Journal of Community Health (2019) 44:587–595
https://doi.org/10.1007/s10900-018-00614-5

ORIGINAL PAPER

Prevalence and Factors Associated with Frailty and Cognitive Frailty Among Community-Dwelling Elderly with Knee Osteoarthritis

Kulthanit Wanaratna[1,2] · Weerasak Muangpaisan[1] · Vilai Kuptniratsaikul[3] · Chalobol Chalermsri[1] · Apiwan Nuttamonwarakul[4]

Published online: 2 January 2019

Abstract
Physical frailty and cognitive impairment are risk factors for adverse outcomes in older people with osteoarthritis of the knee (knee OA). This cross-sectional study was conducted to determine the prevalence and associated factors of frailty and cognitive frailty among community-dwelling older patients with knee OA in four representative cities of Thailand. Data composed of three parts, Part 1: Demographic data, Part 2: The assessment of frailty by Fried phenotype and cognitive function by MiniCog and Part 3: The assessment of factors associated with frailty. Of 780 elders (mean age, 69.4 ± 6.9 years) screened, 101 (12.9%) were classified to be frail, 511 (65.6%) pre-frail and 168 (21.5%) non-frail. The prevalence of cognitive frailty was 2.44%. The correlation between physical activity rated by the Global Physical Activity Questionnaire (GPAQ) and self-rated methods was high (kappa 0.721; $p < 0.001$). Self-rated physical activity yielded similar prevalence of frail (9.4%), pre-frail (69.1%) and non-frail (21.5%). In multivariate analysis, aging (OR 3.42; 95% CI 1.16–10.11), severe knee OA symptoms (OR 18.96; 95% CI 3.53–101.65), malnutrition (OR 2.50; 95% CI 1.23–5.09), and functional dependence (OR 3.94; 95% CI 1.19–13.03) were associated with frailty. The prevalence of frailty and pre-frailty was high in knee OA and associated with aging, severe knee OA symptoms, malnutrition, and functional dependence, whereas the prevalence of cognitive frailty was not uncommon in community-dwelling elderly. Physical activity rated by the GPAQ and self-rated methods were highly correlated. Self-rated physical activity may be used in community surveys of frailty.

Keywords Frailty · Osteoarthritis · Older · Cognitive · Physical activity

Introduction

The reported prevalence of osteoarthritis (OA) varies widely according to the definition of OA, the joint(s) under study, and population characteristics [1]. The prevalence of knee OA is reported to be between 19.2 and 45.6% [2–4]. Prevalence is likely to increase due to the aging population and the obesity epidemic.[1] OA causes functional limitations and affects the ability to perform normal daily activities [1, 5]. Systemic factors (genetics, dietary intake, estrogen use, and bone density) and local biomechanical factors (muscle weakness, obesity, and joint laxity) contribute to OA [2, 6].

Knee OA and frailty are statistically correlated [5] and share some associated factors such as aging and female gender. Knee OA is associated with higher prevalence and risk of developing frailty. Patients with knee OA are likely to reduce their physical activities, which results in loss of muscle mass and may contribute to frailty. Therefore, the presence of frailty in patients with knee OA suggests vulnerability to other adverse outcomes associated with frailty, in addition to those that are independently associated with knee OA. There have been few studies investigating frailty in OA. Some studies were conducted in a hospital where the subjects may not be similar to community dwelling elderly. Previous studies mostly focused on factors associated with

✉ Weerasak Muangpaisan
drweerasak@gmail.com

1 Department of Preventive and Social Medicine, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand

2 Department of Thai Traditional and Alternative Medicine, Ministry of Public Health, Mueang Nonthaburi District, Nonthaburi, Thailand

3 Department of Rehabilitation Medicine, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand

4 Department of Medical Services, Ministry of Public Health, Mueang Nonthaburi District, Thailand

activities of daily living and quality of life but did not study the individual clinical characteristics and other factors such as cognitive, emotional, physical, nutritional status, exercise, and lean muscle mass (sarcopenia) that are associated with frailty in patients with OA [5, 7–12].

Physically frail elderly are more likely to be cognitively impaired than healthy controls. Cognitive frailty is defined as the simultaneous presence of physical frailty and cognitive impairment. It is a risk factor for dementia and mortality in older adults. Previous studies have used the Cardiovascular Health Study (CHS) criteria for frailty and mild cognitive impairment (MCI) status as determined by the Clinical Dementia Rating Scale (CDR) 0.5 or Mini Mental State Examination (MMSE) test for cognitive impairment [13, 14]. The prevalence of cognitive frailty is reported to be 1–5% as defined by physical frailty and CDR 0.5 or MCI scores in community-dwelling older adults [15]. However, using the CDR in a community survey is difficult and limits further routine evaluation of the condition in clinical practice.

The objective of this study was to determine the prevalence and factors associated with frailty and cognitive frailty among community-dwelling older patients with knee OA. The aim was to better understand the magnitude of this problem and devise strategies to prevent frailty among community-dwelling older patients with knee OA. Assessing physical frailty in clinical practice is challenging. The Global Physical Activity Questionnaire (GPAQ) is time-consuming and requires advanced training [16]. Therefore, we investigated the correlation between GPAQ scores and self-rated methods. If the two methods yield similar results, they could be used interchangeably in community setting where human resources and time in assessment are the major concern.

Materials and Methods

The objective of this study was to determine the prevalence and factors associated with frailty and cognitive frailty among community-dwelling older patients with knee OA.

Participants

Participants were required to be aged 60 years and older who received services at a mobile medical unit for patients with osteoarthritis operated by the Department of Medical Service, Ministry of Public Health in Phayao, Mukdahan, Ranong and Angthong cities. Participants had good consciousness, and were able to communicate in the Thai language. Participants were excluded if they had major neurological problems significantly affecting mobility or communication such as Parkinsonism or stroke, or were otherwise unable to be tested with the research instruments. For example, subjects who could not complete handgrip strength measurements, walk independently, had an acute illness, got some metal implanted in the body such as a pacemaker, were excluded.

Instruments and Measurement

The questionnaire included the collection of demographic data, an assessment of frailty and cognitive function, and an exploration of factors associated with frailty as described below.

Frailty

The five criteria of the Cardiovascular Health Study [7] were modified with the local norm in this study to define frailty as follows:

(1) Unintentional weight loss: a decrease of 4.5 kg or more than 5% of the baseline weight within a period of 1 year,
(2) Exhaustion: evaluation of self-perception to answer the question "Last week, how often did you feel any tension or fatigue?" If the answer was fatigue or weakness for at least 3 days in one week, the subject was grouped into "presence of the exhaustion",
(3) Physical activity (PA) was measured by the Global Physical Activity Questionnaire (GPAQ), which was developed by the WHO for physical activity surveillance [16]. The GPAQ measures all activities during everyday life including activity at work, travelling to and from places, and recreational activities. The metabolic equivalent (MET)-minutes per week for each domain was calculated as MET level x minutes of activity per week. The total METs score was in equation:

$$\text{Total PA} = [(\text{vigorous work} \times 8) + (\text{moderate work} \times 4) + (\text{transport} \times 4) + (\text{vigorous recreation} \times 8) + (\text{moderate recreation} \times 4)]$$

then categorized into two levels as follows:

The METs score more than or equal to 600 means moderate to high physical activity and METs score of less than 600 means low physical activity.

A second measurement of physical activity was by performed by interviewing participants to rate "How do you feel about your physical activity?" The possible responses were low, moderate or high level. The participants' answer as low was interpreted as low physical activity.

(4) Slowness: The assessment was done by asking the participants to walk in horizontal distance of 4.5 m, stratified by gender and height as follows [7]:

- In men with a height of ≤ 173 cm or women with a height of ≤ 159 cm, the researcher used a cut-off point of 7 s.
- In men with a height of 173 cm and taller or women with a height of 159 cm and taller, the researcher used a cut-off point of 6 s.

(5) Weakness: measured by Dynamometer. Each hand was evaluated for three times of dominant hand and the best result was chosen. The result was stratified by gender and weight and determined by norm of older Thai aged 60–69 years, as follows [17]:

- A score of less than 0.35 kg/kg of body weight in men was interpreted as weakness.
- A score of less than 0.26 kg/kg of body weight in women was interpreted as weakness.

Participants who had at least 3 of the 5 symptoms were determined to be frail. If they had 1–2 symptoms they were classified as pre-frail or moderately frail.

Cognitive Function

The assessment of cognitive function was performed by using modified MINI-COG™—PS version [18, 19] which can be used effectively after brief training in both healthcare and community settings and takes 3 min to complete. It consists of a 3-item recall test for memory and a clock drawing test. The result is categorized as no impairment (score 3–5) or possible impairment (0–2).

Cognitive frailty was operationalized using the MiniCog (impaired MiniCog: score 0–2) for the evaluation of cognitive function and the five criteria of the Cardiovascular Health Study (cut-off score equal or higher than 3) for the evaluation of physical frailty.

Associated Factors

Measurement of Knee OA

The assessment of the diagnosis and severity of osteoarthritis was based on both history and physical examination including diagnosis in the medical record and the Oxford knee score. The Oxford knee score [20, 21] is a questionnaire intended specifically for knee surgery. Twelve questions are classified into function and pain scales. Severity is categorized into four levels: severe (0–19), moderate (20–29), mild (30–39) and no symptoms (40–48).

Nutritional Assessment

Mini Nutritional assessment-Short Form (MNA-SF) was used to screen participants at risk of malnutrition [22]. A score of 12 points or higher is defined as normal. A score of 11 points or less means the subject is at risk of malnutrition.

Functional Assessment

Barthel's ADL index which consisted of ten questions was used to assess ability to perform basic activities of daily living [23]. There are four levels of scoring: totally dependent (0–4), severe dependent (5–8), moderate dependent (9–11) and mild dependent (≥ 12). Assessment of the ability to do instrumental activities of daily living (IADL) with the equipment involved [24]. This is to evaluate the 6 activities: (1) use of the phone (2) travel outside the home use - do not use vehicles (3) buy food / utensils (4) cook/ heat food (5) financial management and (6) clean house.

Depression

Patient Health Questionnaires (PHQ9) [25] were used to screen for and classify the severity of depressive symptoms with possible scores 0–27. The criteria are divided into four levels: no depression (0–9), mild depression (10–14), moderate depression (15–19) and severe depression (20–27).

Self-Perceived Health Status and Medical Illness

Information on self-perceived health status, physical illness, hospitalization, history of falling within the past year, alcohol consumption and smoking were collected from case record forms and face-to-face interviews.

Data Collection

Ethical approval for this study was obtained from the Siriraj Institutional Review Board of the Faculty of Medicine Siriraj Hospital, Mahidol University. Informed consent was obtained from all study participants. Healthcare personnel were trained to collect the data and use measurement instruments. The researcher introduced the study protocol to the head of a mobile medical unit and asked for cooperation in data collection. The researcher screened sample subjects according to inclusion and exclusion criteria, introduced the study protocol, and asked for informed consent to participate.

Data Analysis

Statistical analysis was performed using SPSS for Windows version 19 software. All data were tested for normality.

Baseline characteristics and characteristics of factors were analyzed using the descriptive statistics. Analytic statistics was used to investigate factors associated with frailty including personal factors, physical/psychological factors and social/environmental factors. Qualitative data were compared by Chi square test and strength of association was calculated by binary logistic regression. Univariate and multivariate regression analyses were applied. All statistically significant variables in the univariate analysis were subjected to multivariate analysis to analyze the predictors of frailty. Statistical significance was set at p-value < 0.05.

Results

A total of 780 elderly participants were recruited with a mean age of 69.4 years (SD: 6.9). Six hundred (77.7%) participants were women, 503 (64.5%) were married, 720 (92.3%) had no more than primary school education, 291 (37.3%) reported income insufficiency, 273 (35%) rated their health status as poor, and 516 (66.1%) had comorbidities other than knee OA. Regarding clinical characteristics, 395 (50.6%) fell in the past year, 124 (15.9%) had impaired cognitive function by MiniCog, 74 (9.5%) were dependent in IADL, 59 (7.5%) were positive for depression by PHQ-9, 389 (49.9%) were obese, while 253 (32.4%) were at risk for malnutrition (Table 1).

The most common items in the frailty diagnostic criteria were slowness 497 (63.6%), low physical activity 281 (36.0%) and weakness 162 (20.7%) (Table 2). The prevalence of frailty was 9.4%, pre-frailty 69.1% and non-frail was 21.5% as determined by self-rated physical activity. Pearson correlation of diagnosis of frail, pre-frail and non-frail by GPAQ and self-reported physical activity were 0.721 (p < 0.001). The prevalence of cognitive frailty was 2.44%. Frailty was present in 101 (12.9%) of all participants, ranging from 5.6% in Angthong city to 21.4% in Mukdahan city (Table 3). The overall prevalence of pre-frailty was 65.6% and the "non-frail" condition was found in 21.5%.

Factors Associated with Frailty Among Community-Dwelling Older Patients with Knee OA

Personal Factors

There were three factors including age group, gender and education level associated with frailty by univariate analyses. Odds ratio in group of over 80 years was 8.69 (95% CI 3.48–21.65), in female was 2.37 (95% CI 1.30–4.32) and in low educational level was 4.07 (95% CI 1.37–12.10).

Physical and Psychological Factors

Poor self-perceived health status, moderate and severe knee OA, impaired cognitive function, at risk for malnutrition, IADL dependency and depression were associated with frailty by crude analyses with OR of 2.89 (95% CI 1.71–4.89), 9.67 (95% CI 2.16–43.37), 33.83 (95% CI 7.39–154.90), 2.35 (95% CI 1.13–4.86), 3.77 (95% CI 2.17–6.53), 11.30 (95% CI 4.17–30.58) and 6.41 (95% CI 2.47–16.68), respectively.

Social and Environmental Factors

Inadequate income was associated with frailty in univariate analysis with OR 1.76 (95% CI 1.07–2.92). There was no association between other social/environmental factors and frailty.

Factors that remained significant in the multivariate analyses were older age, severity of knee OA, malnutrition risk and dependent status in ADLs (Table 4). Age 80 years and older was associated with frailty (OR 3.42; 95% CI 1.16–10.11). Moderate knee OA was associated with frailty (OR 8.98; 95% CI 1.77–101.65) and the OR for severe knee OA was18.96 (95% CI 3.53–101.65). At risk for malnutrition was independently associated with frailty (OR 2.50, 95% CI 1.23–5.09). Moderate to totally dependent IADL was associated with frailty (OR 3.94; 95% CI 1.19–13.03). Multivariate analysis of factors associated with frailty defined by self-rated physical activity were age group 80 years and older (OR 10.96; 95% CI 3.17–37.94; p < 0.001), severe OA knee (OR 14.86; 95% CI 3.56–62.06; p < 0.001), and MNA-SF at risk for malnutrition (OR 2.44; 95% CI 1.13–5.30; p = 0.024).

Discussion

We found that knee OA is associated with frailty. This finding is consistent with a study by Misra et al. which reported a higher prevalence of frailty in participants with radiographic diagnosis (ROA) and symptomatic knee OA (SOA) [26]. The prevalence of frailty in our study was 12.9% which is higher than in that study (4.39% in ROA and 5.88% in SOA), but lower than a study by Miguel et al. (22.4%) [5]. However, the study by Misra et al. showed relatively low prevalence of frailty compared to the prevalence of frailty in the general older population [26]. One possible reason for this discrepancy may be the different diagnostic criteria used to define frailty. Misra et al. used the Study of Osteoporotic Fracture (SOF) index whereas we used Cardiovascular Health Study Index. In addition, the study by Miguel et al. was conducted in 58 participants; therefore, the estimate of prevalence might be less precise [5].

Table 1 Characteristics of participants according to their frailty category

Characteristics	Normal (n, %)	Pre frail (n, %)	Frail (n, %)	Total (n, %)	p-value
Age (mean ± SD)	67.6 ± 5.7	69.4 ± 6.7	72.2 ± 8.6	69.4 ± 6.9	< 0.001
%Female	66.1%	80.6%	82.2%	77.7%	< 0.001
Education level ≤Primary school	85.1%	93.9%	96.0%	92.3%	< 0.001
Marital status					0.343
Single	6.0%	3.3%	2.0%	3.7%	
Married	66.0%	65.2%	58.3%	64.5%	
Widowed	25.0%	27.8%	34.7%	28.1%	
Divorced/separated	3.0%	3.7%	5.0%	3.7%	
Living alone	7.7%	8.6%	7.1%	8.2%	0.775
Income insufficiency	35.7%	35.4%	49.5%	37.3%	0.025
Poor self-perceived health	26.1%	34.9%	50.5%	35.0%	< 0.001
Underlying disease					
Diabetes	13.7%	21.1%	17.0%	19.0%	0.088
Hypertension	47.6%	43.6%	53.0%	45.7%	0.195
Dyslipidemia	17.9%	18.8%	20.0%	18.7%	0.909
Cardiovascular disease	6.0%	5.1%	10.0%	5.9%	0.163
Cancer	0%	0.6%	1.0%	0.5%	0.500
Chronic obstructive pulmonary disease	0%	0.8%	0%	0.5%	0.348
No known underlying disease	36.9%	34.2%	27.0%	33.9%	0.243
Current/previous alcoholic drinking	20.2%	11.7%	10.9%	13.5%	0.014
Current/previous smoking	17.1%	12.1%	13.0%	13.3%	0.265
Health insurance					
Universal coverage	50.0%	56.8%	64.4%	56.3%	0.067
Civil servant medical benefit scheme	16.1%	14.7%	11.9%	14.6%	0.640
Hospital visit during a past year (yes)	41.1%	33.0%	36.0%	35.1%	0.162
Falling during a past year (yes)	48.2%	52.1%	47.0%	50.6%	0.513
Impaired MiniCog	9.0%	17.6%	18.8%	15.9%	0.021
Oxford knee score					< 0.001
Normal	17.6%	11.1%	2.0%	11.3%	
Mild	40.6%	33.5%	16.2%	32.8%	
Moderate	29.1%	30.0%	32.3%	30.1%	
Severe	12.7%	25.4%	49.5%	25.8%	
Body mass index	24.6 ± 3.3	25.0 ± 4.0	26.7 ± 5.4	25.1 ± 4.1	< 0.001
BMI ≥ 25	44.0%	48.6%	66.0%	49.9%	0.002
At risk for malnutrition by MNA-SF	19.0%	33.9%	47.0%	32.4%	< 0.001
Moderate to totally dependent in basic ADL	0.6%	0.4%	2.0%	0.6%	0.190
Moderate to totally dependent in IADL	3.0%	8.4%	25.7%	9.5%	< 0.001
Mild to severe depressive symptoms by PHQ-9	3.6%	6.5%	19.2%	7.5%	< 0.001

The association between frailty and knee OA may reflect pathophysiological mechanisms common to both conditions. Arthralgia in knee OA, especially those with severe OA knee, limits physical activity as observed by the high proportion of slow gait speed (63.6%) and low PA (36%). For comparison, the Cardiovascular Health Study by Fried et al. reported that 20% of their sample had slow gait speed and and 22% had low PA [7]. Knee pain could lead to loss of muscle mass, limitation in walking and daily activity. Furthermore, several studies have reported that inflammatory cytokines involved in frailty also increased in knee OA [27, 28].

Older age can lead to frailty due to the decline of body reserves. Chronic illnesses increase with age, the likelihood of being disabled by disease doubles every 5–7 years, and the risk for functional limitation increases [29]. The association of frailty with advancing age has been clearly established [7, 30, 31]. We found that socioeconomic status (education level, family income insufficiency) was related to frailty. This could be explained by the less opportunity to

Table 2 Distribution of positive items of frailty criteria in four cities

Criteria	Phayao No. (%)	Angthong No. (%)	Ranong No. (%)	Mukdahan No. (%)	Overall No. (%)
Slowness	182 (66.4)	55 (44.0)	149 (72.3)	111 (62.7)	497 (63.6)
Exhaustion	46 (16.8)	6 (4.8)	19 (9.2)	8 (4.5)	79 (10.1)
Weakness	39 (14.2)	17 (13.6)	72 (35.0)	34 (19.2)	162 (20.7)
Weight loss	18 (6.6)	9 (7.2)	7 (3.4)	11 (4.8)	45 (5.8)
Low PA					
GPAQ	72 (26.4)	46 (36.8)	92 (44.9)	71 (40.1)	281 (36.0)

Table 3 Distribution of frail, pre-frail and non-frail in four cities

Category	Payao Number (%)	Angthong Number (%)	Ranong Number (%)	Mukdahan Number (%)	Overall Number (%)
Frail	29 (10.6)	7 (5.6)	44 (21.4)	21 (11.9)	101 (12.9)
Pre-frail	182 (66.7)	79 (63.2)	127 (62.0)	123 (69.5)	511 (65.6)
Non-frail	62 (22.7)	39 (31.2)	34 (16.6)	33 (18.6)	168 (21.5)
Total	273	125	205	177	780

Table 4 The univariate and multivariate analyses for the associated factors and frailty

Variables	Univariate analysis		Multivariate analysis	
	Crude OR (95% CI)	p-value	Adjusted OR (95% CI)	p-value
Age group				
60–69 years old	1.00		1.00	
70–79 years old	1.65 (0.95–2.89)	0.076	1.75 (0.84–3.64)	0.135
80 years old and over	8.69 (3.48–21.65)	< 0.001	3.42 (1.16–10.11)	0.026*
Gender				
Female	2.37 (1.30–4.32)	0.005	1.65 (0.77–3.54)	0.199
Education level				
Under primary school	4.07 (1.37–12.10)	0.012	1.42 (0.38–5.27)	0.602
Income insufficiency				
Not enough	1.76 (1.07–2.92)	0.027	1.44 (0.73–2.84)	0.295
Self-assessed health				
Poor	2.89 (1.71–4.89)	< 0.001	1.56 (0.76–3.20)	0.225
Severity of OA knee				
Mild	3.46 (0.75–16.04)	0.112	4.07 (0.76–21.75)	0.100
Moderate	9.67 (2.16–43.37)	0.003	8.98 (1.77–101.65)	0.008*
Severe	33.83 (7.39–154.90)	< 0.001	18.96 (3.53-101.65)	0.001*
Cognition function				
Impaired	2.35 (1.13–4.86)	0.022	1.85 (0.71–4.84)	0.208
Nutritional status				
Malnutrition risk	3.77 (2.17–6.53)	< 0.001	2.50 (1.23–5.09)	0.012*
IADL				
Mod to totally	11.30 (4.17–30.58)	< 0.001	3.94 (1.19–13.03)	0.025*
Depression				
Mild to severe	6.41 (2.47–16.68)	< 0.001	2.90 (0.84–9.94)	0.091

*$p < 0.05$

promote healthy status and access to healthcare in those with poor socioeconomic status. This finding was consistent with a study by Myers et al. that found low income patients had more than twice the risk of becoming frail compared with those with higher income [33]. Another possible explanation is that the elderly with lower education and lower family income might have lower health awareness and less nutritious food intake which could lead to health and nutritional problems. This finding was in accordance with a study by Castell that found frailty was more frequent in persons with low educational level and socioeconomic status [34].

We observed that malnutrition risk and IADL dependency were associated with frailty, similar to other studies of patients with cardiovascular disease [7, 12]. Poor dietary intake and nutritional deficiencies are recognized as important causes of age-related sarcopenia, dynapenia and frailty [35, 36]. This factor remained significantly associated after adjustment for other variables. IADL dependence would be at higher risk than those who were IADL independent. However, many studies have reported ADL and IADL dependency as an adverse outcome of frailty. Therefore, this research cannot establish a causal relationship between the two conditions [8, 37]. It is not yet clear if frailty leads to IADL dependence or IADL dependence leads to frailty, or both.

The relationship between frailty and cognitive impairment is controversial. Cognitive frailty is defined by the presence of physical frailty together with cognitive impairment. Both conditions share etiologic mechanisms, including chronic inflammation, vascular risk factors, hormonal mechanisms, and nutritional factors [37]. Previous studies used the CHS criteria for frailty and MCI status as determined by CDR 0.5 or impaired MMSE test for cognitive impairment [13, 14]. However, there is no universally accepted definition. CDR needs special training and is time-consuming to execute which limits its use in community surveys and clinical practice. MiniCog is reported to have similar sensitivity and specificity as compared to MMSE and takes less time to complete. Therefore, it may be more practical to screen for cognitive frailty in routine clinical practice or community service [38]. Self-rated physical activity in this study yielded similar prevalence to GPAQ of frailty/pre-frailty and non-frailty with high kappa correlation. It takes less time and could be useful in community surveys and routine clinical practice.

This study has some limitations. We used a convenience sample of elderly that attend community health service clinic that may not be representative of the general population. For example, persons who attend community health service clinics may be different from than those who do not attend in ways that influence the prevalence of frailty. We relied on self-report for several outcomes. Self-report is subject to a variety of biases, potential miscommunications and participants with cognitive impairment might report unreliable data. The researcher assessed the Mini-Cog which has similar sensitivity (76% vs. 79%) and specificity (89% vs. 88%) to the Mini Mental State Examination (MMSE) in screening for cognitive impairment. It was acceptable in screening for community survey with shorter time to administer [39]. Finally, this was a cross-sectional study which was suitable for determining the prevalence of frailty. This design is commonly used for public health planning and allows for the assessment of several outcomes and risk factors simultaneously, is relatively inexpensive and is time saving. However, it does not allow us to make causal inferences because we do not know the temporal relationship between the exposure and outcome. The onset of frailty is not known, as it is a condition that is likely to be under-recognized. Therefore it is likely that the temporal relationship with the exposures could not be determined which might result in reverse causality. The adverse outcomes of frailty should be collected and measured such as health index, morbidity and mortality. A prospective cohort study or survival analysis could give more information regarding the adverse outcomes of frailty. Finally, our results might be confounded by unmeasured factors.

The was the first study of frailty and cognitive frailty in patients with knee OA in Thailand. The study was conducted in a community setting in four representative cities of the country in rural areas. The sample size was sufficiently large to answer questions about the prevalence and detect associated factors. Several factors were measured robustly using standard tools. Moreover, the high correlation between the GPAQ and self-rated physical activity and the similar prevalence as determined by the two methods could allow future use of self-rated physical activity in the community setting. The result can be used the public health policy in the future.

The prevalence of frailty was quite high and the prevalence of pre-frailty was 65.6%. This situation requires management and health care planning to prevent frailty in patients with osteoarthritis of the knee in order to reduce the rate of hospitalization, falls, disability and mortality. Modifiable factors associated with frailty in this study include socioeconomic and nutritional status and severity of OA knee. Socioeconomic factors may be indirectly improved by occupational and educational support. This may lead to opportunities to access healthcare services and improved self-care to reduce frailty. Routine screening for early diagnosis of pre-frailty could be used to prevent future adverse outcomes. Comprehensive geriatric assessment and multimodal interventions to promote physical activity, exercise, healthy diet, cardiovascular risk reduction, social participation and a cognitively active lifestyle may be the most effective intervention to prevent frailty and cognitive frailty [40].

Acknowledgements The authors would like to thank Mrs. Angkana Jongsawaddipatana and all staff members of Institute of Geriatric Medicine, Department of Medical Service, Ministry of Public Health for their collaboration in collecting data.

Funding This work was financially supported by the His Royal Highness Princess Chainat Narenthorn Foundation. The funder had no role in the study design, data collection or analysis, writing of the report, or the decision to publish this article.

Compliance with Ethical Standards

Conflict of interest The authors declare no conflicts of interest, financial or otherwise.

References

1. Zhang, Y., & Jordan, J. M. (2010). Epidemiology of osteoarthritis. *Clinics in Geriatric Medicine, 26*(3), 355–369.
2. Felson, D. T., Lawrence, R. C., Dieppe, P. A., Hirsch, R., Helmick, C. G., Jordan, J. M., … Fries, J. F. (2000). Osteoarthritis: New insights. Part 1: The disease and its risk factors. *Annals of Internal Medicine, 133*(8), 635–646.
3. Woolf, A. D., & Pfleger, B. (2003). Burden of major musculoskeletal conditions. *Bulletin of the World Health Organization, 81*(9), 646–656.
4. Lawrence, R. C., Felson, D. T., Helmick, C. G., Arnold, L. M., Choi, H., Deyo, R. A., … Wolfe, F. (2008). Estimates of the prevalence of arthritis and other rheumatic conditions in the United States. Part II. *Arthritis and Rheumatism, 58*(1), 26–35.
5. Miguel, R. C., Dias, R. C., Dias, J. M., da Silva, S. L., Filho, M., P.R., & Ribeiro, T. M. (2012). Frailty syndrome in the community-dwelling elderly with osteoarthritis. *Revista Brasileira de Reumatologia, 52*(3), 331–347.
6. Collard, R. M., Boter, H., Schoevers, R. A., & Oude Voshaar, R. C. (2012). Prevalence of frailty in community-dwelling older persons: A systematic review. *Journal of the American Geriatrics Society, 60*(8), 1487–1492.
7. Fried, L. P., Tangen, C. M., Walston, J., Newman, A. B., Hirsch, C., Gottdiener, J., … McBurnie, M. A. (2001). Frailty in older adults: Evidence for a phenotype. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 56*(3), 46–56.
8. Rockwood, K., Song, X., MacKnight, C., Bergman, H., Hogan, D. B., McDowell, I.,… Mitnitski, A. (2005). A global clinical measure of fitness and frailty in elderly people. *CMAJ, 173*(5), ,489–495.
9. Pialoux, T., Goyard, J., & Lesourd, B. (2012). Screening tools for frailty in primary health care: A systematic review. *Geriatrics & Gerontology International, 12*(2), 189–197.
10. Clegg, A., & Young, J. (2011). The frailty syndrome. *Clinical Medicine (London, England), 11*(1), 72–75.
11. Kim, S., Park, J. L., Hwang, H. S., & Kim, Y. P. (2014). Correlation between frailty and cognitive function in non-demented community dwelling older Koreans. *Korean Journal of Family Medicine, 35*, 309–320.
12. Shim, E. Y., Ma, S. H., Hong, S. H., Lee, Y. S., Paik, W. Y., Seo, D. S.,… Yoon, J. L. (2011). Correlation between frailty level and adverse health-related outcomes of community-dwelling elderly, one year retrospective study. *Korean Journal of Family Medicine, 32*, 249–256.
13. Delrieu, J., Andrieu, S., Pahor, M., Cantet, C., Cesari, M., Ousset, P. J.,… Vellas, B. (2016). Neuropsychological Profile of "Cognitive Frailty" Subjects in MAPT Study. *Journal of Prevention of Alzheimer's Disease, 3*(3), 151–159.
14. Roppolo, M., Mulasso, A., & Rabaglietti, E. (2017). Cognitive Frailty in Italian community-dwelling older adults: Prevalence rate and its association with disability. *The Journal of Nutrition, Health and Aging, 21*(6), 631–636.
15. Arai, H., Satake, S., & Kozaki, K. (2018). Cognitive Frailty in Geriatrics. *Clinics in Geriatric Medicine, 34*(4), 667–675.
16. World Health Organization. (2007). *Global Physical Activity Questionnaire (GPAQ)*. Geneva:WHO.
17. Samahito, S., Bhatharobhas, V., Ruangthai, R., Sriyaphai, A., & Thearnthong, A. (2004). Physical fitness norms for Thai people and Kasetsart University physical fitness analysis program version 1.0. *Kasetsart Educational Review, 2*, 27–40.
18. Borson, S., Scanlan, J., Brush, M., Vitaliano, P., & Dokmak, A. (2000). The mini-cog: A cognitive 'vital signs' measure for dementia screening in multi-lingual elderly. *International Journal of Geriatric Psychiatry, 15*(11), 1021–1027.
19. Trongsakul, S., Lambert, R., Clark, A., Wongpakaran, N., & Cross, J. (2015). Development of the Thai version of Mini-Cog, a brief cognitive screening test. *Geriatrics & Gerontology International, 15*(5), 594–600.
20. Dawson, J., Fitzpatrick, R., Murray, D., & Carr, A. (1998). Questionnaire on the perception of Patients about total Knee replacement. *The Journal of Bone and Joint Surgery. British, 80*(1), 63–69.
21. Charoencholvanich, K., & Pongcharoen, B. (2005). Oxford Knee Score and SF-36: Translation & reliability for use with total knee arthroscopy patients in Thailand. *Journal of the Medical Association of Thailand, 88*(9), 1194–1202.
22. Kaiser, M. J., Bauer, J. M., Ramsch, C., Uter, W., Guigoz, Y., Cederholm, T.,… Sieber, C. C. (2009). Validation of the Mini Nutritional Assessment Short Form (MNA-SF); A practical tool for identification of nutritional status. *Journal of Nutrition, Health and Aging, 13*, 782–788.
23. Mahoney, F. I., & Barthel, D. W. (1965). Functional evaluation: The Barthel Index. *Maryland State Medical Journal, 14*, 61–65.
24. Lawton, M. P., & Brody, E. M. (1969). Assessment of older people: Self-maintaining and instrumental activities of daily living. *Gerontologist, 9*(3), 179–186.
25. Williams, L. S., Brizendine, E. J., Plue, L., Bakas, T., Tu, W., Hendrie, H.,… Kroenke, K. (2005). Performance of the PHQ-9 as a screening tool for depression after stroke. *Stroke, 36*(3), 635–638.
26. Lotrakul, M., Sumrithe, S., & Saipanish, R. (2008). Reliability and validity of the Thai version of the PHQ-9. *BMC Psychiatry, 8*, 46.
27. Misra, D., Felson, D. T., Silliman, R. A., Nevitt, M., Lewis, C. E., Torner, J.,… Neogi, T. (2015). Knee osteoarthritis and frailty: Findings from the Multicenter Osteoarthritis Study and Osteoarthritis Initiative. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 70*(3), 339–344.
28. Bindawas, S. M., Vennu, V., & Stubbs, B. (2018). Longitudinal relationship between knee pain status and incident frailty: Data from the Osteoarthritis Initiative. *Pain Medicine, 19*(11), 2146–2153.
29. Castell, M. V., van der Pas, S., Otero, A., Siviero, P., Dennison, E., Denkinger, M.,… Deek, D. (2015). Osteoarthritis and frailty in elderly individuals across six European countries: Results from the European Project on OSteoArthritis (EPOSA). *BMC Musculoskeletal Disorder, 16*, 359.
30. Syddall, H., Roberts, H. C., Evandrou, M., Cooper, C., Bergman, H., & Sayer, A., A (2010). Prevalence and correlates of frailty among community-dwelling older men and women: Findings from the Hertfordshire Cohort Study. *Age Ageing., 39*, 197–203.

31. Fried, L. P., Walston, J. D., & Ferrucci, L. (2009). *Hazzard's geriatric medicine and gerontology* (6th ed., pp. 631–645). New York: McGraw-Hill.
32. Clegg, A., Young, J., Iliffe, S., Rikkert, M. O., & Rockwood, K. (2013). Frailty in elderly people. *Lancet, 381*, 752–762.
33. Myers, V., Drory, Y., Goldbourt, U., & Gerber, Y. (2014). Multilevel socioeconomic status and incidence of frailty post myocardial infarction. *International Journal of Cardiology, 170*(3), 338–343.
34. Castell, M. V., Sánchez, M., Julián, R., Queipo, R., Martín, S., & Otero, Á (2013). Frailty prevalence and slow walking speed in persons age 65 and older: Implications for primary care. *BMC Family Practice, 14*, 86.
35. Buckinx, F., Rolland, Y., Reginster, J. Y., Ricour, C., Petermans, J., & Bruyère, O. (2015). Burden of frailty in the elderly population: Perspectives for a public health challenge. *Archives of Public Health, 73*(1), 19.
36. Ng, T. P., Feng, L., Nyunt, M. S., Larbi, A., & Yap, K. B. (2014). Frailty in older persons: Multisystem risk factors and the Frailty Risk Index (FRI). *Journal of the American Medical Directors Association, 15*(9), 635–642.
37. Avila-Funes, J. A., Helmer, C., Amieva, H., Barberger-Gateau, P., Le Goff, M., Ritchie, K., … Dartiques, J. F. (2008). Frailty among community-dwelling elderly people in France: The Three-City study. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 63*(10), 1089–1096.
38. Sheehan, B. (2012). Assessment scales in dementia. *Therapeutic Advances in Neurological Disorders, 5*(6), 349–358.
39. Borson, S., Scanlan, J. M., Chen, P., & Ganguli, M. The Mini-Cog as a screen for dementia: Validation in a population-based sample. *Journal of the American Geriatrics Society*, 51(10):1451–1454.
40. Ngandu, T., Lehtisalo, J., Solomon, A., Levälahti, E., Ahtiluoto, S., Antikainen, R., … Kivipelto, M. (2015). A 2 year multidomain intervention of diet, exercise, cognitive training, and vascular risk monitoring versus control to prevent cognitive decline in at-risk elderly people (FINGER): A randomised controlled trial. *Lancet, 385*(9984), 2255–2263.