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Indirect Associations of Perceived Stress and Sleep Quality in the Relationship Between Andropause Symptoms and Quality of Life Among Middle-Aged Men: A Cross-Sectional Study

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Abstract

This study examined the associations between andropause symptoms, perceived stress, and sleep quality, and determined the indirect pathway of perceived stress and sleep quality in the relationship between andropause symptoms and quality of life (QoL) among middle-aged men. This cross-sectional study employed a quantitative mediation analysis design. In total, 186 middle-aged men completed questionnaires, including the Androgen Deficiency in Aging Males Scale, Perceived Stress Scale, Pittsburgh Sleep Quality Index, and World Health Organization Quality of Life. Data were analyzed using binary logistic regression, Baron and Kenny mediation analysis, and Hayes PROCESS macro. In total, 83.3% of the participants screened positive for andropause symptoms, and 58.6% reported poor sleep quality. Andropause syndrome and perceived stress were significantly associated with an increased risk of poor sleep quality (odds ratio [*OR*] = 6.168, 95% confidence interval [CI] = [2.013, 18.896], $p = .001$; *OR* = 1.279, 95% CI = [1.159, 1.410], $p < .001$). Statistical mediation analysis indicated perceived stress and poor sleep quality explained the link between andropause symptoms and QoL ($B = -0.033$, $p < .001$; $B = -0.060$, $p < .001$; $B = -0.052$, $p < .001$). Bootstrapped mediation analysis revealed two significant indirect associations between andropause symptoms and QoL: perceived stress ($B = -0.861$, 95% CI = [−1.210, −0.514]) and sleep quality ($B = -1.566$, 95% CI = [−2.054, −1.035]). These findings provide empirical evidence that acute and sustained psychosocial burdens associated with andropause symptoms contribute substantially to a decline in overall well-being and health.

Keywords

andropause, stress, sleep quality, quality of life, middle-aged

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Introduction

Andropause syndrome is closely associated with aging and is characterized by physical (e.g., increased abdominal fat, reduced muscle and bone strength, less hair, and skin changes), mood (e.g., depression, decreased concentration and cognitive function, and increased fatigue), and sexual changes (e.g., diminished libido, erectile dysfunction, and reduced sexual drive) (Bhasin et al., 2018; Indirli et al., 2023; Lim & Park, 2025). Recent studies have reported substantial variability in andropause prevalence (late-onset hypogonadism), which typically affects approximately 30% to 40% of middle-aged and older men, depending on the diagnostic criteria and population characteristics (Mei et al., 2024; Sahin et al., 2023). Although androgen levels gradually decline with age,

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hormone secretion continues at a reduced, yet variable rate. Andropause symptoms are generally less distinct than those observed during menopause (Grossmann et al., 2024; Matsumoto, 2002). These symptoms substantially affect quality of life (QoL), representing a major health concern among middle-aged men (Midttun et al., 2024; Rojas-Zambrano et al., 2025). Despite this, andropause symptoms often remain under-recognized and inadequately managed in health care settings.

Declining testosterone levels dysregulate the hypothalamic–pituitary–adrenal (HPA) axis, thereby increasing vulnerability to stress and decreasing physiological resilience (Indirli et al., 2023; Kutlikova et al., 2020). Because testosterone plays a central role in regulating circadian rhythms and sleep architecture, its reduction is associated with reduced sleep efficiency and a higher risk of sleep-related breathing problems, further impairing sleep quality (Liu & Reddy, 2022; Wang et al., 2023).

Midlife is a critical developmental period characterized by substantial transitions involving occupational instability, financial responsibility, and caregiving burdens within the context of extended life expectancy (Wethington, 2000). Growing evidence indicates that chronic stress (Kim et al., 2024) and poor sleep quality (Sella et al., 2023) significantly contribute to health disparities during this stage of life. Each factor was independently associated with detrimental physical and psychological health outcomes (Indirli et al., 2023; Tanji et al., 2025). The interaction between these factors is particularly relevant among men experiencing andropause manifestations. Stress has been shown to exacerbate symptom severity, whereas impaired sleep may further diminish daily functioning and subjective well-being (Martelli et al., 2021). Despite their potentially interrelated effects, research on the integration of these variables within a unified conceptual model remains limited. An integrated model is needed to elucidate the indirect pathways through which andropause symptoms may influence overall well-being in midlife.

Despite the growing recognition of the psychosocial correlates of andropause symptoms, few studies have systematically examined how biological, psychological, and behavioral processes intersect to influence QoL in men. To address this gap, the present study adopted a biopsychosocial perspective grounded in the 4P framework (predisposing, precipitating, perpetuating, and protective factors) (Bolton, 2014) as a conceptual lens to explore the interplay between biological vulnerability and psychosocial processes influencing QoL in middle-aged men. For analytical purposes, andropause symptoms were operationalized as a predisposing factor reflecting underlying biological vulnerability, which was examined as a precipitating factor representing a psychological response to symptom burden, while poor sleep quality was treated as a perpetuating factor that may sustain or exacerbate declines in QoL. Although individual bidirectional associations among andropause symptoms, stress, sleep quality, and QoL have been increasingly documented, the indirect associated mechanisms in relation to QoL remain unclear, particularly among middle-aged men. Accordingly, the present study aimed to (1) examine the associations among andropause symptoms, perceived stress, and sleep quality and (2) identify the indirect paths of perceived stress and sleep quality in the relationship between andropause symptoms and QoL, thereby providing empirical insights to guide future intervention strategies for men experiencing andropause symptoms.

Materials and Methods

Study Design

This cross-sectional study employed a quantitative mediation analysis design to examine the indirect paths of perceived stress and sleep quality in the relationship between andropause symptoms and QoL among middle-aged men (Figure 1).

Participants and Setting

Participants were recruited through the Entrust Survey, an accredited online research company based in Hong Kong with a Korean branch in Daegu City (http://kr.entrustsurvey.com). The accessible population (n = 9,600) comprised middle-aged men aged 40 to 60 years who were registered with the Entrust Survey Panel and met the inclusion criteria. Eligible participants were residents of South Korea who were able to complete an online questionnaire using a computer or mobile device and who voluntarily agreed to participate. Individuals were excluded if they were currently receiving treatment for cancer or psychiatric disorders, or had undergone hormone therapy for andropause.

A power analysis using G*Power 3.1.7 indicated that a minimum sample size of 184 was required for binary logistic regression, two-sided test, $\alpha = .05$, power $1 - \beta = .80$, odds ratio (OR) = 1.7 (Zolfaghari et al., 2020). To account for an anticipated 10% attrition rate, 205 participants were recruited. After excluding 19 incomplete responses, data from 186 participants were included in the final analysis, yielding a completion rate of approximately 90.7%.

Measurements

Participants' Characteristics. The participants' characteristics included 11 items: age, marital status, presence of offspring, educational attainment, employment status,

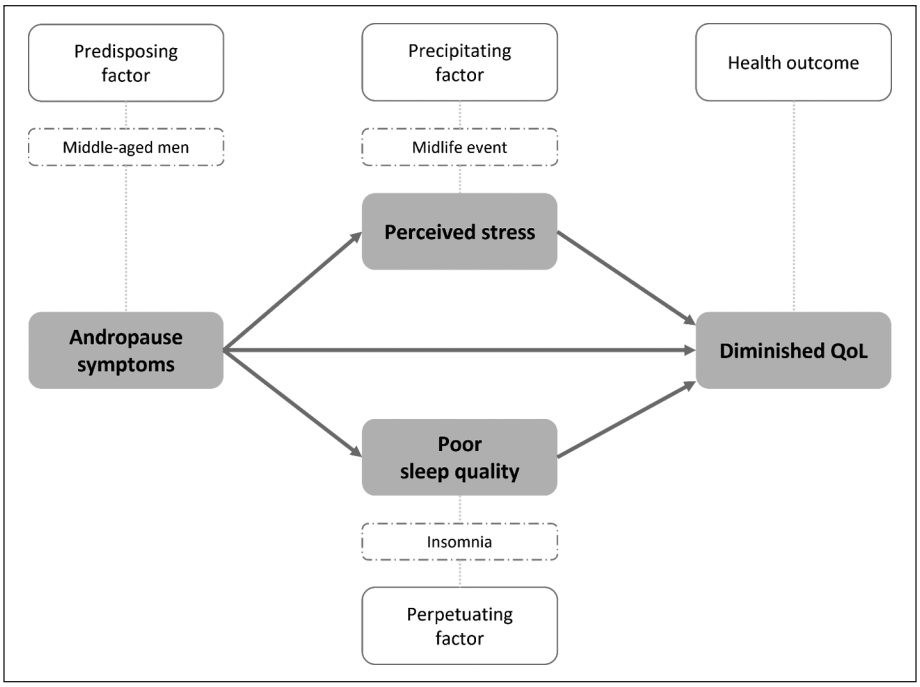

Figure 1. Conceptual Framework

monthly income, religion, smoking habits, alcohol consumption, regular exercise habits, and presence of underlying diseases.

Andropause Symptoms. Andropause symptoms were assessed using the Korean Andropause Deficiency in Aging Males (ADAM) Questionnaire. The ADAM questionnaire was developed by Morley et al. (2000) and later validated in Korean by Kim et al. (2004). Written permission to use the Korean version was obtained from the developer before data collection. The scale comprises 10 items that assess libido, energy, strength and endurance, height, enjoyment of life, feelings of sadness and grumpiness, erectile function, ability to participate in sports, sleep initiation, and work performance. The questionnaire employed a dichotomous response format ("yes" or "no"). Positive responses to items related to libido or erectile function, including positive responses to $\geq$3 of the remaining items, were considered indicative of andropause syndrome as operationally defined by the ADAM screening criteria. The total score was used to determine the severity of andropause symptoms. In this study, the Kuder–Richardson Formula 20 reliability coefficient was .757.

Perceived Stress. Perceived stress was assessed by using the Korean version of the Perceived Stress Scale (PSS). The PSS was developed originally by Cohen et al. (1983), revised by Cohen (1988), and validated in Korean by Lee et al. (2012). Written permission was obtained from the Korean developer prior to data collection. The 10-item PSS comprises six negatively worded items and four positively worded items. Each item is rated on a 5-point scale ranging from zero (never) to four (very often). Total scores of 0 to 13, 14 to 26, and 27 to 40 are considered to represent low, moderate, and high perceived stress, respectively (Torales et al., 2020). Higher total scores indicate greater perceived stress. The Korean version of the scale demonstrated a reliability coefficient of Cronbach's alpha (α) = .819 (Lee et al., 2012), and Cronbach's alpha in the present study was .818.

Sleep Quality. Sleep quality over the 1-month period was assessed using the Pittsburgh Sleep Quality Index (PSQI), developed by Buysse et al. (1989) and translated into Korean by Sohn et al. (2012). Written permission was obtained from the Korean developer before data collection. The PSQI comprises 18 items that assess seven components: sleep quality, sleep-onset latency, sleep duration, sleep efficiency, sleep disturbance, sleep medication use, and daytime dysfunction. An additional five items completed by the participants' bed partners or roommates were excluded from scoring. Each item is rated on a 4-point scale ranging from 0 to 3. The total

PSQI score ranges from 0 to 21, with higher scores indicating poorer sleep quality and daytime functioning. A total score >5 reflects poor sleep quality. The original scale demonstrated a reliability coefficient of Cronbach's $\alpha = .83$ (Buysse et al., 1989), and Cronbach's alpha in the present study was .754.

QoL. QoL was assessed using a brief version of the World Health Organization QoL Scale (WHOQOL-BREF). This instrument was developed by The World Health Organization Quality of Life Group (1998) and translated into Korean by Min et al. (2002). Written permission was obtained from the Korean developer before data collection. The WHOQOL-BREF consists of four domains: physical (seven items), psychological (six items), social relationships (three items), and environmental (eight items). In addition, two items are examined separately: an individual's overall perception of QoL (one item) and overall health perception (one item). Each item was rated on a 5-point Likert-type scale ranging from 1 (not at all) to 5 (completely agree). The total QoL score ranged from 26 to 130 and was transformed into a 0 to 100 scale. The domain scores were scaled in a positive direction, with higher scores indicating better QoL. Cronbach's α was .88 in the study by Min et al. (2002). In the original WHO report (WHO, 1998), Cronbach's α values were .82 for the physical domain, .75 for the psychological domain, .66 for social relationships, and .80 for the environmental domain (WHO, 1998). In the present study, the composite Cronbach's α was .947 ($\alpha = .860$ for the physical domain, $\alpha = .843$ for the psychological domain, $\alpha = .839$ for social relationships, and $\alpha = .758$ for the environmental domain).

Data Collection

Data were collected from October 15 to 22, 2021, using Google Forms administered through the Entrust Survey platform. The survey package included a cover letter, an informed consent statement, and structured questionnaires. The eligible panel members received an invitation containing a brief description of the study and a secure survey link. Participants provided electronic consent by selecting the "I agree" option before proceeding. To ensure data integrity, the research company implemented automated quality control filters to exclude responses with (a) unusually short completion times, (b) uniform responses across items, (c) demographic inconsistencies relative to registered profiles, (d) duplicate IP addresses or multiple accounts, and (e) invalid answers to open-ended questions. Participants could terminate the survey at any time before submission, in which case, no data were stored. Each completed response required approximately 20 to 25 minutes, and the participants received a small incentive upon completion. The anonymized dataset was securely transmitted to the researchers using Microsoft Excel (Microsoft 365).

Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki and was approved by the appropriate institutional review board (IRB No: 1044308-202106-HR-043-02). Given the anonymous and minimal-risk nature of the web-based survey, the IRB waived the requirement for written informed consent. A formal contract was established with the online research organization, including provisions to ensure anonymity, confidentiality, and protection against unauthorized storage and reuse of the collected data. The participants were informed of IRB approval and the authors' contact information at the beginning of the survey. They were also informed of the study objectives and procedures, their right to withdraw at any time without any repercussions, and their right to privacy.

Data Analysis

Data from 186 responses were coded and cleaned using Microsoft Excel (Microsoft 365). The dataset was then imported into SPSS software (version 23; IBM Corp., Armonk, NY, USA) for statistical analysis. Participant characteristics were analyzed using descriptive statistics, including numbers, percentages, means, and standard deviations. The data exhibited acceptable skewness and kurtosis values (−2 to +2) (Hair et al., 2022; Kim, 2013). Normality testing using the Shapiro–Wilk test indicated partial deviations from normality for the ADAM, PSS, PSQI, and QoL scores, depending on participant characteristics. Comparative analyses according to participant characteristics were performed using the Mann–Whitney *U* test or Kruskal–Wallis test with the Bonferroni multiple comparison method. The relationships between the ADAM, PSS, PSQI, and QoL scores were examined using Pearson's correlation analysis. Associations between sleep quality, perceived stress, and andropause syndrome were examined using binary logistic regression. Participants' characteristics associated with andropause symptoms, stress, sleep quality, and QoL were selected to adjust for the impact of covariates in the mediation regression analysis. According to Baron and Kenny's (1986) conceptual framework, a prerequisite regression analysis was performed to explain mediation. Subsequently, indirect paths were examined using the PROCESS Macro (version 4) with 50,000 bootstrap samples. The goodness-of-fit of the regression model was evaluated using the Kolmogorov–Smirnov test for residual normality, the Durbin–Watson range ($D_U <$ Durbin–Watson index $<$ 4-D_U) for autocorrelation, the

Breusch–Pagan test for equal variance, and the variance inflation factor for multicollinearity.

Results

Participants' Andropause Symptoms, Perceived Stress, Sleep Quality, and QoL

The mean scores for andropause symptoms, perceived stress, sleep quality, and QoL were 4.98 ± 2.63, 17.78 ± 4.94, 6.50 ± 2.95, and 84.10 ± 14.43 (converted to a 100-point scale: 64.68 ± 11.10), respectively (Table 1). Among the participants, 83.3% ($n = 155$) were screened for positive andropausal symptoms, with a mean symptom score of 5.88 ± 2.04. The prevalence of low and high perceived stress was 19.4% ($n = 36$) and 4.3% ($n = 8$), respectively. Regarding sleep quality, 58.6% ($n = 109$) of the participants exhibited poor sleep quality.

Participants' Characteristics and Differences in Andropause Syndrome, Perceived Stress, Sleep Quality, and QoL According to Participants' Characteristics

Regarding participant characteristics, 56.5% ($n = 105$) were aged <50 years and 43.5% ($n = 81$) were aged between 50 and 60 years, with a mean age of 48.45 ± 5.39 years. Most participants reported having a spouse (73.1%, $n = 136$) or offspring (71.0%, $n = 132$). In terms of socioeconomic status, most participants had a college education (86.6%, $n = 161$) and were employed (86.6%, $n = 167$), whereas 36.6% ($n = 68$) reported a monthly income exceeding 4 million won. In addition, 54.3% ($n = 101$) of participants were religious. Regarding lifestyle habits, 54.3% ($n = 101$) of the participants were current smokers, 77.4% ($n = 144$) consumed alcohol, and 62.4% ($n = 116$) engaged in regular exercise. Furthermore, 26.3% ($n = 49$) of the patients reported having an underlying disease (Table 2).

The Mann–Whitney U test revealed participants with andropause syndrome were older ($z = -2.32$, $p = .020$) and had a higher smoking rate ($\chi^2 = 3.64$, $p = .044$). Mean scores for andropause symptoms, perceived stress, and sleep quality were significantly higher among those with andropause syndrome ($z = -8.68$, $p < .001$; $z = -4.17$, $p < .001$; $z = -4.94$, $p < .001$, respectively). Moreover, andropause syndrome was associated with a lower QoL ($z = -5.34$, $p < .001$) (Table 2).

Results from the Mann–Whitney U test and Kruskal–Wallis test with Bonferroni's multiple comparison revealed that perceived stress levels were significantly lower among participants earning > 4 million won per month than among those earning < 3 million won per month ($\chi^2 = 10.57$, $p = .005$). Participants with an underlying disease reported poorer sleep quality ($z = -2.25$, $p = .025$). Higher QoL was observed among those with a spouse and children ($z = -2.91$, $p = .004$), those earning > 4 million won per month ($\chi^2 = 14.18$, $p = .001$), and those who were religious ($z = -2.94$, $p = .003$). Furthermore, QoL was significantly higher among participants engaging in regular physical activity ($z = -3.41$, $p = .001$) and those without a preexisting medical condition ($z = -2.03$, $p = .042$) (Table 2). The results showed that the participants' characteristics, including age, spouse, income, religion, smoking, exercise, and disease status, were linked to andropause symptoms, stress, sleep quality, and QoL.

Relationship Among Andropause Symptoms, Perceived Stress, Sleep Quality, and QoL

Pearson's correlation analysis showed that andropause symptoms were significantly correlated with perceived stress ($r = .51$, $p < .001$), sleep quality ($r = .55$, $p < .001$), and QoL ($r = -.62$, $p < .001$). In addition, perceived stress correlated with sleep quality ($r = .55$, $p < .001$) and QoL ($r = -0.66$, $p < .001$). Sleep quality was also significantly correlated with QoL ($r = -0.65$, $p < .001$) (Table 3).

Association of Sleep Quality With Andropause Syndrome and Perceived Stress

Logistic regression analysis revealed that andropause syndrome significantly increased the risk of poor sleep quality ($OR = 6.168$, 95% confidence interval [CI] = [2.013, 18.896], $p = .001$), after adjusting for age, spouse, monthly income, religion, smoking, regular exercise, and underlying disease as covariates. Higher perceived stress was associated with an increased likelihood of poor sleep quality ($OR = 1.279$, 95% CI = [1.159, 1.410], $p < .001$). After adjusting for covariates, the model exhibited a Nagelkerke R^2 of .45, and the Hosmer–Lemeshow goodness-of-fit test indicated an adequate model fit. The model demonstrated a classification accuracy of 77.4% and the variance inflation factor ranged from 1.052 to 1.222 (Table 4).

Statistical Mediation Analysis of Perceived Stress and Sleep Quality in the Relationship Between Andropause Symptoms and QoL

In accordance with the conceptual reference proposed by Baron and Kenny (1986), the prerequisite regression for mediation was examined among andropause symptoms, perceived stress, and sleep quality on QoL after adjusting

Table 1. Participants' Andropause Symptoms, Perceived Stress, Sleep Quality, and QoL ($N = 186$).

Variable domains	Number of items	Score range	Categories (n, %)	$M \pm SD$	Range min-max	Cronbach's α	Skewness	Kurtosis
Andropause symptoms	10	0–10		4.98 ± 2.63	0.00–10.00	.757	−0.239	−0.877
Andropause syndrome			Yes (155, 83.3)	5.88 ± 2.04	1.00–10.00			
			No (31, 16.7)	0.90 ± 0.83	0.00–2.00			
Perceived stress	10	0–40		17.78 ± 4.94	5.00–31.00	.818	.030	.060
			Low (36, 19.4)	10.83 ± 2.29	5.00–13.00			
			Moderate (142, 76.3)	18.94 ± 3.19	14.00–26.00			
			High (8, 4.3)	28.63 ± 1.85	27.00–31.00			
Sleep quality	19	0–21		6.50 ± 2.95	1.00–17.00	.754	.720	.366
		5>	Poor (109, 58.6)	8.36 ± 2.37	6.00–17.00			
		5≤	Good (77, 41.4)	3.87 ± 1.12	1.00–5.00			
Subjective sleep quality	1	0–3		1.41 ± 0.60	0.00–3.00			
Sleep latency	2	0–3		1.30 ± 0.98	0.00–3.00			
Sleep duration	1	0–3		0.95 ± 0.94	0.00–3.00			
Habitual sleep efficiency	3	0–3		0.23 ± 0.56	0.00–3.00			
Sleep disturbance	2	0–3		1.29 ± 0.55	0.00–3.00			
Use of sleeping medication	1	0–3		0.13 ± 0.45	0.00–3.00			
Daytime dysfunction	2	0–3		1.19 ± 0.74	0.00–3.00			
Quality of life	26	26–130, 0–100[a]		84.10 ± 14.43, 64.68 ± 11.10[a]	40.00–117.00	.947	−0.358	.029
Overall perception of QoL	1	1–5 0–100[a]		3.04 ± 0.77, 60.75 ± 15.33[a]	1.00–5.00			
Overall perception of health	1	1–5 0–100[a]		3.01 ± 0.76, 60.22 ± 15.28[a]	1.00–5.00			
Physical domain	7	7–35 0–100[a]		24.01 ± 4.49, 68.60 ± 12.83[a]	12.00–34.00	.860		
Psychological domain	6	6–30		19.13 ± 3.91, 63.78 ± 13.03[a]	6.00–28.00	.843		
Social relationship domain	3	3–15 0–100[a]		8.81 ± 2.17, 58.71 ± 14.48[a]	3.00–14.00	.758		
Environmental domain	8	8–40 0–100[a]		26.10 ± 4.48, 65.24 ± 11.19[a]	15.00–38.00	.839		

Note. M, mean; SD = standard deviation; QoL = quality of life.
[a]Transformed the QoL score into 0 to 100; Andropause syndrome was operationally defined using the Andropause Deficiency in Aging Males (ADAM) screening criteria.

Table 2. Participants' Characteristics and Differences in Andropause Syndrome, Perceived Stress, Sleep Quality, and QoL ($N = 186$).

Characteristics	Categories		Andropause syndrome				PSS			PSQI			QoL		
			Yes ($n = 155$)	No ($n = 31$)											
(Score range)	n (%) or $M \pm SD$		n (%) or $M \pm SD$		χ^2 or z	p	$M \pm SD$	χ^2 or z	p	$M \pm SD$	χ^2 or z	p	$M \pm SD$	χ^2 or z	p
Age (years)		48.45 ± 5.39	48.88 ± 5.37	46.32 ± 5.06	−2.32	.020									
	40–49	105 (56.5)	85 (81.0)	20 (19.0)	.98	.428	18.11 ± 4.80	−1.27	.206	6.54 ± 2.86	−0.55	.586	82.53 ± 14.49	−1.81	.071
	50–60	81 (43.5)	70 (86.4)	11 (13.6)			17.36 ± 5.10			6.44 ± 3.09			86.12 ± 14.19		
Spouse	Yes	136 (73.1)	116 (85.3)	21 (14.7)	1.40	.269	17.74 ± 4.99	−0.34	.735	6.49 ± 2.74	−0.25	.800	86.05 ± 13.73	−2.91	.004
	No	50 (26.9)	39 (78.0)	11 (22.0)			17.90 ± 4.85			6.52 ± 3.50			78.78 ± 15.07		
Offspring	Yes	132 (71.0)	113 (85.6)	19 (14.4)	1.69	.278	17.81 ± 4.98	−0.11	.909	6.52 ± 2.75	−0.43	.666	85.58 ± 13.67	−1.98	.048
	No	54 (29.0)	42 (77.8)	12 (22.2)			17.72 ± 4.89			6.46 ± 3.41			80.46 ± 15.69		
Education	<College	25 (13.4)	21 (84.0)	4 (16.0)	.01	.999†	18.24 ± 4.86	−0.67	.504	7.00 ± 2.48	−1.31	.191	81.76 ± 15.33	−0.96	.337
	≥College	161 (86.6)	134 (83.2)	27 (6.8)			17.71 ± 4.96			6.42 ± 3.02			84.45 ± 14.30		
Employment	Yes	167 (86.6)	140 (83.3)	27 (16.2)	.29	.529†	17.61 ± 4.83	−1.66	.098	6.41 ± 2.84	−0.86	.392	84.74 ± 14.00	−1.41	.159
	No	25 (13.4)	15 (78.9)	4 (21.1)			19.32 ± 5.69			7.26 ± 3.77			78.42 ± 17.17		
Monthly income	<3 [a]	56 (30.1)	44 (78.6)	12 (21.4)	2.25	.311†	19.45 ± 4.74	10.57	.005	6.70 ± 3.12	−0.86	.392	79.84 ± 15.30	−1.73	.084
Million won	3–4 [b]	62 (33.3)	55 (88.7)	7 (11.3)			17.50 ± 4.31		(a>c)	6.79 ± 3.00	3.30	.191	82.37 ± 13.84	14.18	.001
	> 4 [c]	68 (36.6)	56 (82.4)	12 (17.6)			16.67 ± 5.32			6.07 ± 2.75			89.16 ± 12.82		a, b<c
Religion	Yes	101 (54.3)	53 (84.1)	10 (15.9)	.04	.999†	17.03 ± 4.89	−1.73	.083	6.35 ± 2.54	−0.39	.699	88.57 ± 14.17	−2.94	.003
	No	85 (45.7)	102 (82.9)	21 (17.1)			18.17 ± 4.94			6.58 ± 3.15			81.80 ± 14.07		
Current smoking	Yes	101(54.3)	89 (88.1)	12 (11.9)	3.64	.044	17.48 ± 4.67	−0.70	.483	6.72 ± 2.90	−1.43	.151	83.70 ± 14.56	−0.63	.528
	No	85 (45.7)	66 (77.6)	19 (22.4)			18.15 ± 5.24			6.24 ± 3.01			84.56 ± 14.34		
Alcohol	Yes	144 (77.4)	122 (84.7)	22 (15.3)	.89	.481	17.88 ± 4.83	−0.44	.659	6.67 ± 2.95	−1.53	.126	84.78 ± 14.55	−11.00	.317
consumption	No	42 (22.6)	33 (78.6)	9 (21.4)			17.52 ± 5.34			5.93 ± 2.92			81.74 ± 13.91		
Regular exercise	Yes	116 (62.4)	93 (80.2)	23 (19.8)	2.22	.098†	17.28 ± 5.07	−1.53	.126	6.36 ± 2.80	−0.82	.413	86.91 ± 13.92	−3.41	.001
	No	70 (37.6)	62 (88.6)	8 (11.4)			18.61 ± 4.63			6.73 ± 3.19			79.44 ± 14.15		
Underlying disease	Yes	49 (26.3)	44 (89.8)	5 (10.2)	2.00	.114†	18.69 ± 4.91	−1.36	.175	7.16 ± 2.71	−2.25	.025	80.22 ± 13.91	−2.03	.042
	No	137 (73.7)	111 (81.0)	26 (19.0)			17.46 ± 4.92			6.26 ± 3.01			85.48 ± 14.41		
ADAM (0–10)			5.88 ± 2.04	0.90 ± 0.83	−8.68	<.001									
PSS (0–40)			18.48 ± 4.76	14.32 ± 4.38	−4.17	<.001									
PSQI (0–21)			6.94 ± 2.96	4.32 ± 1.70	−4.94	<.001									
QoL (26–130)			81.81 ± 14.28	95.52 ± 8.66	−5.34	<.001									
QoL (0–100)			62.93 ± 10.99	73.47 ± 6.66	−5.34	<.001									

Note. M, mean; SD = standard deviation; z by Mann–Whitney U test; ADAM = andropause symptoms score; PSS = perceived stress score; PSQI = the Pittsburgh Sleep Quality Index (PSQI) score; QOL = quality of life score; z-score calculated using the Mann–Whitney U test; Andropause syndrome was operationally defined using the Andropause Deficiency in Aging Males (ADAM) screening criteria.

†Fisher's Exact test; χ^2 calculated using the Kruskal–Wallis test; letters (a, b, c, d) presented for Bonferroni multiple comparison.

Table 3. Relationship Between Andropause Symptoms, Perceived Stress, Sleep Quality and QoL ($N = 186$).

	Andropause symptoms		Perceived stress		Sleep quality		QoL	
Variable	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
Andropause symptoms	–	–						
Perceived stress	.51	<.001						
Sleep quality	.55	<.001	.55	<.001				
QoL	−.62	<.001	−.66	<.001	−.65	<.001	–	–

Note. r by Pearson's correlation analysis; QoL, quality of life; Andropause syndrome was operationally defined using the Andropause Deficiency in Aging Males (ADAM) screening criteria.

Table 4. Associations of Sleep Quality With Andropause Syndrome and Perceived Stress ($N = 186$).

Variables	*B*	*SE*	*p*	Exp(*B*)	95% CI
Andropause syndrome (Yes = 1)	1.819	.57	.001	6.168	2.013, 18.896
Perceived Stress	.246	.50	<.001	1.279	1.159, 1.410
χ^2 (*p*)			75.57 (<.001)		
−2 Log likelihood			176.74		
Nagelkerke R^2			.450		
Hosmer & Lemeshow test: χ^2 (*p*)			3.87 (.869)		

Note. Logistic regression adjusted by covariates (age, spouse: yes = 1, monthly income, religion: yes = 1, current smoking: yes = 1, regular exercise: yes = 1, underlying disease: yes = 1); Andropause syndrome (yes = 1); Sleep quality was treated as the dependent variable in this model (good = 0, poor = 1); *SE* = standard errors; Exp = exponentiated coefficients; CI = confidence interval; Andropause syndrome was operationally defined using the Andropause Deficiency in Aging Males (ADAM) screening criteria.

for age, spouse, monthly income, religion, smoking, regular exercise, and underlying diseases as covariates. The regression analysis demonstrated an acceptable fit, with no evidence of multicollinearity among independent variables (variance inflation factor range: 1.050–1.759), a normal distribution of residuals (Kolmogorov–Smirnov $z = .59$, $p = .880$), no autocorrelation ($D_U <$ Durbin–Watson index $< 4\text{-}D_U$ of Durbin–Watson range: $1.874 < 1.936 < 2.126$), and presence of equal variance (Breusch–Pagan test, $\chi^2 = 14.91$, $p = .136$).

In the first step, higher andropause symptom scores were significantly associated with higher perceived stress ($B = .969$, $p < .001$), with a moderate explanatory power of 23.7%. Higher andropause symptom scores were also associated with poorer sleep quality ($B = .622$, $p < .001$), with a moderate explanatory power of 27.3%. In the second step, higher andropause symptom scores were associated with lower QoL ($B = -0.121$, $p < .001$), with an explanatory power of 29.4%. In the third step, higher andropause symptom scores ($B = -0.052$, $p < .001$), greater perceived stress ($B = -0.033$, $p < .001$), and poorer sleep quality ($B = -0.060$, $p < .001$) were associated with lower QoL. The magnitude of the effect of andropause symptoms in Step 3 was smaller than that observed in Step 2. The final model accounted for 46.7% of the variance in QoL ($F = 37.2$, $p < .001$).

The indirect mediation analysis using the PROCESS Macro (version 4) with 50,000 bootstrap samples demonstrated two significant indirect paths in the relationship between andropause symptoms and QoL: one via perceived stress, $B = -0.861$, 95% CI = [−1.210, −0.514], and the other via sleep quality ($B = -1.566$, 95% CI = [−2.054, −1.035]) (Table 5 and Figure 2).

Discussion

The present study revealed that andropause symptoms are associated with elevated levels of perceived stress and suboptimal sleep quality, thereby impacting the overall QoL. This study investigated two significant indirect paths in the association between andropause symptoms and QoL: one via perceived stress and the other via sleep quality. These findings suggest that psychosocial processes related to andropause symptoms are involved in diminished well-being. This study advances the understanding of the biopsychosocial mechanisms underlying men's midlife health by applying the 4P framework as an interpretive lens (Bolton, 2014).

Table 5. Statistical Mediating Paths of Perceived Stress and Sleep Quality in the Relationship Between Andropause Symptoms and QoL ($N = 186$).

Three step	Dependent variable	Independent variable	*B*	*SE*	*p*	$\triangle R^2$	*F*, *p*
Step 1	Perceived Stress	Andropause symptoms	.969	.121	<.001	.237	11.58, <.001
	Sleep quality	Andropause symptoms	.622	.074	<.001	.273	10.30, <.001
Step 2	QoL	Andropause symptoms	−0.121	.012	<.001	.294	22.79, <.001
Step 3	QoL	Andropause symptoms	−0.052	.012	<.001	.467	37.20, <.001
		Perceived Stress	−0.033	.006	<.001		
		Sleep quality	−0.060	.010	<.001		
			B	*SE*	*t*	*p*	95% CI
Total effect			−3.158	.307	−10.29	<.001	−3.764, −2.552
Direct effect			−1.349	.311	−4.34	<.001	−1.963, −0.736
Indirect effect			*B*	BootSE			95% Boot CI
Total			−1.809	.269			−2.357, −1.298
X→M1→Y			−0.861	.178			−1.210, −0.514
X→M2→Y			−1.566	.259			−2.054, −1.035

Note. Three step by Baron and Kenny's mediation analysis adjusted by covariates (age, spouse: yes = 1, monthly income, religion: yes = 1, current smoking: yes = 1, regular exercise: yes = 1, underlying disease: yes = 1); *SE* = standard errors; Analyzed using the bootstrap inference for model coefficient (50,000 bootstrapping with model 4 of the Hayes PROCESS macro); CI = confidence interval; QoL = quality of life; X = andropause symptoms; M1 = perceived stress; M2 = sleep quality; Y = quality of life.

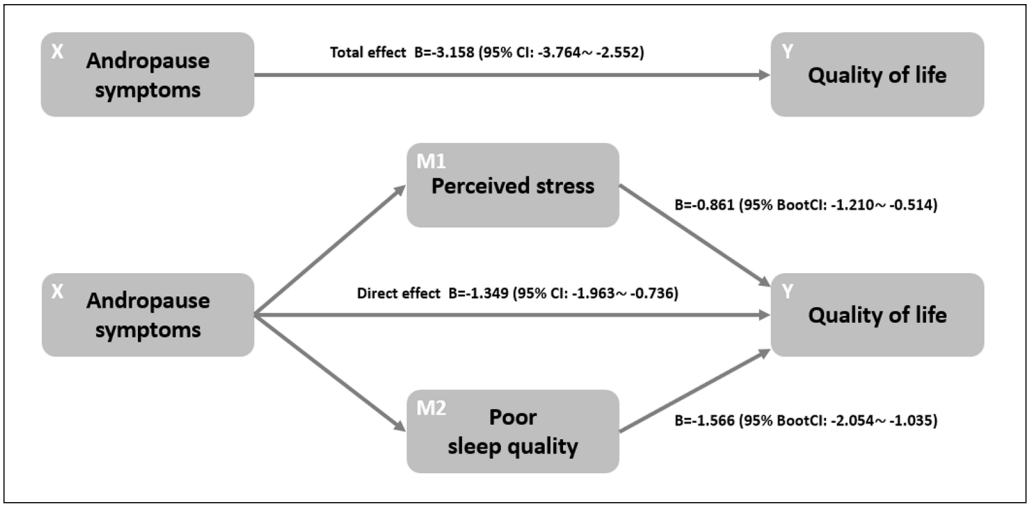

Figure 2. The Indirect Associations of Perceived Stress and Sleep Quality in the Relationship Between Andropause Symptoms and Quality of Life.
Note. Analyzed using bootstrap inference for the model coefficient (50,000 bootstrapping with model 4 of the Hayes PROCESS macro); CI = confidence interval.

A notable finding was the high prevalence of andropause symptoms, with 83% of participants screening positive on the ADAM questionnaire. This rate is consistent with previous Korean studies (60%–70%) (Heo & Im, 2012; Lee & Park, 2013) but exceeds international estimates (30%–40%) (Mei et al., 2024; Sahin et al., 2023). These discrepancies may reflect methodological differences among the studies. International studies have often used diagnostic or symptom severity instruments such as the Aging Males' Symptoms (AMS) scale (Heinemann et al., 1999), whereas most Korean studies, including the present one, have employed the ADAM screening tool, which offers high sensitivity but relatively low specificity and may overestimate prevalence (Morley et al., 2000). In addition, unlike earlier Korean studies that focused on employed men (Heo & Im, 2012; Lee & Park, 2013), this study recruited participants regardless of their employment status, thereby capturing a broader psychosocial spectrum. The use of an online survey platform may also have introduced sampling bias (Lehdonvirta

et al., 2021) because online panel participants often possess higher digital literacy and health awareness than the general population.

Nevertheless, the consistently high prevalence of andropause symptoms in Korean men warrants further public health attention. These findings underscore the need for early detection and tailored interventions to promote men's health during midlife, because both the prevalence and severity of andropause symptoms tend to increase with age (Martelli et al., 2021). Owing to the absence of biochemical hormonal assessments, clinical andropause could not be substantiated. Consequently, ADAM-based findings should be interpreted as symptom screening results rather than diagnostic evidence of andropause, and the observed symptom profiles may also reflect underlying psychological or physical comorbidities.

Guided by the 4P framework (Bolton, 2014), andropause symptoms are conceptualized as biological predisposing factors, perceived stress as a precipitating factor, and poor sleep quality as a perpetuating factor. These variables were analyzed as parallel mediators influencing QoL. Previous studies have indicated interdependence between stress and sleep, including serial pathways (sleep → stress → life satisfaction) among middle-aged adults (Yang et al., 2022) and bidirectional feedback loops in men (Yap et al., 2020). Given these theoretical complexities and previous evidence of reciprocal relationships between andropause symptoms and sleep quality (Liu & Reddy, 2022), caution is warranted when assuming fixed directionality among these variables, as this study employed a simple parallel mediation model.

Physiologically, declining testosterone levels may dysregulate the HPA-axis, impair cortisol regulation, and increase stress reactivity (Kutlikova et al., 2020). Psychologically, androgen-related changes such as fatigue, decreased libido, and diminished muscle strength can challenge masculine identity and perceived competence, eliciting stress responses such as loss of control, frustration, and self-doubt (Chambers et al., 2017; Lim & Park, 2025). In sociocultural contexts in which emotional restraint, self-reliance, and stoicism are emphasized as core masculine norms, psychological distress is less likely to be openly expressed and more likely to be internalized. This internalization may result in delayed help-seeking and amplify psychological burden (Mokhwelepa & Sumbane, 2025). Prolonged stress may lead to emotional exhaustion, depressive mood, and reduced social engagement, collectively undermining the QoL (Kim et al., 2024). Within the 4P framework, perceived stress represents a key precipitating mechanism linking biological vulnerability to psychosocial decline among men experiencing andropause symptoms.

In addition to its psychological effects, testosterone deficiency disrupts sleep regulation. Testosterone plays a critical role in maintaining the circadian rhythm and sleep architecture, particularly by promoting slow-wave and Rapid Eye Movement (REM) sleep. Reduced androgen levels are associated with sleep fragmentation, decreased sleep efficiency, and an elevated risk of sleep-disordered breathing (Liu & Reddy, 2022; Wang et al., 2023). Poor sleep exacerbates fatigue, cognitive impairment, and negative mood, ultimately reducing daily functioning and life satisfaction (Sella et al., 2023). From the 4P framework perspective, sleep disturbance serves as a perpetuating factor that sustains physiological and psychological strain, thereby contributing to a prolonged decline in QoL among men who experience andropause symptoms.

Within the 4P framework, protective factors refer to mechanisms that buffer the negative effects of risk factors or promote recovery, thereby preventing adverse outcomes. Interventions targeting to strengthen these protective domains, such as hormone therapy (Midttun et al., 2024; Rojas-Zambrano et al., 2025), regular physical activity (Corona et al., 2020; Olsson et al., 2023), and enhanced social engagement (Kim et al., 2024; Nikjou et al., 2024), have generally been modest. This may be because such approaches primarily focus on alleviating andropause symptoms or improving QoL directly rather than addressing the proximal psychosocial mechanisms that sustain vulnerability. The present findings, which identified stress and sleep as key mediators between andropause symptoms and QoL, underscore the importance of targeting these modifiable pathways in intervention designs. Evidence-based approaches, such as cognitive-behavioral stress management (Laird et al., 2022) and mindfulness-based programs (Black et al., 2015), have demonstrated efficacy in improving stress regulation and sleep quality. Further expansion of the potential sequential pathway (andropause symptoms, stress, sleep, and QoL) could be achieved through longitudinal structural equation modeling, which could then be used to guide intervention design based on the 4P model. Applying these interventions to men experiencing andropause symptoms may offer a more direct and mechanistically informed strategy for enhancing their well-being. Further studies are required to evaluate their applicability and effectiveness in this population.

This study had several limitations. First, the cross-sectional design precludes causal inferences among variables. Although statistically significant mediation pathways were identified, these results should be interpreted cautiously, given the evidence of reciprocal influences among the variables (Liu & Reddy, 2022; Yap et al., 2020). Second, the use of an online panel may have introduced a sampling bias (Lehdonvirta et al., 2021), limiting the generalizability of the findings to middle-aged men with lower digital access or differing sociodemographic characteristics. Third, reliance on

self-administered measures introduces potential recall and social desirability biases (Althubaiti, 2016), which may either exaggerate or attenuate the observed relationships. Future longitudinal research incorporating both subjective assessments and objective physiological indicators (e.g., testosterone levels and actigraphy) is warranted to clarify causal directions and enhance measurement precision.

Conclusion

This study identified a high prevalence of andropause symptoms among middle-aged Korean men. It demonstrated that both perceived stress and poor sleep quality showed statistically significant mediating associations with the relationship between andropause symptoms and QoL. These findings provide empirical support for the theoretical premise that acute and sustained psychosocial burdens arising from andropause symptoms are a likely factor in the decline of well-being and overall health. These results indicate that symptoms consistent with andropause can be associated not only with biological changes, but also with psychosocial mechanisms that increase vulnerability, rather than indicating a definitive causal process. Although andropause is an inevitable biological process, interventions targeting modifiable pathways such as stress and sleep regulation are recommended to mitigate its psychosocial impact and enhance QoL among middle-aged men.

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Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of CHA University (IRB No. 1044308-202106-HR-043-02).

Consent to Participate

The web-based survey was considered minimal risk and anonymous; therefore, the IRB waived the requirement for written informed consent. Participants were informed of the study purpose, procedures, and their right to withdraw at any time prior to participation.

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Data Availability Statement

Data are available from the corresponding author upon reasonable request.

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