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Comparative Associations of Aerobic Exercise and Resistance Exercise With Depression and Anxiety in Korean Adults: A Nationwide Propensity Score Matching Analysis

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ABSTRACT

Background: Depression and anxiety are psychiatric disorders that significantly affect patients' well-being, morbidity, and mortality. Aerobic exercise (AE) and resistance exercise (RE) have been proposed as interventions to alleviate depressive and anxiety symptoms; however, their comparative effectiveness remains unclear. This study compared the associations of AE, RE, and their combination (total exercise; TE) with depression and anxiety in a large representative sample of the Korean population.
Methods: Data from the Korean National Health and Nutrition Examination Survey (KNHANES) were used to analyze 21,298 participants for depression (measured using the Patient Health Questionnaire-9) and 8,707 participants for anxiety (measured using the Generalized Anxiety Disorder-7). The participants were divided into four exercise groups: TE, AE, RE, and non-AE-RE. Propensity score based exact matching was applied using a 1:1:1:1 ratio across the four exercise groups to control for confounding factors such as age and sex. Multivariate linear and logistic regression analyses were conducted to evaluate the effects of each exercise type on depression and anxiety.
Results: After propensity score matching, the RE group had the lowest depression (β = –0.534; 95% confidence interval [CI], –0.765 to –0.303; P < 0.001) and anxiety (β = –0.459; 95% CI, –0.808 to –0.110; P = 0.010) scores compared with the non-AE-RE group. The TE group also showed favorable associations with depression (β = –0.473; 95% CI, –0.706 to –0.241; P < 0.001), although to a lesser extent than the RE group. AE was not significantly associated with either of the outcomes. Subgroup analyses indicated stronger associations of RE in women and older adults.
Conclusion: RE was more strongly associated with lower depression and anxiety levels than AE, particularly in women and older adults. This study underscores the importance of incorporating resistance training into exercise prescriptions and public health interventions to enhance mental health outcomes.

Keywords: Total Exercise; Aerobic Exercise; Resistance Exercise; Depression; Anxiety; Mental Health

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INTRODUCTION

Depression is the most prevalent psychiatric condition, affecting over 300 million people globally and accounting for approximately 30% of all mental disorders.[1] According to the World Health Organization (WHO), depression is expected to be the leading cause of disability worldwide by 2030.[2] Moreover, depression is associated with high levels of morbidity and mortality, with patients often developing comorbid mental conditions and reporting a lifetime suicide attempt risk of 31%.[3] Depression is also linked to chronic non-psychiatric illnesses, including cardiovascular diseases, chronic metabolic disorders, and cancer.[4]

Anxiety, the second most common psychiatric condition after depression, also causes significant disability.[5] Similar to depression, anxiety often coexists with or exacerbates other medical conditions, including cardiovascular disease, chronic pain, and migraine. However, many cases remain undiagnosed and untreated.[6] Beyond the personal impact, depression and anxiety have profound economic and social consequences, including increased healthcare expenses and financial burdens.[7] The global cost of productivity losses owing to these conditions is estimated to be $1.15 trillion annually, and is expected to triple by 2030.[8]

Pharmacotherapy and psychotherapy are commonly used treatments for these two conditions.[9] However, they often produce only modest effects, with approximately one-third of patients with depression not responding to these treatments.[10] In this context, physical activity is a valuable alternative owing to its effectiveness, safety, and accessibility.[11] Exercise interventions are particularly promising for alleviating depressive and anxiety symptoms, as they avoid the adverse effects and high costs associated with antidepressant medications and psychotherapy.[12,13]

Previous studies have shown the positive effects of various forms of exercise, particularly aerobic exercise (AE) and resistance exercise (RE), on mood and anxiety regulation.[9,14] AE is believed to influence neurobiological processes, such as neuroplasticity and inflammatory responses.[14] By contrast, RE exerts additional benefits through mechanisms such as the hypothalamic-pituitary-adrenal (HPA) axis modulation and myokine release (e.g., brain-derived neurotrophic factor, irisin), as well as through improvements in self-esteem, social connectedness, and physical function.[15-17]

However, considerable inconsistency remains in the literature regarding the comparative effectiveness of different exercise modalities.[18] While some studies suggest combining AE and RE (i.e., total exercise; TE) to yield synergistic effects, others report no added benefit over either modality alone; some even suggest that RE may outperform TE in specific populations.[12,19-21] The diversity of study populations, variations in sample sizes, exercise intensity, and differing outcome measures further limit comparability and hinder robust conclusions.

In Korean populations, existing research has primarily examined the associations between general physical activity levels and mental health outcomes; the individual or combined effects of AE and RE have not been clearly distinguished. For example, previous Korean studies have evaluated the association between energy expenditure and depression or physical activity and chronic illness, but have not conducted head-to-head comparisons between exercise types.[22-24]

To fill this gap, the present study directly compares the effects of TE, AE, and RE on depression and anxiety using a large, nationally representative Korean sample with rigorous propensity score matching (PSM). This approach provides novel insights into the comparative effectiveness of different exercise modalities for mental health in the Korean context and offers empirical evidence to support the development of evidence-based public health interventions.

METHODS

Study design

This study analyzed data from the Korean National Health and Nutrition Examination Survey (KNHANES) for Patient Health Questionnaire-9 (PHQ-9) scores (2014, 2016, 2018, 2020, and 2022) and Generalized Anxiety Disorder-7 (GAD-7) scores (2021 and 2022). Administered by the Korean Ministry of Health and Welfare, the KNHANES targets noninstitutionalized Korean residents using a multistage clustered probability design. The survey questions were formulated by the Korea Institute for Health and Social Affairs and the Korea Disease Control and Prevention Agency (KDCA), with ethical approval. Detailed information about KNHANES is available on their website: https://knhanes.cdc.go.kr/knhanes/eng. A previous study by the same group applied a similar methodology to examine cardiometabolic outcomes using KNHANES data (Kim et al.,[25] BMC Public Health, 2024). The current study addresses a distinct research question focused on mental health (PHQ-9 and GAD-7) using a different time frame and outcome measures.[26]

Participants

This study included Korean adults aged ≥ 19 years. Regarding the PHQ-9 scores, 30,302 adults participated in surveys conducted in 2014, 2016, 2018, 2020, and 2022. The exclusion criteria included unavailable PHQ-9 scores (n = 224), missing exercise questionnaire responses (n = 3,329), or missing laboratory data (n = 5,451), resulting in a final analysis cohort of 21,298 eligible participants (**Fig. 1A**). Regarding the GAD-7 scores, 11,274 adults participated in a health interview survey conducted between 2021 and 2022. The exclusion criteria included lack of GAD-7 scores (n = 36), missing exercise questionnaire data (n = 1,101), or missing laboratory data (n = 1,430), resulting in a final analysis group of 8,707 eligible participants (**Fig. 1B**).

Data collection

Self-report questionnaires were used to collect demographic, socioeconomic, and lifestyle data. Educational attainment was categorized into four categories: less than elementary school, middle school, high school, and college or higher. Household income levels were assessed using standardized metrics stratified by sex and 5-year age intervals, and benchmarked against national income standards for the Korean population. Monthly income was adjusted for household size by dividing the total household income by the square root of the number of household members and then categorized into quartiles. Smoking history was classified into three groups: never smokers (those who had never smoked or had smoked less than five packs and were not currently smoking), former smokers (those with history of smoking more than five packs but who had since quit), and current smokers (those who currently smoke). Participants who reported consuming alcohol at least once per month were categorized as current drinkers.

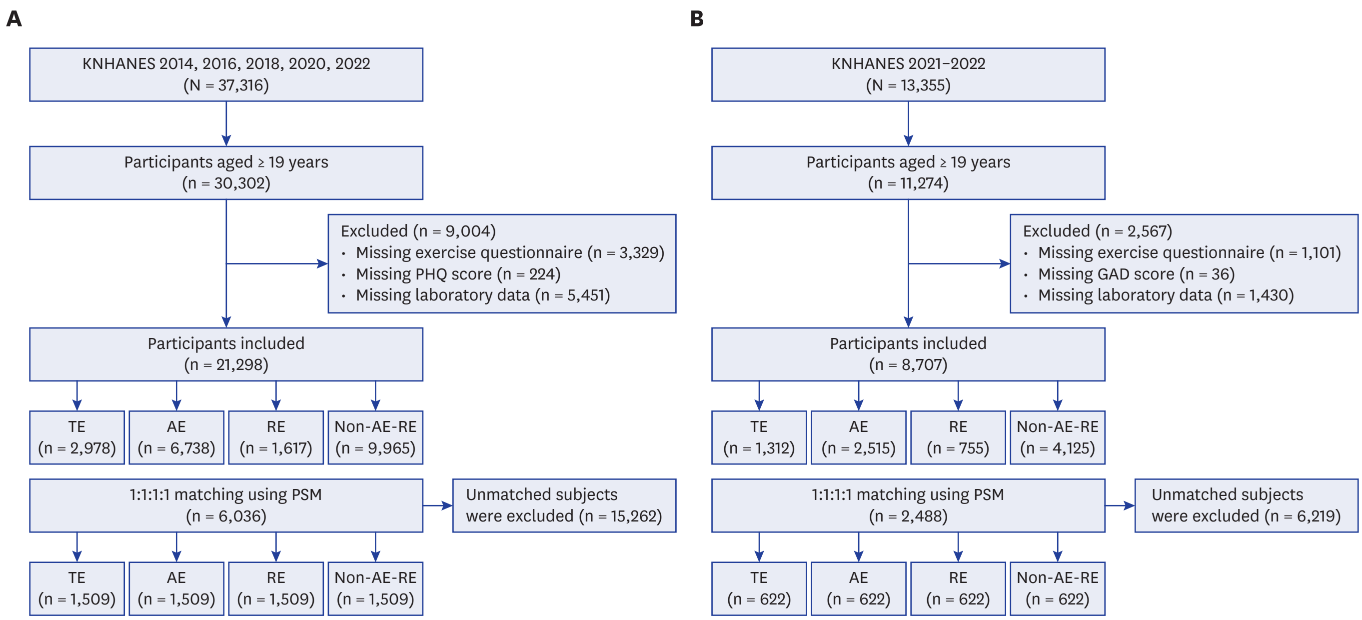

Fig. 1. Flowchart of the study population. (**A**) The 2014, 2016, 2018, 2020, and 2022 KNHANES used for PHQ-9 scores. (**B**) The 2021 and 2022 KNHANES for the GAD-7 score data.
KNHANES = Korean National Health and Nutrition Examination Survey, PHQ = Patient Health Questionnaire, TE = total exercise, AE = aerobic exercise, RE = resistance exercise, PSM = propensity score matching, GAD = Generalized Anxiety Disorder.

Classification of physical activity (TE, RE, AE, and non-AE-RE)

Physical activity levels were evaluated using the World Health Organization's Global Physical Activity Questionnaire (GPAQ), consisting of 16 items covering three domains: occupational, transportation, and recreational domains. The Korean version of the GPAQ used in this study has been validated for reliability in national surveys.[27]

Aerobic physical activity (AE) was operationally defined in accordance with the WHO guidelines as achieving at least 600 MET-min per week, which corresponds to a minimum of 150 minutes of moderate-intensity or 75 minutes of vigorous-intensity aerobic activity per week.[25] In line with the analytic method applied in prior Korean studies using KNHANES data, we set the AE threshold at 1,200 MET-min per week, accounting for more conservative classification of sufficient activity.[26]

RE was defined as engaging in moderate-to-high-intensity muscle-strengthening activities at least two days per week, based on responses to the leisure-time physical activity domain of the GPAQ. Participants were categorized into four mutually exclusive groups: TE group (met both AE and RE criteria), AE group (met AE criteria only), RE group (met RE criteria only), and non-AE-RE group (met neither AE nor RE criteria).

PHQ-9 and GAD-7 measurements

PHQ-9 and GAD-7 scores were collected using self-reported questionnaires. The PHQ-9 consists of nine questions related to depression, with respondents reporting their symptoms over the past two weeks. In this study, a score of 10 or higher, indicating a moderate level of depression, was used as the threshold for categorizing groups.[28] The GAD-7 comprises seven questions related to anxiety, with respondents reporting their symptoms over the past two weeks. A score of 10 or higher, indicating a moderate level of anxiety, was used as the threshold for categorization.[29]

Anthropometric and laboratory measurements

Blood pressure was measured in a seated position; the average of the final two readings was used to calculate systolic and diastolic blood pressures, with mean arterial pressure calculated as Diastolic Blood Pressure + 1/3(Systolic Blood Pressure − Diastolic Blood Pressure). Participants' body weight and height were measured to the nearest 0.1 kg and 0.001 m, respectively, and the body mass index (BMI) was derived as weight divided by height squared (kg/m^2). Obesity classification followed the Asia-Pacific criteria, while abdominal obesity defined based on the Korean-specific criteria (waist circumference [WC] ≥ 90 cm for men and ≥ 85 cm for women).[30]

Blood samples were collected after at least eight hours fast. Biochemical analyses included fasting glucose, lipid profiles (total cholesterol, triglycerides, high-density lipoprotein cholesterol [HDL-C], low-density lipoprotein cholesterol), liver enzymes (aspartate aminotransferase, alanine aminotransferase), insulin and white blood cell count. Insulin resistance was quantified using the homeostasis model assessment-estimated insulin resistance (HOMA-IR) and triglyceride glucose (TyG) indexes. HOMA-IR was calculated as [Fasting Insulin Level (μU/mL)] × Fasting Glucose Level (mg/dL) / 405, while the TyG index was calculated using the natural log of [Fasting Triglyceride Level (mg/dL) × Fasting Glucose Level (mg/dL)/2]. Metabolic syndrome was defined by the presence of ≥ 3 of the following: central obesity, hypertriglyceridemia, reduced HDL-C, elevated blood pressure, or impaired fasting glucose. Hypertension (HTN), diabetes mellitus (DM), and dyslipidemia were identified using standard diagnostic or treatment-based criteria.

Data analysis

Descriptive statistics for the pre-matching data were summarized as mean ± standard error for continuous variables and as prevalence (%) for categorical variables. The analyses incorporated sampling weights to ensure valid population-level estimates under the complex survey design. Group differences in baseline characteristics were assessed using analysis of variance or Student's *t*-test for continuous variables and Pearson's χ^2 test for categorical variables. Propensity score-based exact matching was employed to minimize potential confounding and enhance comparability across groups. To construct a matched sample representing the four groups (TE, AE only, RE only, and non-AE-RE), we adopted a two-step approach. First, the non-AE-RE group was designated as the reference group, and three separate 1:1 exact matchings were conducted between this group and each of the other three groups based on the exact values of age and sex.

Each matched pair was assigned a unique identifier, and only sets with complete matches across all four groups were included in the final analysis. This procedure resulted in a final analytical sample with a 1:1:1:1 matching ratio, ensuring balance in the matched covariates across all groups. Standardized mean differences (SMDs) were used as a diagnostic metric to quantify the balance of covariates achieved through PSM. An SMD value below 0.1 indicates a balanced distribution of data.[31] Multivariate regression analyses were performed to examine differences in PHQ-9 and GAD-7 scores among the physical activity groups, controlling demographic characteristics (age and sex), behavioral factors (alcohol and tobacco use), and socioeconomic indicators (educational attainment and household income). The results are reported as coefficients, 95% confidence intervals (CIs), and *P* values. Anxiety and depression, defined by PHQ-9 and GAD-7 scores ≥ 10, were examined using multiple logistic regression, with results summarized as odds ratios (ORs), 95% CIs, and *P* values. Subgroup analyses were performed according to age and sex. Interaction term tests were conducted by including product terms (exercise × age group; exercise × sex) in the regression models. The statistical significance of the interaction effects was assessed using Wald tests, with a two-sided *P* value < 0.05 considered significant. Analyses were performed separately for binary and continuous outcome variables. Statistical significance was determined as a *P* value less than 0.05. All statistical analyses were performed using R version 4.3.0 (R Foundation for Statistical Computing, Vienna, Austria; http://www.R-project.org/) software.

Ethics statement

The KNHANES was approved by the Institutional Review Board of the KCDC (2018-01-03-P-A, 2018-01-03-C-A, 2018-01-03-2C-A, 2018-01-03-5C-A). Informed consent was obtained from all the participants at the time of enrollment.

RESULTS

Supplementary Table 1 presents the general characteristics of the participants before PSM. For the PHQ-9 analysis, KNHANES data from the years 2014, 2016, 2018, 2020, and 2022 were used. Of the 21,298 individuals, 48.9% were men, with an average age of 47.7 years. For the GAD-7 analysis, the 2021–2022 KNHANES data were used. Of the 8,707 individuals, 49.5% were male, with a mean age of 48.7 years. The participants were categorized into four groups based on their physical activity status in each population cohort. In the population for the PHQ-9 analysis, the non-AE-RE group was the largest (9,965 participants), followed by the AE group (6,738 participants). The TE and RE groups included 2,978 and 1,617 participants, respectively. In the GAD-7 analysis population, the non-AE-RE group was the largest, with 4,125 participants, followed by the AE group, with 2,515 participants. The TE group had 1,312 participants, and the RE group had 755. Significant differences were observed in all socioeconomic and lifestyle variables across the four groups included in the analysis.

Table 1 shows the demographic, metabolic, and psychiatric characteristics according to exercise type after PSM. After matching for the PHQ-9 analysis, the group consisted of 1,509 participants (61.0% male) with an average age of 54.3 years. For the GAD-7 analysis,

Table 1. Clinical characteristics according to exercise type after PSM

Variables	KNHANES 2014, 2016, 2018, 2020, 2022						KNHANES 2021–2022					
	Overall	TE group	AE group	RE group	Non-AE-RE group	*P* value	Overall	TE group	AE group	RE group	Non-AE-RE group	*P* value
Unweighted	6,036	1,509	1,509	1,509	1,509		2,488	622	622	622	622	
Age, yr	54.3 ± 15.7	54.3 ± 15.7	54.3 ± 15.7	54.3 ± 15.7	54.3 ± 15.7	> 0.999	55.9 ± 15.3	55.9 ± 15.3	55.9 ± 15.3	55.9 ± 15.3	55.9 ± 15.3	> 0.999
Sex, %						> 0.999						> 0.999
Male	61.0	61.0	61.0	61.0	61.0		60.6	60.6	60.6	60.6	60.6	
Female	39.0	39.0	39.0	39.0	39.0		39.4	39.4	39.4	39.4	39.4	
Educational status, %						< 0.001**						0.002**
Elementary school	17.5	11.8	18.6	16.3	23.3		15.8	11.3	16.9	15.6	19.3	
Middle school	10.4	9.5	10.0	9.4	12.5		10.0	9.3	10.5	9.0	11.4	
High school	33.9	34.8	33.2	35.7	31.8		34.4	33.9	33.0	36.0	34.7	
College or University	38.2	43.9	38.2	38.6	32.3		39.8	45.5	39.7	39.4	34.6	
Alcohol consumption (yes, %)	57.1	60.4	57.5	55.8	54.7	0.009**	53.5	51.3	56.3	53.7	52.9	0.355
Smoking history, %						< 0.001**						0.049*
No	49.7	51.6	49.8	49.2	48.0		50.0	51.8	51.1	49.0	48.1	
Current	18.6	14.6	19.6	16.4	23.9		15.7	11.9	15.3	16.6	19.0	
Former	31.7	33.8	30.6	34.4	28.0		34.3	36.3	33.6	34.4	33.0	

(continued to the next page)

Table 1. (Continued) Clinical characteristics according to exercise type after PSM

Variables	KNHANES 2014, 2016, 2018, 2020, 2022						KNHANES 2021–2022					
	Overall	TE group	AE group	RE group	Non-AE-RE group	*P* value	Overall	TE group	AE group	RE group	Non-AE-RE group	*P* value
Household income status, %						< 0.001**						< 0.001**
Low	17.0	14.0	19.2	16.0	18.8		17.0	11.4	19.3	18.0	19.3	
Mid-low	24.6	22.9	23.6	23.5	28.4		24.0	24.8	24.9	20.6	25.9	
Mid-high	28.0	27.9	29.5	28.8	25.7		27.3	25.7	27.5	30.2	25.9	
High	30.4	35.1	27.8	31.7	27.1		31.6	38.1	28.3	31.2	28.9	
Body mass index, %						< 0.001**						0.017*
Underweight (< 18.5)	3.0	2.3	2.8	2.8	4.2		3.7	2.1	3.7	4.5	4.3	
Normal (≥ 18.5 and < 25)	60.7	62.6	59.5	63.6	57.3		59.4	63.3	56.4	61.6	56.1	
Obese (≥ 25)	36.2	35.2	37.6	33.5	38.6		37.0	34.6	39.9	33.9	39.5	
WC, cm	84.4 ± 10.0	83.3 ± 9.2	84.9 ± 10.3	84.1 ± 9.9	85.4 ± 10.4	< 0.001**	85.1 ± 10.3	83.7 ± 9.5	85.8 ± 10.5	84.4 ± 10.2	86.4 ± 10.8	< 0.001**
Mean BP, mmHg	90.6 ± 10.7	90.2 ± 10.3	91.1 ± 10.7	90.1 ± 10.9	90.9 ± 10.9	0.022*	90.3 ± 10.6	89.8 ± 10.2	91.1 ± 11.0	89.6 ± 10.7	90.6 ± 10.5	0.038*
Total cholesterol, mg/dL	190.1 ± 39.2	191.4 ± 38.3	189.9 ± 38.9	191.0 ± 39.5	188.2 ± 39.8	0.107	188.9 ± 39.7	191.1 ± 40.2	189.5 ± 37.9	187.1 ± 39.2	188.2 ± 41.5	0.341
TG, mg/dL	137.2 ± 111.5	129.8 ± 106.3	134.8 ± 88.1	133.6 ± 105.3	150.7 ± 139.1	< 0.001**	128.3 ± 94.6	125.5 ± 113.9	128.2 ± 88.4	121.7 ± 74.1	137.6 ± 97.3	0.022*
HDL-cholesterol, mg/dL	51.7 ± 13.4	53.7 ± 14.0	51.6 ± 13.1	51.5 ± 13.6	50.0 ± 12.5	< 0.001**	53.8 ± 14.1	56.1 ± 15.4	53.4 ± 13.2	53.8 ± 13.8	51.7 ± 13.6	< 0.001**
LDL-cholesterol, mg/dL	114.5 ± 34.8	115.1 ± 33.8	114.7 ± 34.6	116.2 ± 35.1	112.3 ± 35.7	0.017*	114.0 ± 35.7	114.0 ± 36.4	114.8 ± 34.5	113.4 ± 35.3	114.0 ± 36.9	0.932
Glucose, mg/dL	102.5 ± 23.3	100.7 ± 20.0	103.5 ± 23.6	101.9 ± 22.7	104.1 ± 26.4	< 0.001**	102.7 ± 20.8	101.5 ± 17.0	103.0 ± 20.5	103.2 ± 23.8	103.2 ± 21.3	0.423
HbA1c, %	5.8 ± 0.8	5.7 ± 0.7	5.8 ± 0.8	5.8 ± 0.8	5.9 ± 0.9	< 0.001**	5.8 ± 0.8	5.7 ± 0.6	5.8 ± 0.8	5.8 ± 0.9	5.8 ± 0.8	0.036*
TyG Index	8.7 ± 0.7	8.6 ± 0.6	8.7 ± 0.6	8.6 ± 0.6	8.7 ± 0.7	< 0.001	8.6 ± 0.6	8.6 ± 0.6	8.6 ± 0.6	8.6 ± 0.6	8.7 ± 0.6	< 0.001**
AST, IU/L	24.5 ± 17.6	25.1 ± 22.7	24.1 ± 12.6	24.7 ± 20.3	24.1 ± 12.6	0.318	25.4 ± 15.5	26.7 ± 21.6	25.2 ± 12.1	24.4 ± 11.9	25.3 ± 14.2	0.066
ALT, IU/L	23.5 ± 18.4	22.8 ± 17.3	23.8 ± 19.6	23.5 ± 19.1	24.0 ± 17.7	0.328	24.4 ± 19.4	24.0 ± 16.0	24.0 ± 16.8	23.4 ± 19.1	26.1 ± 24.6	0.066
WBC, ×10^3/μL	6.2 ± 1.7	6.1 ± 1.7	6.3 ± 1.7	6.1 ± 1.6	6.5 ± 1.9	< 0.001**	6.0 ± 1.6	5.7 ± 1.6	6.0 ± 1.6	6.0 ± 1.6	6.2 ± 1.8	< 0.001**
MetS (yes, %)	28.7	23.3	30.6	27.2	33.7	< 0.001**	27.0	22.7	28.1	27.0	30.2	0.022*
HTN (yes, %)	61.6	60.0	63.8	60.2	62.3	0.112	60.7	55.6	63.8	58.4	64.8	0.002**
DM (yes, %)	48.2	45.1	51.0	47.6	49.2	0.011*	59.6	54.8	61.3	60.3	62.2	0.037*
Dyslipidemia (yes, %)	37.9	35.8	38.6	37.8	39.6	0.178	40.5	38.4	42.0	37.6	44.1	0.070
PHQ-9 score	2.1 ± 3.3	1.8 ± 2.9	2.4 ± 3.6	1.8 ± 2.8	2.5 ± 3.8	< 0.001**	-	-	-	-	-	-
PHQ group (≥ 10)	4.1	2.5	5.0	2.6	6.1	< 0.001**	-	-	-	-	-	-
GAD-7 score	-	-	-	-	-	-	1.8 ± 3.2	1.8 ± 3.2	2.0 ± 3.4	1.6 ± 2.8	2.0 ± 3.4	0.046*
GAD group (≥ 10)	-	-	-	-	-	-	3.8	3.4	4.3	2.7	4.8	0.212

Clinical characteristics from two study populations after PSM: PHQ-9 data were obtained from the 2014, 2016, 2018, 2020, and 2022 KNHANES, while GAD-7 data were obtained from the 2021–2022 KNHANES. All continuous data are presented as means±standard deviation (SD); All categorical data are presented as percentage (%).
PSM = propensity score matching, KNHANES = Korean National Health and Nutrition Examination Survey, TE = total exercise, AE = aerobic exercise, RE = resistance exercise, WC = waist circumference, BP = blood pressure, TG = triglyceride, HDL = high density lipoprotein, LDL = low-density lipoprotein, TyG index = triglyceride and glucose index, AST = aspartate aminotransferase, ALT = alanine aminotransferase, WBC = white blood cell, MetS = metabolic syndrome, HTN = hypertension, DM = diabetes mellitus, PHQ = Patient Health Questionnaire, GAD = Generalized Anxiety Disorder.
Analysis of variance (ANOVA) or Pearson's χ^2 test were used to assess differences across the four groups; *P < 0.05; **P < 0.01.

each group included 622 participants, 60.6% of whom were male, with an average age of 55.9 years. Significant differences in smoking history were observed, with the highest percentage of current smokers in the non-AE-RE group. Household income status also showed significant variation, with the lowest income category being the most prevalent in the non-AE-RE group and the highest income category in the TE group. According to the KNHANES 2021–2022, health indices, including BMI, WC, mean blood pressure, triglyceride levels, HbA1c levels, and the prevalence of HTN and DM, were the lowest in the TE group. Overall, the TE group demonstrated more favorable health outcomes than the other groups.

Table 2. Comparison of PHQ-9 and GAD-7 scores in TE, AE only, RE only and non-AE and RE groups after PSM

Variables	TE group		AE only group		RE only group		Non-AE-RE group		*P* value
	Coefficient (95% CI)	*P* value	Coefficient (95% CI)	*P* value	Coefficient (95% CI)	*P* value	Coefficient (95% CI)	*P* value	
PHQ-9 score	−0.473 (−0.706, −0.241)	< 0.001	0.038 (−0.192, 0.268)	0.746	−0.534 (−0.765, −0.303)	< 0.001	Reference	Reference	< 0.001
GAD-7 score	−0.135 (−0.487, 0.216)	0.450	−0.088 (−0.437, 0.260)	0.619	−0.459 (−0.808, −0.110)	0.010	Reference	Reference	0.055

Regression coefficients for the four physical activity groups after PSM. Both PHQ-9 and GAD-7 scores showed the greatest decrease in the RE-only group. The *P* value represents the significance of coefficients in TE group, AE only group, RE only group compared to non-AE and RE group; the *P* value for the global test to confirm if there is at least one difference among the groups.
PHQ = Patient Health Questionnaire, GAD = Generalized Anxiety Disorder, TE = total exercise, AE = aerobic exercise, RE = resistance exercise, PSM = propensity score matching, CI = confidence interval.

Unlike our previous studies, this study focused specifically on mental health outcomes using PHQ-9 and GAD-7 scores. **Table 2** presents the regression coefficients for the PHQ-9 and GAD-7 scores across the four physical activity groups after PSM. The RE group showed the strongest inverse association with the PHQ-9 scores, followed by the TE group, whereas the AE group showed no statistically significant association. Similarly, RE was significantly associated with lower GAD-7 scores than the non-AE-RE reference group.

Fig. 2 illustrates the ORs for moderate-to-severe depression (PHQ-9 ≥ 10) and anxiety (GAD-7 ≥ 10). Compared with the non-AE-RE group, both the TE (OR, 0.49; 95% CI, 0.33–0.72; $P < 0.001$) and RE (OR, 0.46; 95% CI, 0.31–0.68; $P < 0.001$) groups were significantly associated with lower odds of moderate-to-severe depression. The AE group did not show a statistically significant association (OR, 0.86; $P = 0.372$). For anxiety, the RE group showed a trend toward lower odds (OR, 0.55; $P = 0.057$), but this did not achieve statistical significance.

Fig. 3 shows the comparison of ORs for moderate to severe depression (PHQ-9 ≥ 10) and moderate to severe anxiety (GAD-7 ≥ 10) between the AE and RE groups. The RE group demonstrated a significant reduction in the odds for depression compared with those in the AE group (OR, 0.55; 95% CI, 0.37–0.80; $P = 0.002$). Additionally, while the RE group showed a reduction in the odds for anxiety, this result was not statistically significant (OR, 0.59; 95% CI, 0.32–1.04; $P = 0.074$). These findings are consistent with the regression coefficient comparison between the AE and RE groups (**Supplementary Table 2**).

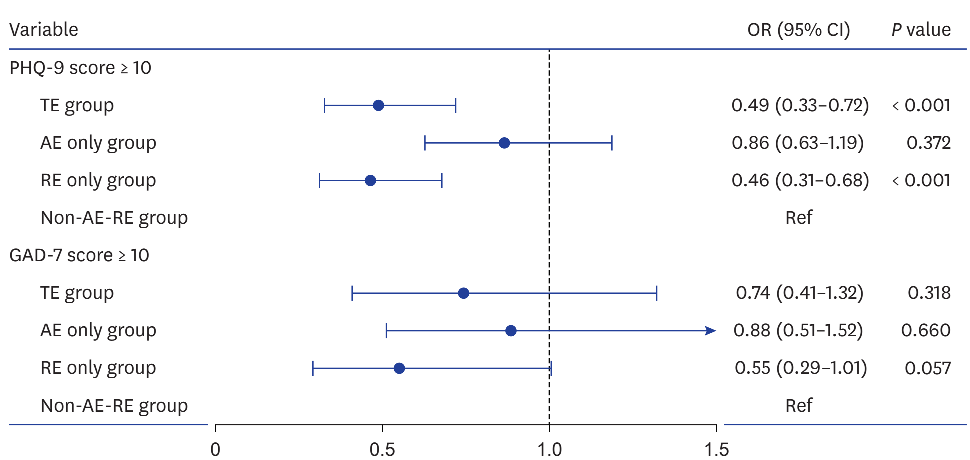

Fig. 2. Comparison of ORs for PHQ-9 scores (≥ 10) and GAD-7 scores (≥ 10) in the TE, AE, RE, and non-AE-RE groups following propensity score matching. Forest plot for comparison between four physical activity groups in the PHQ-9 (PHQ-9 score of 10 or higher) and GAD-7 (GAD-7 score of 10 or higher) scores.
OR = odds ratio, CI = confidence interval, PHQ-9 = Patient Health Questionnaire-9, TE = total exercise, AE = aerobic exercise, RE = resistance exercise, GAD-7 = Generalized Anxiety Disorder-7.

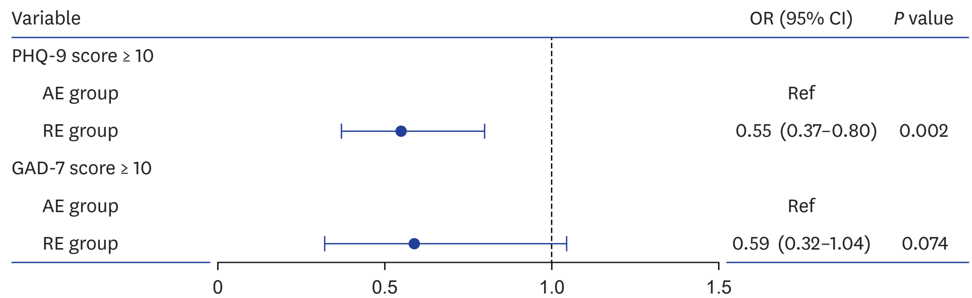

Fig. 3. Comparison of ORs for the PHQ-9 scores (≥ 10) and GAD-7 scores (≥ 10) in the AE and RE groups following propensity score matching. Forest plot for comparison between the AE and RE groups for PHQ-9 scores (PHQ-9 score of 10 or higher) and GAD-7 (GAD-7 score of 10 or higher).
OR = odds ratio, CI = confidence interval, PHQ-9 = Patient Health Questionnaire-9, AE = aerobic exercise, RE = resistance exercise, GAD-7 = Generalized Anxiety Disorder-7.

Supplementary Fig. 1 shows the ORs for moderate-to-severe depression (PHQ-9 score ≥ 10) and anxiety (GAD-7 score ≥ 10) across the four physical activity groups, stratified by age and sex. Among participants aged ≥ 60 years (**Supplementary Fig. 1A**), the RE group had the lowest odds of depression (OR, 0.45; 95% CI, 0.24–0.81; $P = 0.009$), followed by the TE group (OR, 0.54; 95% CI, 0.28–0.97; $P = 0.044$). Among participants aged < 60 years (**Supplementary Fig. 1B**), both the TE (OR, 0.46; 95% CI, 0.28–0.75; $P = 0.003$) and RE groups (OR, 0.46; 95% CI, 0.27–0.75; $P = 0.003$) had the lowest ORs for moderate-to-severe depression. Among male participants (**Supplementary Fig. 1C**), the TE group had the lowest OR for moderate-to-severe depression (OR, 0.47; 95% CI, 0.26–0.82; $P = 0.011$), followed by the RE group (OR, 0.54; 95% CI, 0.31–0.91; $P = 0.024$). For female participants (**Supplementary Fig. 1D**), the RE group had the lowest OR for depression (OR, 0.39; 95% CI, 0.22–0.67; $P < 0.001$), followed by the TE group (OR, 0.49; 95% CI, 0.26–0.82; $P = 0.009$). These findings are in line with the subgroup regression analyses of PHQ-9 and GAD-7 scores (**Supplementary Table 3**).

Supplementary Fig. 2 compares the ORs for moderate-to-severe depression and anxiety between the AE and RE groups, stratified by age and sex. In participants aged ≥ 60 years (**Supplementary Fig. 2A**), RE was significantly associated with lower odds of both depression (OR, 0.51; 95% CI, 0.28–0.87; $P = 0.016$) and anxiety (OR, 0.38; 95% CI, 0.14–0.89; $P = 0.034$) compared with AE. Among participants aged < 60 years (**Supplementary Fig. 2B**), RE was associated with lower odds of depression (OR, 0.56; 95% CI, 0.33–0.94; $P = 0.032$). In male participants (**Supplementary Fig. 2C**), RE was associated with lower odds of depression (OR, 0.56; 95% CI, 0.33–0.95; $P = 0.033$) than AE. Similarly, among female participants (**Supplementary Fig. 2D**), RE was associated with reduced odds of depression (OR, 0.56; 95% CI, 0.31–0.97; $P = 0.043$).

The interaction between the exercise type and age group (≥ 60 vs. < 60 years) was statistically significant for depression, with a P value of 0.006 for the PHQ-9 (≥ 10 vs. < 10), but not for anxiety (GAD-7: $P = 0.921$). In contrast, the interaction was not statistically significant for either the PHQ-9 or GAD-7 scores (PHQ-9: $P = 0.487$; GAD-7: $P = 0.709$). These results indicate that the effect of exercise on the likelihood of clinically relevant depression differs according to age group. The interaction between exercise group and sex was statistically significant only for the PHQ-9 score ($P = 0.017$), but not for the GAD-7 score ($P = 0.533$), or for moderate-to-severe levels of depression ($P = 0.686$) or anxiety ($P = 0.808$). Thus, no consistent evidence was found for the differential effects of exercise by sex.

DISCUSSION

This study examined the associations of TE, AE, and RE with depression and anxiety in a large, nationally representative sample of Koreans using KNHANES data. A key finding of this study was that the RE group was most strongly associated with lower PHQ-9 and GAD-7 scores, and had lower odds of moderate-to-severe depression than the non-AE-RE exercise group. The TE group also had significantly lower overall depression scores than the non-AE-RE group. In contrast, the AE group was not significantly associated with either depression or anxiety scores.

These findings align with the WHO and National Institute for Health and Care Excellence (NICE) guidelines, which recommend exercise as an adjunctive treatment for depression and anxiety.[26,32] This recommendation is supported by meta-analyses that have consistently shown the antidepressant and anxiolytic effects of exercise.[12,33] The positive impact of exercise on mental health may be attributed to various factors, including enhanced physical capabilities, such as improved cardiovascular health and increased muscle strength, and the psychological benefits of improved social interactions.[34]

AE enhances mental health through various physiological mechanisms, including increasing monoamine neurotransmitters, enhancing immune-serotonergic interactions, regulating the HPA axis, and improving heart–brain crosstalk.[35] Additionally, AE reduces inflammation and improves sleep quality, with effects often comparable to those of antidepressant medication.[35] Resistance training positively affects mental health by strengthening the muscle–nervous system connection through consistent overload.[36] This type of exercise also stimulates the release of cytokines and myokines during muscle contraction, which plays a protective role against depression. Furthermore, controlled breathing during resistance training has been shown to enhance mood and alleviate symptoms of anxiety and depression.[37]

While both AE and RE are practical for mild-to-moderate depression, comparing their mental health benefits is challenging because of differing study designs and inconsistent results.[38,39] Some studies, including meta-analyses and Cochrane reviews, suggest that combining aerobic and resistance training is most effective in reducing depressive symptoms and addressing comorbidities.[40,41] However, other studies have indicated that combined exercise is as effective as either type alone, and that AE may have a more favorable antidepressant effect than RE.[42,43] Conversely, a systematic review and meta-analysis by Hart and Buck found that resistance training had the most significant impact on the mental health of older individuals,[18] whereas a meta-analysis by Raymond et al. reported mixed results regarding the relationship between resistance training and overall quality of life.[44]

Our study makes a unique contribution by directly comparing the effects of RE and AE on mental health outcomes. Our findings, which are consistent with several Korean studies, indicate that individuals adhering to the RE guidelines experienced a lower prevalence of depressive symptoms than those who did not engage in RE.[45] The distinguishing feature of our study is the use of a relatively large sample size and PSM, which allowed for a more reliable and robust comparison between AE and RE. Interestingly, our study revealed that RE had a greater impact on mental health than did combined exercise. This finding is consistent with those of several previous studies that showed that mixed aerobic and resistance training had minor effects compared with either aerobic or resistance training alone.[41]

Although the TE group exhibited the most favorable metabolic indicators, including lower BMI, WC, blood pressure, triglycerides, and HbA1c, mental health improvements were more pronounced in the RE group. This discrepancy may reflect the psychological burden and lower adherence associated with complex or high-intensity regimens, as previously reported.[46,47] Physiologically, TE's favorable metabolic profile may be associated with mental health benefits through mechanisms such as improved insulin sensitivity, reduced HOMA-IR, and lower levels of inflammatory markers, including tumor necrosis factor alpha and C-reactive protein.[48,49] These processes are indirectly linked to mental health by modulating neuroinflammation, neurotransmitter function, and HPA-axis regulation.[50,51] Resistance training also contributes to metabolic regulation via increased glucose transporter type 4-mediated glucose uptake and reductions in visceral adiposity.[52,53] Despite these biological pathways, our results showed that RE had a stronger and more consistent association with lower depression and anxiety scores than did TE. These findings suggest that while TE may offer cardiometabolic advantages, RE may provide more accessible and sustainable mental health benefits in real-world settings. However, further research is needed to clarify the relative contributions of metabolic and psychosocial mechanisms in explaining these associations.

The significant impact of RE observed in our study may reflect the distinct characteristics of Korean lifestyle patterns and exercise behaviors. The 2024 Korean Exercise Awareness Survey showed that a majority of Koreans preferred AE (72%) over anaerobic forms (28%) and favored light-intensity activities (67%) over high-intensity ones, regardless of age or sex.[54] These preferences contribute to lower engagement in resistance training and reduced muscle mass in the general population, especially among women and older adults, who are also at greater risk of depression. This pattern may stem not only from individual preferences, but also from structural and cultural barriers, such as limited access to resistance training facilities in residential environments and time constraints resulting from long working hours.[55,56]

Furthermore, Korea ranks among the highest in average daily sedentary time among OECD countries, with many adults spending over 8 hours per day sitting.[57] This sedentary lifestyle, combined with low participation in muscle-strengthening activities, may exacerbate muscle deconditioning, a factor known to be associated with depression and anxiety.[38,58]

In this context, RE may yield particularly strong mental health benefits in Korean adults by directly addressing these behavioral and environmental risk factors. It improves muscle strength and physical function while promoting psychological resilience through both biological and behavioral mechanisms. Incorporating RE into national physical activity strategies may provide a targeted approach to simultaneously reduce physical inactivity and support mental well-being in this population.

The absence of a significant association between AE and depression or anxiety in our study may be attributable to several factors. The intensity or duration of aerobic activities reported by participants may have been insufficient to elicit mental health benefits, as prior intervention studies suggest that a minimum threshold of moderate-to-vigorous intensity and volume is necessary to observe antidepressant effects.[59] Additionally, the predominance of light-intensity aerobic activities, such as walking, in general population surveys, such as the KNHANES, may contribute to the weaker association.

Subgroup analysis by sex and age showed that RE was more consistently associated with lower depression and anxiety scores across groups across all demographic groups, with its effectiveness being particularly pronounced compared with that of AE. Notably, RE was especially beneficial for women and older adults. This may be due to existing physical activity trends, as men and younger adults (19–29 years) are more likely to meet the aerobic and muscle-strengthening guidelines than those aged 70 and above.[57] Consequently, women and older adults may have more room for improvement and thus experience more pronounced benefits from RE.

The limitations of this study include its cross-sectional design, which precludes any causal inference. It is therefore not possible to determine whether specific types of exercise lead to reductions in depression and anxiety or whether individuals with better mental health are more likely to engage in resistance or combined forms of exercise. The use of self-reported physical activity data also introduces potential recall bias and misclassification, particularly regarding the duration and intensity of exercise. Additionally, due to data constraints, we were unable to control for current or past treatment for depression or anxiety, including pharmacological interventions. Finally, our findings are specific to a single ethnic group, which limits their generalizability to other populations. Future research, particularly longitudinal or interventional studies in more diverse populations, is needed to validate and expand these findings.

Nonetheless, the strengths of this study include its large, nationally representative sample, which highlights the effects of resistance training on overall and severe depression and anxiety, with analyses stratified by sex and age. Furthermore, the use of 1:1 PSM reduced selection bias and confounding variables, providing robust results that are particularly valuable when randomized controlled trials are not feasible.

The results of this study suggest that RE is significantly associated with lower depression and anxiety levels among Koreans, although causality cannot be inferred due to the cross-sectional design. Clinically, this highlights the importance of incorporating resistance training into exercise prescriptions for patients with depression or anxiety. Given the Korean lifestyle and cultural characteristics, this study highlights the importance of tailored exercise programs in improving mental health outcomes and offers practical evidence for public health interventions.

SUPPLEMENTARY MATERIALS

Supplementary Table 1
Clinical characteristics according to exercise type before PSM.

Supplementary Table 2
Comparison of PHQ-9 and GAD-7 scores in AE only group and RE only group after PSM.

Supplementary Table 3
Comparison of PHQ-9 and GAD-7 scores in TE, AE only, RE only and Non-AE and RE groups with different sex and age group.

Supplementary Fig. 1
Odds ratios (ORs) for moderate to severe depression (PHQ-9 ≥ 10) and anxiety (GAD-7 ≥ 10) across four physical activity types, stratified as follows: (**A**) ≥ Age 60, (**B**) < Age 60, (**C**) Male, and (**D**) Female.

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Supplementary Fig. 2

Odds ratios (ORs) for moderate to severe depression (PHQ-9 ≥ 10) and anxiety (GAD-7 ≥ 10) comparing RE and AE groups, stratified as follows: (**A**) ≥ Age 60, (**B**) < Age 60, (**C**) Male, and (**D**) Female.

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