Pain Medicine 2013; 14: 1316–1331
Wiley Periodicals, Inc.

PAIN & AGING SECTION

Review Article

Are Older Adults with Chronic Musculoskeletal Pain Less Active than Older Adults Without Pain? A Systematic Review and Meta-Analysis

Brendon Stubbs, BSc (Hons), MSc, MCSP,* Tarik T. Binnekade, MSc,‡ Andy Soundy, PhD,† Pat Schofield, PhD,* Ivan P. J. Huijnen, PhD,§ and Laura H. P. Eggermont, PhD‡

*School of Health and Social Care, University of Greenwich, London;

†Department of Physiotherapy, University of Birmingham, Birmingham, UK;

‡Department of Clinical Neuropsychology, VU University Amsterdam, Amsterdam;

§Department of Rehabilitation Medicine Research School CAPHRI, Maastricht University, Maastricht, The Netherlands

Reprint requests to: Brendon Stubbs, BSc (Hons), MSc, MCSP, School of Health and Social Care, University of Greenwich, London SE9 2UG, UK. Tel: 7447-489-252; Fax: 00441604-696-126; E-mail: b.stubbs@greenwich.ac.uk.

Conflict of interest: No potential conflicts of interest were disclosed.

Abstract

Objective. To compare the overall levels of physical activity of older adults with chronic musculoskeletal pain and asymptomatic controls.

Review Methods. A systematic review of the literature was conducted using a Cochrane methodology and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement. Major electronic databases were searched from inception until December 2012, including the Cochrane Library, CINAHL, EBSCO, EMBASE, Medline, PubMed, PsycINFO, and the international prospective register of systematic reviews. In addition, citation chasing was undertaken, and key authors were contacted. Eligibility criteria were established around participants used and outcome measures focusing on daily physical activity. A meta-analysis was conducted on appropriate studies.

Results. Eight studies met the eligibility criteria, four of these reported a statistically lower level of physical activity in the older adult sampl e with chronic pain compared with the asymptomatic group. It was possible to perform a non-heterogeneous meta-analysis on five studies. This established that 1,159 older adults with chronic pain had a significantly lower level of physical activity (–0.20, confidence interval 95% = –0.34 to –0.06, p = 0.004) compared with 576 without chronic pain.

Conclusion. Older adults with chronic pain appear to be less active than asymptomatic controls. Although this difference was small, it is likely to be clinically meaningful. It is imperative that clinicians encourage older people with chronic pain to remain active as physical activity is a central non-pharmacological strategy in the management of chronic pain and is integral for healthy aging. Future research should prioritize the use of objective measurement of physical activity.

Key Words. Chronic Pain; Healthy Aging; Musculoskeletal Disorder; Physical Activity; Older Adult; Pain Management

Introduction

Life expectancy is increasing across the Western world, and at the same time the number of years impacted by chronic musculoskeletal disorders that cause pain and disability is also rising [1,2]. Prevalence of chronic pain in the older population is high, with up to 50–60% of community-dwelling older adults reporting to experience these symptoms [3,4]. Chronic pain may lead to a range of deleterious effects, including an increased functional disability [5] (Eggermont et al. unpublished) and a decreased quality of life [6,7]. Chronic pain may also result in a reduced level of daily physical activity, which is in contravention of key non-pharmacological management strategies for chronic pain that promote levels of physical activity [8,9].

Reduced levels of physical activity are one of the biggest public health concerns of the twenty-first century [10,11] and are the fourth leading cause of global mortality [12]. Sedentary living is associated with a higher risk for a multitude of chronic health conditions [13–15], such as diabetes, cardiovascular diseases, and cancer [16]. In addition, lower levels of physical activity negatively affects aging due to an increased risk for physical and cognitive impairments [14,17,18], which consequently impacts an individual's quality of life [19,20]. In older people, physiological changes are known to occur at an accelerated rate and are linked to lower levels of physical activity [19]. For instance, reduced physical activity is known to contribute to an increased risk of cardiometabolic disease [21], reduced bone density [22], and sarcopenia [23]. A vicious cycle may develop as such changes may necessitate an increased effort for older persons to engage in their routine daily physical activity, which may ultimately result in further reduced overall levels of physical activity [24].

Recently, a number of studies focusing on individuals of working age have investigated whether physical activity levels differ in people with chronic pain from asymptomatic individuals [8,9,25,26]. Interestingly, the levels of physical activity of persons of working age do not appear to differ between those with or without pain, but it is unclear if a difference exists in older adults. This is highlighted in Griffin et al.'s [25] review, who established that significant lower levels of physical activity were present in a small subgroup analysis of older adult participants with chronic low back pain (CLBP) but not in the working age population nor in adolescent samples. It is well established that older adults engage in lower levels of physical activity [12], but the association with chronic pain remains elusive. To our knowledge, no review has systematically established if older adults with chronic pain are less physically active than those without chronic pain. The aim of this study is to undertake a systematic review to compare the levels of physical activity between older adults with chronic musculoskeletal pain vs asymptomatic controls.

Methods

The systematic review is reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement [27].

Eligibility Criteria

Studies that were considered for inclusion include the following: 1) focused on older adults, participants who were 60 years or above; 2) measured daily levels of physical activity using a specific and validated self-report measure (e.g., Physical Activities Scale for the Elderly [PASE] [28], Baecke Physical Activity Questionnaire [BPAQ] [29], or objective physical activity measure [direct observation, accelerometry, pedometry, or doubly water labeled technique [DWT]]); 3) only objective measures of physical activity reported over three or more valid days were included [30]; 4) had to identify individuals with chronic musculoskeletal pain as against other types of pain (e.g., neuropathic pain); 5) chronic pain could be reported as a clinical diagnosis, or the duration of symptoms were confirmed through a self-report measure for at least 3 months in duration [5]; 6) the type and design of the studies considered for inclusion were not restricted; and 7) reviews, expert opinion pieces, or PhD theses were excluded.

Information Sources

A systematic review of the literature was conducted according to the general guidance provided by Cochrane reviewer's handbook [31]. Major electronic databases were searched from inception until December 2012, including the Cochrane Library, CINAHL, EBSCO, EMBASE, Medline, PubMed, and PsycINFO. Online searches of key journals were conducted, including the "in press" sections of the *European Journal of Pain*, *Pain*, *Pain Medicine*, *Clinical Rehabilitation*, and the *Clinical Journal of Pain*. The reference lists of relevant recent systematic reviews were also checked.

Systematic Search Strategy

The search terms used were developed by the research team in the categories of population (older adults, elderly, frail), diagnosis (chronic pain, pain*, persistent pain, musculoskeletal pain, muscle pain), and outcome (physical activit*, daily activit*, daily steps, step count, exercise, physiotherapy, physical therapy, walking, leisure time act*, acceleromet*, actigraph, actometer, energy expenditure, metabolic equivalent, self-report). Key authors were contacted to establish if any key studies were missed or are currently being undertaken that may warrant inclusion.

If a study reported data on daily physical activity for a number of older adults within a study sample with mean age below 60 years old, the primary authors were contacted for the summary data for those participants 60 and above. Where studies reported physical activity levels in a mixed sample of chronic pain (e.g., neuropathic pain and musculoskeletal pain), the primary author was contacted to provide summary data for the participants with chronic musculoskeletal pain. If any additional information or clarification was required from a study, three attempts were made to contact the authors, and if no response was received the article was excluded.

Study Selection

Two reviewers independently (BS/TB) conducted the search strategy, screening article titles, key words and abstracts to assess for eligibility. Articles that appeared to meet the eligibility criteria were included for consideration in the full text review. Two reviewers (BS/TB) completed the full text review, and a list of articles included in the systematic review was agreed by consensus. Disagreements were mediated through discussion with a third reviewer (AS/LE). When studies reported the same data in different publications, we used the data from the study with the largest sample and/or most recent sample.

Data Collection

Data extraction was initially conducted by one reviewer (BS), and independently scrutinized and validated by a second reviewer (TB). An extraction form was developed from the literature [32], and the information sought included: study design, setting of the study, sample size, gender and age (mean, standard deviation, range), chronic pain assessment, mean duration of pain symptoms, location of pain, physical activity outcome measure, measurement of physical activity reference period, statistical methods, main results, and conclusions.

Methodological and Risk of Bias Assessment

The Newcastle Ottawa Scale (NOS) [33] was utilized to assess the methodological quality of included studies. The NOS was developed to assess the quality of non-randomized controlled trials, and its content validity and reliability have been established [33]. Studies are judged on three broad perspectives: the selection of the groups, the comparability of the groups, and the ascertainment of the outcome of interest. The NOS provides predefined scoring criteria, but some of these can be further specified for the topic of study [34]. The NOS was adapted to account for age, gender, and/or comorbidity as comparability measures and the measurement of physical activity in the exposure category [34]. The NOS provides a score out of 9, and scores of 5 and above are considered satisfactory/good and suitable to be included in a systematic review and meta-analysis [34,35]. If an included study reported on the psychometric properties of the physical activity measure, this was also recorded. The methodological assessment process was completed independently by two reviewers (BS/TB), and consensus was reached through discussion.

Summary Measures

The standardized mean difference (SMD), confidence intervals (CI) at 95%, and *P* value were calculated for the continuous data for each included study. SMD is a useful [31] summary statistic that enables meta-analysis to be completed when a number of studies are measuring the same outcome (physical activity) but through a number of different measures (e.g., PASE [28], BPAQ [29]).

Data Synthesis

Where possible, data were pooled and a meta-analysis was performed, including subgroup analyses, to establish the influence of specific locations of pain (e.g., CLBP) on physical activity. Due to the anticipated heterogeneity of the data acquired from the scales, a random effects model was used for the scales reporting physical activity. The random effects model provides a more conservative score than a fixed effects model as it incorporates within and between study variance; thus, the CI for the SMD are wider. The I_2 statistic was used to measure the heterogeneity between the included studies; scores of less than 40% can be considered unimportant [31]. All data synthesis was conducted with RevMan version 5.2 [36].

Results

Study Selection

The original electronic search yielded a potential of 3,481 articles, and were reduced to 1,921 after the removal of duplicates. The titles, key words, and abstracts of these articles were screened for eligibility, and 432 articles were identified for closer consideration, at which stage 286 were excluded and 140 articles were included in the full text review. At the full text review, 38 authors were contacted for additional information regarding their study, but 37 were consequently excluded with reasons. Following the full text review, a total of 132 articles were excluded with reasons (see Figure 1). Eight articles were included in the narrative synthesis, and seven studies were eligible for pooling in the meta-analysis. The search strategy is outlined in Figure 1.

Study Characteristics

A total of eight studies were included in the review accounting for 1,440 older adults with chronic pain and 735 controls. Seven of the included studies employed a case-control design [37–43], while one was a cohort study [44]. The number of participants with chronic pain in each study ranged from 15 to 482 [41,43], respectively. The number of participants in the asymptomatic control groups ranged in sizes from 15 to 274 [41,43], respectively. The mean age of the participants with chronic pain ranged from 64.4 years of age [38] to 78.0 years [41], which was similar to the comparison group, which ranged from 64.3 years [38] to 77.6 years [41]. No statistical between-group differences were reported for the comparison of age.

Four studies reported exclusively on samples of older adults with CLBP [39,40,42,43], including a total of 309 participants and 281 asymptomatic controls. The other four studies [37,38,41,44] included participants who had mixed sites of chronic pain (N = 1,186) with 488 asymptomatic older adults. Of the four CLBP studies, one recruited participants directly from a chronic pain clinic, and all CLBP was attributed to either osteoporosis or a degenerative spine disorder [40]. Another study [39] recruited participants from the community and primary care, and included participants with an average pain duration of 14.2 years (±14.6 years), while the other two small studies included participants with CLBP of at least 6 and 12 months, respectively [42,43]. The other four studies [37,38,41,44] reported on samples of chronic pain patients with mixed or unknown sites of chronic musculoskeletal pain. One of these studies recruited directly from a chronic pain clinic [37], and two others were large studies recruiting from the community [41,44]. The pain

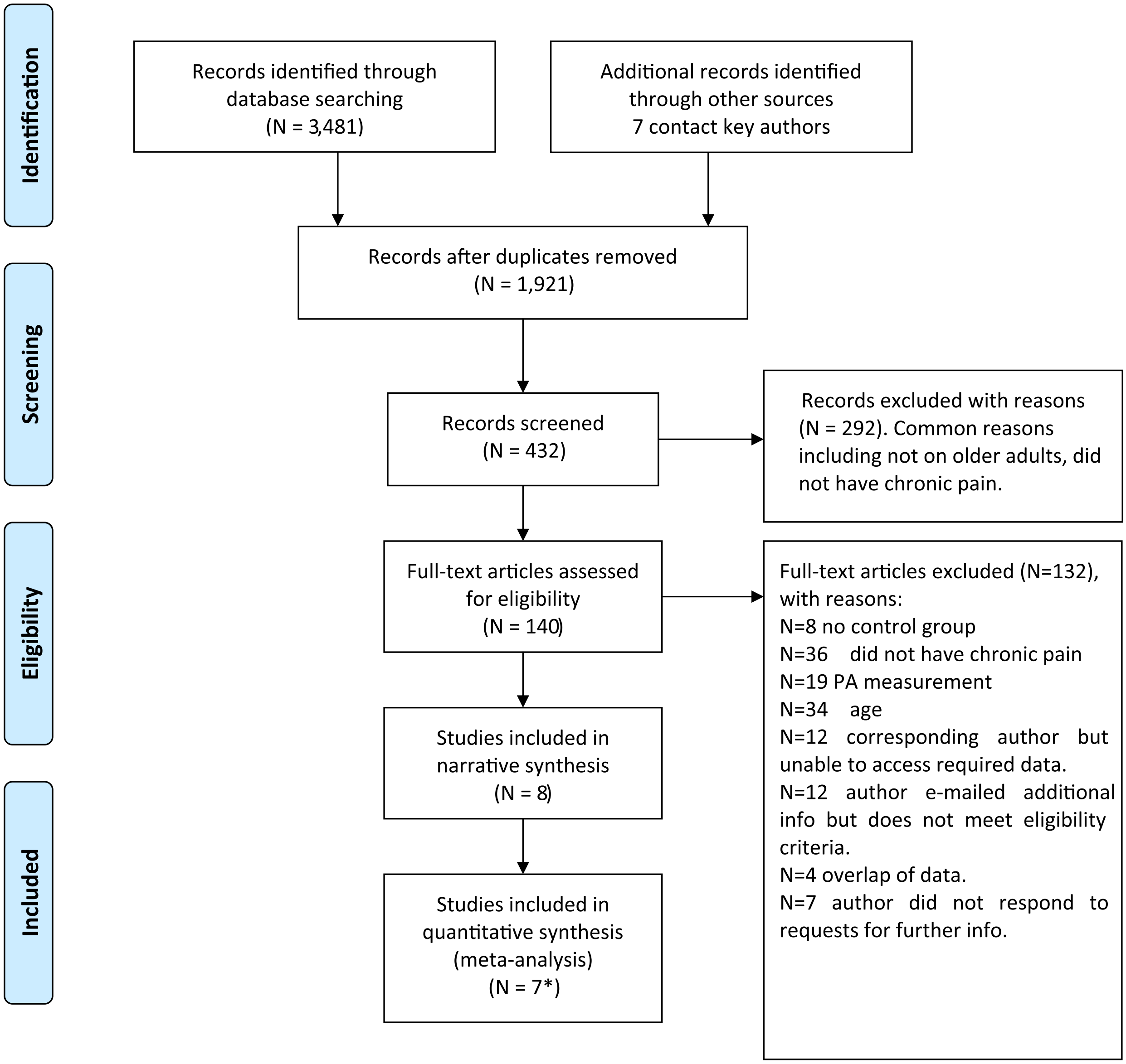

Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Moher et al. 2009 [27]) flow diagram for search strategy. *Only seven studies were eligible for pooling in the meta-analysis, a second meta-analysis was also run with five included studies.

intensity was not available for any of the included studies. A summary of the details of the chronic pain populations is given in Table 1.

The information available on the asymptomatic older adult comparison group varied in each study, but almost all studies stipulated that they had to be free of chronic pain for at least 3 months. Three studies [40,41,44] were very clear that the asymptomatic group were pain-free for at least 3 months, while one stipulated that the comparison group had to be pain-free for at least 12 months [43]. Table 1 represents a summary of the included studies.

Details of comorbidity in each study were generally not well reported; the available data is summarized in Table 1. From the studies that did report comorbidities (N = 5), the following details were provided. Champagne and colleagues [43] identified no between-group differences in chronic conditions reported. Data from another paper of the same cohort [4] established that in the MOBILIZE Boston study [41], depression, heart disease, and peripheral arterial disease were more common in the chronic pain group at baseline. Hopman-Rock and colleagues [38] established that 42% and 23% of the pain group had radiological evidence of osteoarthritis at the hip and knee,

Table 1 Summary of included studies

Author	Design of Study	Characteristics of Participants with Pain (Number, Mean Age Years ± SD)	Characteristics of Participants Without Pain (Number, Age Years ± SD)	Chronic Pain Classification and Comorbidities of Chronic Pain Group	Physical Activity Measurement Tool, Reference Period, and Outcome Measure
Basler et al. (2008) [40]	Case-controlled study	N = 103 71.4 ± 5.2 years 57.3% Patients from the departments of orthopedics and neurosurgery of a university hospital	N = 59 71.1 ± 4.7 years (ns) 58.0% (ns) Recruited via newspaper ads and university lectures for seniors; pain-free for 3 > months	65 > years with diagnosis of CLBP due to osteoporosis or degenerative spine disorder Exact duration of CLBP not stated	FAQ[1] and activity diary The FAQ measures strenuous PA and sporting activity over previous week. Retest reliability after 6 months r = 0.57 – 0.45. Correlation with activity diary in study (r = 0.08) FAQ scores calculated into MET hour/week
Champagne et al. (2012) [43]	Case-controlled study	N = 15 females with CLBP 68.9 ± 6.6 years 100% female Community dwelling	N = 15 females without CLBP 67.2 ± 5.1 years (ns) 100% female (ns) No pain in previous year and never experienced disabling CLBP	6 > months CLBP Presented tension, soreness, and/or stiffness in the lower back region with radiating pain limited to the buttocks Chronic conditions ns between both groups	BPAQ[2] Authors adapted questionnaire, only asked about PA in sports and leisure time PA PA score based on leisure and sport time domains only
Eggermont et al. (2009) [41]	Case-controlled study	N = 482 78.0 ± 5.3 years 62% female	N = 274 77.6 ± 4.9 years (ns) 64% female (ns) Participants in the study who on assessment had pain at no sites over the previous 3 months	Chronic pain >3 months confirmed via interview[3] on at least one bodily site Categorized as: (a) pain in one site (b) pain in multiple sites (c) widespread pain Chronic pain group more likely to have OA ($P < 0.001$), RA ($P = 0.003$), depression ($P < 0.01$), heart disease ($P = 0.08$), and peripheral arterial disease ($P < 0.01$)	PASE[4] 10-item questionnaire asking about physical activity over the past 7 days A total PASE score (sum of PA in past week in domains of leisure, occupation, and household) Provides measures for total number of hours spent in each domain which reflects daily physical activity level
Farrell et al. (1996) [37]	Validation study of the Human Activity Profile (HAP) Measure[5] for use in an elderly population	N = 193 71.8 ± 9.1 years 73% female	N = 55 73.1 ± 6.5 years (ns) 69% female (ns) Volunteers drawn from the register at National Ageing Research Institute in Australia	Consecutive older adults attending pain clinics; mixed location of chronic pain Exact duration of pain unknown but diagnosed as chronic Comorbidities not reported	HAP[5] Measure Measured at one time point Concurrent validity of AAS scores with Barthel Index Spearman's correlation 0.83 ($P < 0.0001$) MET/day expressed as AAS
Hopman-Rock et al. (1996) [38]	Case-controlled study	N = 59 64.4 ± 5.5 years 75% women (N = 44) All community dwelling	N = 72 64.3 ± 5.9 years (ns) 69% female (ns) Recruitment strategy unclear but without pain and matched for age and sex with CP group. No evidence of OA on X ray	Self-report chronic pain hip and/or knee confirmed by study authors Duration of pain unknown 42% and 23% had radiological evidence of OA of hip and knee, respectively	PAQ[6] Measured at one point in time but provides PA score for a typical week Validity assessed with 24 hours repeated recall of PA (r = 0.78) and measurement with pedometer (r = 0.72) Test–retest reliability r = 0.89 PA calculated as hours per week of activity in three domains: household, sports, and leisure time activities

Ledoux et al. (2012) [42]	Case-controlled study	N = 29 older adults with CLBP 69 ± 7 years 49% female Community dwelling	N = 32 67.25 ± 5.13 years (ns) 37.5% female They were without CLBP but no further information given	Classified as having nonspecific CLBP if on assessment they had pain on at least half of the days over a 12-month period. Excluded if had arthritis, major spinal trauma, neuromuscular illness, severe osteoporosis	BPAQ[2] 11-item questionnaire measured at one point in time provides PA score of a typical week over the last year Total Baecke score for PA over a typical week over the last year (sum of three subscales: occupational, leisure time, and sport)
Rudy et al. (2007) [39]	Case-controlled study	N = 162 patients with CLBP 73.6 ± 5.2 years 49% female (N = 80) Community dwelling	N = 158 73.5 ± 4.8 years (ns) 41% female (N = 66) (ns) Pain-free group—"no pain or pain occurring less than once a week of little intensity"	Inclusion criteria were chronic low back pain of moderate intensity for > 3 months measured with pain thermometer[7] Average pain duration 14.2 years ±14.6. Chronic pain group had significantly more comorbidities ($P = 0.001$)	PASE[4] Details as described above
Woo et al. (2009) [44]	Cohort study	N = 397 73.2 ± 5.8 years 26% men 73.0 ± 5.1 years 74% women 73.2 ± 5.4 years	N = 70. 72.4 ± 5.4 years (ns) 33% men (ns) 72.0 ± 5.0 years (ns) 67% women 72.4 ± 5.2 years (ns)	Had pain most of the time or all of the time over the past 12 months across a number of bodily sites. Males with knee pain reported more heart disease ($P < 0.05$), and those with knee pain reported more COPD ($P < 0.05$). Females in all pain groups reported more heart disease ($P < 0.05$), and those with back pain reported more COPD ($P < 0.05$).	PASE[4] Details as described above

CP = chronic pain; CLBP = chronic low back pain; LBP = low back pain; PA = physical activity; MET = metabolic equivalent; SD = standard deviation; ns = nonsignificant difference; OA = osteoarthritis; RA = rheumatoid arthritis; COPD = chronic obstructive pulmonary disease; AAS = activity adjusted score.
[1]FAQ = Freiburg Activity Questionnaire.
[2]BPAQ = Baecke Physical Activity Questionnaire (Baecke et al.) [29].
[3]Leveille et al. [5].
[4]PASE = Physical Activity Scale for the Elderly (Washburn et al.) [28].
[5]HAP = Human Activity Profile (Daughton et al. 1982) [45].
[6]Physical Activity Questionnaire for the Elderly (Voorrips et al.) [46].
[7]Roland and Morris (1983) [47].

respectively, while the control group did not show this evidence. Woo et al. [44] report that males with back pain and knee pain experienced more heart disease and chronic obstructive pulmonary disease (COPD), respectively, while all female groups with pain reported more heart disease and those with knee pain reported more COPD. Rudy and colleagues [39] found the chronic pain group had significantly more comorbidities.

Measurement of Physical Activity in Daily Living

All of the included studies utilized a self-report questionnaire to obtain daily levels of physical activity. The PASE [28] and the BPAQ [29] were used in three [39,41,44] and two studies, respectively [42,43]. The physical activity measurement period was frequently over the previous week [39–41,44], or reported as a typical week over the last year [42,43]. Only three studies reported on the reliability and the validity of the outcome measures they used in their study [37,38,40]. The measurement of physical activity in each study is reported in Table 1.

Risk of Bias within Studies

The mean NOS scores for the included studies were 5.12 (±0.83) and are represented in Table 2. Six of the included studies scored a 5 or above on the NOS and were of acceptable quality [38–41,43,44]; two study scored 4 [37,42].

Results of Overall Levels of Physical Activity in Daily Living vs Asymptomatic Older Adults

The SMD of overall level of physical activity between the chronic pain and asymptomatic groups was calculated for each study. The SMD analysis indicated that four studies reported a significantly lower level of physical activity in the older adult group with chronic pain [37,39,42,43]. However, the SMD of physical activity varied in each study quite considerably. For instance, the Rudy et al. [39] study revealed an SMD of –0.29 (CI = –0.51 to –0.07) in overall levels of physical activity, whereas Farrell and colleagues [37] established that there was an SMD of –9.81 (CI = –10.62 to –9.01). Champagne and colleagues [43] established a significantly lower level of physical activity, with an SMD of –0.96 (CI = –1.72 to –0.20), while Ledoux et al. [42] established an SMD of –1.47 (CI = –2.04 to –0.90). Four other studies [38,40,41,44] all demonstrated that older adults with chronic pain were less physically active, but none of the observed differences reached statistical significance. In a subanalysis of the Hopman-Rock et al. [38] study, the levels of physical activity within the household domain of the physical activity questionnaire [46] were significantly reduced in the chronic pain sample (–0.42, CI = –0.77 to –0.07; $P = 0.02$). Another study [41] established that the older adults who were classified as having multiple sites of chronic pain recorded significantly reduced levels of overall physical activity compared with the asymptomatic group (–0.18, CI = –.37 to 0.00; $P = 0.05$). The results for the individual studies are presented in Table 3.

Meta-Analysis of Included Studies

A meta-analysis was performed by pooling seven of the individual studies, and enabled comparison of physical activity levels of 1,381 older adults with chronic pain with 663 asymptomatic older adults, and is presented in Figure 2A. One study [38] could not be included in the meta-analysis as physical activity data were available for each of the three domains, but a total score was not available. The pooled SMD of overall levels of physical activity was –1.74 (CI = –2.71 to –0.77, $P < 0.00001$). The heterogeneity of the included studies as measured by the I^2 was significant and very high (99%). Two studies [37,42] were considerable outliers in the data, and the meta-analysis was recalculated in a sensitivity analysis with these studies excluded and is presented in Figure 2B. This second meta-analysis demonstrated that the older adults with chronic pain (N = 1159) still had significantly reduced levels of physical activity compared with asymptomatic controls (N = 576), but the SMD was small but significant (–0.20, CI = –0.34 to –0.06, $P = 0.004$). The heterogeneity of the included studies was low (32%) and not significant.

We conducted a subgroup meta-analysis with five studies that provided physical activity data for 641 older adults with CLBP and 334 controls. This established that the overall levels of physical activity in older adults with CLBP were moderately lower and significant (SMD = –0.52, CI = –0.87 to –0.16, $P = 0.004$). The studies were heterogeneous ($I^2 = 80\%$, $P > 0.001$), and we removed one study [42] in a sensitivity analysis and found that older adults with CLBP were less active than the controls, but the effect was small but significant and not heterogeneous (SMD = –0.27, CI = –0.44 to –0.10, $P = 0.002$, $I^2 = 20\%$, $P = 0.29$). The two meta-analyses for older adults with CLBP are displayed in Figure 3.

Discussion

The primary finding from this systematic review is that older adults with chronic pain have consistently reduced levels of physical activity compared with asymptomatic controls. The pooled data for the seven included studies demonstrated that the older adults with chronic pain had a profound and significant lower level of physical activity compared with the asymptomatic controls (–1.74 CI = –2.71 to –0.77, $P < 0.00001$). However, caution must be taken when considering this result as two studies [37,42], although relatively small in the number of participants (total N = 248, N = 62, respectively), produced a profound skewing of the data, and the heterogeneity of the included studies was very high and significant ($I_2 = 99\%$). The second meta-analysis (Figure 2B) excluded these two studies and is likely to represent a more accurate reflection of the actual differences in physical activity between the two groups. This analysis of 1,159 older adults with chronic pain established that the levels of physical activity were significantly lower but that the overall SMD was small (–0.20, CI = –0.34 to –0.06, $P = 0.004$). SMD scores of 0.2–0.49 are considered low by Cohen [48], while scores of 0.5–0.79 and those of 0.8 and above

Table 2 Methodological quality assessment of included studies using the Newcastle Ottawa Scale (NOS)

Case-Control Studies

	Selection				Comparability		Exposure			Score
	Patient definition	Representativeness of Patients	Selection of Controls	Definition of Controls	Age	Gender or Comorbidity	Ascertainment of PA ($)	Same Method of Ascertainment for Cases and Controls	Non-Response Rate	Total
Basler et al. 2008 [40]	MET*	UNCLEAR	MET*	MET*	MET*	UNCLEAR	MET*	MET*	UNMET	6/9
Champagne et al. 2012 [43]	UNMET	UNCLEAR	MET*	MET*	MET*	MET*	UNMET	MET*	UNMET	5/9
Eggermont et al. 2009 [41]	UNMET	UNCLEAR	MET*	MET*	MET*	MET*	MET*	MET*	UNMET	6/9
Farrell et al. 1996 [37]	UNCLEAR	UNCLEAR	UNCLEAR	UNCLEAR	MET*	MET*	MET*	MET*	UNMET	4/9
Hopman-Rock et al. 1996 [38]	UNCLEAR	UNCLEAR	UNCLEAR	MET*	MET*	MET*	MET*	MET*	UNCLEAR	5/9
Ledoux et al. 2012 [42]	UNCLEAR	UNCLEAR	MET*	MET*	MET*	UNCLEAR	UNMET	MET*	UNCLEAR	4/9
Rudy et al. 2007 [39]	MET*	UNCLEAR	MET*	MET*	MET*	UNCLEAR	MET*	MET*	UNCLEAR	6/9

Cohort Study

	Selection				Comparability		Exposure			Score
	Patient Representativeness	Selection of Controls	Ascertainment of Exposure	Outcome of Interest Not Present at Baseline	Age	Gender or Comorbidity	PA Activity Measurement (Use of Accelerometer or Validated Questionnaire)	Follow up long enough (>3 years)	Adequate follow-up	Total
Woo et al. 2009 [44]	MET*	MET*	UNCLEAR	UNMET	MET*	UNCLEAR	MET*	MET*	UNMET	5/9

Note $ the scoring system for the item of PA measurement was adopted from a recent systematic review as follows [34]:
Ascertainment of exposure: a) use of accelerometer*; b) validated questionnaire*; c) not validated questionnaire or no validation is mentioned; d) written self-report; and e) no description.

Table 3 Standard mean differences (95% CI) of physical activity in older adults with chronic pain vs older adults without pain

Author	Older Adults with Chronic Pain (N)	Asymptomatic Older Adults (N)	Physical Activity Measure	Physical Activity Results Chronic Pain Group (Mean, SD)	Physical Activity Results Asymptomatic Group (mean, SD)	Standard Mean Difference (SMD) 95% CI	*P* Value
Basler et al. 2008 [40]	103	59	FAQ[1]	39.95 ± 27.58	46.01 ± 33.00	–0.20 (–0.52 to 0.12)	*P* = 0.21
Champagne et al. 2012 [43]	15	15	BPAQ[2]	12.4 ± 5.4	17.5 ± 4.9	–0.96 (–1.72 to –0.20)	*P* = 0.01
Eggermont et al. 2009 [41] and unpublished data	Total: 482	Total: 274	PASE[3]	104.53 + 72.06	112.5 ± 68.88	Total : –0.11 (–0.26 to 0.04)	*P* = 0.14
				Pain 1 site (183) 111.99 ± 82.88		Pain 1 site vs asymptomatic group: –0.01 (–0.19 to 0.18) *P* = 0.94;	*P* = 0.94
				Pain multiple sites (190) 100.11 ± 65.79*		Multiple pain sites vs asymptomatic group*[6] –0.18 (–0.37 to 0.00);	*P* = 0.05
				Widespread chronic pain (109) 99.70 ± 61.82		Widespread pain vs asymptomatic group: –0.19 (–0.41 to 0.03)	*P* = 0.09
Farrell et al. 1996 [37]	193	55	HAP[4] (AAS)	37.5 ± 2.1	59.1 ± 2.5	–9.81 (–10.62 to –9.01)*	*P* < 0.00001
Hopman-Rock et al. 1996 [38]	59	72	PAQ[5]	Breakdown per domain of scale:	Breakdown per domain of scale:		
				1. *Household activities*: 1.7 ± 0.49	1. *Household activities*: 1.9 ± 0.46*	*Household activities*: –0.42 (–0.77 to –0.07)*	*P* = 0.02
				2. *Sports activities*: 6.0 ± 6.6	2. *Sports activities:* 6.4 ± 7.2	*Sports activities*: –0.06 (–0.40 to 0.29)	*P* = 0.74
				3. *Leisure time activities*: 4.1 ± 4.6	3. *Leisure time activities*: 4.4 ± 5.5	*Leisure time activities*: –0.06 (–0.40 to 0.29)	*P* = 0.74
Ledoux et al. 2012 [42]	29	32	BPAQ[2]	12.15 ± 3.66	18.74 ± 5.01	–1.47 (–2.04 to –0.90)	*P* < 0.00001
Rudy et al. 2007 [39]	162	158	PASE[3]	105.76 ± 64.38	124.42 ± 65.02	–0.29 (–0.51 to –0.07)*	*P* = 0.01
Woo et al. 2009 [44]	Total: 397	Total: 70	PASE[3]	83.25 ± 36.76	88.49 ± 30.75	Total: –0.18 (–0.40 to 0.11)	*P* = 0.26
	104 males	23 males		83.33 ± 45	89.3 ± 34.52	male –0.14 (–0.59 to 0.32)	*P* = 0.55
	273 females	47 females		83.22 ± 33.44	88.09 ± 29.11	female –0.15 (–0.46 to 0.16)	*P* = 0.35

CI = confidence interval; PA = physical activity; AAS = activity adjusted score.

[1]FAQ = Freiburg Activity Questionnaire.

[2]BPAQ = Baecke Physical Activity Questionnaire (Baecke et al.) [29].

[3]PASE = Physical Activity Scale for the Elderly (Washburn et al.) [28].

[4]HAP = Human Activity Profile (Daughton et al. 1982) [45].

[5]Physical Activity Questionnaire for the Elderly (Voorrips et al.) [46].

[6]Independent SMD calculation between older adults with multiple pain sites (190) vs those without pain (274) established the group with chronic pain had significantly lower levels of PA (–0.18, CI = –0.37 to 0.00, *P* = 0.05).

*Statistically significant difference.

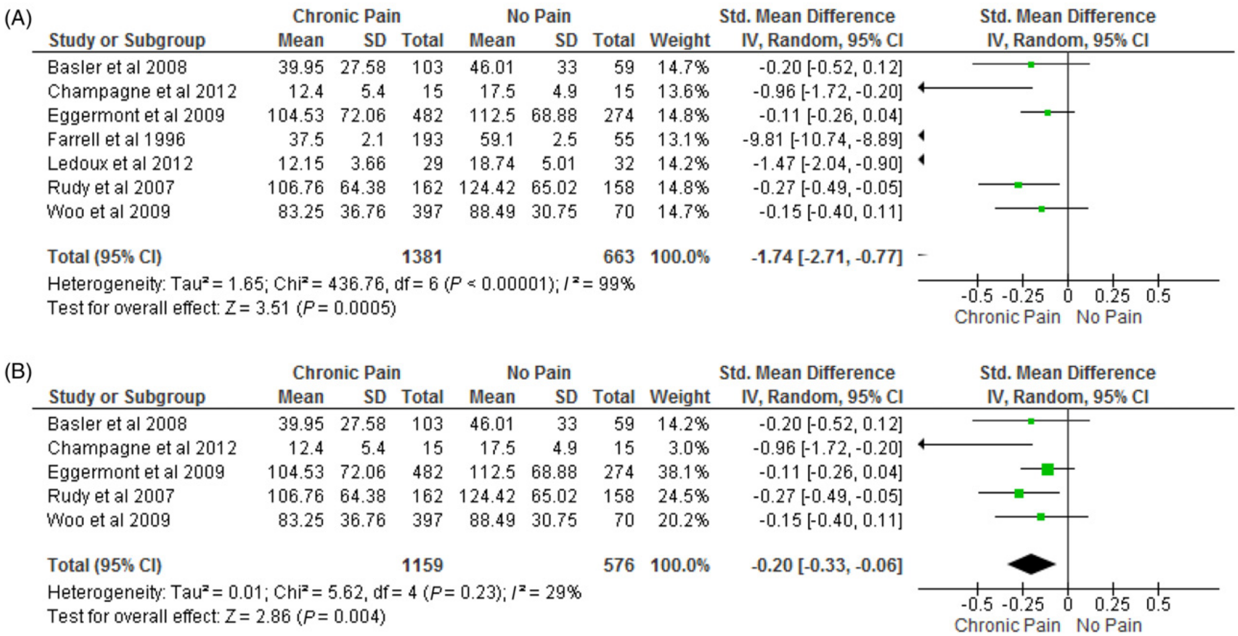

Figure 2 (A) Meta-analysis with all seven studies (total N = 2,044). (B) Meta-analysis excluding two studies [37,42] (total N = 1,735).

are considered medium and large, respectively. Another important factor indicating that the second meta-analysis is likely to be more representative is that this excluded two studies that represented the two lowest scores on NOS (four each, respectively, [37,42]). Exclusion of these studies is warranted as it is recommended that studies scoring less than 5 on the NOS are excluded from meta-analysis on the basis that the risk of bias is high [34]. Our

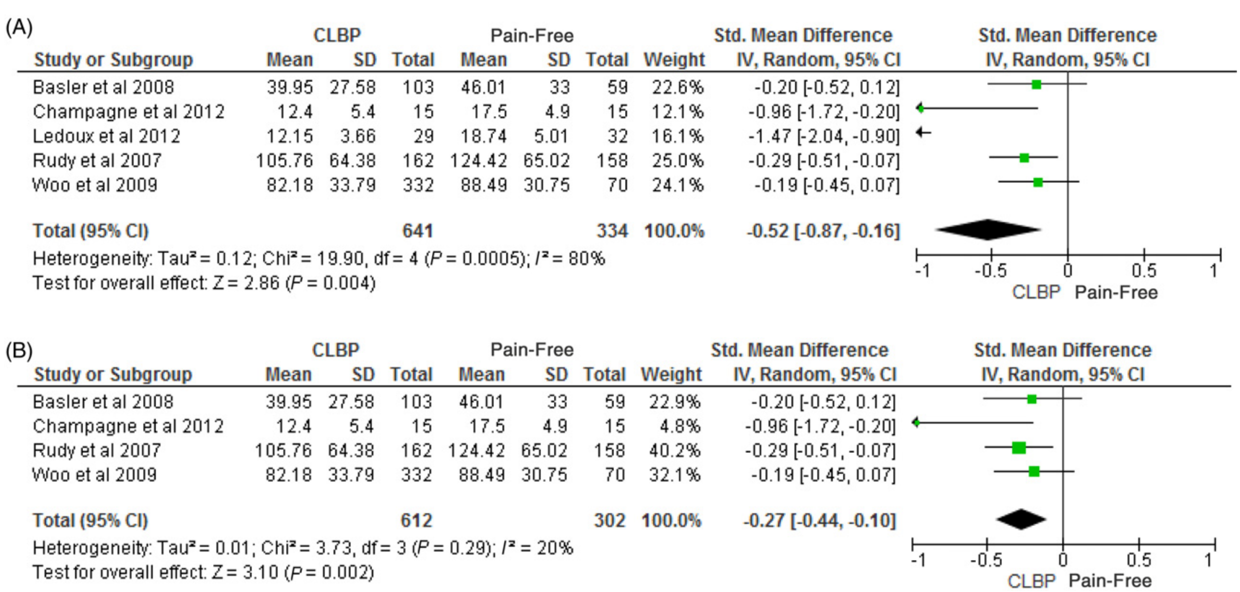

Figure 3 Meta-analysis of physical activity levels in older adults with chronic low back pain (CLBP) vs asymptomatic controls. (A) Analysis with five studies included (total N = 975). (B) Second CLBP meta-analysis with Ledoux et al. [42] excluded in a sensitivity analysis (total N = 914).

subgroup analysis of 612 older adults with CLBP and 302 controls demonstrated that the actual difference in physical activity was small but significant (SMD = –0.27, CI = –0.44 to –0.10, $P = 0.002$, $I^2 = 20\%$, $P = 0.29$).

The results for global pooled SMD for the five included studies and the subgroup analysis of older adults with CLBP are consistent with the results from a recent review that reported a small subgroup analysis of older adults with CLBP [25]. It appears that despite the overall levels of physical activity in the working age population with chronic pain being similar, there is a significant difference in older adults with chronic pain. Reasons for this age-associated difference are likely to be complex and multifaceted, but probably influenced by the higher presence of chronic conditions seen typically within the general older adult population [49]. In addition, it is known that physical activity decreases with age [50], and it may be that for those with chronic pain the impact on physical activity is more profound. Another important consideration is that fear avoidance may be a more pertinent issue in older people, with factors such as fear of falling already known to be high and prevalent in the general older adult population [51–53]. While the evidence for the impact of fear avoidance on physical activity in the general population is inconclusive [10,40], the same cannot be applied to the older adult population with chronic pain and may account for this observed difference in physical activity in our study.

Our primary finding is both a clinical and research concern for a multitude of reasons as the implications of reduced levels of physical activity are particularly profound in this population. Demonstrating lower levels of physical activity in older adults is associated with a number of negative health outcomes, including cognitive impairment [54,55], mobility difficulty/disability [Eggermont et al. unpublished, 56], and falls [4]. The link between reduced levels of physical activity and falls is a concern as falls in old age are a leading cause of accidental death, and this possible relationship warrants exploration [57].

The measurement of physical activity currently being employed in research in older adults with chronic pain is determined by self-report questionnaires. Studies in working age patients with CLBP have established that a patient's self-reported activity level and the actual activity level registered with an accelerometer do not have a strong association [58]. This brings the results of physical activity as measured by a questionnaire under debate whether this indeed represents a patient's actual activity level. It is widely established that the objective measurement of physical activity through techniques such as the DWT are the "gold standard" [59]. Measuring physical activity is complex, and ensuring that researchers accurately measure this is a prerequisite for successfully and accurately determining the association between activity and health outcomes [60]. The use of validated questionnaires is common in epidemiological studies, but it is important that future research utilizes objective measures as by their very nature of being objective this method circumvents reporting errors that may develop through misinterpretation, overestimation, and social desirability [60]. In our study, only three studies reported on the psychometric properties of the physical activity questionnaire they used [37,38,40]. However, three studies utilized the PASE questionnaire; this has been demonstrated to have good psychometric properties [61,62]. The PASE questionnaire is easy to use, relatively quick to administer, and is widely used in the study of physical activity of older adults and appears to be the most suitable questionnaire in this population. However, a recent small study [62] established that although the test–retest reliability and the intraclass correlation coefficient are acceptable and moderate, the construct validity of the PASE compared with accelerometry was poor. Two studies included in this review [42,43] utilized the BPAQ [29] questionnaire, and although this is validated and widely used in the working age population, its psychometric properties for measuring physical activity in older adults are undetermined. In summary, research has identified poor association and agreement between self-report measures and objective-based measures in CLBP patients. As a result of this, currently the only self-report tool that can be identified for use is the PASE [28]. However, clinicians must recognize that the summary score produced by the scale is arbitrary (meaning the level, type, frequency, and intensity of physical activity are not easily identified from the score), and other measures developed for elderly populations (Modified Baecke Questionnaire, Tale Physical Activity Survey) may be appropriate following appropriate psychometric testing. Given this, it is suggested that researchers who are developing intervention trials should consider the use of objective measures, such as accelerometers or pedometers, to obtain more accurate measures of physical activity.

While the ascertainment of physical activity in each included study is not optimal, this review is categorically clear that older adults with chronic pain are less active than those without pain. It is encouraging to note that interventions that seek to increase the levels of physical activity in older people can have far-reaching and profound effects on the increasing older adult population [59] and are an international priority (e.g., WHO [12]). Physical activity programs, such as walking and resistance training, have led to a reduced pain in persons with painful conditions [63] and should be encouraged. For some older persons, exercises such as swimming and water aerobics may be particularly suitable [64], and physiotherapists are well placed to advise on appropriate adaptive and individualized physical activity programs for people with limitations due to pain. The main focus of these programs should be to increase a person's physical activity level and reduce one's limitation due to pain as pain is not a signal to significantly reduce physical activity levels. This is particularly important in older adults with chronic pain as physical activity is a central strategy in the non-pharmacological management of chronic pain, and prolonged periods of reduced levels of physical activity may have a diverse impact on a range of facets of the older person's health and functioning.

Research is warranted to explore the diversity of barriers for older adults with chronic pain engaging in physical activity and also their preferences for increasing it. A recent mixed methods study focusing on community-dwelling older adults with knee pain highlighted that many participants were uncertain about the benefits of exercise for pain [65]. This study further highlighted that there were many barriers to exercise in this group, and although the results of this study are informative they focus on one component of physical activity (exercise). In reality, exercise is one aspect of physical activity [66], and it is important that future efforts are made to understand attitudes, barriers, and facilitators to physical activity and sedentary behavior in its wider sense. It may be difficult to motivate the older person to engage in physical activity, particularly when this may challenge traditional attitudes that rest is the appropriate measure when experiencing pain. However, sedentary behavior (sitting, lying down in the day) is known to be an independent factor that can have pronounced adverse effects on the older person's health [67]. With these factors in mind, it is clearly important to ascertain the older persons with chronic pain attitudes, beliefs and preferences toward physical activity. Obtaining the older person's viewpoint could also inform the focus of future interventional studies that seek to increase overall levels of physical activity and immediate clinical management of those in chronic pain. Even when someone is unable to meet the recommended guidance on levels of physical activity, increasing activity levels can have a multitude of beneficial effects on the older person's health and functioning [59]. The reasons why older people with chronic pain engage in lower levels of physical activity are undoubtedly multifaceted and complex, and this warrants exploration, both through longitudinal epidemiological studies and also in qualitative interviews.

This review highlights a number of important issues for clinicians. The review establishes that older adults with chronic pain are significantly less active than those without pain. Lower levels of physical activity are associated with a plethora of adverse health events and chronic health conditions, while increased levels of physical activity have widespread beneficial effects on the older person's health and well-being [60]. We believe that it is important that clinicians should discuss the individual's preferences for engaging in physical activity (not necessarily "exercise") and encourage patients to reduce sedentary behavior. This should include a minimum of moderate intensity aerobic activity for 30 minutes 5 days per week, or vigorous aerobic activity for 20 minutes three times a week [60]. Naturally, some older adults with particularly high-intensity pain may struggle with this, and in such instances developing a gradual physical activity plan over time is best [60]. Physical therapists are well placed to work with older adults with chronic pain and multiple comorbidities to develop a safe and incremental physical activity plan. The PASE [28] is recommended as an easily applied indicator of overall level of physical activity, and may provide a useful assessment and monitoring of physical activity in clinical practice.

A number of limitations and considerations must be contemplated when interpreting the results of this review. First, the cognitive status of the older adults in each study was not considered in most of the studies included. Cognitive impairments are often present in older adults with pain [41], and it is therefore possible that the recall of physical activity in older participants whose cognitive status is unknown may not have been accurate. Only one study [41] excluded older adults with moderate to severe cognitive impairment (Mini Mental State Examination below 18 [68]). Another consideration is that this review includes a large number of older adults with mixed chronic musculoskeletal pain at various bodily sites, and the level of comorbidity varied in each study. Some of the included studies provided clear information on comorbidity and reported significant differences [39]; others found no difference [43], while others did not report it [37]. However, it is a clinical reality that most older adults with chronic pain have numerous comorbidities, and thereby constitutes a particularly vulnerable group [49]. In addition, it is known that chronic conditions increase with age, and many older adults present with multiple chronic conditions at any one time [49]. Considering the observational designs of the studies included in the meta-analysis, we are not able to identify to what extent other clinical or subclinical conditions may have influenced or reduced the level of physical activity participation. It must be reiterated that the results of this meta-analysis are associations and are not direct cause and effect between chronic pain and physical activity. It may be possible that we observed an age-associated difference in physical activity, while reviews in younger adults did not find this association because of the higher levels of comorbidity typically present in older age.

In addition, we encountered a number of different methods of diagnosing and categorizing chronic musculoskeletal pain, although all stipulated the pain had to have been present on most or all days for 3 or more months. It would be helpful if a common consensus is established for the diagnosis and classification of chronic musculoskeletal pain, and Leveille et al. [5] offer a logical strategy and categorization system for this. Developing uniformity in the way in which chronic pain is diagnosed and classified would enable better synthesis of results from future trials, and therefore targeted interventions to be developed. A simple diagnosis of chronic musculoskeletal pain may not be sufficient, but a classification such as that offered by Leveille et al. [5] enables analysis of the different subsets of people within the broad spectrum of chronic musculoskeletal pain. Under this classification system, older people diagnosed with chronic musculoskeletal pain may have single site, multiple site, or chronic widespread pain, and pain intensity is also considered. The significance of developing different subsets of chronic pain is highlighted in the Eggermont et al.'s [41] study, who completed a subset analysis on older adults with multisite chronic pain and established that they demonstrated significantly lower levels of physical activity. However, the combined analysis of all of the subgroups within the chronic pain classification system revealed no overall significant difference, nor was the subset analysis of those with single or widespread chronic pain.

Future research is needed that provides robust and accurate measurement of daily levels of physical activity in older adults with chronic pain. This research should prioritize the measurement of physical activity through objective measures, such as accelerometers. It is imperative to establish the long-term consequences of reduced levels of physical activity in this population and associations with the fear avoidance model with respect to balance confidence and fear of falling, and should be considered. The research included in this review did not measure sedentary behavior, which is an independently important factor in the health of older people and is different from physical in/activity [67]. Future research should also investigate current patterns of sedentary behavior in older people in pain, with a particular focus on sitting behavior during the waking hours. The beliefs, attitudes, and preferences of the older person toward physical activity warrant investigation, and the development of interventions to promote physical activity should be led by this.

In summary, this review of the available literature confirms that older adults with chronic pain are significantly less active than those without chronic pain. Although the SMD of the pooled data was small, it is still likely clinically meaningful in the rehabilitation of older adults with chronic pain. Clinicians involved in the rehabilitation of the older person with chronic pain have an imperative role to ensure that this population remains as active as possible not only to manage the chronic pain but also to prevent the multitude of secondary consequences that can arise from being inactive. Future research establishing the relationship among physical activity levels, pain, fear of falling, and falls is warranted.

Acknowledgments

We thank the numerous authors who provided additional information for the article, in particular Dr. Jason Leung at the Chinese University of Hong Kong and Prof. Suzanne Leveille in Boston.

References

1 Salomon JA, Wang H, Freeman MK, et al. Healthy life expectancy for 187 countries, 1990–2010: A systematic analysis for the Global Burden Disease Study. Lancet 2013;380:2144–62.

2 Murray CJL, Vos T, Lozano R, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: A systematic analysis for the Global Burden of Disease Study 2010. Lancet 2013;380(9859):2197–223.

3 Helme RD, Gibson SJ. The epidemiology of pain in elderly people. Clin Geriatr Med 2001;17:417–31, v.

4 Leveille SG, Jones RN, Kiely DK, et al. Chronic musculoskeletal pain and the occurrence of falls in an older population. JAMA 2009;302(20):2214–21.

5 Leveille SG, Ling S, Hochberg MC, et al. Widespread musculoskeletal pain and the progression of disability in older disabled women. Ann Intern Med 2001; 135:1038–46.

6 Onder G, Cesari M, Russo A, et al. Association between daily pain and physical function among old–old adults living in the community: Results from the ilSIRENTE study. Pain 2006;121:53–9.

7 Clarke A, Anthony G, Gray D, et al. "I feel so stupid because I can't give a proper answer . . ." How older adults describe chronic pain: A qualitative study. BMC Geriatr 2012;12:78.

8 Heneweer H, Vanhees L, Picavet HS. Physical activity and low back pain: A U-shaped relation? Pain 2009;143(1–2):21–5.

9 Hendrick P, Milosavljevic S, Hale L, et al. The relationship between physical activity and low back pain outcomes: A systematic review of observational studies. Eur Spine J 2011;20:464–74.

10 Verbunt JA, Smeets RJ, Wittink HM. Cause or effect? Deconditioning and chronic low back pain. Pain 2010;149(3):428–30.

11 Blair SN. Physical inactivity: The biggest public health problem of the 21st century. Br J Sports Med 2009;43(1):1–2.

12 World Health Organisation. Global Recommendations for Physical Activity and Health. Geneva: WHO; 2010. ISBN 978 92 4 159 997 9. Available at: http://whqlibdoc.who.int/publications/2010/9789241599979_eng.pdf (accessed January 2013).

13 Tremblay MS, LeBlanc AG, Kho ME, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. Int J Behav Nutr Phys Act 2011;8:98.

14 Frei A, Williams K, Vetsch A, et al. A comprehensive systematic review of the development process of 104 patient-reported outcomes (PROs) for physical activity in chronically ill and elderly people. Health Qual Life Outcomes 2011;9:116.

15 Sawatzky R, Liu-Ambrose T, Miller WC, Marra CA. Physical activity as a mediator of the impact of chronic conditions on quality of life in older adults. Health Qual Life Outcomes 2007;5:68–78.

16 deVries E, Soerjomataram I, Lemmens VE, et al. Lifestyle changes and reduction of colon cancer incidence in Europe: A scenario study of physical activity

promotion and weight reduction. Eur J Cancer 2010;46:2605–16.

17 Angevaren M, Aufdemkampe G, Verhaar HJ, Aleman A, Vanhees L. Physical activity and enhanced fitness to improve cognitive function in older people without known cognitive impairment. Cochrane Database Syst Rev 2008;(3)CD005381.

18 Bridle C, Spanjers K, Patel S, Atherton NM, Lamb SE. Effect of exercise on depression severity in older people: Systematic review and meta-analysis of randomised controlled trials. Br J Psychiatry 2012; 201(3):180–5.

19 Koeneman MA, Verheijden MW, Chinapaw MJ, Hopman-Rock M. Determinants of physical activity and exercise in healthy older adults: A systematic review. Int J Behav Nutr Phys Act 2011;8:142.

20 Balboa-Castillo T, Leon-Munoz LM, Graciani A, Rodriguez-Artalejo F, Guallar-Castillon P. Longitudinal association of physical activity and sedentary behavior during leisure time with health-related quality of life in community-dwelling older adults. Health Qual Life Outcomes 2011;9:47.

21 Stehr MD, von Lengerke T. Preventing weight gain through exercise and physical activity in the elderly: A systematic review. Maturitas 2012;72(1):13–22.

22 Gomez-Cabello A, Ara I, Gonzalez-Aguero A, Casajus JA, Vicente-Rodriguez G. Effects of training on bone mass in older adults: A systematic review. Sports Med 2012;42:301–25.

23 Evans WJ. Skeletal muscle loss: Cachexia, sarcopenia, and inactivity. Am J Clin Nutr 2010;91(4):1123S–7S.

24 Singh MA. Exercise comes of age: Rationale and recommendations for a geriatric exercise prescription. J Gerontol A Biol Sci Med Sci 2002;57:M262–82.

25 Griffin DW, Harmon DC, Kennedy NM. 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. Physiotherapy 2012;98:13–23.

26 Evering RM, van Weering MG, Groothuis-Oudshoorn KC, Vollenbroek-Hutten MM. Daily physical activity of patients with the chronic fatigue syndrome: A systematic review. Clin Rehabil 2011;25(2):112–33. England.

27 Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA statement. PLoS Med 2009;6(7):e1000097. doi: 10.1371/journal.pmed1000097.

28 Washburn RA, Smith KW, Jette AM, Janney CA. The Physical Activity Scale for the Elderly (PASE): Development and evaluation. J Clin Epidemiol 1993;46(2): 153–62.

29 Baecke JA, Burema J, Frijters JE. A short questionnaire for the measurement of habitual physical activity in epidemiological studies. Am J Clin Nutr 1982;36: 936–42.

30 Berlin JE, Storti KL, Brach JS. Using activity monitors to measure physical activity in free-living conditions. Phys Ther 2006;86:1137–45.

31 Higgins J, Green P. Cochrane reviewers handbook for systematic reviews of interventions. The Cochrane Collaboration, Version 5.1.0, 2011.

32 Lin CW, McAuley JH, Macedo L, et al. Relationship between physical activity and disability in low back pain: A systematic review and meta-analysis. Pain 2011;152(3):607–13.

33 Wells GA, Shea B, O'Connell D, Peterson J, et al. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses. Available at: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp (accessed January 2013).

34 Eijkemans M, Mommers M, Draaisma JM, Thijs C, Prins MH. Physical activity and asthma: A systematic review and meta-analysis. PLoS ONE 2012; 7:e50775.

35 Kwon BK, Roffey DM, Bishop PB, Dagenais S, Wai EK. Systematic review: Occupational physical activity and low back pain. Occup Med (Lond) 2011;61(8): 541–8.

36 Review Manager. Version 5.2. Copenhagen: The Nordic Centre, the Cochrane Collaboration. 2012.

37 Farrell MJ, Gibson SJ, Helme RD. Measuring the activity of older people with chronic pain. Clin J Pain 1996;12:6–12.

38 Hopman-Rock M, Kraaimaat FW, Bijlsma JWJ. Physical activity, physical disability, and osteoarthritic pain in older adults. J Aging Phys Act 1996;4:324–37.

39 Rudy TE, Weiner DK, Lieber SJ, Slaboda J, Boston JR. The impact of chronic low back pain on older adults: A comparative study of patients and controls. Pain 2007;131:293–301.

40 Basler H, Luckmann J, Wolf U, Quint S. Fear-avoidance beliefs, physical activity, and disability in elderly individuals with chronic low back pain and healthy controls. Clin J Pain 2008;24:604–10.

41 Eggermont LHP, Milberg WP, Lipsitz LA, Scherder EJA, Leveille SG. Physical activity and executive function in aging: The MOBILIZE Boston study. J Am Geriatr Soc 2009;57:1750–6.

42 Ledoux E, Dubois J-D, Descarreaux M. Physical and psychosocial predictors of functional trunk capacity in older adults with and without low back pain. J Manipulative Physiol Ther 2012;35:338–45.

43 Champagne A, Prince F, Bouffard V, Lafond D. Balance, falls-related self-efficacy, and psychological factors amongst older women with chronic low back pain: A preliminary case-control study. Rehabil Res Pract 2012;2012:430374.

44 Woo J, Leung J, Lau E. Prevalence and correlates of musculoskeletal pain in Chinese elderly and the impact on 4-year physical function and quality of life. Public Health 2009;123:549–56.

45 Daughton DM, Fix AJ, Kass I, et al. Maximum oxygen consumption and the ADAPT quality-oflife scale. Arch Phys Med Rehabil 1982;63:62022.

46 Voorrips LE, Ravelli AC, Dongelmans PC, Deurenberg P, Van Staveren WA. A physical activity questionnaire for the elderly. Med Sci Sports Exerc 1991;23(8): 974–9.

47 Roland MO, Morris RW. A study of the natural history of back pain. Part 1: Development of a reliable and sensitive measure of disability in low back pain. Spine 1983;8:141–4.

48 Cohen J. Statistical Power Analysis for the Behavioral Sciences, 2nd edition. Hillsdale, NJ: Erlbaum; 1988.

49 Tinetti ME, Fried TR, Boyd CM. Designing health care for the most common chronic condition—Multimorbidity. JAMA 2012;307(23):2493–4.

50 Kowalski K, Rhodes R, Naylor PJ, Tuokko H, Macdonald S. Direct and indirect measurement of physical activity in older adults: A systematic review of the literature. Int J Behav Nutr Phys Act 2012;9:148.

51 Zijlstra GA, van Haastregt JC, van Rossum E, et al. Interventions to reduce fear of falling in community-living older people: A systematic review. J Am Geriatr Soc 2007;55(4):603–15.

52 Scheffer AC, Schuurmans MJ, van Dijk N, van der Hooft T, de Rooij SE. Fear of falling: Measurement strategy, prevalence, risk factors and consequences among older persons. Age Ageing 2008;37(1):19–24.

53 Camacho-Soto A, Sowa GA, Perera S, Weiner DK. Fear avoidance beliefs predict disability in older adults with chronic low back pain. PM R 2012;4(7):493–7.

54 Verdelho A, Madureira S, Ferro JM, et al.; LADIS Study. Physical activity prevents progression for cognitive impairment and vascular dementia: Results from the LADIS (Leukoaraiosis and Disability) study. Stroke 2012;43(12):3331–5.

55 Xue QL, Bandeen-Roche K, Mielenz TJ, et al. Patterns of 12-year change in physical activity levels in community-dwelling older women: Can modest levels of physical activity help older women live longer? Am J Epidemiol 2012;176(6):534–43.

56 Mangani I, Cesari M, Russo A, et al. Physical function, physical activity and recent falls. Results from the "Invecchiamento e LongevitànelSirente (ilSIRENTE)" Study. Aging Clin Exp Res 2008;20(3):234–41.

57 Gillespie LD, Robertson MC, Gillespie WJ, et al. Interventions for preventing falls in older people living in the community. Cochrane Database Syst Rev 2012;(9)CD007146.

58 Huijnen IP, Verbunt JA, Peters ML, et al. Do depression and pain intensity interfere with physical activity in daily life in patients with Chronic Low Back Pain? Pain 2010;150(1):161–6.

59 Slater H, Davies SJ, Parsons R, Quintner JL, Schug SA. A policy-into-practice intervention to increase the uptake of evidence-based management of low back pain in primary care: A prospective cohort study. Plos ONE 2012;7(5):e38037.

60 Nelson ME, Rejeski WJ, Blair SN, et al.; American College of Sports Medicine; American Heart Association. Physical activity and public health in older adults: Recommendation from the American College of Sports Medicine and the American Heart Association. Circulation 2007;116(9):1094–105.

61 Forsén L, Loland NW, Vuillemin A, et al. Self-administered physical activity questionnaires for the elderly: A systematic review of measurement properties. Sports Med 2010;40(7):601–23.

62 Svege I, Kolle E, Risberg MA. Reliability and validity of the Physical Activity Scale for the Elderly (PASE) in patients with hip osteoarthritis. BMC Musculoskelet Disord 2012;13:26.

63 Hughes SL, Seymour RB, Campbell RT, et al. Fit and Strong!: Bolstering maintenance of physical activity among older adults with lower-extremity osteoarthritis. Am J Health Behav 2010;34(6):750–63.

64 Segura-Jiménez V, Carbonell-Baeza A, Aparicio VA, et al. A warm water pool-based exercise program decreases immediate pain in female fibromyalgia patients: Uncontrolled clinical trial. Int J Sports Med 2012; [Epub ahead of print].

65 Holden MA, Nicholls EE, Young J, Hay EM, Foster NE. Role of exercise for knee pain: What do older adults in the community think? Arthritis Care Res (Hoboken) 2012;64(10):1554–64.

66 Thompson D, Karpe F, Lafontan M, Frayn K. Physical activity and exercise in the regulation of human adipose tissue physiology. Physiol Rev 2012;92(1): 157–91.

67 Dogra S, Stathokostas L. Sedentary behavior and physical activity are independent predictors of successful aging in middle-aged and older adults. J Aging Res 2012;2012:190654.

68 Folstein MF, Folstein SE, McHugh PR. “Mini-mental state”. A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12(3):189–98.