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Association Between Aerobic and Muscle-Strengthening Activities and Health-Related Quality of Life in Patients with Neck Pain: The National Health and Nutrition Examination Survey 2001–2004

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Purpose: Different types of activities have independent and additive benefits for adult health. This study intended to assess the association between aerobic activity and muscle-strengthening activities and health-related quality of life (HRQoL) and physical and mental health in patients with neck pain.

Methods: This cross-sectional study included data on patients with neck pain from the National Health and Nutrition Examination Survey (NHANES) dataset between 2001 and 2004. Weighted logistic regression analyses were applied to estimate the odds ratio (OR) and 95% confidence interval (CI) for the associations between aerobic activity, muscle-strengthening activities, and their combination, and HRQoL, physically unhealthy days (≥14 days/month), and mentally unhealthy days (≥14 days/month). Subgroup analyses were performed according to age, gender, and screen time.

Results: A total of 794 patients with neck pain were included, of whom 504 had good HRQoL and 290 had poor HRQoL. Aerobic activity (OR=0.35, 95% CI: 0.21–0.57) and muscle-strengthening activities (OR=0.50, 95% CI: 0.26–0.98) were associated with good HRQoL in patients with neck pain, but only aerobic activity (OR=0.42, 95% CI: 0.28–0.63) was linked to shorter physical unhealthy days. No associations were found between aerobic activity, muscle-strengthening activities, and mentally unhealthy days (P>0.05). The trends for the combined result of aerobic activity and muscle-strengthening activities on HRQoL, physically unhealthy days, and mentally unhealthy days were significant (P_{trend}<0.001). Subgroup analyses found that the combined result of aerobic and muscle-strengthening activities was only more significant on HRQoL in patients aged <60 years or ≥60 years, males or females, and patients with screen time <3 hours or ≥3 hours (P_{trend}<0.05).

Conclusion: Aerobic and muscle-strengthening activities were associated with good prognosis in patients with neck pain, but the effect of aerobic activity may be more pronounced.

Keywords: neck pain, health-related quality of life, aerobic activity, muscle-strengthening activities, combined result

Introduction

Neck pain is a common condition that causes considerable pain and financial costs and is one of the major causes of disability worldwide.[1,2] The global incidence of neck pain is reported to be 806.6 per 100,000 population and 352.0 per 100,000 population with a disability due to neck pain.[3] Risk factors for neck pain include psychopathology (eg, depression), genetics, smoking, obesity, sedentary lifestyle, sleep disorders, trauma, and poor general health.[1,4,5] Sports and work injuries are also linked to neck pain.[6] Patients with shorter neck pain durations had a better prognosis than those with prolonged neck pain.[7,8]

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Several studies have reported the benefits of physical activity for back or neck pain.[9–11] A meta-analysis demonstrated that strengthening the neck, shoulder and scapular muscles may be effective in reducing neck pain and disability in office workers,[9] but its effect on health-related quality of life (HRQoL) in patients with neck pain remains unclear. HRQoL is a multi-dimensional structure covering physical, mental, and social health that can provide a holistic understanding of the subjective disease burden associated with an individual's health and help improve overall disease management.[10,11] Aerobic and muscle-strengthening activities have been reported to improve HRQoL in patients with back pain,[12,13] but there is limited research evidence for patients with neck pain. Epidemiologic evidence suggests that each activity type has independent and cumulative health benefits in adults.[14,15] Meeting two guideline activities was associated with a lower risk of all-cause mortality in adults compared with meeting only one guideline activity.[16,17] Aerobic activity combined with neck stretching activities improved the work ability index in patients with neck pain more than neck stretching activities alone.[18] Muscle-strengthening activities combined with aerobic activity were found to be more beneficial in reducing the risk of comorbidity and depression in the general population.[19,20] Moreover, the proportion of people who reported meeting both the guidelines' recommended muscle-strengthening activities and aerobic activity requirements remains low.[21,22] However, the effects of aerobic activity, muscle-strengthening activities, and their combination on HRQoL as well as physical health and mental health in patients with neck pain remain unclear. Thus, this study intended to assess the association between aerobic activity and muscle-strengthening activities and HRQoL and physical and mental health in patients with neck pain.

Methods

Study Design and Participants

This cross-sectional study collected data from the National Health and Nutrition Examination Survey (NHANES) dataset between 2001 and 2004. NHANES is a cross-sectional survey of the health and nutrition of the United States population conducted by the National Center for Health Statistics (NCHS). The NHANES survey uses a complex multi-stage probability sampling design to obtain the survey sample, with a survey cycle every two years (https://www.cdc.gov/nchs/nhanes/index.htm). The NHANES survey format consists of interviews and physical examinations that are used to collect demographic, socioeconomic, dietary, health-related, medical, physiologic measurements, and laboratory test data from participants. Because complete data on neck pain, aerobic activity, muscle-strengthening activities, and HRQoL were only available for the 2001–2002 and 2003–2004 survey cycles, only data from the 2001–2004 NHANES dataset were analyzed for this study. Participants who met the following criteria were included: (1) aged ≥18 years; (2) diagnosed with neck pain; (3) with complete information on aerobic activity and muscle-strengthening activities; (4) with information on HRQoL; and (5) with information on screen time. The exclusion criteria were as follows: (1) pregnant; (2) with cancer or malignancy; and (3) with missing information on pain duration. This study was approved by the Institutional Review Board of The Third Affiliated Hospital of Zhengzhou University (No. 2024-276-01). The need for written informed consent was waived by the Institutional Review Board of The Third Affiliated Hospital of Zhengzhou University due to the retrospective nature of the study. This study was conducted in accordance with the Declaration of Helsinki and clinical practice guidelines.

Outcomes

The primary outcome was HRQoL in patients with neck pain, and the secondary outcomes were physically unhealthy days and mentally unhealthy days. Patients with neck pain were determined by a question on the NHANES questionnaire "During the past 3 months, did you have neck pain?. (Please refer to pain that lasted a whole day or more. Do not report aches and pains that were fleeting or minor)". Participants who answered "yes" to this question were considered to have neck pain. Participants' HRQoL, physical health, and mental health were measured by self-perception through questionnaires. HRQoL was measured by the question "Would you say your health in general is excellent, very good, good, fair, or poor". Participants who replied "excellent, very good, or good" were considered to have good HRQoL, and those who answered "fair or poor" were considered to have poor HRQoL.[23] Physical health and mental health were measured by the number of days reported through the following questions "Thinking about your physical health, which includes

physical illness and injury, for how many days during the past 30 days was your physical health not good?" and "Now thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?", respectively. Participants were considered to have good (<14 days/month) or poor (≥14 days/month) physical health and mental health based on the number of days they reported.[23]

Measurement of Aerobic Activity and Muscle-Strengthening Activities

Aerobic activity was measured through "vigorous activity" and "moderate activity" questionnaire questions. Vigorous activity was measured by the question

> Over the past 30 days, did you do any vigorous activities for at least 10 minutes that caused heavy sweating, or large increases in breathing or heart rate? Some examples are running, lap swimming, aerobics classes or fast bicycling.

Moderate activity was measured by the question

> Over the past 30 days, did you do moderate activities for at least 10 minutes that cause only light sweating or a slight to moderate increase in breathing or heart rate? Some examples are brisk walking, bicycling for pleasure, golf, and dancing.

Participants who answered "yes" to either the "vigorous activity" or "moderate activity" questions were considered to have engaged in aerobic activity.

Muscle-strengthening activities were measured by the question

> Over the past 30 days, did you do any physical activities specifically designed to strengthen your muscles such as lifting weights, push-ups or sit-ups? Include all such activities even if you have mentioned them before.

Participants who replied "yes" to this question were considered to have engaged in muscle-strengthening activities.

Covariates

Age, gender (female, male), race/ethnicity (Mexican American, Non-Hispanic White, Non-Hispanic Black, other race), family poverty-to-income ratio (PIR) (<3.5, ≥3.5), marital status (married, unmarried), smoking (non-smoker, former smoker, current smoker), drinking (no, yes), screen time (<3, ≥3 hours), pain duration (less than 3 months, more than 3 months), pain of other site (no, yes), chronic kidney disease (CKD) (no, yes), osteoporosis (no, yes), arthritis (no, yes), hypertension (no, yes), cardiovascular disease (CVD) (no, yes), dyslipidemia (no, yes), diabetes (no, yes), chronic bronchitis (no, yes), body mass index (BMI) (<25kg/m^2, ≥25kg/m^2), C-reactive protein, analgesics (no, yes), antidepressant (no, yes), and glucocorticoids (no, yes) were collected and considered as potential confounders. CKD was determined by urine albumin to creatinine ratio ≥ 30 mg/g or an estimated glomerular filtration rate (eGFR) ≤ 60 mL/min/m^2.[24] Osteoporosis and arthritis were identified by NHANES questionnaire questions. Hypertension, CVD, dyslipidemia, and diabetes were determined through NHANES questionnaire questions or biochemical diagnostic indicators or the use of related medications.

Statistical Analysis

Due to the complex multi-stage probability sampling design of the NHANES survey, the weighted variables in NHANES (SDMVSTRA, SDMVPSU, WTINT2YR) were applied in the analysis. Continuous variables were expressed as mean and standard error (S.E)., and categorical variables were reported as numbers and percentages [n (%)]. The independent samples *t*-test was utilized to compare differences in continuous variables, and the chi-square test or Fisher's exact test was used to compare differences in categorical variables.

Only a few covariates had missing values, the covariate with the largest percentage of missing values was C-reactive protein (3.15%), and missing values for covariates were imputed using the multiple imputation method. Weighted univariable logistic regression analysis was applied to screen for confounders associated with HRQoL, physically unhealthy days, and mentally unhealthy days, respectively (Supplement Table 1). Covariates with P<0.05 in univariable logistic regression analysis were adjusted as confounders in multivariable logistic regression analysis. Variance inflation factor (VIF) was applied to assess potential multicollinearity between confounders, with VIF ≥ 10 considered to be

multicollinear (Supplement Table 2). Weighted univariable and multivariable logistic regression analyses were used to estimate the odds ratio (OR) and 95% confidence interval (CI) for the relationship between aerobic activity and muscle-strengthening activities and HRQoL, physically unhealthy days, and mentally unhealthy days. To examine the combined result of aerobic activity and muscle-strengthening activity on HRQoL, physically unhealthy days, and mentally unhealthy days, patients were divided into four groups (neither aerobic nor muscle-strengthening activities group, aerobic activity only group, muscle-strengthening activities only group, both aerobic and muscle-strengthening activities group). In addition, subgroup analyses were performed according to age (<60 years, ≥60 years), gender (male, female), and screen time (<3 hours, ≥3 hours). Statistical analyses were conducted using SAS 9.4 software (SAS Institute Inc., Cary, NC, USA), and forest mapping was done using R version 4.3.2 software (Institute for Statistics and Mathematics, Vienna, Austria). A P-value of <0.05 (two-sided) was considered statistically significant.

Results

Characteristics of Patients

In the 2001–2004 NHNAES survey, data were collected from 21,161 participants. After screening, 794 eligible patients with neck pain were included in the analysis (Figure 1). Of these 794 patients, 504 had good HRQoL and 290 had poor HRQoL. The characteristics of these patients were shown in Table 1. The mean (S.E) age was 45.58 (0.74) years. There were 440 (56.88%) females, 532 (63.73%) patients with a BMI ≥25 kg/m^2, and 619 (72.47%) patients with screen time ≥3 hours. The number of patients with pain duration of less than 3 months and more than 3 months were 476 (60.05%) and 318 (39.95%), respectively. There were 443 (63.37%) patients engaged in aerobic activity, 195 (28.76%) patients

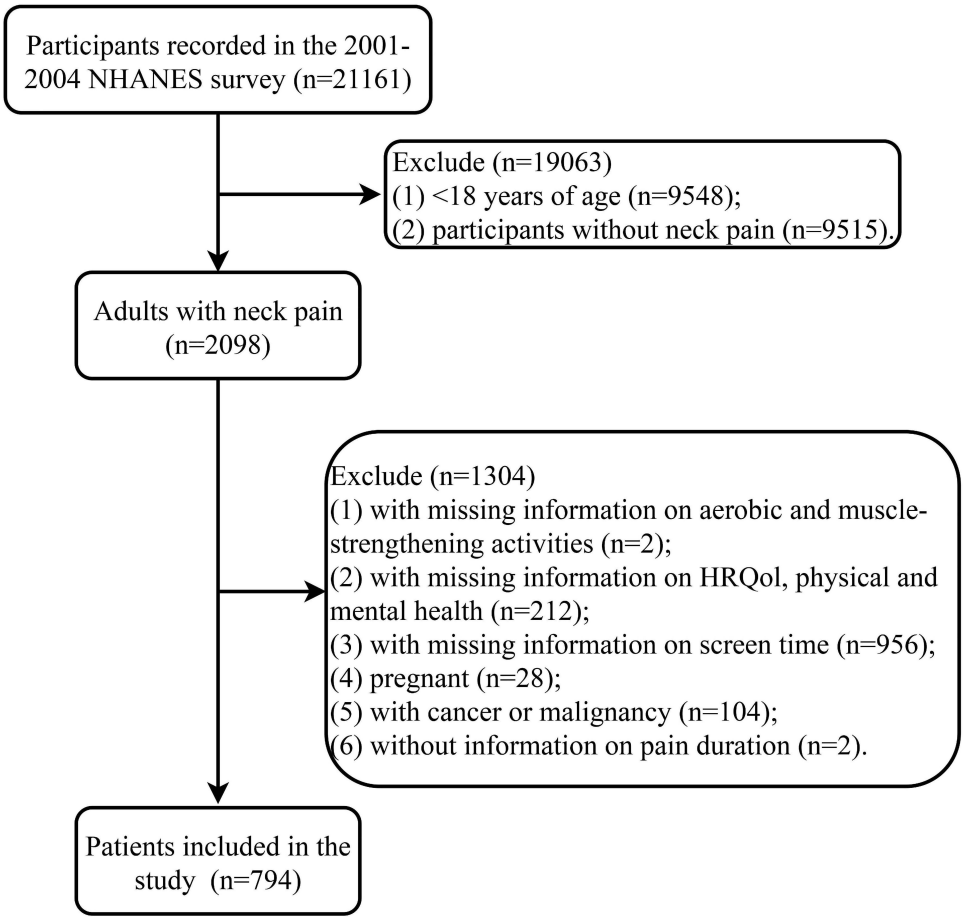

Figure 1 Screening flowchart for the study population. NHANES, the National Health and Nutrition Examination Survey database; HRQoL, health-related quality of life.

Table 1 Characteristics of Patients with Neck Pain

Variables	Total (n=794)	Health-Related Quality of Life		*P*
		Good (n=504)	Poor (n=290)	
Age, years, Mean (S.E)	45.58 (0.74)	43.61 (0.84)	51.12 (0.74)	<0.001
Gender, n (%)				0.073
Female	440 (56.88)	260 (54.45)	180 (63.71)	
Male	354 (43.12)	244 (45.55)	110 (36.29)	
Race/Ethnicity, n (%)				0.001
Mexican American	150 (6.24)	71 (4.99)	79 (9.75)	
Non-Hispanic White	447 (76.67)	315 (79.51)	132 (68.66)	
Non-Hispanic Black	143 (9.47)	81 (7.57)	62 (14.83)	
Other Race	54 (7.62)	37 (7.92)	17 (6.76)	
PIR, n (%)				<0.001
<3.5	556 (61.62)	310 (53.77)	246 (83.69)	
≥3.5	238 (38.38)	194 (46.23)	44 (16.31)	
Marital status, n (%)				<0.001
Married	475 (64.06)	322 (67.83)	153 (53.47)	
Unmarried	319 (35.94)	182 (32.17)	137 (46.53)	
Smoking, n (%)				<0.001
Non-smoker	359 (44.28)	242 (48.24)	117 (33.14)	
Former smoker	208 (24.60)	124 (24.00)	84 (26.31)	
Current smoker	227 (31.12)	138 (27.76)	89 (40.55)	
Drinking, n (%)				0.280
No	116 (11.29)	64 (10.56)	52 (13.36)	
Yes	678 (88.71)	440 (89.44)	238 (86.64)	
Aerobic activity, n (%)				<0.001
No	351 (36.63)	168 (28.36)	183 (59.85)	
Yes	443 (63.37)	336 (71.64)	107 (40.15)	
Muscle-strengthening activities, n (%)				<0.001
No	599 (71.24)	352 (67.12)	247 (82.81)	
Yes	195 (28.76)	152 (32.88)	43 (17.19)	
Aerobic and muscle-strengthening activities, n (%)				<0.001
Neither nor	318 (32.83)	151 (25.09)	167 (54.57)	
Muscle-strengthen activities only	33 (3.80)	17 (3.27)	16 (5.28)	
Aerobic activity only	281 (38.41)	201 (42.03)	80 (28.24)	
Both	162 (24.96)	135 (29.61)	27 (11.91)	
Screen time, n (%)				<0.001
<3 hours	175 (27.53)	135 (30.86)	40 (18.19)	
≥3 hours	619 (72.47)	369 (69.14)	250 (81.81)	
Pain duration, n (%)				<0.001
Less than 3 months	476 (60.05)	330 (65.66)	146 (44.28)	
More than 3 months	318 (39.95)	174 (34.34)	144 (55.72)	
Pain of another site, n (%)				<0.001
No	144 (17.92)	106 (20.63)	38 (10.30)	
Yes	650 (82.08)	398 (79.37)	252 (89.70)	
Osteoporosis n (%)				<0.001
No	707 (91.61)	466 (94.11)	241 (84.59)	
Yes	87 (8.39)	38 (5.89)	49 (15.41)	
Arthritis, n (%)				0.001
No	450 (62.03)	320 (67.42)	130 (46.90)	
Yes	344 (37.97)	184 (32.58)	160 (53.10)	

(*Continued*)

Table 1 (Continued).

Variables	Total (n=794)	Health-Related Quality of Life		*P*
		Good (n=504)	Poor (n=290)	
Hypertension, n (%)				<0.001
No	375 (56.14)	281 (61.66)	94 (40.66)	
Yes	419 (43.86)	223 (38.34)	196 (59.34)	
Dyslipidemia, n (%)				0.029
No	194 (26.95)	136 (28.44)	58 (22.74)	
Yes	600 (73.05)	368 (71.56)	232 (77.26)	
Diabetes, n (%)				<0.001
No	671 (89.35)	458 (93.09)	213 (78.83)	
Yes	123 (10.65)	46 (6.91)	77 (21.17)	
CVD, n (%)				<0.001
No	668 (89.88)	458 (94.31)	210 (77.43)	
Yes	126 (10.12)	46 (5.69)	80 (22.57)	
CKD, n (%)				<0.001
No	664 (89.43)	439 (92.34)	225 (81.24)	
Yes	130 (10.57)	65 (7.66)	65 (18.76)	
Chronic bronchitis, n (%)				0.006
No	712 (89.59)	462 (91.88)	250 (83.16)	
Yes	82 (10.41)	42 (8.12)	40 (16.84)	
BMI, n (%)				0.182
<25kg/m^2	262 (36.27)	186 (37.95)	76 (31.55)	
≥25kg/m^2	532 (63.73)	318 (62.05)	214 (68.45)	
C-reactive protein, mg/dL, Mean (S.E)	0.45 (0.03)	0.40 (0.03)	0.59 (0.09)	0.066
Analgesics, n (%)				<0.001
No	554 (70.73)	382 (76.11)	172 (55.62)	
Yes	240 (29.27)	122 (23.89)	118 (44.38)	
Antidepressant, n (%)				0.028
No	665 (81.67)	429 (83.52)	236 (76.50)	
Yes	129 (18.33)	75 (16.48)	54 (23.50)	
Glucocorticoids, n (%)				0.668
No	774 (97.86)	490 (98.00)	284 (97.45)	
Yes	20 (2.14)	14 (2.00)	6 (2.55)	

Abbreviations: PIR, family poverty-to-income ratio; CVD, cardiovascular disease; CKD, chronic kidney disease; BMI, body mass index.

engaged in muscle-strengthening activities, 162 (24.96%) engaged in both aerobic and muscle-strengthening activities, and 318 (32.83%) patients engaged in neither aerobic nor muscle-strengthening activities.

Association Between Aerobic and Muscle-Strengthening Activities and HRQoL and Physically and Mentally Unhealthy Days

The results of aerobic and muscle-strengthening activities on HRQoL and physically and mentally unhealthy days were presented in Table 2. Aerobic activity (OR=0.35, 95% CI: 0.21–0.57) and muscle-strengthening activities (OR=0.50, 95% CI: 0.26–0.98) were associated with good HRQoL in patients with neck pain in multivariable analysis. For physical health, aerobic activity (OR=0.31, 95% CI: 0.22–0.44) and muscle-strengthening activities (OR=0.41, 95% CI: 0.17–0.97) were linked to shorter physically unhealthy days in univariable analysis, but only aerobic activity (OR=0.42, 95% CI: 0.28–0.63) was related to shorter physically unhealthy days in multivariable analysis. In the analysis of mental health, only aerobic activity (OR=0.57, 95% CI: 0.40–0.81) was linked to shorter mentally unhealthy days in univariable analysis, but not in multivariable analysis (*P*=0.089).

Table 2 Effects of Aerobic and Muscle-Strengthening Activities on Health-Related Quality of Life (HRQoL) and Physically and Mentally Unhealthy Days in Patients with Neck Pain

Outcomes	Variables	Model 1		Model 2	
		OR (95% CI)	*P*	OR (95% CI)	*P*
HRQoL (poor)	Muscle-strengthening activities				
	No	Ref		Ref	
	Yes	0.42 (0.27–0.68)	<0.001	0.50 (0.26–0.98)	0.045
	Aerobic activity				
	No	Ref		Ref	
	Yes	0.27 (0.19–0.38)	<0.001	0.35 (0.21–0.57)	<0.001
Physically unhealthy days (≥14 days/month)	Muscle-strengthening activities				
	No	Ref		Ref	
	Yes	0.41 (0.17–0.97)	0.042	0.50 (0.20–1.26)	0.143
	Aerobic activity				
	No	Ref		Ref	
	Yes	0.31 (0.22–0.44)	<0.001	0.42 (0.28–0.63)	<0.001
Mentally unhealthy days (≥14 days/month)	Muscle-strengthening activities				
	No	Ref		Ref	
	Yes	0.76 (0.44–1.30)	0.310	0.96 (0.53–1.75)	0.897
	Aerobic activity				
	No	Ref		Ref	
	Yes	0.57 (0.40–0.81)	0.002	0.72 (0.49–1.05)	0.089

Notes: Model 1 is a univariable logistical regression analysis; Model 2 is a multivariable logistical regression analysis adjusting for (1) HRQoL: age, race/ethnicity, PIR, marital status, smoking, screen time, pain duration, pain of another site, osteoporosis, arthritis, hypertension, diabetes, CVD, CKD, chronic bronchitis, C-reactive protein, analgesics, and antidepressant; (2) physically unhealthy days: age, race/ethnicity, PIR, pain duration, pain of another site, osteoporosis, arthritis, hypertension, diabetes, CVD, CKD, chronic bronchitis, C-reactive protein, analgesics, and antidepressant; (3) mentally unhealthy days: gender, race/ethnicity, PIR, marital status, smoking, pain duration, pain of another site, arthritis, chronic bronchitis, analgesics, and antidepressant.
Abbreviations: OR, odds ratio; CI, confidence interval; Ref, reference.

The combined result of aerobic activity and muscle-strengthening activities on HRQoL, physically unhealthy days, and mentally unhealthy days were listed in Table 3. Aerobic activity only (OR=0.39, 95% CI: 0.24–0.64) and both aerobic and muscle-strengthening activities (OR=0.25, 95% CI: 0.11–0.58) were associated with good HRQoL compared with patients who performed neither aerobic nor muscle-strengthening activities, but not in muscle-strengthening activities only (P=0.540). The trend for the combined result of aerobic activity and muscle-strengthening activities on HRQoL was significant (P_{trend}<0.001). In the analysis of physical health, aerobic activity only (OR=0.45, 95% CI: 0.29–0.72) and both aerobic and muscle-strengthening activities (OR=0.31, 95% CI: 0.12–0.82) (vs neither aerobic nor muscle-strengthening activities) were linked to shorter physically unhealthy days, but not in muscle-strengthening activities only (P=0.386). The trend for the combined result on physically unhealthy days was significant (P_{trend}<0.001). For mental health, aerobic activity only (OR=0.59, 95% CI: 0.42–0.83) (vs neither aerobic nor muscle-strengthening activities) were related to shorter mentally unhealthy days, but not in muscle-strengthening activities only (P=0.058) and both aerobic and muscle-strengthening activities (P=0.553). The trend for the combined result on mentally unhealthy days was significant (P_{trend}<0.001).

Subgroup Analysis of the Result of Aerobic and Muscle-Strengthening Activities on HRQoL and Physically and Mentally Unhealthy Days

The results of aerobic and muscle-strengthening activities on HRQoL and physically and mentally unhealthy days in age, gender, and screen time subgroups were presented in Figure 2. In patients aged <60 years, aerobic activity only and both aerobic and muscle-strengthening activities (vs neither aerobic nor muscle-strengthening activities) were associated with good HRQoL (P<0.05) and shorter physically unhealthy days (P<0.05), but not in mentally unhealthy days (P>0.05). In patients aged ≥60 years, aerobic activity only and both aerobic and muscle-strengthening activities were linked to good

Table 3 Combined Results of Aerobic and Muscle-Strengthening Activities on Health-Related Quality of Life (HRQoL) and Physically and Mentally Unhealthy Days in Patients with Neck Pain

Outcomes	Variables	Model 1		Model 2	
		OR (95% CI)	*P*	OR (95% CI)	*P*
HRQoL	Aerobic and muscle-strengthening activities				
	Neither nor	Ref		Ref	
	Muscle-strengthen activities only	0.74 (0.39–1.41)	0.364	0.78 (0.35–1.74)	0.540
	Aerobic activity only	0.31 (0.21–0.45)	<0.001	0.39 (0.24–0.64)	<0.001
	Both	0.18 (0.10–0.33)	<0.001	0.25 (0.11–0.58)	0.001
	P-Trend	–	<0.001	–	<0.001
Physically unhealthy days (≥14 days/month)	Aerobic and muscle-strengthening activities				
	Neither nor	Ref		Ref	
	Muscle-strengthen activities only	0.56 (0.19–1.66)	0.296	0.55 (0.14–2.11)	0.386
	Aerobic activity only	0.35 (0.25–0.51)	<0.001	0.45 (0.29–0.72)	<0.001
	Both	0.21 (0.08–0.52)	<0.001	0.31 (0.12–0.82)	0.018
	P-Trend	–	<0.001	–	<0.001
Mentally unhealthy days (≥14 days/month)	Aerobic and muscle-strengthening activities				
	Neither nor	Ref		Ref	
	Muscle-strengthen activities only	0.43 (0.19–0.97)	0.041	0.42 (0.17–1.03)	0.058
	Aerobic activity only	0.51 (0.36–0.72)	<0.001	0.59 (0.42–0.83)	0.002
	Both	0.56 (0.31–1.02)	0.057	0.81 (0.41–1.61)	0.553
	P-Trend	–	0.012	–	<0.001

Notes: Model 1 is univariable logistical regression analysis; Model 2 is multivariable logistical regression analysis adjusting for (1) HRQoL: age, race/ethnicity, PIR, marital status, smoking, screen time, pain duration, pain of another site, osteoporosis, arthritis, hypertension, diabetes, CVD, CKD, chronic bronchitis, C-reactive protein, analgesics, and antidepressant; (2) physically unhealthy days: age, race/ethnicity, PIR, pain duration, pain of another site, osteoporosis, arthritis, hypertension, diabetes, CVD, CKD, chronic bronchitis, C-reactive protein, analgesics, and antidepressant; (3) mentally unhealthy days: gender, race/ethnicity, PIR, marital status, smoking, pain duration, pain of another site, arthritis, chronic bronchitis, analgesics, and antidepressant.
Abbreviations: OR, odds ratio; CI, confidence interval; Ref, reference.

HRQoL (P<0.05), but not in physically unhealthy days (P>0.05). In addition, aerobic activity only was linked to shorter mentally unhealthy days in patients aged ≥60 years (P<0.05).

Among males, aerobic activity only and both aerobic and muscle-strengthening activities were associated with good HRQoL (P<0.05), and aerobic activity only was also related to shorter physically unhealthy days and mentally unhealthy days (P<0.05). Among females, aerobic activity only and both aerobic and muscle-strengthening activities were linked to shorter physically unhealthy days (P<0.05), both aerobic and muscle-strengthening activities were related to good HRQoL (P<0.05), and muscle-strengthening activities only were associated with shorter mentally unhealthy days (P<0.05).

In patients with screen time <3 hours, aerobic activity only, muscle-strengthening activities only, and both aerobic and muscle-strengthening activities were linked to good HRQoL (P<0.05), but not in physically unhealthy days and mentally unhealthy days (P>0.05). Among patients with screen time ≥3 hours, aerobic activity only and both aerobic and muscle-strengthening activities were associated with good HRQoL (P<0.05) and shorter physically unhealthy days (P<0.05), and aerobic activity only was also related to shorter mentally unhealthy days (P>0.05).

In addition, we performed interaction analyses of exposure variables (aerobic activity, muscle-strengthening activities) and subgroup variables (age, gender, screen time) on outcomes (HRQoL, physically unhealthy days, mentally unhealthy days) (Supplement Table 3). There was an interaction of aerobic activity (OR=1.49, 95% CI: 1.17–1.90) and muscle-strengthening activities (OR=1.51, 95% CI: 1.11–2.06) with screen time on poor HRQoL in patients with neck pain.

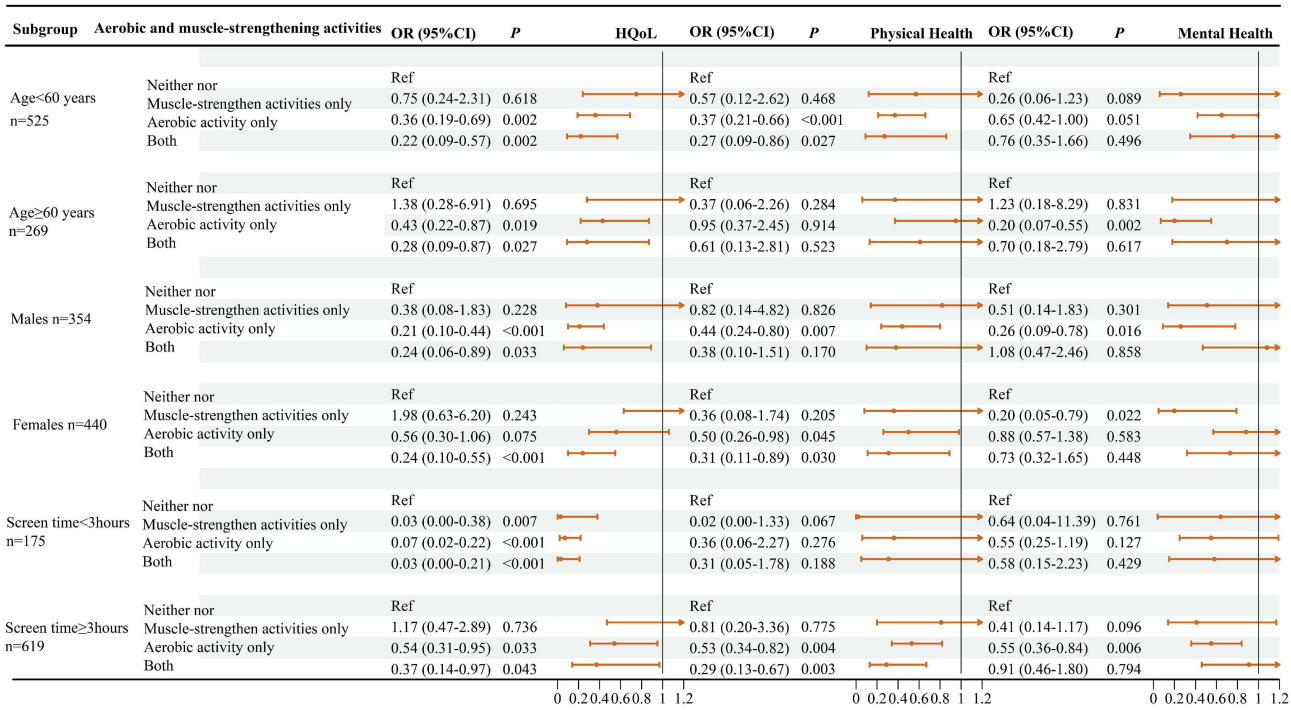

Figure 2 The effects of aerobic and muscle-strengthening activities on health-related quality of life (HRQoL) and physically and mentally unhealthy days in age, gender, and screen time subgroups.

Discussion

The results of aerobic and muscle-strengthening activities on HRQoL and physically and mentally unhealthy days in patients with neck pain were examined in this study. Aerobic activity and muscle-strengthening activities were related to good HRQoL in patients with neck pain, but only aerobic activity was linked to shorter physically unhealthy days. No relationship between aerobic activity and muscle-strengthening activities and mentally unhealthy days was found. In addition, the combined result of aerobic activity and muscle-strengthening activities on HRQoL, physically unhealthy days, and mentally unhealthy days were significant.

Neck pain is one of the leading causes of disability,[8] but there is still a paucity of research related to neck pain. Neck pain can be categorized in a variety of ways, including duration (acute, subacute, chronic), severity, etiology/structure, and type (mechanical, neurologic).[8] A thorough history and physical examination are performed in patients with neck pain to differentiate between neuropathic and mechanical neck pain, as treatment decisions are based on this distinction.[1] Several studies have shown that exercise treatment appears to be beneficial for patients with neck pain.[8,25,26] A study reported that aerobic activity significantly reduced the effects of tension headaches and neck pain.[25] Leisure physical activity has a protective effect on the risk of long duration troublesome neck pain in people without neck pain.[26] According to the World Health Organization, ≥150 min/week of moderate-intensity or ≥75 min/week of vigorous-intensity aerobic physical activity and ≥2 days/week of muscle-strengthening activities are recommended.[27] The current study examined the results of aerobic and muscle-strengthening activities on HRQoL and physically and mentally unhealthy days in patients with neck pain. The results found that aerobic activity and muscle-strengthening activities were associated with good HRQoL in patients with neck pain, but only aerobic activity was related to shorter physically unhealthy days. Physical activity may reduce the risk of neck pain and improve prognosis through increased blood flow and analgesic effects.[28] In addition, one study suggests that physical activity may affect central endogenous pain modulation responses in the brain (eg, frontal lobe).[29]

We also explored the combined result of aerobic activity and muscle-strengthening activities on HRQoL, physically and mentally unhealthy days in patients with neck pain. The trends for the results of muscle-strengthening activities only, aerobic activity only, and both aerobic activity and muscle-strengthening activities (vs neither aerobic nor muscle-

strengthening activities) on HRQoL and physically unhealthy days were significant. Several studies have shown that a combination of aerobic and muscle-strengthening activities is more beneficial to health than activity alone.[21,30,31] Our subgroup analysis found that aerobic activity only and both activities were related to good HRQoL in patients aged <60 years or ≥60 years, but only aerobic activity was associated with shorter physically unhealthy days in patients aged <60 years. This may be related to lower adherence to physical activity among older adults (adults vs older adults: 21.21% vs 13.63%).[21] Although epidemiologic studies have shown that females have lower adherence to a combination of aerobic and muscle-strengthening activities compared to males,[32,33] we found that aerobic activity combined with muscle-strengthening activities was linked to good HRQoL in both males and females. In addition, sedentary behavior, particularly screen time, was strongly associated with the risk of neck pain and HRQoL in the general population.[34,35] Our findings suggested that aerobic activity only, muscle-strengthening activities only, and both activities were more significantly related to HRQoL in patients with screen time <3 hours. Kim et al found that both increasing physical activity and decreasing the duration of sedentary behaviors were associated with better HRQoL in the general population.[23]

The current study was the first to examine the results of aerobic activity, muscle-strengthening activities, and their combination on HRQoL in patients with neck pain. Moreover, the combined result of aerobic activity and muscle-strengthening activities on HRQoL in different subgroups of the population were analyzed. Nevertheless, some limitations should be considered when interpreting the findings of this study. First, this cross-sectional study could not draw a causal association, and the result of muscle-strengthening activities combined with aerobic activity on the HRQoL of patients with neck pain needs to be further validated in prospective studies. Second, although this study included many confounders that may affect outcomes, there were still some potential confounders (eg, lifestyle) that could not be included in the study due to database limitations. Third, there were fewer HNAHES survey cycles and participants that met the study requirements, which may have a selection bias in the study population. Fourth, aerobic activity, muscle-strengthening activities, and HRQoL were all measures based on patients' self-perceptions, which may affect the accuracy of the results. Fifth, measures of mental and physical health were based on unhealthy days in the past 30 days, which could lead to recall bias affecting the accuracy of the results. Sixth, we were unable to assess the results of aerobic and muscle-strengthening activities on HRQoL in patients with different types of neck pain due to database limitations.

Aerobic activity and muscle-strengthening activities were linked to good HRQoL, but only aerobic activity was related to shorter physically unhealthy days in patients with neck pain. The combined result of aerobic activity and muscle-strengthening activities on HRQoL, physically unhealthy days, and mentally unhealthy days were significant, but this combined result was more pronounced for HRQoL and physically unhealthy days. The effects of aerobic activity and muscle-strengthening activities on HRQoL in patients with neck pain may require prospective studies for further validation.

Disclosure

The authors report no conflicts of interest in this work.

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