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Association between healthy lifestyle score changes and quality of life and health-related quality of life: a longitudinal analysis of South Korean panel data

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ABSTRACT

Objectives We aimed to determine the influence of changes in the aggregate score of healthy lifestyle factors on health-related quality of life (HRQOL) and overall quality of life (QOL) in the Korean older adult population.

Design This study used a longitudinal design.

Setting and participants Data on 9474 participants aged 45 years or older were extracted from the Korean Longitudinal Study on Aging for the period 2006–2016. A composite score of four lifestyle factors (smoking, drinking, physical activity and body mass index) was calculated, and biennial changes in aggregate score were computed.

Primary and secondary outcome measures The primary outcomes were HRQOL and QOL.

Results Generalised estimating equation analysis results showed that those with healthy lifestyle score changes from 'Low–High' ($\beta = -0.987$, p=0.002; $\beta = -1.288$, p<0.0001), 'High–Low' ($\beta = -1.281$, p<0.0001; $\beta = -1.952$, p<0.0001) and 'Low–Low' ($\beta = -1.552$, p<0.0001; $\beta = -2.398$, p<0.0001) groups were more likely to be have lower HRQOL and QOL estimates than those in 'High–High' group. Female gender, older age and depression had a more negative impact on HRQOL, while male gender and younger age had a more negative impact on QOL, especially in the Low–Low group. The relationship between changes in scores and HRQOL and QOL varied across different elements of healthy lifestyle scores. Changes in physical activity, drinking and smoking status were significantly associated with lower HRQOL and QOL.

Conclusion The findings suggest an association between a low healthy lifestyle score and poor quality of life, in both general and health-related aspects. Strategies targeting the Korean ageing demographic to promote a healthier lifestyle should be encouraged.

INTRODUCTION

In recent years, the general trend towards an ageing population has increased exponentially worldwide. Between 2015 and 2050, the proportion of the world's population over 60 years is expected to increase from 12% to 22%, according to the WHO.[1] In 2015, the

> **Strengths and limitations of this study**
>
> ► A large, nationally representative sample of Korean older adults was included in this study.
> ► We analysed biennial changes in a composite score of lifestyle factors longitudinally to determine their influence on overall and health-related quality of life.
> ► Our findings could not be generalised to other populations because of the homogeneous nature of our study sample, lack of standardised cut-off points, and categorisations of health behaviours.

Korean National Statistical Office reported that the number of adults aged 65 years or older accounted for 13.2% of the total population, which is expected to rise up to 40% by 2060.[2]

The health and socioeconomic burden of ageing-related problems are becoming a great concern as life expectancy improves. Additionally, many people believe that a good quality of life (QOL) is equally important as the length of life. The WHO defines QOL as the 'individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standard and concerns'.[3] It is a broad concept revolving around how an individual's life is affected in an intricate way by various factors such as the person's physical health, psychological state, level of independence and social relationships.[3] In comparison, health-related quality of life (HRQOL) is a much narrower domain, characterised by influence of multidimensional variables, that considers the physical as well as mental components related to health.[4] In other words, while HRQOL involves the assessment of QOL related to health and
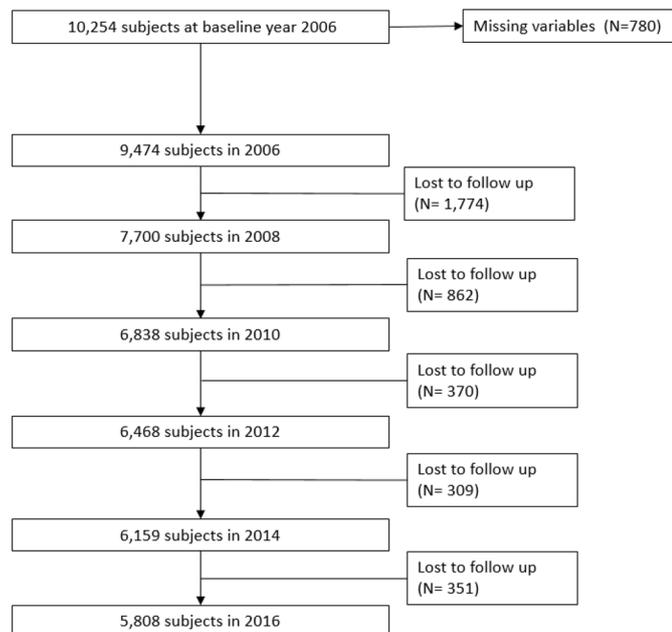
Figure 1 Flowchart of the study participants from 2006 to 2016.

disease, QOL takes into account non-medical concepts as well.[5]

Factors affecting the QOL of the ageing population, both general and health-related, are numerous. Maintaining healthy behaviours in older age, such as a balanced diet, refraining from smoking, and regular physical activity, all contribute to reducing the risk of chronic diseases and mortality, as well as improving physical and mental health.[3] Health behaviours are general indicators of HRQOL in particular.[6 7] In addition, prior evidence suggests that health risk behaviours such as physical inactivity, drinking and smoking are very likely to occur simultaneously in ageing individuals.[8]

In previous studies, a cluster of lifestyle risk factors was associated with a reduction in capacity for activities of daily living[9] and was strongly correlated with morbidity and mortality.[10] In addition, and in older adults, it was also linked to increased hospitalisations and outpatient care use.[11]

While the influence of health behaviours on HRQOL is an essential finding, the effect of an unhealthy lifestyle on an individual's subjective evaluation of QOL and overall aspects of physical, psychological and social well-being should be emphasised as well. Moreover, evidence regarding the degree of impact of lifestyle factors on HRQOL and QOL of Korean older adults is still lacking. Therefore, the present study aimed to investigate the association between changes in a composite score of healthy lifestyle factors with HRQOL and QOL in middle-aged and older Korean adults.

METHODS
We utilised data extracted from the first to sixth waves (2006–2016) of the Korean Longitudinal Study of Aging

(KLoSA). Since 2006, the Korea Labor Institute has collected nationally representative data through use of multistage, stratified probability sampling design to randomly select participants from all regions in Korea with the exception of Jeju Island. The KLoSA panel data were established through repeated surveys in the same sample biennially, thereby reflecting trends over time in middle-aged and older residents aged 45 years or older residing in Korea.[12] The number of participants included in the original survey in 2006 was 10 254, followed by 8875 in 2008, 8229 in 2010, 7813 in 2012, 8387 in 2014 and 7893 participants in 2016. More information about the survey can be found on the panel survey organisation website (https://survey.keis.or.kr/eng/klosa/klosa01.jsp). After excluding those with missing data and those who failed to follow-up, a total of 9474 participants were included in our study. The detailed flow of the participants in our study is depicted in figure 1.

Patient and public involvement
No patient involved.

Measures
Quality of life and health-related quality of life
Comprehensive assessment of overall QOL and HRQOL was carried out using an instrument similar to the EuroQOL visual analogue scale (EQ-VAS), where participants provided a subjective score ranging from 0 to 100 on their perceived QOL. The VAS is an instrument with good reliability and validity compared with multi-item questionnaires.[13]

Healthy lifestyle score
We computed the healthy lifestyle score by assigning a score to each of the following healthy lifestyle factors: (1) smoking status: never smokers (optimal), past smokers (intermediate) and current smokers (poor). (2) Drinking status: never or past drinker was classified as optimal; current drinking behaviour was further classified using the CAGE questionnaire (cutting down, annoyance by criticism, guilty feeling and eye-openers) provided in the KLoSA. If the current drinker answered 'yes' to one or none of the questions, they were classified as normal drinkers (intermediate); otherwise, they were classified as heavy drinkers (poor).[14] (3) Physical activity was categorised as exercising more than 150 min weekly (optimal), less than 150 min (intermediate) and never (poor). (4) Body mass index (BMI) was categorised using the criteria set by WHO to define obesity in an Asian population: a BMI higher than $25 \, kg/m^2$ and an underweight BMI of less than $18 \, kg/m^2$ was rated as poor; slightly overweight BMI of $23–24.9 \, kg/m^2$ was classified as intermediate and a BMI of $18–22.9 \, kg/m^2$ was optimal.[15] A score of 0 points was assigned to poor, 1 point for intermediate and 2 points for optimal. The maximum score was 8 points, and the scores were divided into two categories, based on the median, which were 0–5 points for the low group and 6–8 points for the high group. We detected 2-year changes in

participants' healthy lifestyle by investigating the lagged healthy lifestyle score in the prior year and scores in the following year over 2 consecutive years (2006–2008, 2008–2010, 2010–2012, 2012–2014 and 2014–2016). Therefore, we grouped the scores into four categories: (1) High–High, (2) Low–High, (3) High–Low and (4) Low–Low. Further subgroup analysis of individual components of the composite lifestyle score was conducted by regrouping the poor as the low group and intermediate and optimal as the high group. In addition, the number of participants in each healthy lifestyle component were expressed as percentages in online supplemental table 1.

Covariates

Data regarding sociodemographic characteristics and health-related variables were added as potential confounders in this study. Sociodemographic characteristics included gender, age (45–54, 55–64 and ≥65 years), education level (middle school or lower, high school degree and university degree or higher) and income level per month (low, middle low, middle high and high). Additionally, marital status was classified into married and unmarried, while region was categorised as urban or rural. Economic activity was classified based on whether the individual was economically active or inactive.

Participants was grouped into the 'Yes' category if they participated in at least one social activity; otherwise, they were grouped into the 'No' category. Depression was classified based on the Center for Epidemiological Studies Depression Scale-10 classification. Cognitive function was classified as normal based on whether the respondents' score on the Korean Mini-Mental State Examination was higher than 24 points; otherwise, it was classified as abnormal.[16] Difficulties in activities of daily living (ADL) and instrumental activities of daily living (IADL) were measured based on whether the individual experienced at least one limitation in any daily necessary tasks (getting dressed, washing one's face and hands, bathing, eating meals, leaving a room and using the toilet) for ADL, and social function-related tasks (companionship and mental support, transportation, making phone calls, finance management, cooking meals, doing household chores, laundry, shopping and taking medications) for IADL. The chronic diseases included in this study were hypertension, diabetes, cancer, heart disease, lung disease, liver disease, cerebrovascular disease, psychiatric disease and arthritis; the number of comorbidities were grouped into three categories: 0, 1 and ≥2 diseases. Self-rated health was classified as good, normal or bad.

2-year lagged multivariable generalised estimating equation (GEE) model with an unstructured working correlation was used to longitudinally examine impact of healthy lifestyle score changes on HRQOL and QOL, after controlling for confounders. The GEE is considered an extension of the generalised linear model and allows for analysis of repeated panel data such as the KLoSA by taking within-subject correlation into account and produces estimates based on the mean regression parameters.[17] Data from a total of six waves (2006–2016) were used in this study, and thus, repeated measurements for each participant were conducted up to five times. All data analyses were performed using the statistical package SAS V.9.4, and p values less than 0.05, were considered statistically significant.

RESULTS

Table 1 lists the general characteristics of the population of 7700 people at the first time point of change in healthy lifestyle score, which was the baseline period of 2006–2008. The mean HRQOL was 57.1 (SD: 21.6) for the High–High score group, 53.9 (SD: 20.4) for the Low–High score group, 53.7 (SD: 22.2) for the High–Low group and 56.1 (SD: 21.6) for the Low–Low score group. The mean QOL was 63.4 (SD: 18.7) for the High–High score group, 60.4 (SD: 18.5) for the Low–High score group, 58.7 (SD: 19.1) for the High–Low group and 59.8 (SD: 18.5) for the Low–Low score group.

Table 2 shows the adjusted effect of changes in healthy lifestyle scores on HRQOL and QOL. Compared with those in the High–High group, the HRQOL estimate was $\beta=-0.987$ (p=0.002) for the Low–High group, while the estimate was $\beta=-1.281$ (p<0.0001) for those in the High–Low group; for those in the Low–Low group, the estimate was $\beta=-1.522$ (p<0.0001). Compared with the High–High group, the QOL estimate was $\beta=-1.288$ in the Low–High group (p<0.0001), $\beta=-1.952$ (p<0.0001) in the High–Low group and $\beta=-2.398$ (p<0.0001) in the Low–Low group.

Table 3 shows the subgroup analysis of gender, age and depression with changes in healthy lifestyle scores for HRQOL and QOL. For HRQOL, the Low–Low score group, in particular, had a lower estimate for females ($\beta=-1.639$; p<0.0001); however, for QOL, males had a lower estimate ($\beta=-2.791$; p<0.0001). Older participants aged more than 65 years had lower HRQOL ($\beta=-1.694$; p<0.0001), while younger participants aged 45–54 years had a lower QOL ($\beta=-3.786$, p<0.0001). Individuals who were depressed had a lower HRQOL ($\beta=-1.672$, p<0.0001).

Table 4 shows the subgroup analysis of changes in each component of healthy lifestyle scores within HRQOL and QOL. Compared with the High–High score group, the Low–Low score group showed a statistically significantly lower estimate for both HRQOL ($\beta=-3.722$; p<0.0001) and QOL ($\beta=-4.026$; p<0.0001) for change in physical activity. For smoking status change, both HRQOL and QOL showed significantly lower estimates in the Low–Low score group, that is, $\beta=-1.362$ (p<0.0001) and $\beta=-2.907$ (p<0.0001), respectively. For drinking status change, both HRQOL and QOL showed the lowest estimates in the Low–Low group, that is, $\beta=-1.282$ (p=0.085) and $\beta=-2.780$ (p=0.0002), respectively, although only QOL was significant. The results did not show any statistically significant changes in the BMI status for both HRQOL and QOL.

Table 1 General characteristics of the study population at baseline (2006–2008) (n=7700)

Variables	N	(%)	HRQOL			QOL		
			Mean	SD	P value	Mean	SD	P value
Total	7700	100	55.8	21.6	<0.0001	60.8	18.7	<0.0001
Change in healthy lifestyle score (2006–2008)					0.6236			<0.0001
High–High	2193	(28.5)	57.1	21.6		63.4	18.7	
Low–High	905	(11.8)	53.9	20.4		60.4	18.5	
High–Low	912	(11.8)	53.7	22.2		58.7	19.1	
Low–Low	3690	(47.9)	56.1	21.6		59.8	18.5	
Gender					0.8219			0.0427
Male	3376	(43.8)	59	21.1		62.3	18.2	
Female	4324	(56.2)	53.3	21.6		59.6	19	
Age					<0.0001			<0.0001
45–54	2094	(27.2)	63.3	19.2		63.8	17.6	
55–64	2229	(28.9)	58.2	20.4		63.3	18	
≥65	3377	(43.9)	49.6	21.9		57.3	19.2	
Education level					<0.0001			<0.0001
Lower than middle school	3485	(45.3)	48.8	21.6		56	19	
Middle school graduate	1305	(16.9)	57.8	20		62.1	18	
High school graduate	2134	(27.7)	62.4	19.3		65	16.9	
University graduate	776	(10.1)	66.3	19.1		68.4	17.5	
Income level					<0.0001			<0.0001
Low	2837	(36.8)	48	22.2		54.3	19.7	
Middle low	1782	(23.1)	57	20		61.1	17.8	
Middle high	1691	(22)	60.7	19.5		64.6	16.4	
High	1390	(18.1)	64.5	19.2		68.9	15.5	
Marital status					0.115			<0.0001
Married	6072	(78.9)	58	20.9		62.9	17.6	
Unmarried	1628	(21.1)	47.9	22.3		52.9	20.5	
Economic activity					<0.0001			0.5342
Active	3306	(42.9)	62.3	19.1		63.9	17.1	
Inactive	4394	(57.1)	50.9	22.1		58.5	19.5	
Region					0.0592			<0.0001
Urban	5825	(75.6)	56.9	21.5		61	19	
Rural	1875	(24.4)	52.6	21.4		60	17.8	
Participation in social activities					<0.0001			<0.0001
Yes	5999	(77.9)	58.9	20.2		63.4	17.5	
No	1701	(22.1)	45	22.9		51.5	19.7	
Depression					<0.0001			<0.0001
Yes	4169	(54.1)	48.4	21.4		55.8	19.1	
No	3531	(45.9)	64.6	18.3		66.7	16.3	
Cognitive function					<0.0001			0.0017
Normal	5822	(75.6)	60	19.7		63.2	17.7	
Abnormal	1878	(24.4)	42.9	21.9		53.2	19.6	
ADL difficulty					<0.0001			<0.0001
Yes	269	(3.5)	27.6	21.6		42.5	21.9	

Continued

Table 1 Continued

Variables	N	(%)	HRQOL			QOL		
			Mean	SD	P value	Mean	SD	P value
No	7431	(96.5)	56.9	20.9		61.4	18.2	
IADL difficulty					0.0031			<0.0001
Yes	852	(11.1)	41.8	23.6		50.9	20.7	
No	6848	(88.9)	57.6	20.7		62	18.1	
Self-rated health					<0.0001			<0.0001
Good	3618	(47)	66.3	17.1		66.4	15.8	
Normal	2399	(31.2)	53.8	18		59.6	18.1	
Bad	1683	(21.9)	36.2	20.3		50.4	20.4	
Number of chronic diseases					<0.0001			0.002
0	3506	(45.5)	62.6	19.1		63.6	17.2	
1	2328	(30.2)	54.5	21		61.1	18.6	
≥2	1866	(24.2)	44.7	21.7		55.1	20.3	

ADL, activities of daily living; HRQOL, health-related quality of life; IADL, instrumental activities of daily living; QOL, quality of life.

DISCUSSION

The primary purpose of our study was to investigate the influence of 2-year healthy lifestyle score changes on HRQOL and QOL using longitudinal models to analyse a nationally representative sample of South Korean older adults. Our findings suggested that poor QOL in the general and health-related aspects was associated with presence or transitions from and to a low healthy lifestyle score. In addition, a low lifestyle score had a higher negative correlation with overall QOL than HRQOL. One possible explanation could be that QOL is a holistic concept, encompassing health, well-being, financial stability, social relationships, among others. Therefore, the influence of a low healthy lifestyle score had a greater impact on the general QOL than the HRQOL measure alone.

Prior research revealed that adults with healthier behaviour patterns[18] were more likely to report more positive perceptions of their health and QOL.[19] Although a plethora of studies used individual assessments of health behaviours, these may have provided incomplete estimation of the contribution of a healthy lifestyle to QOL.[20] Moreover, prior evidence indicates that possibly, a low HRQOL is equivalent to the loss of health as perceived by older adults, and therefore, health-promoting behaviours such as regular physical activity and smoking cessation seem to be good indicators of QOL.[21 22]

Our study has important methodological implications as research that demonstrates a relationship between changes in health behaviours over time (especially using a composite lifestyle score) in older people and QOL requires further exploration. Considering that a majority of prior studies used single or stationary assessments of health behaviours, observing the influence of dynamic change of an aggregate of different health behaviours over time on QOL may provide novel information.

A study conducted in Ireland revealed that healthier clusters (former smokers, temperate and healthy lifestyle) reported better self-rated health and higher QOL.[23] A prior study conducted in Korea also showed that current smoking, regular exercise and current alcohol consumption in men largely influenced their perceived QOL.[2]

Further subgroup analysis identified gender and age differences, supporting previous evidence. A study conducted showed that men reported a significantly better HRQOL than women.[24] Additionally, an interesting finding was that QOL estimates showed improvement with increasing age in all patterns of healthy lifestyle scores. In other words, younger participants reported a significantly worse QOL than their older counterparts.

Moreover, depression in the constant Low–Low group was also shown to be a critical indicator of poor HRQOL, suggesting that deteriorating mental condition and combination of unhealthy behaviours significantly affects HRQOL in ageing adults. Depressive symptoms are strongly associated with unhealthy and risky lifestyle behaviours and may lower HRQOL.[25–27]

Other assessments, particularly constant physical inactivity, were also significant indicators in the older adult population.[28] Physical activity is a protective factor for QOL.[29] Physical exercise such as walking is suggested to improve QOL and health, especially in women.[30] Although HRQOL and QOL vis-a-vis BMI status change were not significant, change from Low–High score surprisingly had the lowest estimates of both HRQOL and QOL. As both underweight and obese BMI were grouped in the low score group, our results can partially be explained by presence of an 'obesity paradox', wherein individuals with obesity showed better HRQOL and QOL than those who were normal.[31]

Current smoking has been reported significantly associated with decreased QOL among older adults.[32–34]

Table 2 Association of change in healthy lifestyle score and HRQOL/QOL

Variables	HRQOL			QOL		
	β	SD	P value	β	SD	P value
Change in healthy lifestyle score						
High–High	Ref.			Ref.		
Low–High	−0.987	0.31	0.002	−1.288	0.278	<0.0001
High–Low	−1.281	0.314	<0.0001	−1.952	0.286	<0.0001
Low–Low	−1.552	0.261	<0.0001	−2.398	0.245	<0.0001
Gender						
Male	Ref.			Ref.		
Female	−0.253	0.286	0.377	0.74	0.282	0.009
Age						
45–54	−2.385	0.372	<0.0001	−3.043	0.347	<0.0001
55–64	−0.955	0.262	0	−1.151	0.248	<0.0001
≥65	Ref.			Ref.		
Education level						
Lower than middle school	−4.858	−4.82	0.469	<0.0001	−4.348	0.471
Middle school graduate	−3.089	−3.111	0.47	<0.0001	−3.075	0.48
High school graduate	−1.75	0.423	<0.0001	−2.046	0.425	<0.0001
University graduate	Ref.			Ref.		
Income level						
Low	−3.688	0.341	<0.0001	−6.073	0.318	<0.0001
Middle low	−2.08	0.315	<0.0001	−3.971	0.291	<0.0001
Middle high	−0.978	0.298	0.001	−2.221	0.268	<0.0001
High	Ref.			Ref.		
Marital status						
Married	Ref.			Ref.		
Unmarried	−0.895	0.319	0.005	−3.111	0.338	<0.0001
Economic activity						
Active	Ref.			Ref.		
Inactive	−2.485	0.239	<0.0001	−0.722	0.223	0.001
Region						
Urban	0.316	0.278	0.257	−2.06	0.274	<0.0001
Rural	Ref.			Ref.		
Participation in social activities						
Yes	Ref.			Ref.		
No	−2.87	0.256	<0.0001	−3.056	0.244	<0.0001
Depression						
Yes	−4.846	0.195	<0.0001	−4.291	0.179	<0.0001
No	Ref.			Ref.		
Cognitive function						
Normal	Ref.			Ref.		
Abnormal	−3.808	0.266	<0.0001	−2.102	0.247	<0.0001
ADL difficulty						
Yes	−5.354	0.67	<0.0001	−4.401	0.656	<0.0001
No	Ref.			Ref.		
IADL difficulty						

Table 2 Continued

Variables	HRQOL			QOL		
	β	SD	P value	β	SD	P value
Yes	−2.451	0.367	<0.0001	−2.022	0.35	<0.0001
No	Ref.			Ref.		
Self-rated health						
Good	Ref.			Ref.		
Normal	−5.105	0.209	<0.0001	−2.371	0.191	<0.0001
Bad	−16.223	0.333	<0.0001	−6.925	0.301	<0.0001
Number of chronic diseases						
0	Ref.			Ref.		
1	−2.135	0.266	<0.0001	0.094	0.253	0.711
≥2	−4.605	0.31	<0.0001	−0.837	0.297	0.005

β, regression coefficient; ADL, activities of daily living; HRQOL, health-related quality of life; IADL, instrumental activities of daily living; QOL, quality of life.

Similar to our main findings, continuous smoking (Low–Low) over a span of 2 years showed a greater association with poor QOL than HRQOL. A prior smoking cessation trial study compared the effects of quitting smoking versus continuing smoking on both HRQOL and global QOL. Results suggested that compared with continuing smoking, quitting smoking showed improvement in both HRQOL and global QOL, despite the association being stronger with HRQOL which was different from our present study.[22] Our study also revealed that constant

Table 3 Subgroup analysis of changes in healthy lifestyle score and HRQOL/QOL, stratified by covariates

Variables	Changes in healthy lifestyle score											
	High–High			Low–High			High–Low			Low–Low		
	β	SD	P value	β	SD	P value	β	SD	P value	β	SD	P value
HRQOL												
Gender												
Male	Ref.			−1.135	0.54	0.036	−1.718	0.579	0.003	−1.574	0.448	0.0004
Female	Ref.			−0.944	0.38	0.013	−1.097	0.374	0.003	−1.639	0.326	<0.0001
Age												
45–54	Ref.			−0.589	0.842	0.484	−0.792	0.844	0.348	−1.367	0.679	0.0441
55–64	Ref.			−0.982	0.548	0.073	−1.919	0.546	0	−1.593	0.422	0.0002
≥65	Ref.			−1.127	0.419	0.007	−1.158	0.423	0.006	−1.694	0.354	<0.0001
Depression												
Yes	Ref.			−1.405	0.461	0.002	−1.372	0.464	0.003	−1.672	0.371	<0.0001
No	Ref.			−0.673	0.416	0.106	−1.255	0.423	0.003	−1.407	0.332	<0.0001
QOL												
Gender												
Male	Ref.			−1.077	0.457	0.018	−1.805	0.513	0	−2.791	0.4	<0.0001
Female	Ref.			−1.432	0.349	<0.0001	−2.018	0.343	<0.0001	−2.147	0.313	<0.0001
Age												
45–54	Ref.			−1.991	0.752	0.008	−2.485	0.747	0.001	−3.786	0.613	<0.0001
55–64	Ref.			−1.303	0.495	0.008	−2.029	0.501	<0.0001	−2.425	0.408	<0.0001
≥65	Ref.			−1.172	0.379	0.002	−1.705	0.387	<0.0001	−2.292	0.331	<0.0001
Depression												
Yes	Ref.			−1.338	0.422	0.002	−1.702	0.417	<0.0001	−2.218	0.349	<0.0001
No	Ref.			−1.125	0.364	0.002	−2.023	0.382	<0.0001	−2.638	0.307	<0.0001

β, regression coefficient; HRQOL, health-related quality of life; QOL, quality of life.

Table 4 Subgroup analysis of change in each component of the healthy lifestyle score

Variables	HRQOL			QOL		
	β	SD	P value	β	SD	P value
Change in physical activity						
High–High	Ref.			Ref.		
Low–High	−1.217	0.267	<0.0001	−1.019	0.241	<0.0001
High–Low	−2.707	0.276	<0.0001	−2.835	0.254	<0.0001
Low–Low	−3.772	0.248	<0.0001	−4.026	0.235	<0.0001
Change in BMI status						
High–High	Ref.			Ref.		
Low–High	−0.658	0.289	0.023	−0.238	0.275	0.386
High–Low	−0.385	0.295	0.192	0.086	0.285	0.763
Low–Low	0.336	0.266	0.207	−0.137	0.26	0.6
Change in smoking status						
High–High	Ref.			Ref.		
Low–High	−0.855	0.394	0.03	−0.326	0.381	0.392
High–Low	−1.04	0.449	0.021	−2.43	0.423	<0.0001
Low–Low	−1.362	0.332	<0.0001	−2.907	0.334	<0.0001
Change in drinking status						
High–High	Ref.			Ref.		
Low–High	−0.087	0.383	0.82	−1.103	0.361	0.002
High–Low	−0.218	0.417	0.602	−1.57	0.388	<0.0001
Low–Low	−1.282	0.744	0.085	−2.78	0.75	0.0002

β, regression coefficient; BMI, body mass index; HRQOL, health-related quality of life; QOL, quality of life.

heavy drinking showed the lowest estimates of HRQOL and QOL, but its relationship with QOL was stronger and showed statistically significant values. A study conducted in the Norwegian general population reported that excessive drinking had the poorest QOL in various domains, namely psychological, social relationships and environmental, rather than the physical health domain.[35]

This study has several strengths and limitations. Due to the large and homogeneous nature of the sample, the results can be generalised to South Korean adults aged 45 years and older. Our findings both demonstrate the link between healthy lifestyle scores and the subjective evaluation of the QOL and also provide evidence supporting that among older adults, poor health behaviours may result in worse QOL, both health-related and general. However, this study has several limitations. First, the respondents' responses were subjective; therefore, recall bias may exist. Second, our findings cannot be generalised to non-Korean populations. Third, because of the use of different cut-off points of health behaviour measures, comparisons across studies are complex.[11 36] Fourth, as we used panel data, missing arising from loss of participants due to attrition is inevitable. Finally, we used self-reported measures of health behaviours. The use of objective measures of health behaviours, such as verifying smoking using urine cotinine, actigraphs for physical activity[37] and accurate measurements of the amount and frequency of alcohol consumption might have yielded more precise estimates of a healthy lifestyle.

CONCLUSION
The present study findings suggest an association between healthy lifestyle score changes and QOL, in both overall and health-related aspects. Hence, these findings may prove to be useful in implementing future policies to support partaking in healthy lifestyle choices to improve the QOL and overall life satisfaction of the rapidly ageing population.

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