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ORIGINAL RESEARCH

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Effect of health literacy on health-related quality of life among Korean middle-aged men: mediating roles of anxiety and sleep duration

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Abstract

Background: This study investigated the mediating effects of anxiety and sleep duration on the relationship between health literacy and health-related quality of life (HRQoL) among middle-aged men. **Methods**: This descriptive study involved the secondary analysis of data obtained from the 2023 Korea National Health and Nutrition Examination Survey, an annual government-led survey examining health levels and behaviors. The participants in this study were 1171 middle-aged men aged 40–64 years. The main analysis involved the application of Hayes's PROCESS Macro for SPSS v.4.0, and Model 6 was used to determine the mediating effects of anxiety and sleep duration on the relationship between health literacy and HRQoL. **Results**: In Stage 1, health literacy had a significant effect on anxiety (B = −0.017, $p = 0.040$), and in Stage 2, health literacy (B = −0.062, $p < 0.001$) and anxiety (B = −0.050, $p = 0.009$) had a significant effect on sleep duration. In Stage 3, health literacy (B = 0.001, $p < 0.001$), anxiety (B = −0.009, $p < 0.001$), and sleep duration (B = 0.001, $p < 0.001$) significantly affected HRQoL. In Stage 4, health literacy had a significant effect on HRQoL (B = 0.001, $p < 0.001$). The total effect of health literacy on HRQoL increased from 0.001 to 0.002 ($p < 0.001$) when anxiety and sleep duration were included. **Conclusions**: This study has important implications for the HRQoL of middle-aged men. Significantly, to improve HRQoL among this cohort, it is necessary to increase health literacy and develop interventions to reduce anxiety and maintain adequate sleep time.

Keywords

Middle-aged men; Health literacy; Health-related quality of life; Anxiety; Sleep duration

1. Introduction

Recent research indicates that health behaviors and physiological status during midlife significantly influence later life outcomes, including cognitive function and the risk for chronic diseases [1]. Although older adults are more likely to suffer from chronic conditions, midlife represents a physiological and psychosocial turning point at which the accumulation of stress and early biological changes begin to manifest as increased vulnerability to chronic illness such as metabolic syndrome. Evidence from previous research [2] indicates that early-life exposures and long-term stress contribute to elevated allostatic load in midlife, which in turn accelerates functional decline and predicts later health deterioration. Accordingly, middle-aged adults, defined as those aged 40 to 64 years according to a previous study [3], constitute a critical target group for preventive intervention, as this stage marks the onset of measurable changes in metabolic health, sleep regulation, and overall quality of life preceding old age. Effective lifestyle interventions during midlife are essential to promote healthy aging and prevent age-related functional decline.

Research on gender differences in health-related quality of life (HRQoL) across adulthood reveals a dynamic age-related shift. Women under 65 years generally report lower HRQoL than men; however, this pattern reverses in later life as men experience a steeper decline across physical and psychosocial domains [4–8]. While men aged 40–64 years tend to maintain higher HRQoL, this advantage narrows in early old age and reverses after age 75. These patterns indicate that midlife is a pivotal transition period when men's HRQoL begins to deteriorate more rapidly, underscoring the need for gender-responsive strategies to support psychological and physical well-being during this stage.

Health literacy refers to the ability to understand and effectively use health information [9], and it is recognized as a fundamental skill that positively influences HRQoL by promoting better health behaviors and improving disease management [10]. Despite its recognized significance in improving health outcomes, health literacy remains underutilized owing to various limitations [11]. Previous studies have sought to elucidate the relationship between health literacy and HRQoL [12, 13], particularly among patients with chronic diseases.

Although such studies provide valuable insights, their focus has often been confined to specific chronic conditions, leaving complex pathways and underlying mechanisms unclear, which limits causal interpretations. This study is a secondary analysis using the Korea National Health and Nutrition Examination Survey (KNHANES) 2023 and differs from other studies using KNHANES 2023. For example, the study by Choi *et al.* [14] had different research objectives, variables, and analysis methods, resulting in different results. Previous studies have demonstrated that individuals with low health literacy tend to experience more frequent anxiety symptoms and greater psychological burdens in managing their health. This is largely attributable to deficiencies in accessing, comprehending, and applying health information, which significantly heighten uncertainty in health-related decision-making and consequently elevate anxiety through specific cognitive and emotional pathways [15, 16]. In particular, inadequate health literacy exacerbates information gaps and limits an individual's capacity to engage in disease prevention and management strategies, thereby resulting in intensified health-related fears and adverse emotional responses. Accumulating evidence suggests that higher anxiety levels correlate with poorer HRQoL across both mental and physical domains [17]. These findings collectively highlight the necessity of exploring diverse pathway models between health literacy and HRQoL, drawing growing attention to the potential partial mediating role of anxiety in this relationship. Therefore, further systematic path analyses are required to clarify the structural dynamics among health literacy, anxiety, and HRQoL.

Current findings suggest that elevated anxiety levels adversely affect sleep duration, with individuals experiencing increased anxiety symptoms demonstrating significantly shortened sleep patterns and compromised sleep architecture [18, 19]. Emerging evidence suggests that health literacy substantially influences sleep duration through pathways involving sleep hygiene behaviors and health management capabilities. Notably, Alijanzadeh *et al.* [20] found that individuals with higher levels of health literacy tended to report longer and more appropriate sleep durations, whereas those with lower levels health literacy were more likely to exhibit inadequate sleep patterns and reduced sleep quality. They found that the mechanisms underlying the influence of health literacy on sleep duration were mediated by an enhanced understanding of sleep-related health information, improved sleep hygiene practices, and more effective self-regulation of sleep behaviors [20]. Furthermore, sleep duration has been established as a critical determinant of HRQoL, with both insufficient and excessive sleep durations being associated with significantly diminished physical and mental health components of quality of life across diverse populations [21, 22]. Therefore, sleep duration is an additional pathway that warrants exploration within the complex relationship between health literacy and HRQoL, suggesting the need for comprehensive pathway models that incorporate sleep-related mediating mechanisms.

This study examines the relationship between health literacy and HRQoL among middle-aged men, and investigates whether and how anxiety and sleep duration mediate this relationship. Conceptually, this study draws on the Wilson and Cleary model of HRQoL [23], which views HRQoL as a multidimensional construct determined by the sequential interaction of biological, psychological, and behavioral factors. Within this theoretical structure, individual characteristics (*i.e.*, health literacy) influence psychological responses (*i.e.*, anxiety), which subsequently affect functional behaviors (*i.e.*, sleep duration). These processes collectively shape individuals' perceptions of health and overall quality of life.

While previous studies have reported separate associations among health literacy, anxiety, sleep, and HRQoL, little is known about the underlying mechanism connecting these factors. To address this gap, this study applies a mediating model to clarify how anxiety and sleep duration explain the pathway through which health literacy influences HRQoL in middle-aged men. Mediation analysis offers a rigorous statistical framework with which to delineate the indirect mechanisms through which an independent variable, such as health literacy, impacts a dependent outcome, such as HRQoL. By explicating the specific processes and intermediary variables involved, this approach illuminates the underlying psychological, physiological, and behavioral pathways that govern the observed associations. Incorporating mediators such as anxiety and sleep duration allows this study to address existing research gaps by capturing the complex, sequential, or parallel interactions that traditional direct-effect models often overlook. Mediation models can enhance our theoretical understanding and inform the development of targeted evidence-based interventions to improve public health outcomes. Therefore, this model allows for a more comprehensive understanding of how these variables interact and operate, moving beyond simple associations toward identifying actionable mechanisms relevant to intervention design.

This study investigates whether health literacy affects HRQoL among middle-aged Korean men through the mediating pathways of anxiety and sleep duration. By systematically assessing the relative contributions and combined influences of these mediators, this study confirms the importance of adopting a comprehensive approach that integrates psychological and physiological factors. This approach is essential for the design and implementation of effective targeted interventions and public health programs that address the multifaceted determinants of well-being.

2. Materials and methods

2.1 Study design

This was a descriptive study involving a secondary analysis of data obtained from the Korea National Health and Nutrition Examination Survey (KNHANES) of 2023. This study aimed to identify the mediating effects of anxiety and sleep duration on the relationship between health literacy and HRQoL among middle-aged men.

2.2 Participants

This study used data from the KNHANES, 2023. The National Health and Nutrition Survey is a statutory survey conducted annually by the Ministry of Health and Welfare to understand people's health levels and behaviors. The results of the National Health and Nutrition Survey are used as basic data for

health policies. The total number of KNHANES participants in 2023 was 6929. The participants in this study were 1171 middle-aged men.

2.3 Study variables

2.3.1 General characteristics

General characteristics included age, education level, economic status, marital status, economic activity, and daily smartphone usage duration (less than 1 h, 1–3 h, and 4 h or more). Health behaviors included subjective health, diabetes and hypertension, health checkups, drinking, smoking, stress (a lot or a little), number of walking days per week (0 days, 1–2 days, or 3 or more days), and body mass index (BMI). BMI was calculated by dividing the body weight (kg) by the square of height (m). According to the standards of the Korean Society for the Study of Obesity [24], underweight is defined as a BMI of less than 18.5 kg/m^2, and obesity is defined as a BMI of 25.0 kg/m^2 or more.

2.3.2 Health literacy

Health literacy was measured using the Health Literacy Index developed by Yoon *et al.* [25]. This tool is a 4-point Likert scale consisting of 10 items, including disease prevention, health promotion, health management, and resource utilization. At the time of development, the Cronbach's α for this tool was 0.87, and in this study, the Cronbach's α for this tool was 0.99.

2.3.3 Health-related quality of life

HRQoL was measured using the health-related quality of life instrument with 8 items (HINT-8) index developed by Lee *et al.* [26]. This tool is a 4-point scale (*e.g.*, "I had no difficulty at all in (doing)", "I had some difficulty in (doing)", "I had a lot of difficulty in (doing)", and "I could not (do)") consisting of eight items in eight areas: climbing stairs, pain, vitality, work, depression, memory, sleep, and happiness. This study used Lee *et al.*'s [26] index calculation formula, expressed as follows: $1 - (0.073 + 0.018 \times CL2 + 0.072 \times CL3 + 0.122 \times CL4 + 0.055 \times PA2 + 0.116 \times PA3 + 0.188 \times PA4 + 0.019 \times VI23 + 0.070 \times VI4 + 0.004 \times WO2 + 0.028 \times WO3 + 0.036 \times WO4 + 0.012 \times DE2 + 0.044 \times DE3 + 0.098 \times DE4 + 0.014 \times ME2 + 0.058 \times ME3 + 0.109 \times ME4 + 0.020 \times SL3 + 0.090 \times SL4 + 0.014 \times HA2 + 0.068 \times HA3 + 0.082 \times HA4)$.

Values ranged from 0.132 to 1. The closer the value is to 1, the better the HRQoL [27].

2.3.4 Anxiety

Anxiety was measured using the Generalized Anxiety Disorder-7 (GAD-7) tool developed by Spitzer *et al.* [28]. GAD-7 consists of seven items rated on a 4-point Likert scale, with higher scores indicating more severe anxiety. At the time of tool development, the tool had a sensitivity of 60.6%–89%, with specificity of 82%–87.6%. In this study, this instrument had a Cronbach's α of 0.93.

2.3.5 Sleep duration

Sleep duration was measured using an open-ended question: "How many hours do you usually sleep per day?".

2.4 Analysis

Analysis of the study data was performed using SPSS/WIN version 27.0 (IBM Corp., Armonk, NY, USA), and the significance level was set at 0.05. Descriptive statistics were used to analyze the general characteristics of the participants and degree of the major variables (HRQoL, health literacy, anxiety, and sleep duration). *t*-tests and analysis of variance (ANOVA) were used to determine differences in HRQoL according to general characteristics, and Scheffé's test was used for *post-hoc* analyses. Correlations among HRQoL, health literacy, anxiety, and sleep duration were analyzed using Pearson's correlation coefficient. To identify the mediating effects of anxiety and sleep duration on health literacy and HRQoL, Model 6 of Hayes' PROCESS Macro for SPSS v.4.0 [29] was used. Bootstrapping (10,000) was used to validate the significance of the mediating effect.

According to the 2022–2023 Usage Guidelines from the Korea Disease Control and Prevention Agency [30], using weights in the KNHANES data analysis process can improve the representativeness and accuracy of estimates by correcting for coverage errors, unequal sampling rates, and survey non-response errors (missing data) due to differences in household and population size between the sampling design and survey periods. This study utilized weighted data for analysis, thereby correcting for missing data.

3. Results

3.1 Relationship between general characteristics and HRQoL

As Table 1 shows, there were significant differences in HRQoL scores depending on economic level, marital status, subjective health, hypertension, health checkups, economic activity, smoking, stress, and number of walking days ($p < 0.05$). The HRQoL scores were higher among participants with higher education levels, living with a spouse, subjectively perceiving themselves as healthier, not having hypertension, undergoing health checkups, not smoking, experiencing less stress, and walking more frequently.

3.2 Mean and standard deviation of anxiety, sleep duration, health literacy, and health

The mean HRQoL was 0.78 (0.09), the mean health literacy was 29.56 (5.49), the mean anxiety was 1.66 (3.01), and the mean sleep duration was 8.45 (12.88) (Table 2).

3.3 Correlation among HRQoL, health literacy, anxiety, and sleep duration

HRQoL and anxiety were negatively correlated ($r = -0.42$, $p < 0.001$), and HRQoL and sleep duration were positively correlated ($r = 0.21$, $p < 0.001$). Health literacy was negatively correlated with anxiety ($r = -0.06$, $p = 0.037$) and sleep duration ($r = -0.50$, $p < 0.001$). Anxiety and sleep duration

TABLE 1. Differences in HRQoL according to general characteristics (n = 1171).

Characteristics	Categories	n (%)	HRQoL	
			M ± SD	*t*/*F*(*p*) Scheffé
Age (yr)				
	40–49	428	0.78 (0.08)	
	50–49	447	0.78 (0.10)	0.65 (0.519)
	60–64	296	0.79 (0.10)	
Education level				
	≤High school	529	0.77 (0.10)	−1.80 (0.067)
	≥College	617	0.78 (0.08)	
Economic level				
	Upper[a]	483	0.79 (0.09)	12.64 (<0.001) a, b > c
	Middle[b]	590	0.78 (0.09)	
	Lower[c]	94	0.73 (0.13)	
Marital status				
	With spouse	937	0.79 (0.09)	3.43 (0.001)
	Others	98	0.75 (0.11)	
Subjective health				
	Healthy[a]	383	0.82 (0.07)	93.25 (<0.001) a > b > c
	Normal[b]	513	0.78 (0.08)	
	Not healthy[c]	162	0.70 (0.11)	
Hypertension				
	Yes	330	0.77 (0.11)	−2.21 (0.027)
	No	840	0.79 (0.09)	
Diabetes				
	Yes	159	0.77 (0.10)	−1.75 (0.080)
	No	1011	0.78 (0.09)	
Health checkup				
	Yes	820	0.78 (0.09)	2.06 (0.039)
	No	235	0.77 (0.10)	
Economic activity				
	Yes	919	0.79 (0.08)	4.72 (<0.001)
	No	136	0.74 (0.13)	
Drinking				
	More than one glass/mon	823	0.78 (0.09)	0.46 (0.645)
	Less than one drink/mon	325	0.78 (0.10)	
Smoking				
	Yes	437	0.76 (0.09)	−4.37 (<0.001)
	No	710	0.79 (0.09)	
Stress				
	Feel less	860	0.80 (0.08)	10.40 (<0.001)
	Feel more	288	0.73 (0.09)	
Number of walking days/wk				
	0[a]	200	0.77 (0.10)	5.45 (0.004) a, b < c
	1–2[b]	207	0.76 (0.09)	
	≥3[c]	649	0.79 (0.09)	

TABLE 1. Continued.

Characteristics	Categories	n (%)	HRQoL	
			M ± SD	*t*/*F*(*p*) Scheffé
BMI (kg/m^2)				
	<18.5	24	0.76 (0.10)	
	18.5–24.9	605	0.78 (0.09)	1.01 (0.366)
	≥25	529	0.78 (0.09)	
Smartphone usage time/d				
	<1	81	0.76 (0.10)	
	1–3	288	0.78 (0.09)	1.24 (0.288)
	≥4	344	0.78 (0.08)	

M: Mean; SD: Standard deviation; t: t value of t-test; F: F value of ANOVA; Scheffe: post-hoc analyses; HRQoL: health-related quality of life; BMI: body mass index.

TABLE 2. Mean and standard deviation of HRQoL, health literacy, anxiety, and sleep duration.

	HRQoL	Health literacy	Anxiety	Sleep duration
Mean (SD)	0.78 (0.09)	29.56 (5.49)	1.66 (3.01)	8.45 (12.88)

SD: Standard deviation; HRQoL: health-related quality of life.

were negatively correlated ($r = -0.07$, $p = 0.008$) (Table 3).

3.4 Mediating effects of anxiety and sleep duration on the relationship between health literacy and HRQoL

The mediating effects of anxiety and sleep duration on health literacy and HRQoL were analyzed using Model 6 of the PROCESS Macro for SPSS v.4.0.

The results showed that each model was statistically significant (Table 4 and Fig. 1). In Stage 1, health literacy had a significant effect on anxiety (B = −0.017, $p = 0.040$), and in Stage 2, health literacy (B = −0.062, $p < 0.001$) and anxiety (B = −0.050, $p = 0.009$) had a significant effect on sleep duration. In Stage 3, health literacy (B = 0.001, $p < 0.001$), anxiety (B = −0.009, $p < 0.001$), and sleep duration (B = 0.001, $p < 0.001$) significantly affected HRQoL. In Stage 4, health literacy had a significant effect on HRQoL (B = 0.001, $p < 0.001$). The total effect of the relationship between health literacy and HRQoL increased from 0.001 to 0.002 ($p < 0.001$) when anxiety and sleep duration were included (Table 5). Therefore, sleep duration has a positive effect on HRQoL, while anxiety has a negative effect. This indicates a dual mediating effect (*i.e.*, indirect mediating effect).

To determine the significance and influence of the double mediation effect, a comparison was made among three pathways: the path with only the first parameter input, the path with only the second parameter input, and the effect of the path with both the first and second parameter inputs. To verify the significance of the mediating effect, a bootstrapping method was used, and 10,000 samples were resampled. Statistical significance was determined using 95% confidence intervals.

Table 6 shows the health literacy path to HRQoL scores via anxiety (B = 0.008, 95% Confidence interval (CI): 0.001–0.017), the health literacy path to HRQoL scores via sleep duration (B = −0.005, 95% CI: −0.011—0.001), and the health literacy path to HRQoL scores via anxiety and sleep duration (B = 0.001, 95% CI: 0.001–0.001). The bootstrapping results confirm that the indirect effects of anxiety and sleep duration on the relationship between health literacy and HRQoL are statistically significant, with all confidence intervals excluding zero.

4. Discussion

This study examined the relationship between health literacy and HRQoL among middle-aged men and explored the mediating roles of anxiety and sleep duration. As confirmed in this study, the overall effect of health literacy on HRQoL in middle-aged men was significantly positive, consistent with previous research findings [12, 31, 32]. For example, previous studies have shown that health literacy enhances self-management skills [31] and promotes preventive behaviors [32], thereby improving quality of life. However, mediation analysis in this study revealed that health literacy simultaneously operates through protective psychological pathways, such as anxiety, and detrimental behavioral pathways, such as reduced sleep duration. These pathways are linked to sociocultural stress, long working hours, and sleep deprivation in middle-aged Korean men, suggesting that the positive effects of health literacy are partially attenuated by sleep deprivation. Therefore, this study contextualizes the relationship between health literacy and HRQoL by examining the interaction between psychological and behavioral factors within a high-stress population of middle-aged men. This focus is particularly relevant given evidence that men in midlife often demonstrate lower helpseeking behaviors and stronger workoriented identities, making them more vulnerable to stressrelated declines in HRQoL.

Regarding its relationship with anxiety, previous studies

TABLE 3. Correlation between HRQoL, health literacy, anxiety, and sleep duration (n = 1171).

Variables	HRQoL *r* (*p*)	Health literacy *r* (*p*)	Anxiety *r* (*p*)	Sleep duration *r* (*p*)
HRQoL	1			
Health literacy	0.01 (0.957)	1		
Anxiety	−0.42 (<0.001)	−0.06 (0.037)	1	
Sleep duration	0.21 (<0.001)	−0.50 (<0.001)	−0.07 (0.008)	1

HRQoL: Health-related quality of life.

TABLE 4. Mediating effect of anxiety and sleep duration on the relationship between HRQoL and health literacy in middle aged men (n = 1171).

No	Variables		B (Coeffect)	SE	*p*	95% CI		R^2
						LLCI	ULCI	
1	Health literacy	Anxiety	−0.017	0.008	0.040	−0.034	−0.001	0.218
2								
	Health literacy	Sleep duration	−0.062	0.011	<0.001	−0.083	0.040	0.014
	Anxiety	Sleep duration	−0.050	0.019	0.009	−0.088	−0.012	
3								
	Health literacy	HRQoL	0.001	0.001	<0.001	0.001	0.002	
	Anxiety	HRQoL	−0.009	0.001	<0.001	−0.010	−0.008	0.351
	Sleep duration	HRQoL	0.001	0.001	<0.001	0.001	0.002	
4	Health literacy	HRQoL	0.001	0.001	<0.001	0.001	0.002	0.279

HRQoL: Health-related quality of life; SE: Standard error; CI: Confidence interval; LLCI: Lower limit confidence interval; ULCI: Upper limit confidence interval.

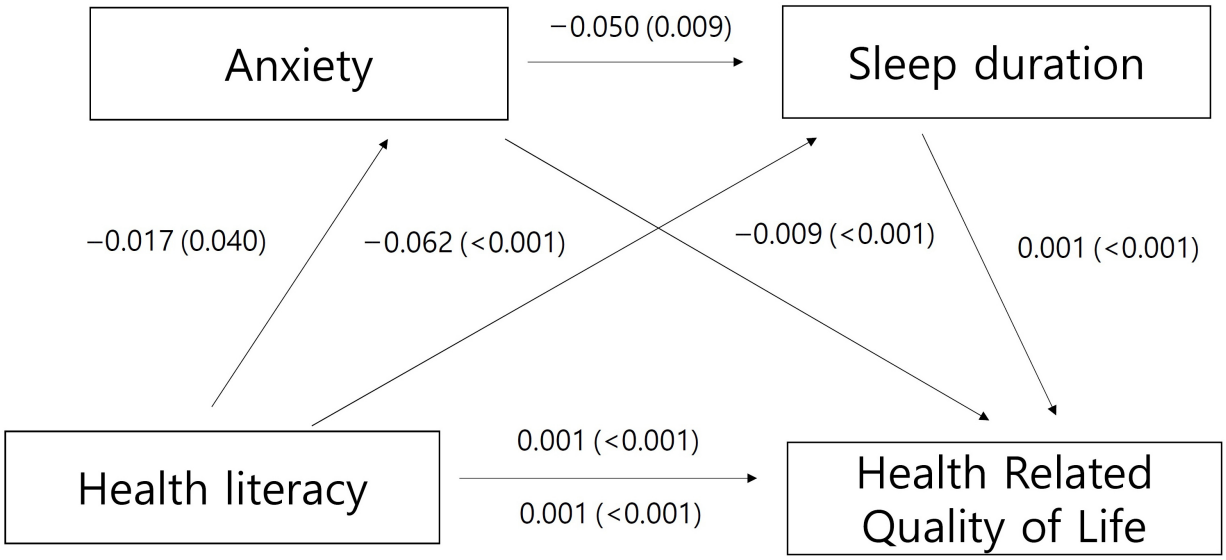

FIGURE 1. Mediating effect of variables.

TABLE 5. Total effect, direct effect (n = 1171).

	Effect	SE	*p*	95% CI	
				LLCI	ULCI
Total effect	0.001	0.003	<0.001	0.001	0.002
Direct effect	0.001	0.003	<0.001	0.001	0.002

SE: Standard error; CI: Confidence interval; LLCI: Lower limit confidence interval; ULCI: Upper limit confidence interval.

TABLE 6. Validation of mediating effect (Bootstrapping) (n = 1171).

Variables		Effect	Boot SE	95% CI	
				LLCI	ULCI
Indirect 1	Health literacy → Anxiety → HRQoL	0.008	0.004	0.001	0.017
Indirect 2	Health literacy → Sleep duration → HRQoL	−0.005	0.002	−0.011	−0.001
Indirect 3	Health literacy → Anxiety → Sleep duration → HRQoL	0.001	0.001	0.001	0.001

HRQoL: Health-related quality of life; SE: Standard error; CI: Confidence interval; LLCI: Lower limit confidence interval; ULCI: Upper limit confidence interval.

have reported that limited health literacy increases health-related uncertainty and psychological burden, leading to elevated anxiety levels [15, 33, 34]. Zhang *et al.* [35] found that mental health literacy strengthens psychological resilience, whereas inadequate literacy exacerbates psychological hardship and anxiety, suggesting that enhancing health literacy may serve as an effective strategy for alleviating anxiety. Given that middle-aged men exhibit distinctive stress profiles and coping behaviors shaped by occupational pressures, our findings emphasize that improving health literacy in this group may contribute to anxiety relief through mechanisms different from those observed in mixed-gender samples. Consistent with these previous studies, this study empirically confirmed through a mediation model that health literacy significantly affects anxiety levels and that increased anxiety ultimately leads to a decline in HRQoL. This underscores the pivotal role of anxiety as a psychological mechanism linking health literacy to HRQoL among middle-aged Korean men, a population particularly vulnerable to anxiety arising from work-related and lifestyle pressures [12, 17, 36].

The observed negative association between health literacy and sleep duration was an unexpected finding in this study. Rather than indicating a direct causal relationship, this result should be interpreted cautiously as a hypothesis-generating observation that may reflect the unique sociocultural context of middle-aged Korean men. In this population, higher levels of health literacy are often aligned with professional employment that entails substantial responsibilities and elevated stress levels. Such positions are frequently associated with long working hours and the burden of being primary economic providers, both of which may constrain opportunities for sufficient sleep. Within a society characterized by the longest working hours among the Organisation for Economic Co-operation and Development (OECD) countries, these structural and cultural pressures may restrict men's ability to translate their health knowledge into adequate rest. Consequently, despite possessing relatively high health literacy, these men may experience lower HRQoL as a result of insufficient recovery and persistent work-related strain. This interpretation aligns with prior evidence indicating that middle-aged men often face organizational and temporal barriers to engaging in health-promoting activities and tend to prioritize economic responsibilities over personal health needs [6]. Therefore, while health literacy may serve a psychologically protective role by reducing anxiety, it may simultaneously operate within a behavioral context that limits healthy sleep.

This study has several limitations. First, the cross-sectional design using data from the KNHANES limits the ability to clearly establish causal relationships. Therefore, longitudinal or linked-cohort studies are needed to clarify the associations among anxiety, sleep, and HRQoL. Second, the sleep duration was measured using a single self-report item, making it vulnerable to recall bias and failing to reflect other important aspects, such as sleep quality. Third, the analytic model did not incorporate additional psychosocial and occupational variables—such as job strain, work–life balance, and organizational culture—that may further elucidate the knowledge–behavior gap suggested by the present findings.

Despite these limitations, this study offers several important academic contributions. First, it expands upon existing linear relationships by empirically identifying complex mediating pathways among health literacy, anxiety, sleep duration, and HRQoL. Second, it presents a structural model that integrates psychological variables (anxiety) and behavioral variables (sleep duration). Third, by focusing on Korean middle-aged men, the study broadens the demographic scope of HRQoL research and foregrounds the importance of gender- and life stage-specific analyses. In particular, a distinctive contribution of this study lies in demonstrating that health literacy may simultaneously alleviate anxiety yet be associated with shorter sleep duration, ultimately exerting a mixed influence on HRQoL. These findings suggest that information provision alone is insufficient as a health literacy intervention strategy for middle-aged men and that health promotion programs should explicitly integrate anxiety reduction with sleep improvement components. Furthermore, the results underscore the need for gender- and age-responsive policies that address structural barriers to behavior change, thereby narrowing the knowledge–behavior gap identified in this population.

5. Conclusions

This study holds important insights into HRQoL among middle-aged men in Korea. Although middle-aged men may appear to maintain relatively stable HRQoL levels, the results of the study demonstrate that health literacy influences HRQoL through the mediating factors of anxiety and sleep duration. Notably, increased anxiety and shorter sleep duration were identified as significant variables negatively associated with HRQoL in this population. These findings highlight the limitations of traditional health-information delivery strategies and the need for integrated interventions that simultaneously address anxiety management and sleep duration improvement. Such comprehensive approaches

are essential to prevent the deterioration of HRQoL among middle-aged men. Furthermore, this study has shed light on psychological and behavioral pathways hitherto underexplored in research on men's health, thereby providing foundational evidence for developing targeted midlife interventions and gender-sensitive health policies.

AVAILABILITY OF DATA AND MATERIALS

The datasets analyzed during the current study are available from the Korea National Health and Nutrition Examination Survey (KNHANES) repository, https://knhanes.kdca.go.kr.

AUTHOR CONTRIBUTIONS

MK, SAK and JK—Conceptualization; Writing–original draft preparation; Writing–review and editing. MK and SAK—methodology. MK—formal analysis; described the variables. SAK—described the subjects. JK—visualization; supplemented the description of the variables and their relationships. All authors have read and agreed to the published version of the manuscript. All authors discussed the concept of this study together.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

In compliance with the Personal Information Protection Act and the Statistics Act, the Korea Disease Control and Prevention Agency only provides de-identified data, preventing individuals from being identified from survey data. Data were downloaded from the National Health and Nutrition Survey website in December 2024, with permission from the administrator for academic research purposes. The KNHANES, 2023, was approved by the Institutional Review Board of the Korea Disease Control and Prevention Agency (No. 2022-114-16-R-A).

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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