Novel Association Between Asthma and Osteoarthritis: A Nationwide Health and Nutrition Examination Survey

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Abstract

Backgrounds: Asthma and osteoarthritis (OA) are medical conditions that disable physical activity and deteriorate patients’ quality of life. Despite the high prevalence, there are limited studies focusing on the comorbid condition and association between asthma and OA. The aim of study was to assess the prevalence and identify the clinical considerations for this special population.

Methods: Adult patients aged over 40 years who completed questionnaire assessments and spirometry were enrolled from Korean National Health and Nutrition Examination Survey. Asthma and OA were defined on the history of doctor-diagnosed disease. Radiographic severities of OA were measured using the Kellgren/Lawrence grading system. Chronic obstructive pulmonary disease (COPD) as a comparative respiratory disease was diagnosed on the basis of spirometric results.

Results: A total of 9344 subjects were enrolled, and the prevalence of asthma and COPD were 4.6%±0.3% and 12.0%±0.5%, respectively. The prevalence of OA in the asthma group was 31.9%±2.8%, which was significantly higher than those in the COPD (17.8%±1.5%) or control (16.2%±0.6%) groups. OA was more prevalent in asthma patients after adjusting for age, sex, body mass index, and smoking status (OR, 1.65; 95% CI, 1.27-2.13). After further adjustment of this model for prescription of OA medication, OA was still independently associated with asthma (OR, 1.56; 95% CI, 1.10-2.20). In contrast, the relationship of OA medication with asthma was not significant (P=0.64). This relationship was evident in subjects with asthma without airflow limitation measured by spirometry (OR, 1.97; 95% CI, 1.32-2.93). Moreover, radiographic severity of knee OA correlated with asthma (OR, 1.10; 95% CI, 1.0-1.21).

Conclusions: OA shows a high prevalence in patients with asthma, with the prevalence being higher than that in COPD patients or controls. The comorbid characteristics of these two conditions need to be considered in clinical practice.

Background

Asthma is a common disease, and the World Health Organization estimates that approximately 300 million people worldwide suffer from this disease [1–3]. The Global Initiative for asthma reports that the prevalence of this disease ranges from 1–18% in different countries [3], and it accounts for about 1% of all disability adjusted life years lost worldwide [4]. Asthma is characterized by chronic airway inflammation with variable airflow limitation, and multifactorial components such as genetic and environmental variations may contribute to its development [3]. Recent reports have suggested that patients with severe asthma who require systemic glucocorticoid therapy have a higher rate of comorbidities, including osteoporosis, dyspeptic disorder, cataract, and obstructive sleep apnea [5]. However, the risk factors and comorbidities of asthma except for atopic disease are largely unknown.

Osteoarthritis (OA) is a degenerative joint disease causing structural joint damage with pain. The prevalence of clinical hand, hip, or knee joint OA in US adults aged 25 years or older increased from 21 million in 1995 to 27 million in just over a decade [6]. OA is prevalent in female patients, increases in
prevalence with age (≥ 50 years), and more frequently affects joints of the hand and knee [6]. Elderly patients with joint pains have limited physical activity that indeed affect their quality of life [7].

Owing to the high prevalence of asthma and OA, they are commonly encountered as comorbid conditions in clinical practice. However, studies to identify the association between asthma and OA are limited. The underlying etiologies of OA and asthma are different; however, they have synergistic effects in hindering physical activity. In both OA and asthma, physical activity is limited due to joint pain and dyspnea, respectively; thus, both conditions lead to a deterioration in the quality of life. However, this comorbidity may be under-recognized in those who prefer a sedentary lifestyle to cope with joint pain or dyspnea. Furthermore, there is concern that non-steroidal anti-inflammatory drugs (NSAIDs), which are commonly prescribed in OA patients, may aggravate the symptoms of asthma [8]. Therefore, examining the prevalence and relationship of OA and asthma is essential to understand their clinical implications on aspects such as physical activities and quality of life. This study aimed to determine the prevalence of OA co-occurring with asthma and identify the characteristics of these comorbid conditions. OA was characterized in normal adults, asthma patients, and chronic obstructive pulmonary disease (COPD) subjects; COPD was selected as a comparative respiratory disease for asthma. The data from the Korean National Health and Nutrition Examination Survey (KNHANES) were used for analyses.

**Methods**

**Study design and participants**

The KNHANES is a collection of nationally representative, cross-sectional, population-based health and nutritional surveys conducted by the Korean Centers for Disease Control and Prevention (KCDC) since 1998. The participants were chosen by proportional allocation system sampling with multiple stratification based on geographical area, age, and sex. KNHANES includes a health interview, physical examination, laboratory tests, and nutritional questionnaire. All subjects who completed the questionnaire, laboratory test, and a pulmonary function test were selected. The entire survey population participated voluntarily and provided written informed consent. The KNHANES protocol was approved by the institutional review board of the KCDC.

**Definition**

Asthma and OA were defined on the basis of responses to a self-reported questionnaire asking “Have you been diagnosed with the disease by a doctor?” (Yes/No) and “Do you take medicine or treatment for the disease?” Asthma patients were divided into two groups according to the presence of airflow limitation on spirometry (forced expiratory volume in 1 second [FEV₁: L]/forced vital capacity [FVC: L] < 0.7). COPD was defined by a spirometry result showing airway obstruction (FEV₁/FVC < 0.7) among adults > 40 years of age without a history of asthma according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines [9]. Other comorbidities, including hypertension, diabetes, hypercholesterolemia, and obesity, were also defined based on the KNHANES protocol. Hypertension was defined as systolic blood
pressure $\geq 140$ mmHg or diastolic blood pressure $\geq 90$ mmHg, or current use of anti-hypertensive medication [10]. Diabetes was defined as a fasting glucose level of $\geq 126$ mg/dL or hemoglobin A1c level of $\geq 6.5\%$, and/or diabetes treatment [11]. Hypercholesterolemia was defined by total cholesterol level $> 240$ mg/dL or current use of lipid-lowering agents [12]. Obesity was defined when subjects had a body mass index (BMI) greater than 25 kg/m$^2$ based on the World Health Organization recommendations for the Asian population [13].

**Measurements**

Spirometry was performed for subjects aged $> 40$ years by using standardized equipment (model 1022; SensorMedics Corp, BD, Franklin Lakes, NJ, USA) according to guidelines of the American Thoracic Society/European Respiratory Society [14]. Spirometry was repeated at least three times to ensure reproducibility and validity. Calculation for predicted values was based on the predictive equation for Korean population [15]. Radiography for the joint was performed with a SD3000 Synchro Stand (Accele Ray, Switzerland) to evaluate OA for subjects $> 50$ years of age. Anteroposterior and lateral plain radiographs of the knee, hip, and spine were taken. Radiographic changes related to OA in each joint were independently assessed by two trained radiologists using the Kellgren/Lawrence (KL) grading system [16, 17]. If the KL grades given by the two radiologists differed for the same case, the higher grade was accepted. If the difference was more than one grade, a third radiologist was consulted, and the grade concordant with the third grade was accepted. Radiographic knee KL grade greater than or equal to 2 in one or both knees was defined as radiographic knee OA. In addition, all subjects described their current symptoms related to sites of pain. Quality of life (QOL) was measured by the validated Korean version of the 5-item self-administered EuroQOL instrument (EQ-5D) [18].

**Statistical analysis**

KNHANES was designed using a complex, stratified, multistage probability-sampling model, and data were analyzed via the complex-sample design to represent the prevalence in the Korean national population using SAS version 9.3 and R version 3.6.0. Data were presented as mean $\pm$ standard error, or frequency ($\%$). In order to compare the characteristics of each subgroup, generalized linear regression was used for continuous variables and logistic regression was used for categorical variables. Models for associations of OA with diseases, including asthma and COPD, were adjusted for age, sex, BMI, current smoking status (model 1) or further adjustment for the prescription of OA medication to the previous model (model 2). Models for the association of pain site or severity of OA on radiographic KL grade with each disease were adjusted for age, sex, BMI, and current smoking status. A $P$-value $< 0.05$ was used to indicate statistical significance.

**Results**

**Characteristics of the participants**
The completed questionnaire and spirometry data for a total of 9344 subjects aged > 40 years from 2010 to 2012 were retrieved from KNHANES. Among these, 425 subjects had self-reported asthma (prevalence, 4.6% ± 0.3%), and 1131 subjects had COPD on the basis of spirometric measurements (prevalence, 12.0% ± 0.5%). In the asthma group, 161 subjects (prevalence, 1.7 ± 0.2%) showed airflow limitation on spirometry (Fig. 1 and Supplemental Figure S1). The demographic and clinical characteristics of participant with the two respiratory diseases—asthma and COPD—were compared with those of the control groups (Table 1). Age of participants with asthma was higher than that in the control group, but lower than that in the COPD group. In comparison with COPD patients, the asthma group included more females and more obese subjects. Subjects with asthma showed comorbid hypertension more frequently than the control group, but less frequently than the COPD group. However, the prevalence of other metabolic syndromes, such as diabetes or hypercholesterolemia, did not significantly differ from that in controls. Subjects with asthma presented the lowest FVC, and those with COPD showed the worst FEV<sub>1</sub>. In addition, QOL measured by EuroQOL was the lowest in the asthma group (Table 1).
Table 1
Baseline characteristics comparing asthma and COPD patients with control groups

|                        | Controls (N = 7787) | Asthma (N = 425) | COPD (N = 1131) | P-value                        |
|------------------------|---------------------|------------------|-----------------|-------------------------------|
|                        | Control vs. Asthma  | Control vs. COPD | Asthma vs. COPD  |
| Prevalence, %          | 83.4 ± 0.6          | 4.6 ± 0.3        | 12.0 ± 0.5      | < 0.001 < 0.001 < 0.001       |
| Age, mean ± SD         | 54.2 ± 0.2          | 60.6 ± 0.9*      | 64.7 ± 0.4*     | 0.93 < 0.001 < 0.001          |
| Male sex, %            | 44.0 ± 0.6          | 43.8 ± 2.9       | 76.3 ± 1.7*     | 0.98 < 0.001 < 0.001          |
| BMI, kg/m²             | 24.4 ± 0.04         | 24.4 ± 0.2       | 23.6 ± 0.1*     | 0.82 < 0.001 0.001            |
| Obesity, %             | 39.5 ± 0.7          | 41.4 ± 3.1       | 29.6 ± 1.8*     | 0.27 < 0.001 < 0.001          |
| Smoking, %             |                     |                  |                 |                               |
| Never                  | 58.6 ± 0.7          | 53.7 ± 2.9       | 26.1 ± 1.7      |                               |
| Ex-                    | 20.6 ± 0.6          | 23.1 ± 2.7       | 40.3 ± 1.8*     |                               |
| Current                | 20.8 ± 0.7          | 23.2 ± 2.7       | 33.6 ± 1.7*     |                               |
| Comorbidities, %       |                     |                  |                 |                               |
| Hypertension           | 37.7 ± 0.8          | 49.4 ± 3.4*      | 53.2 ± 1.8*     | 0.05 < 0.001 0.24             |
| Diabetes               | 11.2 ± 0.5          | 13.2 ± 1.9       | 17.1 ± 1.4*     | 0.50 < 0.001 0.06             |
| Hypercholesterolemia   | 18.0 ± 0.6          | 20.1 ± 2.6       | 16.2 ± 1.5      | 0.41 0.26 0.17                |
| Osteoarthritis         | 16.2 ± 0.6          | 31.9 ± 2.8*      | 17.8 ± 1.5      | < 0.001 0.48 < 0.001          |
| OA medication          | 5.6 ± 0.3           | 13.5 ± 2.2*      | 5.8 ± 0.8       | < 0.001 0.69 < 0.001          |

* indicates clinical significance (P < 0.05)

** P values were analyzed with control groups (Asthma & COPD group)

COPD, chronic obstructive pulmonary disease; BMI, body mass index; OA, osteoarthritis; FVC, forced vital capacity; FEV₁, forced expiratory volume in 1 second
|                         | Controls (N = 7787) | Asthma (N = 425) | COPD (N = 1131) | P-value     |
|-------------------------|---------------------|------------------|-----------------|-------------|
|                         |         |                  |                 | Control vs. Asthma | Control vs. COPD | Asthma vs. COPD |
| **Pulmonary function**  |         |                  |                 |             |             |               |
| FVC, L                  | 3.53 ± 0.01 | 3.22 ± 0.06*     | 3.66 ± 0.04*    | < 0.001     | < 0.002     | < 0.001       |
| FVC, %                  | 93.4 ± 0.2  | 88.8 ± 0.8*      | 91.5 ± 0.5*     | < 0.001     | < 0.001     | 0.004         |
| FEV₁, L                 | 2.81 ± 0.01 | 2.27 ± 0.05*     | 2.34 ± 0.03*    | < 0.001     | < 0.001     | 0.24          |
| FEV₁, %                 | 94.6 ± 0.2  | 82.7 ± 1.1*      | 79.8 ± 0.5*     | < 0.001     | < 0.001     | 0.02          |
| FEV₁/FVC, %             | 79.8 ± 0.1  | 70.3 ± 0.7*      | 63.9 ± 0.2*     | < 0.001     | < 0.001     | < 0.001       |
| **EuroQOL**             |         |                  |                 |             |             |               |
| EQ5D-index              | 0.94 ± 0.002| 0.88 ± 0.01*     | 0.92 ± 0.01*    | < 0.001     | < 0.001     | 0.003         |
| EQ5D-VAS                | 75.6 ± 0.5  | 70.2 ± 2.5*      | 73.4 ± 1.4*     | 0.04        | 0.02        | 0.44          |

* indicates clinical significance (P < 0.05)

** P values were analyzed with control groups (Asthma & COPD group)

COPD, chronic obstructive pulmonary disease; BMI, body mass index; OA, osteoarthritis; FVC, forced vital capacity; FEV₁, forced expiratory volume in 1 second

**Association between asthma and OA**

Among adults aged > 40 years, 1190 subjects (prevalence, 17.0% ± 0.5%) were diagnosed with OA by doctors. The prevalence of OA was higher in subjects with asthma (31.9% ± 2.8%) than in those with COPD (17.8% ± 1.5%) or controls (16.2% ± 0.6%) (Fig. 1). In univariate analysis, OA showed a significant association with asthma (OR, 2.15; 95% CI, 1.70–2.72), but not with COPD (P = 0.34). The association between asthma and OA was significant regardless of the presence of airflow limitation on spirometry, but the effects were attenuated in subjects with airflow limitation (OR for asthma without airflow limitation = 2.36 [95% CI, 1.77–3.14]; OR for asthma with airflow limitation = 1.72 [95% CI, 1.16–2.54]). After adjustment of confounding factors such as age, sex, BMI, and smoking status (model 1), OA was still significantly associated with asthma (OR, 1.65; 95% CI, 1.27–2.13), but not with COPD (P = 0.40). To identify any sex differences for this association, the interaction term between sex and the presence of OA was added to the previous multivariable model, but no significant interaction between sex and OA was noted (P = 0.43). To examine the influence of OA medication on asthma, multivariable analysis also
included current medical treatment for OA with adjusted variables (model 2). The presence of OA was still significantly associated with asthma (OR, 1.56; 95% CI, 1.10–2.20) independent of OA medication. Moreover, OA medication had no statistically significant influence on asthma development ($P=0.63$: Table 2). Asthma subjects were stratified according to the presence of airflow limitation in model 2; this association was only significant in asthma subjects without airflow limitation (Table 2). Since development of airflow limitation could be affected by tobacco smoking, sensitivity analysis excluding current smokers were repeated, and the presence of OA still significantly associated with asthma (OR, 1.60; 95% CI, 1.11–2.31) independent of the presence of OA medication ($P=0.64$).

| Table 2 |
| Association of asthma and COPD with osteoarthritis |

| Osteoarthritis | OR   | 95% CI        | $P$  |
|----------------|------|---------------|------|
| Asthma         | 1.56 | 1.10–2.20     | 0.013|
| Without Airflow limitation | 1.97 | 1.32–2.93     | <0.001|
| With Airflow limitation    | 0.94 | 0.46–1.89     | 0.855|
| COPD            | 0.83 | 0.61–1.14     | 0.220|

*adjusted by age, sex, body mass index, and current smoking status

COPD, chronic obstructive pulmonary disease

To determine difference among various sites of OA in relation to asthma, each location of pain was subanalyzed. The prevalence of knee, back, and hip pain were all higher in asthma subjects than controls, but not in COPD subjects (Table 3). The results of univariable analysis are summarized in Table 4. In multivariable analysis, both knee and back pain were related to the presence of asthma, but hip pain was not significant ($P=0.30$: Table 4). Among the 9,344 individuals, joint radiography was evaluated for 6,674, and the prevalence of radiographic knee OA using the KL grading system was 20.5% ± 2.9% in the asthma group, 9.2% ± 1.1% in the COPD group, and 12.1% ± 0.6% in the control group. Severe knee OA (KL grade 3 or 4) was also more prevalent in the asthma group than in the COPD or control groups (Table 3). The radiographic KL score for the knee joint was significantly associated with the presence of asthma in both univariable and multivariable analyses (Table 4). The radiographic KL score for the lumbar spine was related to the presence of asthma in univariable analysis but lost significance in multivariable analysis ($P=0.53$). The radiographic KL score for the hip joint was not significant in both univariable ($P=0.26$) and multivariable analyses ($P=0.65$). Associations of asthma and radiographic KL scores for each joint are summarized in Table 4.
Table 3
Comparison of characteristics of affected joints

|                     | Controls (N = 7787) | Asthma (N = 425) | COPD (N = 1131) |
|---------------------|---------------------|------------------|-----------------|
| Knee pain, %        | 13.0 ± 0.5          | 26.0 ± 2.8*      | 14.6 ± 1.3      |
| Hip pain, %         | 6.1 ± 0.3           | 10.5 ± 1.8*      | 6.5 ± 0.9       |
| Back pain, %        | 14.8 ± 0.6          | 25.3 ± 2.6*      | 18.2 ± 1.5      |
| Radiographic OA     | 12.1 ± 0.6          | 20.5 ± 2.9*      | 9.2 ± 1.1*      |

Knee scale (KL grade)

| KL grade | Controls | Asthma | COPD |
|----------|----------|--------|------|
| 0        | 44.2 ± 1.1 | 36.2 ± 3.2 | 40.6 ± 2.0 |
| 1        | 22.9 ± 0.8 | 20.4 ± 2.8 | 27.3 ± 1.9* |
| 2        | 13.0 ± 0.6 | 17.2 ± 2.7* | 15.4 ± 1.4* |
| 3        | 13.5 ± 0.7 | 17.2 ± 2.4* | 11.4 ± 1.3 |
| 4        | 6.4 ± 0.5  | 9.0 ± 1.9*  | 5.3 ± 1.0      |

* indicates clinical significance (P < 0.05)

COPD, chronic obstructive pulmonary disease; KL grade, Kellgren/Lawrence grade
Table 4
Association of the location of pain or radiographic severities of osteoarthritis with asthma and COPD

|                  | Asthma                          | COPD                          |
|------------------|--------------------------------|--------------------------------|
|                  | Univariable  | Multivariable | Univariable  | Multivariable |
| Pain site        | OR      | 95% CI        | OR      | 95% CI        | OR      | 95% CI        | OR      | 95% CI        |
| Knee             | 2.25    | 1.80–2.80     | 1.78    | 1.40–2.26     | 0.92    | 0.77–1.10     | 0.78    | 0.64–0.96     |
| Back             | 1.76    | 1.41–2.20     | 1.37    | 1.08–1.74     | 1.09    | 0.93–1.29     | 0.96    | 0.79–1.15     |
| Hip              | 1.54    | 1.11–2.12     | 1.19    | 0.86–1.66     | 0.94    | 0.74–1.21     | 0.88    | 0.67–2.26     |
| Radiographic KL grade |          |                |          |                |          |                |          |                |
| Knee joint       | 1.19    | 1.10–1.29     | 1.10    | 1.01–1.21     | 0.97    | 0.92–1.03     | 0.94    | 0.88–1.00     |
| Lumbar spine     | 1.25    | 1.08–1.46     | 1.05    | 0.89–1.24     | 1.49    | 1.36–1.64     | 1.15    | 0.99–1.25     |
| Pelvis joint     | 1.16    | 0.90–1.49     | 1.06    | 0.82–1.38     | 1.51    | 1.30–1.75     | 0.95    | 0.81–1.12     |

COPD, chronic obstructive pulmonary disease

KL, Kellgren/Lawrence

Discussion

The nationwide survey data collected from the general population revealed a significant correlation between asthma and OA. Despite the high prevalence of OA and asthma, there was no report describing the prevalence of both as comorbid conditions. Our study revealed the prevalence of OA in patients with asthma reaches as high as 31.9%. Moreover, the prevalence of OA was higher in subjects with asthma compared to those in normal controls or those with COPD, which is a comparative respiratory disease. The relationship between OA and asthma was remarkable in the group without airflow limitations, and the radiographic severity of the knee joint also correlated with asthma. The lower QOL in the asthma group may be a consequence of high comorbid condition with OA in this population.

OA and asthma have contributing factors for each other through several mechanisms. First, asthma has immunological and inflammatory pathogenesis which could simultaneously affect development of arthritis. There is strong evidence that the endogenous and exogenous reactive oxygen and nitrogen species play major roles in airway inflammation, which determines the severity of asthma [19]. The oxidative stress described above is also known to be an important factor in the development of OA [20, 21]. Genome-wide association studies (GWAS) have shown that several SNPs of the gene encoding SMAD family member 3 (SMAD3) have been reported to be associated with knee OA or hip OA in both Caucasian and Asian populations [22–24]. SMAD3 is located on chromosome 15q21-22 and known to have important anabolic effects on chondrocytes through intracellular messengers in the transforming
growth factor-β signaling pathway \[25, 26\]. Remarkably, an epigenome-wide association study (EWAS) for asthma also reported differential methylation in inflammatory-related genes including SMAD3 \[27\]. Second, medication for arthritis, such as NSAIDs, could influence the development of asthma, although the independent effect of such medication on asthma development was not significant in the present study. Our study suggests that the association between asthma and NSAIDs could be attributable to the effect of OA instead of NSAIDs itself, but further larger studies to confirm our findings are needed. Third, both asthma and OA have common features that are influenced by age, sex, obesity, and tobacco smoking, which might act as confounders, although we tried to adjust these effects in multiple ways on multivariable analysis.

This study reveals that the knee joint in OA patients showed the most significant relationship with asthma. Since OA is a degenerative joint disease, its mechanisms are primarily related to weight bearing and/or repetitive mechanical force; thus, the most commonly affected joints are known to be the hand and knee. However, the etiology of OA also includes the interaction between local tissue damage and the immune system, which may leads to chronic low-grade joint inflammation \[28\]. Altered levels of inflammatory mediators are detected in OA synovial fluid suggesting synovial inflammation after meniscal damage \[29\]. Synovial joints are composed of diverse tissues that involve different loads; have distinct functional requirements; and possess differing proportional tissue types. The interactions of these factors may explain the preference of OA for certain anatomical sites, specifically knee, hip, spine, hands or feet \[30\]. Some reports have described strong genetic penetrance with diverse hereditary contribution, which is estimated to range from 30–65% depending upon the joint sites \[31–34\]. Based on these studies, the association of asthma with OA, especially knee OA, could be explained, but we still cannot conclude whether there is a clear mechanism for this association.

The relationship between OA and asthma was significant after adjusting for several confounding variables, and their association was more evident in the asthma group without airflow limitation. Asthma and COPD share similar phenotypic features and happen to be frequently misdiagnosed in clinical practice. Since COPD subjects may co-exist in a group of asthma patients with airflow limitation, the asthma group was split according to the presence of airflow limitation, and they presented distinct aspects of association with OA. In order to remove the COPD subjects mixed in the asthma group, we performed sensitivity analysis excluding smokers and obtained a higher effect estimate.

Although the present study described the novel relationship between asthma and OA, the following limitations of the study should be addressed to facilitate interpretation of our results. First, the prevalence of asthma was calculated by a self-reported questionnaire, not by a provocation test, which created the risk of misclassified patients. Moreover, owing to the absence of a provocation test, we could not compare the severity correlation of these diseases, such as the value of provocative concentration causing a 20% drop in FEV\(_1\). Although our study included patients diagnosed by doctors, misdiagnosis or under-diagnosis could have still occurred, especially in asthma accompanying airflow limitation with COPD. Therefore, we tried to stratify asthma subjects according to presence of airflow limitation, and the association with OA was evident in a relatively pure asthma group without airflow limitation. Second, we
had less information about OA involvement in each patient, including its severity, radiological and clinical information, and treatment information. Moreover, it is possible that the patients with severe OA and poor health condition were not included in this study because they could not attend a nationwide survey. Finally, although OA medication alone was not associated with asthma in the subgroup analysis, we could not determine the exact type of medication, such as steroids or NSAIDs. Further analyses showing differences based on the influence of joint location or pattern of arthritis are needed.

In conclusion, OA in patients with asthma has a high prevalence. OA and asthma can be considered as risk factors for each other. Considering their comorbid characteristics, these patients need special attention in terms of physical activity and QOL in clinical practice. Further larger studies based on GWAS and EWAS or intervention studies to confirm our findings are needed.

Abbreviations

BMI: body mass index; COPD: chronic obstructive pulmonary disease; EQ-5D: EuroQOL instrument; FEV$_1$: forced expiratory volume in 1 second; FVC: forced vital capacity; GOLD: Global Initiative for Chronic Obstructive Lung Disease; KNHANES: Korean National Health and Nutrition Examination Survey; KL grade: Kellgren/Lawrence grade; NSAIDs: non-steroidal anti-inflammatory drugs; OA: osteoarthritis; QOL: quality of life

Declarations

Authors’ contributions

HKK, PS and JHL preformed the literature review, conducted data analysis, and drafted the manuscript. They contributed to the interpretation of the data, critically revised the paper, and approved the final version. They developed the study conception, directed the analytic strategy of the study, and supervised the drafting of the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work

Competing interests

The authors declare that they have no competing interests.

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