of persistence behaviour exist; namely task-persistence (focus on getting the job done); pain-contingent persistence (activity behaviour is determined by pain levels) and excessive persistence (not respecting one’s limits by doing too much). Only the latter was positively related to depression and disability and surprisingly, task-contingent persistence was negatively associated with depression and disability. This finding has been supported by a recent systematic review examining PA patterns in people with chronic
musculoskeletal pain (Andrews et al. 2012). Therefore, persistence behaviour appears maladaptive in some cases only and in other cases may contribute to lower levels of disability.

Importantly, patients are unlikely to rely on one specific activity pattern or strategy. Researchers have identified a subgroup of patients with CLBP who report both persistence and avoidance behaviour (Huijnen et al. 2011a; Hasenbring et al. 2012). These so-called “mixed performers” differ from “persisters” in that they also score high on avoidance measures. The idea that patients may persist with activity despite scoring high on a fear-avoidance measure may also explain the apparent lack of association between fear-avoidance variables and PA as discussed previously.

2.4.2 Models of Disability

2.4.2.1 Self-efficacy Model

Self-efficacy is “the belief in one’s capabilities to organize and execute the courses of action required to manage prospective situations” (Bandura, 1986). In simple terms, it refers to the individual’s belief in his/her ability to successfully perform a specific behaviour such as PA (Dutton et al. 2009). Self-efficacy beliefs are believed to influence an individual’s course of action, effort and perseverance in the presence of adversity (Bandura, 1986). Self-efficacy beliefs have been found to be associated with actual PA levels in healthy individuals and in patients with a variety of clinical conditions including multiple sclerosis (Motl et al. 2006; Motl & Snook, 2008), type-II diabetes mellitus (Dutton et al. 2009) and patients undergoing cardiac rehabilitation (Woodgate & Brawley, 2008). We are not aware however of any study that has investigated this relationship in patients with CLBP. Self-efficacy appears to mediate the relationship between pain intensity and disability in patients with CLBP and is more important than fear of movement (Costa et al. 2011). In a prospective, longitudinal study, Foster et al. (2010) found that self-efficacy was more important than depression, fear-avoidance and catastrophizing in explaining
disability levels in patients with CLBP. In view of these findings, research investigating the role of self-efficacy and its association with PA in patients with CLBP is warranted.

2.4.2.2 Acceptance and Commitment Model

Acceptance involves “a willingness to engage in activity with pain present and to allow pain to register in experience without attempts to control or avoid it” (McCracken & O'Brien, 2010). Acceptance behaviour is characterised by engaging in valued life activities despite pain (activity engagement) as well as a willingness to experience pain without necessarily trying to control it (pain willingness) (McCracken & Eccleston, 2005). Acceptance and commitment therapy aims to encourage participants to persist with valued activities despite the presence of pain (Kerns et al. 2011) and a recent systematic review found a small to moderate treatment effect using this approach (Veehof et al. 2011). In this way, pain acceptance is the antithesis of experiential avoidance as proposed in the FAM. Therefore, in theory it may be positively associated with higher levels of PA. Using a cross-sectional study design, McCracken and Samuel (2007) showed that patients with chronic pain who reported high “persistence” behaviours and low FABs had significantly higher levels of acceptance compared to individuals characterised by avoidance behaviours. This study did not specifically measure PA however. These findings are supported by a more recent study among female patients with arthritis (Gyurcsik et al. 2011). Patients with a higher level of acceptance engaged in more self-reported moderate or vigorous PA. Finally, Richardson et al. (2010) found acceptance to be a significant predictor of self reported pain interference in daily activities in people with chronic pain. In light of the above findings, acceptance appears to be important in understanding patient functioning in chronic pain. Its association however with actual PA should be addressed in future studies.
2.4.2.3 Stress Model

The experience of anxiety and depression are central to our understanding of the stress model of chronic pain. It is estimated that depression and pain coexist in approximately 30-50% of cases (Kroenke et al. 2009). There is strong evidence that the presence of depression is positively associated with self-reported disability levels in people with chronic musculoskeletal pain (Arnow et al. 2011; Hall et al. 2011). Moreover, depression is associated with poor treatment outcome in people with chronic pain (Linton et al. 2011; Bergbom et al. 2011). The presence of depression increases the likelihood of developing persistent pain, however persistent pain also increases the likelihood of developing depression (Linton et al. 2011).

Despite its established associations with disability and treatment outcomes, few studies have examined the relationship between depression and PA in people with CLBP. Bousema et al. (2007) found that patients with a depressed mood were more likely to exhibit a decrease in their habitual level of PA, one year after the onset of pain. Conversely, a more recent study failed to show a significant relationship between depression and objectively measured PA in people with CLBP (Huijnen et al. 2010). In contrast there was a significant relationship between depression and the difference between the objective and self-reported PA levels. In this regard, it is possible that patients with CLBP and coexisting depression may perceive their activity level as lower than it really is. These findings by Huijnen et al. (2010) are surprising given the established association between depression and PA in healthy individuals, an association which appears to be bidirectional in nature (Azevedo Da Silva et al. 2012). The conflicting findings of the limited number of studies that have been undertaken among people with CLBP to date emphasize the need for further work in this area.

2.5. Summary

In summary, a number of cognitive-behavioural models have been proposed for people with chronic pain. While the ability of these models to explain the development and persistence of disability has been extensively
examined, the ability of the individual models and their component variables to explain PA behaviour is less well investigated. The findings of studies thus far suggest that explaining PA is more complex than explaining disability levels with the findings often inconclusive and/or conflicting.

2.6. Measurement of Physical Activity

2.6.1 Background

Physical activity is a multidimensional and complex behaviour that is difficult to measure accurately. Although, by definition, PA is associated with EE, the terms are not synonymous. Physical activity is a behaviour with EE being a consequence of this behaviour. Moreover EE due to PA only accounts for approximately 15-30% of total EE (Lagerros & Lagiou, 2007). Resting metabolic rate and the thermic effects of feeding (EE due to digestion and absorption of food) together account for approximately 70-85% of total EE (Lagerros & Lagiou, 2007). Measures of PA are broadly classified as being self-report or objective. Examples of the former include questionnaires and diaries. Examples of the latter include activity monitors, physiological sensors and pedometers.

2.6.2. Self-report versus Objective Measures of Physical Activity

Physical activity may be measured using direct observation or assessed using a variety of self report measures including questionnaires and activity diaries. Questionnaire-based measures of PA have been the method of choice for use in larger epidemiological studies considering their low cost and ease of use (Lagerros, 2009). However, recall bias and social desirability bias are significant problem associated with these measures (Slootmaker et al. 2009). Moreover the response to a questionnaire will be influenced by depression/anxiety, health status and cognitive functioning (Murphy, 2009). This is an important consideration in chronic pain populations due to the increased likelihood of depression/anxiety and cognitive impairment (Moriarty et al. 2011;
In patients with CLBP there is evidence that self-report measures do not provide an accurate estimate of PA when compared to objective methods (van Weering et al. 2011). Objective measures of PA include accelerometers and pedometers and are believed to overcome many of the problems of self-report measures. They provide real-time data storage and can record activity continuously over a long time period (Slootmaker et al. 2009). Although accelerometers are not without their limitations, they appear to provide a more accurate measure of actual free-living PA than self-report measures (Bussmann et al. 2009).

### 2.6.3. Activity monitors/Accelerometers

Accelerometers are “devices that measure applied accelerations along a sensitive axis which can be used to measure the rate and intensity of body movement in up to three planes” (Godfrey et al. 2007). Accelerometers can be used to classify the duration, frequency and intensity of PA. They are generally small in size and are able to record data on free-living PA over long time periods. Objective measures of PA such as accelerometers are believed to overcome many of the disadvantages of self-report measures discussed earlier. The raw output of most accelerometers is known as “counts”. Counts are stored and summed over a given time period called an “epoch”. Total count number represents the *volume* of PA. Studies to date have validated various accelerometers by assessing the relationship between accelerometer counts and EE measured using doubly-labeled water (DLW) or indirect calorimetry. Several regression equations based on this relationship have been obtained to predict EE based on total counts. All of these equations are based on the assumption of a linear relationship between accelerometer counts and EE (Crouter & Bassett, 2008). The equations and cut-offs determined from these calibrations are sensitive to the type of activities included in the particular study (Troiano, 2006). Therefore, the generalisability of results to estimate free-living EE from accelerometers validated under laboratory conditions using treadmill walking or running is limited (Crouter et al. 2006). To overcome the limitation of counts, other monitors provide data on postural PA e.g. time sitting, lying,
walking etc. Such an approach may have better clinical utility by providing more readily interpretable information. The ActivPAL™ activity monitor is one such example and will be discussed in detail later in this chapter.

2.6.4. Using Activity Monitors in Research: Methodological Considerations

2.6.4.1. Monitor Selection

The large number of PA monitors currently available can make it difficult to decide on the most appropriate measure to use. The precise domain of PA under investigation (e.g. type of activity; EE; sedentary activity etc) will to a large extent dictate the measure used (Warren et al. 2010). However, other factors such as cost, availability, participant burden, population specific concerns and time will also impact on the choice of measure (Warren et al. 2010). In patients with chronic pain, activity monitors that can identify specific activities and postures may be advantageous (Verbunt et al. 2012). Recent evidence supports the existence of subgroups of individuals who use various cognitive-behavioural coping strategies to manage their activity levels (i.e. avoidance versus endurance coping) (Huijnen et al. 2011a; Hasenbring et al. 2012). These groups may present with distinct patterns of PA where it is possible that the total time spent in active (standing, walking) and passive postures (sitting, lying) is different as well as the distribution of active/passive postures over the course of a day (Verbunt et al. 2012).

2.6.4.2. Number of Days Recording

For healthy adults it is recommended that three to five full recording days are included in the analysis (Trost et al. 2005). To meet this requirement, many studies use a measurement frame of seven days to allow for missing data due to non-wear time or monitor malfunctioning. For people with chronic pain it is recommended to include more that the lower limit of three days (Verbunt et al. 2012). People with chronic pain may exhibit fluctuating activity levels day to day.
(Huijnen et al. 2009) which may not be accurately captured using a shorter timeframe. For people with chronic pain, it is also recommended that at least one weekend day be included in the analysis (Verbunt et al. 2012).

2.6.4.3. Number of Recorded Minutes per Day

Activity monitors may be worn for the whole 24 hour period or during “waking” hours only. Moreover, the monitor may be intermittently removed for certain activities such as showering, swimming etc or may be removed for other reasons by participants. Researchers must account for this in the analysis and decide how much “non-wear time” is acceptable for a day to still be considered a valid representation of their “habitual” level of PA. For healthy populations and for people with chronic pain, it is recommended that a “valid” day must include at least 600 minutes of wear-time during waking hours (Healy et al. 2011; Verbunt et al. 2012).

2.6.4.4. Identification of Non-wear Time

During the course of the measurement period, participants may remove the monitor which must be identified in the analysis. Researchers normally rely on “count” values to determine non-wear periods. In theory, when a monitor is not worn and therefore not moving, the count value will be zero. The most common approach in the literature is to exclude time periods of ≥ 60 minutes of consecutive zero counts from the analysis (e.g. Healy et al. 2011; Hamer et al. 2012a). Studies which involve adolescent participants often use a timeframe of 20 minutes (e.g. Carson & Janssen, 2011), with recent data suggesting that a period of ≥ 90 minutes of zero counts may be more appropriate for elderly groups or certain clinical populations (due to the increased likelihood of being sedentary) (Semanik et al. 2010; Choi et al. 2011). Furthermore, some authors advocate allowing short “interruptions” of limited movement (counts) of ≤ two minutes within the time period (Winkler et al. 2012). Caution is needed however; as most of the research on non-wear algorithms has been conducted using the
Actigraph monitor and therefore the results may not necessarily be applicable when using other monitors.

2.7. The ActivPAL™ Activity Monitor

The ActivPAL™ activity monitor (PAL Technologies, Glasgow, UK), consisting of a uniaxial piezoresistive accelerometer is a small (35mm x 53mm x 7mm), lightweight (15g) device used to measure postural PA. It is worn on the midline or the lower one third of the anterior thigh. Currently the monitor is not waterproof and needs to be removed during water-based activities. Raw accelerations (ActivPAL™ counts) are recorded every tenth of a seconds and are summed over 15 seconds “epochs” using the ActivPAL™ proprietary software. Information on the following parameters is readily available: time spent standing, time spent sitting/lying, time spent stepping (walking), time spent upright (stepping plus standing), step count, cadence, metabolic equivalent (MET) value (based on a proprietary calibration equation) and the number of transitions between sitting and standing.

2.7.1. Validity of the ActivPAL™ Activity Monitor

Postural PA: The criterion validity of the ActivPAL™ activity monitor as a measure of postural PA has been confirmed. Grant et al. (2006) showed that the ActivPAL™ was valid in measuring time spent sitting, upright, standing and stepping compared to the criterion measure of direct observation. The time difference between the two measures was 0.19%, 0.27%, 1.4% and 2% for time spent sitting, upright, standing and walking respectively. In CLBP specifically, Ryan et al. (2008) found a high agreement (97%) between the ActivPAL™ posture classification and direct observation. Differences between the ActivPAL™ and direct observation were minimal across both “posture-based tasks” and “activities of daily living tasks”. However, time spent standing and walking were less accurately measured by the ActivPAL™ during “activities of daily living tasks” compared to the “posture-based tasks”, both showing wide limits of agreement (LoA). Although the LoA were wide, the mean difference
between the ActivPAL™ and direct observation for walking and standing was small (1.2% and 2.4% respectively).

**Step Count:** Among patients with CLBP, Ryan et al. (2008) showed that the ActivPAL™ was 99% accurate in measuring step count and cadence during treadmill walking. Studies involving healthy volunteers have confirmed the accuracy of the ActivPAL™ for measuring step count during treadmill walking (approx 99% accuracy) (Grant et al. 2006; Dahlgren et al. 2010; Feito et al. 2012). Feito et al. (2012) showed that the device appeared somewhat less accurate with slower treadmill speeds and during free-living walking tasks. During the free-living walking trial, the ActivPAL™ underestimated step count by approximately 30%. These findings are in direct contrast to the results from Busse et al. (2009) who found that the ActivPAL™ recorded 0.03% more steps during outdoor walking. Also the ActivPAL™ appears to overestimate step count during jogging by 10-15% (Dahlgren et al. 2010).

**Sedentary Activity** (Time sitting or lying): As described above, in a laboratory-based study, Ryan et al. (2008) found the ActivPAL™ to be a highly accurate measure of time spent sitting or lying in patients with CLBP. Kozey-Keadle et al. (2011) found that in a free-living environment, the ActivPAL™ underestimated sedentary time by only 2.8% when compared to direct observation. Given its precise estimates of time spent sitting/lying, the ActivPAL™ activity monitor is now considered as the gold standard measure of sedentary activity. For the purposes of this thesis, sedentary activity will be defined as time spent in sitting and/or lying.

Overall, the ActivPAL™ activity monitor is a valid measure of PA, sedentary activity and step count. The step count accuracy appears better during treadmill walking or continuous walking compared to free-living activities or activities of daily living but this is not surprising given the controlled nature of the laboratory testing. Free-living activity is likely comprised of intermittent activity compared to the continuous nature of walking in laboratory settings which may explain the findings (Feito et al. 2012). There is a need for more studies examining the accuracy of the ActivPAL™ as a measure of step count during free-living walking, as to date findings have been conflicting. The ability
of the ActivPAL™ to measure both sedentary activity and PA is one of its main advantages. The ActivPAL™ activity monitor is unique in its ability to differentiate upright posture from sitting and lying. Importantly it is also accurate in differentiating sitting/lying from standing. This is important as recent evidence suggests that replacing sitting/lying activities with quiet standing is beneficial for overall cardio-metabolic health (Owen et al. 2010). Finally, for the purposes of the current study, the established validity of the ActivPAL™ among individuals with CLBP (Ryan et al. 2008) is important. Few monitors have been validated specifically in people with CLBP which can make monitor selection for use in research studies more difficult.

2.7.2. Reliability of the ActivPAL™ Activity Monitor

**Test-retest reliability:** The test-retest reliability of the ActivPAL™ for step count is high. Dahlgren et al. (2010) reported intraclass correlation coefficient (ICC) values of between 0.88 and 0.95 for treadmill walking across three different speeds. As is to be expected the ICC value was moderate (0.69) for self-paced, overground walking. This is likely to reflect a true difference in step count between both measurement periods and not measurement error. These findings are supported by Khalid et al. (2011) who found the ActivPAL™ to be highly reliable across three different treadmill speeds, both on the flat and on a 5% incline (ICC= 0.99). The test-retest reliability for treadmill jogging was also high (ICC= 0.81).

**Inter-instrument reliability:** The inter-instrument reliability refers to the comparative accuracy of two identical ActivPAL™ monitors. Grant et al. (2006) reported ICC values greater than 0.99 for time spent sitting, standing, walking and upright during “posture-based tasks” and during “activities of daily living”. The inter-instrument reliability for determining step count is high (≥0.99) during treadmill walking and outdoor (free-living) walking at various speeds (Ryan et al. 2006). These findings have been supported by Moorhead et al. (2007) who reported “excellent” inter-instrument reliability for the ActivPAL™ during treadmill walking and self-paced walking on flat ground.
2.8. Summary

Physical activity behaviour in patients with CLBP is likely complex with no single factor or model likely sufficient to fully explain it. The various cognitive-behavioural models discussed in this chapter are all potentially relevant to better understanding PA and further research is needed to determine the degree of interplay between these models among patients with CLBP. Measuring PA in patients with CLBP is dependent on the use of an accurate activity monitor. The choice of monitor and the methodology used can influence study outcome. In this chapter, we have discussed the considerations needed when choosing an appropriate monitor and current best practice guidelines for measuring free-living PA using activity monitors. More specifically, the ActivPAL™ activity monitor is a valid, reliable and user-friendly monitor that is appropriate for measuring free-living, habitual PA among people with CLBP. Its small size and clinically relevant outcomes make it useful for use among clinical populations.
CHAPTER THREE

Do Patients with Chronic Low Back Pain Have an Altered Level and/or Pattern of Physical Activity Compared to Healthy Individuals? A Systematic Review of the Literature
3.1. Background

It is reported that as many as 80% of the population will experience an acute episode of LBP during their lifetime (Freburger et al. 2009). Despite the favourable prognosis of acute LBP, approximately 5% of patients will subsequently develop sub-acute and CLBP (Apkarian et al. 2009). Chronic low back pain remains a highly prevalent, global medical problem and is a source of high levels of disability and distress for patients (Carey et al. 2009). To date, no treatment appears to be superior to another in the management of CLBP (Wand & O’Connell, 2008).

Physical inactivity has been described as “the greatest public health problem of the 21st century” (Blair, 2009). The common assumption that patients with CLBP are less active than comparable healthy individuals is in the most part due to the large body of literature supporting the FAM. According to the FAM in chronic pain, disuse or a decreased level of PA results from fear of pain and subsequent fear and avoidance of activities that are known or believed to exacerbate pain (Vlaeyen & Linton, 2000; Leeuw et al. 2007). The Avoidance-Endurance Model (Hasenbring et al. 2001) suggests however, that in addition to patients who are fearful of their pain, a subgroup of patients exists who ignore their pain and therefore persist with activity despite pain. Therefore, the commonly held belief that all patients with CLBP are less active than healthy individuals is challenged by this model. A recent study (Heneweer et al. 2009) showed that both high and low levels of PA were associated with a greater prevalence of CLBP which suggests that not all patients with CLBP exhibit low levels of PA.

In a systematic review, van Weering et al. (2007) examined the comparative activity levels of patients with chronic pain and asymptomatic individuals. The authors found that there was no conclusive evidence to suggest that patients with CLBP are less active than healthy individuals. These findings were based on only two cross-sectional studies that were available at the time. Since the publication of this review, the topic of PA in patients with CLBP has gained considerable attention and more, relevant studies have since been published. Therefore, the primary aim of this systematic review was to
determine if a difference exists in the level and/or pattern of PA between patients with CLBP and healthy individuals based on the current body of evidence.

3.2. Methods

3.2.1. Overview

Considering the nature of the research question being addressed in this review i.e. non-interventional, a non-experimental study design is most appropriate. Thus, this systematic review focused on non-experimental study designs. In addition, recent evidence highlights that the prevalence of LBP among adolescents is high (Pellise et al. 2009). Therefore, the present review included studies irrespective of the age of the participants. This was to ensure that the review is both comprehensive and current.

3.2.2. Types of Studies/Interventions

All non-experimental studies comparing the level and/or pattern of free-living PA of patients with CLBP with asymptomatic healthy individuals were included.

3.2.3. Type of Participants

Patients with CLBP of all age groups were eligible for inclusion. Chronic low back pain was defined as pain located between the 12th rib and the gluteal fold with or without leg pain that was present for at least three months. Patients with or without a NeuP component were included, provided that the results for patients with and without a NeuP component were presented separately. Patients with “red-flag” disorders were excluded (e.g. neoplasm, inflammatory disease, fracture).
3.2.4. Type of Outcome Measures

Studies using a self-report and/or objective measure of PA were included. Such measures include questionnaires, accelerometers, pedometers, heart rate monitors, calorimetry or the DLW technique.

3.2.5. Search Strategy

A comprehensive search of the following databases was conducted: Embase, Medline, ISI Web of Knowledge, Cinahl, Sport Discus and Nursing and Allied Health: Basic Edition. All databases were searched from the beginning of each database until the end of December 2009. In addition the “European Journal of Pain” and “Pain” were searched separately. This was mainly to ensure that articles “in press” were not missed. These journals were chosen as there has been a recent increase in the number of articles on PA in CLBP published in these journals.

Keywords or phrases used during the search were: ("chronic low* back pain" OR "persistent low* back pain") and ("physical activit*" OR "daily activit*" OR "daily living") and ("acceleromet*" OR "pedomet*" OR "activity monitor*" OR "ambulat* monitor*" OR "actigraph*" OR "questionnaire" OR "observation" OR "diary" OR "double labeled water technique" OR "heart rate monitor*"). No language restriction was imposed.

3.2.6. Study Selection

Each article obtained from the search was assessed for eligibility by the primary author (DG). The title, abstract and keywords of each article were assessed to determine if it fulfilled the inclusion criteria outlined above. Studies which met the inclusion criteria were included for full-text review. In cases where the abstract did not provide sufficient detail, the full article was obtained. Also, the reference lists of articles which met the inclusion criteria were manually searched to ensure other relevant articles were not omitted.
3.2.7. Data Extraction

Data extraction was carried out by one reviewer (DG). For each article which met the inclusion criteria, the following information was documented: 1) inclusion/exclusion criteria, 2) setting(s) from which the patient population and controls were recruited, 3) number of participants, 4) age, gender and work status of patients and controls, 5) duration of symptoms, 6) type and name of outcome measure used, 7) statistical methods 8) main results and 9) conclusions.

3.2.8. Quality Assessment

The methodological tool used to assess the quality of studies included in the review was based on the *Newcastle-Ottawa Scale (NOS) for case-control studies* (Wells et al. 2000). The NOS is recommended by the Cochrane Collaboration group to assess the quality of observational studies. The original scale assesses the quality of studies on three main areas: *Selection, Comparability and Outcome or Exposure*. For the purposes of this study, the scale was modified to include assessment of the validity and reliability of the measure of PA used in the study. The psychometric properties of the measure of PA were deemed essential in determining the overall external validity of the study. In addition, aspects of statistical analysis were also assessed (see figure 3.4 for detailed description of quality assessment procedure). However, the authors did not feel it was appropriate to award an overall score to each study. Sanderson et al. (2007) stated that “summary scores involve inherent weighting of component items, some of which may not be directly related to the validity of a study’s findings”. Also, some items are likely to be more important than others. Therefore an overall score may not truly reflect the quality of the study. The quality assessment procedure was carried out by two reviewers. In situations where consensus was not reached between the two reviewers, a third person made the final decision.
3.2.9. Data Synthesis

For studies with sufficient data, we calculated the Standardised Mean Difference (SMD) and its 95% Confidence Intervals (CI) for continuous variables. Where appropriate, we pooled the data using a random-effects model. A random-effects model was chosen due to heterogeneity of outcome reporting across the individual studies. For pooled data, heterogeneity between studies was measured using \( I^2 \) statistics (Higgins & Thompson, 2002). The analysis was carried out using RevMan Version 5 (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2008).

3.3. Results

3.3.1. Study Selection

The electronic search resulted in 1414 potentially relevant citations. 374 duplicates were removed and subsequently 1009 articles were excluded following screening of the title, abstract and keywords of each article. The excluded studies did not fit with the aims of this review. 29 articles were obtained in full-text for further review. An additional text was included following manual searching of the reference lists. Moreover, an additional text that the authors became aware of, published following the search strategy was also included. Therefore, 31 articles were included in the full-text review. Following full-text review, 24 articles were excluded (see figure 3.1). Seven articles were included in the final review (Verbunt et al. 2001; Spenkelink et al. 2002; Ryan et al. 2009; van Weering et al. 2009; Basler et al. 2008; Rudy et al. 2007; Astfalck et al. 2010). The selection procedure is outlined in figure 3.1.
3.3.2. Description of Included Studies

A detailed description of the included studies is presented in table 3.1. Four studies included patients between 18 and 65 years (Verbunt et al. 2001; Spenkelink et al. 2002; Ryan et al. 2009; van Weering et al. 2009), one study included patients aged 14-16 only (Astfalck et al. 2010) and two studies included patients ≥ 65 years (Basler et al. 2008; Rudy et al. 2007). The number of patients in the CLBP group ranged from 12-162 and the number of individuals in the asymptomatic control group ranged from 10-158. The mean age of patients with CLBP ranged from 36.6 years to 73.6 years and the mean age of controls ranged from 29.2 years to 73.5 years. The study by Astfalck et al. (2010) recruited patients aged 14-16 and involved measuring many variables in addition to PA. However not all participants consented to take part in the PA component of the study. The age and gender breakdown of those who did participate in this component of the study was not presented separately. Five of the included studies measured PA occurring over seven days (Ryan et al. 2009; van Weering et al. 2009; Basler et al. 2008; Rudy et al. 2007; Astfalck et al. 2010), one measured PA over a 24 hour period (Spenkelink et al. 2002) and one study measured PA over two weeks (Verbunt et al. 2001).

3.3.3. Reporting of Physical Activity

Two studies reported on PA as the amount of time spent in various postures (i.e. time spent in standing, sitting, lying and walking) and using step frequency (Spenkelink et al. 2002; Ryan et al. 2009). Three studies reported on PA in terms of “volume” or overall level of PA (Spenkelink et al. 2002, van Weering et al. 2009, Rudy et al. 2007) and two studies reported on PA in terms of overall EE (Verbunt et al. 2001, Basler et al. 2008). Astfalck et al. (2010) reported on the amount of time spent at moderate or vigorous activity and total weekly step count. Three of the included studies examined the within- and between-group difference in PA level between different parts of the day (Spenkelink et al. 2002; Ryan et al. 2009; van Weering et al. 2009). Two of the included studies presented data on the within- and between group difference in PA level during work days and non-work days (Ryan et al. 2009; van Weering et
al. 2009). One of the included studies presented data on the within- and between-group difference in PA level during weekdays and the weekend (van Weering et al. 2009).

**Figure 3.1:** Flow Chart of Study Selection Procedure.

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**Note:** *PA: Physical activity; CLBP: Chronic low back pain*
3.3.4. Measurement of Physical Activity

Each of the included studies used a different measurement tool to assess free-living PA. The DLW technique which is considered the gold-standard measure of total EE, provides information on the overall volume of PA and was used only in one of the studies (Verbunt et al. 2001). Three studies used an activity monitor/accelerometer to record PA (Spenkelink et al. 2002; Ryan et al. 2009; van Weering et al. 2009) and one study used a pedometer (Astfalck et al. 2010). Three studies used a self-report questionnaire to measure PA (Basler et al. 2008; Rudy et al. 2007; Astfalck et al. 2010). Physical activity was expressed in different ways across the different studies (e.g. “volume” of PA or EE, time spent in different activities including walking, lying/sitting). (see table 3.1 for how PA was reported in each of the included studies).

3.3.5. Description of Results

3.3.5.1. Overall Level of Physical Activity

Adults (18-65 years): Verbunt et al. (2001) found no significant difference in the PA level (PAL i.e. a measure of activity-related EE) of men (SMD = -0.34, 95% CI = -1.32 – 0.65) and women (SMD = 0.16, 95% CI = -1.23 – 1.55) with CLBP compared to healthy controls. van Weering et al. (2009) found no significant difference in total accelerometer counts between patients and controls. The pooled data from these two studies revealed no significant difference between the PA levels of patients and controls (SMD = -0.06, 95% CI = -0.52 – 0.41. p = 0.81) (see figure 3.2a).

Elderly (>65 years): Rudy et al. (2007) found that patients with CLBP had a significant lower overall level of PA compared to controls (SMD= -0.29. CI = -0.51 – -0.07). Basler et al. (2008) found no significant difference between patients with CLBP and healthy controls regarding overall level of PA (SMD= -0.20. 95% CI = -0.52 – 0.12). The pooled data from these two studies indicate
that elderly patients with CLBP are less active than healthy controls (SMD = -0.26. CI = -0.44 – -0.08. p = 0.005) (see figure 3.2b).

**Adolescents (<18 years):** Astfalck et al. (2010) found no statistically significant difference between patients with CLBP and healthy controls for time spent at moderate-vigorous intensity per week (SMD = 0.44. 95% CI = -0.31 – 1.19. p=0.25).

### 3.3.5.2. Postural Physical Activity and Step Count

**Adults (18-65 years):** Ryan et al. (2009) reported that patients with CLBP spent significantly less time walking (SMD= -1.14. 95% CI = -1.91 – -0.36. p = 0.004) and took significantly fewer number of steps (SMD = -1.47. 95% CI = -2.29 – -0.65. p = 0.0004) over a 24 hour period compared to healthy controls. There was no statistically significant difference in time spent standing between the two groups (SMD = -0.30. 95% CI = -1.02 – 0.42).
<table>
<thead>
<tr>
<th>Citation</th>
<th>Participant Characteristics</th>
<th>Age (years ±SD) and Gender (male, female)</th>
<th>Measurement Reference Period</th>
<th>Measure of PA</th>
<th>Main Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbunt et al (2001)</td>
<td>Patients with NSCLBP (18-60 years)</td>
<td>Patients: 45.0 ± 3.0 (9M, 4F) Controls: 45.7 ± 2.93 (9M, 4F)</td>
<td>14 days</td>
<td>Doubly-labelled water technique Outcome: 1) PA Level (PAL) (Average daily metabolic rate divided by resting metabolic rate)</td>
<td>PA level (PAL) did not differ significantly between patients with NSCLBP and healthy controls.</td>
</tr>
<tr>
<td>Spenkelink et al (2002)</td>
<td>Patients with NSCLBP ≥ 6 months</td>
<td>Patients: 36.6 ± 9.0 (27M, 20F) Controls: 29.2 ± 4.3 (4M, 6F)</td>
<td>24 hours</td>
<td>Dynaport activity monitor (McRoberts BV, Netherlands) Outcome: 1) Time spent sitting, lying, standing, in locomotion (walking) 2) PA Level (PAL) (an overall level of PA that combines several parameters).</td>
<td>Patients with NSCLBP spent significantly more time lying and had a significantly less walking frequency (steps/min) than controls during the day and the evening (p&lt;0.01). Patients spent significantly less time standing in the evening compared to controls (p&lt;0.01) and had a significantly lower PA level (PAL) compared to controls. Patients and controls showed a high day to day variability in levels of PA.</td>
</tr>
<tr>
<td>Van Weering et al (2009)</td>
<td>Patients with NSCLBP (18-65 years)</td>
<td>Patients: 44.41 ± 13.64 (n=29; 55%M, 45%F) Controls: 40.63 ± 14.61 (n=20; 45%M, 55%F)</td>
<td>7 days</td>
<td>MT9 Sensor (Xsens Technologies BV, Netherlands) Outcome: 1) Mean acceleration per minute.</td>
<td>On average, over a 24hr period there was no significant difference between patients and controls with regards to mean accelerations (0.75 vs. 0.71 respectively). During weekdays, patients had a significantly higher activity level in the morning (p&lt;0.001) and a significantly lower activity level in the evening (p&lt;0.05) compared to controls. The PA less was not significantly different (p&gt;0.05) between patients who worked and those who were not working.</td>
</tr>
<tr>
<td>Ryan et al (2009)</td>
<td>Patients with NSCLBP</td>
<td>Patients: 39.0 ± 11.0 (3M, 12F)</td>
<td>7 days</td>
<td>ActivPAL™ activity monitor (PAL Technologies, Glasgow, UK)</td>
<td>Patients with NSCLBP spent 0.7 fewer hours walking and took 3480 fewer steps (p&lt;0.01) than controls.</td>
</tr>
</tbody>
</table>
Controls: 40.0 ± 11.0 (3M, 12F)

Outcome:
1) Time spent in standing, stepping (walking),
2) Step count.
3) Cadence.

Patient with chronic LBP took 793 fewer steps per day during moderate walks (20-100 steps) and took 1214 fewer steps per day during long (100-499 steps) walks than healthy controls.

Patients with NSCLBP took 11 fewer steps per minute during extra-long walks (>500 steps) compared with controls.

**Table 3.1:** Description of the Studies Included in the Review.

<table>
<thead>
<tr>
<th>Study</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Astfalck et al (2010)</td>
<td>Patients with NSCLBP (14-16 years)</td>
<td>Controls: n=17</td>
<td>Patient with chronic LBP took 793 fewer steps per day during moderate walks (20-100 steps) and took 1214 fewer steps per day during long (100-499 steps) walks than healthy controls. Patients with NSCLBP took 11 fewer steps per minute during extra-long walks (&gt;500 steps) compared with controls.</td>
</tr>
<tr>
<td></td>
<td>Age and gender breakdown for patients who participated in the PA arm of the study is not presented</td>
<td>Age and gender breakdown for patients who participated in the PA arm of the study is not presented</td>
<td>Multimedia Activity Recall for Children and Adolescents Outcome: 1) Number of minutes at moderate/vigorous activity intensity per week. Yamax Digiwalker SW200 Pedometer (Yamaha Tokei Keiki Co, Tokyo, ActivPAL activity monitor) Outcome: 1) Weekly step count</td>
</tr>
<tr>
<td></td>
<td>Patients: n=12</td>
<td>Patients: n=12</td>
<td>No significant difference was found with regard to time spent in moderate or vigorous activity (mins/week) between patients with NSCLBP (1158) and controls (919). Although patients had a lower weekly step count compared to controls (80707 versus 89010 respectively), this difference was not significant.</td>
</tr>
<tr>
<td></td>
<td>Controls: n=17</td>
<td>Controls: n=17</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7 days (self-report questionnaire)</td>
<td>7 days (self-report questionnaire)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>At least three weekdays and one weekend day (pedometer)</td>
<td>At least three weekdays and one weekend day (pedometer)</td>
<td></td>
</tr>
<tr>
<td>Rudy et al (2007)</td>
<td>Patients with CLBP (65-84 years)</td>
<td>Patients: 73.6± 5.2 (94M, 66F) Controls: 73.5± 4.8 (83M, 80F)</td>
<td>Elderly patients with CLBP had a significantly lower volume of PA (p&lt;0.05) compared with healthy controls (124.42 PASE points versus 105.76 PASE points).</td>
</tr>
<tr>
<td></td>
<td>7 days</td>
<td>7 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PA Scale (PASE)</td>
<td>PA Scale (PASE)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outcome: 1) Total PA score (measure of volume of physical activity over one week)</td>
<td>Outcome: 1) Total PA score (measure of volume of physical activity over one week)</td>
<td></td>
</tr>
<tr>
<td>Basler et al (2008)</td>
<td>Patients with CLBP due to osteoporosis or degenerative spine disorders (≥ 65 years)</td>
<td>Patients: 71.41± 5.2 (94M, 66F) Controls: 71.19± 4.73 (83M, 80F)</td>
<td>No difference between patients and controls was detected in regard to energy expenditure (MET h/wk) measured using the activity diary (14.55 versus 14.26 respectively; p=0.819) and the questionnaire (39.95 versus 33.0 respectively; p=0.213).</td>
</tr>
<tr>
<td></td>
<td>7 days</td>
<td>7 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Activity Diary and Freiburg Activity Questionnaire</td>
<td>Activity Diary and Freiburg Activity Questionnaire</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outcome: MET hours (Metabolic Equivalent) per week.</td>
<td>Outcome: MET hours (Metabolic Equivalent) per week.</td>
<td></td>
</tr>
</tbody>
</table>
### Figure 3.2:

**a.** Comparison of the overall Physical Activity Level of Adults (18-65 years) with Chronic Low Back Pain and Healthy Controls.

**b.** Comparison of the overall Physical Activity Level of Older Adults (> 65 years) with Chronic Low Back Pain and Healthy Controls.

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>LBP group</th>
<th>Control group</th>
<th>Std. Mean Difference</th>
<th>Std. Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Total</td>
<td>Mean</td>
</tr>
<tr>
<td>Verbrunt et al (Females)</td>
<td>1.77</td>
<td>0.21</td>
<td>4</td>
<td>1.73</td>
</tr>
<tr>
<td>Verbrunt et al (Males)</td>
<td>1.66</td>
<td>0.3</td>
<td>8</td>
<td>1.77</td>
</tr>
<tr>
<td>van Weering et al</td>
<td>0.74</td>
<td>0.44</td>
<td>29</td>
<td>0.74</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>41</td>
<td>32</td>
<td>63</td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: Tau² = 0.00; Chi² = 5.44, df = 2 (P = 0.04); I² = 0%

Test for overall effect: Z = 2.41 (P = 0.01)

---

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>LBP group</th>
<th>Control group</th>
<th>Std. Mean Difference</th>
<th>Std. Mean Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Total</td>
<td>Mean</td>
</tr>
<tr>
<td>Ruddy et al</td>
<td>105.76</td>
<td>94.38</td>
<td>162</td>
<td>124.42</td>
</tr>
<tr>
<td>Basler et al</td>
<td>39.95</td>
<td>27.98</td>
<td>103</td>
<td>46.91</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>265</td>
<td>217</td>
<td>482</td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: Tau² = 0.00; Chi² = 1.18, df = 1 (P = 0.67); I² = 0%

Test for overall effect: Z = 2.81 (P = 0.005)

---

### Figure 3.3:

**a)** Comparison of the Overall Physical Activity Level of Patients with Chronic Low Back Pain and Healthy Controls during the Morning.

**b)** Comparison of the Overall Physical Activity Level of Patients with Chronic Low Back Pain and Healthy Controls during the Evening.
Adolescents (<18 years): Astfalck et al. (2010) reported that adolescents with CLBP took 8303 less steps per week but this difference was not statistically significant (SMD = -0.16. 95% CI = -0.90 – 0.58. p = 0.67).

3.3.5.3. Pattern of Physical Activity

Adults (18-65 years): van Weering et al. (2009) showed that patients with CLBP has a significantly higher overall level of PA in the morning (SMD = 0.74. 95% CI = 0.15 – 1.33. p = 0.01) (see figure 3.3a). Pooled data from two studies show that patients with CLBP are significantly less active than healthy controls during the evening (SMD = -0.49. 95% CI = -0.94 – -0.04. p = 0.03) (see figure 3.3b). Spenkelink et al. (2002) found that patients spent significantly more time lying during the daytime (SMD = 0.80. 95% CI = 0.08 – 1.51. p = 0.03) and evening (SMD = 0.97. 95% CI = 0.25 – 1.70. p = 0.009) compared to controls.

Spenkelink et al. (2002) found no significant difference in time spent walking during the daytime (SMD = 0.36. 95% CI = -0.34 – -1.06. p = 0.31) or evening (SMD = 0.07. 95% CI = -0.63 – 0.76. p = 0.85) between patients with CLBP and healthy controls. Ryan et al. (2009) reported that patients with CLBP spent less time walking during the daytime on working (SMD = -0.55. 95% CI = -1.28 – 0.18. p = 0.14) and non-working days (SMD = -0.64. 95% CI = -1.38 – 0.09. p = 0.09). A similar pattern was reported during the evening time. Spenkelink et al. (2002) reported that patients with CLBP had a significantly slower cadence during the day (SMD = -1.14. 95% CI = -1.87 – -0.40. p = 0.002) and evening time (SMD = -0.87. 95% CI = -1.59 – -0.15. p = 0.02) compared to controls. Similarly, Ryan et al. (2009) reported that during extra-long walks (>500 steps), patients with CLBP had a reduced cadence compared to controls (SMD = -0.84. 95% CI = -1.59 – -0.09. p = 0.03).
3.3.5.4. Methodological Study Quality

A detailed analysis of the quality of included studies is provided in figure 3.4. The majority the studies provided sufficient information on the inclusion and exclusion criteria. Five of the included studies (Spenkelink et al. 2002; Ryan et al. 2009; van Weering et al. 2009; Basler et al. 2008; Astfalck et al. 2010) included controls without a recent history of LBP. The remaining two studies (Verbunt et al. 2001, Rudy et al. 2007) reported that controls were “healthy” or “asymptomatic” which was considered inadequate information. This is due to the high prevalence rate of LBP in the general population. Only two studies adequately controlled for work status (in terms of physical demand) in addition to age and sex (Ryan et al. 2009, van Weering et al. 2009). Although, most studies used a reliable and objective measure of PA in a healthy population, only two of the included studies (Verbunt et al. 2001, Ryan et al. 2009) used an assessment tool valid for measuring PA in a CLBP population. The other measures have not been validated in a pain population. Two studies adequately reported on the sampling procedure (Rudy et al. 2007, Astfalck et al. 2010). It is unclear from the remaining studies whether consecutive or random sampling was used or not. Only one study justified the sample size used (Basler et al. 2008). Although Astfalck et al. (2010) did justify the sample size; this was based on detecting a difference in usual sitting posture which was another main aim of the study in addition to measuring PA.
<table>
<thead>
<tr>
<th>Study</th>
<th>Patient Definition</th>
<th>Representativeness of patients</th>
<th>Selection of controls</th>
<th>Definition of controls</th>
<th>Age &amp; Gender</th>
<th>Work demand</th>
<th>Reliability of outcome measure</th>
<th>Validity of outcome measure</th>
<th>Sample Size</th>
<th>Statistical Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verbunt et al (2001)</td>
<td>MET</td>
<td>UNCLAR</td>
<td>MET</td>
<td>UNCLAR</td>
<td>MET</td>
<td>NOT MET</td>
<td>MCT</td>
<td>MCT</td>
<td>NOT MET</td>
<td>MET</td>
</tr>
<tr>
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<td>MET</td>
<td>UNCLAR</td>
<td>MET</td>
<td>MET</td>
<td>NOT MET</td>
<td>UNCLAR</td>
<td>UNCLEAR</td>
<td>MET</td>
<td>NOT MET</td>
<td>MET</td>
</tr>
<tr>
<td>van Weering et al (2009)</td>
<td>MET</td>
<td>UNCLAR</td>
<td>MET</td>
<td>MET</td>
<td>MET</td>
<td>MET</td>
<td>UNCLEAR</td>
<td>UNCLEAR</td>
<td>NOT MET</td>
<td>MET</td>
</tr>
<tr>
<td>Ryan et al (2009)</td>
<td>MET</td>
<td>UNCLAR</td>
<td>MET</td>
<td>MET</td>
<td>MET</td>
<td>MET</td>
<td>MET</td>
<td>MET</td>
<td>NOT MET</td>
<td>MET</td>
</tr>
<tr>
<td>Rudy et al (2007)</td>
<td>MET</td>
<td>UNCLAR</td>
<td>MET</td>
<td>UNCLAR</td>
<td>MET</td>
<td>NOT MET</td>
<td>MET</td>
<td>MET</td>
<td>NOT MET</td>
<td>MET</td>
</tr>
<tr>
<td>Basler et al (2008)</td>
<td>MET</td>
<td>UNCLAR</td>
<td>MET</td>
<td>MET</td>
<td>UNCLAR</td>
<td>MET</td>
<td>MET</td>
<td>MET</td>
<td>NOT MET</td>
<td>MET</td>
</tr>
<tr>
<td>Auffalck et al (2010)</td>
<td>MET</td>
<td>UNCLAR</td>
<td>MET</td>
<td>UNCLAR</td>
<td>MCT</td>
<td>MCT</td>
<td>NOT MCT</td>
<td>MET</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. The inclusion/exclusion criteria are well defined.

b. Consecutive or obvious representative series of patients (e.g. random sample).

c. Controls were derived from the same community as patients.

d. Controls defined as ‘healthy’ with no history of low back pain in the previous 6 months.

e. The patient group and control group were adequately matched for age and gender.

f. The patient group and control group were adequately matched for work status (in term of work demand).

g. The measure of physical activity has documented reliability.

h. The measure of physical activity has documented validity.

i. The sample size was justified (or sample size calculation described).

j. The statistical analysis was clearly described and was appropriate.

**Figure 3.4** Methodological Quality Appraisal Using a Modified Version of the Newcastle-Ottawa Scale.
3.4. Discussion

3.4.1. Main Findings

This review did not find any consistent or conclusive evidence that adults or adolescents with CLBP are less active than their healthy counterparts. However, based on the pooled data from a limited number of studies, there is evidence that older adults are less active than controls. There is considerable evidence that PA declines with advancing age in healthy individuals (Heiekkinen, 2006). Any additional factor including musculoskeletal pain which negatively impacts on the PA level of this group may have adverse consequences for overall health. Although the pooled SMD was small, the difference is therefore likely to still be clinically important. Caution is needed however, as both of these studies measured PA using a self-report measure. van Weering et al. (2009) found that patients with CLBP had a significantly higher overall level of PA in the morning compared to controls. In contrast, pooled data from two studies showed that patients with CLBP are significantly less active than controls during the evening. These results suggest that the distribution of PA over a 24 hour period is different between patients with CLBP and healthy individuals. Finally, there is evidence from two studies that patients with CLBP move at a slower cadence compared to healthy controls. This finding is in agreement with the results of a study by van den Berg-Emons et al. (2007) who found that patients with chronic pain were active at a significantly less intensity compared to healthy controls.

The finding that patients with CLBP are not less active than controls is not wholly consistent with the FAM. It is possible that patients fear and avoid specific movements or activities without reducing their overall activity levels (Leeuw et al. 2007). There is a growing body of evidence which suggests that the level of FABs may not be associated with objectively-measured free-living PA (Leonhardt et al. 2009; Bousema et al. 2007; Smeets et al. 2009). Hasenbring et al. (2001) proposed that, in addition to patients who fear their pain and avoid activity (“avoiders”), a sub-group of patients exists who ignore their pain and suppress pain-related thoughts. The latter group have been
termed “persisters” and persist with PA despite pain (Hasenbring et al. 2001). There is empirical evidence to support this concept (Hasenbring et al. 2006; McCracken & Samuel, 2007). The concept of persisting with PA despite pain may also explain why patients become progressively less active over the course of a day (Hasenbring & Verbunt, 2010). Patients may attempt to complete various activities during the earlier part of the day when pain levels may be lower (van Weering et al. 2009).

3.4.2. Methodological Considerations

The primary limitation of the included studies is their small sample size. Only one study appears to have been adequately powered. Therefore there is a high possibility of Type-II errors occurring. Only two of the studies included in this review used an objective measure of PA previously validated in a CLBP population. Verbunt et al. (2001) measured total EE using the DLW method. Ryan et al. (2009) used the ActivPAL™ activity monitor which has documented validity in a CLBP population and has good test-retest and inter-instrument reliability. Although the need for validation within specific clinical populations is debated in the literature (Verbunt et al. 2009), patients with CLBP may exhibit altered movement patterns or antalgic postures which may directly influence the output of the measurement device (Gironda et al. 2007). Both studies which measured PA in older adults used self-report measures. Self-report measures, although providing important contextual information, are less accurate compared to more objective measures (Bussmann et al. 2009). The sampling procedure is unclear in the majority of the studies. Apart from one study, it is not clear if consecutive or random sampling was used. Therefore the possibility of selection bias cannot completely be ruled out.

3.4.3. Clinical Implications

The clinical implications of this review need to be considered within the context of the broader literature in this area. As previously discussed, there is evidence that cognitive-behavioural subgroups of patients with CLBP exist, who
exhibit maladaptive PA patterns including “avoidance” and “persistence”. Although exercise and increasing a patient’s level of PA is integral to the management of LBP, physiotherapists need to be aware that both these subgroups will require a different approach to achieve this. “Avoiders” may benefit from a graded exercise intervention or exposure interventions that target specific feared movements or activities. There is evidence that patients with a high level of FABs regain physical fitness using a graded activity intervention (De Peuter et al. 2009). In contrast, “persisters” may benefit from pacing strategies designed to alternate period of activity with adequate rest. Although loosely defined in the literature, pacing involves breaking down one’s daily activities into more manageable parts (Andrews et al. 2012). According to the AEM, pacing is characterised by low levels of both “avoidance” and “persistence” behaviour and is believed to lead to lower levels of disability (Hasenbring & Verbunt, 2010). Such an approach, targeting specific maladaptive activity patterns has recently been shown to be successful in patients with fibromyalgia (van Kouil et al. 2010). The avoidance-endurance questionnaire (Hasenbring et al. 2009) and the Patterns of Activity Measure in Pain (POAM-P) (Cane et al. 2007) are relatively new validated, self-report measures that may help physiotherapists determine the activity pattern of patients with CLBP.

3.4.4. Research Implications

Measuring PA using accelerometers is often based on the assumption that there is a linear relationship between accelerometer counts and volume of PA and EE (Motl et al. 2009). Also within many studies, there is an implied assumption that this relationship is similar for patients with CLBP and healthy controls. Few studies have examined the validity of accelerometers specifically in a LBP population. There is consensus in the literature that more studies are needed to examine the validity of accelerometers for measuring PA in patients with CLBP (Verbunt et al. 2010). Additionally, in the future, studies examining PA or exercise-based interventions for patients with CLBP should determine if
tailored treatment, targeting specific maladaptive PA patterns is more effective compared to a more generic intervention.

### 3.4.5. Limitations

The primary limitation of this review is that all of the included studies were cross-sectional. However this review did not seek to determine the effectiveness of an intervention, for which a randomised-controlled design would be more appropriate. Instead the primary aim of this study was to determine if patients with CLBP had an altered level and/or pattern of PA compared to healthy individuals. Studies using a cross-sectional design were appropriate to address this question. Also we did not search for any unpublished literature in this area and so it is possible that relevant studies may have been missed. The lack of a consensus in the literature on how best to examine the methodological quality of observational studies is another limitation of this review. In this review we chose to use a modified version of the NOS. We did not give an overall score to each of the included studies. We have outlined the reasons for this in the results section. In an attempt to make the study quality appraisal more comprehensive, we modified the scale to address essential elements of the study that would impact on its overall external validity (e.g. sample size, reliability/validity of measurement tools). Considering the limitations of assessing observational study quality, we have identified the major methodological limitations of the studies included in this review which we have discussed above. Finally the findings of this review are based on a limited number of studies, the majority of which used a small sample size. Although this is not a limitation of this review per se, the findings must be interpreted with caution and more studies using a larger sample size are needed to confirm the findings. However the finding of this review, considered together with the broader literature in this area may have important implications for the physiotherapy management of patients with CLBP and we have outlined these above.
3.5. Conclusions

There is no conclusive evidence that adults or adolescents with CLBP are less active than healthy, age-matched individuals. Based on a limited number of studies there is some evidence that elderly patients with CLBP are less active than healthy controls. However more studies, using objective measures of PA are necessary to confirm these findings. Finally there is some evidence that the distribution of PA over the course of the day is different between patients with CLBP and controls. Due to the small sample size used in the majority of the studies, the findings must be interpreted with caution and need to be replicated in future studies using a large sample size. Finally, further work is needed to determine the validity of objective PA measures such as accelerometers in patients with CLBP.
CHAPTER FOUR

Criterion Validity and Calibration of the ActivPAL™ Activity Monitor as a Measure of Energy Expenditure during Physical Activity in People with Chronic Low Back Pain
4.1. Background

The health benefits of engaging in regular PA are well established (Hallal et al. 2012). Physical activity may be defined in terms of duration, frequency, type or intensity of movement. The precise measurement of PA intensity is of importance considering its established associations with many indices of cardiometabolic health. For example, individuals who engage in at least 15 minutes of moderate intensity PA per day have a 14% reduced risk of all-cause mortality (Wen et al. 2011). Similarly, replacing sedentary activities (e.g. television viewing) with light intensity PA is beneficial for overall health (Powell et al. 2011; Dunstan et al. 2012). Finally, it is possible that individuals with chronic illness including chronic pain exhibit a reduced intensity of PA (van Remoortel et al. 2012). There is some empirical evidence to support this notion in people with chronic pain (van den Berg-Emons et al. 2007; Ryan et al. 2009). Therefore, a measurement device that can accurately measure the intensity of PA in addition to duration and frequency is of importance.

The ActivPAL™ activity monitor (PAL Technologies, Glasgow, UK) is a unique, lightweight and unobtrusive device that has been validated for use among healthy adults (Grant et al. 2006), preschool and adolescent children (Davies et al. 2012; Aminian & Hinckson, 2012) as well as individuals with CLBP (Ryan et al. 2008). Specifically, among individuals with CLBP, the device is an accurate measure of time spent walking, standing and upright as well as the time spent in sitting or lying (Ryan et al. 2008). The device also provides an estimate of PA intensity (METs) that is based on a proprietary prediction equation based on step rate. The validity of the EE estimate has rarely been investigated and has not been validated among any clinical population. Prior research has found a moderate relationship between EE measured using indirect calorimetry and the ActivPAL™ estimate of intensity during treadmill walking among healthy females (Harrington et al. 2011). Similar to other activity monitors, accelerometer “counts” are also available from the raw data, which is retrieved using the ActivPAL™ proprietary software program. Interestingly, the association between EE (measured using indirect calorimetry) and ActivPAL™ “counts” appears to be stronger than that between EE and step rate (Harrington et al. 2011). Considering the ActivPAL™ in-built equation calculates EE using
steps, an algorithm based on “counts” may provide a more accurate estimate. The strong relationship between ActivPAL™ counts and EE measured using indirect calorimetry has been confirmed in a recent study involving adolescent females (Dowd et al. 2012a).

The aim of this study was to examine the criterion validity of the ActivPAL™ as a measure of EE among people with CLBP. There were three main objectives of this study. The first objective was to test the accuracy of the in-built prediction equation versus the criterion measure of indirect calorimetry during treadmill walking (locomotor activity) and activities of daily living (non-locomotor activity) performed in a laboratory setting. The second objective was to compare the relationship between EE measured using indirect calorimetry and i) step rate; ii) ActivPAL™ counts. The third and final objective was to investigate the inter-device reliability of the ActivPAL™ to determine if the ActivPAL™ activity monitor may be used interchangeably and attached to either leg among individuals with CLBP.

4.2. Methods

4.2.1. Participants

Patients with a primary complaint of LBP (with or without leg pain) attending the pain clinic in the Mid Western Regional Hospital Limerick were recruited for this study. The primary inclusion criteria were: a) primary complaint of LBP with or without leg pain; b) pain present for at least three months, c) aged between 18 and 65 years inclusive and d) normal gait pattern. Exclusion criteria included: a) inflammatory (e.g. rheumatoid arthritis), neurological (e.g. multiple sclerosis) or cardio-respiratory disease (any self-reported respiratory condition including severe, uncontrolled asthma, unstable angina, history of myocardial infarction, cardiac surgery or heart failure); b) back surgery in the previous year; c) pregnancy; d) the presence of serious spinal pathology such as fracture, infection or cauda equina syndrome; e) spinal injection in the past month and f) an inability to walk without the use of an aid. All participants were
required to complete the Physical Activity Readiness Questionnaire (PAR-Q) (see Appendix C1) to determine if it were safe for them to engage in PA. Ethical approval for the study was granted by the Mid-Western Regional Ethics Committee.

4.2.2. Physical Activity Measurement Device

Physical activity was measured during the study using the ActivPAL™ activity monitor. The ActivPAL™ activity monitor, which is worn along the mid-line of the anterior thigh, is a small, lightweight device that provides information on time spent walking, standing, upright and sitting/lying. In addition, PA intensity (METs), the number of steps, cadence and raw activity counts (ActivPAL™ counts) are also recorded and readily accessed. For the purposes of this study, each subject was required to wear two ActivPAL™ activity monitors (one on each leg). The monitor was initially attached using double-sided medical tape and was secured using single-sided adhesive medical tape.

4.2.3. Metabolic Unit

Breath by breath ventilation was measured using the Jaeger Oxycon Mobile® (VIASYS Healthcare GmbH, Leibnizstr, Germany). The Oxycon Mobile® is an automated, portable metabolic gas analysis system that has been validated as a measure of PA intensity compared to the Douglas Bag method (Rosdahl et al. 2010). It consists of a lightweight (approx 950g), battery-operated ergospirometry system that is attached to the individual using a vest. Data is examined breath by breath and expired gas is collected through a facemask. This information is transferred to and stored in the host computer in real time. The data is presented for every 30 seconds of recording. In line with the manufacturer’s recommendations, the power and calibration unit (PCa unit) was switched on and connected to the Sensorbox unit (SBx unit) for at least 15 minutes prior to use. Subsequently, the flow sensor was calibrated using the in-built automated “Auto-Cal” procedure as per the manufacturer’s instructions.
Gas calibration was performed prior to each experiment by using a reference gas of known composition.

### 4.2.4. Testing Protocol

All testing took place in the Health Sciences Building at the University of Limerick. All participants were required to fast for four hours prior to testing. The purpose of this was to control for the metabolic cost of digestion and the four hour fasting period is similar to that used in other similar studies (Swartz et al. 2011; John et al. 2011). On arrival at the laboratory, participants’ weight was measured in kilograms using a digital weighting scale and height was measured in centimetres with shoes removed. Participants were required to wear light and comfortable clothing for the duration of testing. The Oxycon Mobile® was initialised by inputting participants’ data (weight, height, gender, date of birth) and current ambient conditions.

For the initial 30 minutes of the testing protocol, participants were required to lie supine on a physiotherapy plinth and were instructed to remain as still as possible. Subsequently, each participant was required to undertake eight separate tasks. Three of these tasks involved treadmill walking (i.e. locomotor tasks). Participants were required to walk at three pre-selected speeds (0.89m.s$^{-1}$, 1.22m.s$^{-1}$ and 1.56m.s$^{-1}$). The remaining five tasks (non-locomotor tasks) were washing dishes, stair climbing, folding clothes, sweeping and reading while sitting. Each of the treadmill tasks were performed for seven minutes and the non-locomotor tasks were performed for 10 minutes with the exception of stair climbing which was performed for seven minutes. There was a two minute rest break between tasks.

### 4.2.5. Data Processing

**Metabolic Unit:** At the end of the testing protocol, the measurement was saved and an Excel file was created using the proprietary software program
(JLAB, CareFusion, San Diego, CA, USA). Energy expenditure was recorded and presented in 30 second intervals. To calculate an individual’s resting metabolic rate, the final 10 minutes of the 30 minutes rest period that preceded testing was used to determine the average EE in that time period. For each of the treadmill tasks and the stair climbing task, the MET value for that activity was calculated by averaging the EE between minutes three and seven and dividing this value by the resting metabolic rate. For all other tasks, minutes two to nine were used to calculate the MET value for that activity.

*ActivPAL™ Activity Monitor:* Data stored on each monitor was downloaded and processed using the ActivPAL™ proprietary software. The data was presented in an Excel file for every 15 seconds of recording. For the treadmill tasks and stair climbing task, the average number of steps (steps/min), ActivPAL™ counts (counts/min) and the MET value for the activity was calculated for minutes three to seven. For all other tasks, the same procedure was followed but minutes two to nine were used for the analysis.

4.2.6. Data Analysis

Data was analysed using IBM SPSS Statistics 18. Summary statistics were used to describe the data. Data are presented as mean (standard deviation) or median (range) for normally and non-normally distributed data respectively. Normality was examined using the Shapiro-Wilks test and by visually inspecting the histograms and quartile-quartile (Q-Q) plots. A sample of the data analysis SPSS output is presented in Appendix B1.

4.2.6.1. Criterion Validity of the ActivPAL™ as a Measure of EE

Agreement between the estimate of EE from the ActivPAL™ activity monitor and indirect calorimetry was examined using intraclass correlation coefficients (ICC) values and the Bland and Altman method for i) the treadmill protocol and ii) non-locomotor protocol. For all comparisons between the
ActivPAL™ and the criterion measure, only data from the ActivPAL™ worn on the left leg was used. Relative agreement was examined using a two-way fixed effects model with a single measure ICC \{ICC (3,1)\}. The ICC value was interpreted according to Fleiss 1986: <0.4: poor agreement; 0.41-0.74: moderate agreement; ≥0.75: excellent agreement. Absolute agreement was examined using the Bland and Altman method. The traditional approach as outlined by Bland & Altman, (1986) was inappropriate for use in the currently study. As indicated in figure 4.1, LoA based on regression were calculated due to the presence of proportional bias in the data. Proportional bias occurs when the magnitude of the mean of the measurements is related to the difference between the measurements. In an attempt to address this, log transformation was initially undertaken but it failed to rectify the problem. As a result, LoA based on regression were the most appropriate method to use (Bland & Altman, 1999).

4.2.6.2. The Relationship between EE and i) Step Rate, ii) ActivPAL™ Counts

For the treadmill protocol, we compared the relationship between measured EE (indirect calorimetry) versus i) step rate (based on the ActivPAL™ proprietary software) and ii) ActivPAL™ counts. Pearson’s correlation coefficient was used to measure the direction and strength of these relationships. The correlation coefficient was interpreted according to Cohen, (1988): 0.10-0.29: small; 0.30-0.49: moderate and 0.50-1.0: strong. Linear regression was used to determine the amount of the variance in EE explained by i) step rate and ii) ActivPAL™ counts.

4.2.6.3. Inter-device Reliability

Agreement between the ActivPAL™ output (MET values, step rate and ActivPAL™ counts) from monitors worn on the left and right leg was examined using ICCs as outlined in section 4.2.6.1. In addition, this analysis was supplemented by constructing Bland and Altman plots for each of the individual
ActivPAL™ outputs (i.e. MET values, step rate and ActivPAL™ counts) for both the treadmill (locomotor) protocol and the activities of daily living (non-locomotor) protocol.

4.3. Results

4.3.1. Participants

Five male and eight female subjects participated in the study. The mean age of participants was 44.92±10.47 years. The mean BMI score was 28.54±4.31. All initial data sets were examined for the presence of outliers. For normally distributed data sets, an outlier was defined as a point that was 1.96 times the standard deviation (SD) above or below the mean score. For skewed data sets, an outlier was defined as a point 1.5 times the interquartile range below the first quartile or above the third quartile. This approach is similar to that of other studies (Hendrick et al. 2010). For one participant, their EE as assessed with indirect calorimetry was found to be an outlier for three on the activities where the score was significantly higher than other participants. Moreover, where this participant was not identified as an outlier there was a trend for them to have a higher EE value. As a result of this analysis, the indirect calorimetry scores for this individual were removed from the analysis.

4.3.2. Summary Data

Energy expenditure (METs) assessed using both indirect calorimetry and the ActivPAL™ activity monitor as well as step rate and ActivPAL™ counts are presented for the treadmill protocol and for the non-locomotor activities protocol in table 4.1 and table 4.2 respectively.
### Table 4.1: Energy Expenditure, Step Rate and ActivPAL™ Counts for the Treadmill Protocol.

Data are presented as mean (SD) or median (range); IC: Indirect Calorimetry

<table>
<thead>
<tr>
<th>Walking speed (m.s⁻¹)</th>
<th>MET Value (IC)</th>
<th>MET Value (ActivPAL™)</th>
<th>Step Rate (per min)</th>
<th>Activity Counts (per min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.89m.s⁻¹</td>
<td>3.20 (0.63)</td>
<td>3.65 (0.26)</td>
<td>103.94 (11.85)</td>
<td>13018 (3987)</td>
</tr>
<tr>
<td>1.22m.s⁻¹</td>
<td>3.88 (0.68)</td>
<td>3.82 (3.64-4.45)</td>
<td>111.60 (103.6-140.4)</td>
<td>17834 (14797-27264)</td>
</tr>
<tr>
<td>1.56m.s⁻¹</td>
<td>5.01 (0.87)</td>
<td>4.01 (0.12)</td>
<td>120.56 (5.59)</td>
<td>25044 (3365)</td>
</tr>
</tbody>
</table>

#### 4.3.3. Comparison of Indirect Calorimetry versus the ActivPAL™ for EE

**Treadmill Activities:** The ICC for the association between indirect calorimetry values and ActivPAL™ values for EE during treadmill walking was 0.332 (95% CI: -0.001, 0.599). The Bland and Altman plot comparing the mean score versus the differences between the measures is shown in figure 4.1a. Due to the presence of proportional bias, 95% LoA based on regression are presented. Figure 4.1a shows that there was a trend for the ActivPAL™ to overestimate EE at the lowest walking speed (0.89m.s⁻¹) and to underestimate EE at the highest walking speed (1.56m.s⁻¹). The agreement was best for the middle walking speed (1.22m.s⁻¹). Twenty-seven out of the 34 data points showed a difference of less than one MET and 18 data points showed a difference of less than 0.5 METs.

**Non-locomotor Activities:** The ICC value for the association between indirect calorimetry values and ActivPAL™ values for EE during the non-locomotor tasks was 0.404 (95% CI: -0.052, 0.683). The Bland and Altman plot comparing the mean score versus the differences between the measures is shown in figure 4.1b. Due to the presence of proportional bias, 95% LoA based

### Table 4.2: Energy Expenditure, Step Rate and ActivPAL™ Counts for the Non-locomotor Protocol.

Data are presented as mean (SD) or median (range); IC: Indirect Calorimetry

<table>
<thead>
<tr>
<th>Activity</th>
<th>MET Value (IC)</th>
<th>MET Value (ActivPAL™)</th>
<th>Step Rate (per min)</th>
<th>Activity Counts (per min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washing dishes</td>
<td>2.04 (0.25)</td>
<td>1.39 (0.00)</td>
<td>0.06 (0.15)</td>
<td>459 (229)</td>
</tr>
<tr>
<td>Folding Clothes</td>
<td>2.15 (0.37)</td>
<td>1.39 (0.01)</td>
<td>0.15 (0.30)</td>
<td>652 (408)</td>
</tr>
<tr>
<td>Stairs</td>
<td>4.74 (1.21)</td>
<td>2.44 (0.55)</td>
<td>49.41 (21.52)</td>
<td>8516 (3804)</td>
</tr>
<tr>
<td>Sweeping</td>
<td>3.09 (0.63)</td>
<td>1.71 (0.30)</td>
<td>16.24 (14.18)</td>
<td>2761 (1701-5962)</td>
</tr>
<tr>
<td>Reading</td>
<td>1.17 (0.13)</td>
<td>1.25 (0.00)</td>
<td>0.00 (0.00)</td>
<td>5 (0-86)</td>
</tr>
</tbody>
</table>
on regression are presented. The accuracy was greatest for the low intensity activities (washing dishes, folding clothes and reading). The ActivPAL™ was most inaccurate for moderate intensity activities (stair climbing, sweeping).

![Figure 4.1: Bland & Altman Scatterplot Plotting the Mean of the Two Energy Expenditure Measurements (Indirect Calorimetry and ActivPAL™) versus the Difference between the Measurements for a) The Treadmill Protocol and b) The Non-locomotor Protocol.](image-url)
4.3.4. Correlation between EE (Indirect Calorimetry) and ActivPAL™ “Counts” and Step Rate

There was a strong and positive relationship between EE measured using indirect calorimetry and ActivPAL™ counts ($r=0.799$, $p<0.001$). There was also a strong and positive correlation between EE measured using indirect calorimetry and step rate, although the relationship was weaker when compared to ActivPAL™ counts ($r=0.713$, $p<0.001$). A scatterplot showing both of these relationships is presented in figure 4.2 and figure 4.3 respectively.

![Figure 4.2](image1.png)

**Figure 4.2:** Scatterplot Showing the Relationship between Energy Expenditure (Indirect Calorimetry) and ActivPAL™ Counts during Treadmill Walking.

![Figure 4.3](image2.png)

**Figure 4.3:** Scatterplot Showing the Relationship between Energy Expenditure (Indirect Calorimetry) and Step Rate during Treadmill Walking.
4.3.5. Inter-device Reliability

The agreement between the ActivPAL™ activity monitors (one worn on each leg) was “excellent” for MET value (ICC=0.997, 95% CI: 0.94, 0.98), step rate (ICC=0.99, 95% CI: 0.98, 0.99) and ActivPAL™ counts (ICC=0.945, 95% CI: 0.90, 0.97). The Bland and Altman plots for the inter-instrument reliability during the treadmill protocol are presented in figure 4.4.

![Bland and Altman plots](image-url)
Figure 4.4: Bland and Altman Plot Showing the Agreement between the ActivPAL™ Activity monitor Worn on the Left and Right Leg during Treadmill Walking for a) MET Value, b) Step Rate and c) ActivPAL™ Counts.

Note: The black horizontal line represents the mean difference. The red lines are the 95% limits of agreement.

For the non-locomotor protocol, the agreement between both ActivPAL™ monitors was excellent for MET value (ICC=0.933, 95% CI: 0.89, 0.96), step rate (ICC=0.96, 95% CI: 0.94, 0.98) and ActivPAL™ counts (ICC=0.99, 95% CI: 0.99, 1.0). The Bland and Altman plots for the inter-instrument reliability during the non-locomotor protocol are presented in figure 4.5.
Figure 4.5: Bland and Altman Plot Showing the Agreement between the ActivPAL™ Activity Monitor Worn on the Left and Right Leg during Non-locomotor Activities for a) MET Value, b) Step Rate and c) ActivPAL™ Counts.

Note: The black horizontal line represents the mean difference. The red lines are the 95% limits of agreement.
4.4. Discussion

The first aim of this study was to determine the accuracy of the EE estimate of the ActivPAL™ activity monitor when compared to the criterion measure of indirect calorimetry. The low ICC value obtained for the treadmill protocol would suggest “poor agreement”. However, using ICC values alone to determine validity is not recommended. ICC values are partly dependent on the variability in the data set under investigation (Atkinson & Nevill, 1998). When variability is low, the ICC value will be reduced. In the current study, EE during three walking treadmill speeds was examined. There was only a small difference in the mean measured EE during the two lower speeds (3.2 METs versus 3.88 METs). Therefore, it is possible that the narrow range of speeds investigated led to reduced variability in the data and as a result the ICC value for the protocol is low. The Bland and Altman plot presented in figure 4.1a suggest that the validity of the ActivPAL™ EE estimate during treadmill walking is better than that suggested by the ICC value. From the graph it is apparent that the ActivPAL™ activity monitor tends to overestimate EE at lower treadmill speeds and tends to underestimate EE at higher speeds. The findings presented in table 4.1 suggest that the ActivPAL™ is most inaccurate at higher speeds (1.56m.s$^{-1}$ in the current study). Overall however, the validity of the ActivPAL™ appeared reasonable to estimate EE during treadmill walking. Importantly, only moderate intensity walking was measured in the current study. Therefore, the validity of the monitor to measure EE during light intensity or vigorous walking or jogging/running cannot be commented on in the current study.

For the non-locomotor tasks, the validity of the ActivPAL™ to estimate EE was poorer than for treadmill walking. Although the ICC value was somewhat higher, the Bland and Altman plot in figure 4.2b shows that the difference between the two measurements was often large and greater than that observed for the treadmill protocol. For the lower intensity tasks that involved primarily standing or sitting (washing dishes, reading and folding clothes) the accuracy of the monitor was reasonable. However the two remaining tasks of sweeping the floor and stair climbing produced much larger discrepancies between the ActivPAL™ output and EE measured using indirect
calorimetry. When sweeping the floor, the ActivPAL™ is not able to capture the EE resulting from upper limb movement. Likewise, it is not able to capture the additional EE required during stair climbing. The results of this study therefore confirm that the proprietary ActivPAL™ estimate of EE is not accurate during tasks where the upper limb contributes significantly to the resulting EE or during climbing tasks where the increased muscle force required will not be reflected in the step rate.

The EE estimate provided by the ActivPAL™ activity monitor is based on an “in-built” equation using step rate. A recent systematic review suggested that more attention be paid to direct monitor output (e.g. activity counts, step rate etc) and their relationship with EE (van Remoortel et al. 2012). In the current study, we examined the relationship between i) step rate, ii) ActivPAL™ counts and EE during the treadmill walking protocol. There was a “strong” relationship between i) step rate, ii) ActivPAL™ count and EE. Interestingly, the strength of the relationship between ActivPAL™ counts and EE was stronger than that between step rate and EE. This is important as the in-built ActivPAL™ prediction equation is based on step rate. Our findings are in agreement with Harrington et al. (2011) who showed a similar trend among healthy young adults. Therefore the findings of the current study suggest that when measuring EE in people with CLBP, ActivPAL™ counts may provide a more accurate estimate than step rate. The relationship between ActivPAL™ counts and EE in the current study (figure 4.2) may therefore be used to define a “counts threshold” which corresponds to light or moderate-vigorous PA (MVPA). In this thesis, we will use this threshold to determine PA intensity during free-living PA as reported in Chapter Five. The regression equation describing the relationship between EE and ActivPAL™ counts as presented in figure 4.2. is:

\[
\text{ActivPAL™ counts (per min)} = 4733\times(\text{MET value}) - 103.3.
\]

Therefore, it was determined that an ActivPAL™ count value of ≥ 14096 per minute (or 3524 per 15 sec epoch) corresponds to ≥ 3 METs or MVPA. As the population under investigation in this study is similar to that used in the current calibration study, this approach is justified. However further work is needed to determine “count” thresholds that may be more applicable to the
wider LBP population. Our findings are preliminary but they highlight the potential of the ActivPAL™ to measure PA intensity accurately especially during continuous locomotor activity.

Finally, in the current study, we also examined the inter-device reliability of the ActivPAL™ activity monitor. The agreement between both monitors, one worn on each leg was “excellent” for MET estimate, step rate and ActivPAL™ counts for both the treadmill protocol and the non-locomotor protocol. This finding is important given the clinical population under investigation. People with CLBP also often experience leg pain. A portion of the participants in the current study reported leg pain in addition to their LBP. Therefore it is important to determine if the presence of leg pain during PA may affect the ActivPAL™ output. The findings of the current study suggest that the presence of leg pain does not affect the ActivPAL™ output and therefore people with CLBP can wear the ActivPAL™ on either leg in the presence or absence of leg pain without compromising the output.

Limitations

The primary limitation of the current study is the small sample size. A larger sample size was limited by the time-consuming nature of the testing protocol as well as recruitment difficulties due to the logistical and physical demands on patients. Secondly, only three treadmill speeds were examined in the current study. A wider range of treadmill speeds would have strengthened the study, however as many of the patients were relatively disabled due to their back pain, faster treadmill speed may have been inappropriate and have caused extra pain. As with many calibration/validation studies, testing under laboratory conditions is limited. Testing in free-living environments (e.g. using over-ground, self-paced walking) would likely strengthen the external validity of the findings and provide a more natural and realistic setting to undertake the validation process. One must acknowledge that developing thresholds based on linear regression means that the results only apply to the population under investigation and the activities included in the calibration. However, one of the aims of the current study was to determine a preliminary, yet accurate method
of measuring PA intensity that we could apply during free-living PA as reported in Chapter Five. As the profile of participants in this study (Chapter Five) was similar to the profile of participants in the current calibration study, this approach was justified. While our findings may therefore not necessarily apply to the wider LBP community, they do suggest that the ActivPAL™ has the potential to measure PA intensity accurately in people with CLBP and this needs to be further assessed in future studies. Finally, determining count thresholds based on a linear regression model fails to take into account the effect of repeated measures. To overcome this, some studies use receiver-operating characteristic (ROC) plots to determine an appropriate count threshold which corresponds to a specified level of PA intensity (Bassett et al. 2012). The current study was designed as a preliminary investigation of the validity of the ActivPAL™ monitor as a measure of EE in people with CLBP. Therefore, the statistical approach taken in this study is appropriate and consistent with previous studies. Despite the above limitations, the results of this study and the findings of others (Dowd et al. 2012a) suggest that the ActivPAL™ can provide important information about PA intensity in people with LBP as well as healthy individuals. Further studies, using a larger sample size should consider the use of more advanced statistical methods (such as ROC plots) to determine appropriate count thresholds and cross-validate their findings to strengthen the external validity of the results.

4.5. Conclusions

Our findings suggest that while the proprietary ActivPAL™ equation provides reasonable estimates of EE during moderate-intensity treadmill walking, an equation based on accelerometer counts may provide a more accurate estimate of EE in people with CLBP. Estimating EE during non-locomotor activities is more challenging and less accurate. This is especially true for activities where EE is significantly influenced by upper limb activity or during climbing activities. Finally, the inter-device reliability of the ActivPAL™ is excellent and people with CLBP may wear the monitor on either leg in the presence or absence of leg pain.
CHAPTER FIVE-PART ONE

Correlates of Objectively-measured Free-living Physical Activity in Individuals with Chronic Low Back Pain
5.1. Background

Low back pain is one of the most commonly reported musculoskeletal pain problem globally (Balague et al. 2011). Despite a plethora of research, LBP is often difficult to manage and there is some suggestion that its prevalence may be increasing (Freburger et al. 2009). Low back pain becomes persistent only in a minority of cases; however CLBP is costly and can result in significant disability for patients (Foster et al. 2010).

Physical activity is an essential component of a healthy lifestyle and is a recommended treatment in LBP international guidelines (Koes et al. 2010). The transition from acute to CLBP appears to be largely determined by psychological factors (Chou & Shekelle, 2010). The FAM hypothesises that following an episode of LBP; individuals may appraise their pain negatively (i.e. catastrophizing) and subsequently develop a fear of pain or re-injury, leading to avoidance of activities (Vlaeyen & Linton, 2000). Although fear and catastrophizing are positively and negatively associated with disability and treatment outcome respectively (Rainville et al. 2011; Lundberg et al. 2011), there is no conclusive evidence that patients with CLBP are less active than healthy individuals (van Weering et al. 2007; Verbunt et al. 2010; Griffin et al. 2012). “Avoidance” may only reflect one strategy used by patients to manage pain. Recent works points to other activity patterns in patients with CLBP, including “persistence” whereby patients may continue with PA with little regard to the presence or the intensity of pain (Huijnen et al. 2011a; Hasenbring et al. 2012). A high number of patients may exhibit signs of both “avoidance” and “persistence” behaviour (McCracken & Samuel, 2011; Huijnen et al. 2011a). A likely explanation for this is that the particular coping style adopted is both context and task-specific (Huijnen et al. 2011a).

The FAM therefore appears insufficient to fully explain the PA behaviour of patients with CLBP. In addition to fear of pain, it is well documented that other psychological factors are associated with disability in CLBP. Catastrophizing, depression/anxiety (Linton et al. 2011; Arnow et al. 2011), self-efficacy beliefs (Foster et al. 2010) and acceptance beliefs (McCracken & O’Brien, 2010) all appear to be associated with disability level. Currently, there
is limited data to determine whether these factors may also be associated with PA.

The ActivPAL™ activity monitor is a novel device used to measure habitual, free-living PA. It has previously been validated in patients with CLBP (Ryan et al. 2008) and importantly, it is also an accurate measure of sedentary behaviour (sitting or lying) (Ryan et al. 2008; Kozey-Keadle et al. 2011). Time spent in sedentary activities is associated with adverse health consequences; an association that appears to be independent of PA (Owen et al. 2010). Physical activity and sedentary activity are therefore different constructs and need to be measured independently. At this time, we are not aware of any data on the sedentary behaviour per se of individuals with CLBP.

The aim of the current study was to profile the PA and sedentary behaviour of individuals with CLBP and to explore the physical and psychological factors that are associated with disability, PA and sedentary activity. This information is necessary to better inform the management of patients with CLBP.

5.2. Methods

5.2.1. Design & Setting

The design of this study was cross-sectional. Participants were recruited from a specialist-led pain clinic at the Mid-western Regional Hospital, Limerick, Ireland. No specific requirements needed to be met in order to receive treatment at the clinic. The clinic provides a service to a large catchment area. Ethical approval for this study was granted by the Mid-Western Regional Ethics Committee.
5.2.2. Participants

The primary inclusion criteria were: a) primary complaint of LBP with or without leg pain; b) pain present for at least three months and c) aged between 18 and 65 years inclusive. Exclusion criteria included: a) inflammatory (e.g. rheumatoid arthritis), neurological (e.g. multiple sclerosis) or cardio-respiratory disease (any self-reported respiratory condition including severe, uncontrolled asthma, unstable angina, history of myocardial infarction or cardiac surgery, heart failure); b) back surgery in the previous year; c) pregnancy; d) the presence of serious spinal pathology such as fracture, infection or cauda equina syndrome; e) spinal injection in the past month and f) an inability to walk without the use of an aid.

Participants were recruited in two main ways: Patients currently attending the pain clinic and those on the waiting list with a primary complaint of LBP (with or without leg pain) were eligible for inclusion. For the latter group, the principal investigator (PI) contacted the patient directly by telephone to determine the patient’s suitability for inclusion in the study.

5.2.3. Procedure

All patients gave written, informed consent prior to participation in the study. Each participant was required to wear a PA monitor (ActivPAL™ activity monitor) on his/her thigh for a period of seven consecutive days. The monitor was worn for 24 hours a day and participants were advised to remove the monitor only during water-based activities. In addition, participants completed a battery of self-report questionnaires related to their pain and psychological status (see Appendix C2-C9). Following the measurement period, participants returned the monitor and the completed questionnaires to the PI by post or alternatively the PI collected the data directly from the patient.
5.2.4. Measures

5.2.4.1. Demographic Variables

A number of demographic variables were recorded for each participant on a standardized questionnaire (see Appendix D) designed for the study: age, sex, BMI, employment status, marital status, education level, current medication and medical co-morbidities were all documented.

5.2.4.2. Pain-related Variables

Pain Intensity

Pain intensity was measured using the 101-point numerical rating scale (101-NRS). Participants were asked to rate their pain “on a scale from 0-100 where 0 means no pain and 100 means the worst pain imaginable”. Pain intensity on average over the past seven days was recorded. The validity, reliability and responsiveness of the 101-NRS are well documented (Jensen & Karoly, 1992; Jensen et al. 1996; Williamson & Hoggart, 2005; Ferreira-Valente et al. 2011).

Pain Duration

The duration of the patient’s LBP (with or without leg pain) was recorded in years and months. For the purposes of this study, pain duration was classified into one of four main categories: < 1 year, 1-5 years, 5-10 years, >10 years.

Pain Mechanism

The painDETECT questionnaire (PD-Q) (Freynhagen et al. 2006) is a screening questionnaire designed to detect the presence or absence of a
neuropathic component to the patient’s pain. The total score on the scale ranges from 0 to 38. Patients with a score of between 0 and 12 inclusive are classified as having “nociceptive” pain, patients with a score between 13 and 18 inclusive are classified as “unknown” and a score of ≥19 indicates that a neuropathic pain component is present. The questionnaire has 80% specificity and 85% sensitivity for correctly identifying the presence of a neuropathic component in LBP (Freynhagen et al. 2006).

**Disability**

Disability was assessed using the Oswestry Disability Index (ODI) (Fairbank et al. 1980). It is a disease-specific measure, consisting of 10-items and is the most commonly used measure of functioning in patients with LBP. The total score ranges from zero to 100, with a higher score indicating more disability. The measure has established validity, reliability and responsiveness in a LBP population (Chapman et al. 2011).

5.2.4.3. Psychological Variables

**Fear of Movement**

The 11-item Tampa Scale for Kinesiophobia (TSK-11) (Woby et al. 2005) was used to measure fear of movement. Participants were required to respond to each of the 11 items on a five-point Likert scale. The total score ranges from zero to 44 with a higher score indicating a greater degree of fear. The scale has high internal consistency (α: 0.79); excellent test-retest reliability (ICC: 0.81) and a high degree of responsiveness (SRM: -1.11) in patients with LBP (Woby et al. 2005; Tkachuk & Harris, 2012).
**Self-efficacy Beliefs**

The pain self efficacy questionnaire (PSEQ) (Nicholas, 1989) is a 10-item questionnaire designed to measure a patient’s confidence in their ability to perform a number of daily activities despite pain. The total score ranges from zero to 60 with a higher score indicating better levels of self-efficacy. The psychometric properties of the PSEQ are well established (Nicholas, 2007; Miles et al. 2011).

**Catastrophizing Thoughts**

The pain catastrophizing scale (PCS) (Sullivan et al. 1995) is a 13 item questionnaire designed to assess the degree of a patient’s negative orientation towards pain. The total score range from zero (no catastrophizing) to 52 (severe catastrophizing). It consists of three subscales measuring the constructs of rumination, magnification and helplessness. For people with pain, the scale has excellent internal consistency ($\alpha$: 0.92) (Osman et al. 2000) and high test-retest reliability at 6 weeks ($r$: 0.75) and 10 weeks ($r$: 0.70) has been shown in healthy individuals (Sullivan et al. 1995). Catastrophizing as measured using the PCS is positively associated with fear of movement, depression and pain intensity, supporting the scale’s convergent validity (Wideman et al. 2009).

**Acceptance**

The Chronic Pain Acceptance Questionnaire (CPAQ) (Geiser, 1992) consists of 20 items designed to examine of a patient’s willingness to experience pain. The scale is composed of two subscales: pain willingness (nine items) and activity engagement (11 items). The score ranges from zero to 54 (pain willingness) and from zero to 66 (activity engagement) with a higher score indicating a higher level of acceptance. The psychometric properties of the CPAQ have been confirmed (Reneman et al. 2010).
**Anxiety & Depression**

The Hospital Anxiety and Depression Scale (HADS) (Zigmond & Snaith, 1983) is a self-report measure of depressive and anxiety symptoms. It is a 14 item questionnaire, measuring both anxiety (seven items) and depression (seven items). The score ranges from zero to 21 for each of the subscales with a higher score reflecting a higher level of depression or anxiety. The HADS has good internal consistency, test-retest reliability and is sensitive to change (Zigmond & Snaith, 1983). An advantage of the HADS is it is quick to complete and it evaluates both anxiety and depression separately (Brennan et al. 2010).

5.2.4.4. Physical Activity Variables

**Pattern of Physical Activity**

The Patterns of Activity Measure-Pain (POAM-P) (Cane, 2007) is a self-report questionnaire measuring three important activity patterns in chronic pain namely avoidance (10 items), pacing (10 items) and persistence (10 items). Participants are asked to indicate how much each statement applies to them using a five-point Likert scale. The score for each subscale ranges from zero to 40. The scale’s psychometric properties have been established (Cane et al. 2012).

**Habitual, Free-living Physical Activity**

Free-living PA was measured using the ActivPAL™ activity monitor (PAL Technologies, Glasgow, UK). The ActivPAL™ activity monitor is a small (35mm x 53mm x 7mm), lightweight (15g) uniaxial monitoring device that provides information on the amount of time spent in sitting/lying, standing and stepping/walking (i.e. postural PA) (Godfrey et al. 2007). In addition the ActivPAL™ activity monitor provides information on step count, cadence and EE. The ActivPAL™ activity monitor has been shown to be a valid measure of
postural PA, step count and cadence in healthy populations (Grant et al. 2006; Godfrey et al. 2007) and in patients with CLBP (Ryan et al. 2008). The ActivPAL™ activity monitor is worn on the anterior aspect of the thigh and for the purposes of this study was attached using Micropore™ hypoallergenic medical tape.

5.2.5. Data Analysis

5.2.5.1. Summary Statistics

All data analysis was performed using IBM SPSS Statistics 18. Continuous variables were checked for normality using the Kolmogorov-Smirnov test together with visual inspection of the histograms and Q-Q plots. Data are presented as mean (SD) or median (range) for normally-distributed and non-normally distributed data respectively. All questionnaires were examined and scored as per the authors’ instructions. Where no clear method of dealing with missing data was reported, we chose to exclude data where greater than 10% of items for each scale or subscale were missing. A sample of the data analysis SPSS output is presented in Appendix B2.

5.2.5.2. Physical Activity Data Analysis

Step 1: Physical activity data stored on the ActivPAL™ activity monitor was downloaded using the ActivPAL™ activity monitor proprietary software. A summary file for each day of recording was obtained and exported to Microsoft Excel®, where PA data was presented for each 15 second epoch.

Step 2: As participants wore the ActivPAL™ activity monitor continuously for 24 hours, it was necessary to identify uptime from bedtime. Time going to bed was identified by the last recorded transition from standing to sitting which was followed by at least 60 consecutive minutes of sedentary time (sitting/lying).
Rise time was identified by the first transition from sitting to standing which was clearly followed by a period of activity (standing or walking). Bedtime was therefore defined as the total time between time going to bed and rise time. Uptime was defined as the time between rise time and the time going to be. This approach is similar to that reported by Dowd et al. (2012b). In an attempt to improve the accuracy of this method; where identification of time going to bed or rise time was not clear based on the activity monitor recordings alone (e.g. due to participants getting up during the night or getting up early to use the toilet), we referred to the participant’s log where they reported on the time going to bed and getting up. In such cases we identified the time on the ActivPAL™ activity monitor that was closest to that recorded in the log.

**Step 3:** The data was subsequently checked to ensure that the basic requirements for inclusion were met. In line with previous studies, at least four days of monitoring (including at least one weekend day) of at least 600 minutes per day during uptime was required. Where the acceleration signal remained at zero for ≥ 60 consecutive minutes, this was classified as non-wear time. Non-wear time was identified using a Macro developed for Microsoft Excel® (see figure 5.1) which examined each file and identified strings of ≥ 240 zero counts (or 60 minutes). Periods of non-wear time were removed and the 24-hour period adjusted accordingly. Subsequently, for each day, time spent i) walking; ii) standing iii) upright (standing and walking combined) was calculated as was the total step count and the total activity counts (ActivPAL™ counts). In addition, time spent in moderate-vigorous PA (MVPA) was identified using a “counts” threshold based on the relationship between ActivPAL™ counts and EE as presented in Chapter Four. Using the regression equation, it was determined that a count threshold of ≥ 3524.15s⁻¹ was the equivalent of ≥ 3 METs. Subsequently, time spent walking at or above this threshold was classified as MVPA. Walking time spent below this threshold was classified as light-intensity PA (LPA). The PA data is presented as the average daily step count, the average daily ActivPAL™ counts and the average daily time spent walking, standing, upright and in MVPA/LPA for i) weekdays, ii) weekend days and iii) the full week.
Step 4: To further explore patterns of sedentary behaviour, a customised 
MatLab® program (MathWorks, MA, USA) was developed. Each sedentary bout 
(time spent sitting/lying) for every 24-hour period was identified and outputted to 
an Excel® file. The total sedentary time per day during uptime, accumulated in 
bouts ≥ 30 minutes were calculated. This timeframe was chosen as previous 
research suggests that sedentary bouts greater than 30 minutes in duration are 
negatively associated with cardio-metabolic health (Carson & Janssen, 2011). 
In addition, the number of sedentary bouts per day was also calculated. 
Sedentary data are presented as the average daily time spent sitting/lying, the 
average number of sedentary bouts per day and the total sedentary time per 
day during upright time, accumulated in bouts ≥ 30 minutes for i) weekdays, ii) 
weekend days and iii) the full week.

Comparison of the PA and sedentary activity profile on weekdays versus 
weekend days was carried out using a paired sample t-test or Wilcoxin-rank 
Signed test for normally and non-normally distributed data respectively.

Figure 5.1: A Screenshot of the Microsoft Excel® output Using a Customised 
Macro to Determine Non-wear Time. A period of ≥ 60 minutes of continuous 
zero accelerations was highlighted in yellow.
5.2.5.3. Predictors of Disability, Physical Activity and Sedentary Activity

Bivariate correlation analysis was used to examine the relationship between the demographic variables, pain-related variables, psychological variables and the dependent variables: i) disability (ODI), ii) PA (average daily time spent walking, average daily step count, average daily ActivPAL™ counts and average daily time spent in MVPA/LPA for the full week), iii) sedentary activity (average daily time spent sitting/lying and average daily sedentary time accumulated in bouts of ≥ 30 minutes per day for the full week). Pearson’s correlation coefficient (r) or the Spearmann’s Rho coefficient (ρ) was calculated for normally distributed and non-normally distributed data respectively. Where the relationship between the predictor variable and the dependent variable resulted in a p-value of ≤ 0.1, we entered the variable into a backward regression model (similar to Collins et al. 2010). The model of best fit was identified by the highest adjusted R-squared value and this was chosen as the final model (similar to Cunningham et al. 2011). The relationship between potential confounder variables (age, gender, body mass index and work status) and the dependent variables was checked and entered into the regression model where p ≤ 0.01. Clinearity tolerance statistics were examined to detect the presence of multicollinearity in the data. A decision to exclude variables with a tolerance level ≤ 0.1 was made. An alpha level of 0.05 was used for all data analyses.

5.3. Results

5.3.1. Participants

Seventy one individuals were initially recruited to participate in the study. Of these, five were subsequently excluded from all analyses {failure to return data (n=1), allergy to the adhesive medical tape used to apply the monitor (n=1), withdrawal from the study (n=2), presence of co-morbidities likely to affect PA (n=1)}. Therefore data for 66 individuals was used in the final analysis. Two individuals did not meet the requirements for inclusion of the PA
data (see section 5.2.5.2) and were excluded from this part of the analysis. A further four individuals had sufficient weekday data only. Therefore, for the PA component of the analysis, data from 64 and 60 individuals was available for the weekday and weekend/full week period respectively.

5.3.2. Demographic Profile

A detailed description of the demographic profile of the participants is presented in table 5.1. The mean age of participants was 46.05 ± 8.13 years. More females than males participated in the study and participants were generally in the overweight category with a mean BMI score of 28.5 ± 5.02. Less than one-third of participants were in paid employment at the time of the study.

5.3.3. Physical & Psychological Profile

A detailed description of the physical and psychological profile of participants is presented in table 5.2. The mean pain score measured using the NRS-101 was 59.45 ± 20.58. 23% of participants reported “mild” pain (1-40 NRS). 36% of participants reported “moderate” levels of pain (40-70 NRS) and 41% of participants reported “severe” pain (70-100 NRS). Nociceptive pain was the most common pain type as assessed using the PD-Q. The mean disability score measured using the ODI was high at 40.17. Only two participants reported “minimal” disability (ODI score 0-20). 53% and 39% of participants reported moderate (ODI score 21-40) and severe disability (ODI score 41-60) respectively. Two participants were classified in the “crippled” category. Self-efficacy levels were generally low and in line with normative data reported for people with CLBP (Nicholas et al. 2008). The total fear avoidance score measured using the TSK-11 was lower than that previously reported in patients with CLBP (Roelofs et al. 2011). 66% of participants reported an anxiety score of greater than seven. Of this group, 58%, 40% and 2% reported mild, moderate and severe levels of anxiety respectively. 65% of participants reported a depression score of greater than 7. Of this group, 64%, 26% and 10% reported
mild, moderate and severe levels of depression respectively. Acceptance scores were generally low especially for the pain willingness sub-scale. Finally, 39% of participants had a catastrophizing score ≥ 30 which reflects clinically relevant levels of catastrophizing. The bivariate correlations between pain-related variables, PA variables (self-report activity patterns) and psychological variables are presented in table 5.3.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean (SD) Or N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>46.05 (8.13)</td>
</tr>
<tr>
<td>Body mass index (BMI)</td>
<td>28.5 (5.02)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>29 (40.8%)</td>
</tr>
<tr>
<td>Female</td>
<td>37 (52.1%)</td>
</tr>
<tr>
<td>Work Status</td>
<td></td>
</tr>
<tr>
<td>Paid employment</td>
<td>20 (30.3%)</td>
</tr>
<tr>
<td>Not working</td>
<td>37 (56.1%)</td>
</tr>
<tr>
<td>Home duties</td>
<td>8 (12.1%)</td>
</tr>
<tr>
<td>Student/Other</td>
<td>1 (1.5%)</td>
</tr>
<tr>
<td>Education Level</td>
<td></td>
</tr>
<tr>
<td>Primary level</td>
<td>18 (27.3%)</td>
</tr>
<tr>
<td>Lower secondary</td>
<td>21 (31.8%)</td>
</tr>
<tr>
<td>Upper secondary</td>
<td>19 (28.8%)</td>
</tr>
<tr>
<td>Third level</td>
<td>7 (10.6%)</td>
</tr>
<tr>
<td>Other</td>
<td>1 (1.5%)</td>
</tr>
<tr>
<td>Marital Status</td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>36 (54.5%)</td>
</tr>
<tr>
<td>Never married</td>
<td>13 (19.7%)</td>
</tr>
<tr>
<td>Separated/Divorced</td>
<td>16 (24.2%)</td>
</tr>
<tr>
<td>Widowed</td>
<td>1 (1.5%)</td>
</tr>
</tbody>
</table>

Table 5.1: Demographic Profile of the Study Participants.
<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean (SD) or Median (range)</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain Variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain Intensity (NRS-101)</td>
<td>59.45 (20.58)</td>
<td>20-58</td>
</tr>
<tr>
<td>Pain Duration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 1 year</td>
<td>3 (4.55%)</td>
<td></td>
</tr>
<tr>
<td>1-5 years</td>
<td>30 (45.45%)</td>
<td></td>
</tr>
<tr>
<td>5-10 years</td>
<td>14 (21.21%)</td>
<td></td>
</tr>
<tr>
<td>&gt; 10 years</td>
<td>18 (27.27%)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>1 (1.52%)</td>
<td></td>
</tr>
<tr>
<td>Pain Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nociceptive</td>
<td>27 (40.9%)</td>
<td></td>
</tr>
<tr>
<td>Unknown</td>
<td>19 (30.3%)</td>
<td></td>
</tr>
<tr>
<td>Neuropathic</td>
<td>20 (28.8%)</td>
<td></td>
</tr>
<tr>
<td>Disability (ODI)</td>
<td>40.17 (13.28)</td>
<td>12-70</td>
</tr>
<tr>
<td>Psychological Variables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-efficacy (PSEQ)</td>
<td>23 (3-53)</td>
<td>3-53</td>
</tr>
<tr>
<td>Catastrophizing (PCS)</td>
<td>25.69 (12.37)</td>
<td>2-52</td>
</tr>
<tr>
<td>Anxiety (HADS-A)</td>
<td>9.01 (4.15)</td>
<td>0-18</td>
</tr>
<tr>
<td>Depression (HADS-D)</td>
<td>8.66 (4.24)</td>
<td>1-19</td>
</tr>
<tr>
<td>Fear Avoidance (TSK11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity avoidance (TSK11-AA)</td>
<td>13 (8-20)</td>
<td>8-20</td>
</tr>
<tr>
<td>Somatic focus (TSK11-SF)</td>
<td>17.28 (3.62)</td>
<td>10-24</td>
</tr>
<tr>
<td>Total score (TSK11-Tot)</td>
<td>30.43 (6.01)</td>
<td>19-44</td>
</tr>
<tr>
<td>Acceptance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity Engagement (CPAQ-AE)</td>
<td>31.62 (12.12)</td>
<td>1-66</td>
</tr>
<tr>
<td>Pain Willingness (CPAQ-PW)</td>
<td>19.18 (11.99)</td>
<td>2-54</td>
</tr>
<tr>
<td>Total score (CPAQ-Tot)</td>
<td>48 (11-120)</td>
<td>11-120</td>
</tr>
<tr>
<td>Physical Activity Pattern</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avoidance (POAM-P Avoid)</td>
<td>29 (6-40)</td>
<td>6-40</td>
</tr>
<tr>
<td>Pacing (POAM-P Pac)</td>
<td>26.97 (8.24)</td>
<td>3-40</td>
</tr>
<tr>
<td>Overdoing (POAM-P Per)</td>
<td>21.33 (8.28)</td>
<td>1-37</td>
</tr>
</tbody>
</table>

Table 5.2: Pain Profile, Psychological Profile & Physical Activity Pattern Profile of the Study Participants at Entry into the Study.
5.3.4. Physical activity/Sedentary Activity

Participants spent 6.01 ± 1.83 hours upright on an average day over the full week. Of the time spent upright, participants only spent 1.56 ± 0.60 hours walking/stepping with the remaining time spent standing. Conversely participants spent 17.57 ± 1.83 hours sitting or lying per day. During waking hours specifically, participants spent 3.41 hours (median) sitting/lying accumulated in bouts of ≥ 30 minutes. The median number of sedentary bouts per day was 49 (21-104). Differences in the PA and sedentary behaviour profile between weekdays and weekend days in presented in table 5.4. For clarity purposes, data on the volume of PA expressed as average daily ActivPAL™ counts is not presented. Participants took fewer steps, spent less time standing, walking and upright and spent more time sedentary during the weekend compared to weekdays (p < 0.05).

5.3.5. Predictors of Disability

The relationships between pain-related variables and psychological variables with disability (ODI) are presented in table 5.3. In addition, gender (r=0.275, p=0.025) and work status (r=0.279, p=0.023) were significantly associated with disability. The final regression model (p<0.001) presented in table 5.5 accounted for 61.2% of the variance in disability levels. Four variables remained significant in the final model: PD-Q score; activity pacing (POAM-P Pacing), pain acceptance for activity engagement (CPAQ-AE) (all p < 0.001) and gender (p <0.01). Specifically, female gender, a higher score on the PD-Q and greater activity pacing were all positively associated with disability level. Pain acceptance for activity engagement was negatively associated with disability level. Pain intensity and work status were also retained in the final model but were not statistically significant (p > 0.05).
Table 5.3: Bivariate Correlation Analysis between Disability, Pain Intensity, Psychological Variables and Self-report Physical Activity Pattern Variables. *p<0.05, **p<0.01

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Disability (ODI)</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2</td>
<td>Fear-Activity Avoidance (TSK-11-AA)</td>
<td>.296*</td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td>Fear-Somatic Focus (TSK-11-SF)</td>
<td>.334** .735**</td>
<td></td>
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<tr>
<td>4</td>
<td>Fear-Total Score (TSK-11-TOT)</td>
<td>.336** .896** .945**</td>
<td></td>
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<tr>
<td>5</td>
<td>Catastrophizing (PCS)</td>
<td>.342** .530** .544** .596**</td>
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</tr>
<tr>
<td>6</td>
<td>Pain Self-efficacy (PSEQ)</td>
<td></td>
<td>.429** -.292* -.236 -.272* -.246*</td>
<td></td>
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<td></td>
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<tr>
<td>7</td>
<td>Acceptance-Activity engagement (CPAQ-AE)</td>
<td></td>
<td>-.488** -.347** -.366** -.370** -.436** .737**</td>
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<tr>
<td>8</td>
<td>Acceptance-Pain willingness (CPAQ-PW)</td>
<td></td>
<td>-.319** -.408** -.421** -.420** -.346** .427** .513**</td>
<td></td>
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</tr>
<tr>
<td>9</td>
<td>Acceptance-Total score (CPAQ-TOT)</td>
<td></td>
<td>-.566** -.489** -.607** -.602** -.556** .633** .841** .816**</td>
<td></td>
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</tr>
<tr>
<td>10</td>
<td>Anxiety (HADS-A)</td>
<td></td>
<td>.344** .427** .471** .489** .586** -.414** -.483** -.396** -.499**</td>
<td></td>
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</tr>
<tr>
<td>11</td>
<td>Depression (HADS-D)</td>
<td></td>
<td>.499** .427** .425** .428** .508** -.607** -.550** -.472** -.598** .671**</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>12</td>
<td>Pain Intensity (101-pt NRS)</td>
<td></td>
<td>.387** .035 .192 .120 .083 -.279* -.233 -.286* -.261* .214 .368**</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>13</td>
<td>Avoidance (POAMP-A)</td>
<td></td>
<td>.498** .332** .401** .387** .412** -.605** -.526** -.370** -.542** .390** .574** .230</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Pacing (POAMP-PAC)</td>
<td></td>
<td>.477** .310* .258* .323** .182 -.267* -.279* -.308* -.297* .299* .441** .183 .633**</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Persistence (POAM-PER)</td>
<td></td>
<td>-.256* -.274* -.403** -.418** -.235 .341** .514** .321** .449** -.286* -.313* -.166 -.274* -.152</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
ODI-Oswestry disability index; **TSK-11-AA**: 11-pt Tampa Scale for Kinesiophobia-activity avoidance; **TSK-11-SF**: 11-pt Tampa Scale for Kinesiophobia-somatic focus; **TSK-11-TOT**: 11-pt Tampa Scale for Kinesiophobia-total score; **PCS**: Pain Catastrophizing Scale; **PSEQ**: Pain Self-efficacy Questionnaire; **CPAQ-AE**: Chronic pain Acceptance Questionnaire-activity engagement subscale; **CPAQ-PW**: Chronic pain Acceptance Questionnaire-pain willingness subscale; **CPAQ-TOT**: Chronic pain Acceptance Questionnaire-total score; **HADS-A**: Hospital Anxiety and depression scale-anxiety subscale; **HADS-D**: Hospital Anxiety and depression scale-depression subscale; **101-pt NRS**: 101 point Numerical Rating Scale; **POAMP-A**: Patterns of Activity Measure in Pain-avoidance subscale; **POAMP-Pac**: Patterns of Activity Measure in Pain-pacing subscale; **POAMP-Per**: Patterns of Activity Measure in Pain-persistence subscale
### Table 5.4: Daily Physical Activity and Sedentary Activity: A Comparison of Weekday versus Weekend Data.

Data are presented as mean (standard deviation) or median (range).

<table>
<thead>
<tr>
<th></th>
<th>Weekday</th>
<th>Weekend</th>
<th>p-value</th>
<th>Full Week</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Physical Activity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standing time (hrs)(^a)</td>
<td>4.55 (1.60)</td>
<td>4.17 (1.37)</td>
<td>.005*</td>
<td>4.45 (1.38)</td>
</tr>
<tr>
<td>Walking time (hrs)(^a)</td>
<td>1.59 (0.64)</td>
<td>1.42 (0.62)</td>
<td>.003*</td>
<td>1.56 (0.60)</td>
</tr>
<tr>
<td>Upright time (hrs)(^a)</td>
<td>6.14 (2.04)</td>
<td>5.59 (1.85)</td>
<td>.003*</td>
<td>6.01 (1.83)</td>
</tr>
<tr>
<td>Step count (no.)(^b)</td>
<td>6552[1752-7028]</td>
<td>6041[1437-4140]</td>
<td>.003*</td>
<td>6503[1626-16203]</td>
</tr>
<tr>
<td>MVPA (hrs)(^b)</td>
<td>0.25 [0-1.59]</td>
<td>0.22 [0-1.92]</td>
<td>NS</td>
<td>0.27 [0.01-1.83]</td>
</tr>
<tr>
<td>LPA (hrs)(^a)</td>
<td>1.25 (0.46)</td>
<td>1.11 (0.48)</td>
<td>.002*</td>
<td>1.22 (0.42)</td>
</tr>
</tbody>
</table>

| **Sedentary Activity** |          |         |         |           |
| Sitting/Lying (hrs)\(^a\) | 17.43 (2.07) | 18.01 (1.77) | .004* | 17.57 (1.83) |
| No of Sedentary Bouts\(^b\) | 54 [23-113] | 49 [26-81] | NS | 49 [21-104] |
| Time accumulated in bouts ≥ 30 minutes (hrs)\(^b\) | 3.70 (1.89) | 4.19 (1.86) | .009* | 3.41 (0.82-9.15) |
| Non-wear time (hrs)   | 0.43 (0.63) | 0.40 (0.68) |         | 0.42 (0.57) |

*Paired sample t-test; \(^b\) Wilcoxon signed rank test; MVPA: moderate-vigorous physical activity; LPA: light-intensity physical activity; NS: not significant; * p<0.01
### 5.3.6. Predictors of Physical Activity

**Duration of PA:** Bivariate correlation analysis revealed that disability ($r = -0.260$, $p = 0.045$) and depression ($r = -0.336$, $p = 0.009$) were negatively associated with the average daily time spent walking/stepping over the full week. Pain intensity ($p = 0.067$), avoidance ($p = 0.053$) and body mass index ($p = 0.064$) were approaching significance. The results of the backward regression model are presented in Table 5.6. Only depression remained significantly associated with daily time spent walking after controlling for BMI.

**Volume of PA:** Depression ($p = -0.302$, $p = 0.020$), disability ($p = -0.271$, $p = 0.036$) and BMI ($p = -0.264$, $p = 0.042$) were significantly and negatively associated with average daily step count for the full week. Disability ($p = -0.410$, $p = 0.001$), depression ($p = -0.352$, $p = 0.006$), avoidance ($p = -0.343$, $p = 0.007$) and pacing ($p = -0.337$, $p = 0.009$) were all significantly and negatively associated with average daily ActivPAL™ counts. Pain intensity ($p = 0.055$) and BMI ($p = 0.053$) were approaching significance. The results of the backward regression model shows that depression was the only significant variable associated with both average daily step count and average daily ActivPAL™ counts.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Predictor</th>
<th>$\beta$</th>
<th>$P$</th>
<th>$R^2$</th>
<th>Adj $R^2$</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disability</td>
<td>Gender</td>
<td>-7.94</td>
<td>.001</td>
<td>.649</td>
<td>.612</td>
<td>.000</td>
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<tr>
<td></td>
<td>Work status</td>
<td>4.48</td>
<td>.078</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PainDETECT</td>
<td>.673</td>
<td>.000</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Pacing</td>
<td>.512</td>
<td>.000</td>
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</tr>
<tr>
<td></td>
<td>Acceptance-Activity Engagement</td>
<td>-.350</td>
<td>.000</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Pain intensity</td>
<td>.069</td>
<td>.220</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Table 5.5:** Final Regression Model for the Prediction of the Self-reported Level of Disability.
Intensity of PA: Pain intensity ($\rho=-.303$, $p=0.018$), disability ($\rho=-.415$, $p=0.001$), depression ($\rho=-.368$, $p=0.004$), avoidance ($\rho=-.285$, $p=0.027$) and pacing ($\rho=-.325$, $p=0.011$) were all negatively associated with average daily time spent in MVPA. In the final regression model presented in table 5.6, none of the predictor variables were significantly associated with average daily time spent in MVPA, although the overall model was significant. Only BMI ($r=-.303$, $p=0.019$) was negatively associated with average daily time spent in LPA. Therefore, no backward regression analysis was undertaken for average daily time spent in LPA.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Predictor</th>
<th>$\beta$</th>
<th>P</th>
<th>$R^2$</th>
<th>Adj $R^2$</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily time walking/stepping</td>
<td>Depression</td>
<td>-.327</td>
<td>.010</td>
<td>.169</td>
<td>.139</td>
<td>.006</td>
</tr>
<tr>
<td></td>
<td>BMI</td>
<td>-.238</td>
<td>.056</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily step count</td>
<td>Depression</td>
<td>-.334</td>
<td>.008</td>
<td>.166</td>
<td>.136</td>
<td>.006</td>
</tr>
<tr>
<td></td>
<td>BMI</td>
<td>-.223</td>
<td>.073</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily volume of physical activity (activity counts)</td>
<td>Depression</td>
<td>-.310</td>
<td>.023</td>
<td>.237</td>
<td>.196</td>
<td>.002</td>
</tr>
<tr>
<td></td>
<td>Disability</td>
<td>-.228</td>
<td>.092</td>
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<tr>
<td></td>
<td>BMI</td>
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<td>.262</td>
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</tr>
<tr>
<td>Daily MVPA</td>
<td>Depression</td>
<td>-.219</td>
<td>.108</td>
<td>.257</td>
<td>.216</td>
<td>.001</td>
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<td></td>
<td>Disability</td>
<td>-.247</td>
<td>.074</td>
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</tr>
<tr>
<td></td>
<td>Pain Intensity</td>
<td>-.185</td>
<td>.158</td>
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</tbody>
</table>

**Table 5.6:** Final Regression Model for the Prediction of Average Daily Time Walking, Average Daily Step Count, Average Daily ActivPAL™ Counts and Average Daily Time Spent in Moderate-vigorous Physical Activity.
5.3.7. Post-hoc Mediation Analysis

Based on the results of the univariate correlation analysis and the subsequent regression model with volume of PA (ActivPAL™ counts) as the dependent variable, we carried out a mediation analysis to supplement the analysis described above. There is evidence that disability is associated with lower levels of PA (Lin et al. 2011). We attempted to further explore this relationship using mediation analysis. Specifically, we hypothesised that:

**Hypothesis One:** Depression mediates the relationship between disability and volume of PA (average daily ActivPAL™ counts).

Finally, there is evidence that activity pacing is positive associated with levels of disability (Andrews et al. 2012), a finding supported in the current study. However, the direction of causality is unknown. With this in mind, we tested two alternative hypotheses:

**Hypothesis Two:** Pacing mediates the relationship between disability and volume of PA (average daily ActivPAL™ counts).

**Hypothesis Three:** Disability mediates the relationship between pacing and volume of PA (average daily ActivPAL™ counts).

Baron and Kenny (1986) specified several requirements that must be met in order to determine if a variable mediates a relationship:

i) The independent variable is significantly associated with the dependent variable.

ii) The independent variable is significantly associated with the mediator variable.

iii) The mediator variable remains significantly associated with the dependent variable after controlling for the independent variable.

In addition to ensuring that these requirements were met, we carried out a bootstrapping procedure to test the robustness of the model. A macro designed for use with SPSS which is freely available online was used (www.afhayes.com/spss-sas-and-mplus-macros-and-code.htm). Bootstrapping
is now the preferred method to determine if the size of the indirect effect (i.e. the amount of mediation) is statistically significant (Hayes, 2009). It is especially suitable for smaller sample sizes and does not rely on the distribution of the data. With bootstrapping, the original sample is re-sampled a large number of times without replacement. Therefore, many “phantom” or bootstrap samples are created and the indirect effect for each sample is calculated (Preacher & Hayes, 2004). As the data is re-sampled without replacement, this means that each original data point may occur more than once in a bootstrap sample and other original data points may not occur at all. The indirect effect and its 95% CIs were calculated. Where ‘zero’ did not occur between the upper and lower limits of the 95% CI, statistical significance could be assumed supporting the proposed mediation model.

The results of the mediation analysis support hypothesis one. That is, depression was found to mediate the relationship of disability on volume of PA. The results of the bootstrapping procedure confirmed that the indirect effect was statistically significant (see table 5.7). Finally, disability was found to mediate the relationship between pacing and volume of PA and not vice versa. The statistical significance of this relationship was confirmed using the bootstrapping procedure (see table 5.7). Each of the two statistically significant relationships that we found is summarised in figure 5.2 as per the criteria outlined by Baron and Kenny, (1986).

\[ \beta = -0.236 \]

\[ R^2 = 22.0\% \]

\[ \beta = 0.499^{***} \]

\[ \beta = -0.312^* \]
Figure 5.2: a) Depression Mediates the Relationship between Disability and Volume of Physical Activity (ActivPAL™ Counts); b) Disability Mediates the Relationship between Pacing and Volume of Physical Activity (ActivPAL™ Counts).

*p<0.05; **p<0.01; ***p<0.001

<table>
<thead>
<tr>
<th>Condition</th>
<th>Predictor</th>
<th>β</th>
<th>p-value</th>
<th>Adj R² (%)</th>
<th>Indirect effect</th>
<th>Bootstrap CIs</th>
</tr>
</thead>
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<tr>
<td>Regression analysis with depression as a mediator between disability and volume of PA</td>
<td>Activity Counts</td>
<td>Disability</td>
<td>-.236</td>
<td>.081</td>
<td>19.2</td>
<td>-7975 to -16683</td>
</tr>
<tr>
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<td>Depression</td>
<td>-.312</td>
<td>.022</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression analysis with pacing as a mediator between disability and volume of PA</td>
<td>Activity Counts</td>
<td>Disability</td>
<td>-.335</td>
<td>.015</td>
<td>13.0</td>
<td>-2838 to -9779 to 2650</td>
</tr>
<tr>
<td></td>
<td>Pacing</td>
<td>-.119</td>
<td>.379</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regression analysis with disability as a mediator between pacing and volume of PA</td>
<td>Activity Counts</td>
<td>Pacing</td>
<td>-.106</td>
<td>.379</td>
<td>13.0</td>
<td>-13289 to -27777 to -1505</td>
</tr>
<tr>
<td></td>
<td>Disability</td>
<td>-.338</td>
<td>.015</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.7: Results of the post-hoc mediation analysis using regression analysis and the bootstrapping procedure.
5.3.8. Predictors of Sedentary Activity

We did not find a significant relationship between any pain-related or psychological variable and average daily time sitting/lying or average daily sedentary time accumulated in bouts of ≥ 30 minutes. Only BMI was significantly and positively associated with average daily sedentary time \((r= .265, \ p= 0.048)\) and average daily sedentary time accumulated in bouts of ≥ 30 minutes \((r= .276, \ p= 0.033)\). Therefore, no backward regression analysis for sedentary activity was performed.

5.4. Discussion

5.4.1. General Findings

The results of the current study confirm that patients with CLBP attending a specialist-led pain clinic spend the majority of their day in sedentary activity (i.e. sitting or lying). Our findings can be compared to one previous study which measured PA in patients with CLBP using the same activity monitor (Ryan et al. 2009). In comparison to the findings of Ryan et al. (2009) participants in the current study spent 0.95 more hours standing and 0.61 less hours walking over an average day. Participants in the current study were older, had a higher mean BMI score and were more likely to be unemployed. While this differing demographic profile may explain the reduced time spent walking in the current study, an alternative explanation may be that patients in the current study were recruited from a specialist pain clinic. Patients attending pain clinics are generally believed to experience more complex and intractable pain problems and there is evidence that such patients are more disabled, report greater functional limitations and experience more psychological distress compared to patients seen in primary care settings (Crook et al. 1986). In line with these findings, among the current cohort of patients, the mean disability score was 40 which is reflective of ‘severe disability’. In a recent systematic review, Lin et al. (2011) showed that patients with CLBP with high levels of disability were more likely to have lower levels of PA.
Comparison of the PA profile on weekdays versus weekend days revealed that patients with CLBP were less physically active and spent more time sedentary (lying or sitting) during the weekend. In addition, the total sedentary time accumulated in bouts ≥ 30 minutes was significantly higher during the weekend. These findings are in contrast to van Weering et al. (2009) who reported no difference in the volume of PA between weekdays and weekend days. Given the high levels of disability of participants in the current study, it is hypothesised that patients may use the weekend as a rest period in an attempt to control their symptoms. However this is speculative at present and merits further research.

5.4.2. Predictors of Disability

This study revealed that a higher disability score measured using the ODI was best explained by four variables: female gender, a higher score on the PD-Q, activity pacing and a lower acceptance score for activity engagement. The final regression model which explained 61.2% of the variance in disability score also included pain intensity but it didn’t remain significant.

Our finding that female gender was associated with a higher level of disability is consistent with epidemiological observations. There is evidence that women are more likely to experience CLBP and chronic musculoskeletal pain in general compared to their male counterparts (Fillingim et al. 2009). Moreover, women with chronic pain report greater pain severity and pain-related disability compared to men (Stubbs et al. 2009; Greenspan et al. 2007). However a recent study of primary care patients with CLBP failed to show a significant relationship between gender and disability (Arnow et al. 2011). With these inconsistent findings in mind, the relationship between gender and pain-related disability is likely complex, may be population specific and may be moderated by other known or unknown variables.

A higher score on the PD-Q is suggestive of a greater NeuP component to the patient’s LBP (Freynhagen et al. 2006) or heightened central nervous system sensitivity i.e. CS (Gwilym et al. 2009; Amris et al. 2010). Its association
with pain-related disability in the current study is not surprising. A NeuP component or CS when present is associated with higher levels of pain, disability and psychosocial co-morbidities (Beith et al. 2011; Smart et al. 2011). Also, patients with neuropathic CLBP account for a disproportionate amount of the costs associated with LBP. (Schmidt et al. 2009).

The positive association between activity pacing and increasing disability is interesting, although not entirely unexpected. Such an association has been previously reported among patients with chronic pain (McCracken & Samuel, 2007; Andrews et al. 2012). There is a lack of a clear definition of “pacing” in the literature. Vlaeyen et al. (2011) highlighted that pacing may be pain-contingent, time-contingent or goal-contingent. In the former type, patients rely on pain intensity to inform their decision to continue or cease an activity. Therefore and rather paradoxically, some patients may employ pacing as an avoidance strategy (Karsdorp & Vlaeyen, 2009). In the current study, we were unable to determine the type of pacing strategy employed. Importantly, due to the cross-sectional design, causality cannot be assumed and it is possible that patients with higher levels of disability rely on pacing as a coping strategy.

Acceptance refers to an individual’s willingness to experience pain without necessarily trying to control or avoid it. There is a growing body of evidence to suggest that a higher level of acceptance is associated with reduced disability and increased physical and psychological functioning in patients with chronic pain (McCracken & Vowles, 2008; McCracken & O’Brien, 2010; McCracken & Velleman, 2010). In the current study, disability was negatively associated with a higher level of acceptance for activity engagement. In simple terms, this suggests that patients who continue to engage in valued life activity are less disabled. It is hypothesised that patients with a higher level of acceptance are less motivated to avoid pain and therefore continue in the pursuit of life activities despite experiencing pain (McCracken et al. 2004; Crombez et al. 2012).
5.4.3. Predictors of Physical Activity

In the current study, only depression was independently associated with average daily time spent stepping/walking (duration of PA), the average daily step count (volume of PA) and the average daily ActivPAL™ counts (volume of PA) after controlling for a number of other variables. This finding is consistent with previous studies among patients with CLBP. Bousema et al. (2007) showed that depression was prospectively associated with reduced levels of objectively measured PA during the transition phase from sub-acute to CLBP. Similarly, Ryan et al. (2010) showed that depression was the only independent variable associated with time spent upright (walking and standing) in a cohort of patients with CLBP. The relationship between depression and PA is also well established in the general population (Roshanaei-Maghaddam et al. 2009) as well as in a variety of clinical populations including patients with multiple sclerosis (Jensen et al. 2012), cardiovascular disease (Whooley et al. 2008) and diabetes mellitus (Pan et al. 2011).

However, our findings differ from Huijnen et al. (2010) who did not find an association between the level of depression and objectively measured PA in people with CLBP. In their study, the median depression score, measured using the Beck Depression Inventory-II was only 11. This corresponds to “minimal depression” and is within the normal range for non-clinical samples. In contrast, in the current sample, the mean depression score measured using the HADS was 8.66 which reflects “mild depression”. Therefore, it is possible that the level of depression in the study by Huijnen et al. (2010) was too low to show any relationship with PA. Alternatively, the inconsistent findings may simple be due to the different measures used to measure depressive symptoms in both studies.

In a recent systematic review, Lin et al. (2011) confirmed the existence of a moderate and negative relationship between disability level and PA measured both using self report and objective measures in people with CLBP. Our findings support this relationship but an independent relationship between disability and PA was not confirmed. Specifically, we found that depression mediated the
relationship between disability and PA. This further emphasises the importance of the depression-PA relationship among patients with CLBP.

An interesting finding in the current study was that BMI was the only variable associated with daily time spent in LPA. This was in contrast to the results of the bivariate correlation analysis which showed that a number of variables including pain intensity, disability, depression, avoidance and pacing were negatively associated with average daily time spent in MVPA. This finding may have important clinical implications as it suggests that time spent in MVPA is more affected by the experience of chronic pain. However, given the strong empirical evidence that MVPA is important for cardiometabolic health, any factor that may limit the amount of MVPA may result in negative health outcomes. It is important to note that in the final regression model, none of the predictor variables were significantly associated with time spent in MVPA. This may be due to many of the predictor variables being related to each other (i.e. possible confounding) although we were careful to rule out the presence of multicollinearity. Most studies to date examining PA in people with CLBP have measured volume of PA. Measuring intensity of PA separately in this study has resulted in some novel findings and therefore researchers should be encouraged to measure intensity of PA in future studies.

Our finding that activity pacing was significantly and negatively associated with volume of PA is in accordance with the findings of a recent systematic review. Andrews et al. (2012) showed that rather paradoxically, pacing was associated with higher levels of psychological functioning but lower levels of physical functioning. A limitation of the current research is that causation cannot be determined due to methodological shortcomings. In our study, we found that disability mediated the relationship between activity pacing and volume of PA. While this implies that pacing results in disability, causation cannot be confirmed due to the cross-sectional design, although it poses an interesting hypothesis. Andrews et al. (2012) suggest that the way in which people with chronic pain use activity pacing may be pivotal in understanding its relationship with disability and physical function. More specifically, the authors highlight previous findings which suggest that with increasing levels of pain during the day, patients begin to rely on pacing as a coping strategy. In this
way, pacing may result in a decreased level of activity and therefore increases the patient’s perception of their level of disability. However, in contrast, pacing is an intervention designed to gradually increase one’s level of PA. Our findings concerning activity pacing are preliminary and need to be replicated in larger and preferably studies which use a prospective, longitudinal design.

It is somewhat surprising that traditional psychological variables associated with the FAM or the self-efficacy and acceptance models were not associated with the level of PA. Similarly, other studies have failed to show a relationship between PA and a number of psychological variables including fear of movement/re-injury (Helmus et al. 2012; Ryan et al. 2010, Bousema et al. 2007; Smeets et al. 2009), catastrophizing (Ryan et al. 2010, Bousema et al. 2007) and self-efficacy (Ryan et al. 2010) among patients with chronic musculoskeletal pain.

Fear of movement, catastrophizing and depression as components of the FAM are well established correlates and predictors of disability in patients with CLBP. Our findings however only support depression as being associated with the level of PA. However, a recent study (Alschuler et al. 2011) did find a significant relationship between fear of movement/re-injury and PA in people with CLBP. It is possible that the relationship between PA and fear of movement/re-injury may be moderated by other variables including the motivational context of the task (van Damme et al. 2012). This may explain the inconsistent association between fear of movement and PA in the chronic pain literature. The general lack of association between psychological variables (excluding depression) and PA in the current study may have another explanation. Fear of movement (Leeuw et al. 2007), catastrophizing (Quartana et al. 2009) and self-efficacy (Bandura, 1986) are task or situational-specific. It is possible that patients engage in and/or avoid specific movements or activities which may or may not influence their overall activity levels (Leeuw et al. 2007).
5.4.4. Predictors of Sedentary Activity

Only BMI was associated with the average daily time spent sitting/lying and the average daily sedentary time accumulated in bouts ≥ 30 minutes. This is an important finding as there is emerging evidence that prolonged, uninterrupted sitting or lying is a risk factor for weight gain and poor cardio-metabolic health (Henson et al. 2013). Although in the current study the direction of causality cannot be determined, it is commonly assumed that a reduced level of PA results in weight gain (Healy et al. 2008). However, there is evidence that the relationship between obesity and sedentary behaviour is bidirectional in nature (Hamer et al. 2012b). In a qualitative investigation among patients with chronic pain, Janke & Kozak, (2012) showed that both hunger and binge eating in response to pain are common. Therefore, although physical inactivity due to weight gain is likely among patients with chronic pain, the reverse is also possible i.e. weight gain due to a variety of reasons (e.g. binge eating, medication etc) may be a risk factor for adverse sedentary behaviour patterns. The bidirectional nature of this relationship has important clinical implications.

It is interesting to note that in the current study, the predictors of PA and sedentary behaviour were not the same. In context, this means that although individuals with CLBP with a higher level of depression had a lower level of PA, they did not necessarily spend more time in sitting or lying. The obvious reason for this is that the ActivPAL™ activity monitor also measures time spent standing independent of walking or sitting/lying. In the current study, no variable was significantly correlated with time spent standing. Studies have shown that quiet standing instead of sitting results in increased levels of EE which can have important health benefits (Healy et al. 2008). Therefore, in patients with CLBP with high levels of disability such as in the current cohort, interventions to promote standing instead of sitting may be beneficial. However, given that BMI was associated with time spent in LPA in the current study, replacing sedentary time with LPA may prove beneficial. The most effective approach to reducing sedentary activity however will require further research.
5.4.5. Clinical Implications

The current cohort of patients with CLBP attending a specialist pain clinic was highly inactive. Although these findings may not apply to other populations with CLBP such as those in primary care, it is clear that interventions to promote PA and minimise sedentary behaviour are required. For patients with a high level of disability, clinicians should identify those with elevated levels of depression and increased BMI due to the increased risk of a lower level of PA and adverse sedentary behaviour patterns respectively. While other factors such as fear-avoidance, catastrophizing and self-efficacy were not associated with objectively measured PA in the current study, this does not mean that they are not important. Physical activity behaviour in patients with CLBP is highly complex and it is likely that psychological variables interact with other variables across environmental, social, cultural and personal domains. For practical reasons we were limited in the number of variables that we could measure and therefore important relationships may not have been apparent.

Our findings that activity pacing and a greater neuropathic component to the pain are both associated with the level of disability also have important clinical implications. Neuropathic LBP and CS are challenging clinical problems and clinicians managing these patients should ensure that they adhere to the latest evidence-based guidelines which may involve referral to other healthcare professionals where necessary. Finally, clinicians encouraging activity pacing among their patients should do so with caution. Although more research is clearly needed, using pain intensity to guide activity may in fact promote avoidance behaviour. We hypothesise that time- or goal-contingent pacing may be more clinically appropriate to reduce the level of pain-related disability.

5.4.6. Limitations

The primary limitation of the current study is the cross-sectional design. The cross-sectional nature of this study means that the direction of causation cannot be determined. In the discussion section we have highlighted based on the broader body of evidence that many of the relationships are likely
bidirectional. Our findings need to be confirmed and further investigated using a prospective study design. In the current study, participants were recruited from a specialist pain clinic. While this may limit the generalisability of the findings to the wider LBP community, this cohort of patients represents a highly disabled group who account for a high proportion of the cost associated with CLBP. Therefore, research among this cohort of patients is warranted and justified. Although our sample size was relatively small, it is in line with other studies measuring PA in CLBP. For linear regression it is recommended that at least five to 10 events per variable be reached (Vittinghoff & McCulloch, 2007). Our PA analysis in this study was in line with this recommendation. However due to the large number of variables correlated with disability in the current study, our analysis in relation to disability may have been underpowered and the findings should be considered preliminary. Finally, the ActivPAL™ activity monitor is not waterproof and therefore cannot measure water-based PA such as swimming. However, only a small number of participants reported removing the monitor for water-based activities during the measurement period. As a result, this will not have significantly influenced the results of the current study. The ActivPAL™ activity monitor is also unable to accurately identify activities that are not step-based such as cycling. Although, walking is the most commonly reported leisure time PA in the general population (Tudor-Locke et al. 2011) it is possible that activities such as cycling may have been fully captured using the ActivPAL™ activity monitor in the current study and may therefore on occasion have led to an underestimation of the level of PA.

5.5. Conclusion

The findings of this study confirm that patients with CLBP with or without leg pain attending a specialist-led pain clinic spent a large proportion of their day engaged in sedentary activity. Female gender, a higher score on the PD-Q, activity pacing and lower levels of acceptance for activity engagement were associated with the level of disability. On the contrary, the variation in their level of PA was more difficult to explain with depression being the only factor associated with average daily time spent walking, the average daily step count
and the average daily volume of PA (ActivPAL™ counts). Body mass index was the only variable associated with the average daily time spent sitting/lying and the average daily time spent sitting/lying, accumulated in bouts ≥ 30 minutes. Therefore, among patients with CLBP, clinicians should promptly identify patients with co-morbid depression and/or patients with an elevated BMI as such patients may be at risk of reduced PA and increased sedentary activity respectively.
CHAPTER FIVE-PART TWO

A Comparison of the Physical Activity and Sedentary Activity Profile of Individuals with Chronic Low Back Pain with and without a Neuropathic Pain Component
5.6. Background

Low back pain is a common, complex and often difficult to treat musculoskeletal pain problem (Balague et al. 2011). The majority of patients with CLBP are said to experience ‘mechanical’ or NSLBP (Fourney et al. 2011). “Non-specific” is a reference to the inability of the clinical examination or diagnostic imaging to accurately identify the “source” of the pain (Chou et al. 2011; Wassenaar et al. 2012). Nociceptive pain is characterised by localised, movement-evoked pain (Smart et al. 2010) and is the primary pain mechanism underlying NSLBP (O’Sullivan, 2005). Neuropathic pain is defined as “pain arising as a result of injury/dysfunction to the somato-sensory system” (Treede et al. 2008). Neuropathic pain is less prevalent than nociceptive pain in individuals with CLBP and is present in 20-35% of patients (Freynhagen & Baron, 2009).

There is evidence that patients with neuropathic CLBP report higher pain intensity, experience greater depressive/anxiety symptoms, report greater disability and reduced quality of life compared to individuals without a NeuP component (Beith et al. 2011; Smart et al. 2011). Moreover, neuropathic CLBP accounts for a disproportionate amount of the costs attributed to LBP (Schmidt et al. 2009).

Physical activity is an essential component of healthy living and is widely recommended in the management of CLBP (Koes et al. 2010). Currently, there is no strong evidence that individuals with CLBP are less active than age-matched healthy individuals (van Weering et al. 2007; Verbunt et al. 2010). However, the literature to date on this topic largely concerns patients with NSLBP. The findings of a recent study confirm that patients with neuropathic CLBP report greater “activity limitations” compared to patients with nociceptive CLBP (Morsø et al. 2011). Accordingly and considering their higher self-reported disability levels, it is plausible to speculate that patients with neuropathic CLBP exhibit lower levels of PA compared to patients with nociceptive CLBP. This has not yet been addressed in the literature.

The aim of the current study was to examine the comparative PA and sedentary activity of individuals with CLBP with and without a NeuP component,
as measured using the PD-Q. In addition, we aimed to assess the physical and psychological profile of each of these groups using standardised self-report questionnaires. We hypothesise that patients with a neuropathic component to their LBP are less active and have poorer psychological functioning compared than those without a NeuP component. The findings of this study may have important management implications for individuals with CLBP.

5.7. Methods

5.7.1. Design

The design of the study was the same as that for the study presented in Part One of this chapter.

5.7.2. Participants

The participant cohort in this study was the same as that for the study presented in Part One of this chapter.

5.7.3. Procedure

The methodology in this study was the same as that for the study presented in Part One of this chapter.

5.7.4. Pain-related Measures, Psychosocial Measures and Physical Activity Measures

The measures used were the same as those used in Part One of this chapter. The PD-Q (Freynhagen et al. 2006) was used to identify the primary pain mechanism underlying a patient’s LBP. The questionnaire has 80%
specificity and 85% sensitivity for correctly identifying the presence of a neuropathic component in LBP (Freynhagen et al. 2006).

5.7.5. Data Analysis

5.7.5.1. Summary Statistics

All data analysis was performed using IBM SPSS Statistics 18. Data was checked for normality by using the Shapiro-Wilks test and visual inspection of the Q-Q plots and histograms. Self-report based measures were examined and scored in line with the author’s instructions where available. Data was summarised using descriptive statistics and are presented as mean (standard deviation) or median (range) for normally and non-normally distributed data respectively. A sample of the data analysis SPSS output is presented in Appendix B3.

5.7.5.2. Physical Activity Data

Physical activity data was processed and analysed as per Part One of this chapter.

5.7.5.3. Between and Within Group Comparisons

Participants were classified into three main groups using the PD-Q: nociceptive or unknown or neuropathic. Between group comparisons for pain-related variables, psychological variables, PA variables and sedentary activity variables were conducted using a one-way analysis of variance (one-way ANOVA) or the Kruskall-Wallis H Test for normally and non-normally distributed data respectively. When these tests were significant (α = 0.05), post hoc comparisons between groups were performed using independent sample t-tests (normally distributed data) or the Mann Whitney U-Test (non-normally
distributed data) with Bonferroni correction (Corrected significance level: \( P = 0.05/3 = 0.017 \)).

Within each group, the PA and sedentary activity profile was compared between weekdays and weekend days using a paired t-test or Wilcoxon signed rank test for normally distributed and non-normally distributed data respectively.

5.8. Results

5.8.1. Participant Characteristics

The descriptive characteristics of each of the three groups are presented in Table 5.8. There was no statistically significant difference between the groups for age \( (p=0.472) \) or BMI \( (p=0.536) \). Nociceptive pain was the most common pain type. Patients with a neuropathic component were less likely to be working and were less likely to have remained in education beyond primary level.

5.8.2. Between Group Comparisons for Pain-related & Psychological Variables

The psychological profile for each of the three groups is shown in Table 5.9. There was no statistically significant difference between the “nociceptive” and the “unknown” group for any of the variables measured. However, the “neuropathic” group reported more disability, fear-avoidance, catastrophizing, anxiety and depression \( (p<0.05) \) compared to the other two groups. The “neuropathic” group also reported higher levels of pain and lower levels of self-efficacy compared to the other groups but this difference did not reach statistical significance.
5.8.3. Between Group Comparisons for Physical Activity and Sedentary Activity Variables

The PA and sedentary activity profile was similar for all three groups (see table 5.10 and table 5.11 respectively). There was no statistically significant difference between the groups for any of the measured variables. Moreover, the within group analysis did not reveal any statistically significant difference between activity levels of weekdays versus weekend days for any of the three groups (p>0.05).
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Nociceptive (n=27)</th>
<th>Unknown (n=19)</th>
<th>Neuropathic (n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>47.52 (7.88)</td>
<td>45.26 (8.25)</td>
<td>44.80 (8.47)</td>
</tr>
<tr>
<td>BMI</td>
<td>29.33 (4.91)</td>
<td>27.83 (5.11)</td>
<td>28.01 (5.16)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Male</td>
<td>13 (48.1%)</td>
<td>7 (36.8%)</td>
<td>9 (45.0%)</td>
</tr>
<tr>
<td>Female</td>
<td>14 (51.9%)</td>
<td>12 (63.2%)</td>
<td>11 (55.0%)</td>
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<td>Work Status</td>
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<td></td>
</tr>
<tr>
<td>Paid employment</td>
<td>10 (37.0%)</td>
<td>5 (26.3%)</td>
<td>5 (25.0%)</td>
</tr>
<tr>
<td>Home Duties</td>
<td>4 (14.8%)</td>
<td>2 (10.5%)</td>
<td>2 (10.0%)</td>
</tr>
<tr>
<td>Not working</td>
<td>12 (44.4%)</td>
<td>12 (63.2%)</td>
<td>13 (65.0%)</td>
</tr>
<tr>
<td>Student/Other</td>
<td>1 (3.7%)</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
</tr>
<tr>
<td>Education Level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary level</td>
<td>4 (14.8%)</td>
<td>6 (31.6%)</td>
<td>8 (40.0%)</td>
</tr>
<tr>
<td>Lower secondary</td>
<td>12 (44.4%)</td>
<td>5 (26.3%)</td>
<td>4 (20.0%)</td>
</tr>
<tr>
<td>Upper secondary</td>
<td>9 (33.3%)</td>
<td>5 (26.3%)</td>
<td>5 (25.0%)</td>
</tr>
<tr>
<td>Third level</td>
<td>2 (7.4%)</td>
<td>3 (15.8%)</td>
<td>2 (10.0%)</td>
</tr>
<tr>
<td>Other</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
<td>1 (5.0%)</td>
</tr>
<tr>
<td>Marital Status</td>
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<tr>
<td>Married</td>
<td>13 (48.1%)</td>
<td>13 (68.4%)</td>
<td>10 (50.0%)</td>
</tr>
<tr>
<td>Never married</td>
<td>8 (29.6%)</td>
<td>2 (10.5%)</td>
<td>3 (15.0%)</td>
</tr>
<tr>
<td>Separated/Divorced</td>
<td>5 (18.5%)</td>
<td>4 (21.1%)</td>
<td>7 (35.0%)</td>
</tr>
<tr>
<td>Widowed</td>
<td>1 (3.7%)</td>
<td>0 (0.0%)</td>
<td>0 (0.0%)</td>
</tr>
</tbody>
</table>

**Table 5.8:** Demographic Profile for Each of the Three Pain Groups (Nociceptive, Unknown and Neuropathic).

Data are presented as mean (SD) or n (%)
<table>
<thead>
<tr>
<th>Variable</th>
<th>Nociceptive (n=27)</th>
<th>Unknown (n=19)</th>
<th>Neuropathic (n=20)</th>
<th>Sig</th>
<th>Post-hoc comparisons&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain (101-NRS)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>56.11 (18.73)</td>
<td>60.26 (17.6)</td>
<td>63.2 (25.4)</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Disability (ODI)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>29 (12-70)</td>
<td>39.21 (8.51)</td>
<td>49.63 (12.44)</td>
<td>.001  **</td>
<td>Noc = unknown &lt; Neuro</td>
</tr>
<tr>
<td>Fear-Avoidance (TSK-11)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity avoidance&lt;sup&gt;a&lt;/sup&gt;</td>
<td>12.56 (2.89)</td>
<td>12.24 (2.63)</td>
<td>14.89 (2.29)</td>
<td>.005  **</td>
<td>Noc = unknown &lt; Neuro</td>
</tr>
<tr>
<td>Somatic Focus&lt;sup&gt;a&lt;/sup&gt;</td>
<td>16.68 (3.34)</td>
<td>16.37 (3.92)</td>
<td>19.05 (3.22)</td>
<td>.036*</td>
<td>NS</td>
</tr>
<tr>
<td>Total score&lt;sup&gt;a&lt;/sup&gt;</td>
<td>29.24 (5.64)</td>
<td>28.61 (6.27)</td>
<td>33.94 (4.95)</td>
<td>.008  **</td>
<td>Noc = unknown &lt; Neuro</td>
</tr>
<tr>
<td>Catastrophizing (PCS)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>20.5 (8-52)</td>
<td>21.21 (13.62)</td>
<td>33.53 (9.61)</td>
<td>.003  **</td>
<td>Noc = unknown &lt; Neuro</td>
</tr>
<tr>
<td>Acceptance (CPAQ)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activity Engagement&lt;sup&gt;a&lt;/sup&gt;</td>
<td>32.97 (9.92)</td>
<td>35.02 (12.08)</td>
<td>26.32 (13.98)</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Pain Willingness&lt;sup&gt;b&lt;/sup&gt;</td>
<td>19.74 (10.73)</td>
<td>21.28 (13.99)</td>
<td>16 (3-54)</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Total score&lt;sup&gt;b&lt;/sup&gt;</td>
<td>52.71 (16.45)</td>
<td>56.29 (22.75)</td>
<td>36 (11-120)</td>
<td>.041*</td>
<td>NS</td>
</tr>
<tr>
<td>Self efficacy (PSEQ)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>26.69 (11.13)</td>
<td>26.67 (13.75)</td>
<td>19.00 (10.51)</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Anxiety (HADS-A)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>8.15 (3.82)</td>
<td>7.63 (4.25)</td>
<td>11.62 (3.43)</td>
<td>.003  **</td>
<td>Noc = unknown &lt; Neuro</td>
</tr>
<tr>
<td>Depression (HADS-D)&lt;sup&gt;a&lt;/sup&gt;</td>
<td>7.67 (3.29)</td>
<td>7.21 (4.04)</td>
<td>11.53 (4.42)</td>
<td>.001  **</td>
<td>Noc = unknown &lt; Neuro</td>
</tr>
</tbody>
</table>

Table 5.9: A Comparison of the Pain-related and Psychological Profile of the Three Pain Groups. Data are presented as mean (SD) or median (range)

<sup>a</sup> one-way analysis of variance (ANOVA); <sup>b</sup> Kruskal-Wallis test; <sup>c</sup> with Bonferroni correction; * p<0.05; ** p<0.01, NS: Not Significant

101-NRS: 101 point numerical rating scale; ODI: Oswestry Disability Index; TSK-11: 11 item Tampa Scale for Kinesiophobia; PCS: Pain Catastrophizing Scale; CPAQ: Chronic pain Acceptance Questionnaire; PSEQ: Pain Self-efficacy Questionnaire; HADS-A: Hospital Anxiety and Depression Scale-anxiety subscale; HADS-D: Hospital Anxiety and Depression Scale-depression subscale.
<table>
<thead>
<tr>
<th>Activity/Posture</th>
<th>Nociceptive</th>
<th>Unknown</th>
<th>Neuropathic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weekday</strong></td>
<td>N=26</td>
<td>N=19</td>
<td>N=19</td>
<td></td>
</tr>
<tr>
<td>Walking (hrs)(^b)</td>
<td>1.52 (0.70-3.34)</td>
<td>1.57 (0.63)</td>
<td>1.54 (0.62)</td>
<td>0.987</td>
</tr>
<tr>
<td>Standing (hrs)(^a)</td>
<td>4.26 (1.64)</td>
<td>4.93 (1.56)</td>
<td>4.55 (1.49)</td>
<td>0.380</td>
</tr>
<tr>
<td>Upright (hrs)(^a)</td>
<td>5.90 (2.18)</td>
<td>6.50 (2.07)</td>
<td>6.09 (1.87)</td>
<td>0.620</td>
</tr>
<tr>
<td>Daily step count(^b)</td>
<td>6588 (2860-17028)</td>
<td>6952 (2992)</td>
<td>6984 (3287)</td>
<td>0.958</td>
</tr>
<tr>
<td>Daily MVPA (hrs)(^b)</td>
<td>0.24 (0.02-1.59)</td>
<td>0.29 (0.04-0.85)</td>
<td>0.25 (0.01-1.30)</td>
<td>0.632</td>
</tr>
<tr>
<td>Daily LPA (hrs)(^a)</td>
<td>1.24 (0.46)</td>
<td>1.27 (0.45)</td>
<td>1.25 (0.48)</td>
<td>0.984</td>
</tr>
<tr>
<td><strong>Weekend</strong></td>
<td>N=24</td>
<td>N=19</td>
<td>N=17</td>
<td></td>
</tr>
<tr>
<td>Walking (hrs)(^b)</td>
<td>1.31 (0.66-2.88)</td>
<td>1.38 (0.63)</td>
<td>1.33 (0.58)</td>
<td>0.721</td>
</tr>
<tr>
<td>Standing (hrs)(^a)</td>
<td>4.04 (1.42)</td>
<td>4.55 (1.43)</td>
<td>3.92 (1.21)</td>
<td>0.328</td>
</tr>
<tr>
<td>Upright (hrs)(^a)</td>
<td>5.56 (1.83)</td>
<td>5.94 (1.96)</td>
<td>5.24 (1.65)</td>
<td>0.535</td>
</tr>
<tr>
<td>Daily step count(^b)</td>
<td>6386 (2620-14140)</td>
<td>6034 (2992)</td>
<td>5867 (2884)</td>
<td>0.633</td>
</tr>
<tr>
<td>Daily MVPA (hrs)(^b)</td>
<td>0.32 (0-1.92)</td>
<td>0.17 (0-0.77)</td>
<td>0.20 (0-0.80)</td>
<td>0.357</td>
</tr>
<tr>
<td>Daily LPA(^a)</td>
<td>1.10 (0.52)</td>
<td>1.14 (0.46)</td>
<td>1.11 (0.45)</td>
<td>0.962</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>N=24</td>
<td>N=19</td>
<td>N=17</td>
<td></td>
</tr>
<tr>
<td>Walking (hrs)(^a)</td>
<td>1.66 (0.64)</td>
<td>1.52 (0.61)</td>
<td>1.47 (0.56)</td>
<td>0.601</td>
</tr>
<tr>
<td>Standing (hrs)(^a)</td>
<td>4.31 (1.42)</td>
<td>4.84 (1.40)</td>
<td>4.20 (1.26)</td>
<td>0.319</td>
</tr>
<tr>
<td>Upright (hrs)(^a)</td>
<td>5.97 (1.90)</td>
<td>6.36 (1.90)</td>
<td>5.68 (1.69)</td>
<td>0.540</td>
</tr>
<tr>
<td>Daily step count(^b)</td>
<td>6669 (2816-16203)</td>
<td>6689 (2881)</td>
<td>6652 (2828)</td>
<td>0.870</td>
</tr>
<tr>
<td>Daily MVPA (hrs)(^b)</td>
<td>0.26 (0.02-1.83)</td>
<td>0.28 (0.03-0.83)</td>
<td>0.27 (0.01-0.81)</td>
<td>0.711</td>
</tr>
<tr>
<td>Daily LPA (hrs)(^a)</td>
<td>1.24 (0.42)</td>
<td>1.23 (0.42)</td>
<td>1.19 (0.43)</td>
<td>0.930</td>
</tr>
</tbody>
</table>

**Table 5.10**: The Physical Activity Profile of the Three Main Pain Groups: A Comparison of Weekday versus Weekend Data.

Data are presented as mean (SD) or median (range) and non-wear time is excluded

\(^a\) one-way analysis of variance (ANOVA); \(^b\) Kruskal-Wallis test; **MVPA**: moderate-vigorous physical activity; **LPA**: light-intensity physical activity.
Table 5.11: The Sedentary Activity Profile of the Three Main Pain Groups: A Comparison of Weekday versus Weekend Data.

<table>
<thead>
<tr>
<th>Activity/Posture</th>
<th>Nociceptive</th>
<th>Unknown</th>
<th>Neuropathic</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weekday</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sitting/Lying (hrs)\textsuperscript{a}</td>
<td>17.47 (2.19)</td>
<td>17.40 (2.14)</td>
<td>17.42 (1.96)</td>
<td>0.993</td>
</tr>
<tr>
<td>No of sedentary bouts\textsuperscript{b}</td>
<td>51 (31-110)</td>
<td>48 (11)</td>
<td>50 (36-105)</td>
<td>0.673</td>
</tr>
<tr>
<td>Total time in sedentary bouts ≥ 30 minutes\textsuperscript{b}</td>
<td>4.07 (1.94)</td>
<td>2.83 (0.62-10.34)</td>
<td>3.53 (1.45)</td>
<td>0.282</td>
</tr>
<tr>
<td><strong>Weekend</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sitting/Lying (hrs)\textsuperscript{a}</td>
<td>17.91 (1.80)</td>
<td>17.85 (1.86)</td>
<td>18.35 (1.70)</td>
<td>0.661</td>
</tr>
<tr>
<td>No of sedentary bouts\textsuperscript{b}</td>
<td>46 (28-96)</td>
<td>45 (12)</td>
<td>57 (22)</td>
<td>0.266</td>
</tr>
<tr>
<td>Total time in sedentary bouts ≥ 30 minutes\textsuperscript{b}</td>
<td>4.22 (1.25-9.43)</td>
<td>3.17 (1.31-7.37)</td>
<td>3.91 (1.91)</td>
<td>0.095</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sitting/Lying (hrs)\textsuperscript{a}</td>
<td>17.42 (1.94)</td>
<td>17.52 (1.94)</td>
<td>17.84 (1.76)</td>
<td>0.770</td>
</tr>
<tr>
<td>No of sedentary bouts\textsuperscript{b}</td>
<td>50 (35-99)</td>
<td>48 (11)</td>
<td>52 (33-104)</td>
<td>0.511</td>
</tr>
<tr>
<td>Total time in sedentary bouts ≥ 30 minutes\textsuperscript{b}</td>
<td>3.63 (1.40-34.22)</td>
<td>3.03 (0.82-9.15)</td>
<td>3.71 (1.49)</td>
<td>0.293</td>
</tr>
</tbody>
</table>

\textsuperscript{a} one-way analysis of variance (ANOVA); \textsuperscript{b} Kruskal-Wallis test

Data are presented as mean (SD) or median (range) and non-wear time is excluded.

5.9. Discussion

5.9.1. Main Findings

The findings of this study support our first hypothesis. Patients in the current study with a NeuP component had impaired psychological functioning compared to patients classified in the “nociceptive” or “unknown” groups. More specifically, patients with a NeuP component reported greater levels of disability, anxiety, depression, fear-avoidance and catastrophizing thoughts. Although they also reported greater pain intensity and lower levels of self-
efficacy and acceptance, these differences did not reach statistical significance but are still likely to be clinically meaningful. These findings are in line with recent studies among patients with CLBP seen in primary care (Beith et al. 2011; Smart et al. 2011).

However, our second hypothesis that individuals with neuropathic LBP are less active than patients with “nociceptive” pain, was not supported. We are not aware of any previous study that has compared the PA profile of patients with and without a neuropathic component to their LBP making comparisons with the broader literature difficult. Patients in the current study were recruited from a specialist pain clinic and likely represent a more complex group, experiencing more intractable pain that had failed to improve in a primary care setting. Also patients in the current study were highly inactive irrespective of their group allocation. It is therefore likely that patients attending specialist pain clinics may represent a more disabled group which may explain our failure to find a difference in the PA or sedentary behaviour profile of patients with and without a neuropathic component to their LBP. It is well established that PA behaviour is influenced by a large number of factors (Bauman et al. 2012). Therefore, for people with LBP, the underlying pain mechanism should be seen as only one of many variables that may have influenced their level of PA. This complex interaction between different variables is another possible reason why there was no apparent difference in the PA or sedentary activity behaviour of the three groups. Moreover, the small number of participants in each of the groups in this study may have been too small to adequately control for the many variables (in addition to the underlying pain mechanism) that may influence PA in this group resulting in an increased likelihood of a Type-II error.

Our results suggest that the higher level of disability and impaired psychological functioning among patients with neuropathic LBP cannot be explained by their level of PA. Although speculative, there are a number of reasons that may help to explain this finding. Neuropathic pain is often characterised by spontaneous, non-mechanical pain (von Hehn et al. 2012) and may be associated with other symptoms including paresthesia, numbness or hyperalgesia/allodynia (Baron et al. 2010). The lack of a clear stimulus-pain relationship would suggest that patients with NeuP may have less control over
their symptoms. Moreover, NeuP is often unresponsive to treatment which may be another source of distress for patients. Therefore it is possible that factors specific to NeuP and its management may account for the increased levels of disability and distress without necessarily impacting on the patient’s level of PA above and beyond that of patients with LBP in general.

In the current study, the PD-Q was used to identify the primary pain mechanism and classify patients accordingly. The questionnaire is population-specific to LBP and has a sensitivity and specificity of 80%. Recent evidence suggests that a diagnosis of NeuP should include clinical bedside tests (e.g. straight leg raise, sensory testing etc) in addition to the use of a screening questionnaire such as the PD-Q (Scholz et al. 2009; Haanpaa et al. 2011). It is therefore possible that some patients in the current study may have been misclassified. However it is important to point out that the PD-Q has documented discriminative validity and appears to be superior to MRI in identifying a NeuP component in people with CLBP (Beith et al. 2011). The PD-Q score has also been shown to correlate with measures of heightened central nervous system sensitivity such as pressure-pain threshold (Amris et al. 2010) and increased cortical activation in the periaqueductal gray (Gwilym et al. 2009). It is therefore possible that the group classified as “neuropathic pain” in the current study may have included patients where the dominant pain mechanism was CS in the absence of any nerve lesion or injury. In this manner, one may regard a higher score on the PD-Q as reflecting more complex neurophysiological processing and not indicative of NeuP per se as defined by Treede et al. (2008).

5.9.2. Clinical Implications

It is clear from our findings and those of others (Smart et al. 2011) that patients with neuropathic LBP (and/or patients with CS) represent a highly disabled group with impaired psychological functioning. Clinicians therefore should aim to identify such patients at an early stage during their pain course and implement appropriate management strategies in line with best available evidence. Our failure to show a difference in the PA or sedentary behaviour
profile of patients with different underlying pain mechanisms does not mean that a PA intervention is not necessary or appropriate. As mentioned earlier, the current cohort of patients was very inactive with the majority of the day spent in sedentary activity. In addition to the well established health related benefits of PA, PA interventions may be beneficial in the primary prevention of CLBP. Recent evidence suggests that PA may be useful in the modulation of pain at least in the short-term (McLoughlin et al. 2011; Ellingson et al. 2012). Finally there is experimental evidence that aerobic exercise is beneficial for NeuP and reduces central nervous system hypersensitivity (Stagg et al. 2011; Chen et al. 2012; Sluka et al. 2013). Therefore, PA or exercise should be an integral part of any multidisciplinary approach to the management of CLBP.

5.9.3. Limitations

The primary limitation of the current study was the relatively small sample size. Therefore, the statistical analysis may have been underpowered to detect a difference between the groups. However, our finding that patients with neuropathic LBP (and/or CS) report poorer psychological functioning is consistent with other larger studies that have been conducted (Smart et al. 2011). The finding however that patients with neuropathic LBP (and/or CS) are not less physically active need to be confirmed in further studies. In the current study, we used the PD-Q to determine the primary pain mechanism underlying the patient’s disorder. While the specificity and sensitivity of the questionnaire is high, it may misclassify up to 20% of patients. Furthermore, some patients classified as “neuropathic pain” may have been experiencing CS given the overlap of clinical signs and symptoms between these two pain mechanisms. Therefore, further studies should take this into account when examining any differences between groups of patients with CLBP with different underlying pain mechanisms. The use of a detailed subjective and physical examination together with the use of quantitative sensory testing in future studies may be helpful in this regard.
5.10 Conclusion

In the current study, patients with CLBP with a neuropathic pain component (and/or CS) reported higher levels of disability and poorer overall psychological function compared to the other subgroups of patients. However, there was no apparent difference in the level of PA or the sedentary activity profile between the groups. Therefore, the higher levels of disability among patients with neuropathic LBP (and/or CS) cannot be explained by their levels of PA.
CHAPTER SIX

The Experience of Physical Activity among Individuals with Chronic Low Back Pain: A Qualitative Study
6.1. Background

It is well recognised that PA promotes good health and is essential in the primary and secondary prevention of chronic disease (Powell et al. 2010). Patients with LBP may misinterpret their pain as a sign of serious injury and as a result may avoid activities or tasks that they associate with their pain (De Peuter et al. 2009). This is the primary assumption of the FAM and suggests that patients with LBP are at risk of lower levels of PA (Vlaeyen & Linton, 2000; Leeuw et al. 2007). Surprisingly, there is little empirical evidence to suggests that patients with CLBP are less active that their healthy counterparts (van Weering et al. 2007; Verbunt et al. 2010). According to the AEM (Hasenbring et al. 2001), a subgroup of patients with CLBP may persist with activity with little or no regard to their pain. Heneweer et al. (2009) reported that the prevalence of CLBP was highest among individuals with low and high levels of PA. This suggests that not all individuals with CLBP exhibit low activity levels. The PA behaviours of individuals with CLBP therefore appear complex.

According to the social-ecological theory, PA behaviour is likely affected by a number of factors including biological, psychological, social, cultural and environmental factors or importantly the interaction between these factors (Richard et al. 2011). In patients with CLBP, the role of such factors in explaining disability level is well supported (Linton & Shaw, 2011; Hill & Fritz, 2011). However, whether (and how) these factors influence actual behaviour such as PA is less well investigated and warrants further consideration.

To date the majority of research studies examining PA in patients with CLBP have used a quantitative methodology. Qualitative methodologies have the potential to add to this body of work by providing novel personal insights into inter-individual differences in the activity behaviour of individuals with CLBP which may go undetected using quantitative methods solely. Furthermore, qualitative research facilitates exploration of issues that are difficult to assess objectively. For example a recent study (Alschuler et al. 2011) found that the response of significant others was associated with the PA level of individuals with CLBP. The precise nature of this relationship however remains unknown and may be further explored using a qualitative methodology. Examples of other
factors that may be better explored using qualitative methods include the influence (if any) of medication and advice from healthcare professionals on the PA behaviour of patients with CLBP.

This study presents a series on one-on-one in-depth interviews examining the perception, attitudes and beliefs among individuals with CLBP towards PA. More specifically, the aim of this study was to better understand the PA behaviour among these individuals and the determinants/correlates of this behaviour. In an attempt to be comprehensive and in line with the biopsychosocial model of chronic pain we explore a number of factors crossing physical, psychological, cognitive, social and environmental domains.

6.2. Methods

6.2.1. Design

A qualitative study methodology was adopted using in-depth semi-structured interviews. The controlled nature of quantitative methodologies is often insufficient to answer complex questions regarding complex human behaviour patterns. The qualitative methodology adopted in this study allowed for in depth investigation of the patient’s perspective of PA within their own social environment. Ethical approval for this study was granted by the Mid Western Regional Hospital Ethic Committee.

6.2.2. Participants

Patients aged 18 to 65 years, with a primary complaint of LBP for greater than three months were eligible to participate. Patients with a significant co-morbidity that could affect PA, patients who were pregnant or those with confirmed serious spinal pathology (e.g. fracture, infection, cauda equina syndrome) were excluded. All participants had previously taken part in a larger study examining the correlates of objectively measured, habitual PA levels (see
We adopted a purposeful sampling strategy, whereby participants who had participated in this previous study were identified, aiming for variation in age, gender, living environment (rural versus urban), presence (or absence) of leg pain and self-reported disability. Potential participants were subsequently contacted by telephone and informed consent was obtained before the interviews took place.

**6.2.3. Data Collection**

Face to face, in-depth interviews were conducted with each participant in their own home. Each interview lasted approximately 35-50 minutes and was recorded using a digital Dictaphone.

Prior to data collection, an ‘interview schedule’ was prepared which outlined the main questions or topics to be covered during the interview (see Appendix F). This acted only as a guide during the interview and the interviewer was not obliged to rigidly adhere to it. The questions were based on a similar study in a different clinical population by Azar et al. (2010). Questions were generally open-ended to encourage detailed responses. However, in specific circumstances, questions were more focused to gather more information on a specific topic.

The interview covered a variety of topics including the impact of LBP on PA, barriers and facilitators of PA, the role of social support, advice given by healthcare professionals regarding PA, effects (if any) of medication on PA and the influence on the environment on PA levels.

**6.2.4. Data Analysis**

All interviews were recorded using a digital Dictaphone and subsequently transcribed verbatim. A sample of the interview transcripts is presented in Appendix E. All interviews were analysed using NVIVO 10 software. Data was analysed using the qualitative method of inductive thematic analysis (Braun & Clarke, 2006). Physical activity is a complex human behaviour that is highly
individual and is likely influenced by a number of physical, psychological, social and environmental factors, all specific to the individual. Inductive thematic analysis was chosen as a suitable and flexible method to capture these inter-individual differences. Data analysis in the current study was conducted in five main steps (similar to Turner et al. 2002).

1. The first step in the analysis involved reading and re-reading all interviews to get a deep understanding of the content of the interviews and similarities and differences between the interviews.

2. Manual, preliminary coding was then carried out on a sub-sample of the interviews using the pen and paper method and a list of potential codes and emerging themes was drawn up.

3. Subsequently, interviews were then formally analysed on a line by line basis using NVIVO 10 with similar content being ascribed to a particular “code”. Coding the data in this manner was important to prevent interpretation of the data using pre-determined constructs or ideas (Turner et al. 2002).

4. When all interviews had been analysed, each “code” and its contents were re-analysed to ensure that the content was appropriate for the “code” in question. The “codes” were thoroughly analysed and interrelationships between the codes were identified. In this way, the findings were grouped into major “themes” and “sub-themes”. The identification of major themes and sub-themes was carried out with consideration given to the theoretical constructs and underpinnings derived from the quantitative literature.

5. The final stage of the analysis involved discussion on the identified themes and subthemes with one of the co-authors of this study (NK). This ensured that the themes made logical sense and were supported by appropriate quotations.

6.2.5. Trustworthiness

Qualitative research is examined for its degree of trustworthiness (Lincoln & Guba, 1985). Trustworthiness is comprised of the following four constructs: i) credibility, ii) confirmability, iii) dependability and iv) transferability.
In qualitative research, credibility refers to the “believability” of the findings. In the current study, this was enhanced by various methods. All transcripts were initially read and re-read without any data coding. This allowed for a deeper understanding of the subject area as well as the similarities and differences between individuals. Moreover, during the coding process, as codes and themes emerged, the findings were discussed with one of the co-authors of this study (NK). This was helpful in determining how the themes fitted together and if they were logical, compatible with the underlying theoretical framework and furthered one’s understanding of the subject area.

Confirmability refers to the degree to which the research findings are free of researcher bias. In the current study this was enhanced in a number of ways. Firstly, a purposeful sample was recruited. This ensured that different participants with potentially different opinions and beliefs were adequately represented. Secondly, consistency of themes and sub-themes between individuals and a comparison with quantitative data in the broader literature further enhanced confirmability.

Dependability refers to the likelihood of getting similar findings and reaching similar conclusions if the study was to be repeated. In the current study this was enhanced by careful transcription of each recorded interview and the subsequent checking of each transcript with the original interview.

Finally, transferability refers to the applicability of the findings to different groups across different contexts. In the current study this was enhanced by clearly describing the research setting and providing a detailed profile of each of the participants interviewed. This allows the reader to determine to which patient group(s) the findings are likely to apply.

6.3. Results

6.3.1. Participants

Nine participants (5F, 4M) participated in the study. A detailed demographic and clinical profile for each of the participants is presented in table
6.1. The majority of participants (66%) had “nociceptive” LBP and disability status ranged from “mild disability” to “crippled”. Participants reported “moderate” or “severe” pain and participants reported PA avoidance, persistence or pacing to varying degrees.

6.3.2. Thematic Analysis

Five major themes were identified from the data:

I. Impact of low back pain and its management on physical activity
II. Barriers to physical activity
III. Motivations for physical activity
IV. Mood and physical activity
V. Patterns of physical activity

At the beginning of each interview, participants were asked about their understanding of the term “PA”. Most participants defined PA in terms of the type(s) of activities that they performed. There was evidence from the participants’ responses that they considered PA across different domains, with household and leisure-time activities being the most commonly mentioned. Work-related activities were referenced less frequently. While there were some differences in the interpretation of “PA”, participants’ understanding of the concept was largely consistent with the definition proposed by Caspersen et al. (1985), which is widely used in the PA literature. Therefore, participants in the current study showed a broad understanding of the term “PA” which is important for the external validity of the findings.
Table 6.1: Characteristics of the Participants Included in the Study.

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*101-point Numerical rating scale (0-100); *Oswestry Disability Index (0-100); PainDETECT (Nociceptive vs. unknown vs. neuropathic); *Patterns of Activity Measure in Pain-avoidance subscale (0-40); *Patterns of Activity Measure in Pain-persistence subscale (0-40); *Patterns of Activity Measure in Pain-pacing subscale (0-40); **BMI**: Body Mass Index
Theme I: Impact of Low Back Pain and its Management on Physical Activity

Current versus Previous Level of Physical Activity

All participants reported that their level of PA had been negatively affected by their pain. Comparing their current level of PA to their previous level of activity, participants described how their recreational PA was reduced. For some participants, they reported a high level of PA prior to the onset of their pain, while others reported more moderate levels of PA. Examples of the types of recreational activities mentioned included kickboxing, power walking, gardening and running. Irrespective of their previous level of PA, all participants reported that their current level of PA was reduced. Participants also commented on their reduced ability to perform many everyday household tasks due to their pain. Tasks such as hoovering, cleaning and climbing stair were most often mentioned.

“Before I had back pain, I could do five miles a day walking. I mean power walking. I walked and ran in mini-marathons. It’s changed totally”.

A reduced level of PA led to reduced mood for some of the participants. Two participants described how their identity was built around their previous level of PA and as a result of their pain their identity was affected:

“A lot of my identity was around my physicality as a person, as a woman, as a capable woman, as a strong woman and I feel that’s been diluted by this whole experience”.

Two of the participants reported that they accepted their limitation regarding PA and were therefore less susceptible to low mood. Another participant described how the process of acceptance can take a long time, adding that she had not yet fully accepted her reduced physical abilities. This difference in participants’ response is illustrated by the following two quotations:
“I just continue on with what I can do and I suppose I’m lucky that I
can walk and I can cycle”.

“I’m still not there because I still push myself to do stuff that I really
shouldn’t do but yeah it’s been very, very hard and a very long
process of acceptance”.

**Advice from Healthcare Professionals Regarding Physical Activity**

The advice given by healthcare professionals to participants regarding
PA appeared to be varied. There is evidence from the participants’ responses
that while advice regarding activity was sometimes given, this was not a
universal finding. Participants were more often advised to avoid specific
activities. Where participants were advised to engage in PA, leisure time
activities such as walking, swimming and cycling were the activities most
commonly recommended by healthcare professionals. Advice to limit or monitor
PA in terms of frequency, volume or intensity was commonly given with the
primary reason being to avoid an exacerbation in the pain level.

“They have all mentioned that walking at a reasonably brisk pace is
very good. Continue to do exercising and cycling. I’ve got a few
second opinions and they all seem to think that the cycling is ok to
the point of that you don’t really stretch yourself to the pain barrier
because that is not doing you any good”.

There was little evidence that patients were advised in relation to other
domains of PA including household and work-related PA. Although not a
common finding, advice between different healthcare professionals was at times
conflicting and this impacted negatively on the individual’s level of PA.

“At one stage I asked was walking any good and you would be told
by one of them that a certain amount of it was good and then you’re
told by another one not to walk so where do you go like, which one
do you believe in”.
One participant who had received little or no advice regarding PA believed that overly focusing on treating the pain per se meant that other “satellite” issues were not addressed:

“I think that they just see somebody in extreme pain and they want to deal with the pain. I don’t think they think of the other sort of satellite issues surrounding the person. The pain situation could be from somebody just been completely immobile most at a time sitting at a desk or sitting on the sofa watching TV or whatever and you know a bit of exercise might actually cure the pain”.

Almost all participants reported being told to avoid specific activities. This mainly involved manual tasks and tasks involving lifting and bending but was not always limited to such tasks.

“Yes and hoovering, then he said that was to be cut out, anything with bending down I had to cut that out but what I am going to do like?”

Healthcare professionals were often very specific in their advice to avoid specific activities. It was evident from some responses that even when participants suggested activities that they could do, they were often advised not to:

“I asked about doing the, even the aqua aerobics classes, whatever and I was told no but to walk in it [the swimming pool] and I was advised to go to the hydrotherapy pool which I did and spent my hour walking up and down the pool”.

Solicitous Response from Family and Friends towards Physical Activity

Almost all participants commented on how friends and family members commonly encouraged them to rest, advised them to limit their activity levels or to avoid undertaking certain activities.
“Now they do try to protect me and try to limit me themselves really sometimes. Oh don’t pick this up or don’t do that or Come on (name withheld), your back!”

Most participants viewed this as their friends and family being concerned for them. For one participant, she believed that the response of family members and friends was often overprotective. She highlighted that it was up to the patient themselves not to allow this to negatively impact on their daily activities.

“It is up to you and stand back and you either let them do everything for you or you gain your independence”.

Theme II: Barriers to Physical Activity

Pain

Most participants reported that the pain experienced with exercise and PA was the main barrier preventing them from engaging in more PA. There is some indication from the responses that the severity or intensity of the pain is the primary limiting factor and not the pain itself per se. Responses indicated that participants would be reluctant to maintain activity beyond a certain point due to increasing pain:

“I mean if I go to a certain stage and I know that I won’t be able to do anymore and I’m stuck in a situation that I won’t be able to move so I know how far I can push myself”.

Fear

It was common for participants to report fear as a barrier to PA. For some, they were fearful of provoking more pain. For others, fear of making the problem worse was the main factor. This difference is illustrated in the following two quotes from two different individuals:
“Yes, there is certain things I won’t do for fear of aggravating it”. “I wouldn’t lift this table for instance because I am sure that would aggravate it”.

“I am afraid that if I keep doing a thing that I am going to do more harm to myself. That I will make myself worse and that I could end up not able to walk around”.

The latter quote also illustrates that fear was sometimes accompanied by catastrophizing thoughts regarding PA and its consequences. One participant described in detail how successfully completing an activity despite fear of aggravating the pain did not simply “dispel” the fear associated with doing that activity:

“The next time I go to cut that hedge, I will be scared. I will be wondering is there something different that I am going to do even though it is basically the same activity. Is there going to be something different that is going to actually cause the pain. I would imagine that it would take several different times for me to cut the hedge without experiencing a severe bout of pain. For me to be confident that this is now a safe activity for me”.

**Environmental Factors**

Factors relating to the environment were also cited by some as barriers to PA. Some participants highlighted that lack of facilities or difficulty with access to facilities due to transport difficulties limited their level of PA. One participant who had been advised to go swimming expressed how access to facilities made this difficult.

“Swimming is the thing that I haven’t been at because like everything else it’s not around. Where do I go? You’re twenty five miles you know. There is one locally but I wouldn’t use it. So you’re talking twenty plus miles to the other one”.
Participants who lived in rural areas commented on the limited opportunity for social interaction and lack of facilities or services for people living ‘out of town’. One of the participants who didn’t drive expressed concern on having to rely on others for transport which often negatively impacted on opportunity for PA:

“You are depending on the next person to take you everywhere you want to go and if you want to go somewhere then and they don’t want to go, then what way does it end up? You just stay inside isn’t it”?

The physical environment was highlighted by one participant as a potential barrier to PA:

“I go to the Parkway Shopping Centre or the Crescent Shopping Centre because the surface is flat and I can walk around those shopping centres whereas if I try and walk on the street you have the constant potholes or uneven surfaces and you are constantly on different levels’.

*Impaired Sleep*

There was clear evidence that sleep disruption was common among the participants. Pain was the most common reason given for the disrupted sleep. However, some participants believed that relative physical inactivity during the day contributed to the problem. They believed that their activity levels during the day were insufficient to result in sufficient fatigue to facilitate sleep. Most participants reported that a lack of sleep or a broken sleep pattern often resulted in reduced PA the following day. Fatigue and low mood as a result of the lack of sufficient sleep were the most common reasons cited. One participant commented on the effect that lack of sleep had on her level of PA activity prior to using sleeping medication:

“It had massive effects because I was tired all the time and mentally so depressed and anxious all the time that I didn’t want to leave the house”.
Two of the participants mentioned that their PA was not negatively affected by impaired or reduced sleep time. This was particularly evident among participants who were highly disabled due to their pain and were already significantly limited in terms of everyday PA. Another participant described how his sleeping patterns had already been variable prior to the onset of pain and as a result did not perceive lack of pain as affecting his level of functioning:

“For instance, I didn’t sleep at all Monday or Tuesday. I slept like a top last night. I got eight hours sleep. I am not under any fatigue. The lack of sleep in the previous two days hasn’t had any effect on me”.

**Medication**

Participants have varying opinions on the effects of the medication they were taking on their PA levels. Some participants reported that their PA levels were limited due to the side effects of some medications. Such side effects included fatigue, reduced muscle power and stomach upset. As a result, some participants also reported only taking the medication when absolutely necessary or reducing their medication intake:

“The medication simply made me stoned. Lethargic, disinterested and stoned. It fixed the pain. It did what it was supposed to do but at the cost of incapacitating”.

For other, especially those that were more disabled by pain, the medication that they were taking appeared helpful in allowing them to function better. For such participants, they were keen to stress that the medication simply helped to take the edge off the pain and not completely resolve the pain:

“I feel that I don’t seize up as much, I mean there are a couple of days there now and it happened one weekend where I had no pain medication. Never, that was horrendous”. 
Theme III: Motivations for Physical Activity

Motivations for PA were more varied than the barriers for PA. The most commonly reported motivations for engaging in PA were the enjoyment/reward associated with the activity, a desire to remain healthy and fit and wanting to live a normal life. Participants were motivated to do tasks or activities that they enjoyed. In addition to enjoying the activity itself, some participants enjoyed the scenic environment during an activity or the social interaction associated with the activity. This is illustrated in the following two quotes:

“There is a risk for pain for fishing. I will still go fishing because the feeling of catching a fish is euphoric so the pain to pleasure ratio is worth it”

“I’d much prefer to be out in the countryside, you know, there’s big mountain walks here, there’s forest walks here so yeah it’s great and, you know, with the dogs as well, interacting with them and seeing them having fun again is another sort of gratification of my efforts and exercise.

Although social support often facilitated PA and participants were motivated by being with friends, many participants preferred to exercise alone. This was as a result of their LBP and a desire to exercise at their own pace given their physical limitations:

“I prefer to go at my own pace because I’m conscious of the problem I have with my back and my pain. I have good days and bad days. Some days I could cycle and keep going and other days I can’t so I don’t want to affect anyone else”.

Two participants cited a desire to keep fit as a motivation to do PA. Both of these participants described themselves as being very active prior to their back pain.

“I used to do a lot of running years ago so now running is a major problem with my back. I can’t do it anymore but cycling I find I can so I just like to keep fit”.

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Other factors including wanting to lead a normal life or the mental health benefits of PA (see “Mood and Physical activity”) were mentioned by some as motivations of PA. One participant described how she was motivated to do more activity when her pain levels were less:

“I suppose having a good day. Being in relatively less pain I suppose I would be motivated to get out and do more things”.

Theme IV: Physical Activity Patterns in People with Low Back Pain

It was evident from participants’ responses that people with LBP use a variety of different strategies to manage their PA. It was also clear that participants used different strategies depending on the specific task in question or the context of the activity. Participants did not appear to rely solely on any one strategy.

Almost all participants reported avoiding certain activities. The main reason for this appeared to be the pain associated with the activity. Most participants were specific in their response regarding the types of activities that they avoided. Household and leisure time physical activities were most commonly cited:

“I avoid activities that I know are going to cause me pain. For example, hoovering for some reason really really causes me a lot of pain”

Some participants reported the need to assess a situation in more detail before engaging in an activity and modify the task accordingly:

“Going to a concert for instance. Before I had any pain I would [be] up front and happy to be in the crush. Now I simply would just go and sort of sit back and enjoy the vibe of the concert rather than risk the crush”.

Although it was clear that participants avoided specific activities due to fear of pain etc, the nature of this avoidance appeared to be context or task specific. All participants commonly reported persisting with PA despite pain,
sometimes even in the knowledge that this would result in a pain flare-up. The
degree to which they persisted with an activity was dependent of the
motivational context of the task. Generally speaking motivations fell into three
broad categories: activities that were enjoyable, tasks that were seen as a
necessary part of daily living e.g. cooking or those that were important for the
person’s sense of identity or independence. For participants who persisted with
activities that were enjoyable, they tended to weight the potential for pain
against the rewarding nature of the task:

“I go fishing and if you cast the rod and pull your back the pain
would be just as bad as anyplace else but because the pleasure
aspect to that, you would tend not to consider it. You look at the
pleasure and that is far more important than pain”

For others, feelings of responsibility to do necessary household activities
or a desire to be independent, in control and to live a normal life were the main
factors associated with persisting with an activity despite pain:

“The washing, cleaning, the upper presses or whatever. There are
things that have to be done and things that you have to do and you
can’t constantly ask other people to do things for you. If you want
your independence you do it”.

Participants often persisted with activities to the point where their pain
significantly worsened. Moreover, although persisting with an activity despite
pain appeared to be task specific, some participants reported engaging in more
activity on ‘good days’ when the pain intensity was less. This often led to a
significant increase in pain levels subsequently:

“I know that they say that people with chronic pain often, you know,
when they are feeling a bit better push themselves further than they
should and then end up being really sore for the next few days.
Maybe I fall into that category”.

Pacing which consisted of splitting activities into smaller parts was used
by some participants but was referred to less often than ‘avoidance’ or
‘persistence’. Participants were sometimes reluctant to engage in activity pacing
or pointed out that they believed that it was not always a practical strategy to use:

“You can’t start cleaning a house and sit down every five minutes. You would never be finished. You can’t cook a meal for five minutes, turn it off and sit down for five minutes”.

Theme V: Mood and Physical Activity

There was evidence from participants’ responses that the relationship between PA and mood was bidirectional. That is, engaging in PA was beneficial to mental health and conversely, positive mood resulted in more PA. Participants highlighted how physical inactivity often negatively impacted on the mood and sometimes resulted in depressive feelings. Engaging in PA was often cited as a way to prevent such a situation arising. Participants’ mood improved due to being able to do activities outside the house that they enjoyed and also because of the social benefits (e.g. interaction with friends) associated with the activity:

“You can’t sit in a position where you sit on a chair or a couch for extended periods without it leading to absolute and total depression. You have to drag yourself up and get up there for fear of falling into a rut where you feel that you are not capable of doing anything which simply isn’t the fact”

Conversely participants reported lower levels of PA on days when one’s mood was lower. It was clear from the responses that lower mood often resulted in poor motivation for activity:

“As with anyone you can get into a very bad mood or have a very dark day and just not wish to get off the couch”.
6.4. Discussion

6.4.1. Impact of Low Back Pain on Physical Activity

All participants reported that their level of PA was reduced due to their LBP. While some of the participants accepted their physical limitations, for others low mood and a loss of identity were consequences of their reduced levels of PA. Importantly, not all participants were encouraged by healthcare professionals to remain active or given information on the benefits of PA in the management of their LBP. This is in spite of the fact that PA is a key recommendation in LBP clinical guidelines (Koes et al. 2010). Simmonds et al. (2012) recently reported that physiotherapists with a strong biomedical focus or those with postgraduate training in manual therapy were less likely to advise on return to work or the resumption of normal activities. Advice from healthcare professionals appeared to be based on a biomedical model of care. Healthcare professionals in general, with a biomedical orientation are more likely to advise patients to rest and limit their PA (Darlow et al. 2011) There is also evidence that clinicians are more likely to offer advice on PA in line with the clinical guidelines following a standardised educational program based on the biopsychosocial model of chronic pain (Domenech et al. 2011; Slater et al. 2012). Therefore, there is a need to ensure that healthcare providers are educated using such an approach.

When participants were advised to undertake PA, this was often accompanied by advice to avoid other activities. Such activities tended to include lifting, forward bending tasks and manual labour. Such recommendations lack empirical support as there is no evidence that these activities are associated with the development of LBP (Kwon et al. 2011). Furthermore, there is evidence from randomised controlled trials that among working individuals with LBP, physical or ergonomic interventions are not effective at reducing short or long-term LBP or pain intensity (Driessen et al. 2010). In addition, participants were commonly advised to undertake specific forms of exercise such as walking or swimming, even though one form of exercise does not appear superior to another in the management of LBP (van
Middelkoop et al. 2010; Sullivan et al. 2012). A more sensible option may be to encourage activities that the patient likes or is motivated to do.

6.4.2. Barriers & Motivations for Physical Activity

Participants generally reported that their pain was the main barrier to engaging in more PA. This finding however is in direct contrast to the many quantitative reports in the literature suggesting that pain intensity is not associated with levels of PA among patients with CLBP (Huijnen et al. 2010). Pain intensity is difficult to measure clinically and current methods such as numerical pain rating scales may be insufficient to capture inter-individuals differences and the subjective nature of pain intensity. However it is also possible that participants continue with certain activities despite pain accounting for the lack of association between pain intensity and PA in previous studies (discussed later in this discussion).

The finding that fear was a barrier to engaging in PA is consistent with the FAM of chronic pain. There is much evidence supporting the relationship between avoidance behaviour and disability among patient with CLBP. In the current study, participants were fearful of provoking or increasing pain during PA and to a lesser extent were fearful of making the injury worse. One participant succinctly described how repeated exposure to the “feared” activity was necessary to lessen the fear associated with the activity. This idea is central to graded in vivo exposure therapy which is an appropriate and evidence-based intervention for patients with chronic pain exhibiting high levels of fear avoidance behaviours (Vlaeyen et al. 2002). Therefore, it may be important for clinicians to identify specific activities that the patient is fearful of and subsequently address their fears using a graded approach where the patient is exposed to the activity in a graded manner. This is in line with research evidence that fear reduction towards a particular movement or activity does not generalise to other movements or activities (Goubert et al. 2002).

Environmental factors were also mentioned by some participants as potential barriers to engaging in PA. Participants commented on lack of facilities especially in rural area resulting in less opportunity for PA. One participant also
remarked on the physical environment (e.g. terrain, condition of walking surfaces) as a potential barrier to PA. Environmental barriers to PA are not specific to individuals with chronic pain with recent evidence showing a link between certain environmental factors (e.g. recreation facilities and locations, transportation environment) and total volume of PA in the general population (Bauman et al. 2012). Clinicians prescribing exercise or PA to patients with chronic pain therefore need to consider a patient’s environmental surroundings or preferences in their prescription.

Enjoyment associated with an activity was the most commonly cited motivation for engaging in PA. There is strong evidence that a lack of enjoyment is a major barrier to engaging in PA (Dacey et al. 2008; Cleland et al. 2010; Burton et al. 2012). Our findings suggest that this hold true also for people with CLBP. There is strong evidence for the role of positive mood in pain perception (Wiech & Tracey, 2009). It is likely that when patients with CLBP are prescribed PA or exercise that they enjoy, they are more likely to undertake the exercise and may benefit to a greater extent from the non-specific effects of exercise/PA on pain processing (e.g. through improved mood) (Sullivan et al. 2012). Therefore, when prescribing exercise, clinicians are encouraged to engage in a collaborative process with the patient to help indentify activities that they enjoy and are likely to persist with.

Our findings regarding social support and PA are interesting. Firstly, being with others often facilitated and motivated the participants to engage in PA. However, participants often chose to be active alone as they perceived a need to go at their own pace and not affect others around them. This may have important clinical implications. When prescribing PA or exercise for people with LBP, especially in group settings, clinicians should be aware that being active with people with greater physical abilities may not be ideal. Perhaps, facilitating PA with other individuals of similar physical capabilities may allow patients to experience the social benefits of the exercise without experiencing any of the potential negative consequences that may arise due to differences in peoples’ physical capabilities. Secondly, it was common for family and friends to encourage participants to rest and limit their activity. A recent study has found that an overly protective response from significant others was associated with
reduced objectively measured PA (Alschuler et al. 2011). The response of significant others is again consistent with a biomedical view of LBP and further highlights the need to educate not just patients with LBP but also the general public at large on the bio psychosocial model of pain.

A desire to remain physically fit was mentioned by some participants as a motivation for PA. This was especially evident for participants who reported high levels of PA prior to the onset of their low back pain. This finding may be interpreted in accordance with “self discrepancy theory” (Higgins, 1987). There may be a discrepancy between an individual’s “actual” level of PA (which may be impaired due to back pain) and their “ideal” level of PA (which may be influenced by their previous high level of PA). Due to this discrepancy, an individual might be motivated to engage in more PA to get closer to their “ideal” level of PA. There is some support in the literature to support this concept in people with CLBP (Huijnen et al. 2011b).

Other motivations for engaging in PA included the social aspect of the activity and the positive effect of activity on mental health (see “Mood and Physical activity”).

6.4.3. Patterns of Physical Activity

As previously discussed, avoidance of PA was often reported by participants. This was mainly due to the pain associated with the activity or due to fear of making the pain worse. However, the results also suggest that participants continue to engage in an activity despite pain or fear under certain circumstances. This was especially true for activities that i) they enjoyed, ii) were necessary as part of everyday living and iii) gave participant’s a sense of identity, independence or control. These qualitative findings are supported by recent experimental investigations which suggest that pain and avoidance should be analysed in relation to other important goals (Crombez et al. 2012). van Damme et al. (2012) showed using an experimental design that the relationship between fear of pain and avoidance was moderated by the motivational context of the task. Where participants were ‘motivated’ (for monetary reward) to perform a pain-evoking task, this resulted in greater
willingness to persist with the activity and not avoid it. Also, there is evidence that when patients are presented with competing goals (in addition to their goal of avoiding pain), the attentional bias to pain during the task is inhibited (Schrooten et al. 2012). This is another possible reason why some patients may continue to engage in certain activities despite an increase in pain. Our findings suggest that patients are more likely to engage in and persist with activity when there are competing non-pain goals. This further supports the need for clinicians to promote activities that are enjoyable or that are of personal importance or intrinsically motivating to the patient.

Whether activity persistence is an adaptive or maladaptive coping strategy is a current cause for debate. There is some suggestion in the literature that persisting with PA to the point of severe pain exacerbation is associated with higher levels of disability and lower physical functioning. In the current study, some participants stated that they compared the potential for pain with the rewarding nature of the activity (e.g. enjoyment). We hypothesise that the degree of intrinsic motivation and the resulting reward (e.g. sense of enjoyment, accomplishment etc) is compared to the degree of pain experienced during or after the activity. In this way, persistence with activity may be adaptive or maladaptive under different circumstances and is not necessarily dependent on the pain intensity per se.

6.4.4. Mood and Physical Activity

Mood was often cited as a barrier to engaging in PA. Conversely, participants commented on the benefit of PA/exercise for their mental health. These findings support recent findings by Roshanaei-Moghaddam et al. (2009) who showed that depression was a determinant of PA in healthy individuals. Similarly, Bousema et al. (2007) showed that depression was a significant predictor of the decline in PA in patients with LBP. Therefore it is likely that while depression may lead to reduced levels of PA, a lower level of PA in people with chronic pain may increase depressive symptoms, thereby setting up a vicious cycle. The bidirectional association between PA and low mood/depression has been reported in a recent prospective longitudinal study.
of almost ten thousand participants (Azevedo Da Silva et al. 2012). Clinicians should therefore be aware of patients with chronic pain who also experience depression or low mood. This group may be an especially important group to target with a PA intervention. Finally, our findings regarding mood support the findings presented in Chapter Four where we found that the level of depressive symptoms was negatively and significantly associated with objectively measured duration and volume of PA in people with CLBP.

6.4.5. Sleep and Physical Activity

Finally, sleep disturbance due to pain was a common finding in the current study. There is empirical evidence that patients with CLBP experience greater sleep disturbance, reduced sleep quality and reduced sleep duration (Kelly et al. 2011). Most participants believed that a lack of sleep negatively impacted on their activity levels the following day. Fatigue and low mood as a result of sleep disturbance appeared to mediate this relationship. Fatigue has been studied little in patients with CLBP. Our findings suggest that more work is needed to examine the relationship between fatigue and PA in people with CLBP. This will be important as not all participants believed that their sleep influenced their activity levels. This was especially true for those individuals who reported high levels of disability and low daily levels of PA. It is possible therefore, that given their already low levels of activity, any negative effects due to lack of sleep (e.g. fatigue) did not have an additional effect on their activity levels. This may partly explain the findings of a recent systematic review that found inconsistent evidence for an associated between sleep disturbance and PA in people with CLBP (Kelly et al. 2011).

6.5. Conclusion

The results of this study confirm that a number of physical, psychosocial and environmental factors may be important in explaining the PA behaviour of individuals with CLBP. Clinicians need to be aware of their complex interactions when prescribing PA interventions for people with CLBP. Finally, PA patterns
appear complex and patients may use different strategies in different contexts. We question recent attempts to sub-classify patients into distinct PA pattern categories (avoidance, persistence, pacing) as our findings suggest that individuals may use a combination of such strategies.
CHAPTER SEVEN

General Discussion
7.1. Scope of the Thesis

The impact of chronic pain on free-living PA has long been of interest to researchers; however it is not until recently that researchers began to measure PA in a formal way using objective measurement devices among chronic pain populations. While PA and exercise are generally considered an important component of the management of people with CLBP, little research has examined how best to promote and facilitate PA in people with chronic pain in a clinical setting. In order to encourage behaviour change in people with CLBP, it is essential that one first understands the correlates or determinants of a given behaviour such as PA. Bauman et al. (2012), in one of the most comprehensive reviews to date on the correlates and determinants of PA in healthy individuals highlight that PA behaviour is highly complex and is influenced by many factors across physical, psychological, social and environmental domains. While there is no reason to suggest that many of these factors would not also apply to people with chronic pain, specific correlates or determinants relating to the experience of chronic disease (such as chronic pain) are also likely to be important. In this regard, the FAM is the most documented and researched model in people with chronic pain. According to this model, fear of pain or re-injury is an important driver of avoidance behaviour and it is hypothesised that this may result in a reduction in one's level of habitual PA. The ability of this model alone to explain PA behaviour among people with CLBP has recently been questioned as there is emerging evidence that many people with chronic pain persist with activity despite pain. This further highlights the need for a better understanding of the correlates of PA behaviour in people with CLBP and this is the main focus of this thesis. The specific aims of this thesis were:

i) To determine, based on the current body of evidence if people with CLBP are less active that their healthy counterparts.

ii) To examine if the ActivPAL™ activity monitor is accurately able to measure the intensity of PA in people with CLBP.

iii) To increase our understanding of the correlates of PA in people with CLBP from a quantitative and qualitative perspective.
iv) To determine if people with CLBP with different underlying pain mechanisms have a differing psychological profile, PA profile and sedentary activity profile.

In this general discussion, the results of the thesis will be summarised and integrated and discussed with consideration to the current body of scientific evidence in this area. Finally, important clinical implications from the results of this thesis will be discussed.

7.2. Are Patients with Chronic Low Back Pain Less Active than Healthy Individuals?

In Chapter Three of this thesis, we present the results of a systematic review examining if individuals with CLBP have an altered PA level or pattern compared to healthy individuals. For adults aged 18-65 and for adolescents, there is no consistent evidence that individuals with CLBP have a lower level of PA. There is some evidence that older adults with CLBP have a lower volume of PA compared to controls, although care is required in interpreting these results as only two studies were available and PA was measured using self-report questionnaires in both studies. For adults (18-65 years), the results across the studies were inconsistent. For example, two of the studies showed that the volume of PA was similar to that of healthy controls while another study showed that patients with CLBP spent less time walking and took fewer daily steps compared to controls. An important consideration in many of the studies included in the review was the low sample size. Given the often large inter-individual variability in an individual’s level of PA, a small sample size may not be truly reflective of the PA level of the population under investigation as a whole. Moreover, from a statistical standpoint, a lower sample size may have resulted in an increased likelihood of a type-II error. In Chapter Six of this thesis we present the findings of a qualitative study among individuals with CLBP. In this study all of the participants commented on how their pain had negatively affected their level and type of PA compared to before they began experiencing pain. Although this does not necessarily imply that they are less active that healthy controls, Verbunt et al. (2005) showed that “perceived” decline in PA rather than the current activity levels of individuals with CLBP was more
important in explaining disability. Therefore, although there is no consistent
evidence for a lower level of PA compared to healthy controls among people
with CLBP, PA interventions are still likely to be clinically important especially
among those who perceive that their level of PA has reduced.

The lack of consistent evidence for a lower level of PA among people
with CLBP compared to controls may have another explanation. Recent
evidence suggests that there is a moderate, negative relationship between level
of disability and PA in people with CLBP (Lin et al. 2011). In the cross-sectional
study presented in Chapter Five, we also found a statistically significant
relationship between level of disability and volume of PA. Therefore, one may
hypothesise that not all individuals with CLBP are equally affected in regards to
their level of PA. From the results of the studies presented in the systematic
review, we cannot determine if this is the case. It is possible that if specific sub-
groups were to be examined individually (e.g. those with high levels of
disability), the results may be different to studies not attempting to sub-classify
due to the possibility of a “wash-out” effect in the latter. If this is the case, then
one would expect that certain sub-groups of individuals with CLBP may also
benefit more from PA interventions. In an attempt to further explore this
concept, a recent individual participant data meta-analysis has been proposed
to determine if exercise therapy is effective in people with CLBP (Hayden et al.
2012). Their results will be useful to determine if possible subgroups of patients
exist and may further shed light on why some individuals may remain active
despite pain.

Finally, the results from two studies included in the systematic review
found that patients with CLBP walked at a lower intensity compared to healthy
controls. Both of these studies used cadence as a proxy measure of intensity.
This finding is consistent with the results presented in Chapter Five of this
thesis where we found significant relationships between pain intensity, disability
and depression with daily time spent in MVPA. Together, these results suggest
that CLBP may preferentially result in lower time engaged in MVPA compared
to lower intensity activities. The reasons why this may be cannot be determined
from the current study. It is possible that higher intensity levels result in more
pain, however it is also possible that reduced aerobic fitness among individuals
with CLBP is a barrier to engaging in MVPA. Irrespective of the reasons, a lower time engaged in MVPA is of concern given its established association with improved cardiometabolic health. Care is needed however, as the lack of a control group in our study means that one cannot confirm that time spent in MVPA is preferentially affected in people with CLBP.

7.3. Can the ActivPAL™ Activity Monitor Accurately Measure PA Intensity in People with CLBP?

The ActivPAL™ activity monitor has been previously validated for use among individuals with CLBP. To summarise, it appears to be valid to determine time spent walking, standing, upright and sitting/lying in people with CLBP. Moreover, it is an accurate measure of step count and cadence in this group. However as alluded to above, PA intensity is an important measurement domain in the broader PA literature. It is possible to estimate PA intensity using two different methods using the ActivPAL™ activity monitor. Firstly, the in-built proprietary calibration equation based on step rate may be used. However, it is also possible to determine PA intensity using count thresholds from the raw acceleration data. In the study presented in Chapter Four, we aimed to compare the accuracy of both of these methods to determine EE during treadmill walking and activities of daily living. Our results show that while the in-built calibration equation is reasonable to predict intensity during treadmill walking, it is less accurate during activities of daily living especially those where a significant proportion of the EE is derived from upper limb movements or where the EE is not solely based on step rate (e.g. stair climbing). An interesting finding was that the relationship between ActivPAL™ counts and intensity was better that that for step rate. This is consistent with a recent study using the ActivPAL™ involving healthy participants (Harrington et al. 2011). The relationship between ActivPAL™ counts and PA intensity in the current study was high, being slightly less than 0.8. Therefore it is reasonable to expect that the ActivPAL™ count function may be useful to determine PA intensity in people with CLBP. Our findings suggest that researchers should consider using ActivPAL™ counts and not the in-built prediction equation to estimate intensity using the ActivPAL™ activity monitor. Although such an approach would require population specific
calibration to determine appropriate count thresholds, the estimates are likely to be more accurate. While the current study presented in this thesis was not designed to be a comprehensive validation of the ActivPAL™ in people with CLBP, it does highlight the potential usefulness of the monitor to measure PA intensity. A recent study by Dowd et al. (2012a) used the ActivPAL™ activity monitor to develop count thresholds that correspond to a given PA intensity using more sophisticated statistical techniques including ROC plots. The study involved adolescent females and the resulting count thresholds proved highly accurate in the cross-validation component of the study involving outdoor locomotor activity. The findings of this study further support the use of ActivPAL™ counts in predicting PA intensity during locomotor activity although this will require further investigation in people with CLBP.

7.4. Correlates of Physical Activity in People with Chronic Low Back Pain

In Chapter Five of this thesis, we present the findings of a cross-sectional study examining the physical and psychological correlates of free-living, objectively measured PA in people with CLBP. Results of the regression analysis suggest that only depression is significantly associated with duration of PA (average daily time walking) and volume of PA (average daily step count and average daily ActivPAL™ counts). Conversely, only BMI was associated with sedentary activity (average daily time spent sitting/lying, daily sedentary time accumulated in bouts ≥ 30 minutes). The relationship between depression and PA is not surprising. While the cross-sectional nature of the study does not allow the direction of causation to be determined, the broader literature would suggest that the relationship is likely to be bidirectional (Azevedo Da Silva et al. 2012). Furthermore, the results of the qualitative study presented in Chapter Six support the bidirectional nature of this relationship. From participants’ responses, it was clear that low mood negatively affected their PA level. Conversely, many participants commented on the benefits of engaging in PA for their mental health. People with depression experience high negative affect (feeling of distress and tension) and low positive affect (lethargic and decreased motivation) which may explain why people with depression or those who exhibit depressive symptoms engage in less PA (White et al. 2009). A number of other
factors including social isolation and low energy levels and apathy may explain this relationship (Azevedo Da Silva et al. 2012). Low mood and depressive symptoms may also lead to maladaptive brain changes that enhance pain perception (Berna et al. 2010) which may subsequently reduce PA levels. Patients with depressive symptoms are also at high risk for weight gain. While reduced levels of PA may explain this, other factors such as weight gain due to anti-depressant medication and overeating are also important considerations. The above mechanisms help to explain why people who exhibit depressive symptoms may engage in less PA. However and as previously mentioned, a lower level of PA may increase the likelihood of experiencing depression. This has been established in a recent longitudinal prospective study (Roshanaei-Moghaddam et al. 2009). Engaging in PA therefore may help with symptoms of depression. The mechanism(s) for this are as of yet unclear but may be related to changes in self-esteem and physical self-perceptions as well as providing a means of distraction from negative thoughts and promoting social interaction (Pickett et al. 2012). More complex neurobiological mechanisms may also be at play including an increase in the synaptic transmission of monoamines in response to PA or exercise which are believed to have anti-depressant effects (Azevedo Da Silva et al. 2012).

Our findings regarding intensity of PA merit further consideration. Specifically, a number of factors (pain intensity, disability, depression, avoidance and pacing) were all negatively associated with time spent in MVPA. Interestingly, only BMI was associated with time spent in LPA. Although care is needed in presuming the direction of causality, these findings suggest that time spent in MVPA is more affected in people with CLBP. While this makes intuitive sense, ours is one of the first studies to confirm this within a CLBP population. It must be pointed out that none of the predictor variables (pain intensity, disability, depression) were significantly associated with time spent in MVPA in the final regression model. Although we could confirm that multicollinearity was not present, it remains possible that confounding between the predictor variables resulted in the non-significant effects. Therefore, our findings regarding PA intensity should be considered preliminary and further research in this area is warranted.
Time spent in sedentary activity (i.e. sitting/lying) was more difficult to explain. Only BMI was significantly and positively associated with average daily time spent sitting/lying and the total daily sedentary time accumulated in bouts ≥ 30 minutes. In Chapter Five, we have highlighted that the relationship between sedentary behaviour and BMI may be bidirectional. A final point worth mentioning is that we were unable to find any significant relationship between time spent standing and any of the variables that we measured. The ActivPAL™ activity monitor is unique in its ability to differentiate standing from sitting/lying. While standing is often considered as ‘sedentary’ in many studies, there is mounting evidence that quiet, intermittent standing can mitigate some of the negative cardiometabolic effects of prolonged sitting (Dunstan & Owen, 2012). Patients in our study spent a high portion of the day sitting/lying. Replacing sitting/lying with standing or LPA given its negative association with BMI may be a reasonable clinical goal in an attempt to promote health. However, given the absence of any significant correlations with time standing in the current study, further work is needed to determine how one may achieve this in a clinical environment.

The findings of our qualitative study presented in Chapter Six also highlight more potential barriers to PA that were not apparent in our quantitative investigation. Participants commented on how the intensity of their pain and fear of making their pain worse were potential barriers to engaging in PA. Although this is consistent with the main hypothesis of the FAM, in our quantitative study, we did not find a relationship between pain intensity or fear avoidance and objectively measured PA. A deeper exploration of the qualitative findings may help to explain why this was so and this is addressed in the next section.

7.5. Avoidance Behaviour and Physical Activity: A Motivational Perspective

The findings of the qualitative study are interesting. While there was evidence that participants engaged in avoidance behaviour, all participants reported that they often engaged in PA despite experiencing pain, even to the point where they experienced a significant worsening of their symptoms. This
behaviour is consistent with the AEM of chronic pain which postulates that a subgroup of patients with pain often persists with activity despite pain i.e. “persisters”. In our study it was apparent that a decision to persist with activity despite pain was dependent on the motivational context of the task. For example many participants were motivated by the enjoyment that they got from the activity. For others, the motivation for continuing with an activity was to retain a sense of independence or identity. Importantly, these findings are supported by recent experimental evidence. There is evidence that the motivational context of a task moderates the relationship between fear of pain and persisting with the activity (van Damme et al. 2012). Similarly, attentional bias to pain cues appears to be inhibited in the presence of other competing non-pain goals (Schrooten et al. 2012). In this regard, it is possible to be fearful of an activity but still engage in that activity despite experiencing pain. This is a possible reason why there was no apparent relationship between variables such as fear-avoidance and catastrophizing and objectively measured free-living PA in the study presented in Chapter Five. Any relationship between fear and PA is likely more complex than previously thought. Crombez et al. (2012) propose an update to the FAM and highlight that pain and avoidance behaviour need to be analysed in relation to other important goals. Based on the wider body of evidence and the findings presented in this thesis, it is likely that avoiding pain is only one of many competing goals during everyday life activities. Many studies to date have attempted to gain a deeper understanding of subgroups of patients with CLBP who exhibit different PA behaviour patterns (i.e. avoiders, persisters, copers or mixed performers). However, given the highly contextual nature of avoidance or persistence as highlighted in the current study and from the wider literature, it is unlikely that patients rely on any one strategy. Therefore one may question the relevance and validity of classifying patients into broad-subgroups as such an approach may fail to capture the highly dynamic and contextual nature of PA.
7.6. Promoting Physical Activity to People with CLBP in the Clinic

The findings of the qualitative study presented in Chapter Six suggest that advice from healthcare practitioners to avoid specific activities was more common than advice to engage in PA. This finding is in contrast to international LBP guidelines which recommend that clinicians encourage patients to remain physically active (Koes et al. 2010). Recent evidence has highlighted how the attitudes and beliefs towards LBP among healthcare professionals influence the management approach that they use (Fullen et al. 2011; Darlow et al. 2012; Briggs et al. 2012). A biomedical orientation towards the management of LBP emphasises spinal structure and tissue injury as being the source of the pain. However, as discussed in Chapter One, structural changes based on imaging are of little prognostic value in the management of LBP. This has led to a call from researchers for LBP to be managed using the broader bio-psychosocial approach (Nijs et al. 2012; O’Sullivan, 2012). This is important as there is evidence that a strict biomedical view of LBP is associated with an increased likelihood of a healthcare practitioner recommending rest. Encouragingly, there is evidence that the beliefs and attitudes of healthcare providers can be changed through education resulting in improved adherence to clinical guidelines (Domenech et al. 2011; O’Sullivan et al. 2013). Therefore, the results of our study point towards the continuing need to educate clinicians on the bio-psychosocial management of LBP, if we are to expect that LBP be management in accordance with the best available scientific evidence.

7.7. The Influence of the Primary Pain Mechanism on the PA and Psychological Profile of Patients with CLBP

There are currently a number of different approaches used to subclassify patients with LBP. One such approach is by identifying the primary underlying pain mechanism (Woolf et al. 1998; Smart et al. 2010). In Chapter Five-Part Two, the findings of a study in which the PA and psychological profile of patients with NeuP or CS as the primary underlying pain mechanism are compared to those with nociceptive pain. The results are in line with previous findings that people with NeuP and/or CS are more disabled and experience a
higher level of psychological co-morbidities compared to those with nociceptive pain. However there was no difference in the PA or sedentary activity profile between the groups. These findings may reflect the setting in which the study was undertaken. It is hypothesised that patients attending a chronic pain clinic experience more disabling pain and greater functional limitations. Therefore the patients included in the current study may represent a relatively homogenous group and therefore differences between the groups in terms of PA may not be present. The findings suggest that the increased disability for people classified as “neuropathic pain” cannot be explained by their level of PA. At this stage, one can only speculate on why this group report higher levels of disability and psychological co-morbidities. One hypothesis reflects the characteristics of the pain between the groups. Patients with nociceptive LBP will often report specific aggravating and easing factors in relation to their pain (Smart et al. 2012a). This implies that they have at least some control over their level of pain. On the other hand, NeuP and CS are often associated with spontaneous pain and pain at rest reflecting more complex changes in neurobiological processing (von Hehn et al. 2012). The reduced ability of this group to control their pain may be one reason why they feel more disabled and distressed. Further work in this area however is needed.

7.8. Clinical Implications

Our findings suggest that depression plays a critical role in the PA behaviour of people with CLBP. Therefore, it is recommended that clinicians screen for depressive symptoms using appropriate screening tools and refer patients for appropriate management of their depression if necessary. Given the likely bidirectional relationship between PA and depression and the high prevalence of depression in chronic pain populations, clinicians should promote and facilitate PA interventions as a means of reducing depressive symptoms.

Other factors such as pain intensity and fear avoidance beliefs are also important for clinicians to assess and may play a role in the PA behaviour of people with CLBP. However, the findings of this thesis suggest that such factors do not always lead to avoidance or a reduced level of PA. Clinicians should be
aware of the recent evidence suggesting that the motivational context of the task is crucial in a patient’s decision to engage in or avoid an activity. Motivational factors such as the enjoyment/pleasure associated with an activity can often be more important than controlling pain intensity per se. Although persisting with activity despite experiencing pain can be maladaptive in certain cases, clinicians should consider the motivational nature of any PA intervention that they prescribe. For example, patients should be encouraged to engage in activities that they enjoy or are motivated to perform instead of prescribing a generic programme without consideration to the patient’s personal preferences.

Our findings regarding activity pacing and its positive association with disability require careful consideration. Although the direction of causality cannot be confirmed, there is emerging evidence that specific forms of pacing may result in higher levels of disability. Where clinicians encourage patients to use pain as a guide to stop or persist with activity, this may in effect lead to avoidance behaviour. It is recommended that, when advising on activity pacing techniques, task contingent pacing or time contingent pacing should be encouraged. In such cases the main goal is not necessarily to avoid pain and is therefore more likely to promote PA engagement.

Clinicians involved in the management of people with LBP need to be educated on the limitations on the biomedical model to explain pain. Recent evidence suggests that education programmes based on the bio-psychosocial model are sufficient to changes attitudes and beliefs so that they align better with the best available scientific evidence. A better understanding of the bio-psychosocial model would help clinicians to view PA, not only as a physical treatment (e.g. to improve fitness and strength) but also as an means to address many of the co-morbidities such as depression and impaired sleep.

Finally, clinicians should readily identify patients with a NeuP component and/or CS due to their association with a higher level of self-reported disability and psychological co-morbidities. Although we did not find any difference in the PA levels or sedentary activity of patients with NeuP or CS compared to those with nociceptive pain, PA still remains important for all patients with CLBP. There is emerging evidence that aerobic activity positively impacts on the symptoms of NeuP and reduces central nervous system hypersensitivity.
Therefore, clinicians should be encouraged to prescribe such programmes as part of a multimodal management approach for all people with CLBP.

7.9. Strengths of this Thesis

There are a number of strengths of this thesis, both in terms of the methods used and the findings of the thesis.

In Chapter Four, we have shown that the ActivPAL™ activity monitor has potential to accurately measure EE in people with CLBP, especially during continuous locomotion tasks. Although we acknowledge that the results are preliminary given the small sample size and the controlled nature of the testing, our findings further recent work which has found the ActivPAL™ to be a valid measure of postural PA. Therefore our findings add to the growing body of literature supporting the use of the ActivPAL™ in both clinical and non-clinical populations.

In Chapter Five-Part One, we examined a number of potential physical and psychological correlates of PA in people with LBP. This study has a number of strengths. Firstly, we measured a wide range of potential correlates. These potential correlates were selected based on the main cognitive-behavioural models that have been proposed to explain PA and disability in people with chronic pain. Our study is one of the first studies to investigate these correlates and their relationship with PA, together within the one study. Secondly, we used an objective measure of PA which has been previously validated in people with CLBP. Furthermore the ActivPAL™ activity monitor is unique in its ability to measure PA and sedentary activity separately which is one of its major strengths. Most studies to date have examined only volume of PA. In our study, we were able to examine the correlates of duration, volume and intensity of PA separately as well as the correlates of sedentary activity.

In Chapter Five-Part Two, we compared the PA and psychological profile of individuals with and without neuropathic CLBP. This is a novel question and we are not aware of any previous study that has addressed this question previously. Our findings are novel and suggest that the established higher level
of disability in people with neuropathic CLBP is not mirrored in their level of PA or sedentary activity.

One of the main strengths of this thesis was the use of a mixed methodology approach. Considering the limitations of quantitative research alone to explore and understand complex issue such as PA, in Chapter Six, we also investigated the PA behaviour among patients with CLBP using a qualitative design. There are recent calls in the physiotherapy literature for greater use of qualitative methods to enhance or inform qualitative studies (Petty et al. 2012). Importantly, the results of our qualitative analysis enhanced our interpretation of our quantitative study described earlier. Furthermore, the use of different methodologies to address a similar question adds to the external validity of our findings.

7.10. Limitations of this Thesis

There are a number of limitations that need to be considered when interpreting our findings. In this section we will outline the main limitations only. The limitations of each of the individual studies are discussed in the relevant chapter.

The validation study presented in Chapter Four involved a low number of participants. Therefore our findings need to be considered as preliminary. Further studies using a larger sample size and more sophisticated statistical analysis techniques are required.

The cross-sectional study presented in Chapter Five-Part One also has a number of limitations. Firstly, data reduction of the ActivPAL™ output required us to identify period of non-wear time. There is no consensus in the literature on how best to do this. This is especially true for people with chronic disease and they may be more likely to spend more time sedentary. This makes it potentially problematic to distinguish between period of non-wear and time sitting/lying. Although our approach to indentify non-wear time was in line with other studies, it is possible that sedentary activity may on occasion be misclassified as non-wear time and may have influenced the findings. Secondly due to the many
variables correlated with level of disability, our regression analysis relating to
disability may have been underpowered and needs to be considered in
interpreting the findings. Thirdly, the cross-sectional nature of the study means
that for many of the relationships identified, the direction of causality cannot be
determined. Although, longitudinal prospective designs are to be encouraged,
the logistical and time consuming nature of such studies meant that for the
current thesis this approach was not feasible.

In Chapter Five-Part Two we compared the psychological and PA profile
between different groups of patients with CLBP. This study was designed as
explorative as there has been no study to date that we are aware of to address
this question. As a result, no sample-size calculation was performed. Therefore
there is an increased likelihood of Type-II errors occurring. In this regard, this
study may have been underpowered to detect differences between the groups.
Also, the low number of participants in each group means that the groups might
not representative of the wider sample population. However, the clear
differences in the psychological profile between the groups support the
discriminative validity of the individual groups. Finally, the data from this study
may be useful in determining an appropriate sample size for future studies to
ensure that they are adequately powered to detect any possible differences.

Finally, there are some limitations to consider when interpreting the
results of our qualitative study presented in Chapter Six. There are three main
limitations of this study. Firstly, the main limitation is that the data coding
procedure was undertaken by the principal investigator only. Therefore it is
possible that the findings are biased by the researchers’ own beliefs or
preconceptions. A second person to code the data, who preferably does not
know the subject area, would have strengthened the study. Secondly, as all
participants had previously participated in the study presented in Chapter Five,
we cannot exclude the possibility of selection bias. However, the selection of
participants was based on their scores on a number of self-report
questionnaires as well as the likelihood of them being able to provide data-rich
information. The use of such purposeful samples is very common is qualitative
research. Also this study was not designed to provide a single conclusive
answer or perspective. Instead, it was designed to explore different
perspectives relating to PA that may help in the understanding of many of the quantitative studies that have been published to date of the topic. Thirdly, we did not undertake member checking in this study. Member checking is a process whereby participants review their transcript and/or the researcher’s interpretations of the data and verifies it. It is commonly used to increased the validity of the findings and mitigate the effects of researcher bias in interpreting the data. However, such as approach is not without its limitations. For example, participants’ spontaneous responses and though processes during an interview may be different to their responses when given an opportunity to review their own data and the researchers’ interpretation of this data (Hagens et al. 2009). In this way, some information may be lost or in the case of substantial differences following the review process, the entire interview may have to be excluded. This was an important consideration in the current study given the low sample size.

7.11. Summary of Findings and Take-home Messages

In summary, there are a number of novel findings in this thesis:

1. The “counts” function of the ActivPAL™ activity monitor has potential to accurately predict EE during PA in people with CLBP. Although further work is needed, this will allow researchers in the future to measure PA intensity separately from other component of PA. (Chapter Four)

2. Disability and PA are related but distinct constructs with different correlates. (Chapter Five-Part One)

3. Depression was associated with duration and volume of objective-measured free-living PA in people with CLBP. Only BMI was associated with sedentary activity. Therefore, clinicians should identify patients with co-morbid depression and/or elevated BMI as such patients may be particularly susceptible to a low level of PA. (Chapter Five-Part One)
4. The findings of this thesis suggest that time spent in MVPA may be more affected than time spent in LPA in people with CLBP. The lack of a control group however means that these findings are preliminary. (Chapter Five-Part One)

5. The findings of this thesis are in line with previous work which shows that patients with neuropathic CLBP or those with CS are more disabled and have poorer psychological functioning compared to patients with nociceptive pain. However, a novel finding of this thesis is that there was no difference between the groups regarding their level of PA and sedentary activity. (Chapter Five-Part Two)

6. Finally, the results of the qualitative study highlight the complexity of PA behaviour in CLBP. Factors including pain, fear, disturbed sleep and medication usage were all identified as potential barriers to PA in people with CLBP. However, whether or not a patient engages in an activity appears to be dependent on the motivational context of the task. In this way, factors such as fear and pain intensity may not always lead to avoidance of activity if the patient is motivated to do the activity by other competing non-pain goals. These findings corroborate recent experimental evidence. (Chapter Six)


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APPENDICES
APPENDIX A:

Information Leaflets & Consent Forms
Title:

Criterion validity and calibration of the ActivPAL™ activity monitor and the SenseWear® armband as a measure of energy expenditure in patients with chronic low back pain

Background Information:

Physical activity is an important part of a healthy lifestyle. However it is difficult to measure the amount of activity that a person does during their daily life. The aim of this study is to identify a suitable measure of physical activity in patients with chronic low back pain.

Procedure:

If you are suitable, medically fit and have agreed to take part in the study, you will be asked to attend the University of Limerick at a time and date of your convenience. You will be required to fast and avoid exercise for four hours before testing. During testing you will have to wear the ActivPAL™ activity monitor which will be attached to your thigh and the SenseWear® armband which will be worn on the upper arm. For the first part of testing, you will be asked to perform a number of activities that resemble activities you do at home on a daily basis. Such activities including walking up and down stairs, brushing the floor and washing dishes. Each activity will last for 10 minutes and there will be a 1-2 minute rest period between each activity. You will need to perform 6-9 such activities. While doing this, the amount of energy that you are using will be measured with a facemask which is attached to two units which will be secured to your chest using a comfortable vest. For the second phase of testing, you will be required to walk at three different speeds on a treadmill which wearing the facemask. You will need to walk at each of the speeds for 10 minutes and there will be a 1-2 minute rest break between the different speeds. The entire process should not last longer than 2.5 hours.

Benefits:

By participating in this study, you will be helping to provide valuable information regarding the most appropriate means of measuring physical activity in patients with chronic low back pain.
Risks:
You may experience minor discomfort from wearing the facemask. In addition, you may experience some mild muscle soreness following testing which is considered normal. As you will be performing activities that you do regularly and as there will be a rest break between each activity, any muscle soreness will be minimal.

Inclusion Criteria:
You can only participate in this study if you meet the following criteria:
1) Have had low back pain for at least three months.
2) Do not suffer from cardiovascular (heart), respiratory (lung), neurological or severe degenerative disease (osteoarthritis).
3) Have back pain that is not related to any serious condition e.g. fracture, rheumatoid arthritis.
4) Deemed fit to participate in physical activity by your consultant and by the Readiness for Physical activity questionnaire.

Confidentiality and voluntary participation:
Your identity shall remain anonymous and confidential. All data recorded will not be traceable back to you and will be available to the research team only. Your name will not be published next to your results at any time during the study. You are not obliged to participate in the study. You may withdraw from the study at any time without giving a reason and you will not be penalized in any way.

Further Information:
If you require any additional information, please do not hesitate to contact any of the following persons: Derek Griffin, 086 3516003, email: derek.griffin@ul.ie; Dr Norelee Kennedy, 061 213371, email: norelee.kennedy@ul.ie; Prof. Dominic Harmon, email: dominic.harmon@hse.ie

Complaint Procedure:
If you have any concerns or complaints about this study and wish to contact someone independent, you may contact The Chairperson of the Mid-Western Ethics Committee.

The Chairperson
Scientific Research Ethics Committee,
Limerick Regional Hospital,
Dooradoyle,
Limerick.
Participant Consent Form

Criterion validity and calibration of the ActivPAL™ activity monitor and the SenseWear® armband as a measure of energy expenditure in patients with chronic low back pain

Please read the following statements and place a tick in the box to indicate that you agree with the statement.

☐ I have read and clearly understand all the detail provided on the subject information sheet.

☐ I understand what the study is about, what is expected of me as a volunteer and why the study is being carried out.

☐ I clearly understand that my participation is voluntary and that I can withdraw from this study at any time without explanation.

☐ I agree to inform the investigator immediate of any side-effects which may arise during the study.

☐ I agree to participate in this study.

If you are happy with the above statements and agree to participate in this study, please sign below:

Participant: ____________________ Date: ___________

Investigator: ____________________
The correlates of objectively-measured free-living physical activity in patients with chronic low back pain

**Background:**
Physical activity is any type of movement that a person does. Patients with chronic low back pain often report that the pain affects their activity levels in the home, at work or during leisure time. The aim of this study is to identify the factors that influence everyday activity levels in patients with chronic low back pain.

**Procedure:**
All participants will be required to provide written consent before beginning the study. At the beginning of testing information on work status, marital status, education level and pain duration and severity. You will also be asked to complete three brief questionnaires that will ask questions related to the symptoms that you feel, how pain affects your daily life and how your activity levels are affected by your pain. An ActivPAL™ activity monitor will then be attached to the front of your thigh. This is a small electronic device and will record how much movement that you do. You will wear it for the next 7 days. It is very small and will not interfere with you daily life. After the seven days you will be asked to complete 5 questionnaires that examine how you cope and feel with your pain.

**Benefits:**
A better understanding of how people cope with pain and how physical activity is affected in chronic low back pain will help to improve the management of the condition in the future.

**Risks:**
The tape used to attach the accelerometer to the thigh may cause an allergic reaction in some people. Participants will be asked to remove the accelerometer at the end of the 1st day and inspect the skin for signs of an allergic reaction. If a person notices anything at this time or at an earlier stage when bathing, showering etc, he/she will be asked to stop wearing the monitor and to contact the research team.
Exclusion from participation:

All patients over the age of 18 and with a diagnosis of chronic low back pain are eligible to participate in the study. Patients must have experienced pain for at least 3 months in order to participate.

You cannot participate if:
You have other conditions including severe osteoarthritis, rheumatoid arthritis, neurological conditions or other conditions that affect physical activity;
You are pregnant or are younger than 18 years or older than 65 years;
You have had back surgery in the last 12 months;
You have had an injection for your pain in the last 4 weeks.

Compensation:

There will be no remuneration for participating in this study.

Confidentiality and voluntary participation:

Your identity shall remain anonymous and confidential. All data recorded will not be traceable back to you and will be available to the research team only. Your name will not be published next to your results at any time during the study. You are not obliged to participate in the study. You may withdraw from the study at any time without giving a reason and you will not be penalised in any way.

Further Information:

If you require any additional information, please do not hesitate to contact any of the following persons: Derek Griffin, 086 3516003, email: derek.griffin@ul.ie; Dr Norelee Kennedy, 061 213371, email: norelee.kennedy@ul.ie; Prof. Dominic Harmon, email: dominic.harmon@hse.ie

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The Chairperson
Scientific Research Ethics Committee,
Limerick Regional Hospital,
Dooradoyle,
Limerick.
Participant Consent Form

The correlates of objectively-measured free-living physical activity in patients with chronic low back pain.

Please read the following statements and place a tick in the box to indicate that you agree with the statement.

I have read and clearly understand all the detail provided on the subject information sheet.

I understand what the study is about, what is expected of me as a volunteer and why the study is being carried out.

I clearly understand that my participation is voluntary and that I can withdraw from this study at any time without explanation.

I agree to inform the investigator immediate of any side-effects which may arise during the study.

I agree to participate in this study.

If you are happy with the above statements and agree to participate in this study, please sign below:

Participant: ____________________  Date: ___________

Investigator: ____________________
The perception and understanding of physical activity among patients with chronic low back pain: A qualitative study.

**Aim:**
The aim of this study is to gain important information of the understanding and perceptions of physical activity among patients with chronic low back pain.

**Procedure:**
Each participant will be required to participate in a one-on-one interview with one of the researchers. The interview will last for 40-60 minutes and will be audio recorded. The interview will take place at a time and place of convenience for the participant. During the interview, each participant will be asked questions regarding their understanding of physical activity and the different factors that influence their physical activity on a daily basis.

**Benefits:**
There is no direct benefit to the patient for participating in this study. However, a better understanding of physical activity in low back pain from the patient’s perspective, may lead to improved management of the low back pain.

**Risks:**
There are no risks associated with participating in this study

**Exclusion from participation:**
All patients over the age of 18 and with a diagnosis of chronic low back pain are eligible to participate in the study. Patients must have experienced pain for at least 3 months in order to participate.

*You cannot participate if:*
You have other conditions including severe osteoarthritis, rheumatoid arthritis, neurological conditions or other conditions that affect physical activity;
You are pregnant or are younger than 18 years or older than 65 years;
You have had an injection for your pain in the last 4 weeks.
Compensation:
There will be no remuneration for participating in this study.

Confidentiality and voluntary participation:
Your identity shall remain anonymous and confidential. All data recorded will not be traceable back to you and will be available to the research team only. Your name will not be published next to your data at any time during the study. You are not obliged to participate in the study. You may withdraw from the study at any time without giving a reason and you will not be penalised in any way.

Further Information:
If you require any additional information, please do not hesitate to contact any of the following persons: Derek Griffin, 086 3516003, email: derek.griffin@ul.ie; Dr Norelee Kennedy, 061 213371, email: norelee.kennedy@ul.ie; Prof. Dominic Harmon, email: dominic.harmon@hse.ie

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Limerick.
Participant Consent Form

The perception and understanding of physical activity among patients with chronic low back pain: A qualitative study.

Please read the following statements and place a tick in the box to indicate that you agree with the statement.

☐ I have read and clearly understand all the detail provided on the subject information sheet.

☐ I understand what the study is about, what is expected of me as a volunteer and why the study is being carried out.

☐ I clearly understand that my participation is voluntary and that I can withdraw from this study at any time without explanation.

☐ I understand that the interview will be recorded and that the information will be available only to the research team.

☐ I agree to participate in this study.

If you are happy with the above statements and agree to participate in this study, please sign below:

Participant: ____________________ Date: ___________
Investigator: ____________________
APPENDIX B:

Statistical Analysis & SPSS Output
B1-STATISTICS FOR CHAPTER 4

ICC ANALYSIS

AGREEMENT (ICC VALUES) BETWEEN ACTIVPAL AND INDIRECT CALORIMETRY ESTIMATES OF EE DURING TREADMILL WALKING AND NON-LOCOMOTOR TASK

Intraclass Correlation Coefficient

<table>
<thead>
<tr>
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<th>Intraclass Correlation</th>
<th>95% Confidence Interval</th>
<th>F Test with True Value 0</th>
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</thead>
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<tr>
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Two-way mixed effects model where people effects are random and measures effects are fixed.

a. Type A intraclass correlation coefficients using an absolute agreement definition.
b. The estimator is the same, whether the interaction effect is present or not.
c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

CALORIMETRY ESTIMATES OF EE DURING TREADMILL WALKING AND NON-LOCOMOTOR TASK

Intraclass Correlation Coefficient

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<td>Average Measures</td>
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<td>.812</td>
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Two-way mixed effects model where people effects are random and measures effects are fixed.

a. Type A intraclass correlation coefficients using an absolute agreement definition.
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c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

INTERDEVICE RELIABILITY (ICC VALUES) FOR MET VALUE, STEP RATE AND ACTIVPAL COUNTS DURING TREADMILL WALKING

Intraclass Correlation Coefficient

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<td>.999</td>
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Two-way mixed effects model where people effects are random and measures effects are fixed.

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Two-way mixed effects model where people effects are random and measures effects are fixed.

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## INTERDEVICE RELIABILITY (ICC VALUES) FOR MET VALUE, STEP RATE AND ACTIVPAL COUNTS DURING NON LOCOMOTOR TASKS

## Intraclass Correlation Coefficient

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Two-way mixed effects model where people effects are random and measures effects are fixed.

a. Type A intraclass correlation coefficients using an absolute agreement definition.
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Two-way mixed effects model where people effects are random and measures effects are fixed.

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Two-way mixed effects model where people effects are random and measures effects are fixed.

- a. Type A intraclass correlation coefficients using an absolute agreement definition.
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- c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.
## BACKWARDS LINEAR REGRESSION MODELS (SUMMARY DATA)

### REGRESSION MODELS FOR THE PREDICTION OF DISABILITY LEVEL

<table>
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<tr>
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<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
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*a. Predictors: (Constant), Gender, TSK11SF, PainDETECT, WorkStatus, Pacing, Pain, Persistence, PSEQ, CHRONIC PAINAQPW, PCS, HADSA, TSK11AA, HADSD, CHRONIC PAINAQAE, Avoidance*

*b. Predictors: (Constant), Gender, TSK11SF, PainDETECT, WorkStatus, Pacing, Pain, Persistence, PSEQ, CHRONIC PAINAQPW, PCS, HADSA, HADSD, CHRONIC PAINAQAE, Avoidance*

*c. Predictors: (Constant), Gender, PainDETECT, WorkStatus, Pacing, Pain, Persistence, PSEQ, CHRONIC PAINAQPW, PCS, HADSA, HADSD, CHRONIC PAINAQAE, Avoidance*

*d. Predictors: (Constant), Gender, PainDETECT, WorkStatus, Pacing, Pain, Persistence, PSEQ, CHRONIC PAINAQPW, HADSA, HADSD, CHRONIC PAINAQAE, Avoidance*

*e. Predictors: (Constant), Gender, PainDETECT, WorkStatus, Pacing, Pain, PSEQ, CHRONIC PAINAQPW, HADSA, HADSD, CHRONIC PAINAQAE, Avoidance*

*f. Predictors: (Constant), Gender, PainDETECT, WorkStatus, Pacing, Pain, CHRONIC PAINAQPW, HADSA, HADSD, CHRONIC PAINAQAE, Avoidance*

*g. Predictors: (Constant), Gender, PainDETECT, WorkStatus, Pacing, Pain, CHRONIC PAINAQPW, HADSA, CHRONIC PAINAQAE, Avoidance*

*h. Predictors: (Constant), Gender, PainDETECT, WorkStatus, Pacing, Pain, CHRONIC PAINAQPW, CHRONIC PAINAQAE, Avoidance*

*i. Predictors: (Constant), Gender, PainDETECT, WorkStatus, Pacing, Pain, CHRONIC PAINAQAE, Avoidance*

*j. Predictors: (Constant), Gender, PainDETECT, WorkStatus, Pacing, Pain, CHRONIC PAINAQAE*

*k. Predictors: (Constant), Gender, PainDETECT, WorkStatus, Pacing, CHRONIC PAINAQAE*
### AVERAGE DAILY TIME WALKING OVER THE FULL WEEK

**Model Summary**

<table>
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<th>Std. Error of the Estimate</th>
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a. Predictors: (Constant), BMI, Pain, Avoidance, ODI, HADSD  
b. Predictors: (Constant), BMI, Pain, ODI, HADSD  
c. Predictors: (Constant), BMI, Pain, HADSD  
d. Predictors: (Constant), BMI, HADSD

### AVERAGE DAILY STEP COUNT FOR THE FULL WEEK

**Model Summary**

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a. Predictors: (Constant), Pacing, BMI, HADSD, ODI, Avoidance  
b. Predictors: (Constant), Pacing, BMI, HADSD, ODI  
c. Predictors: (Constant), BMI, HADSD, ODI  
d. Predictors: (Constant), BMI, HADSD

### AVERAGE DAILY VOLUME OF PHYSICAL ACTIVITY (ACTIVPAL COUNTS)

**Model Summary**

<table>
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<th>Model</th>
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a. Predictors: (Constant), Pacing, BMI, HADSD, ODI, Avoidance  
b. Predictors: (Constant), Pacing, BMI, HADSD, ODI  
c. Predictors: (Constant), BMI, HADSD, ODI  
d. Predictors: (Constant), BMI, HADSD  
e. Predictors: (Constant), BMI, HADSD
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a. Predictors: (Constant), BMI, Pain, Pacing, HADSD, ODI, Avoidance
b. Predictors: (Constant), BMI, Pain, Pacing, HADSD, ODI
c. Predictors: (Constant), BMI, Pain, HADSD, ODI
d. Predictors: (Constant), BMI, HADSD, ODI
e. Predictors: (Constant), HADSD, ODI

AVERAGE DAILY TIME SPENT IN MOD-VIG PA OVER THE FULL WEEK

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<th>Adjusted R Square</th>
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<td>.479(^e)</td>
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a. Predictors: (Constant), Pacing, Pain, HADSA, ODI, HADSD, Avoidance
b. Predictors: (Constant), Pacing, Pain, HADSA, ODI, HADSD
c. Predictors: (Constant), Pain, HADSA, ODI, HADSD
d. Predictors: (Constant), Pain, ODI, HADSD
e. Predictors: (Constant), ODI, HADSD

MEDIATION ANALYSIS (BOOTSTRAPPING PROCEDURE)

DEPRESSION AS A MEDIATOR BETWEEN DISABILITY AND VOLUME OF PA

VARIABLES IN SIMPLE MEDIATION MODEL
Y  COUNTSTO
X  ODI
M  HADSD

DESCRIPTIVES STATISTICS AND PEARSON CORRELATIONS

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<tr>
<th>COUNTSTO</th>
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<th>HADSD</th>
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ODI  40.0847  13.2539  -.3778  1.0000  .4567
HADSD  8.6288  4.1057  -.4191  .4567  1.0000

SAMPLE SIZE
59

DIRECT AND TOTAL EFFECTS
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<th>Coeff</th>
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<th>t</th>
<th>Sig(two)</th>
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INDIRECT EFFECT AND SIGNIFICANCE USING NORMAL DISTRIBUTION
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<th>UL95CI</th>
<th>Z</th>
<th>Sig(two)</th>
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<tr>
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BOOTSTRAP RESULTS FOR INDIRECT EFFECT

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<th>LL95CI</th>
<th>UL95CI</th>
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NUMBER OF BOOTSTRAP RESAMPLES
5000

PACING AS A MEDIATOR BETWEEN DISABILITY AND VOLUME OF PA

VARIABLES IN SIMPLE MEDIATION MODEL
Y  COUNTSTO
X  ODI
M  Pacing

DESCRIPTIVES STATISTICS AND PEARSON CORRELATIONS

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<tr>
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<th>ODI</th>
<th>Pacing</th>
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DIRECT AND TOTAL EFFECTS

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INDIRECT EFFECT AND SIGNIFICANCE USING NORMAL DISTRIBUTION

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BOOTSTRAP RESULTS FOR INDIRECT EFFECT

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NUMBER OF BOOTSTRAP RESAMPLES
5000
DISABILITY AS A MEDIATOR BETWEEN PACING AND VOLUME OF PA

VARIABLES IN SIMPLE MEDIATION MODEL
Y COUNTSTO
X Pacing
M ODI

DESCRIPTIVES STATISTICS AND PEARSON CORRELATIONS

<table>
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SAMPLE SIZE
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DIRECT AND TOTAL EFFECTS

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INDIRECT EFFECT AND SIGNIFICANCE USING NORMAL DISTRIBUTION

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BOOTSTRAP RESULTS FOR INDIRECT EFFECT

<table>
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<th>UL99 CI</th>
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NUMBER OF BOOTSTRAP RESAMPLES 5000
B3-STATISTICS FOR CHAPTER 5-PART 2

BETWEEN GROUP COMPARISONS (ONE-WAY ANOVA) FOR PHYSICAL ACTIVITY DATA

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<th>Mean Square</th>
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### BETWEEN GROUP COMPARISONS (KRUSKAL WALLIS TEST) FOR PA DATA

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<th>WalkWD</th>
<th>StepsWD</th>
<th>MVPAWD</th>
<th>COUNTSWD</th>
<th>WalkWE</th>
<th>StepsWE</th>
<th>MVPAWE</th>
<th>COUNTSWE</th>
<th>StepsTOT</th>
<th>MVPATOT</th>
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<sup>a</sup> Kruskal Wallis Test  
<sup>b</sup> Grouping Variable: PainMech

### BETWEEN GROUP COMPARISONS (ONE-WAY ANOVA) FOR SEDENTARY ACTIVITY DATA

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<thead>
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### BETWEEN GROUP COMPARISONS (KRUSKAL WALLIS TEST) FOR SEDENTARY ACTIVITY DATA

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<th>COUNTSTOT</th>
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<td>.266</td>
<td>.511</td>
<td>.849</td>
<td>.531</td>
<td>.703</td>
<td>.282</td>
</tr>
</tbody>
</table>

<sup>a</sup> Kruskal Wallis Test  
<sup>b</sup> Grouping Variable: PainMech
APPENDIX C:

Questionnaires Used in this Thesis
PAR - Q
A Participant Activity Readiness Questionnaire

Regular physical activity is fun and healthy, and increasingly, more and more people like yourself are training for endurance events. However, some people should check with their doctor before they become much more physically active.

If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES NO
____ ____ Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?
____ ____ Do you feel a pain in your chest when you do physical activity?
____ ____ In the past month, have you had chest pain when you were not doing physical activity?
____ ____ Do you lose your balance because of dizziness or do you ever lose consciousness?
____ ____ Do you have a bone or joint problem that could be made worse by a change in your physical activity?
____ ____ Is your doctor currently prescribing drugs (i.e., water pills) for your blood pressure or heart condition?
____ ____ Do you know of any other reason why you should not do physical activity?

YES to one or more questions
If you answered Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.
• You may be able to do any activity you want - as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice
• Find out which community programs are safe and helpful to you

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:
• start becoming much more physically active - begin slowly and build up gradually. This is the safest and easiest way to go.
• take part in a fitness appraisal - this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively.

NO to all questions

DELAY BECOMING MUCH MORE ACTIVE:
• if you are not feeling well because of a temporary illness such as cold or fever - wait until you feel better; or
• if you are or may be pregnant - talk to your doctor before you start becoming more active.

Please note: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Note: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

I have read, understood and completed the questionnaire. Any questions I had were answered to my full satisfaction.

Print Name __________________________________________
Signature: __________________________________________ Date: ____________________________
C2-PAIN DETECT QUESTIONNAIRE

**PAIN QUESTIONNAIRE**

**Date:** [ ]  |  **Patient:** [ ] **Last name:** [ ]  |  **First name:** [ ]

How would you assess your pain now, at this moment?

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>max.</td>
</tr>
</tbody>
</table>

How strong was the strongest pain during the past 4 weeks?

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>max.</td>
</tr>
</tbody>
</table>

How strong was the pain during the past 4 weeks on average?

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>no</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>max.</td>
</tr>
</tbody>
</table>

Mark the picture that best describes the course of your pain:

- Persistent pain with slight fluctuations [ ]
- Persistent pain with pain attacks [ ]
- Pain attacks without pain between them [ ]
- Pain attacks with pain between them [ ]

Please mark your main area of pain:

Does your pain radiate to other regions of your body? yes [ ] no [ ]

If yes, please draw the direction in which the pain radiates.

Do you suffer from a burning sensation (e.g., stinging nettles) in the marked areas?

- never [ ] hardly noticed [ ] slightly [ ] moderately [ ] strongly [ ] very strongly [ ]

Do you have a tingling or prickling sensation in the area of your pain (like crawling ants or electrical tingling)?

- never [ ] hardly noticed [ ] slightly [ ] moderately [ ] strongly [ ] very strongly [ ]

Is light touching (clothing, a blanket) in this area painful?

- never [ ] hardly noticed [ ] slightly [ ] moderately [ ] strongly [ ] very strongly [ ]

Do you have sudden pain attacks in the area of your pain, like electric shocks?

- never [ ] hardly noticed [ ] slightly [ ] moderately [ ] strongly [ ] very strongly [ ]

Is cold or heat (bath water) in this area occasionally painful?

- never [ ] hardly noticed [ ] slightly [ ] moderately [ ] strongly [ ] very strongly [ ]

Do you suffer from a sensation of numbness in the areas that you marked?

- never [ ] hardly noticed [ ] slightly [ ] moderately [ ] strongly [ ] very strongly [ ]

**Does slight pressure in this area, e.g., with a finger, trigger pain?**

(Ticks filled out by the physician)

- never [ ] hardly noticed [ ] slightly [ ] moderately [ ] strongly [ ] very strongly [ ]

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>x 0 = 0</td>
<td>x 1 = [ ]</td>
<td>x 2 = [ ]</td>
<td>x 3 = [ ]</td>
<td>x 4 = [ ]</td>
<td>x 5 = [ ]</td>
</tr>
</tbody>
</table>

Total score [ ] out of 35

This questionnaire is designed to give us information as to how your back (or leg) trouble affects your ability to manage in everyday life.
Please answer every section. Mark one box only in each section that most closely describes you today.

Section 1 - Pain intensity

- I have no pain at the moment.
- The pain is very mild at the moment.
- The pain is moderate at the moment.
- The pain is fairly severe at the moment.
- The pain is very severe at the moment.
- The pain is the worst imaginable at the moment.

Section 2 - Personal care (washing, dressing, etc.)

- I can look after myself normally without causing extra pain.
- I can look after myself normally but it is very painful.
- It is painful to look after myself and I am slow and careful.
- I need some help but manage most of my personal care.
- I need help every day in most aspects of self care.
- I do not get dressed, wash with difficulty and stay in bed.

Section 3 - Lifting

- I can lift heavy weights without extra pain.
- I can lift heavy weights but it gives extra pain.
- Pain prevents me from lifting heavy weights off the floor but I can manage if they are conveniently positioned, e.g. on a table.
- Pain prevents me from lifting heavy weights but I can manage light to medium weights if they are conveniently positioned.
- I can lift only very light weights.
- I cannot lift or carry anything at all.

Section 4 - Walking

- Pain does not prevent me walking any distance.
• ☐ Pain prevents me walking more than one mile.
• ☐ Pain prevents me walking more than a quarter of a mile.
• ☐ Pain prevents me walking more than 100 yards.
• ☐ I can only walk using a stick or crutches.
• ☐ I am in bed most of the time and have to crawl to the toilet.

Section 5 - Sitting

• ☐ I can sit in any chair as long as I like.
• ☐ I can sit in my favourite chair as long as I like.
• ☐ Pain prevents me from sitting for more than 1 hour.
• ☐ Pain prevents me from sitting for more than half an hour.
• ☐ Pain prevents me from sitting for more than 10 minutes.
• ☐ Pain prevents me from sitting at all.

Section 6 - Standing

• ☐ I can stand as long as I want without extra pain.
• ☐ I can stand as long as I want but it gives me extra pain.
• ☐ Pain prevents me from standing for more than 1 hour.
• ☐ Pain prevents me from standing for more than half an hour.
• ☐ Pain prevents me from standing for more than 10 minutes.
• ☐ Pain prevents me from standing at all.

Section 7 - Sleeping

• ☐ My sleep is never disturbed by pain.
• ☐ My sleep is occasionally disturbed by pain.
• ☐ Because of pain I have less than 6 hours sleep.
• ☐ Because of pain I have less than 4 hours sleep.
• ☐ Because of pain I have less than 2 hours sleep.
• ☐ Pain prevents me from sleeping at all.
Section 8 - Sex life (if applicable)

- My sex life is normal and causes no extra pain.
- My sex life is normal but causes some extra pain.
- My sex life is nearly normal but is very painful.
- My sex life is severely restricted by pain.
- My sex life is nearly absent because of pain.
- Pain prevents any sex life at all.

Section 9 - Social life

- My social life is normal and causes me no extra pain.
- My social life is normal but increases the degree of pain.
- Pain has no significant effect on my social life apart from limiting my more energetic interests, e.g. sport, etc.
- Pain has restricted my social life and I do not go out as often.
- Pain has restricted social life to my home.
- I have no social life because of pain.

Section 10 - Travelling

- I can travel anywhere without pain.
- I can travel anywhere but it gives extra pain.
- Pain is bad but I manage journeys over two hours.
- Pain restricts me to journeys of less than one hour.
- Pain restricts me to short necessary journeys under 30 minutes.
- Pain prevents me from travelling except to receive treatment

Result

Your ODI = [%]
C4-TAMPA SCALE FOR KINESIOPHOBIA-11

Tampa Scale for Kinesiophobia-11
(Woby et al 2005)

1 = strongly disagree
2 = disagree
3 = agree
4 = strongly agree

<p>| | | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>I’m afraid that I might injury myself if I exercise</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>If I were to try to overcome it, my pain would Increase</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>My body is telling me I have something dangerously wrong</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>People aren’t taking my medical condition seriously enough</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>My accident has put my body at risk for the rest of my life</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>Pain always means I have injured my body</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>Simply being careful that I do not make any unnecessary movements is the safest thing I can do to prevent my pain from worsening</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>I wouldn’t have this much pain if there weren’t something potentially dangerous going on in my Body</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Pain lets me know when to stop exercising so that I don’t injure myself</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>I can’t do all the things normal people do because it’s too easy for me to get injured</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>No one should have to exercise when he/she is in Pain</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Everyone experiences painful situations at some point in their lives. Such experiences may include headaches, tooth pain, joint or muscle pain. People are often exposed to situations that may cause pain such as illness, injury, dental procedures or surgery.

We are interested in the types of thoughts and feelings that you have when you are in pain. Listed below are thirteen statements describing different thoughts and feelings that may be associated with pain. Using the following scale, please indicate the degree to which you have these thoughts and feelings when you are experiencing pain.

0 – not at all  1 – to a slight degree  2 – to a moderate degree  3 – to a great degree  4 – all the time

When I’m in pain …

1. I worry all the time about whether the pain will end.
2. I feel I can’t go on.
3. It’s terrible and I think it’s never going to get any better.
4. It’s awful and I feel that it overwhelms me.
5. I feel I can’t stand it anymore.
6. I become afraid that the pain will get worse.
7. I keep thinking of other painful events.
8. I anxiously want the pain to go away.
9. I can’t seem to keep it out of my mind.
10. I keep thinking about how much it hurts.
11. I keep thinking about how badly I want the pain to stop.
12. There’s nothing I can do to reduce the intensity of the pain.
13. I wonder whether something serious may happen.

...Total
PAIN S-E QUESTIONNAIRE (PSEQ)
Nicholas (1989)

NAME: __________________________ Date: __________________

Please rate how confident you are that you can do the following things at present, despite the pain. To indicate your answer circle one of the numbers on the scale under each item, where 0 = not at all confident and 6 = completely confident.

For example:

<table>
<thead>
<tr>
<th>Not at all confident</th>
<th>Completely confident</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>6</td>
</tr>
</tbody>
</table>

Remember, this questionnaire is not asking whether or not you have been doing these things, but rather how confident you are that you can do them at present, despite the pain.

<table>
<thead>
<tr>
<th></th>
<th>Not at all confident</th>
<th>Completely confident</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I can enjoy things, despite the pain</td>
<td>0 1 2 3 4 5 6</td>
<td></td>
</tr>
<tr>
<td>2. I can do most of the household chores (e.g. tidying-up, washing dishes, etc.), despite the pain</td>
<td>0 1 2 3 4 5 6</td>
<td></td>
</tr>
<tr>
<td>3. I can socialise with my friends or family members as often as I used to do, despite the pain</td>
<td>0 1 2 3 4 5 6</td>
<td></td>
</tr>
<tr>
<td>4. I can cope with my pain in most situations</td>
<td>0 1 2 3 4 5 6</td>
<td></td>
</tr>
<tr>
<td>5. I can do some form of work, despite the pain. (&quot;work&quot; includes housework, paid and unpaid work)</td>
<td>0 1 2 3 4 5 6</td>
<td></td>
</tr>
<tr>
<td>6. I can still do many of the things I enjoy doing, such as hobbies or leisure activities, despite the pain</td>
<td>0 1 2 3 4 5 6</td>
<td></td>
</tr>
<tr>
<td>7. I can cope with my pain without medication.</td>
<td>0 1 2 3 4 5 6</td>
<td></td>
</tr>
<tr>
<td>8. I can still accomplish most of my goals in life, despite the pain</td>
<td>0 1 2 3 4 5 6</td>
<td></td>
</tr>
<tr>
<td>9. I can live a normal lifestyle, despite the pain</td>
<td>0 1 2 3 4 5 6</td>
<td></td>
</tr>
<tr>
<td>10. I can gradually become more active, despite the pain</td>
<td>0 1 2 3 4 5 6</td>
<td></td>
</tr>
</tbody>
</table>
C6-CHRONIC PAIN ACCEPTANCE QUESTIONNAIRE

CPAQ

Directions: Below you will find a list of statements. Please rate the truth of each statement as it applies to you by circling a number. Use the following rating scale to make your choices. For instance, if you believe a statement is “Always True”, you would circle the 6 next to that statement.

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never True</td>
<td>Very Rarely True</td>
<td>Seldom True</td>
<td>Sometimes True</td>
<td>Often True</td>
<td>Almost Always True</td>
<td>Always True</td>
</tr>
</tbody>
</table>

1. I am getting on with the business of living no matter what my level of pain is

2. My life is going well, even though I have chronic pain

3. It’s O.K. to experience pain

4. I would gladly sacrifice important things in my life to control this pain better

5. It’s not necessary for me to control my pain in order to handle my life well

6. Although things have changed, I am living a normal life despite my chronic pain

7. I need to concentrate on getting rid of my pain

8. There are many activities I do when I feel pain

9. I lead a full life even though I have chronic pain

10. Controlling pain is less important than other goals in my life
<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>11. My thoughts and feelings about pain must change before I can take important steps in my life</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>12. Despite the pain, I am now sticking to a certain course in my life</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>13. Keeping my pain level under control takes first priority whenever I am doing something</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>14. Before I can make any serious plans, I have to get some control over my pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>15. When my pain increases, I can still take care of my responsibilities</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>16. I will have better control over my life if I can control my negative thoughts about pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>17. I avoid putting myself in situations where pain might increase</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>18. My worries and fears about what pain will do to me are true</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>19. It's a relief to realize that I don't have to change my pain to get on with my life</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>20. I have to struggle to do things when I have pain</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
C7-HOSPITAL ANXIETY AND DEPRESSION SCALE

Patients are asked to choose one response from the four given for each interview. They should give an immediate response and be dissuaded from thinking too long about their answers. The questions relating to anxiety are marked "A", and to depression "D". The score for each answer is given in the right column. Instruct the patient to answer how it currently describes their feelings.

<table>
<thead>
<tr>
<th>A</th>
<th>I feel tense or 'wound up':</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Most of the time</td>
</tr>
<tr>
<td></td>
<td>A lot of the time</td>
</tr>
<tr>
<td></td>
<td>From time to time, occasionally</td>
</tr>
<tr>
<td></td>
<td>Not at all</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D</th>
<th>I still enjoy the things I used to enjoy:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Definitely as much</td>
</tr>
<tr>
<td></td>
<td>Not quite so much</td>
</tr>
<tr>
<td></td>
<td>Only a little</td>
</tr>
<tr>
<td></td>
<td>Hardly at all</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A</th>
<th>I get a sort of frightened feeling as if something awful is about to happen:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very definitely and quite badly</td>
</tr>
<tr>
<td></td>
<td>Yes, but not too badly</td>
</tr>
<tr>
<td>A</td>
<td>Worrying thoughts go through my mind:</td>
</tr>
<tr>
<td>---</td>
<td>-------------------------------------</td>
</tr>
<tr>
<td></td>
<td>A great deal of the time</td>
</tr>
<tr>
<td></td>
<td>A lot of the time</td>
</tr>
<tr>
<td></td>
<td>From time to time, but not too often</td>
</tr>
<tr>
<td></td>
<td>Only occasionally</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D</th>
<th>I can laugh and see the funny side of things:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>As much as I always could</td>
</tr>
<tr>
<td></td>
<td>Not quite so much now</td>
</tr>
<tr>
<td></td>
<td>Definitely not so much now</td>
</tr>
<tr>
<td></td>
<td>Not at all</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D</th>
<th>I feel cheerful:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
</tr>
<tr>
<td></td>
<td>Not often</td>
</tr>
<tr>
<td></td>
<td>Sometimes</td>
</tr>
<tr>
<td>Most of the time</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A</th>
<th>I can sit at ease and feel relaxed:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitely</td>
<td>0</td>
</tr>
<tr>
<td>Usually</td>
<td>1</td>
</tr>
<tr>
<td>Not Often</td>
<td>2</td>
</tr>
<tr>
<td>Not at all</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D</th>
<th>I feel as if I am slowed down:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nearly all the time</td>
<td>3</td>
</tr>
<tr>
<td>Very often</td>
<td>2</td>
</tr>
<tr>
<td>Sometimes</td>
<td>1</td>
</tr>
<tr>
<td>Not at all</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A</th>
<th>I get a sort of frightened feeling like 'butterflies' in the stomach:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td>0</td>
</tr>
<tr>
<td>Occasionally</td>
<td>1</td>
</tr>
<tr>
<td>Quite Often</td>
<td>2</td>
</tr>
<tr>
<td>Very Often</td>
<td>3</td>
</tr>
</tbody>
</table>
### I have lost interest in my appearance:

<table>
<thead>
<tr>
<th>Option</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitely</td>
<td>3</td>
</tr>
<tr>
<td>I don't take as much care as I should</td>
<td>2</td>
</tr>
<tr>
<td>I may not take quite as much care</td>
<td>1</td>
</tr>
<tr>
<td>I take just as much care as ever</td>
<td>0</td>
</tr>
</tbody>
</table>

### I feel restless as I have to be on the move:

<table>
<thead>
<tr>
<th>Option</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very much indeed</td>
<td>3</td>
</tr>
<tr>
<td>Quite a lot</td>
<td>2</td>
</tr>
<tr>
<td>Not very much</td>
<td>1</td>
</tr>
<tr>
<td>Not at all</td>
<td>0</td>
</tr>
</tbody>
</table>

### I look forward with enjoyment to things:

<table>
<thead>
<tr>
<th>Option</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>As much as I ever did</td>
<td>0</td>
</tr>
<tr>
<td>Rather less than I used to</td>
<td>1</td>
</tr>
<tr>
<td>Definitely less than I used to</td>
<td>2</td>
</tr>
<tr>
<td>Hardly at all</td>
<td>3</td>
</tr>
</tbody>
</table>

### I get sudden feelings of panic:

---
<table>
<thead>
<tr>
<th>Very often indeed</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quite often</td>
<td>2</td>
</tr>
<tr>
<td>Not very often</td>
<td>1</td>
</tr>
<tr>
<td>Not at all</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>I can enjoy a good book or radio or TV program:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Often</td>
</tr>
<tr>
<td>Sometimes</td>
</tr>
<tr>
<td>Not often</td>
</tr>
<tr>
<td>Very seldom</td>
</tr>
</tbody>
</table>

Scoring (add the As = Anxiety. Add the Ds = Depression). The norms below will give you an idea of the level of Anxiety and Depression.

- 0-7 = Normal
- 8-10 = Borderline abnormal
- 11-21 = Abnormal

Reference:

Zigmond and Snaith (1983)
People who have pain use different ways to do their daily activities. Think about how you usually do your daily activities. For each of the statements below, circle the number between 0 and 4 that best describes how you usually do your daily activities.

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I stop what I am doing when my pain starts to get worse.</td>
<td>Not at all</td>
<td>Sometimes</td>
<td>All the time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. When I’m doing an activity I don’t stop until it is finished.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. I go back and forth between working and taking breaks when doing an activity.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. I take on extra tasks when I am having a good pain day.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. When I start an activity I think about how to split it into smaller parts.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6. There are many activities that I avoid because they flare up my pain.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7. I make the most of my good pain days by doing more things.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8. When my pain starts to get worse I know it’s time to stop what I am doing.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9. I do my activities at a slow and steady pace.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10. I keep doing what I am doing until my pain is so bad that I have to stop.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>11. I avoid activities that I know will make my pain worse.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>12. When I do an activity I stop after a while and then come back later to do more.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>13. Most days my pain keeps me from doing much at all.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Not at all</td>
<td>Sometimes</td>
<td>All the time</td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>------------</td>
<td>-----------</td>
<td>--------------</td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>I go slower and work at a steady pace when I’m doing things.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>15.</td>
<td>Once I start an activity I keep going until it is done.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>16.</td>
<td>I limit my activities to the ones that I know will not make my pain worse.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>17.</td>
<td>When I do an activity I break it into small parts and do one part at a time.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>18.</td>
<td>I just ignore my pain and keep doing what I’m doing as long as I can.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>19.</td>
<td>Because of my pain most days I spend more time resting than doing activities.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>20.</td>
<td>I keep going until I can’t stand the pain anymore.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>21.</td>
<td>Instead of doing an activity all at once I do a little bit at a time.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>22.</td>
<td>I don’t start an activity if I know it will make my pain worse.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>23.</td>
<td>I do extra on days when my pain is less.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>24.</td>
<td>I remember to stop and take breaks when I’m doing an activity.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>25.</td>
<td>If I know that something will make my pain worse I don’t do it anymore.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>26.</td>
<td>When I do an activity I do the whole thing all at once.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>27.</td>
<td>Instead of doing the whole activity I divide it into small parts and do one part at a time.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>28.</td>
<td>I’ve cut back my activities by not doing the ones that make my pain worse.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>29.</td>
<td>When I do an activity I work for a while, take a break, and then go back to work again.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>30.</td>
<td>Some days I do a lot, other days I don’t do much.</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
APPENDIX D:

Data Collection Form for Study Presented in Chapter 5
1. Gender
Male □
Female □

2. Pain Location

3. Pain Intensity
NRS-Pain at the moment (0-100) □
NRS-Average pain over the past 7 days (0-100) □

In the past 2 weeks, how bothersome has your back pain been?
Not at all □  Slightly □  Moderately □  Very much □  Extremely □
0-10 (0=not at all bothersome; 10=extremely bothersome): __________

Signs of spinal stenosis
1. Numbness and/or pain in the thighs down to the calves and shins.  Yes  No
2. Numbness and/or pain increase in intensity after walking for a while, but are relieved by taking a rest.  Yes  No
3. Standing for a while brings on numbness and/or pain in the thighs down to the calves and shins.  Yes  No
4. Numbness and/or pain are reduced by bending forward.  Yes  No
5. Numbness is present in both legs. 
6. Numbness is present in the soles of both feet. 
7. Numbness arises around the buttocks. 
8. Numbness is present, but pain is absent. 
9. A burning sensation arises around the buttocks. 
10. Walking nearly causes urination.

Yes No

4. Pain Duration
_____ (years)  _____ (months)

5. Work Status
Full-time/Part-time work
Home Duties
Unemployed due to pain
Retired
Other

6. Marital Status

Type of work

We would like to know the type and amount of physical activity involved in your work. Please tick (V) the option that best corresponds with your occupation(s) in the last 4 weeks from the following four possibilities:

Please tick only one of the following

1. Sedentary occupation
You spend most of your time sitting (such as in an office)

2. Standing occupation
You spend most of your time standing or walking. However, your work does not require intense physical effort (e.g. shop assistant, hairdresser, guard)

3. Manual work
This involves some physical effort including handling of heavy objects and use of tools (e.g. plumber, electrician, carpenter)

4. Heavy manual work
This implies very vigorous physical activity including handling of very heavy objects (e.g. dock worker, miner, bricklayer, construction worker)
7. Educational Status
Completed primary level  □
Junior Certificate completed  □
Leaving Certificate completed  □
Third level qualification  □
Other  □  Please specify ____________________

8. Medication List

<table>
<thead>
<tr>
<th>Date Started</th>
<th>Name of Medicine</th>
<th>Dose</th>
<th>When Do You Take It?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9. General Health
Cardiovascular Disease  □
Diabetes  □
Asthma  □
<table>
<thead>
<tr>
<th>Condition</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Osteoarthritis</td>
<td></td>
</tr>
<tr>
<td>Rheumatoid Arthritis</td>
<td></td>
</tr>
<tr>
<td>Fibromyalgia</td>
<td></td>
</tr>
<tr>
<td>Cancer</td>
<td></td>
</tr>
<tr>
<td>Neurological disease</td>
<td></td>
</tr>
<tr>
<td>Cauda Equina</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX E:

Sample Transcript Excerpts
Interview 1

Okay and is your back pain in any way affecting your sleep patterns or the amount of sleep that you are getting?

Oh it can do. It really can that you just try to lie down like and maybe you just can’t. Your back, I don’t know, I call it a spasm or whatever like. It’s just a constant ache or chronic pain it can get to at that stage and you just find that you have to get up out of the bed like. You are not going to sleep that night like. You take your medication again and hope to God that that might give you some relief like or as I say take your machine, put the machine on, the old Tens Machine and I normally get relief out of that. Some bit of relief off it anyway.

And would your sleep affect your physical activity?

Oh the following day you could be quite knackered like. The following day that you haven’t got a good night’s sleep. It can take a toll on you like, you know, I mean you could have your dinner there then the following evening and you’d be falling asleep on the chair like which wasn’t me like, you know, but lately now I noticed after a meal or whatever you could nearly take a kip on the chair like unnoticed to yourself. You could be gone out for 15 or 20 minutes, you know. On that side of it like that what the effect now seems to be like.

Interview 2

And is there any activity that you avoid because of pain or that you have been advised not to do?

Yeah, a lot of driving is a problem and up to last year before I went through my separation I was doing a serious amount of driving coming from Limerick and getting out of the car was a major problem so much so that maybe for the first hour I was very conscious of even twisting or turning. I had to be because it was the position I was in when I was driving but my driving isn’t as bad now but I have been warned that excessive driving or the way I get in and out of the car could really affect my back for the first couple of hours of work so I’m very conscious of that. As I said lifting at home or lifting at work we have manual handling techniques which I follow and I do and other than that, that’s about it.

Ok so in terms of general exercise then so walking, swimming, cycling, is that affected by your back pain?

Oh well it’s there the whole time like. Even when I’m talking to you now the way, you know, sometimes I forget myself and I sit wrong in a chair. I try to use hard chairs the whole time. I try to avoid as much bending as I can, sudden bending. Something I know I’m going to do I have no problem with but if I do a sudden movement or if I drop something and bend down quickly to pick it up or I get out of the car very fast then I’m in trouble and I get a serious start so now I’m conscious of it so I really, really check what I’m doing before I go doing it but it’s an automatic reaction sometimes, it just happens. Even getting out of bed in the morning it can be a very acute pain. I could take maybe an hour or two just to warm up to get free flowing we’ll say.
Interview 4

Okay, and what would your activity levels be like now compared to what they were like before the pain, before you had the back pain?

What are they like? Well, every day seems to be a struggle. That is what it is. I might do something today and I might do nothing at all tomorrow, that’s it and then there are days that I can’t do the thing and I see that it has to be done. I will force myself to do it but then I will suffer and that’s it.

Okay, so if the job has to be done you will persist with the pain, is that what you’re saying?

I would, yes. I would persist with the pain and I will do it and that is it.

And what affect in terms of pain will that have on you then if you persist with it?

If I persist with it and keep doing the thing I will end up with a pain across my back and I won’t be able to straighten. All I have to do is lie down and get a hot water bottle to see would it ease the pain.

Interview 3

Has your low back pain impacted on your physical activities generally?

Yes there is certain things I won’t do for fear of aggravating it. There are certain things I can’t do because I know it will aggravate it. There are certain things that I continue to do but after a certain length of time the pain will be aggravated such as standing for long periods of time. The only time that I would really be standing for any long periods of time is if I am in a pub. It is sort of weighted by the numbing affect of alcohol so it is not something that cripples me but yes it definitely limits my own perception of what I can do rather than what I may be able to do. I wouldn’t lift this table for instance because I am sure that would aggravate it. I would lift it with somebody else. Prior to my back injury I would have no problem giving a go myself so you do sort of restrain yourself.

Can you just talk to me a little bit more; you said that certain activities you might be fearful of doing. Can you describe some of those activities and maybe give me an idea of why you would have developed this fearfulness of the activity?

Let’s say for instance gardening, not particularly mowing the lawn, I have a self propelled lawnmower so there is no pushing involved in that. Cutting my hedge, I have got a very high hedge so I am reluctant to tackle that job because of the reach involved. There isn’t a heavy weight in the hedge trimmer itself but it is reaching that high level and overstretching my back and the concern of pulling something out or something like that would be real. Cycling; I tried to get into cycling recently but extended physical activity in a very awkward position on the bike, leaning forward etc, I found that difficult so I have not done that. Primarily I would say that the heavier jobs are things that involve a reach aspect with the possibility of actually pulling or aggravating the thing.
Interview 5

Ok and can I ask you then in terms of your physical activity levels does your medication help or in some way hinder your physical activity?

Well I suppose because the medication is fairly low key it doesn’t really make much the difference. The anti-inflamatories are ruining my stomach but apart from that no it doesn’t hinder. It helps I suppose in a way because it sort of takes the edge off but I’m never completely pain free.

And apart from this stomach upset are you having any side effects from the medication?

No because I chose to keep the medication so low key that it wouldn’t give me side effects. I’m on other medications for depression and I also take medication to help me sleep so, you know, I didn’t want to be mixing opiate analgesics in with that or any other sort of mind bending analgesics so, you know, I keep the pain relief fairly low key.

Ok and I suppose talking a little bit more about the depression side of things when you are active does that in any way help your depression?

It does because it sort of makes you forget your situation, you know, it sort of helps to lift you and especially being around friends, you know, that really helps. When the depression was very, very bad I didn’t want to see anyone and I actually didn’t leave the house and I didn’t want to do anything and I wasn’t motivated to do anything. It was bit all encumbersing really but yeah I mean it does affect me, you know, it does affect me but being with friends and being, you know, just even going up to mass really helps, you know.

Interview 6

How would your mood affect how much you do?

Well I suppose when you get annoyed, I suppose you start feeling a bit sorry for yourself, you wouldn’t be doing much, just staying in, just, I don’t know, you just, I suppose you’d be getting annoyed. I don’t know if it’s your mood or not, you just get annoyed that you can’t do it either. I suppose you get a bit fed up and bit down on yourself and I suppose… It’s as simple as that you just get a bit down on yourself.

Then on the other extreme is there anything that motivates you to do more activity? So what would help you to do more or what facilitates you?

I suppose like everything else what I do now, because I haven’t got work, it revolves around the dogs. Every day I have to do something with the dogs because they’re there, regardless of how I feel or how much or how little I have to do something. I have to get up, I have to keep the place clean, so I suppose having them motivates me to get up and just not being in the house all day because it doesn’t being inside in the house all day. So it motivates me to get out because I just don’t like being confined.
Interview 7

And how does the medication, either positively or negatively impact on your physical activity levels?

I don’t think the medication does anything to, it doesn’t stop me doing things, it doesn’t make me conk out but it takes the edge away.

So, does the medication help you be more active or not?

It does, yes because I can keep going. I feel that I don’t seize up as much, I mean there are a couple of days there now and it happened one weekend where I had no pain medication. Never, that was horrendous, it was just that I hadn’t actually, I thought it had some there and I hadn’t been up to the chemist. No, it takes the edge off and I can’t keep going. The weekends are a disaster because then I am literally, I suppose any chance I get and it is not out of laziness but any chance I get I go to bed because it really helps with the pain, whether it is the heat or whether it is the fact that I am just lying still. So, during the week here I could go to bed for an hour here in the evening time at the weekends I could go up to bed five or six times in the one day, even if it is only for 10 minutes. It could be for a couple of hours.

Interview 8

Do you ever find yourself comparing your physical activity levels now before the back pain?

Totally whereas before if one of the kids had the bike out in the road I could cycle around Westbury. I wouldn’t think twice about cycling a bike. Now I know if went to cycle a bike I wouldn’t be able to get off it.

How does that make you feel that discrepancy between what you could do and what you can do now?

My thing on things like that is you can either lie down with it or get up and get on with it. It limits me in some ways but I am one of the people who believe life is for living. Going back to my social life you think I don’t but I do what I want to do within reason.

Is there anything that you are not doing at the moment or you can’t do that is really having a big effect on you that you would love to do?

As I said before I love painting. I love painting my house. My kitchen badly needs to be painted at the moment. I never allowed my children to paint so now none of them will paint it for me. Either I pay someone to come in which would go totally against my grind or I will just wait until I am able and if I have to suffer the consequences I will do it.
Interview 9

What type of activities have they advised you to do or not to do?

They told me I would know myself that I would know myself. I would love to be able to go out and do a bit of work if only light work you know. There is a day care up here if it was only for an hour or two just to get out of the house. I did do a computer course there lately. It was for six weeks one day a week but it was tough going to sit for the hour. It was tough going. It would be rolling down my face while I would be there.

Have you got any conflicting advice ever because you see so many different people?

No. The only one that gave me any bit of hope was the last man I went too, the physio in Kilmallock. He didn’t have anything from the hospitals or anything. He was only going on what I was telling him but on his; when he examined me and things, he gave me a guarantee that I would be that the pain would be reduced and definitely now all going well.
APPENDIX F:

Interview Schedule for Qualitative Study Presented in Chapter 6
**Understanding of Physical Activity:**

What do you understand by the term ‘physical activity’?

**Current Activity Level**

Can you describe your physical activity level and pattern on a typical week days and during the weekend?

How much physical activity do you currently do?

What types of physical activities do you do for leisure/work/household/transport?

How do these physical activities make you feel?

**Influences on physical activity**

Do you want to do more physical activity?

Does your low back pain influence your physical activity?

Does the medication that you take for your back pain affect your physical activity?

What are the main factors that may prevent you from being as active as you’d like?

If you’re feeling tired/stressed/unwell, does this impact on your physical activity in your leisure-time?

How confident are you that you can overcome these feelings at the time and still be active in your leisure-time?

Does your mood predict how active you are?

What helps/motivates you to be active?

**Social Influences**

What have healthcare professionals advised you on physical activity when you have low back pain?

Who are you active with in your leisure-time?

Is it a different experience for you when you are active with someone rather than alone?

How active are the people around you?

Do they encourage you to be active?

Does anyone try to stop you from being active?
Does their physical activity behaviours influence yours?

**Environmental influences**

Where are you active in your leisure-time?

Thinking about these places, what things are important to you being physically active there?

What things do you think would help you to be more physically active around your neighbourhood?

**Sleep**

Do you feel tired or fatigued as a result of your back pain?

Do you sleep well at present?

What are the main factors that influence your sleep?