Architecture Image Studies
AIS Scientific Journal

Vol.6, Issue 3, pp.879-887, 2025
DOI: https://doi.org/10.62754/ais.v6i3.344

https://journals.ap2.pt/index.php/ais/index

Longitudinal Trends in Health-Related Quality of Life, Preventive Health Behaviors, and Handgrip Strength Among Korean Adults (2011–2023): Implications for Active and Digital Preventive Healthcare

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Abstract

Background: Korea's rapid population aging and the prolonged COVID-19 pandemic have intensified the need to sustain health-related quality of life (HRQoL) through preventive behaviors and functional health maintenance. While previous research has examined isolated factors such as physical activity or chronic disease, longitudinal evidence linking behavioral trends and physical function to HRQoL remains limited. Methods: This study analyzed 13 years of nationally representative data from the Korea National Health and Nutrition Examination Survey (KNHANES, 2011–2023). HRQoL was measured using the EQ-5D-3L index, and preventive health behaviors included participation in health screening, influenza vaccination, physical activity, and sedentary time. Handgrip strength (HGS) was assessed using a digital dynamometer as an objective indicator of physical function. Weighted descriptive statistics, linear trend analyses, correlation tests, and multiple regression models were applied, adjusting for age, sex, education, income, and chronic disease status. Results: HRQoL remained generally stable across the study period (mean EQ-5D: 0.940–0.956), with a temporary decline during the pandemic (2020–2021). Health screening and vaccination rates steadily increased, while physical activity decreased from 56% to 45% and sedentary time rose by nearly two hours per day. Average handgrip strength declined gradually—by 5.7% in men and 2.9% in women—especially among older adults. Correlation analysis revealed that HRQoL was positively associated with physical activity ($r = 0.72$), handgrip strength ($r = 0.75$), and health screening ($r = 0.68$), and negatively associated with sedentary time ($r = –0.61$). Multiple regression confirmed handgrip strength and physical activity as the strongest predictors of HRQoL (Adjusted $R^2 = 0.69$). From 2011 to 2023, Korea experienced a paradoxical pattern of improved biomedical prevention (screening, vaccination) but declining behavioral health and muscular function. These findings underscore the importance of integrating functional capacity—particularly handgrip strength—into national preventive healthcare systems. The adoption of IoT-enabled strength and activity monitoring may enhance early detection of decline, support personalized interventions, and promote active, data-driven aging in the post-pandemic era.

Keywords: *Health-related quality of life (HRQoL), Handgrip strength, Preventive behavior, Physical activity.*

Introduction

Korea has entered an era of rapid population aging, with the proportion of adults aged 65 years and older projected to exceed 30% by 2035 (OECD, 2023). This demographic shift, combined with a near-universal increase in life expectancy, has amplified the importance of health-related quality of life (HRQoL) as a central policy priority. HRQoL encompasses not only morbidity and mortality but also the subjective perception of physical, psychological, and social well-being (Kim et al., 2013). As healthcare transitions from disease treatment to health promotion, understanding the determinants of HRQoL across age groups—particularly among older adults—has become vital for achieving sustainable population health.

The EQ-5D index, a standardized and globally validated measure, has been extensively used in Korea since its integration into the Korea National Health and Nutrition Examination Survey (KNHANES) in 2005 (Kweon et al., 2014; Kim et al., 2016). Its wide adoption enables international comparison and long-term monitoring of population-level health status. According to OECD Health Statistics, Korea

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consistently reports relatively high EQ-5D scores compared to other member nations, yet displays one of the lowest levels of leisure-time physical activity and one of the highest rates of sedentary behavior (OECD, 2023). This paradox—high subjective health ratings amid limited physical activity—suggests that behavioral determinants of HRQoL may be underestimated in public health policy.

Over the past decade, Korea has implemented nationwide preventive health programs such as regular medical check-ups and influenza vaccination campaigns, with participation steadily increasing (Song et al., 2022; Suh et al., 2016). However, lifestyle behaviors—especially physical inactivity, prolonged sedentary time, and obesity—remain pressing concerns. Data from KNHANES 2014–2021 revealed a decline in physical activity from 56% to 45%, accompanied by a consistent rise in sedentary time (Han et al., 2024). These patterns are concerning, given that diminished physical activity is closely linked to both metabolic disorders and decreased HRQoL (Janssen et al., 2019; Oh et al., 2017).

The COVID-19 pandemic (2020–2021) further disrupted these behavioral trends. Numerous studies have reported significant reductions in healthcare utilization and preventive services, including cancer screening and routine health examinations, as well as widespread increases in psychological stress and social isolation (Lee YJ et al., 2025; Yeo et al., 2023). Although vaccination coverage against influenza and COVID-19 increased sharply as part of national emergency response measures (Kim K et al., 2025), the pandemic paradoxically accelerated the decline in physical activity, particularly among older adults who experienced stricter movement restrictions. Thus, the pandemic can be seen as a structural break that revealed vulnerabilities in Korea's prevention-centered health system—strengthening biomedical prevention while weakening behavioral health maintenance.

Among measurable physical indicators, handgrip strength (HGS) has emerged as a powerful proxy for overall functional capacity, frailty, and independence (Paek et al., 2019; Chang et al., 2022). HGS is not only an indicator of muscular fitness but also a predictor of cardiovascular disease, cognitive decline, and mortality. Korean and international research alike show that lower HGS is associated with poorer HRQoL, greater functional limitation, and higher depression prevalence (Oh et al., 2017; Kim J et al., 2022). Longitudinal analyses between 2011 and 2023 demonstrate a gradual decline in mean HGS—approximately 2–3 kg among men and 1 kg among women—indicating age-related loss of physical function that is particularly pronounced in adults aged ≥60 years.

These empirical findings emphasize the necessity of reframing preventive health behavior in the context of functional resilience and active aging. While earlier Korean health policies prioritized screening and vaccination participation, growing evidence indicates that maintaining musculoskeletal and functional health may have a more profound impact on HRQoL over time (Han S et al., 2024). As such, digital and IoT-based healthcare devices capable of continuous monitoring of grip strength and physical activity represent a transformative innovation for early detection of functional decline and for personalized health interventions (OECD, 2023).

For example, emerging smart dynamometers and AI-integrated wearables can capture real-time data on handgrip strength, posture, and mobility, allowing for predictive analytics on frailty risk or rehabilitation progress. Integrating such technology into Korea's national screening infrastructure could support the shift toward a data-driven preventive healthcare ecosystem that aligns with the country's Digital New Deal and K-Health 2025 initiatives.

Despite extensive literature on HRQoL determinants, few studies have holistically examined nationwide longitudinal patterns across preventive behaviors and physical-function indicators over more than a decade. Moreover, the COVID-19 pandemic has not yet been quantitatively positioned as a turning point in these long-term trajectories.

To address these research gaps, the present study aimed to:

(1) analyze trends in HRQoL, preventive health behaviors, and physical function among Korean adults from 2011 to 2023;

(2) compare behavioral and HRQoL changes before and after the COVID-19 pandemic; and

(3) assess the association between handgrip strength and HRQoL as a potential foundation for developing IoT-enabled healthcare solutions for older adults.

By integrating 13 years of KNHANES data, this study seeks to elucidate how preventive behaviors and physical function collectively shape population-level HRQoL, offering empirical insights to inform sustainable, technology-supported aging strategies in Korea.

Methods

This study was based on secondary analysis of data from the Korea National Health and Nutrition Examination Survey (KNHANES), collected between 2011 and 2023. KNHANES is a nationally representative, cross-sectional survey managed by the Korea Disease Control and Prevention Agency (KDCA) and utilizes a two-stage stratified cluster sampling design with probability proportional to size (PPS) to ensure representativeness by age, sex, and geographic region (Kweon et al., 2014).

A total of approximately 100,000 adults aged ≥19 years with complete data on EQ-5D, preventive health behaviors, and handgrip strength were included. Annual sample sizes ranged from 6,800 to 8,500. Individuals with missing or implausible data were excluded through complete-case analysis, and a sensitivity test using multiple imputation was conducted to assess robustness.

Health-Related Quality of Life (HRQoL) was measured using the EQ-5D-3L index, previously validated in Korean populations (Kim et al., 2013; Kim et al., 2016). EQ-5D index scores were derived using the Korean valuation model:

EQ5D = 1 - (0.05 + 0.096M2 + 0.418M3 + 0.046SC2 + 0.136SC3 + 0.051UA2 + 0.208UA3 + 0.037PD2 + 0.151PD3 + 0.043AD2 + 0.158AD3)

where each subscript corresponds to level 2 or 3 response in each dimension. This allows for comparability across international HRQoL studies.

Preventive health behaviors included participation in national health screening programs, influenza vaccination, engagement in regular physical activity, and average sedentary time.

Health screening and vaccination participation were self-reported based on the preceding two and twelve months, respectively (Song et al., 2022). Physical activity was classified according to WHO recommendations: individuals engaging in ≥150 minutes of moderate or ≥75 minutes of vigorous activity per week were defined as “active” (Han et al., 2024). Sedentary behavior was quantified by daily sitting hours. Smoking status and alcohol frequency were analyzed as risk-related behavioral covariates.

Handgrip strength (HGS) served as the principal indicator of physical function. Using a digital dynamometer (T.K.K. 5401; Takei, Japan), participants performed three maximal efforts per hand while standing, and the highest value from the dominant hand was recorded. Sex-specific averages and relative handgrip strength (HGS/body weight) were computed (Paek et al., 2019; Chang et al., 2022).

Covariates included age, sex, education, income, and chronic disease status (hypertension, diabetes, dyslipidemia). Age was both continuous and categorical (19–39, 40–59, ≥60 years), enabling stratified analysis by life stage, particularly for assessing older adults’ functional decline.

All analyses incorporated survey weights to adjust for complex sampling and ensure national representativeness. Weighted descriptive statistics were used to summarize variable distributions.

Temporal trends from 2011 to 2023 were analyzed using Joinpoint regression and linear trend tests, identifying structural changes associated with the pandemic period (2020–2021). To confirm the robustness of these findings, segmented regression was performed comparing the pre-pandemic (2011–2019) and pandemic/recovery (2020–2023) phases.

Associations between HRQoL and preventive behaviors were examined using Pearson’s correlations and multivariate linear regression models adjusted for sociodemographic covariates. Handgrip strength, physical activity, and health screening were treated as continuous predictors of EQ-5D. An interaction term (Physical Activity × Pandemic) tested for moderation effects of the pandemic on the relationship between physical activity and HRQoL.

Statistical analyses were conducted using Python (v3.11; pandas, numpy, statsmodels, matplotlib) and SPSS (v28.0). Two-tailed p-values below 0.05 were considered statistically significant, and model performance was evaluated via R^2, Akaike Information Criterion (AIC), and visual diagnostics of residual normality.

As KNHANES data are publicly available and fully anonymized, ethical approval was not required under Korean regulations. The study complied with the principles of the Declaration of Helsinki and the KDCA’s data-sharing policy.

Results

The analysis encompassed thirteen years of nationally representative data from 2011 to 2023, capturing major demographic and behavioral transitions in the Korean adult population. Weighted descriptive statistics and trend analyses revealed distinct shifts in health-related quality of life (HRQoL), preventive health behaviors, and physical function (handgrip strength) over time.

Temporal Trends in HRQoL (2011–2023)

The mean EQ-5D index among Korean adults remained high across the observation period, fluctuating within a narrow range between 0.940 and 0.956. From 2011 to 2019, the EQ-5D exhibited relative stability with only minor variation. However, a sharp downturn was observed during the COVID-19 pandemic (2020–2021), when the national mean temporarily dropped to 0.941, representing a 1.5% reduction compared to pre-pandemic levels.

Following the pandemic, the EQ-5D index gradually rebounded, reaching 0.950 in 2022 and 0.953 in 2023, indicating partial recovery but not a full return to the 2011–2018 average. This U-shaped pattern suggests that the pandemic produced a temporary but measurable deterioration in perceived health and daily functioning.

When disaggregated by age, the older adult group (≥60 years) exhibited both the lowest HRQoL scores and the slowest recovery after 2021. The average EQ-5D in this group fell from 0.933 in 2019 to 0.921 in 2021, and although it improved modestly afterward, it remained below pre-pandemic levels by 2023. In contrast, younger adults (19–39 years) showed only a minor decline during the same period, reflecting a stronger resilience to pandemic-related disruptions.

Trends in Preventive Health Behaviors

The analysis of preventive behaviors revealed divergent trajectories among behavioral indicators.

Health screening participation increased steadily from 68.4% in 2011 to 78.9% in 2023, demonstrating Korea's sustained expansion of its national screening system. The sharpest decline occurred in 2020 (–3.2 percentage points) due to temporary service suspension, followed by rapid recovery in 2021–2022 once screening centers reopened.

Influenza vaccination rates followed a similar upward trend, rising from 43% in 2011 to over 55% in 2023. Interestingly, the pandemic period led to an exceptional peak (approximately 60–62%) as preventive behavior intensified under heightened public health awareness.

In contrast, physical activity declined notably throughout the decade. The proportion of adults meeting WHO guidelines dropped from 56% in 2011 to 45% in 2023, while average sedentary time increased by nearly 2 hours per day. These trends were particularly evident among urban residents and office workers, reflecting lifestyle shifts toward sedentary occupations and screen-based leisure.

As summarized in Table 1, physical activity and sedentary time followed opposing trajectories during the study period, while other preventive behaviors such as health screening and vaccination continued to improve.

Table 1. Trends in HRQoL, Preventive Behaviors, and Physical Function among Korean Adults (2011–2023)

Year	EQ-5D (Mean ± SD)	Health Screening (%)	Influenza Vaccination (%)	Physically Active (%)	Sedentary Time (hr/day)	Handgrip Strength (Men, kg)	Handgrip Strength (Women, kg)
2011	0.951 ± 0.09	68.4	43.0	56.0	6.1	40.5	24.1
2013	0.952 ± 0.08	70.2	45.6	54.1	6.3	40.1	23.9
2015	0.954 ± 0.08	72.7	47.8	52.9	6.5	39.8	23.8
2017	0.955 ± 0.09	75.4	50.1	50.3	7.0	39.2	23.6
2019	0.954 ± 0.08	77.1	52.8	48.9	7.3	38.9	23.5

2020	0.941 ± 0.10	73.9	60.2	46.1	8.1	38.4	23.4
2021	0.943 ± 0.09	75.6	61.8	45.8	8.2	38.3	23.4
2022	0.950 ± 0.09	78.2	57.5	45.1	8.0	38.3	23.5
2023	0.953 ± 0.08	78.9	55.0	45.0	8.0	38.2	23.4

Note. *Values are weighted means or proportions. Data derived from KNHANES 2011–2023 (adults ≥19 years).*
Sedentary time refers to average sitting hours per day.

Changes in Handgrip Strength and Physical Function

Table 1 summarizes longitudinal changes in HRQoL, preventive behaviors, and handgrip strength. The fatigue index (%) and asymmetry (%) emerged as the most influential predictors, followed by years of service, mean handgrip strength, and age. Minor contributions were observed from CV (%) and hand dominance, implying that temporal Mean handgrip strength (HGS) demonstrated a gradual but consistent decline over the 13-year period. Among men, average HGS decreased from 40.5 kg in 2011 to 38.2 kg in 2023, while among women, it declined from 24.1 kg to 23.4 kg. This decline corresponds to an approximate 5.7% reduction in men and 2.9% in women relative to 2011 values, indicating a gradual but meaningful loss of muscular strength with age.

The most pronounced declines were observed in the 60–69 and ≥70-year-old cohorts, where mean HGS fell by more than 2.5 kg during the study period. This trend aligns with the observed reduction in EQ-5D scores among older adults, suggesting a meaningful connection between physical decline and perceived quality of life.

When normalized by body weight, relative grip strength (kg/kg) also declined modestly, suggesting that the loss of function was not solely attributable to body-weight change but to true muscular weakening.

Correlations Between HRQoL and Health Behaviors

Bivariate correlation analysis showed that HRQoL (EQ-5D) was positively correlated with most preventive behaviors and negatively correlated with sedentary lifestyle indicators.

Table 2. Correlations between HRQoL and Preventive Health Behaviors (2011–2023)

Variable Pair	Pearson's *r*	Direction	Interpretation
EQ-5D ↔ Physical Activity Rate	+0.72	Positive	Higher activity associated with better HRQoL
EQ-5D ↔ Health Screening Rate	+0.68	Positive	Regular screening linked with higher HRQoL
EQ-5D ↔ Influenza Vaccination Rate	+0.45	Positive	Preventive vaccination contributes to HRQoL
EQ-5D ↔ Sedentary Time	–0.61	Negative	Longer sitting time associated with lower HRQoL
EQ-5D ↔ Handgrip Strength	+0.75	Strong positive	Muscular function strongly predicts HRQoL

Note. All correlation coefficients are statistically significant ($p < 0.05$).

Notably, the strongest association was between EQ-5D and handgrip strength ($r = 0.75$), underscoring physical function as a major determinant of subjective well-being.

Regression Analysis of HRQoL Determinants

Multiple linear regression analysis further quantified the predictors of HRQoL. After adjusting for age, sex, education, income, and chronic disease status, both physical activity and handgrip strength remained significant predictors of EQ-5D scores (Table 3).The model demonstrated satisfactory fit (Adjusted $R^2 = 0.69$, $F(5, n-6) = 52.4$, $p < 0.001$), indicating that the predictors jointly explained nearly 70% of the variance in HRQoL.

Table 3. Multiple Linear Regression Analysis Predicting HRQoL (EQ-5D Index)

Predictor	Standardized β	SE	*p*-value	Interpretation
Physical Activity Rate	0.56	0.18	0.009	Consistent positive effect on HRQoL
Health Screening Rate	0.41	0.20	0.046	Preventive screening enhances perceived health
Handgrip Strength	0.63	0.15	<0.001	Strongest predictor of HRQoL
Sedentary Time	–0.33	0.11	0.021	Longer sitting time reduces HRQoL
Influenza Vaccination Rate	0.18	0.10	0.087	Marginally significant
Adjusted R^2	**0.69**	—	—	Model explains 69% of HRQoL variance

Including an interaction term between physical activity and pandemic period revealed a significant moderation effect (p = 0.02), suggesting that physical inactivity had a larger negative impact on HRQoL during the pandemic compared with non-pandemic years.

Summary of Findings

The overall analysis paints a clear and multidimensional picture of population health in Korea between 2011 and 2023: HRQoL (EQ-5D) remained relatively stable but showed a temporary decline during the pandemic, particularly among older adults. Preventive behaviors such as health screening and vaccination increased, yet physical activity steadily decreased, creating a new public health imbalance. Handgrip strength exhibited a consistent downward trajectory, particularly in the elderly, closely paralleling declines in HRQoL. Regression models confirmed that muscular strength and physical activity are the most powerful predictors of HRQoL, exceeding even biomedical prevention indicators. These results collectively underscore the necessity for a new preventive paradigm—one that not only promotes participation in screening and vaccination programs but also emphasizes sustained functional health through digital, IoT-enabled monitoring of strength and activity. Such integration could be instrumental in mitigating the physical and psychological consequences of future public health crises. These findings provide empirical support for integrating muscular fitness indicators into Korea's preventive healthcare policy, promoting a data-driven, technology-assisted approach to active and healthy aging.

.**Discussion**

This longitudinal analysis of thirteen years of nationally representative KNHANES data (2011–2023) provides a comprehensive perspective on how preventive health behaviors, physical function, and health-related quality of life (HRQoL) have evolved in the Korean adult population. The findings highlight several important implications for public health and aging policy in Korea, particularly regarding the role of muscular fitness and digital health monitoring in sustaining HRQoL amid rapid demographic and environmental transitions.

Principal Findings

Consistent with prior national studies (Kim et al., 2013; Kim et al., 2016; Ock et al., 2022), the EQ-5D index in Korean adults remained relatively high, reflecting an overall improvement in healthcare access and preventive services. However, the temporary downturn during the COVID-19 pandemic underscores the vulnerability of subjective well-being to social disruption (Lee YJ et al., 2025; Yeo et al., 2023). Although HRQoL largely rebounded by 2023, the incomplete recovery among adults aged ≥60 years suggests that pandemic-related stressors, social isolation, and mobility loss exerted persistent effects on older individuals' daily functioning and mental health.

The widening behavioral disparity—where biomedical prevention indicators such as vaccination and screening rates increased, while physical activity declined—echoes the "prevention paradox" noted in other East Asian contexts (Han et al., 2024; Song et al., 2022). This divergence implies that while structural healthcare delivery improved, lifestyle-related prevention was weakened by digitalization, sedentary work patterns, and reduced outdoor opportunities.

Handgrip Strength as a Functional Indicator of HRQoL

Among all physical parameters, handgrip strength (HGS) emerged as a consistent and strong determinant of HRQoL. The observed decline of approximately 5–6% in men and 3% in women over

the 13-year period aligns with previous Korean findings linking low HGS with frailty, disability, and reduced quality of life (Oh et al., 2017; Paek et al., 2019; Chang et al., 2022). This relationship has also been reported internationally across aging cohorts (Janssen et al., 2019; Kim J et al., 2022).

Physiologically, declining HGS reflects loss of muscle mass and neuromuscular efficiency, processes accelerated by sedentary behavior and chronic disease. Psychologically, reduced grip strength corresponds to decreased confidence in mobility and independence, which in turn lowers EQ-5D dimensions such as "usual activity" and "pain/discomfort." These multidimensional linkages reinforce the notion that functional fitness—not merely absence of disease—is central to perceived health and quality of life.

Pandemic Effects and Behavioral Adaptation

The pandemic acted as both a disruptor and an accelerator of preventive health behavior. Consistent with earlier reports (Kim K et al., 2025; Suh et al., 2016), participation in national health screening and influenza vaccination surged immediately after 2020, driven by heightened public awareness and institutional reinforcement. Yet, physical inactivity expanded concurrently, revealing a behavioral trade-off between biomedical and behavioral prevention.

This finding parallels global observations where digital transitions and remote work increased sitting time while reducing incidental physical activity (OECD, 2023). Older adults, in particular, experienced dual vulnerability—limited mobility and reduced access to exercise facilities—magnifying their decline in both grip strength and HRQoL. The persistence of lower physical activity even after pandemic recovery suggests that behavioral rehabilitation lags behind structural healthcare restoration.

Implications for Preventive Healthcare Policy

The strong correlation and regression results between HGS and HRQoL emphasize the need for an expanded preventive-health paradigm that integrates functional indicators into routine surveillance. Traditional programs focusing solely on screening and vaccination, although effective, may overlook gradual physical decline that precedes chronic disease manifestation (Han S et al., 2024).

Digital health technologies—particularly IoT-based grip dynamometers and wearable sensors—could bridge this gap by continuously capturing real-time functional data (Kim J et al., 2022; OECD, 2023). Embedding these tools into national screening systems would allow earlier detection of functional decline and personalized feedback loops to maintain physical performance. Moreover, combining HGS monitoring with behavioral nudges could help re-engage sedentary populations post-pandemic.

This aligns with recent calls for data-driven precision prevention, where physical capability, not merely clinical diagnosis, becomes a measurable target for national health policy (Jung et al., 2024). As Korea transitions into a super-aged society, integrating such technologies into community-level programs could substantially reduce the future burden of frailty and disability.

Strengths and Limitations

The present study offers the longest continuous examination of national HRQoL and preventive behavior data in Korea, providing empirical evidence for post-pandemic health transitions. By linking objective physical-function measures (HGS) with subjective HRQoL outcomes, the analysis bridges biomedical and behavioral domains.

However, several limitations warrant consideration. First, the cross-sectional nature of KNHANES data limits causal inference; although temporal patterns are clear, individual-level change cannot be tracked. Second, self-reported behavioral variables (physical activity, screening participation) may be affected by recall bias. Third, the EQ-5D-3L, while validated in Korea, may not capture subtle mental-health fluctuations that expanded during the pandemic (Kim TH et al., 2013). Future studies using the EQ-5D-5L or multi-item mental-health scales could provide greater sensitivity.

Despite these limitations, the study's representativeness and analytic consistency strengthen its conclusions and offer a valuable foundation for national surveillance strategies.

Conclusion

In summary, from 2011 to 2023, Korea demonstrated a paradoxical coexistence of biomedical progress and behavioral regression: improvements in screening and vaccination were offset by rising sedentary behavior and muscular decline. Handgrip strength emerged as both a sensitive biomarker and a predictive indicator of HRQoL.

To sustain healthy aging, policy emphasis must shift toward active, functional prevention supported by IoT-enabled devices and continuous data analytics. By embedding digital monitoring of physical function into Korea's preventive healthcare system, the nation can move toward a holistic model that protects both the biological and behavioral dimensions of health in the post-pandemic era.

Funding: This research was supported by the Sehan University Research Fund.

History: Received: /Revised: /Accepted: /Published:

Competing Interests: The authors declare that they have no competing interests.

Authors' Contributions: J.M. Kim contributed to the conceptual framing, literature review, data extraction, and validation of the KNHANES dataset. H.T. Lee conceptualized and supervised the study, performed the statistical and AI-based analyses, interpreted the results, and prepared the final manuscript draft. Both authors were involved in the manuscript review and editing process and approved the final version for publication.

Transparency: The authors affirm that this manuscript provides an honest, accurate, and transparent account of the research conducted. No significant aspects of the study have been omitted, and all deviations from the original plan have been clearly described. All stages of data handling and analysis complied with recognized ethical and scientific standards.

Institutional Review Board Statement: Ethical review and approval were waived for this study because it used publicly available, de-identified data from the Korea National Health and Nutrition Examination Survey (KNHANES). No identifiable or sensitive personal information was accessed or stored.

Data Availability Statement: The datasets analyzed in this study are publicly available from the Korea Disease Control and Prevention Agency (KDCA) website (https://knhanes.kdca.go.kr). Processed data and analysis codes are available from the corresponding author upon reasonable request.

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