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RESEARCH

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Occupational but not leisure-time physical activity associated with high-risk of obstructive sleep apnea status: a population-based study

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Abstract

Purpose Despite the well-documented benefits of physical activity, the distinct impacts of occupational physical activity (OPA) and leisure-time physical activity (LTPA) on the risk of obstructive sleep apnea (OSA) remain poorly understood. The objective of this study was to examine the relationship between OPA/LTPA and the risk of developing OSA within a nationally representative sample. We hypothesized that high-intensity OPA could potentially elevate the risk of OSA, whereas the effect of LTPA on OSA risk might be different.

Methods The cross-sectional study utilized data from the Korean National Health and Nutritional Examination Survey database (2019–2020), encompassing a total of 8093 participants. OSA risk was assessed using the STOP-BANG questionnaire, where a score of ≥ 3 signified high risk. Physical activity levels were evaluated using questions adapted from the Korean version of the Global Physical Activity Questionnaire. Participants were allocated based on their high or low levels of LTPA or OPA. Logistic regression analyses were conducted to unveil the associations between OSA and LTPA/OPA.

Results The multivariate regression analysis revealed that high-intensity OPA posed a risk factor for OSA (odds ratio [OR] = 1.738, 95% confidence interval [CI]: 1.134, 2.666), particularly among individuals with age ≥ 60 years old (OR = 1.321, 95% CI: 1.036, 1.682), those with a BMI ≥ 25 (OR = 1.967, 95% CI: 1.027, 3.767), and individuals with hypertension (OR = 3.729, 95% CI: 1.586, 8.768). Furthermore, a visible association was observed between high-intensity OPA and increased tiredness (OR = 1.447, 95% CI: 1.107, 1.891). However, no notable correlation was detected between LTPA and OSA prevalence in both overall and subgroup analyses (all $P > 0.5$).

Conclusion The study supported the link between high-intensity OPA and an elevated risk of OSA, suggesting the need to manage the duration and intensity of OPA.

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Keywords Obstructive sleep apnea, Leisure-time physical activity, Occupational physical activity, Population-based study

Introduction

Obstructive sleep apnea (OSA) is the most prevalent sleep-related breathing disorder, marked by recurring instances of partial or complete blockage of airway during sleep. This results in fragmented sleep patterns and reduced oxygen saturation [1], leading to excessive daytime sleepiness and fatigue. These symptoms impair the patient's functionality and leads to a diminished economic productivity. Furthermore, OSA greatly increased the risk of psychiatric disorders, cardiovascular diseases, and metabolic diseases [2–4]. It has emerged as a major global public health concern, impacting around 1 billion adults worldwide [5]. Consequently, it is vital to comprehensively understand the potential risk factors and protective measures of OSA, and to devise new prevention and intervention strategies.

The American Thoracic Society recommend physical activity as a treatment option for overweight or obese OSA patients, emphasizing that lifestyle changes such as dietary control and physical activity can benefit OSA patients [6]. Although the health benefits of physical activity are generally acknowledged, not all forms of physical activity contribute equally to health and well-being [7–8]. Physical activity is generally categorized into leisure, occupational, transportation, and household activities [9]. The health benefits and disease prevention associated with physical activity are primarily linked to leisure-time physical activity (LTPA) [10]. Conversely, the evidence regarding the impact of occupational physical activity (OPA) is conflicting, with some studies suggesting potential harmful effects on health [11].

Different types of physical activities confer varying health benefits, which may explain the ongoing controversy regarding the connection between physical activity and OSA observed in various studies. Some studies have demonstrated that physical activity can lower the risk of developing OSA [12], while in others, there is no visibly link between physical activity and OSA [13]. Hausswirth et al. [14] demonstrated that high-intensity physical training significantly disrupts sleep quality of athletes, resulting in increased daytime sleepiness. Previous studies have not adequately differentiated between the types of physical activity. Therefore, this study utilized the Korean National Health and Nutritional Examination Survey (KNHANES) database to explore the relationship between OSA and OPA/LTPA, aiming to provide an epidemiological evidence for the recommendation of using physical activity as a remedy for OSA.

Materials and methods

Participants selection and data collection

The study utilized data from KNHANES (2019–2020), an ongoing monitoring system primarily aimed at providing comprehensive national data on the dietary patterns, health-related behaviors, and health status of the Korean population [15]. The study was conducted in accordance with a stratified, multi-stage, probability cluster sampling method, and participant information was obtained through face-to-face interviews. Initially, 15,469 participants were included in the study. After excluding non-respondents to the LTPA/OPA questionnaire ($n = 4{,}133$) and the STOP-BANG questionnaire ($n = 3{,}243$), a total of 8,093 participants were ultimately included in the analysis (Fig. 1). All KNHANES participants volunteered and provided informed consent.

Occupational and leisure-time physical activity assessment

The assessment of physical activity levels relied on questions in the Korean version of the Global Physical Activity Questionnaire (K-GPAQ), which specifically targeted OPA and LTPA [16]. "Vigorous-intensity activity" refers to physical activities requiring intense physical exertion, significantly increasing heart or breathing rate. Conversely, "moderate-intensity activity" indicated physical activities involving moderate physical exertion, resulting in a slight elevation of heart or breathing rate. The comprehensive inquiries can be found in the Supplementary K-GPAQ questions for OPA/LTPA. By summing the duration of moderate-intensity activity per week and doubling the reported duration of vigorous-intensity activity per week, we calculated the total weekly activity duration. Participants were then divided into two cohorts according to the current guidelines: those with low LTPA or OPA (< 150 min/week), and those with high LTPA or OPA (≥ 150 min/week) [17].

Obstructive sleep apnea assessment

The STOP-BANG questionnaire is a rapid and simple screening tool for targeting detecting OSA populations with a sensitivity of 83.6% [18]. The questionnaire consists of total eight items pertaining to clinical characteristics of sleep apnea (tiredness, snoring, observed apnea, hypertension, age, male gender, neck circumference, and body mass index (BMI)). The assessment

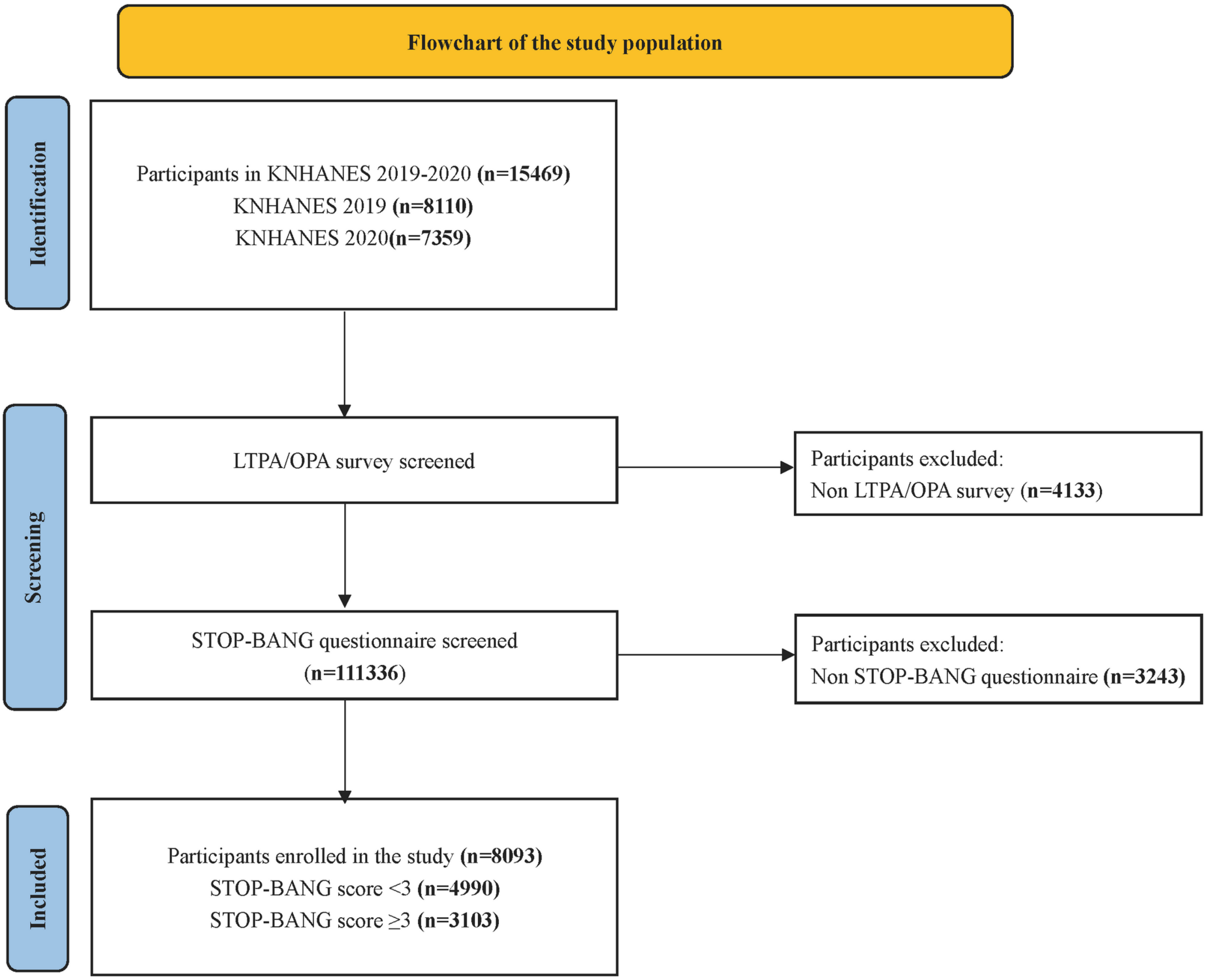

Fig. 1 Flowchart of the study population

of tiredness, snoring, observed apnea, and hypertension is based on "yes" or "no" responses to the following questions: "Do you often feel tired, fatigued, or sleepy during the day?" "Is your snoring loud?" "Has anyone observed you stop breathing while sleeping?" and "Have you ever received a diagnosis of hypertension from a healthcare professional?" Additionally, the four demographic criteria include: age ≥ 50 years, male gender, neck circumference ≥ 40 cm, and BMI ≥ 35 kg/m^2. A total score of three or more classifies individuals are at high risk.

Covariate variables

We collected information on gender, age, educational level (below high school, high school graduate, and college degree or higher), BMI (classified as < 25 kg/m^2 for normal, and ≥ 25 kg/m^2 for obese), residence (urban and rural), occupation, smoking history (< 5 or ≥ 5 packs of cigarettes in a lifetime), alcohol intake (less than twice a week or twice a week or more), and comorbidities (hypertension, history of cerebral hemorrhage, cardiovascular disease, thyroid disease, diabetes mellitus, gout, chronic kidney disease, and asthma) as potential covariates associated with OSA.

Statistical analysis

The data from KNHANES (2019–2020) was pooled and utilized for complex sample analysis, integrating sampling weights to address the multi-stage sampling design. Continuous variables were presented as mean ± standard deviation (SD), while categorical variables were represented as percentages. Before conducting the logistic regression analyses, we assessed the multicollinearity among the independent variables using the variance inflation factor (VIF). A VIF value greater than 5 was considered to indicate high multicollinearity.

Multivariate analysis employed logistic regression to explore the associations between OSA and OPA/LTPA. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were computed for LTPA and OPA across three different models. Model 1 was adjusted for age, gender, and BMI; Model 2 was adjusted for age, gender, BMI, residence, family income, educational level, occupation, smoking, and alcohol intake; and Model 3 included all covariates in Model 2 along with comorbidities. Additionally, factors with a significance level of $P<0.05$ in the multiple regression analyses were considered as covariates. The results of subgroup analyses for each respective variable were presented. The level of statistical significance was set at $P<0.05$.

Results

Characteristics of sociodemographics and clinical features

As shown in Table 1, this study included 8093 participants in total, of which 3103 individuals had a STOP-BANG score ≥ 3, representing approximately 51.67 million Korean adults in the weighted population. The average age of participants was 59.58 ± 11.60 years, with 43.4% being males and 56.6% females. The majority of participants resided in urban areas (77.9%), have a normal BMI (62.8%), smoked < 5 packs in a lifetime (60.9%), and reported alcohol intake less than twice a week (75.9%). Among the OSA-related comorbidities, 33.5%, 3.1%, 4.3%, 3.1%, 5.0%, 13.7%, 1.3%, and 2.2% of participants reported hypertension, history of cerebral hemorrhage, cardiovascular disease, thyroid disease, diabetes mellitus, gout, chronic kidney disease, and asthma, respectively. In terms of LTPA and OPA, the majority of participants reported low levels of physical activity, with weighted percentages of 86.8% for LTPA and 96.6% for OPA. There was a significant statistical difference in the distribution of occupational categories between males and females, and male participants were more likely to be in blue-collar and green-collar occupations, while females were more likely to be unemployed or in white-collar occupations ($\chi2=478.83$, $P<0.0001$) (Supplementary Table S1).

The association of LTPA/OPA with OSA

Logistic regression analysis was adopted to explore the connection between LTPA/OPA and OSA. As shown in Fig. 2, both in univariate analysis (OR = 1.637, 95% CI: 1.245, 2.153) and analysis adjusting for all covariates (model 3) (OR = 1.738, 95% CI:1.134, 2.666), high OPA was markedly connected with an elevated risk of OSA, whereas LTPA did not increase the risk of developing OSA (all $P>0.05$).

Subgroup analysis of LTPA/OPA with OSA

Subgroup analysis was conducted on covariates with $P<0.05$ in the multiple regression analyses (Table S2). The results uncovered a marked association between high OPA and high risk of OSA, particularly among individuals with age ≥ 60 years old (OR = 1.321, 95% CI: 1.036, 1.682), those with a BMI ≥ 25 (OR = 1.967, 95% CI: 1.027, 3.767), and individuals with hypertension (OR = 3.729, 95% CI: 1.586, 8.768) (Table 2). Furthermore, LTPA was not correlated with an elevated the risk of OSA in different subgroups (all $P>0.05$) (Table S3).

The link between OSA risk and physical activity

Logistic regression analysis was utilized to investigate the connection between LTPA/OPA and OSA risk (tiredness, snoring, and observed apnea). As illustrated in Table 3, after adjusting for covariate variables (Model 3), a notable connection was observed between high-intensity OPA and tiredness (OR = 1.447, 95% CI: 1.107, 1.891), particularly among males (OR = 1.629, 95% CI:1.191, 2.228). Additionally, a significant connection was found between high levels of LTPA and snoring (OR = 1.236, 95% CI: 1.011, 1.512).

Discussion

The results of this study indicated that high levels of OPA pose a risk factor for OSA, especially among individuals with age ≥ 60 years old, BMI ≥ 25, and those with hypertension. Further analysis revealed that high levels of OPA may elevate the risk of feelings of tiredness, particularly among males. While high levels of LTPA were linked to an elevated risk of snoring, no evidence was found to suggest that LTPA either mitigated or exacerbates the occurrence of OSA. This study suggested that patients with OSA should be advised to steer clear of high levels of OPA, as such exertion may worsen their condition. Additionally, given the lack of a substantial association between LTPA and the risk of OSA, healthcare providers might not consider LTPA as an essential therapeutic requirement for OSA. This aligns with the findings of previous study, Duan et al. [19] revealed no significant association between LTPA and the risk of OSA. Nevertheless, it is crucial to emphasize the comprehensive health advantages and the potential beneficial effects of LTPA on mental well-being and cardiovascular fitness, which are generally recommended for overall health promotion [20].

Currently, the link between physical activity and the risk of developing OSA is still uncertain. While many studies indicated that physical activity can independently improve OSA regardless of weight loss [21–22], some researches had failed to establish this connection [23]. Therefore, it is crucial to explore the effects

Table 1 Characteristics of the study population

Characteristics	N	Weighted N in millions	Overall	STOP - BANG Score < 3 [a]	STOP - BANG Score ≥ 3 [b]
Age(years), **Mean(SD)**	8093	51.67	59.58 ± 11.60	57.55 ± 11.76	62.84 ± 10.56
Gender, **N (%)**					
Male	3511	22.42	43.4%	16.1%	27.3%
Female	4582	29.25	56.6%	45.6%	11.0%
Residence, **N (%)**					
Urban	6304	40.25	77.9%	49.2%	28.7%
Rural	1789	11.42	22.1%	12.5%	9.6%
Smoking, **N (%)**					
< 5 pack in a lifetime	4927	31.47	60.9%	45.6%	15.3%
≥ 5 pack in a lifetime	3157	20.20	39.1%	16.1%	23.0%
Alcohol intake, **N (%)**					
Less than twice a week	5290	39.22	75.9%	49.4%	26.5%
Twice a week or more	1677	12.45	24.1%	12.3%	11.8%
BMI (Kg/m^2), **N (%)**					
<25	5079	32.45	62.8%	29.1%	33.7%
≥ 25	3014	19.22	37.2%	32.6%	4.6%
Hypertension					
No	5384	34.36	66.5%	52.0%	14.5%
Yes	2709	17.31	33.5%	9.7%	23.8%
History of cerebral hemorrhage					
No	7843	50.07	96.9%	60.5%	36.4%
Yes	250	1.60	3.1%	1.2%	1.9%
Cardiovascular disease					
No	7741	49.45	95.7%	59.7%	36.0%
Yes	352	2.22	4.3%	2.0%	2.3%
Thyroid disease					
No	7841	50.07	96.9%	59.4%	37.5%
Yes	252	1.60	3.1%	2.3%	0.8%
Diabetes mellitus					
No	7687	49.09	95.0%	59.7%	36.0%
Yes	406	2.58	5.0%	2.0%	2.3%
Gout					
No	6983	44.59	86.3%	53.9%	32.4%
Yes	1110	7.08	13.7%	7.8%	5.9%
Chronic kidney disease					
No	7985	51.00	98.7%	61.1%	37.6%
Yes	108	0.67	1.3%	0.6%	0.7%
Asthma, **N (%)**					
No	7914	50.53	97.8%	60.5%	37.3%
Yes	179	1.14	2.2%	1.2%	1.0%
LTPA, **N (%)**					
low	7007	44.85	86.8%	53.9%	32.9%
High	1086	6.82	13.2%	7.8%	5.4%
OPA, **N (%)**					
low	7820	49.91	96.6%	59.9%	36.7%
High	273	1.76	3.4%	1.8%	1.6%

[a] STOP– BANG Score < 3: *N* = 4990; Weighted N in millions = 31.88

[b] STOP– BANG Score ≥ 3: *N* = 3103; Weighted N in millions = 19.79

LTPA: Leisure-time physical activity

OPA: Occupational physical activity

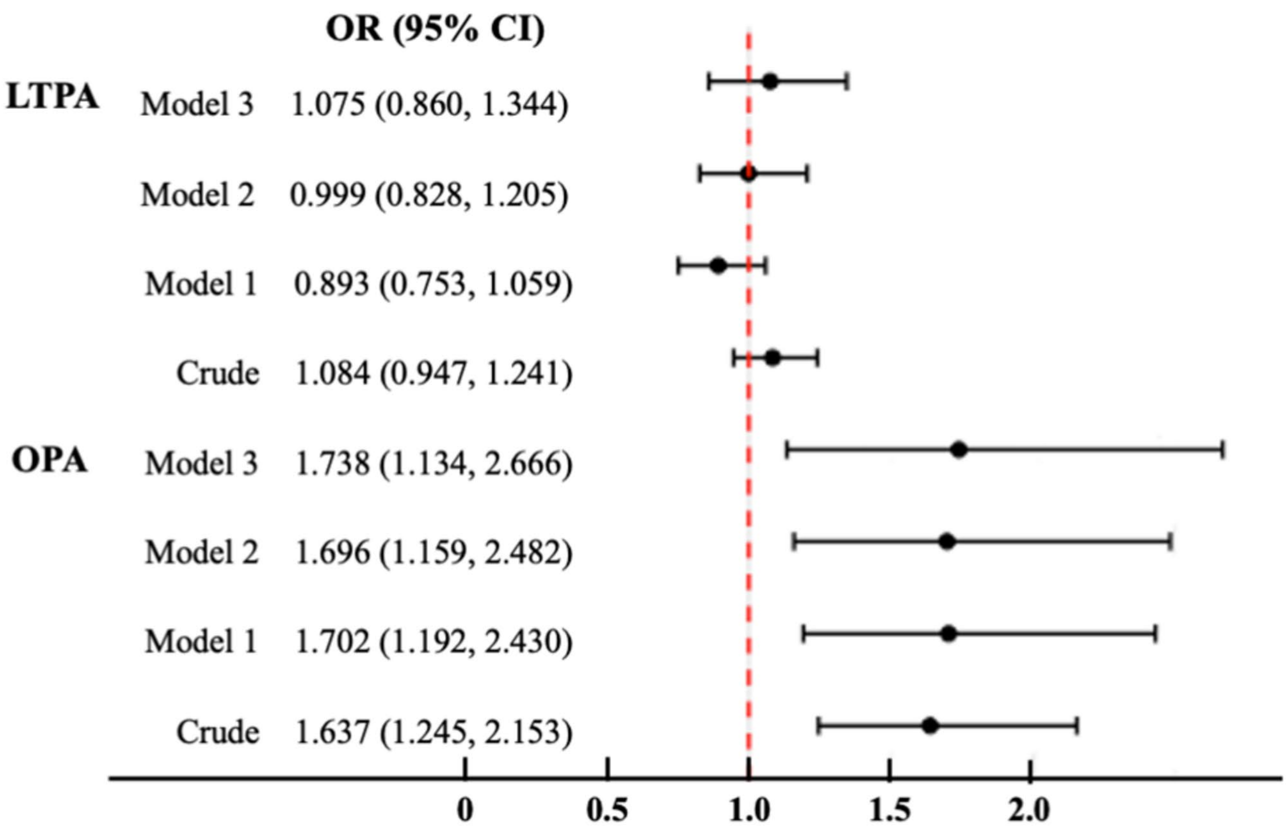

Fig. 2 The association of leisure-time and occupational physical activity with obstructive sleep apnea

of different types of physical activity on OSA. Murillo et al. [24] evinced that moderate and high-intensity transport activity could reduce the likelihood of mild OSA. However, Duan et al. [25] demonstrated that three aspects of physical activity, encompassing OPA, LTPA, and transport activity, were not linked to OSA risk using the Berlin Questionnaire. This discrepancy from our study may be due to differences in the assessment of OSA. Multiple studies suggest that the STOP-BANG questionnaire is recommended as a more precise tool for identifying mild, moderate, and severe OSA, and recommend for its implementation in OSA screening [26–27].

The exact reasons for the heightened risk of developing OSA due to high levels of OPA are not entirely clear. Delving into its molecular mechanisms, it has been confirmed that elevated OPA levels are linked to systemic inflammatory responses and elevated blood pressure, manifested as increased circulating hs-CRP, interleukin-6/8 levels, and heightened cardiovascular disease risk [28]. The relationship between systemic inflammation and OSA is bidirectional. Sleep regulation by the central nervous system dynamically modulates the immune system by producing and redistributing of inflammatory cytokines, primarily involving the sympathetic nervous system and the hypothalamic-pituitary-adrenal axis [29]. Additionally, research indicated that increased levels of cytokines in the nervous system can lead to fragmented sleep patterns in rodents [30]. Furthermore, systemic inflammation is associated with impaired respiratory chemoreflex and plasticity, disrupting ventilatory control and increasing the susceptibility of OSA [31].

Subgroup analysis revealed that elevated levels of OPA represent a risk factor for OSA, particularly among individuals with age ≥ 60 years old, BMI ≥ 25, and those with hypertension, all of these covariates were established risk factors for OSA. Chung et al. [16] demonstrated a higher proportion of males, older individuals, and those with higher BMI and blood pressure among OSA patients compared to non-OSA populations. Matarredona-Quiles et al. [32] indicated that several factors contribute to the increased risk of OSA, including the relaxing effect of higher testosterone levels on upper airway muscles in males, age-related decline in muscle strength and respiratory control in elderly individuals, adipose tissue accumulation and inflammation in the upper airway of obese and hypertensive patients. Therefore, it is essential for individuals in these groups to be particularly attentive to managing the duration and intensity of their occupational physical activities, in order to mitigate the

Table 2 Subgroup analysis for the association between obstructive sleep apnea with different clinical characteristics and OPA

Obstructive sleep apnea	Age		Gender		BMI	
OR (95% CI)	< 60 years old	≥ 60 years old	Males	Females	< 25	≥ 25
OPA High OPA (vs. low OPA) Model 3	1.403 (0.816, 2.412)	**2.361 (1.346, 4.142)** †	**1.694 (1.021, 2.813)** *	**2.508 (1.194, 5.266)** *	1.419 (0.810, 2.484)	**1.967 (1.027, 3.767)** *

Obstructive sleep apnea	Smoking		Hypertension	
OR (95% CI)	< 5 pack in a lifetime	≥ 5 pack in a lifetime	No	Yes
OPA High OPA (vs. low OPA) Model 3	1.555 (0.907, 2.656)	1.482 (0.873, 2.311)	1.601 (0.983, 2.608)	**3.729 (1.586, 8.768)** †

* $p < 0.05$; † $p < 0.01$

Model 3: adjusted for age, gender, BMI, education level, occupation, family income, residence, and comorbidities (hypertension, history of cerebral hemorrhage, cardiovascular disease, thyroid disease, diabetes mellitus, gout, chronic kidney disease, and asthma)

Occupational physical activity: OPA

heightened risk of exacerbating OSA due to fatigue and excessive strain.

One notable strength of our study lied in its evaluation of the connection between OSA and physical activity within a nationally representative sample of the general population. Furthermore, we differentiated between LTPA and OPA in their respective effects on OSA, and conducted analyses targeting various subgroups. However, our study also presented certain limitations. Firstly, we relied on the STOP-BANG questionnaire to screen for high-risk OSA, although it is not a conclusive diagnostic tool for OSA and may therefore have lower accuracy compared to clinical examination measurements. Nonetheless, it is worth noting that several large-scale population-based studies also employed questionnaires to assess OSA. Secondly, the cross-sectional nature of our study hindered our capacity to determine a causal relationship between OPA and OSA. Additionally, our study did not allow for an analysis based on the severity of OSA, accelerometer data or overnight oximetry due to the absence of specific sleep data from the KNHANES database. One significant limitation of our study was the potential for selection bias, as we excluded more than 10% of the initial population due to non-response, resulting in a sample that is not fully representative of the general Korean population. Moreover, the study population was predominantly composed of a relatively healthy, urban working group, limiting the generalizability of our findings to other populations, such as those living in rural areas or with different employment statuses. Additionally, the high-intensity OPA exposure and the use of the STOP-BANG questionnaire in this group might be influenced by "tiredness" from overworking, rather than actual airway obstruction during sleep, which could affect the interpretation of our results. Therefore, future studies should consider designing prospective cohort studies that utilize polysomnography for OSA diagnosis to better understand the causal relationship between OPA and OSA, and they should also aim to include a more diverse participant pool, encompassing individuals from rural areas and various employment statuses, to enhance the external validity of the findings.

Conclusion

In summary, the current study provides evidence supporting the association between high-intensity OPA and an increased risk of OSA, particularly in individuals ≥ 60 years old, those with a BMI ≥ 25, and individuals with hypertension. High levels of OPA may contribute to promoting the feeling of tiredness. The impact of OPA on OSA warrants further comprehensive evaluation in the near future to enhance

Table 3 Simple and multiple estimates for the association between physical activity and OSA risk

OSA risk OR (95% CI)		Snoring	Tiredness	Observed apnea
OPA (High vs. low)				
Total	Crude	1.747 (1.225, 2.491) *	1.406 (1.091, 1.813) *	1.610 (1.101, 2.353) *
	Model 3	1.407 (0.949, 2.087)	**1.447 (1.107, 1.891) ***	1.187 (0.781, 1.805)
Male	Model 3	1.354 (0.864, 2.122)	**1.629 (1.191, 2.228) †**	1.180 (0.744, 1.871)
Female	Model 3	1.675 (0.893, 3.142)	1.182 (0.738, 1.895)	1.496 (0.497, 4.502)
LTPA (High vs. low)				
Crude		**1.307 (1.092, 1.565) ***	0.853 (0.721, 1.010)	**1.289 (1.017, 1.634) ***
Model 3		**1.236 (1.011, 1.512) ***	0.904 (0.754, 1.084)	1.022 (0.791, 1.320)
Male	Model 3	1.187 (0.945, 1.491)	0.857 (0.677, 1.085)	0.945 (0.729, 1.225)
Female	Model 3	1.309 (0.968, 1.771)	0.919 (0.720, 1.172)	1.485 (0.907, 2.431)

Leisure-time physical activity: LTPA, Occupational physical activity: OPA, Obstructive sleep apnea: OSA

Model 3: adjusted for age, gender, BMI, education level, occupation, family income, residence, smoking, alcohol intake, and comorbidities (hypertension, history of cerebral hemorrhage, cardiovascular disease, thyroid disease, diabetes mellitus, gout, chronic kidney disease, and asthma)

*p<0.05; † p<0.01, ‡ p<0.001

public health awareness and management of health risks among individuals with OSA.

Abbreviations

CI	Confidence interval
K-GPAQ	The Korean version of the Global Physical Activity Questionnaire
KNHANES	The Korean National Health and Nutritional Examination Survey
LTPA	Leisure-time physical activity
OPA	Occupational physical activity
OR	Odds ratio
OSA	Obstructive sleep apnea
SE	Standard errors

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12890-025-03672-3.

Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

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Not applicable.

Author contributions
Conceptualization: Han Chen. Data curation: Lin Wang. Formal analysis: Lin Wang. Funding acquisition: Longgang Yu, Yan Jiang. Investigation: Lin Wang. Methodology: Han Chen. Project administration: Longgang Yu, Yan Jiang. Resources: Jisheng Zhang. Software: Jisheng Zhang. Supervision: Longgang Yu. Validation: Han Chen. Visualization: Xudong Yan. Writing - original draft: Han Chen. Writing - review & editing: Longgang Yu, Yan Jiang.

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Data availability
The datasets analyzed in this study are from the KNHANES 2019-2020, which are publicly available and can be downloaded from the KNHANES website: https://knhanes.kdca.go.kr/knhanes/main.do.

Declarations

Ethics approval and consent to participate
The study received approval from the Institutional Review Board of the Korea Centers for Disease Control and Prevention (No. 2018-01-03-C-A, No. 2018-01-03–2 C-A). All KNHANES participants volunteered and provided informed consent.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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