Association between objectively measured physical activity and the number of chronic musculoskeletal pain sites in community-dwelling older adults

Murata, Shunsuke

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博 士 論 文

Association between objectively measured physical activity and the number of chronic musculoskeletal pain sites in community-dwelling older adults

（地域在住高齢者における運動器慢性痛の部位数と客観的に測定された身体活動の関連）

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神戸大学大学院保健学研究科保健学専攻

Shunsuke Murata

村田　峻輔

Abstract

Objective: Physical inactivity is recognized as a pandemic health problem. The association of pain with physical activity, particularly when measured objectively, in older adults is unclear. This study investigates the association of number of chronic musculoskeletal pain sites and pain severity with objectively measured physical activity in community-dwelling older adults.

Design: Observational study

Setting: Community

Subjects: We analyzed 267 community-dwelling older adults (mean age: 75.3 years, women: 67.0 %).

Methods: Number of chronic musculoskeletal pain sites and pain severity were measured using a self-reported questionnaire. Mean steps per day and mean minutes of light physical activity per day and moderate to vigorous physical activity per day were measured using an accelerometer. Linear regression models were applied to analyze the association of number of chronic musculoskeletal pain sites and pain severity with physical activity.

Results: The results suggest that a higher number of chronic musculoskeletal pain sites is associated with lower step count (beta：−333.5, 95% confidence interval : −655.9 to

−11.0, $P < 0.05$) and moderate to vigorous physical activity (beta: −2.5, 95% confidence interval: −4.7 to −0.4, $P < 0.05$) even after adjustment for age, gender, years of schooling, obesity, alcohol habits, smoking status, number of comorbidities, recent surgery, and depressive symptoms.

Conclusions: Our results suggest that the number of chronic musculoskeletal pain sites is associated with low physical activity in older adults. Therefore, low physical activity due to chronic musculoskeletal pain should not be overlooked.

Key words: chronic musculoskeletal pain, physical activity, moderate to vigorous physical activity, older adults

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The title is “Association Between Objectively Measured Physical Activity and the Number of Chronic Musculoskeletal Pain Sites in Community-Dwelling Older Adults.”

Introduction

Physical activity decreases with aging [1], and the pandemic of physical inactivity is a global public health priority [2]. The World Health Organization has reported that physical inactivity is the fourth leading cause of global mortality [3]. Physical activity is crucial for healthy aging [4]. Additionally, physical inactivity is a risk factor for disability, cognitive decline, and depressive symptoms [5–7]. The factors related to physical inactivity should be elucidated to develop a preventive strategy.

Chronic musculoskeletal pain increases with aging, which predicts adverse outcomes such as depression and disability [8,9]. Chronic musculoskeletal pain can make older adults avoid physical activity. A systematic review has revealed that older adults with chronic musculoskeletal pain reduce their physical activity compared with asymptomatic controls [10]. However, all eight studies selected in this systematic review assessed physical activity by self-reported questionnaires. Even among young people, self-reported physical activity is thought be subject to recall bias, resulting in underestimation or overestimation [11]. Physical activity measured objectively using an accelerometer is thought to be appropriate, particularly in older adults due to fluctuations in their health status and mood, depression, anxiety, or cognitive ability [12]. In addition, studies should investigate the association considering pain characteristics such as the number of chronic musculoskeletal pain sites and pain severity because pain severity and multisite pain are associated with health problems, such as disability and low quality of life [13,14].

We hypothesize that chronic musculoskeletal pain is associated with physical activity. This study investigates the association of number of chronic musculoskeletal pain sites and pain severity with objectively measured physical activity in community-dwelling older adults.

Methods

Subjects

Japanese community-dwelling older adults aged 65 years or older were recruited from eight community clubs. The sole inclusion criterion was an ability to walk independently. Data collection took place in the spring (May) or autumn (September–November) of 2015. We avoided data collection in summer and winter because of the effect of season on physical activity. Three hundred twenty-two community-dwelling older adults participated in this study. The exclusion criteria for this study were scoring under 18 in the Mini-Mental State Examination (MMSE; N = 3) [15], broken or lost accelerometer (N = 10), not meeting criteria to analyze accelerometer data (described in the next subsection; N = 29), and not completing all examinations (N = 13). Two hundred sixty-seven older people met the criteria and were available for the final analysis in this study (mean age ± standard deviation: 75.3 ± 5.4 years, 67.0% women) (Figure 1). The Research Ethics Committee of Kobe University Graduate School of Health Sciences approved the study, and informed consent was obtained from all subjects before participation.

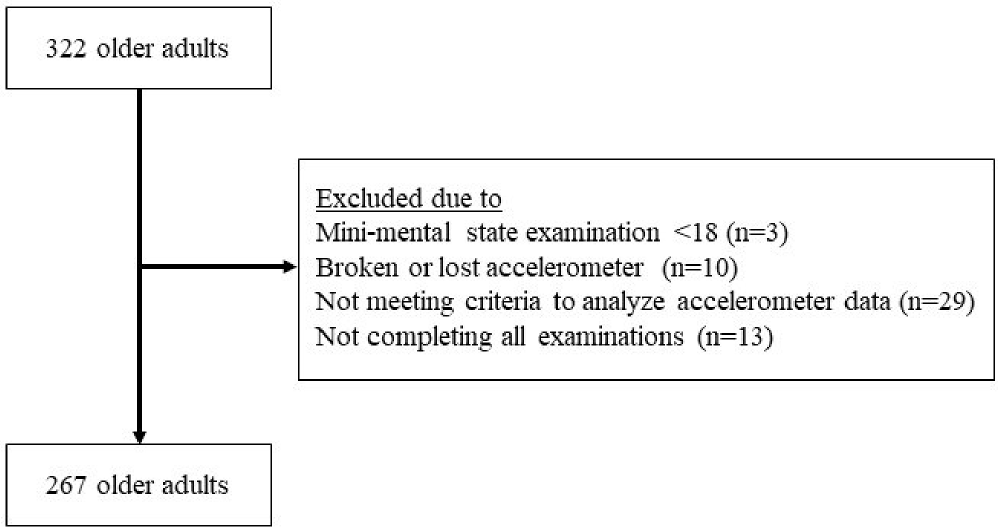

Figure 1. Flow diagram of the present study

Evaluation of physical activity

Physical activity was assessed using a uniaxial accelerometer (Kenz Lifecorder EX; Suzuken Co, Ltd, Aichi, Japan). This accelerometer has validity and reliability to assess steps and intensity of physical activity [16,17]. Mean number of minutes of light physical activity (LPA) and moderate to vigorous physical activity (MVPA) per day and mean number of steps per day were calculated. LPA was defined as 1.5–2.9 metabolic equivalents of task (METs), and MVPA was defined as $\geq$3.0 METs [18]. Participants were asked to wear the accelerometer on their hip for one week and to take off the accelerometer only while sleeping, bathing, or swimming. Data were scored in MATLAB (MATLAB, Release 2016a; The MathWorks Japan, Tokyo, Japan). We analyzed the accelerometer results based on previous studies [19,20]. Non–wear time was defined as periods of at least 60 consecutive minutes of zero counts. Validated days of wearing the accelerometer were determined as days with 10 hours or more of wear time. Participants with three or fewer valid days were excluded from the study.

Assessment of pain

Chronic musculoskeletal pain was defined as pain lasting three months or more at any of eight musculoskeletal locations: neck, low back, shoulder, elbow, hand or wrist, hip, knee, and ankle or foot [21]. We had specific information on the laterality of the pain, except for neck and low back, and counted the number of musculoskeletal pain sites (range: 0–14). Pain site was assessed using a body diagram, including a check box at each site. We used the number of chronic musculoskeletal pain sites as continuous variables in the analysis. Pain severity was assessed using a subscale of the Brief Pain Inventory [22,23]. This scale is well validated to assess noncancer pain with good reliability. The Japanese version of the Brief Pain Inventory is also well validated and has good reliability [24]. This subscale is an 11-point numerical rating scale of four conditions—worst pain, least pain, pain on average, and pain now—and the average of the four conditions is calculated and used in the analysis. Higher scores on the subscale of the Brief Pain Inventory represent more severe pain, and the range was from 0 to 10.

Other variables

Demographic data were recorded, including age, gender, years of education (≤9 years, 10–12 years, or ≥13 years), body mass index (BMI), smoking, and alcohol consumption status. Height and weight were measured using standard procedures, and BMI was calculated as weight (kg) divided by height (m) squared. Obesity was defined as BMI $\geq$25 kg/m2 following Japanese criteria [25]. Smoking status was scored in three categories (never, past, current smoking). Alcohol consumption was evaluated by four categories of drinking frequency, including never, rarely, sometimes, or every day, wherein alcohol habits were categorized as occasional and daily consumption and no alcohol habits included never or rarely consumed. Cognitive function was assessed using the Mini-Mental State Examination (MMSE) [26]. Depressive symptoms were assessed using the Geriatric Depression Scale-15 (GDS) [27]. The GDS is a 15-item inventory with a yes/no format. Depressive symptoms were defined as GDS score$\geq$6[28]. Self-reported comorbidities including orthopedic diseases were evaluated (stroke, diabetes, heart disease, respiratory illnesses, eye disease, hip osteoarthritis, knee osteoarthritis, rheumatoid arthritis, and spinal disease including spinal disc herniation, spinal canal stenosis, or compression fracture of the spine). The sum of the comorbidities was calculated using stroke, MMSE $<$24, diabetes, heart disease, respiratory illness, and eye disease (not including orthopedic disease), and the comorbidities were classified into three groups based on the number of medical conditions in a participant: no comorbidities, one comorbidity, and two or more comorbidities. Recent surgery within three months was assessed using a self-reported questionnaire. Mobility was assessed by a Timed Up and Go Test using a stopwatch [29]. The participants were asked to stand up from a standard armchair, walk three meters, then turn around, walk back to the chair, and sit down again. We measured the time required to complete the test. We measured up to two decimal places.

Statistical Analysis

Linear regression models were used, with physical activity as the dependent variable and number of musculoskeletal pain sites or pain severity as the independent variables. Crude and adjusted models were constructed. The following variables were adjusted as confounding factors in the adjusted model: age, gender, years of schooling, obesity, alcohol habits, smoking status, number of comorbidities, recent surgery, and depressive symptoms. Linear regression models were also applied, with physical activity as the dependent variable and axial pain, upper extremity pain, or lower extremity pain as the independent variables. Beta and 95% confidence interval (95% CI) were calculated by linear regression models. Statistical significance was set at $P<0.05$, and all analyses were conducted using STATA, version 13.1 (StataCorp, College Station, TX, USA).

Results

The prevalence rates of chronic single-site and multisite musculoskeletal pain were 28.8% (N = 77) and 30.3% (N = 81), respectively. The mean (standard deviation) pain severity score was 1.53 (1.59). The prevalence rates of site-specific chronic musculoskeletal pain in the low back, knee, shoulder, neck, ankle or feet, hip, wrist or hand, and elbows were 34.5 (N = 92), 30.7 (N = 82), 13.5 (N = 36), 6.0 (N = 16), 4.9 (N = 13), 4.1 (N = 11), 3.8 (N = 10), and 1.9 (N = 5), respectively. Table 1 shows the demographic and clinical characteristics of all 267 participants. Seventy-seven older adults had one or more orthopedic diseases (prevalence = 28.8%).

Table 1. Demographic and clinical characteristics of all participants

	All participants (N = 267)
Age (years)[a]	75.3 (5.4)
Women	179 (67.0%)
Years of education	
10 years >	47 (17.6%)
10–12 years	163 (61.0%)
12 years <	57 (21.3%)
Obesity	73 (27.3%)
Cigarette	
Never	188 (70.4%)
Past	70 (26.2%)
Current	9 (3.4%)
Alcohol habits	109 (40.8%)
Timed up and go test[a]	9.2 (2.5)
Recent surgery	5 (1.9%)
The number of comorbidities	
No	117 (43.8%)
One	112 (41.9%)
Two or more	38 (14.2%)

Table 1. Continued

	All participants (N = 267)
Stroke	4 (1.5%)
MMSE[c] < 24	11 (4.1%)
Diabetes	26 (9.7%)
Heart disease	32 (12.0%)
Respiratory illness	16 (6.0%)
Eye disease	104 (39.0%)
Depressive symptoms	45 (16.9%)
Spinal disease	44 (16.6%)
Hip osteoarthritis[d]	19 (7.1%)
Knee osteoarthritis[c]	41 (15.4%)
Rheumatoid arthritis[c]	5 (1.9%)
Steps	8472.2 (3838.7)
MVPA	26.6 (24.9)
LPA	69.6 (34.1)

[a]Data of age, timed up and go test, steps, MVPA, and LPA are expressed as mean (standard deviation), and the others are expressed as N (%).

[b]Number of comorbidities is sum of stroke, MMSE< 24, diabetes, heart disease, respiratory illness, and eye disease.

[c]MMSE, Mini-Mental State Examination; MVPA, Moderate to vigorous physical activity; LPA, Light physical activity.

[d]The total number of data points for spinal disease and knee osteoarthritis is 265 and 266 due to some missing data, respectively.

The results of the univariate and multivariate linear regression models are shown in Table2. Even after adjustment, the number of chronic musculoskeletal pain sites was significantly associated with low step count (beta: −333.5, 95% CI: −655.9 to −11.0, *P*<0.05) and MVPA (beta: −2.5, 95% CI: −4.7 to −0.4, *P*<0.05). After adjustment, no significant association of axial pain, upper extremity pain, and lower extremity pain with physical activity was observed (data not shown).

Table 2. Association of pain severity and number of musculoskeletal pain sites with physical activity: linear regression model

	Steps (step/day)		MVPA (min/day)		LPA (min/day)	
	Crude model	Adjusted model	Crude model	Adjusted model	Crude model	Adjusted model
Number	−453.5[b]	−333.5[a]	−3.2[b]	−2.5[a]	−2.0	−0.8
	(−789.5 to −117.5)	(−655.9 to −11.0)	(−5.3 to −1.0)	(−4.7 to −0.4)	(−5.0 to 1.0)	(−3.7 to 2.1)
Severity	−260.2	−101.7	−2.0[a]	−0.9	−1.6	−0.8
	(−550.3 to 30.0)	(−379.7 to 176.2)	(−3.9 to −0.2)	(−2.8 to 0.9)	(−4.2 to 1.0)	(−3.2 to 1.7)

Data are expressed as beta (95% Confidence Interval). [a]$P < 0.05$, [b]$P < 0.01$

MVPA, Moderate to vigorous physical activity; LPA, Light physical activity.

Adjusted for age, gender, years of schooling, obesity, alcohol habits, smoking status, number of comorbidities, recent surgery, and depressive symptoms.

Discussion

Our results reveal an association between the number of chronic musculoskeletal pain sites and both low step count and MVPA in this population, even after adjusting for confounding factors. On the contrary, no significant association of pain severity and chronic pain location (axial pain, upper extremity, and lower extremity pain) with objectively measured physical activity was observed after adjustment.

Our results suggest that a higher number of chronic musculoskeletal pain sites is associated with low physical activity. One cross-sectional study of the general population, partly including older adults, reported that persons with chronic widespread pain, but not chronic multisite pain, had reduced objectively measured MVPA compared with pain-free persons [30]. Subanalysis of another study suggested that both chronic widespread pain and multisite pain were not significantly associated with reduced physical activity [10]. In the latter study, the analysis did not adjust for confounding factors, and physical activity was assessed using a self-report questionnaire. Our study provides data of objectively measured physical activity and clarifies the association of a higher number of chronic musculoskeletal pain with low step count and MVPA after adjustment for confounding factors such as age, gender, obesity, and depressive symptoms. Thus, our findings expand those studies and provide further insight into the effect of pain on physical activity.

This is the first study to investigate the association of overall pain severity with objectively measured physical activity in older adults, though no significant association was observed. One cross-sectional study suggested that older adults with moderate and severe pain are less frequently engaged in self-reported MVPA than a pain-free group [31]. One possible reason for the inconsistent results may be that participants in our study had relatively lower pain severity than those of the previous study. In our study, the prevalence of moderate or greater pain (numeric rating scale for current pain≥4) was only 12.0% (N = 32). In contrast, the prevalence in the cross-sectional study was greater than 20% [31]. The sample of relatively lower pain severity may lead to no significant association between pain severity and physical activity in our study. Further study including older adults with higher pain severity should be conducted to clarify the association between pain severity and physical activity.

In our study, no significant association of axial pain, upper extremity pain, and lower extremity pain with physical activity was observed. There was also no significant association between any site-specific chronic musculoskeletal pain and physical activity (data not shown). One study reported that chronic low back pain was associated with low physical activity in community-dwelling older adults, although the study conducted only univariate analyses [32]. In addition, low back pain was defined as having at least moderate pain or experiencing pain almost every day or more, whereas the definition in our study was to have any pain. These differences in analytical methods and pain definitions likely contributed, in part, to the varied results. Further study should be conducted to clarify the association between site-specific chronic musculoskeletal pain and physical activity while accounting for site-specific pain severity.

In our results, for each increase in the number of pain sites, the number of steps and the time engaging in MVPA per day decreased by 333.5 steps and 2.5 minutes, respectively. MVPA and steps are crucial for maintaining health. The Nakanojo cohort study has reported in detail the effects of physical activity on health problems and revealed that the various thresholds of step and MVPA duration which are associated with adverse clinical outcomes, such as osteoporosis, sarcopenia, and low health-related quality of life [33]. Moreover, the various thresholds of the step count and/or duration of MVPA were reported, such as 4,000 steps/d and/or 5 min/d at MVPA for better mental health, including a lower depression score; 7,000–8,000 steps/d and/or 15–20 min/d at MVPA for lesser aortic stiffening, more favorable sonic markers of bone health and dual x-ray estimates of muscle mass, and a greater level of physical fitness. Finally, it is recommended that older adults do 20 minutes or more of MVPA per day and 8,000 steps or more of walking activity per day based on Nakanojo cohort study findings [33]. The difference of MVPA and steps in our study could be meaningful based on the various thresholds of the step count and MVPA, although the differences of the time spent on MVPA and step counts are not remarkable. Physical inactivity as a result of chronic multisite musculoskeletal pain may cause further disuse. A previous study has reported that osteoarthritis (the main condition of chronic pain) is a risk factor for depression, cardiovascular disease, and cardiovascular-related mortality [34–36]. These associations may be mediated by physical inactivity.

The linkage of physical inactivity with chronic pain requires the development of a preventive strategy and examination of the mechanism. The current study did not investigate the reason for the occurrence of this effect. Some previous studies have suggested that pain is associated with fear of falling, low balance confidence, and falling [37–39], which may lead to less activity. These reasons are plausible. It is also possible that pain directly affects physical activity. Our results, that is, decreased physical activity due to chronic multisite pain, suggest that clinicians should assess and promote physical activity in treating older adults with chronic musculoskeletal pain. To maintain or increase physical activity, a monitoring intervention using pedometers could be efficacious [40]. Further studies are required to develop suitable intervention strategies for older adults with chronic musculoskeletal pain to promote physical activity and to reduce disuse due to decreased physical activity.

Although this study has provided a number of important contributions, some limitations should be taken into account. First, the sample size was small. Second, we could not investigate the association between sedentary behavior and chronic musculoskeletal pain. The Lifecorder EX used in this study cannot detect sedentary behavior, and a previous validation study of Lifecorder EX reported that this accelerometer overestimates light activity level [17]. Third, the association between pain and physical activity is thought to be bidirectional, and our study was short term. Therefore, a longitudinal study with longer follow-up is required to uncover this bidirectional association. Finally, as can be seen from the low prevalence of MMSE scores <24 and high mean score for the Timed Up and Go Test, our participants were relatively healthy, with low levels of pain. Thus, further studies that include more frail older adults will be required to examine whether the association between chronic musculoskeletal pain and physical activity holds up.

Conclusions

Higher number of chronic musculoskeletal pain sites is associated with low step count and decreased MVPA in community-dwelling older adults. In treating older adults with chronic multisite musculoskeletal pain, clinicians should take physical inactivity into account as well as pain.

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Reference

1. Troiano RP, Berrigan D, Dodd KW, et al. Physical activity in the United States measured by accelerometer. Med Sci Sports Exerc 2008;40(1):181–8.

2. Kohl HW 3rd, Craig CL, Lambert EV, et al. The pandemic of physical inactivity: Global action for public health. Lancet 2012;380(9838):294–305.

3. World Health Organization. Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks. Geneva, Switzerland: WHO Press; 2009. Available at: http://apps.who.int/iris/bitstream/10665/44203/1/9789241563871_eng.pdf (accessed September 2017).

4. Daskalopoulou C, Stubbs B, Kralj C, et al. Physical activity and healthy ageing: A systematic review and meta-analysis of longitudinal cohort studies. Ageing Res Rev 2017;38:6–17.

5. Boyle PA, Buchman AS, Wilson RS, Bienias JL, Bennett DA. Physical activity is associated with incident disability in community-based older persons. J Am Geriatr Soc 2007;55(2):195–201.

6. Barnes DE, Yaffe K. The projected effect of risk factor reduction on Alzheimer's disease prevalence. Lancet Neurol 2011;10(9):819–28.

7. Strawbridge WJ, Deleger S, Roberts RE, Kaplan GA. Physical activity reduces the risk

of subsequent depression for older adults. Am J Epidemiol 2002; 156(4):328–34.

8. Denkinger MD, Lukas A, Nikolaus T, et al. Multisite pain, pain frequency and pain severity are associated with depression in older adults: Results from the ActiFE Ulm study. Age Ageing 2014;43(4):510.

9. Eggermont LH, Leveille SG, Shi L, et al. Pain characteristics associated with the onset of disability in older adults: The maintenance of balance, independent living, intellect, and zest in the Elderly Boston Study. J Am Geriatr Soc 2014;62(6):1007–16.

10. Stubbs B, Binnekade TT, Soundy A, et al. Are older adults with chronic musculoskeletal pain less active than older adults without pain? A systematic review and meta-analysis. Pain Med 2013;14(9):1316–31.

11. Hagstromer M, Ainsworth BE, Oja P, Sjostrom M. Comparison of a subjective and an objective measure of physical activity in a population sample. J Phys Act Health 2010;7(4):541–50.

12. Rikli RE. Reliability, validity, and methodological issues in assessing physical activity in older adults. Res Q Exerc Sport 2000;71(suppl 2):S89–96.

13. Eggermont LH, Bean JF, Guralnik JM, Leveille SG. Comparing pain severity versus pain location in the MOBILIZE Boston study: Chronic pain and lower extremity function. J Gerontol A Biol Sci Med Sci 2009; 64(7):763–70.

14. Laslett LL, Quinn SJ, Winzenberg TM, et al. A prospective study of the impact of musculoskeletal pain and radiographic osteoarthritis on health related quality of life in community dwelling older people. BMCMusculoskelet Disord 2012;13(1):168.

15. Makizako H, Shimada H, Doi T, Tsutsumimoto K, Suzuki T. Impact of physical frailty on disability in community-dwelling older adults: A prospective cohort study. BMJ Open 2015;5(9):e008462.

16. Schneider PL, Crouter SE, Lukajic O, Bassett DR Jr. Accuracy and reliability of 10 pedometers for measuring steps over a 400-m walk. Med Sci Sports Exerc 2003;35(10):1779–84.

17. Kumahara H, Schutz Y, Ayabe M, et al. The use of uniaxial accelerometry for the assessment of physicalactivity-related energy expenditure: A validation study against whole-body indirect calorimetry. Br J Nutr 2004;91(2):235–43.

18. Pate RR, Pratt M, Blair SN, et al. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. JAMA 1995; 273(5):402–7.

19. Freedson PS, Miller K. Objective monitoring of physical activity using motion sensors and heart rate. Res Q Exerc Sport 2000;71(suppl 2):S21–9.

20. Winkler EA, Gardiner PA, Healy GN, et al. Distinguishing true sedentary from

accelerometer non-wearing time: Accuracy of two automated wear-time estimations. Med Sci Sports Exerc 2009;41: 171–2.

21. Treede RD, Rief W, Barke A, et al. A classification of chronic pain for ICD-11. Pain 2015;156(6):1003–7.

22. Keller S, Bann CM, Dodd SL, et al. Validity of the brief pain inventory for use in documenting the outcomes of patients with noncancer pain. Clin J Pain 2004;20(5):309–18.

23. Tan G, Jensen MP, Thornby JI, Shanti BF. Validation of the Brief Pain Inventory for chronic nonmalignant pain. J Pain 2004;5(2):133–7.

24. Uki J, Mendoza T, Cleeland CS, Nakamura Y, Takeda F. A brief cancer pain assessment tool in Japanese: The utility of the Japanese Brief Pain Inventory–BPI-J. J Pain Symptom Manage 1998;16 (6):364–73.

25. The Examination Committee of Criteria for Metabolic Syndrome. Definition and criteria of metabolic syndrome. J Jpn Soc Int Med 2005;94:794–809.

26. 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.

27. Yesavage JA. Geriatric depression scale. Psychopharmacol Bull 1988;24(4):709–11.

28. Friedman B, Heisel MJ, Delavan RL. Psychometric properties of the 15-item geriatric depression scale in functionally impaired, cognitively intact, communitydwelling elderly primary care patients. J Am Geriatr Soc 2005;53(9):1570–6.

29. Podsiadlo D, Richardson S. The timed "Up &Go": A test of basic functional mobility for frail elderly persons. J AmGeriatr Soc 1991;39(2):142–8.

30. Dansie EJ, Turk DC, Martin KR, Van Domelen DR, Patel KV. Association of chronic widespread pain with objectively measured physical activity in adults: Findings from the National Health and Nutrition Examination survey. J Pain 2014;15(5):507–15.

31. Grubert E, Baker TA, McGeever K, Shaw BA. The role of pain in understanding racial/ethnic differences in the frequency of physical activity among older adults. J Aging Health 2013;25(3):405–21.

32. 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(3):293–301.

33. Aoyagi Y, Shephard RJ. Sex differences in relationships between habitual physical activity and health in the elderly: Practical implications for epidemiologists based on pedometer/accelerometer data from the Nakanojo Study. Arch Gerontol Geriatr 2013;56 (2):327–38.

34. Stubbs B, Aluko Y, Myint PK, Smith TO. Prevalence of depressive symptoms and anxiety in osteoarthritis: A systematic review and meta-analysis. Age Ageing 2016;45(2):228–35.

35. Hall AJ, Stubbs B, Mamas MA, Myint PK, Smith TO. Association between osteoarthritis and cardiovascular disease: Systematic review and meta-analysis. Eur J Prev Cardiol 2016;23(9):938–46.

36. Veronese N, Cereda E, Maggi S, et al. Osteoarthritis and mortality: A prospective cohort study and systematic review with meta-analysis. Semin Arthritis Rheum 2016;46(2):160–7.

37. Stubbs B, Patchay S, Soundy A, Schofield P. The avoidance of activities due to fear of falling contributes to sedentary behavior among communitydwelling older adults with chronic musculoskeletal pain: A multisite observational study. Pain Med 2014;15(11):1861–71.

38. Stubbs B, Schofield P, Patchay S, Leveille S. Musculoskeletal pain characteristics associated with lower balance confidence in community-dwelling older adults. Physiotherapy 2016;102:152–8.

39. Stubbs B, Binnekade T, Eggermont L, et al. Pain and the risk for falls in community-dwelling older adults: Systematic review and meta-analysis. Arch Phys Med Rehabil

2014;95(1):175–87.e9.

40. Mansi S, Milosavljevic S, Baxter GD, Tumilty S, Hendrick P. A systematic review of studies using pedometers as an intervention for musculoskeletal diseases. BMC Musculoskelet Disord 2014;15 (1):231.