TITLE: "Musculoskeletal pain profile of obese individuals attending a multidisciplinary weight management service."

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ABSTRACT

Obesity is associated with numerous chronic diseases, including musculoskeletal (MSK) pain, which impacts on quality of life (QoL). There is, however, limited research providing a comprehensive MSK pain profile of an obese cohort. This retrospective study was undertaken using the patient database at a national weight management service (WMS). Following ethical approval, anonymized patient data were statistically analyzed to develop a pain profile, investigate relationships between pain, sleep, and function, and explore variables associated with having low back pain (LBP) and knee pain. Overall, 915 individuals attended the WMS from January 2011 to September 2015 [male, 35% (*n*=318; CI=32–38); female, 65% (*n*=597; CI=62–68); mean age 44.6]. Most patients were Class III obese (BMI ≥40 kg/m^2), 92% (*n*=835; CI=91–94)]. Approximately 91% reported MSK pain: LBP, 69% (*n*=539; CI=65–72) [mean NRS 7.4]; knee pain, 58% (*n*=447; CI=55–61) [mean NRS 6.8]. Class III obese and multi-site pain patients had lower QoL and physical activity levels, reduced sleep, and poorer physical function than less obese patients and those without pain (p<0.05). Relationships were found between demographic, pain, self-report, psychological, and functional measures (p<0.05). Patients who slept fewer hours and had poorer functional outcomes were more likely to have LBP; patients who were divorced, had lower QoL, and more frequent nocturia were more likely to have knee pain (p<0.05). Multi-site MSK pain is prevalent and severe in obese patients and is negatively associated with most self-report and functional outcomes. This high prevalence suggests pain management strategies must be considered when treating obesity.

KEY WORDS

Obesity; weight management service; musculoskeletal pain; prevalence

INTRODUCTION

According to the World Health Organization (WHO), in 2014 nearly two billion (39%) adults were overweight and 600 million (13%) were obese [49]. Despite increased attention to this relatively new epidemic, the prevalence of obesity continues to rise. Morbid obesity presents a significant risk to health; the higher the body mass index (BMI), the greater the risk of developing obesity-related conditions including diabetes, cardiovascular disease, cancer, and musculoskeletal (MSK) disorders [19,23]. These disorders have a negative impact on individuals, populations, and healthcare service expenditure [12,38].

In obese populations, MSK pain is commonly reported in the low back and major weight-bearing structures of the lower extremities (e.g. hips, knees, ankles, and feet) [15,35]; together these are frequently reported as multi-site pain [7]. Prevalence rates for low back pain (LBP) range from 15% to 63%, with stronger associations reported in women compared to men [7,8]. Knee pain prevalence rates has been reported between 27% to 31% [1,22]. Mechanisms linking obesity and pain are complex and include mechanical, structural, behavioral, and genetic factors [9,33].

The National Institute for Health and Care Excellence (NICE) guidelines for obesity recommend specialized multidisciplinary weight management services (WMS) to support and educate patients in skills to reduce and maintain their weight long-term [30]. Whilst programs vary in format, the key aims are for patients to optimize their dietary balance and physical activity levels (PAL) in order to manage their weight. Traditionally, primary outcome measures for such WMS include weight and BMI, with secondary outcomes including PAL and quality of life (QoL) [3]. Despite high pain prevalence rates in this population, pain has rarely been included as a primary outcome in WMS, nor is its association with function, sleep, and other demographic variables usually been explored.

The lack of pain outcomes in the current obesity literature is a true limitation given the established impact MSK pain has on PAL, physical function, sleep, and QoL in a general population [4,11]. Although there is a shortage of studies on pain in obese patients within a WMS, research outside of the WMS context have established associations between MSK pain and anthropometric variables (e.g. BMI classification, pain location, etc.) [51], mental health scores [50], and self-report levels of function and sleep [41,44]. However, what is not evident is a comprehensive profile of MSK pain in obese patients attending a national conservative WMS and the associations between pain and demographic, anthropometric, self-report and functional measures. Given that the core aims of a WMS are to improve dietary and PAL balance to manage weight, establishing barriers and enabling factors, such as a baseline pain prevalence, and exploring potential relationships is important in terms of setting individualized lifestyle goals, monitoring exercise and PAL progression, and improving QoL.

Therefore, the aims of this study were to: (i) establish a MSK pain profile of individuals attending a multidisciplinary WMS; (ii) investigate the relationships between pain, anthropometric, self-report, and functional outcome measures; and (iii) determine baseline characteristics associated with LBP and knee pain prevalence.

METHODS

Study design and participants

A retrospective analysis of the patient database at the national WMS in the Republic of Ireland was undertaken to establish MSK pain prevalence, relationships between pain, demographics and other outcome measures, and the independent predictors for having MSK pain. All data were anonymized on-site by the data manager prior to investigation. This study was approved by St. Vincent's University Hospital Ethics and Medical Research Committee (30 September 2015; reference number: September2015MacLellan).

All obese patients who attended and completed a multidisciplinary team assessment in the WMS from January 2011 to September 2015 were included in the analyses, as illustrated in Figure 1.

Weight management service

The outpatient multidisciplinary WMS is a publicly funded conservative program staffed by consultant endocrinologists, medical registrar, nurses, administrative staff, dietitians, psychologists, and chartered physiotherapists. Patients are referred to the program by their general practitioner, medical consultant or allied healthcare professional if they have a body mass index (BMI) of >40 kg/m^2 or a BMI of 35 kg/m^2 with a significant comorbidity.

Initial assessments include individual meetings with multidisciplinary team members to perform baseline blood tests, screen for additional comorbidities, develop personalized behavioral goals, and complete a battery of functional tests. Patients attend the clinic for a total of 10 appointments over approximately one year with a repeat assessment completed approximately six months into the program.

Measures

Anthropometric measures and demographic information

Anthropometric measures included height (cm), weight (kg), BMI (kg/m^2), and bilateral ankle and neck circumferences (cm). Obesity levels were classified according to BMI: Class I obese 30–34.99 kg/m^2; Class II obese 35–39.99 kg/m^2; and Class III obese ≥40 kg/m^2 [48].

Demographic information included age, gender, past medical history [e.g. type two diabetes, obstructive sleep apnea (OSA), cardiovascular and respiratory diseases], marital status, number of children, educational attainment, employment status (information on manual and shift work), health behaviors (e.g. smoking and alcohol habits), and prescription medications (e.g. sleep or pain management). Diagnoses of OSA were made by an external healthcare provider prior to patient referral to the WMS and additional screening was carried out during their medical assessment.

Psychological determinants

(i) *Quality of life:* Patients were asked to rate their current QoL on a Likert scale from zero to 10; zero being very poor and 10 being excellent.

(ii) *Mood:* Patients were asked to rate whether they felt “blue or down in the dumps” on a four-point Likert scale: “not at all”, “somewhat”, “very much so”, or “extremely”.

The follow-on question asked that if the patient felt blue, at what time of day was their mood lowest: “early morning”, “late morning”, “afternoon”, “early evening”, “late evening/night-time”, or “my mood does not change”.

(iii) *Importance of losing weight:* Patients were asked to rate how important losing weight was to them on a Likert scale from one to seven; one being “not at all important” and seven being “extremely important”.

(iv) *Confidence in ability to lose weight:* Patients were asked to rate how confident they were in their ability to lose weight on a one to seven Likert scale; one being “not at all confident” and seven being “extremely confident”.

Pain measures

Pain severity at worst was assessed with the validated Numeric Rating Scale (NRS) [14] and specific questions regarding pain location (e.g. low back, knee, and up to three other MSK pain sites) were included. Pain duration for each site was classified as either acute (<1 month), subacute (1–3 months), or chronic (>3 months).

Self-report measures

(i) *Physical activity:* In line with physical activity recommendations, self-reported physical activity levels (PAL) were defined and measured as the estimated minutes of exercise per week in the past two weeks. This was classified as being non-domestic, occupational, transportation, or leisure activity [43]. Zero minutes per week were recorded for patients without any structured or significant physical activity beyond engaging in domestic activity.

(ii) *Sleep habits:* Sleep was assessed as mean number of hours per night and nocturia was reported as mean number of episodes per night.

(iii) *Falls history:* This was calculated as the self-reported number of falls in the last 12 months.

Functional measures

Baseline functional measures were assessed through a short battery of physical performance tests [18]:

(i) *Timed Up and Go (TUAG):* Patients began the test seated in a chair without arm rests. They were asked to stand up, walk a three-meter distance, turn around, walk back, and return to sit in the chair. The time taken to complete the test was recorded [25].

(ii) *Five Times Sit to Stand (5xSTS):* With their arms folded across their chest, patients were asked to complete five sit to stands from a chair and the time taken to complete the test was recorded [28].

(iii) *Modified Step Test (ST):* The modified ST is a high-intensity aerobic test. It was completed without a metronome and patients were advised to ascend and descend a 17 cm step to a maximum of 50 or until they needed to stop. The time and number of steps achieved were taken to calculate step speed (steps per second).

(iv) *500 Meter Walk Test (500mWT):* Patients were instructed to walk a 500-meter mapped-out course on hospital grounds. The distance achieved and the time were recorded to calculate gait speed (meters per second) [2].

(v) *Borg Rate of Perceived Exertion:* During the ST and 500mWT, patients were asked to exert themselves to a level they found "slightly challenging" or less than or equal to a six on a 10-point Borg scale [17].

Statistical analysis

The anonymized and coded data were entered into the Statistical Packages for the Social Sciences (V.20) and subsequently cleaned. A profile of patient demographics and characteristics were reported using descriptive statistics. This profile was categorized according to obesity classification (i.e. Class I–III) and number of pain sites (i.e. none, one pain site, two pain sites, and three or more pain sites). Following Kolmogorov-Smirnov tests for normality, comparisons between baseline profiles based on obesity classification and number of pain sites were assessed with chi-square and nonparametric Kruskal-Wallis H tests. Post-hoc Mann-Whitney U and chi-square tests were completed to analyze pair-wise comparisons between Class I and II, Class I and III, and Class II and III obese categories (Bonferroni's correction 0.05/2= $p<0.017$), as well as between groups based on number of pain sites (e.g. none versus one site, none versus two sites, none versus three or more sites, etc.) (Bonferroni's correction 0.05/6= $p<0.008$).

Relationships between continuous measures of pain, anthropometric, self-report, and functional outcome measures were analyzed with non-parametric Spearman's correlation coefficient. Holding age and gender constant, univariable logistic regression was performed to extract significant variables associated with having LBP and knee pain ($p<0.1$). Then backward step-wise logistic regression was performed using all significant variables to establish adjusted odds ratios and 95% confidence intervals in order to build a model of independent variables associated with LBP and knee pain prevalence ($p<0.05$).

RESULTS

Baseline profile

In total, 915 obese patients attended the WMS from January 2011 to September 2015 [male, 35% (*n*=318; CI=32–38); female, 65% (*n*=597; CI=62–68); mean (SD) age of 44.6 (±12.2) years]. The mean (SD) BMI was 50.7 (±8.7) kg/m^2 and 92% (*n*=835; CI=90–94) were classified as Class III obese. Nearly half of patients (49%, *n*=426; CI=46–53) were married, over two-fifths (43%, *n*=340; CI=40–47) had between two and four children, nearly two-thirds had completed secondary level education (61%, *n*=491; CI=58–64), and just under half were employed (47%, *n*=402; CI=43–50).

In regards to health behaviors, only 14% (*n*=23; CI=9–19) of respondents were smokers while 86% (*n*=143; CI=81–91) were either were ex-smokers or did not smoke; additionally, 44% (*n*=63; CI=36–52) reported not drinking alcohol. Full patient profiles including past medical history and anthropometric measures are summarized in Table 1.

Psychological determinants

Overall, the mean (SD) QoL was 4.9 (±2.3) out of a maximum of 10. Patients deemed weight loss to be very important to them with a mean (SD) score of 6.7 (±0.8) out of seven. These patients were also moderately confident in their ability to lose weight with a mean (SD) of 4.9 (±1.6) out of seven.

With regards to mood, valid responses from 583 patients described nearly a third of patients (31%, *n*=181; CI=27–35) reporting that their mood was not affected. Just over a quarter (28%, *n*=162; CI=24–31) of patients reported feeling blue or down in the dumps “a little” of the time, one-fifth (22%, *n*=130; CI=19–26) felt it “somewhat” of the time, 13% (*n*=80; CI=10–16) felt it “increasingly so”, and 5% (*n*=30; CI=3–7) reported feeling “extremely” blue or down in the dumps. Of those who reported their mood as being affected, the worst time of day was late evening or night-time (21%, *n*=118; CI=17–24), or early evening (14%, *n*=78;

CI=11–17). Almost two-fifths (38%, *n*=214; CI=34–42) of patients did not report their mood changing throughout the day.

Pain prevalence

Complaints of MSK pain were reported in 91% (*n*=724; CI=89–93) of patients. Of these, 69% (*n*=539; CI=65–72) reported LBP with a mean (SD) NRS of 7.4 (±2.4); the majority (96%, *n*=408; CI=94–98) classified their LBP as chronic. Knee pain was found in 58% (*n*=447; CI=55–61) of patients with a mean (SD) NRS of 6.8 (±2.3); the majority (96%, *n*=340; CI=94–98) reported their knee pain as chronic. Excluding knee pain, other common MSK pain sites included the lower (59%, *n*=278; CI=55–64) and upper extremities (22%, *n*=103; CI=18–26). Pain in two locations was reported in 37% (*n*=298; CI=34–41) of patients and 41% (*n*=73; CI=18–26) reported taking pain medication.

Self-report measures

Patients reported sleeping a mean (SD) 6.4 (±1.6; *n*=499) hours per night, and 12% of respondents (*n*=18; CI=7–17) took prescription sleep medication. Mean (SD) nocturia per night was 1.5 (±1.7; *n*=440). Most patients had experienced a fall in the previous year [mean (SD) number of falls were 1.7 (±17.9; *n*=912)]. The mean (SD) PAL was 94.5 (±135.4; *n*=908) minutes per week.

Impact of obesity classification on patient profiles

Following stratification by obesity classification (Class I–III obese), most patients were found to be Class III obese (92%, *n*=835; CI=90–94), followed by Class II (6%; *n*=58; CI=5–8), and only 2% (*n*=16; CI=1–3) in Class I. As expected, Class III obese patients had larger bilateral ankle and neck circumference measurements than the other two obese categories (Bonferroni's correction; $p<0.017$). No significant differences were found between obesity classifications for any social demographics (e.g. marital or employment status, etc.), smoking or alcohol intake ($p>0.05$). Similarly, no significant differences were found for how patients rated the importance of weight loss, their confidence in losing weight, or mood variables (p>0.05) (Table 1).

With regards to pain profiles, overall significant differences were found between obesity classifications for LBP NRS scores and knee pain duration (p<0.05), however with post-hoc analysis, this difference was no longer significant (Bonferroni's correction; p>0.017). Similarly, age profiles differed significantly between groups (p<0.05), but again, post-hoc analysis reduced this finding to non-significant (Bonferroni's correction; p>0.017).

Class III obese patients had poorer scores in seven of the eight functional tests than the other two obese categories (Bonferroni's correction; p<0.017). They also slept fewer hours and had lower QoL than patients in Class I (Bonferroni's correction; p<0.017).

Class I obese patients reported sleeping more hours than patients in Class II or III. They also reported higher QoL, achieved faster TUAG times, and quicker 500mWT gait speeds than Class III obese patients (Bonferroni's correction; p<0.017).

Class II obese patients reported fewer sleep hours than Class I obese patients, but performed better in seven of the eight functional tests than Class III obese patients (Bonferroni's correction; p<0.017).

Impact of number of pain sites on patient profiles

Only 10% (n=76; CI=7–12) of patients did not report having MSK pain. Of those who did report pain (91%, n=724; CI=89–93), over a quarter of them (28%; n=223; CI=25–31) had pain in one site, 37% (n=298; CI=34–41) had pain in two sites, and 25% (n=203; CI=22–28) had pain in three or more sites. No significant differences were found for smoking or alcohol intake between number of pain sites (p>0.05). Significant differences were found between patients according to number of pain sites for confidence in losing weight (p<0.05); however, post-hoc analysis reduced this finding to non-significant (Bonferroni's correction; p>0.008). (Table 2)

Based on self-reported number of pain sites (i.e. none, one, two, and three or more), patients without pain reported more sleep hours, increased PAL and QoL, fewer episodes of nocturia, and fewer falls in the past year than those with MSK pain (Bonferroni's correction; $p<0.008$). They were also younger and achieved better scores in six of the eight functional tests (Bonferroni's correction; $p<0.008$). In terms of social demographics, they tended to be single, have no children, and have higher rates of employment than patients with two or more pain sites (Bonferroni's correction; $p<0.008$).

Patients with three or more pain sites were older, reported more falls over the past year, and had poorer functional outcomes than patients with less than three or no pain sites (Bonferroni's correction; $p<0.008$). These patients also slept fewer hours, had lower PAL and QoL, increased nightly nocturia, took more pain medication than patients without MSK pain (Bonferroni's correction; $p<0.008$). Additionally, patients with two or more pain sites had a higher unemployment rate, were retired or unable to work due to disability, had two or more children, were either married or divorced, and were female compared to patients without pain (Bonferroni's correction; $p<0.008$).

Relationships between pain, anthropometric, self-report, and functional measures

The relationships between continuous measures of pain, anthropometric, self-report, and functional outcome measures are summarized in Table 3.

Number of pain sites

The number of pain sites was associated with LBP and knee pain NRS, and patient age (*rho*= 0.20–0.39; $p<0.01$). Number of pain sites correlated negatively with neck circumference, self-reported PAL, sleep hours, QoL, and confidence in ability to lose weight (*rho*= -0.13 – -0.09; $p<0.01$–0.05). Positive correlations were found between number of pain sites, nocturia, and falls (*rho*= 0.15–0.17; $p<0.01$). Functional measures also correlated with number of pain sites: TUAG, 5xSTS, 500mWT Borg (*rho*= 0.14–0.20; *p*<0.01), ST number of steps, ST speed, 500mWT distance, and 500mWT speed (*rho*= -0.22 – -0.11; *p*<0.01).

Low back pain scores

Pain scores for LBP were associated with knee pain NRS (*rho*= 0.27; *p*<0.01). Correlations were also found between LBP NRS and all self-report measures: PAL, sleep, (*rho*= -0.19 – -0.18; *p*<0.01–0.05), nocturia, and falls (*rho*= 0.11–0.18; *p*<0.01). Quality of life was associated with LBP NRS (*rho*= -0.19; *p*<0.01), as was self-determined importance of losing weight (*rho*= 0.13; *p*<0.01). Functional measures were also associated with LBP NRS [TUAG, 5xSTS, 500mWT Borg (*rho*= 0.13–0.15; *p*<0.01), ST number of steps, ST speed, 500mWT distance, and 500mWT speed (*rho*= -0.21 – -0.09; *p*<0.01–0.05)].

Knee pain scores

Knee pain NRS was associated with age (*rho*= 0.15; *p*<0.01), neck circumference (*rho*= -0.13; *p*<0.01), and nearly all self-report measures: PAL, sleep (*rho*= -0.13 – -0.10; *p*<0.05), nocturia, and falls (*rho*= 0.13–0.16; *p*<0.01). Knee pain NRS also associated with self-determined importance of losing weight, TUAG, 5xSTS, Borg post 500mWT (*rho*= 0.11–0.21; *p*<0.01–0.05), ST number of steps, ST speed, 500mWT distance, and 500mWT speed (*rho*= -0.22 – -0.12; *p*<0.01).

Independent factors associated with low back and knee pain prevalence

Holding age and gender constant, binary logistic regression was performed to determine independent factors associated with having LBP and knee pain. (Table 4)

Low back pain prevalence

The independent factors associated with having LBP were patients with slower 500mWT speeds (OR=0.255, CI=0.079–0.820; *p*<0.05), patients who reported sleeping fewer hours per night (OR=0.806, CI=0.857–0.990; $p<0.05$), and those who reported more severe NRS scores for their knee pain (OR=1.117, CI=1.020–1.223; $p<0.05$).

Knee pain prevalence

The independent factors associated with having knee pain were patients who had lower QoL (OR=0.844, CI=0.741–1.408; $p<0.05$), had more frequent episodes of nocturia per night (OR=1.263, CI=1.036–1.540; $p<0.05$), had LBP (OR=0.527; CI=0.294–0.943; $p<0.05$), and were divorced (OR=13.517, CI=1.661–109.983; $p<0.05$).

DISCUSSION

This study established the MSK pain profile in a large cohort of obese patients attending a national WMS. The vast majority of individuals (92%) who attended the WMS were Class III obese; this figure is much more severe than the 29% and 67% reported in previous obesity literature [6,21]. Results from the current study illustrated a high MSK pain prevalence, irrespective of obesity classification, especially in areas of increased mechanical load (e.g. low back and knees). Pain was negatively associated with self-reported sleep, QoL, and PAL. Multi-site MSK pain was also common, especially in older obese adults, and impacted on both QoL and physical function. Patients who slept less and had poor physical function were more likely to have LBP. Low QoL, being divorced, and having more frequent nocturia per night were associated with having knee pain. No significant associations were found between obesity classification, number of pain sites, and social determinants (e.g. smoking, alcohol, etc.).

In line with previous research, a large percentage (69%) of the current study cohort reported LBP [7,12], which is close to the 63% reported in another obese cohort study by Brady *et al* [7]. Mechanical overload due to reduced postural control by central adiposity may contribute to LBP in obese individuals [34]. Interestingly, with regards to knee pain, the prevalence reported in the current study (58%) surpasses study findings from Australia (27%)

[1] and the United Kingdom (31%) [22]. Mechanisms for the biomedical component of patients' pain, i.e. its association with a disease process (symptomatic osteoarthritis or neuropathic pain in those with diabetes), are not possible as the database did not include condition-specific diagnostic criteria. Rather, the data reports on pain-as-a-complaint in a large patient cohort and its associations with physical and psychological variables. The epidemiology of osteoarthritis is reliant on intrinsic (e.g. genetics, metabolic factors) and extrinsic factors (e.g. joint overload, trauma) [42,45]. The high pain prevalence results from the current study highlight the need for further consideration of MSK pain in obese individuals throughout WMS participation.

It is also important to acknowledge the impact of psychosocial factors on pain perception. Reflecting the literature, in the current study, divorced individuals had increased odds of having knee pain than patients who were single, married, or widowed [39]. In addition, in response to pain, divorced people have been found to experience more emotional suffering in the form of depression, anxiety, and anger than those who are either single, married, or widowed [47]. Additionally, low QoL was also a factor associated with knee pain prevalence indicating the need for comprehensive biopsychosocial screening of all patients attending the WMS. It suggests that pain in this population may not merely be associated with mechanical loading or systemic inflammation and is in line with associations found between pain and psychological stress in the wider pain population.

Guidelines for WMS advocate a physical activity component focusing on activities that fit into patients' lives such as walking, cycling, or dancing [30]. However, none of these guidelines discuss pain prevalence or pain management. In the current study patients with LBP had slower functional walking speeds, supporting evidence that pain is a limiting factor to exercise participation [46] and good physical function. However, as the current study is cross-sectional, determining whether poor physical function preceded MSK pain is not possible. Previous studies have found that higher BMI and low PAL were associated with poor functional outcomes [24] and an increased risk of developing chronic MSK pain [32]. This may reflect the well-established pattern in obesity of increased time spent in sedentary behaviors and less time spent physically active [24]. Reduced physical activity contributes to the loss of muscle mass and strength, poor lumbar spine motor control, and subsequent gait changes. The combination of all these components may contribute to the development of MSK pain as a result of inappropriate joint loading and impaired physical function [46].

Given the high prevalence of MSK pain and poor physical function, pain knowledge education and pain management strategies such as motor control exercises and cognitive behavioral strategies (e.g. pacing, goal-setting, flare-up management, relaxation, etc.) ought to be included given that increased PAL is a specific outcome shown to positively impact on both pain and function [40]. In the current study, the tool to establish PAL excluded domestic activity [43]. Given that the demographic profile showed that nearly half of patients (49%) were either unemployed, homemakers, retired, or unable to work, domestic activity may be their only opportunity for regular physical activity. Incorporating actigraphy may track physical activity engagement, including domestic activity, more accurately and should be considered.

Patients with multi-site MSK pain were significantly older, had more falls, and poorer functional outcome scores than patients without pain. These results were similar to findings from a recent longitudinal study where patients within their study cohort reporting multiple MSK pain sites were also significantly older and had poorer levels of physical activity [20]; it is unclear whether this relationship is cause, effect, or bidirectional. Furthermore, the previous study described patients with pain as having a higher BMI than those without [20]; however, the current study depicts the high prevalence of MSK pain in older patients as irrespective of individuals' BMI. This finding indicates that although an obese individual may maintain their weight and not gain further weight over time, they still have an increased risk of developing multiple MSK pain sites if they continue to remain obese with age. There are numerous implications of this risk for the growing elderly population who are obese, for example the impact of chronic pain on the osteoarthritis development from mechanical strain and inflammation within weight-bearing joints, and reduced physical activity [11,37].

Surprisingly, the high prevalence of young individuals who are Class III obese in the current study is also concerning as they are more likely to develop MSK pain than their non-obese peers [16]. The overwhelming evidence emphasizes the need to develop interventions targeting our youth through obesity prevention strategies to promote healthy weight management and subsequently reduce the extremely high risk of developing secondary conditions such as MSK pain, premature osteoarthritis, or other related comorbidities. For individuals who are already obese, the engagement in weight management interventions early on through dietary education and physical activity programs [26,33] may facilitate increased PAL and improve physical function to potentially reduce the risk of the development and severity of chronic MSK pain in later adulthood [32,40,41].

Emerging research regarding the effect of sleep quality on MSK pain has determined a close relationship between the two in non-obese individuals. In regards to obesity, it is likely that poor sleep habits are a consequence of OSA and frequent nocturia [5,10]. Poor sleep quality and sleep disturbances secondary to OSA contribute to more severe, widespread MSK pain, reduced pain thresholds, and altered pain processing in both LBP and knee pain [4,29,36]. The current study results demonstrate high LBP and knee pain NRS scores and fewer hours of sleep in patients who reported having MSK pain. As OSA is extremely common in obesity, the relatively low prevalence was interesting despite the high BMI and large neck circumferences (mean >43 cm) recorded in the current cohort of patients. This may be a result of underdiagnosed OSA or a lack of recognition of sleep disturbances. The association between frequent nocturia (undiagnosed diabetes may also play a role) and having knee pain in the current study may also be closely linked with OSA and poor sleep quality [10]. Recurrent sleep disturbances caused by nocturia [27] may also directly impact on psychological functioning and alter pain perception [36,10].

Both MSK pain and OSA are common obesity-related disorders and sleep quality is an integral compound of pain management. Linking LBP with functional walking speed and sleep, as well as knee pain with nocturia in this population may help establish potential treatment protocols, particularly around the area of sleep. Therefore, these components require additional clinical consideration via preemptive assessment and education throughout one's participation in a multidisciplinary WMS to holistically manage both obesity and chronic pain.

The results of this study must be considered in light of its limitations. It is a retrospective cross-sectional study which precludes any casual interpretations being made. Whilst some psychological variables are included, the authors recognize the need for validated outcome measures to fully analyze patients' psychological status and its impact on their pain.

Persistent MSK pain is a significant problem in obese patients and has a negative relationship with sleep, QoL, and physical function. Due to the high prevalence rates of LBP and knee pain, as well as poor baseline function, further consideration must be given to MSK pain and the integration of pain management strategies, including sleep disturbance, when managing obese individuals.

ACKNOWLEDGEMENTS

No financial support was received throughout the course of this research and there are no conflicts of interest. The authors would like to thank the administrative staff at the WMS for their assistance.

Grace A. MacLellan and Colin Dunlevy are joint first authors, and Dr. Brona M. Fullen and Professor Donal O'Shea are joint last authors.

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FIGURE LEGENDS

Figure 1. Study flow chart.

Table 1. Baseline profile of patients according to obesity classification.

Table 2. Baseline profile of patients based on self-reported number of pain sites.

Table 3. Correlations between continuous measures of pain, anthropometric, self-report, and functional outcome measures.

Table 4. Independent factors associated with low back and knee pain prevalence.

Table 1. Baseline profile of patients based on obesity classifications.

Demographics	**Total** ***n*=915**	**Class I** ***n*=16**	**Class II** ***n*=58**	**Class III** ***n*=835**	***p*-value (<0.05)**
Gender *n* (%)					
Male	318 (34.8)	6 (37.5)	22 (37.9)	290 (34.7)	0.87*
Female	597 (65.2)	10 (62.5)	36 (62.1)	545 (65.3)	
Age *n* (years±SD)	915 (44.6±12.2)	16 (50.3±11.1)	58 (47.1±12.9)	835 (44.4±12.1)	**0.02**†
Weight *n* (kg ± SD)	912 (145.5±29.9)	16 (95.4±12.9)	58 (113.0±13.6)	835 (148.7±28.7)	**0.01**†
BMI *n* (kg/m^2±SD)	909 (50.7±8.7)	16 (33.2±1.1)	58 (38.0±1.4)	835 (51.9±8.0)	**0.01**†
Body measurements *n* (cm±SD)					
Right ankle	903 (32.8±5.5)	16 (27.0±2.6)	57 (28.0 2.4)	824 (33.3±5.5)	**0.01**†
Left ankle	907 (32.9±5.7)	16 (27.4±2.5)	57 (28.1±2.9)	828 (33.3±5.7)	**0.01**†
Neck	458 (43.7±5.0)	9 (39.6 2.7)	28 (40.4±3.9)	415 (44.1±4.9)	**0.01**†
Marital status *n* (%)					
Single	341 (39.5)	6 (40.0)	22 (39.3)	309 (39.3)	0.92*
Married	426 (49.4)	7 (46.7)	29 (51.8)	388 (49.4)	
Divorced/separated	76 (8.8)	2 (13.3)	3 (5.4)	71 (9.0)	
Widowed	20 (2.3)	-	2 (3.6)	18 (2.3)	
Number of children *n* (%)					
None	287 (36.5)	5 (38.5)	18 (36.0)	262 (36.5)	0.59*
1	116 (14.7)	1 (7.7)	4 (8.0)	111 (15.5)	
2–4	340 (43.2)	7 (53.9)	26 (52.0)	303 (42.1)	
≥5	44 (5.6)	-	2 (4.0)	42 (5.8)	
Educational attainment *n* (%)					
Primary	93 (11.5)	-	8 (15.1)	85 (11.6)	0.32*
Secondary	491 (60.9)	8 (53.3)	30 (56.6)	449 (61.3)	
Tertiary	222 (27.5)	7 (46.7)	15 (28.3)	198 (27.0)	
Employment status *n* (%)					
Unemployed	117 (13.6)	2 (13.3)	2 (3.5)	112 (14.3)	0.18*
Employed	402 (46.6)	6 (40.0)	32 (56.1)	362 (46.2)	
Homemaker/carer	156 (18.1)	1 (6.7)	11 (19.3)	141 (18.0)	
Student	42 (4.9)	1 (6.7)	4 (7.0)	37 (4.7)	
Retired	58 (6.7)	2 (13.3)	6 (10.5)	50 (6.4)	
Unable to work (disability)	87 (10.1)	3 (20.0)	2 (3.5)	82 (10.5)	

Manual work *n* (%)	142 (36.7)	1 (20.0)	11 (30.6)	130 (38.1)	0.49*
Shift work *n* (%)	80 (21.8)	2 (40.0)	5 (14.7)	71 (22.0)	0.37*
Past medical history *n* (%)					
Type 2 diabetes	118 (26.6)	3 (33.3)	11 (39.3)	103 (25.7)	0.26*
Obstructive sleep apnea	110 (24.8)	1 (11.1)	7 (25.9)	102 (25.4)	0.62*
Cardiovascular disease	19 (6.1)	-	3 (12.0)	16 (5.7)	0.36*
Respiratory disease	25 (26.6)	1 (50.0)	-	24 (27.9)	0.25*
Psychological Determinants					
QoL *n* (mean±SD)	510 (4.9±2.3)	9 (6.9±2.1)	34 (5.±2.3)	461 (4.8±2.2)	**0.01**†
Importance of losing weight *n* (mean±SD)	618 (6.7±0.8)	9 (6.9±0.3)	39 (6.6±0.8)	564 (6.7±0.8)	0.25†
Confidence in losing weight *n* (mean±SD)	618 (4.9±1.6)	9 (5.0±1.7)	39 (4.6±1.8)	564 (4.9±1.6)	0.52†
Currently feeling blue/down in the dumps? *n* (%)					
Not at all	181 (31.0)	4 (44.4)	16 (43.2)	159 (29.9)	0.58*
A little	162 (27.8)	3 (33.3)	6 (16.2)	153 (28.8)	
Somewhat	130 (22.3)	1 (11.1)	7 (18.9)	122 (23.0)	
Very much so	80 (13.7)	1 (11.1)	5 (13.5)	72 (13.6)	
Extremely	30 (5.1)	-	3 (8.1)	25 (4.7)	
When you are blue, is your mood lowest in: *n* (%)					
Early morning	61 (10.7)	2 (22.2)	3 (8.1)	56 (10.9)	0.49*
Late morning	39 (6.9)	1 (11.1)	2 (5.4)	36 (7.0)	
Afternoon	58 (10.2)	1 (11.1)	1 (2.7)	54 (10.5)	
Early evening	78 (13.7)	-	3 (8.1)	75 (14.5)	
Late evening/night-time	118 (20.8)	1 (11.1)	12 (32.4)	104 (20.2)	
Mood does not change	214 (37.7)	4 (44.4)	16 (43.2)	191 (37.0)	
Pain Variables					
Number of pain sites *n* (%)					
None	76 (9.5)	4 (28.6)	4 (7.8)	68 (9.3)	0.24*
1 site	223 (27.9)	3 (21.4)	14 (27.5)	205 (28.1)	
2 sites	298 (37.3)	6 (42.9)	21 (41.2)	269 (36.9)	
≥3 sites	203 (25.4)	1 (7.1)	12 (23.5)	187 (25.7)	

LBP prevalence *n* (%)	539 (68.7)	7 (50.0)	37 (72.5)	489 (68.5)	0.27*
NRS at worst *n* (mean±SD)	512 (7.4±2.4)	7 (6.5±3.5)	33 (6.1±2.6)	466 (7.5±2.4)	**0.01**†
LBP duration *n* (%)					
Acute	7 (1.7)	-	1 (3.3)	6 (1.6)	0.96*
Subacute	8 (1.9)	-	-	8 (2.1)	
Chronic	408 (96.2)	6 (100.0)	29 (96.7)	367 (96.1)	
Knee pain prevalence *n* (%)	447 (58.0)	5 (38.5)	23 (46.9)	415 (58.9)	0.09*
NRS at worst *n* (mean±SD)	422 (6.8±2.3)	5 (6.4±2.1)	22 (5.7±2.5)	391 (6.9±2.3)	0.11†
Knee pain duration *n* (%)					
Acute	5 (1.4)	-	1 (4.8)	4 (1.2)	**0.04***
Subacute	9 (2.5)	1 (25.0)	-	8 (2.5)	
Chronic	340 (96.0)	3 (75.0)	20 (95.2)	313 (96.3)	
MSK pain locations *n* (%)					
Lower extremity	278 (59.4)	3 (50.0)	20 (57.1)	252 (59.6)	0.63*
Upper extremity	103 (22.0)	1 (16.7)	11 (31.4)	91 (21.5)	
Spinal/headaches	65 (13.9)	1 (16.7)	3 (8.6)	61 (14.5)	
Abdominal	2 (0.4)	-	-	1 (0.2)	
Other	20 (4.3)	1 (16.7)	1 (2.9)	18 (4.3)	
Health Behaviors					
Medications *n* (%)					
Pain medications	73 (41.2)	3 (75.0)	4 (30.8)	66 (41.3)	0.29*
Sleep medications	18 (12.0)	1 (33.3)	1 (8.3)	16 (11.9)	0.49*
Smoker *n* (%)					
Yes	23 (13.9)	1 (25.0)	1 (9.1)	20 (13.3)	0.46*
No	115 (69.3)	2 (50.0)	10 (90.9)	103 (68.7)	
Ex-smoker	28 (16.9)	1 (25.0)	-	27 (18.0)	
Alcohol days per week *n* (%)					
Never	63 (44.1)	1 (33.3)	1 (9.1)	61 (47.3)	0.31†
<1	53 (37.1)	2 (67.3)	4 (36.4)	47 (36.4)	
1–3	17 (11.9)	-	4 (36.4)	13 (10.1)	
≥4	10 (7.0)	-	2 (18.2)	8 (6.3)	
Self-Report Measures					

PAL *n* (min per week±SD)	908 (94.5±135.4)	16 (181.6±175.6)	56 (151.7±208.8)	830 (89.6±127.1)	**0.02**†
Sleep *n* (hours±SD)	499 (6.4±1.6)	9 (7.7±1.2)	30 (6.3±1.5)	454 (6.3±1.6)	**0.03**†
Nocturia *n* (mean±SD)	440 (1.5±1.7)	9 (0.7±0.9)	26 (1.2±1.5)	399 (1.5±1.6)	0.15†
Falls history *n* (falls per year±SD)	912 (1.7±17.9)	16 (0.4±0.9)	58 (0.5±1.1)	832 (1.8±18.7)	0.37†
Functional Measures					
TUAG *n* (seconds±SD)	901 (9.0±13.5)	16 (6.5±2.0)	57 (7.2±2.2)	822 (9.2±14.1)	**0.01**†
5xSTS *n* (seconds±SD	803 (13.8±6.2)	16 (11.1±3.7)	52 (12.7±4.4)	729 (14.0±6.3)	**0.02**†
ST *n* (steps±SD)	851 (43.5±18.6)	13 (48.9±23.6)	55 (50.5±14.9)	778 (43.1±18.6)	**0.01**†
ST step speed *n* (steps/sec±SD)	826 (0.6±0.7)	12 (0.7±0.4)	54 (0.7±0.6)	757 (0.6±0.7)	**0.01**†
ST Borg *n* (mean±SD)	822 (6.2±1.7)	12 (5.2±1.9)	53 (5.3±1.5)	754 (6.2±1.7)	**0.01**†
500mWT *n* (distance m±SD)	795 (441.9±136.1)	13 (475.1±89.9)	49 (500.0±0.0)	727 (437.2±140.7)	**0.01**†
500mWT speed *n* (m/sec±SD)	793 (1.1±0.6)	13 (1.4±0.3)	49 (1.4±0.2)	725 (1.1±0.6)	**0.01**†
500mWT Borg *n* (mean±SD)	448 (4.9±2.3)	13 (4.5±2.2)	49 (4.2±1.9)	717 (5.3±2.1)	**0.01**†

QoL = quality of life; LBP = low back pain; NRS = Numeric Rating Scale; MSK = musculoskeletal; PAL = physical activity level; TUAG = Timed Up and Go; 5xSTS = Five Time Sit to Stand Test; ST = modified Step Test; 500mWT = 500 Meter Walk Test

* Chi^2 test

† Kruskal-Wallis H test

Table 2. Baseline profile of patients based on self-reported number of pain sites.

Demographics	**Total** ***n*=915**	**None** ***n*=76**	**1 pain site** ***n*=223**	**2 pain sites** ***n*=298**	**≥3 pain sites** ***n*=203**	***p*-value (<0.05)**
Gender *n* (%)						
Male	318 (34.8)	34 (44.7)	83 (37.2)	100 (33.6)	57 (28.1)	**0.04***
Female	597 (65.2)	42 (55.3)	140 (62.8)	198 (66.4)	146 (71.9)	
Age *n* (years±SD)	915 (44.6±12.2)	76 (41.1±13.2)	223 (42.3±11.4)	298 (45.7±12.4)	203 (48.1±10.9)	**0.01**†
Weight *n* (kg ± SD)	912 (145.5±29.9)	76 (147.0±32.3)	222 (147.1±32.9)	297 (144.2±29.9)	202 (143.3±26.3)	0.40†
BMI *n* (kg/m^2±SD)	909 (50.7±8.7)	76 (50.1±9.1)	222 (51.1±9.5)	296 (50.5±8.5)	200 (50.6±7.8)	0.98†
Obesity classification *n* (%)						
Class I	16 (1.8)	4 (5.3)	3 (1.4)	6 (2.0)	1 (0.5)	0.24*
Class II	58 (6.4)	4 (5.3)	14 (6.3)	21 (7.1)	12 (6.0)	
Class III	835 (91.9)	68 (89.5)	205 (92.3)	269 (90.9)	187 (93.5)	
Body measurements *n* (cm±SD)						
Right ankle	903 (32.8±5.5)	75 (32.5±5.8)	219 (33.2±5.9)	293 (32.7±5.3)	201 (32.8±5.5)	0.65†
Left ankle	907 (32.9±5.7)	75 (32.6±5.9)	221 (33.4±5.9)	295 (32.6±5.8)	201 (33.0±5.5)	0.24†
Neck	458 (43.7±5.0)	41 (43.4±5.5)	119 (44.5±4.9)	184 (43.6±4.5)	109 (43.0±5.3)	0.08†
Marital status *n* (%)						
Single	341 (39.5)	39 (53.4)	99 (47.1)	107 (37.3)	61 (31.9)	**0.01***
Married	426 (49.4)	29 (39.7)	95 (45.2)	145 (50.5)	100 (52.4)	
Divorced/separated	76 (8.8)	5 (6.8)	14 (6.7)	26 (9.1)	23 (12.0)	
Widowed	20 (2.3)	-	2 (1.0)	9 (3.1)	7 (3.7)	
Number of children *n* (%)						
None	287 (36.5)	35 (54.7)	72 (38.7)	80 (30.7)	58 (32.6)	**0.01***
1	116 (14.7)	8 (12.5)	36 (19.4)	41 (15.7)	19 (10.7)	
2–4	340 (43.2)	18 (28.1)	71 (38.2)	123 (47.1)	88 (49.4)	
≥5	44 (5.6)	3 (4.7)	7 (3.8)	17 (6.5)	13 (7.3)	
Educational attainment *n* (%)						
Primary	93 (11.5)	7 (10.4)	21 (10.8)	34 (12.5)	24 (13.9)	0.79*
Secondary	491 (60.9)	38 (56.7)	121 (62.1)	173 (63.6)	105 (60.7)	
Tertiary	222 (27.5)	22 (32.8)	53 (27.2)	65 (23.9)	44 (25.4)	
Employment status *n* (%)						
Unemployed	117 (13.6)	5 (6.9)	28 (13.5)	37 (12.9)	33 (17.2)	**0.002***
Employed	402 (46.6)	45 (62.5)	101 (28.8)	125 (43.6)	74 (38.5)	
Homemaker/carer	156 (18.1)	9 (12.5)	38 (18.4)	53 (18.5)	46 (24.0)	
Student	42 (4.9)	7 (9.7)	11 (5.3)	7 (2.4)	5 (2.6)	
Retired	58 (6.7)	3 (4.2)	9 (4.3)	26 (9.1)	16 (8.4)	
Unable to work (disability)	87 (10.1)	3 (4.2)	20 (9.7)	39 (13.6)	18 (9.4)	

Manual work *n* (%)	142 (36.7)	19 (44.2)	39 (34.2)	48 (39.3)	36 (40.0)	0.66*
Shift work *n* (%)	80 (21.8)	11 (27.5)	22 (21.0)	28 (22.6)	17 (20.0)	0.80*
Past medical history *n* (%)						
Type 2 diabetes	118 (26.6)	10 (23.3)	30 (24.8)	45 (26.6)	31 (29.5)	0.82*
Obstructive sleep apnea	110 (24.8)	9 (20.9)	30 (25.0)	39 (23.4)	29 (27.1)	0.84*
Cardiovascular disease	19 (6.1)	1 (3.2)	4 (4.8)	8 (6.4)	6 (8.5)	0.70*
Respiratory disease	25 (26.6)	3 (23.1)	7 (30.4)	10 (27.8)	5 (22.7)	0.93*
Psychological Determinants						
QoL *n* (mean±SD)	510 (4.9±2.3)	45 (6.0±2.2)	139 (5.0±2.4)	198 (4.7±2.2)	122 (4.7±2.1)	**0.01**†
Importance of losing weight *n* (mean±SD)	618 (6.7±0.8)	57 (6.6±0.9)	174 (6.7±0.8)	231 (6.8±0.8)	151 (6.7±0.8)	0.28†
Confidence in losing weighty *n* (mean±SD)	618 (4.9±1.6)	57 (5.1±1.6)	174 (5.1±1.6)	231 (4.9±1.6)	151 (4.6±1.7)	**0.045**†
Currently feeling blue/down in the dumps? *n* (%)						
Not at all	181 (31.0)	28 (52.8)	56 (33.9)	58 (26.7)	36 (25.0)	0.05*
A little	162 (27.8)	13 (24.5)	45 (27.3)	64 (29.5)	40 (27.8)	
Somewhat	130 (22.3)	9 (17.0)	34 (20.6)	50 (23.0)	36 (25.0)	
Very much so	80 (13.7)	3 (5.7)	20 (12.1)	33 (15.2)	24 (16.7)	
Extremely	30 (5.1)	-	10 (6.1)	12 (5.5)	8 (5.6)	
When you are blue, is your mood lowest in: *n* (%)						
Early morning	61 (10.7)	3 (5.8)	14 (8.9)	23 (10.8)	20 (14.2)	0.54*
Late morning	39 (6.9)	4 (7.7)	13 (8.2)	15 (7.0)	6 (4.3)	
Afternoon	58 (10.2)	7 (13.5)	11 (7.0)	20 (9.4)	20 (14.2)	
Early evening	78 (13.7)	5 (9.6)	22 (13.9)	28 (13.1)	23 (16.3)	
Late evening/night-time	118 (20.8)	10 (19.2)	33 (20.9)	48 (22.5)	26 (18.4)	
Mood does not change	214 (37.7)	23 (44.2)	65 (41.1)	79 (37.1)	46 (32.6)	
Pain Variables						
LBP prevalence *n* (%)	539 (68.7)	-	110 (51.9)	230 (77.7)	199 (98.5)	**0.01***
NRS at worst *n* (mean±SD)	512 (7.4±2.4)	-	103 (7.2±2.5)	215 (7.3±2.4)	194 (7.5±2.5)	0.35†
LBP duration *n* (%)						
Acute	7 (1.7)	-	4 (4.9)	2 (1.1)	1 (0.6)	0.16*
Subacute	8 (1.9)	-	1 (1.2)	5 (2.8)	2 (1.2)	
Chronic	408 (96.2)	-	77 (93.9)	172 (95.6)	159 (98.1)	

Knee pain prevalence *n* (%)	447 (58.0)	-	56 (27.6)	195 (66.8)	196 (96.6)	**0.01***
NRS at worst *n* (mean±SD)	422 (6.8±2.3)	-	49 (6.6±2.4)	183 (6.9±2.3)	190 (6.8±2.4)	0.62†
Knee pain duration *n* (%)						
Acute	5 (1.4)	-	1 (2.1)	3 (2.0)	1 (0.6)	0.52*
Subacute	9 (2.5)	-	2 (4.3)	5 (3.3)	2 (1.3)	
Chronic	340 (96.0)	-	44 (93.6)	142 (94.7)	154 (98.1)	
MSK pain locations *n* (%)						
Lower extremity	278 (59.4)	-	43 (74.1)	103 (60.2)	132 (55.2)	0.26*
Upper extremity	103 (22.0)	-	4 (6.9)	37 (21.6)	62 (25.9)	
Spinal/headaches	65 (13.9)	-	7 (12.1)	22 (12.9)	36 (15.1)	
Abdominal	2 (0.4)	-	-	1 (0.6)	1 (0.4)	
Other	20 (4.3)	-	4 (6.9)	8 (3.5)	8 (3.3)	
Health Behaviors						
Medications *n* (%)						
Pain medications	73 (41.2)	2 (11.8)	14 (30.4)	34 (47.2)	22 (55.0)	**0.01***
Sleep medications	18 (12.0)	1 (6.7)	9 (21.4)	7 (11.7)	1 (3.1)	0.10*
Smoker *n* (%)						
Yes	23 (13.9)	3 (20.0)	6 (13.6)	11 (16.4)	3 (7.9)	0.16*
No	115 (69.3)	10 (66.7)	33 (75.0)	48 (71.6)	23 (60.5)	
Ex-smoker	28 (16.9)	2 (13.3)	5 (11.4)	8 (11.9)	12 (31.6)	
Alcohol days per week *n* (%)						
Never	63 (44.1)	5 (35.7)	17 (42.5)	28 (50.0)	13 (40.6)	0.55†
<1	53 (37.1)	5 (35.7)	18 (45.0)	16 (28.6)	14 (43.8)	
1–3	17 (11.9)	4 (18.6)	3 (7.5)	6 (10.7)	3 (9.4)	
≥4	10 (7.0)	-	2 (5.0)	6 (10.7)	2 (6.2)	
Self-Report Measures						
PAL *n* (min per week±SD)	908 (94.5±135.4)	75 (116.7±117.0)	222 (102.0±141.5)	295 (77.0±116.5)	202 (89.5±140.1)	**0.01†**
Sleep *n* (hours±SD)	499 (6.4±1.6)	44 (7.2±1.3)	134 (6.4±1.5)	195 (6.3±1.7)	119 (6.1±1.5)	**0.01†**
Nocturia *n* (mean±SD)	440 (1.5±1.7)	39 (0.8±1.2)	114 (1.3±.7)	178 (1.6±1.8)	104 (1.6±1.6)	**0.01†**
Falls history *n* (falls per year±SD)	912 (1.7±17.9)	76 (0.4±0.9)	222 (2.1±24.5)	297 (0.8±2.4)	203 (3.7±27.7)	**0.01†**
Functional Measures						
TUAG *n* (seconds±SD)	901 (9.0±13.5)	76 (7.4±2.1)	221 (7.6±2.1)	292 (9.5±7.8)	199 (10.9±26.9)	**0.01†**
5xSTS *n* (seconds±SD	803 (13.8±6.2)	73 (12.5±3.4)	220 (12.5±4.1)	275 (13.7±5.2)	193 (15.7±6.9)	**0.01†**
ST *n* (steps±SD)	851 (43.5±18.6)	73 (49.4±17.7)	208 (44.6±17.4)	267 (43.8±20.6)	190 (40.6±19.1)	**0.01†**
ST step speed *n* (steps/sec±SD)	826 (0.6±0.7)	72 (0.7±0.7)	199 (0.6±0.5)	259 (0.7±0.9)	186 (0.6±0.7)	**0.03†**
ST Borg *n* (mean±SD)	822 (6.2±1.7)	70 (5.7±2.0)	200 (6.3±1.8)	258 (6.2±1.7)	185 (6.1±1.5)	**0.045†**

500mWT *n* (distance m±SD)	795 (441.9±136.1)	62 (487.5±56.9)	194 (456.8±125.6)	250 (429.0±147.0)	178 (414.1±158.0)	**0.01**†
500mWT speed *n* (m/sec±SD)	793 (1.1±0.6)	62 (1.2±0.2)	192 (1.2±0.3)	250 (1.1±0.9)	178 (1.0±0.3)	**0.01**†
500mWT Borg *n* (mean±SD)	448 (4.9±2.3)	60 (4.4±2.1)	192 (5.1±2.1)	248 (5.4±2.1)	176 (5.6±2.1)	**0.01**†

QoL = quality of life; LBP = low back pain; NRS = Numeric Rating Scale; MSK = musculoskeletal; PAL = physical activity level; TUAG = Timed Up and Go; 5xSTS = Five Time Sit to Stand Test; ST = modified Step Test; 500mWT = 500 Meter Walk Test

* Chi^2 test

† Kruskal-Wallis H tests

Table 3. Correlations between pain, anthropometric, self-report, and functional measures.

Spearman's *rho*	Pain sites	LBP NRS	Knee NRS	Age	Weight	BMI	Neck	QoL	Imp WL	Conf	PAL	Sleep	Noct	Falls	TUAG	5xSTS	ST steps	ST speed	ST Borg	500mWT D	50
Pain sites	-																				
LBP NRS	0.39**	-																			
Knee NRS	0.36**	0.27**	-																		
Age	0.20**	-	0.15**	-																	
Weight	-	-	-	-0.22**	-																
BMI	-	-	-	-0.17**	0.80**	-															
Neck	-0.09*	-	-0.13*	-	0.58**	0.37**	-														
QoL	-0.14**	-0.19**	-	-	-	-0.15**	-	-													
Imp WL	-	0.13**	0.14**	-	-	-	-	-0.14**	-												
Conf	-0.11**	-	-	-0.08*	-0.09*	-	-	0.13**	0.17**	-											
PAL	-0.10**	-0.08*	-0.10*	-0.16**	-0.12**	-0.18**	-	0.19**	-	0.15**	-										
Sleep	-0.13**	-0.18**	-0.13*	-	0.10*	-	-	0.14**	-0.10*	-	0.12**	-									
Nocturia	0.15**	0.18**	0.16**	0.24**	-	0.13**	-	-0.16**	-	-	0.19**	-0.21**	-								
Falls	0.17**	0.11**	0.13**	-	-	-	-	-0.16**	-	-	-	-	0.16**	-							
TUAG	0.20**	0.15**	0.21**	0.39**	0.10**	0.20**	0.15**	-0.28**	-	-0.11**	-0.16**	-0.10*	0.17**	0.11**	-						
5xSTS	0.20**	0.13**	0.19**	0.36**	0.15**	0.10**	0.17**	-0.14**	-	-0.12**	-0.19**	-	-	0.09*	0.67**	-					
ST steps	-0.13**	-0.13**	-0.14**	-0.24**	-0.16**	-0.23**	-	0.19**	-	0.09*	0.22**	-	-0.20**	-0.07*	-0.38**	-0.29**	-				
ST speed	-0.11**	-0.09*	-0.12**	-0.33**	-0.18**	-0.23**	-	0.17**	0.12**	0.13**	0.19**	-	-0.20**	-0.09**	-0.56**	-0.51**	0.63**	-			
ST Borg	-	-	-	-	0.16**	0.24**	-	-	-	-	-0.12**	-	-	-	0.08*	-	-0.08*	-	-		
500mWT D	-0.17**	-0.20**	-0.22**	-0.19**	-0.26**	-0.33**	-0.23**	0.26**	-	-	0.24**	-	-0.16**	-0.08*	-0.40**	-0.33**	0.58**	0.41**	-0.13**	-	
500mWT S	-0.22**	-0.21**	-0.18**	-0.29**	-0.36**	-0.50**	-0.24**	0.28**	-	0.12**	0.30**	-	-0.27**	-0.09*	-0.58**	-0.43**	0.55*	0.68**	-0.20**	0.54**	
500mWT B	0.14**	0.14**	0.11*	0.19**	0.25**	0.32**	0.20**	-0.21**	-	-0.11*	-0.23**	-	0.16**	-	0.27**	0.23**	-0.35**	-0.35**	0.39**	-0.38**	-

Pain sites = number of pain sites; LBP = low back pain; Knee = knee pain; NRS = Numeric Rating Scale; QoL = quality of life; Imp WL = How important is it to you to lose weight?; Conf = How confident are you in losing weight?; PAL = physical activity level; Sleep = hours; Noct = nocturia; Falls = falls per year; TUAG = Timed Up and Go (seconds); 5xSTS = Five Time Sit to Stand (seconds); ST steps/speed = modified Step Test number of steps and steps/second; 500mWT D/S/B = 500 Meter Walk Test distance, speed (m/second), and Borg

** Correlation is significant at the 0.01 level (2-tailed), * Correlation is significant at the 0.05 level (2-tailed)

Table 4. Independent factors associated with low back and knee pain prevalence.

	***p* <0.05**	**Exp (B)**	**95% Confidence Interval**	
			Lower	Upper
Associations with LBP prevalence				
Age	0.608	1.008	0.979	1.037
Gender (female)	0.161	1.585	0.833	3.017
Sleep hours	**0.040**	0.806	0.657	0.990
500mWT speed (m/sec)	**0.022**	0.255	0.079	0.820
Knee pain NRS	**0.017**	1.117	1.020	1.223
Widowed	0.999	0.000	0.000	-
Associations with knee pain prevalence				
Age	0.857	0.998	0.974	1.022
Gender (female)	0.431	0.795	0.448	1.408
Nocturia	**0.021**	1.263	1.036	1.540
QoL	**0.011**	0.844	0.741	0.962
LBP	**0.031**	0.527	0.294	0.943
Divorced	**0.015**	13.517	1.661	109.983

Figure 1. Study flow chart.