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Associations among Movement Behavior, Latent Metabolic Risk, and Health-Related Quality of Life in Adults Aged 40 Years and Older

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[Abstract]

This study examined associations among movement behaviors, latent metabolic risk, and health-related quality of life(EQ-5D) among Korean adults aged 40 years and older. Data were drawn from the 2024 Korea National Health and Nutrition Examination Survey(N=3,894). Sampling-weighted structural equation modeling was used. Walking and resistance exercise were negatively associated with metabolic risk, whereas sedentary time was positively associated with metabolic risk. Metabolic risk was negatively associated with EQ-5D. Resistance exercise and sedentary time showed significant indirect associations with health-related quality of life(EQ-5D) through metabolic risk. Walking also showed a significant indirect association, although the magnitude of the effect was relatively small.

▸ **Key words**: Movement behaviors, metabolic risk, EQ-5D, Adults, Health

[요　　약]

본 연구는 40세 이상 한국 성인을 대상으로 행동습관, 근력운동, 앉아있는 시간, 잠재 대사위험 및 건강관련 삶의 질(EQ-5D)간의 관계를 분석하였다. 2024년 국민건강영양조사 자료를 활용하였으며, 최종 분석대상은 3,894명이었다. 본 연구에서는 표본가중치를 적용한 구조방정식모형을 분석방법으로 적용하였다. 분석 결과, 걷기와 근력운동은 대사위험과 부적 관련을 보였고, 앉아있는 시간은 대사위험과 정적 관련을 나타냈다. 또한 대사위험은 EQ-5D와 부적 관련을 보였다. 근력운동과 앉아있는 시간은 대사위험을 매개로 하여 건강관련 삶의 질(EQ-5D)에 유의한 간접효과를 나타냈다. 걷기 또한 유의한 간접효과를 보였으나, 그 효과의 크기가 매우 작았다.

▸ **주제어**: 행동습관, 대사위험, EQ-5D, 성인, 건강

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I. Introduction

Metabolic syndrome refers to the clustering of abdominal obesity, elevated blood pressure, impaired glucose regulation, elevated triglycerides, and reduced high-density lipoprotein cholesterol(HDL-C), which together increase the risk of all-cause and cardiovascular mortality[1][2]. These risks become increasingly important from midlife onward because cardiometabolic abnormalities and age-related functional limitations tend to accumulate during this period. According to the 2024 Metabolic Syndrome Fact Sheet, the prevalence of metabolic syndrome in Korea was 26.7% among adults aged 40–49 years, 34.2% among those aged 50–59 years, 41.5% among those aged 60–69 years, and 49.1% among those aged 70 years or older, indicating that the prevalence increases progressively from midlife to older age[3]. These age-related patterns highlight the need to identify modifiable factors that may help reduce metabolic risk among adults aged 40 years and older.

Beyond its clinical consequences, metabolic syndrome is also relevant to health-related quality of life. Previous evidence from Korean adults indicates that higher metabolic risk is associated with lower EQ-5D scores, reflecting poorer health-related quality of life[4]. Movement behaviors represent one key set of modifiable factors associated with both metabolic risk and EQ-5D[4][5]. Current guidelines recommend that adults engage in regular aerobic physical activity, perform muscle-strengthening activities involving major muscle groups, and reduce sedentary behavior as key behavioral strategies for improving overall health and reducing metabolic risk[6][7]. Among middle-aged and older adults, walking is a highly relevant and accessible form of aerobic physical activity because it is low-cost, requires minimal equipment, can be self-paced, and can be incorporated into daily life[6].

Walking may improve metabolic health by increasing energy expenditure, enhancing cardiorespiratory fitness, and supporting favorable glucose and blood pressure regulation[8]. Resistance exercise may also be especially relevant for middle-aged and older adults because it helps preserve skeletal-muscle mass and function, supports glucose uptake, improves body composition, and counteracts age-related declines in muscle strength[9]. Prior evidence suggests that muscle-strengthening activity is associated with a lower likelihood of metabolic syndrome and more favorable cardiometabolic outcomes[7][10]. In contrast, prolonged sedentary time may increase metabolic risk by reducing skeletal-muscle contractile activity, lowering energy expenditure, and impairing glucose and lipid metabolism, even among individuals who engage in some physical activity[11][12]. Therefore, walking frequency and resistance exercise frequency may be expected to relate to lower metabolic risk, whereas sedentary time may be expected to relate to higher metabolic risk.

Although previous studies have linked metabolic syndrome, movement behaviors, and health-related quality of life, these factors have rarely been examined together within a single model. In particular, it remains unclear whether walking, resistance exercise, and sedentary time are directly associated with EQ-5D, indirectly associated through latent metabolic risk, or both. Examining these relationships within an integrated research model may provide valuable empirical evidence for health-related policy development and future research. The distinct contribution of the present study lies not merely in reconfirming the individual associations among physical activity, metabolic health, and health-related quality of life, but in simultaneously comparing different movement behaviors, including walking, resistance exercise, and sedentary time, within a single integrated model. Accordingly, the present study aimed to examine the associations among these movement behaviors, latent metabolic risk, and EQ-5D health-related quality of life among Korean adults aged 40 years and older. Accordingly, the following hypotheses were established.

H1. Walking frequency is negatively associated with latent metabolic risk.

H2. Resistance-exercise frequency is negatively associated with latent metabolic risk.

H3. Sedentary time is positively associated with latent metabolic risk.

H4. Latent metabolic risk is negatively associated with EQ-5D health-related quality of life.

H5. Walking frequency, resistance-exercise frequency, and sedentary time are directly associated with EQ-5D health-related quality of life.

H6. Walking frequency, resistance-exercise frequency, and sedentary time are indirectly associated with EQ-5D health-related quality of life through latent metabolic risk.

II. Material & methods

1. Study Design and Participants

This study used data from the 2024 Korea National Health and Nutrition Examination Survey (KNHANES). KNHANES is a nationally representative health surveillance system that uses a stratified, multistage clustered probability sampling design to assess the health and nutritional status of the Korean population[13]. The present analysis focused on adults aged 40 years and older because metabolic disease risk increases from midlife.

The final analytic sample included 3,894 adults aged 40 years and older with complete data on walking frequency, resistance-exercise frequency, sedentary time, metabolic risk indicators, EQ-5D health-related quality of life, covariates, and complex survey design variables. The KNHANES sampling weight, cluster variable, and stratification variable were incorporated in the complex sample analysis in this study.

2. Movement Behavior

Three movement behaviors were examined: walking, resistance-exercise, and sedentary time. All variables were derived from the KNHANES self-reported physical activity questionnaire. Walking was assessed using the item asking the number of days during the past week on which participants walked for at least 10 consecutive minutes at a time. The item instructed respondents to include walking for commuting, transportation, and exercise. The original response categories were recoded to represent the actual number of walking days per week, ranging from 0=no walking to 7=walking every day. Walking frequency was treated as a continuous predictor. Resistance-exercise was measured as the number of days per week on which participants performed muscle-strengthening activities, such as push-ups, sit-ups, dumbbell exercises, barbell exercises, or pull-ups. The original weekly frequency scale was retained and treated as a continuous predictor, ranging from 0=no participation to 5=five or more days per week. Sedentary time was assessed as the usual amount of time per day spent sitting or lying down, excluding sleep. The item covered sedentary time during work, transportation, social activities, and leisure. Reported hours and minutes were converted into decimal hours per day using the formula hours + minutes/60.

3. Latent Metabolic Risk

Latent metabolic risk was modeled using five metabolic risk indicators including waist circumference, blood pressure risk, fasting plasma glucose, triglycerides, and HDL-cholesterol risk. These indicators correspond to major components of the harmonized definition of metabolic syndrome[1]. Triglycerides were log-transformed to reduce skewness, and all five indicators were standardized before analysis. Blood pressure risk was derived from systolic and diastolic blood pressure values. These two blood pressure measures were first standardized separately, and the average of the two z-scores was then re-standardized to create a single continuous blood pressure risk indicator. HDL cholesterol was reverse-coded so that higher values consistently indicated greater metabolic risk. The five standardized indicators were specified as observed indicators of a single latent metabolic risk factor. A residual covariance between triglycerides and HDL-cholesterol risk was freely estimated to account for shared lipid-metabolism variance.

4. Health-Related Quality of Life

The KNHANES raw data provide EQ5D as a derived health-related quality of life index that reflects quality weights for health states[14][15]. In the EQ-5D index, a value of 1.000 represents full health, and lower values indicate poorer health-related quality of life. For ease of interpretation, the index was multiplied by 100 in the present analysis.

5. Covariates

Age, sex, household income, and educational attainment were included as covariates. Age was treated as a continuous variable, sex was recoded as male=1 and female=0, household income was coded from 1 (low) to 4 (high), and educational attainment was coded from 1 (elementary school or less) to 4 (college or higher). Age, household income, and educational attainment were mean-centered before inclusion in the SEM.

6. Statistical Analysis

CFA and SEM were conducted in R using the lavaan, survey, and lavaan.survey packages[16-18]. All analyses incorporated the KNHANES sampling weight(wt_itvex), cluster variable(psu), and stratification variable(kstrata) to account for the complex survey design[13][17-19]. CFA and SEM were first specified and estimated in lavaan and then adjusted for the KNHANES complex survey design using the lavaan.survey package. Robust standard errors and Satorra-Bentler scaled test statistics were used[20].

First, confirmatory factor analysis was conducted to evaluate the measurement structure of latent metabolic risk. Second, the structural equation model tested whether walking frequency, resistance-exercise frequency, and sedentary time were associated with EQ-5D directly and indirectly through latent metabolic risk. Age, sex, household income, and educational attainment were included as covariates and specified as predictors of both latent metabolic risk and EQ-5D. Indirect effects were estimated using the product-of-coefficients approach[21]. Their statistical significance was evaluated using survey-adjusted standard errors obtained from the lavaan.survey framework[18].

Table 1. Participant Characteristics of the analytic sample (Unweighted N=3,894; Weighted N=25,780,548)

Category		Weighted N(%)
Sex	Female	13,242,007(51.4%)
	Male	12,538,541(48.6%)
Age group	40-49	6,657,309(25.8%)
	50-59	7,578,856(29.4%)
	60-69	6,583,635(25.5%)
	70 or older	4,960,749(19.2%)
Household income	Low	3,901,612(15.1%)
	Lower-middle	6,236,131(24.2%)
	Upper-middle	7,394,857(28.7%)
	High	8,247,948(32.0%)
Education Level	Elementary school or less	4,011,591(15.6%)
	Middle school	3,003,980(11.7%)
	High school	8,364,678(32.4%)
	College or higher	10,400,299(40.3%)

III. Results

1. Participant Characteristics

The final analytic sample included 3,894 adults (Weighted N=25,780,548) aged 40 years or older. The weighted mean age was 58.5 years and 51.4% of participants were female. By age group, 25.8% were aged 40-49 years, 29.4% were aged 50-59 years, 25.5% were aged 60-69 years, and 19.2% were aged 70 years or older. Regarding socioeconomic characteristics, 32.0% were in the high household-income group, and 40.3% had college-level education or higher(Table 1).

Table 2. CFA Factor Loadings for Latent Metabolic Risk

Indicator	*B*	SE	*β*	*p*
Waist circumference	.648	.022	.778	<.001
Blood pressure risk	.346	.019	.359	<.001
Fasting glucose	.378	.022	.365	<.001
Triglycerides	.504	.022	.509	<.001
HDL-cholesterol risk	.551	.023	.548	<.001

B= unstandardized factor loading, SE= robust standard error, *β*= standardized factor loading

2. Confirmatory Factor Analysis of Metabolic Risk

The model specified metabolic risk as a latent factor indicated by waist circumference, blood pressure risk, fasting glucose, triglycerides, and HDL-cholesterol risk. Because triglycerides and HDL-cholesterol risk are conceptually and physiologically related lipid-metabolism indicators, their residual covariance was freely estimated. Although the factor loadings for blood pressure and fasting glucose were relatively low, both indicators were retained because they are theoretically established core components of metabolic syndrome.

The complex survey-adjusted CFA demonstrated good overall fit to the data: $\chi^2(4)=50.683$, $p< .001$, CFI=.980, TLI=.951, RMSEA=.055, SRMR=.019. Although the chi-square test was significant, the CFI and TLI exceeded conventional criteria for good fit[22], and the SRMR indicated excellent absolute fit. The RMSEA was slightly above .05 but remained within an acceptable range. Therefore, the measurement model was considered adequate for representing latent metabolic risk.

All factor loadings were statistically significant(Table 2). The residual covariance between triglycerides and HDL-cholesterol risk was also significant(β=.349, p<.001), supporting the inclusion of this residual association in the measurement model.

3. Structural equation modeling

The complex survey-adjusted SEM demonstrated acceptable overall fit to the data, although the fit indices did not uniformly meet conventional criteria: $\chi^2(36)=351.889$, $p<.001$, CFI=.922, TLI=.877, RMSEA=.047, SRMR=.029. The TLI fell below the conventional .90 criterion, indicating a limitation in the incremental fit of the model. However, the CFI exceeded .90, and both the RMSEA and SRMR indicated good approximate and residual fit, respectively. Because these indices evaluate different aspects of model fit, the model was assessed based on their combined pattern rather than on the TLI alone[22][23]. Accordingly, the acceptable CFI and the favorable RMSEA and SRMR values were considered to support the overall acceptability of the model for interpreting the hypothesized structural pathways, while acknowledging the comparatively low TLI(Table 3 and Fig. 1).

Table 3. Direct Structural Effects

Path	*β*	SE	*p*
Walking→Metabolic risk	-.038	.019	0.47
Resistance-exercise→ Metabolic risk	-.112	.017	<.001
Sedentary time→ Metabolic risk	.112	.017	<.001
Age→Metabolic risk	.035	.027	.203
Male sex→Metabolic risk	.569	.016	<.001
Household income→Metabolic risk	.011	.024	.657
Education→Metabolic risk	-.195	.026	<.001
Walking→EQ-5D	.076	.017	<.001
Resistance exercise→EQ-5D	.013	.016	.411
Sedentary time→EQ-5D	-.083	.021	<.001
Metabolic risk→EQ-5D	-.115	.031	<.001
Age→EQ-5D	-.097	.025	<.001
Male sex→EQ-5D	.199	.027	<.001
Household income→EQ-5D	.118	.020	<.001
Education→EQ-5D	.128	.020	<.001

SE= robust standard error, *β*= standardized direct effect

Walking was significantly and negatively associated with metabolic risk(β=-.038, p=.048), although the effect size was small. Resistance-exercise was also significantly and negatively associated with metabolic risk(β=-.112, p<.001), whereas sedentary time was significantly and positively associated with metabolic risk(β=.112, p<.001). Metabolic risk was significantly and negatively associated with EQ-5D(β=-.115, p<.001).

Regarding direct associations with EQ-5D, walking showed a significant positive direct association(β=.076, p<.001), whereas sedentary time showed a significant negative direct association(β

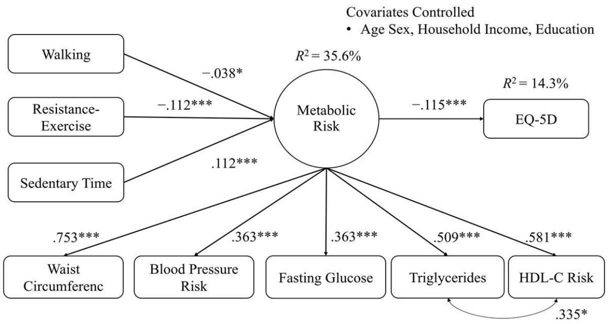

Fig. 1. Results of structural equation modeling. Standardized coefficients are presented. $^*p$<.05, $^{***}p$<.001. R^2 values represent the variance explained by all predictors in the model, including movement behaviors and covariates.

=-.083, p<.001). Resistance-exercise was not directly associated with EQ-5D(β=.013, p=.408).

Walking had a statistically significant but very small positive indirect effect on EQ-5D through metabolic risk(β=.004, p<.05). Resistance-exercise also showed a significant positive indirect effect through metabolic risk(β=.013, p<.01). By contrast, sedentary time showed a significant negative indirect effect through metabolic risk(β=-.013, p<.01), indicating that greater sedentary time was indirectly associated with lower EQ-5D scores via higher metabolic risk(Table 4).

The model explained 35.6% of the variance in metabolic risk and 14.3% of the variance in EQ-5D health-related quality of life. Overall, the results suggest that walking, resistance-exercise, and sedentary time were each associated with the metabolic-risk pathway, although their effect sizes and direct associations with EQ-5D differed. Walking and sedentary time were associated with EQ-5D both directly and indirectly through metabolic risk, whereas resistance-exercise was associated with EQ-5D primarily through the metabolic-risk pathway.

Table 4. Indirect Effects on EQ-5D

Path	β	SE / 95% CI
Walking→ Metabolic risk→EQ-5D	.004*	.002
		[0.000, 0.009]
Resistance exercise→ Metabolic risk→EQ-5D	.013**	.004
		[0.005, 0.021]
Sedentary time→ Metabolic risk→EQ-5D	-.013**	.004
		[-0.021, -0.005]

$^*p$<.05, $^{**}p$<.01, SE= robust standard error, β= standardized indirect effect

IV. Discussion

This study examined the associations among walking frequency, resistance-exercise frequency, sedentary time, metabolic risk, and EQ-5D health-related quality of life among Korean adults aged 40 years and older. Using complex survey-adjusted structural equation modeling based on nationally representative KNHANES data, the findings generally supported the hypothesized model, although the strength and pattern of associations differed across movement behaviors. Overall, the results suggest that walking, resistance exercise, and sedentary time may be differently related to health-related quality of life, both directly and indirectly through latent metabolic risk.

Regarding H1, walking frequency was negatively associated with metabolic risk, supporting the hypothesis. This finding is consistent with guideline-level evidence emphasizing the health benefits of regular physical activity in adults[6] and with walking-intervention evidence showing favorable effects on several cardiovascular and metabolic risk factors, including body mass, blood pressure, and fasting glucose[8]. However, the association observed in the present study was small, suggesting that walking frequency alone may not fully capture the metabolic benefits of walking behavior. Because the measure reflected only the number of walking days, it did not account for walking intensity, pace, duration, accumulated volume, or long-term consistency. Therefore, although walking remains an accessible and practical form of daily movement, future research should consider more detailed indicators of walking behavior to better understand its relationship with metabolic health.

Regarding H2, resistance-exercise frequency was negatively associated with metabolic risk, supporting the hypothesis. This finding aligns with current physical activity guidelines, which emphasize muscle-strengthening activity as a core component of adult health promotion in addition to aerobic activity[6]. It is also consistent with evidence linking muscle-strengthening exercise to a lower prevalence of metabolic syndrome in Korean adults aged 40 years and older[7] and with prospective evidence showing that muscle-strengthening activities are associated with lower risk and mortality in major non-communicable disease outcomes[10]. Mechanistically, resistance exercise may support cardiometabolic health by preserving skeletal-muscle mass and strength, improving glucose regulation, enhancing body composition, and counteracting age-related declines in muscle function[9]. These findings suggest that resistance exercise may be particularly important from midlife onward, when age-related losses in muscle mass and metabolic function become increasingly relevant.

Regarding H3, sedentary time was positively associated with metabolic risk, supporting the hypothesis. This result is in agreement with the sedentary behavior literature, which conceptualizes sedentary behavior as a distinct health-related exposure rather than merely the absence of physical activity[11]. Prolonged sedentary time may reduce skeletal-muscle contractile activity and energy expenditure, thereby adversely influencing glucose and lipid metabolism[11]. Epidemiological evidence also links greater sedentary time with higher risk of diabetes, cardiovascular disease, and mortality[12]. The present study extends this literature by showing that sedentary time was associated with EQ-5D both directly and indirectly through metabolic risk. The indirect pathway is consistent with the possibility that prolonged sedentary time is related to poorer health-related quality of life partly through less favorable cardiometabolic health.

Regarding H4, latent metabolic risk was negatively associated with EQ-5D health-related quality of life. This finding supports the hypothesis that poorer metabolic health is associated with lower health-related quality of life. The result is broadly related to previous KNHANES-based evidence examining the association between metabolic syndrome and EQ-5D health-related quality of life[4]. However, whereas prior work found that the association between metabolic syndrome and HRQoL was attenuated after adjustment for sociodemographic factors, comorbidities, and obesity[4], the present study extends this literature by modeling metabolic risk as a continuous latent construct rather than as a categorical metabolic syndrome diagnosis. This approach may capture subclinical variation in clustered metabolic risk indicators that is not fully represented by a dichotomous metabolic syndrome classification. Because metabolic syndrome becomes increasingly prevalent from midlife onward in Korea[3], metabolic-risk management may be important not only for preventing cardiometabolic disease but also for maintaining health-related quality of life among adults aged 40 years and older.

Regarding H5, the direct associations between movement behaviors and EQ-5D were only partially supported. Specifically, walking frequency was directly and positively associated with EQ-5D, whereas sedentary time was directly and negatively associated with EQ-5D. This interpretation is consistent with systematic review evidence indicating a generally positive association between physical activity level and health-related quality of life in adult populations[5]. Walking may be directly related to better EQ-5D because it is a simple, accessible, and functional form of daily movement that can be closely connected to mobility, independence, and perceived health in middle-aged and older adults. Conversely, prolonged sedentary time may reflect or contribute to poorer functional status, lower daily activity engagement, and less favorable perceptions of health and daily life.

In contrast, resistance-exercise frequency was not directly associated with EQ-5D, differing from previous evidence linking overall physical activity to better health-related quality of life[5]. This difference may reflect the present study's simultaneous adjustment for walking, sedentary time, metabolic risk, and sociodemographic factors, which allowed the unique direct contribution of resistance exercise to be isolated. The association may also have been attenuated because resistance exercise was measured only by weekly frequency, without accounting for intensity, duration, training volume, or adherence. Moreover, the significant indirect association through metabolic risk suggests that resistance exercise may contribute to EQ-5D primarily through improved cardiometabolic health rather than through an independent direct pathway.

Regarding H6, statistically significant indirect association through metabolic risk were observed for walking frequency, resistance-exercise frequency, and sedentary time, although their magnitude and interpretation differed across movement behaviors. Walking frequency had a statistically significant but very small positive indirect association with EQ-5D through lower metabolic risk, suggesting that the association may be of limited practical significance. Resistance-exercise frequency showed a significant positive indirect association with EQ-5D through lower latent metabolic risk, despite the absence of a significant direct association with EQ-5D. This finding suggests that resistance-exercise frequency may be related to health-related quality of life partly through its association with cardiometabolic health rather than through a direct association with perceived quality of life. Sedentary time showed a significant negative indirect association with EQ-5D through higher latent metabolic risk, suggesting that greater sedentary time may be related to poorer health-related quality of life partly through its association with greater metabolic risk. Thus, H6 was supported, although the magnitude and potential practical importance of these indirect associations differed across movement behaviors.

Taken together, the findings provide a differentiated interpretation of the movement behavior–metabolic risk–health-related quality of life relationship. Walking frequency appeared to be more clearly related to EQ-5D through a direct pathway than through a strong metabolic-risk pathway. Resistance-exercise frequency appeared to be more relevant to EQ-5D through lower metabolic risk, highlighting the importance of muscle-strengthening activity for cardiometabolic health. Sedentary time showed both direct and indirect associations with EQ-5D, suggesting that prolonged sitting may be relevant to health-related quality of life through multiple pathways. These findings indicate that different movement behaviors should not be interpreted as interchangeable. Rather, walking, resistance exercise, and sedentary time may represent distinct behavioral domains with different implications for metabolic health and health-related quality of life.

From a practical perspective, these findings suggest that health promotion for Korean adults aged 40 years and older should move beyond the general message to "exercise more." Although participation in structured or complex sports activities may provide important health benefits, the present findings suggest that simple and feasible daily movement strategies may also be meaningful. Walking more frequently and reducing prolonged sedentary time may represent practical behavioral targets associated with more favorable metabolic indicators and better perceived health and daily life. Walking should be promoted as an accessible form of daily movement because it was directly associated with better EQ-5D and modestly associated with lower metabolic risk. Resistance exercise should also be emphasized as an essential component of cardiometabolic health promotion because it was associated with lower metabolic risk and indirectly associated with better EQ-5D. Reducing sedentary time should be treated as a distinct behavioral target because sedentary time was associated with poorer EQ-5D both directly and indirectly through higher metabolic risk. Therefore, an integrated and practical strategy of sitting less, walking more frequently, and engaging in regular resistance exercise may be more appropriate than a single-domain physical activity message. Such a strategy may help adults not only maintain cardiometabolic health but also support better health-related quality of life from midlife onward.

Several limitations should be noted. First, the cross-sectional design prevents causal inference. Although the model specified directional associations linking movement behaviors to EQ-5D through metabolic risk, the cross-sectional design does not establish temporal ordering, and reverse or bidirectional associations remain possible. Therefore, longitudinal and intervention studies are needed to clarify the temporal ordering and causal mechanisms among movement behaviors, metabolic risk, and health-related quality of life. Second, movement behaviors were self-reported and may be affected by recall bias or social desirability bias. In particular, walking frequency was measured only as the number of days of walking and did not capture intensity, pace, duration, total volume, or long-term consistency. Third, latent metabolic risk was based on major cardiometabolic indicators but should not be interpreted as a clinical diagnosis of metabolic syndrome. Fourth, although major sociodemographic covariates were included, residual confounding by factors such as diet, medication use, comorbid conditions, occupational activity, or psychological health may remain. Fifth, EQ-5D scores commonly exhibit a ceiling effect in general-population samples, with a substantial proportion of participants reporting full health. Future studies should consider analytical approaches that explicitly account for the bounded and ceiling-inflated distribution of EQ-5D scores and should conduct sensitivity analyses using alternative model specifications.

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