

Associations of Physical Activity and Sleep with Depression, Anxiety, and Loneliness Among U.S. Adults: A Population-Based Cross-Sectional Study

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Received June 8, 2026; Accepted for
publication July 21, 2026; Published
online August 18, 2026, Kans J Med
2026 Jul-Aug; 19:84-101. [https://doi.
org/10.17161/kjm.vol19.25605](https://doi.org/10.17161/kjm.vol19.25605).

Conflict of Interest Disclosure: Samuel
Ofei-Dodoo is the Editor-in-Chief and
Managing Editor for *The Kansas Journal
of Medicine*.

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ABSTRACT

Introduction. Physical activity, strength training, and sleep are important determinants of mental health. The authors of this study examined the associations of these lifestyle behaviors with emotional health outcomes among U.S. adults.

Methods. Authors conducted a cross-sectional analysis of data from the 2024 Health Information National Trends Survey[®] 7, a nationally representative survey of U.S. adults aged ≥ 18 years ($N = 7278$). Outcomes included depression (PHQ-2), anxiety (GAD-2), overall loneliness (PROMIS Social Isolation Short Form), social loneliness, and emotional loneliness. Predictors included moderate-intensity physical activity (≥ 150 min/week), strength training (≥ 2 days/week), and weekday and weekend sleep duration. Survey-weighted logistic and multinomial logistic regression analyses were performed, adjusting for sociodemographic and health-related covariates.

Results. Most respondents screened negative for depression (79.4%) and anxiety (78.4%), and 61.6% reported low loneliness. Most respondents did not meet the recommended levels of moderate-intensity physical activity (56.6%) or strength training (55.4%). In adjusted analyses, meeting strength-training guidelines was associated with lower odds of depression (adjusted odds ratio [aOR], 0.71; 95% confidence interval [CI], 0.53-0.95) and loneliness (aOR, 0.65; 95% CI, 0.43-0.98). Moderate-intensity physical activity was not independently associated with emotional health outcomes. Obtaining the recommended 7-9 hours of weekend sleep was associated with lower odds of depression, anxiety, and loneliness, whereas obtaining the recommended weekday sleep duration was associated with lower social and emotional loneliness.

Conclusions. Strength training and adequate sleep were independently associated with better emotional health among U.S. adults. These findings support muscle-strengthening activities and healthy sleep habits as potential targets for mental health promotion.

INTRODUCTION

Depression, anxiety, and loneliness are prevalent mental health concerns among U.S. adults and are associated with impaired functioning, reduced quality of life, and increased health care utilization.^{1,2} Identifying modifiable lifestyle behaviors that promote psychological well-being is therefore a public health priority.

Physical activity and sleep are well-established behavioral determinants of mental health.¹⁻³ Regular moderate-intensity aerobic activity is associated with a lower risk of depression and anxiety through biological, psychological, and social mechanisms, including enhanced neuroplasticity, reduced inflammation, improved self-efficacy, and greater social engagement.^{1,2,4-13} Resistance training may provide additional mental health benefits, with evidence linking muscle-strengthening activities to reduced depressive symptoms, improved self-efficacy, and greater participation in social and functional activities.^{5,14-20}

Sleep also plays an important role in emotional regulation and psychological functioning. Both insufficient and excessive sleep are associated with poorer mental health, whereas recommended sleep duration is associated with a lower risk of depression and anxiety.^{3,21-31} In addition, inadequate sleep may impair social functioning, contributing to social withdrawal and increased loneliness.²⁶⁻²⁹

These lifestyle behaviors are interconnected. Physical activity can improve sleep quality, whereas adequate sleep may facilitate sustained engagement in physical activity.³²⁻³⁹ Their associations with mental health also may vary across demographic and socioeconomic groups because factors such as age, race/ethnicity, education, income, and body mass index influence both health behaviors and emotional well-being.⁴⁰⁻⁴¹ Although substantial evidence supports the independent associations of physical activity and sleep with mental health, fewer population-based studies have examined the relative contributions of moderate-intensity physical activity, strength training, and sleep while simultaneously accounting for demographic and socioeconomic characteristics. Therefore, we examined the associations of moderate-intensity physical activity, strength training, and sleep duration with depression, anxiety, and loneliness among U.S. adults after adjusting for demographic, socioeconomic, and health-related factors.

METHODS

Study Design and Data Source

This cross-sectional study used publicly available data from the 2024 Health Information National Trends Survey[®] 7 (HINTS 7).⁴² The analysis included adults aged ≥ 18 years who completed measures of depression, anxiety, and loneliness. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE)⁴³ and Preferred Reporting Items for Complex Sample Survey Analysis (PRICSSA)⁴⁴ guidelines. Institutional Review Board approval was not required because the data were publicly available and de-identified. The NIH Office of IRB Operations designated HINTS 7 as “Not Human Subjects Research” (February 8, 2024; IRB ID: IRB002042).⁴⁵ Additional details regarding the survey methodology have been published elsewhere.^{46,47}

Target Population and Sample Design

HINTS 7 is a nationally representative mail- and web-based survey of U.S. civilian, noninstitutionalized adults aged ≥ 18 years conducted between March 25 and September 16, 2024. A two-stage stratified sampling design was used, in which residential addresses were sampled first, followed by the selection of one adult per household. Sampling strata were expanded to incorporate rural-urban classification. The final sample included 7,278 respondents (response rate, 27.3%), representing an estimated 262,266,460 U.S. adults after weighting.⁴⁸ Table 1 presents the unweighted sample characteristics.

Outcome Variables

We examined three mental health outcomes. Participants reported how they have felt over the past two weeks. These outcomes were selected *a priori* because previous research has demonstrated associations with physical activity, strength training, and sleep.^{5,20,21}

Symptoms of depression. Depression symptoms were measured using the 2-item Patient Health Questionnaire (PHQ-2),⁴⁹ which assesses the frequency of (1) little interest or pleasure in doing things and (2) feeling down, depressed, or hopeless during the previous two weeks. Responses were recorded on a 4-point Likert scale (1 = *Nearly every day* to 4 = *Not at all*). Item scores were summed (range, 2-8), with lower scores indicating greater depressive symptoms. Scores of 2-5 were categorized *a priori* as screening positive for depression, whereas scores of 6-8 were categorized as screening negative

Table 1. Demographic information (N = 7278).

Characteristics	Measure ^a
Sex	
Male	4017 (55.2)
Female	2646 (36.4)
Don't know (<i>a response option in the survey</i>)	44 (0.6)
Missing	571 (7.8)
Age, years	
Mean (SD), y	49.0 (18.0)
Median	48.3
Minimum	18
Maximum	102
Age group	
18-34	1080 (14.8)
35-49	1355 (18.6)
50-64	1728 (23.7)
65-74	1466 (20.1)
≥75	1036 (14.2)
Missing	613 (8.4)
Educational level	
Up to high school	1564 (21.5)
Post high school/some college	1941 (26.7)
College graduate	1863 (25.6)
Postgraduate	1327 (18.2)
Missing	583 (8.0)
Household income	
< \$20,000	1123 (15.4)
\$20,000 to < \$35,000	802 (11.0)
\$35,000 to < \$50,000	782 (10.7)
\$50,000 to < \$75,000	1030 (14.2)
≥75,000 to <\$100,000	785 (10.8)
≥100,000	1857 (25.5)
Missing	899 (12.4)
Race/Ethnicity	
Non-Hispanic White	3548 (48.7)
Non-Hispanic Black or African American	968 (13.3)
Hispanic	1323 (18.2)
Non-Hispanic Asian	342 (4.7)
Non-Hispanic Other	257 (3.5)
Missing	840 (11.5)
Place of residence	
Rural	1008 (13.8)
Urban	6270 (86.2)

Note: ^aData are presented as the No. (%) of respondents unless otherwise indicated.

for depression.

Symptoms of anxiety. Anxiety symptoms were measured using the 2-item Generalized Anxiety Disorder scale (GAD-2),⁴⁹ which assesses the frequency of (1) feeling nervous,

anxious, or on edge and (2) not being able to stop or control worrying during the past 2 weeks. Responses were recorded on the same 4-point Likert scale. Item scores were summed (range, 2-8), with lower scores indicating greater anxiety symptoms. Scores of 2-5 were categorized *a priori* as screening positive for anxiety, whereas scores of 6-8 were categorized as screening negative for anxiety.

Loneliness. Loneliness was measured using the 4-item PROMIS Social Isolation Short Form as reported in HINTS 7 database,⁴² which assesses the frequency of feeling (1) left out, (2) isolated from others, (3) that people barely know me, and (4) that people are around me but not with me. Responses were recorded on a 5-point Likert scale (1 = *never* to 5 = *always*). Item scores were summed (range, 4-20) and categorized *a priori* as low (4-8), moderate (9-14), or high (15-20) loneliness. To examine specific dimensions of loneliness, the measure was further divided into social and emotional loneliness.

Social loneliness. Social loneliness was assessed using the first two items ("left out" and "isolated from others"), with summed scores ranging from 2 to 10. Scores of 2-4, 5-7, and 8-10 were categorized *a priori* as low, moderate, and high social loneliness, respectively.

Emotional loneliness. Emotional loneliness was assessed using the last two items ("people barely know me" and "people are around me but not with me"), with summed scores ranging from 2 to 10. Scores of 2-4, 5-7, and 8-10 were categorized *a priori* as low, moderate, and high emotional loneliness, respectively.

Predictors

Three modifiable lifestyle behaviors were selected *a priori* based on their clinical relevance and prior evidence linking them to mental health outcomes.^{50,51}

Moderate-intensity physical activity. Moderate-intensity physical activity was estimated from participants' self-reported weekly frequency and duration of moderate-intensity activity. Total minutes per week were calculated and categorized as <150 or ≥150 minutes/week, consistent with the *Physical Activity Guidelines for Americans*.^{52,53}

Strength training. Strength training was assessed as the number of days per week participants engaged in leisure-time muscle-strengthening activities and categorized as <2 or ≥2 days/week, consistent with national guidelines.^{52,53}

Sleep. Sleep duration was assessed using participants'

self-reported average weekday and weekend sleep during the past 30 days, as collected in HINTS 7.⁵⁴ Because HINTS 7 includes measures of sleep duration but not sleep quality, analyses were limited to sleep duration. Sleep duration was categorized as <7 hours (insufficient sleep), 7-9 hours (recommended sleep), and >9 hours (long sleep), consistent with categories commonly used in sleep research.⁵⁵

Covariates

Covariates were selected *a priori* to reduce confounding based on previous literature.^{56,57} Included covariates were age (18-34, 35-49, 50-64, 65-74, and ≥75 years), sex (male, female), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, non-Hispanic Asian, and non-Hispanic Other [including American Indian or Alaska Native, Native Hawaiian, Guamanian or Chamorro, Samoan, and other Pacific Islander groups]), education (≤high school, some college/post-high school, college graduate, postgraduate), household income (<\$20,000, \$20,000-\$34,999, \$35,000-\$49,999, \$50,000-\$74,999, \$75,000-\$99,999, and ≥\$100,000), residence (urban, rural), and body mass index (BMI; <18.5, 18.5-24.9, 25.0-29.9, and ≥30.0 kg/m²). Rural-urban classification was based on the 2013 USDA Rural-Urban Continuum Codes (RUCC), with codes 1-3 classified as urban and codes 4-9 as rural.⁵⁴

Missing Data

Missing data were assumed to be missing at random (MAR) and were handled using maximum likelihood estimation.^{58,59} Under the MAR assumption, the probability of missingness may depend on observed characteristics but not on unobserved values. Although the MAR assumption cannot be empirically distinguished from a missing not at random (MNAR) mechanism using the observed data alone, it is widely accepted for handling incomplete survey data and helps reduce bias while improving the stability of parameter estimates and standard errors.⁶⁰

Statistical Analysis

Analyses followed a three-stage survey-weighted approach. First, descriptive analyses summarized participant characteristics using weighted frequencies and percentages for categorical variables and weighted means for continuous variables. Second, bivariate associations between mental health outcomes and covariates (age, sex, education, race/

ethnicity, residence, and BMI) were assessed using Rao-Scott adjusted chi-square tests with Bonferroni or false discovery rate correction for multiple comparisons.

Third, survey-weighted multivariable logistic regression models estimated the independent associations of lifestyle behaviors with depression and anxiety after adjustment for potential confounders. To reduce small-sample bias and address potential separation resulting from outcome imbalance, a multivariable extension of Firth's bias-reduced logistic regression was applied when appropriate (with PROC LOGISTIC).⁵⁶ Models incorporated sampling weights, stratification, and clustering, and adjusted odds ratios (aORs) with 95% confidence intervals (CIs) were reported.

Because social and emotional loneliness were categorized into three levels (low, moderate, and high), survey-weighted multinomial logistic regression with a generalized logit link was used rather than proportional odds models, thereby avoiding the proportional odds assumption. A two-sided $p < 0.05$ was considered statistically significant. Analyses were conducted using SAS version 9.4 (SAS Institute Inc., Cary, NC) with PROC SURVEYLOGISTIC and a generalized *logit* link. Analyses were conducted in May 2026.

RESULTS

Demographic Information

Tables 1 and 2 summarize respondent characteristics and health outcomes. As shown in Table 1 (N = 7278), the mean age was 49.0 years (SD, 18.0); 55.2% of respondents were male, 48.7% were non-Hispanic White, 48.2% had some college education or less, 51.3% reported an annual household income <\$75,000, and 86.2% resided in urban areas.

As shown in Table 2, the mean BMI was 28.8 kg/m² (SD, 6.9), and 35.8% of respondents had obesity. Most respondents screened negative for depression (79.4%) and anxiety (78.4%). Regarding loneliness, 6.8% reported high overall loneliness, 24.7% reported high social loneliness, and 6.7% reported high emotional loneliness. Most respondents did not meet the recommended levels of physical activity, with 56.6% reporting <150 minutes/week of moderate-intensity physical activity and 55.4% reporting strength training on <2 days/week. In contrast, most respondents met the recommended sleep duration on both weekdays (57.4%) and weekends (63.2%).

Table 2. Proportion of participants' emotional health outcomes and lifestyle activities, HINTS 2024 (N = 7278).

Variables	N (%)
Depression	
Screened negative	5779 (79.4)
Screen positive	1499 (20.6)
Anxiety	
Screened negative	5708 (78.4)
Screen positive	1570 (21.6)
Loneliness	
Low	4483 (61.6)
Moderate	1866 (25.6)
High	492 (6.8)
Missing	437 (6.0)
Social loneliness	
Low	3141 (43.2)
Moderate	1924 (26.4)
High	1799 (24.7)
Missing	414 (5.7)
Emotional loneliness	
Low	4661 (64.0)
Moderate	1699 (23.3)
High	487 (6.7)
Missing	431 (5.9)
Minutes per week of moderate-intensity exercise	
<150 minutes/week	4119 (56.6)
≥150 minutes/week	2643 (36.3)
Missing	516 (7.1)
Strength training	
<2 days/week	4035 (55.4)
≥2 days/week	2795 (38.4)
Missing	448 (6.2)
Weekday sleep	
<7 hours of sleep per night (insufficient sleep)	2279 (31.3)
7-9 hours of sleep per night (recommended sleep)	4176 (57.4)
>9 hours of sleep per night (long sleep)	309 (4.2)
Missing	514 (7.1)
Weekend sleep	
<7 hours of sleep per night (insufficient sleep)	1501 (20.6)
7-9 hours of sleep per night (recommended sleep)	4597 (63.2)
>9 hours of sleep per night (long sleep)	678 (9.3)
Missing	502 (6.9)
Body mass index	n = 6806
Mean (SD), kg/m ²	28.8 (6.9)
<18.5 kg/m ² (Underweight)	136 (2.0)
18.5-24.9 kg/m ² (Healthy weight)	2019 (29.7)
25.0-29.9 kg/m ² (Overweight)	2215 (32.5)
≥30.0 kg/m ² (Obese)	2436 (35.8)

Table 2. *Continued.*

Variables	N (%)
30.0-34.9 kg/m ² (Obesity Class I)	1348 (55.3)
35.0-39.9 kg/m ² (Obesity Class II)	612 (25.1)
≥40.0 kg/m ² (Severe obesity)	476 (19.5)

Note: HINTS, Health Information National Trends Survey.

Results of Bivariate Analysis

Physical activity. Table 3a presents the distribution of physical activity behaviors across respondent characteristics. Among respondents who did not meet the recommended moderate-intensity physical activity guideline (<150 minutes/week), the proportion was higher among men (38.8%; $\chi^2[2] = 70.63$, $p < 0.0001$), adults aged 50-64 years (15.8%; $\chi^2[4] = 11.42$, $p = 0.0223$), non-Hispanic White individuals (32.0%; $\chi^2[4] = 55.78$, $p < 0.0001$), respondents with some college or post-high school education (18.2%; $\chi^2[3] = 82.51$, $p < 0.0001$), those with annual household incomes ≥\$100,000 (15.7%; $\chi^2[5] = 111.24$, $p < 0.0001$), and urban residents (52.1%; $\chi^2[1] = 4.04$, $p = 0.0445$).

Similarly, among respondents who did not meet the muscle-strengthening activity recommendation (<2 days/week), the proportion was higher among men (36.9%; $\chi^2[2] = 30.88$, $p < 0.0001$), adults aged 50-64 years (15.9%; $\chi^2[4] = 42.43$, $p < 0.0001$), non-Hispanic White individuals (33.1%; $\chi^2[4] = 11.08$, $p = 0.0257$), respondents with some college or post-high school education (18.3%; $\chi^2[3] = 80.87$, $p < 0.0001$), those with annual household incomes ≥\$100,000 (15.6%; $\chi^2[5] = 51.69$, $p < 0.0001$), and urban residents (50.2%; $\chi^2[1] = 10.13$, $p = 0.0115$).

Mental health outcomes. Table 3b summarizes the distribution of depression, anxiety, and loneliness outcomes across respondent characteristics.

Depression. Among respondents screening negative for depression, the proportion was higher among men (49.2%; $\chi^2[2] = 15.95$, $p = 0.0003$), non-Hispanic White individuals (47.8%; $\chi^2[4] = 69.56$, $p < 0.0001$), college graduates (24.1%; $\chi^2[3] = 140.88$, $p < 0.0001$), adults aged 50-64 years (21.7%; $\chi^2[4] = 84.28$, $p < 0.0001$), and respondents with annual household incomes ≥\$100,000 (27.0%; $\chi^2[5] = 315.79$, $p < 0.0001$).

Anxiety. Among respondents screening negative for anxiety, the proportion was higher among men (48.0%; $\chi^2[2] = 33.97$, $p < 0.0001$), non-Hispanic White individuals (46.7%; $\chi^2[4] = 46.79$, $p < 0.0001$), respondents with some college or postsecondary education (23.7%; $\chi^2[3] = 70.07$, $p < 0.0001$),

Table 3a. Distribution of participants' physical activities, HINTS 2024 (N = 7278).^a

Measure	Minutes per week of moderate-intensity physical activity ^b				Strength training		
	<150 min-utes/week	≥150 min-utes/week	Rao-Scott $\chi^2(df)$	P-value	<2 days/week	≥2 days/week	Rao-Scott $\chi^2(df)$ P-value*
Sex			70.62 (2)	<0.0001			30.88 (2) <0.0001
Male	2541 (38.8)	1377 (21.0)			2444 (36.9)	1513 (22.9)	
Female	1418 (21.6)	1180 (18.0)			1447 (21.9)	1171 (17.7)	
Don't know (a response option)	28 (0.4)	12 (0.2)			20 (0.3)	24 (0.4)	
Total	3987 (60.8)	2569 (39.2)			3911 (59.1)	2708 (40.9)	
Age category			11.42 (4)	0.0223			42.43 (4) <0.0001
18-34	637 (9.8)	431 (6.6)			562 (8.5)	511 (7.8)	
35-49	838 (12.8)	505 (7.7)			755 (11.5)	593 (9.0)	
50-64	1033 (15.8)	662 (10.1)			1045 (15.9)	663 (10.1)	
65-74	825 (12.6)	605 (9.3)			884 (13.4)	561 (8.5)	
≥75	631 (9.7)	359 (5.5)			649 (9.9)	360 (5.5)	
Total	3964 (60.7)	2562 (39.3)			3895 (59.2)	2688 (40.8)	
Race/Ethnicity^c			55.76 (4)	<0.0001			11.08 (4) 0.0257
Non-Hispanic White	2022 (32.0)	1476 (23.4)			2106 (33.1)	1405 (22.1)	
Non-Hispanic Black	665 (10.5)	272 (4.3)			593 (9.3)	360 (5.7)	
Hispanic	778 (12.3)	514 (8.1)			737 (11.6)	572 (9.0)	
Non-Hispanic Asian	219 (3.5)	122 (1.9)			193 (3.0)	148 (2.3)	
Non-Hispanic Other	150 (2.4)	102 (1.6)			144 (2.3)	113 (1.8)	
Total	3834 (60.7)	2486 (39.3)			3773 (59.2)	2598 (40.8)	
Educational level			82.51 (3)	<0.0001			80.87 (3) <0.0001
Up to high school	1022 (15.6)	470 (7.2)			1004 (15.2)	523 (7.9)	
Post high school/some college	1192 (18.2)	705 (10.8)			1209 (18.3)	709 (10.7)	
College graduate	1075 (16.4)	768 (11.7)			1008 (15.3)	834 (12.6)	
Postgraduate	689 (10.5)	622 (9.5)			689 (10.4)	631 (9.6)	
Total	3978 (60.8)	2565 (39.2)			3910 (59.2)	2697 (40.8)	
Household income			111.24 (5)	<0.0001			51.69 (5) <0.0001
< \$20,000	757 (12.1)	319 (5.1)			687 (10.9)	399 (6.3)	
\$20,000 to < \$35,000	534 (8.5)	241 (3.9)			516 (8.2)	277 (4.4)	
\$35,000 to < \$50,000	484 (7.7)	291 (4.7)			486 (7.7)	289 (4.6)	
\$50,000 to < \$75,000	603 (9.6)	414 (6.6)			609 (9.7)	416 (6.6)	
≥ \$75,000 to < \$100,000	443 (7.1)	330 (5.3)			452 (7.2)	326 (5.2)	
≥ \$100,000	981 (15.7)	858 (13.7)			981 (15.6)	867 (13.8)	
Total	3802 (60.8)	2453 (39.2)			3731 (59.2)	2574 (40.8)	
Place of residence			4.04 (1)	0.0445			10.13 (1) 0.0015
Rural	598 (8.8)	338 (5.0)			606 (8.9)	344 (5.0)	
Urban	3521 (52.1)	2305 (34.1)			3429 (50.2)	2451 (35.9)	
Total	4119 (60.9)	2643 (39.1)			4035 (59.1)	2795 (40.9)	

^aData are presented as the No. (%) of respondent. ^bFrequencies and proportions were derived from the weighted survey analysis, with unweighted frequencies reported in the table. Chi-square statistics and corresponding p-values were calculated using the Rao-Scott first-order adjusted chi-square test. ^cNon-Hispanic Other included American Indian or Alaska Native, Native Hawaiian, Guamanian or Chamorro, Samoan, and Other Pacific Islander. *The association between the variables were tested using Rao-Scott chi-square based on the weighted survey results.

Table 3b. Distribution of participants' mental health outcomes, HINTS 2024 (N = 7278).^a

Measure	Depression ^b			Anxiety ^b		
	Screened negative	Screened positive	Rao-Scott $\chi^2(df)$	P-value	Screened negative	Screened positive
Sex						
Male	3297 (49.2)	720 (10.7)	15.95 (2)	0.0003	3218 (48.0)	799 (11.9)
Female	2263 (33.7)	383 (5.7)			2267 (33.8)	379 (5.7)
Don't know (a response option)	33 (0.5)	11 (0.2)			36 (0.5)	8 (0.1)
Total	5593 (83.4)	1114 (16.6)			5521 (82.3)	1186 (17.7)
Age category						
18-34	817 (12.3)	263 (4.0)	84.28 (4)	<0.0001	745 (11.2)	335 (5.0)
35-49	1106 (16.6)	249 (3.7)			1069 (16.0)	286 (4.3)
50-64	1446 (21.7)	282 (4.2)			1453 (21.8)	275 (4.1)
65-74	1288 (19.3)	178 (2.7)			1311 (19.7)	155 (2.3)
≥75	907 (13.6)	129 (1.9)			910 (13.7)	126 (1.9)
Total	5564 (83.5)	1101 (16.5)			5488 (82.3)	1177 (17.7)
Race/Ethnicity^c						
Non-Hispanic White	3076 (47.8)	472 (7.3)	69.56 (4)	<0.0001	3007 (46.7)	541 (8.4)
Non-Hispanic Black	787 (12.2)	181 (2.8)			803 (12.5)	165 (2.6)
Hispanic	1037 (16.1)	286 (4.4)			1014 (15.8)	309 (4.8)
Non-Hispanic Asian	298 (4.6)	44 (0.7)			290 (4.5)	52 (0.8)
Non-Hispanic Other	195 (3.0)	62 (1.0)			205 (3.2)	52 (0.8)
Total	5393 (83.8)	1045 (16.2)			5319 (82.6)	1119 (17.4)
Educational level						
Up to high school	1181 (17.6)	383 (5.7)	140.88 (3)	<0.0001	1193 (17.8)	371 (5.5)
Post high school/some college	1588 (23.7)	353 (5.3)			1587 (23.7)	354 (5.3)
College graduate	1616 (24.1)	247 (3.7)			1564 (23.4)	299 (4.5)
Postgraduate	1204 (18.0)	123 (1.8)			1172 (17.5)	155 (2.3)
Total	5589 (83.5)	1106 (16.5)			5516 (82.4)	1179 (17.6)
Household income						
< \$20,000	775 (12.2)	348 (5.5)	315.79 (5)	<0.0001	776 (12.2)	347 (5.4)
\$20,000 to < \$35,000	632 (9.9)	170 (2.7)			633 (9.9)	169 (2.7)
\$35,000 to < \$50,000	639 (10.0)	143 (2.2)			638 (10.0)	144 (2.3)
\$50,000 to < \$75,000	856 (13.4)	174 (2.7)			856 (13.4)	174 (2.7)
≥ \$75,000 to < \$100,000	699 (11.0)	86 (1.4)			680 (10.7)	105 (1.7)
≥ \$100,000	1721 (27.0)	136 (2.1)			1666 (26.1)	191 (3.0)
Total	5322 (83.4)	1057 (16.6)			5249 (82.3)	1130 (17.7)
Place of residence						
Rural	799 (11.0)	209 (2.9)	0.01 (1)	0.9072	788 (10.8)	220 (3.0)
Urban	4980 (68.4)	1290 (17.7)			4920 (67.6)	1350 (18.6)
Total	5779 (79.4)	1499 (20.6)			5708 (78.4)	1570 (21.6)

Continued on next page.

Table 3b. Continued.

Measure	Overall Loneliness ^b				P-value*
	Low	Moderate	High	Rao-Scott χ^2 (df)	
Sex				25.61 (4)	<0.0001
Male	2512 (38.0)	1147 (17.3)	302 (4.6)		
Female	1797 (27.2)	652 (9.9)	163 (2.5)		
Don't know (a response option)	27 (0.4)	10 (0.2)	7 (0.1)		
Total	4336 (65.5)	1809 (27.3)	472 (7.1)		
Age category				279.49 (8)	<0.0001
18-34	533 (8.1)	393 (6.0)	150 (2.3)		
35-49	797 (12.1)	432 (6.6)	119 (1.8)		
50-64	1136 (17.3)	461 (7.0)	107 (1.6)		
65-74	1062 (16.1)	313 (4.8)	63 (1.0)		
≥75	777 (11.8)	206 (3.1)	31 (0.5)		
Total	4305 (65.4)	1805 (27.4)	470 (7.1)		
Race/Ethnicity^c				60.30 (8)	<0.0001
Non-Hispanic White	2289 (36.0)	1010 (15.9)	221 (3.5)		
Non-Hispanic Black	656 (10.3)	226 (3.6)	72 (1.1)		
Hispanic	854 (13.4)	338 (5.3)	107 (1.7)		
Non-Hispanic Asian	237 (3.7)	82 (1.3)	20 (0.3)		
Non-Hispanic Other	123 (1.9)	95 (1.5)	38 (0.6)		
Total	4159 (65.3)	1751 (27.5)	458 (7.2)		
Educational level				61.45 (6)	<0.0001
Up to high school	1011 (15.3)	361 (5.5)	154 (2.3)		
Post high school/some college	1228 (18.6)	537 (8.1)	153 (2.3)		
College graduate	1180 (17.9)	564 (8.5)	101 (1.5)		
Postgraduate	912 (13.8)	348 (5.3)	58 (0.9)		
Total	4331 (65.6)	1810 (27.4)	466 (7.1)		
Household income				149.86 (10)	<0.0001
<\$20,000	616 (9.8)	330 (5.2)	152 (2.4)		
\$20,000 to <\$35,000	490 (7.8)	240 (3.8)	56 (0.9)		
\$35,000 to <\$50,000	486 (7.7)	226 (3.6)	67 (1.1)		
\$50,000 to <\$75,000	669 (10.6)	280 (4.4)	75 (1.2)		
≥\$75,000 to <\$100,000	525 (8.3)	211 (3.3)	40 (0.6)		
≥\$100,000	1317 (20.9)	467 (7.4)	61 (1.0)		
Total	4103 (65.0)	1754 (27.8)	451 (7.2)		
Place of residence				5.24 (2)	0.0728
Rural	607 (8.9)	265 (3.9)	85 (1.2)		
Urban	3876 (56.7)	1601 (23.4)	407 (6.0)		
Total	4483 (65.5)	1866 (27.3)	492 (7.2)		

^aData are presented as the No. (%) of respondent. ^bThe frequencies and proportions were derived from the weighted survey analysis, with unweighted frequencies reported in the table. Chi-square statistics and corresponding p-values were calculated using the Rao-Scott first-order adjusted chi-square test. ^cNon-Hispanic Other included American Indian or Alaska Native, Native Hawaiian, Guamanian or Chamorro, Samoan, and Other Pacific Islander. *The association between the variables were tested using Rao-Scott chi-square based on the weighted survey results.

adults aged 50-64 years (21.8%; $\chi^2[4] = 219.41$, $p < 0.0001$), and those with annual household incomes $\geq \$100,000$ (26.1%; $\chi^2[5] = 221.32$, $p < 0.0001$).

Loneliness. Among respondents reporting high loneliness, the proportion was higher among men (4.6%; $\chi^2[4] = 25.61$, $p < 0.0001$), non-Hispanic White individuals (3.5%; $\chi^2[8] = 60.30$, $p < 0.0001$), respondents with some college or postsecondary education (2.5%; $\chi^2[6] = 61.45$, $p < 0.0001$), adults aged 18-34 years (2.3%; $\chi^2[8] = 279.49$, $p < 0.0001$), and respondents with annual household incomes $< \$20,000$ (20.9%; $\chi^2[10] = 149.86$, $p < 0.0001$).

Results of Multivariable Analysis

Table 4a presents survey-weighted multivariable logistic regression results comparing respondents who screened positive versus negative for depression and anxiety. Tables 4b and 4c present survey-weighted multinomial regression results examining associations with overall, social, and emotional loneliness.

Depression. Meeting moderate-intensity physical activity guidelines (≥ 150 minutes/week) was not associated with screening positive for depression in unadjusted or adjusted analyses. In contrast, meeting strength-training guidelines (≥ 2 days/week) was associated with lower odds of screening positive for depression in both unadjusted (OR, 0.69; 95% CI, 0.54-0.88) and adjusted analyses (aOR, 0.71; 95% CI, 0.53-0.95). Weekday sleep duration was not associated with depression; however, obtaining 7-9 hours of weekend sleep was associated with lower odds of screening positive for depression in unadjusted (OR, 0.49; 95% CI, 0.34-0.70) and adjusted analyses (aOR, 0.57; 95% CI, 0.39-0.84; Table 4a).

In adjusted analyses, overweight BMI category (aOR, 0.71; 95% CI, 0.51-0.99), non-Hispanic Asian race/ethnicity (aOR, 0.37; 95% CI, 0.17-0.80), and higher household income ($\geq \$100,000$; aOR, 0.23; 95% CI, 0.14-0.38) were associated with lower odds of screening positive for depression. Conversely, adults aged 18-34 years had higher odds of screening positive for depression (aOR, 3.33; 95% CI, 2.00-5.57; Table 4a).

Anxiety. Moderate-intensity physical activity and strength-training guidelines were not associated with screening positive for anxiety in unadjusted or adjusted analyses. Similarly, weekday sleep duration was not associated with anxiety. However, obtaining 7-9 hours of weekend sleep was associated with lower odds of screening positive for anxiety

in unadjusted (OR, 0.54; 95% CI, 0.38-0.77) and adjusted analyses (aOR, 0.51; 95% CI, 0.35-0.75; Table 4a).

In adjusted analyses, non-Hispanic Black race/ethnicity (aOR, 0.59; 95% CI, 0.41-0.86) and household income $\geq \$100,000$ (aOR, 0.25; 95% CI, 0.16-0.40) were associated with lower odds of screening positive for anxiety. Adults aged 18-34 years had higher odds of screening positive for anxiety (aOR, 5.73; 95% CI, 3.18-10.34; Table 4a).

Overall loneliness. Meeting moderate-intensity physical activity guidelines was not associated with high loneliness in unadjusted or adjusted analyses. In contrast, meeting strength-training guidelines was associated with lower odds of reporting high loneliness in unadjusted (OR, 0.60; 95% CI, 0.42-0.85) and adjusted analyses (aOR, 0.65; 95% CI, 0.43-0.98). Obtaining 7-9 hours of sleep on weekdays and weekends also was associated with lower odds of reporting high loneliness in adjusted analyses (weekday: aOR, 0.57; 95% CI, 0.37-0.88; weekend: aOR, 0.44; 95% CI, 0.27-0.70; Table 4b).

In multinomial models, non-Hispanic Black race/ethnicity (aOR, 0.46; 95% CI, 0.28-0.77) and household income $\geq \$100,000$ (aOR, 0.34; 95% CI, 0.17-0.66) were associated with lower odds of high loneliness. Adults aged 18-34 years had higher odds of high loneliness (aOR, 26.28; 95% CI, 11.81-58.49; Table 4b).

Social loneliness. Meeting moderate-intensity physical activity and strength-training guidelines was not associated with high social loneliness. However, obtaining 7-9 hours of weekday sleep was associated with lower odds of high social loneliness in unadjusted (OR, 0.64; 95% CI, 0.49-0.82) and adjusted analyses (aOR, 0.58; 95% CI, 0.44-0.76). Weekend sleep duration was not associated with social loneliness (Table 4c).

In adjusted multinomial models, female sex (aOR, 0.77; 95% CI, 0.59-0.99), high school education or less (aOR, 0.59; 95% CI, 0.36-0.98), non-Hispanic Black race/ethnicity (aOR, 0.43; 95% CI, 0.30-0.61), and household income $\geq \$100,000$ (aOR, 0.32; 95% CI, 0.21-0.48) were associated with lower odds of high social loneliness. Adults aged 18-34 years had higher odds of high social loneliness (aOR, 4.47; 95% CI, 2.78-7.16; Table 4c).

Emotional loneliness. Meeting moderate-intensity physical activity guidelines (≥ 150 minutes/week) was not associated with high emotional loneliness in either unadjusted or adjusted analyses. Meeting strength-training guidelines (≥ 2 days/week) was associated with lower odds of reporting high

Table 4a. Factors associated with mental health outcomes, HINTS 2024.

Variable	Depression ^a		Anxiety ^b	
	Screened positive vs Screened negative aOR (95% Confidence Limits)	Standard Error	Screened positive vs Screened negative aOR (95% Confidence Limits)	Standard Error
Intercept		0.16		0.17
Minutes per week of moderate-intensity exercise				
≥150 minutes/week vs <150 minutes/week	0.83 (0.61, 1.13)	0.08	1.00 (0.74, 1.36)	0.08
Strength training				
≥2 days/week vs <2 days/week	0.71 (0.53, 0.95)	0.07	0.91 (0.69, 1.21)	0.07
Weekday sleep				
7-9 hours of sleep per night vs <7 hours of sleep per night	0.72 (0.52, 1.00)	0.12	0.73 (0.53, 1.01)	0.12
>9 hours of sleep per night vs <7 hours of sleep per night	1.67 (0.85, 3.29)	0.23	1.36 (0.66, 2.84)	0.23
Weekend sleep				
7-9 hours of sleep per night vs <7 hours of sleep per night	0.57 (0.39, 0.84)	0.10	0.51 (0.35, 0.75)	0.10
>9 hours of sleep per night vs <7 hours of sleep per night	0.64 (0.38, 1.08)	0.15	0.62 (0.37, 1.05)	0.15
Body Mass Index				
Underweight vs Obese	1.85 (0.73, 4.67)	0.34	1.46 (0.57, 3.75)	0.10
Healthy weight vs Obese	0.84 (0.58, 1.22)	0.15	0.78 (0.55, 1.11)	0.15
Overweight vs Obese	0.71 (0.51, 0.99)	0.14	0.90 (0.66, 1.22)	
Age, y				
18-34 vs ≥75	3.33 (2.00, 5.57)	0.15	5.73 (3.18, 10.34)	0.15
35-49 vs ≥75	2.45 (1.50, 4.02)	0.11	3.06 (1.83, 5.10)	0.11
50-64 vs ≥75	2.37 (1.46, 3.85)	0.12	2.29 (1.35, 3.88)	0.12
65-74 vs ≥75	1.09 (0.65, 1.84)	0.18	1.01 (0.54, 1.87)	0.18
Sex				
Female vs Male	1.09 (0.79, 1.49)	0.08	0.77 (0.57, 1.05)	0.08
Educational level				
Up to high school vs postgraduate	1.34 (0.82, 2.18)	0.13	1.12 (0.68, 1.84)	0.13
Post high school/some college vs postgraduate	1.16 (0.80, 1.68)	0.11	0.87 (0.56, 1.35)	0.11
College graduate vs postgraduate	1.26 (0.82, 1.93)	0.12	1.04 (0.68, 1.60)	0.12
Race and ethnicity				
Non-Hispanic Black vs Non-Hispanic White	0.81 (0.58, 1.13)	0.17	0.59 (0.41, 0.86)	0.17
Hispanic vs Non-Hispanic White	1.09 (0.81, 1.46)	0.13	0.96 (0.71, 1.32)	0.13
Non-Hispanic Asian vs Non-Hispanic White	0.37 (0.17, 0.80)	0.34	0.63 (0.28, 1.41)	0.34
Non-Hispanic Other vs Non-Hispanic White	1.55 (0.81, 3.00)	0.28	0.84 (0.45, 1.58)	0.28
Annual income, \$				
20,000 to <35,000 vs <20,000	0.75 (0.49, 1.16)	0.17	0.77 (0.50, 1.18)	0.17
35,000 to <50,000 vs <20,000	0.53 (0.35, 0.80)	0.15	0.42 (0.27, 0.65)	0.15
50,000 to <75,000 vs <20,000	0.55 (0.36, 0.83)	0.13	0.45 (0.30, 0.66)	0.13
≥75,000 to 100,000 vs <20,000	0.37 (0.23, 0.58)	0.16	0.47 (0.30, 0.75)	0.16
>100,001 vs <20,000	0.23 (0.14, 0.38)	0.15	0.25 (0.16, 0.40)	0.15
Place of residence				
Urban vs Rural	0.91 (0.64, 1.29)	0.11	0.86 (0.57, 1.29)	0.11

Note: HINTS, Health Information National Trends Survey; aOR, adjusted odds ratio. ^ac-Statistics: 0.72. ^bc-Statistics: 0.73.

Table 4b. Factors associated with mental health outcomes, HINTS 2024.^a

Variable	Loneliness		Loneliness	
	aOR (95% Confidence Limits)	Standard Error	Moderate vs Low	Standard Error
Intercept		0.28		0.17
Minutes per week of moderate-intensity exercise				
≥150 minutes/week vs <150 minutes/week	1.10 (0.71, 1.71)	0.11	0.88 (0.7, 1.11)	0.06
Strength training				
≥2 days/week vs <2 days/week	0.65 (0.43, 0.98)	0.11	0.96 (0.76, 1.21)	0.06
Weekday sleep				
7-9 hours of sleep per night vs <7 hours of sleep per night	0.57 (0.37, 0.88)	0.16	0.67 (0.53, 0.84)	0.10
>9 hours of sleep per night vs <7 hours of sleep per night	3.21 (1.45, 7.11)	0.25	0.67 (0.39, 1.17)	0.18
Weekend sleep				
7-9 hours of sleep per night vs <7 hours of sleep per night	0.44 (0.27, 0.70)	0.13	0.85 (0.62, 1.17)	0.09
>9 hours of sleep per night vs <7 hours of sleep per night	0.52 (0.28, 0.98)	0.18	1.21 (0.80, 1.83)	0.12
Body Mass Index				
Underweight vs Obese	0.92 (0.18, 4.63)	0.62	0.58 (0.21, 1.57)	0.38
Healthy weight vs Obese	0.81 (0.50, 1.32)	0.24	1.27 (0.98, 1.65)	0.14
Overweight vs Obese	0.80 (0.50, 1.26)	0.26	1.02 (0.79, 1.26)	0.15
Age, y				
18-34 vs ≥75	26.28 (11.81, 58.49)	0.19	2.81 (1.88, 4.20)	0.11
35-49 vs ≥75	12.17 (5.52, 26.81)	0.18	1.67 (1.16, 2.41)	0.08
50-64 vs ≥75	8.85 (4.07, 19.23)	0.17	1.52 (1.06, 2.20)	0.09
65-74 vs ≥75	4.63 (1.81, 11.84)	0.29	1.04 (0.69, 1.56)	0.12
Sex				
Female vs Male	0.86 (0.58, 1.28)	0.10	0.82 (0.64, 1.06)	0.06
Educational level				
Up to high school vs postgraduate	1.20 (0.60, 2.38)	0.20	0.56 (0.35, 0.89)	0.14
Post high school/some college vs postgraduate	1.06 (0.62, 1.81)	0.13	0.82 (0.58, 1.16)	0.10
College graduate vs postgraduate	0.72 (0.44, 1.21)	0.16	1.01 (0.74, 1.36)	0.09
Race and ethnicity				
Non-Hispanic Black vs Non-Hispanic White	0.46 (0.28, 0.77)	0.21	0.68 (0.50, 0.93)	0.15
Hispanic vs Non-Hispanic White	0.67 (0.41, 1.10)	0.19	0.67 (0.51, 0.88)	0.11
Non-Hispanic Asian vs Non-Hispanic White	0.32 (0.12, 0.85)	0.42	0.67 (0.36, 1.24)	0.25
Non-Hispanic Other vs Non-Hispanic White	1.55 (0.66, 3.64)	0.36	1.36 (0.86, 2.16)	0.18
Annual income, \$				
20,000 to <35,000 vs <20,000	0.60 (0.33, 1.09)	0.23	1.11 (0.76, 1.62)	0.14
35,000 to <50,000 vs <20,000	0.84 (0.44, 1.61)	0.26	0.74 (0.47, 1.17)	0.14
50,000 to <75,000 vs <20,000	0.70 (0.40, 1.24)	0.19	0.61 (0.42, 0.91)	0.13
≥75,000 to 100,000 vs <20,000	0.64 (0.31, 1.33)	0.28	0.55 (0.39, 0.78)	0.12
>100,001 vs <20,000	0.34 (0.17, 0.66)	0.23	0.42 (0.28, 0.61)	0.11
Place of residence				
Urban vs Rural	0.75 (0.47, 1.17)	0.12	0.91 (0.69, 1.21)	0.07

Note: HINTS, Health Information National Trends Survey; aOR, adjusted odds ratio.^aMultinomial Logistic Regression Comparing High vs. Low Levels.

Table 4c. Factors associated with mental health outcomes, HINTS 2024.^a

Variable	Social Loneliness		Emotional Loneliness	
	aOR (95% Confidence Limits)	Standard Error	aOR (95% Confidence Limits)	Standard Error
Intercept		0.21		0.35
Minutes per week of moderate-intensity exercise				
≥150 minutes/week vs <150 minutes/week	0.85 (0.65, 1.09)	0.07	0.91 (0.42, 1.97)	0.20
Strength training				
≥2 days/week vs <2 days/week	0.83 (0.64, 1.06)	0.06	0.86 (0.42, 1.76)	0.18
Weekday sleep				
7-9 hours of sleep per night vs <7 hours of sleep per night	0.58 (0.44, 0.76)	0.11	0.56 (0.32, 0.97)	0.20
>9 hours of sleep per night vs <7 hours of sleep per night	0.97 (0.50, 1.90)	0.21	5.67 (1.98, 16.24)	0.33
Weekend sleep				
7-9 hours of sleep per night vs <7 hours of sleep per night	0.71 (0.49, 1.01)	0.10	0.32 (0.17, 0.59)	0.18
>9 hours of sleep per night vs <7 hours of sleep per night	0.94 (0.57, 1.57)	0.14	0.36 (0.16, 0.82)	0.24
Body Mass Index^b				
Underweight vs Obese	0.57 (0.14, 2.28)	0.52		
Healthy weight vs Obese	1.05 (0.78, 1.41)	0.19		
Overweight vs Obese	0.89 (0.68, 1.17)	0.19		
Age, y				
18-34 vs ≥75	4.47 (2.78, 7.16)	0.12	52.09 (15.93, 170.39)	7.03
35-49 vs ≥75	2.61 (1.68, 4.05)	0.10	22.46 (7.01, 72.01)	0.26
50-64 vs ≥75	1.81 (1.22, 2.70)	0.10	6.74 (2.07, 21.88)	0.26
65-74 vs ≥75	1.12 (0.69, 1.81)	0.14	2.34 (0.68, 8.04)	0.36
Sex				
Female vs Male	0.77 (0.59, 0.99)	0.07	1.05 (0.62, 1.79)	0.19
Educational level				
Up to high school vs postgraduate	0.59 (0.36, 0.98)	0.15	3.5 (0.98, 12.53)	0.34
Post high school/some college vs postgraduate	0.82 (0.54, 1.24)	0.11	2.19 (0.76, 6.32)	0.22
College graduate vs postgraduate	0.94 (0.66, 1.34)	0.11	1.15 (0.40, 3.30)	0.30
Race and ethnicity				
Non-Hispanic Black vs Non-Hispanic White	0.43 (0.30, 0.61)	0.15	0.30 (0.15, 0.62)	0.27
Hispanic vs Non-Hispanic White	0.61 (0.45, 0.83)	0.12	0.29 (0.12, 0.68)	0.31
Non-Hispanic Asian vs Non-Hispanic White	0.45 (0.23, 0.88)	0.29		
Non-Hispanic Other vs Non-Hispanic White	1.02 (0.59, 1.75)	0.23	0.42 (0.12, 1.50)	0.49
Annual income, \$				
20,000 to <35,000 vs <20,000	0.85 (0.58, 1.25)	0.15	1.21 (0.51, 2.88)	0.34
35,000 to <50,000 vs <20,000	0.78 (0.49, 1.23)	0.15	1.46 (0.58, 3.67)	0.34
50,000 to <75,000 vs <20,000	0.58 (0.40, 0.83)	0.12	1.62 (0.65, 4.02)	0.28
≥75,000 to 100,000 vs <20,000	0.59 (0.40, 0.87)	0.15	0.91 (0.25, 3.28)	0.44
>100,001 vs <20,000	0.32 (0.21, 0.48)	0.13	0.87 (0.27, 2.82)	0.40
Place of residence				
Urban vs Rural	0.92 (0.68, 1.26)	0.08	1.96 (1.00, 3.84)	1.96

Note: HINTS, Health Information National Trends Survey; aOR, adjusted odds ratio. ^aMultinomial logistic regression comparing on low vs high levels. ^bThere were insufficient observations to estimate the regression coefficient(s) for BMI.

emotional loneliness in unadjusted analyses (OR, 0.48; 95% CI, 0.31-0.73); however, this association was no longer statistically significant after adjustment. Obtaining 7-9 hours of sleep on weekdays was associated with lower odds of reporting high emotional loneliness in both unadjusted (OR, 0.25; 95% CI, 0.09-0.65) and adjusted analyses (aOR, 0.56; 95% CI, 0.32-0.97).

In multinomial models, non-Hispanic Black race/ethnicity was associated with lower odds of reporting high emotional loneliness (aOR, 0.30; 95% CI, 0.15-0.62). Conversely, adults aged 18-34 years had higher odds of reporting high emotional loneliness (aOR, 52.09; 95% CI, 15.93-170.39).

DISCUSSION

In this nationally representative sample of U.S. adults, most respondents screened negative for depression and anxiety and reported low levels of loneliness. Despite these generally favorable emotional health indicators, more than half of respondents did not meet the recommended levels of moderate-intensity physical activity or strength training.

A key finding was that meeting strength-training recommendations (≥ 2 days/week) was associated with lower odds of screening positive for depression and lower odds of reporting high loneliness, whereas meeting moderate-intensity physical activity guidelines was not independently associated with depression, anxiety, or loneliness after adjustment. These findings are consistent with growing evidence that resistance exercise may provide unique mental health benefits beyond those associated with moderate-intensity aerobic activity.^{14,61} Previous studies have linked resistance training and greater muscular strength with lower depressive symptoms, improved psychological well-being, and enhanced self-efficacy.⁶¹⁻⁶³

Resistance exercise may influence mental health through neurobiological, psychological, and social pathways, including reduced inflammation, enhanced neuroplasticity, improved self-efficacy, and greater social engagement.^{62,63} The absence of an independent association between moderate-intensity physical activity and emotional health after adjustment may reflect residual confounding, measurement limitations of self-reported physical activity, or overlap between aerobic activity and other lifestyle or socioeconomic factors included in the multivariable models.

The association between strength training and loneliness

is particularly noteworthy. Although physical activity often is examined broadly, evidence suggests that activities involving structured participation and social interaction may be especially beneficial for reducing loneliness.^{64,65} Many strength-training activities may occur in social settings, such as fitness centers, exercise classes, or organized programs, which can facilitate social connection while also providing physiological benefits.⁶³

Sleep emerged as the most consistent predictor of emotional health. Obtaining the recommended 7-9 hours of sleep was consistently associated with lower odds of depression, anxiety, and loneliness, particularly for weekend sleep. Recommended weekday sleep also was associated with lower odds of overall, social, and emotional loneliness. These findings are consistent with extensive evidence linking adequate sleep with improved emotional regulation, psychological well-being, and social functioning.^{21-30,66-69} Sleep deprivation has been shown to impair emotional processing and increase social withdrawal, whereas adequate sleep may promote resilience, interpersonal engagement, and emotional stability.^{21-29,69}

Several demographic disparities also emerged. Lower household income was consistently associated with higher odds of depression, anxiety, and loneliness, highlighting the importance of social and economic determinants of emotional health.⁷⁰ Financial strain may increase chronic stress and reduce access to resources that support psychological well-being.⁷⁰ In addition, racial and ethnic differences were observed across several outcomes. These patterns may reflect differences in social support, coping strategies, cultural norms surrounding mental health, or experiences of structural disadvantage and discrimination.^{71,72}

Younger adults (18-34 years) consistently had higher odds of depression, anxiety, and loneliness than older adults. These findings align with recent studies documenting elevated mental health concerns among younger adults in the United States.^{73,74} Younger adulthood often is characterized by educational, occupational, and social transitions that may increase vulnerability to emotional distress and loneliness. However, the wide confidence intervals observed for some loneliness estimates suggest that these findings should be interpreted cautiously because of limited precision.

The distinction between social and emotional loneliness provided additional insight. Recommended weekday sleep

was associated with lower odds of both social and emotional loneliness, whereas physical activity showed few independent associations after adjustment. These findings suggest that sleep may be a more consistent correlate of loneliness than physical activity alone and underscore the interconnected nature of sleep, social relationships, and emotional well-being. Given the growing recognition of loneliness as a public health concern, interventions that promote healthy sleep behaviors may represent a promising strategy for improving both mental and social health.^{1,2,67}

Limitations

Several limitations should be considered. First, the cross-sectional design precludes causal inference, and reverse causation cannot be excluded. Second, all measures were self-reported and therefore subject to recall and social desirability bias. Third, physical activity and sleep were assessed using brief survey measures rather than objective assessments. Fourth, residual confounding from unmeasured variables cannot be excluded despite adjustment for multiple demographic and health-related covariates. Finally, potentially important factors, including sleep quality, social support, chronic stress, and preexisting mental and physical health conditions, were not available in HINTS 7 and may have influenced the observed associations.

Despite these limitations, this study has several strengths, including a large nationally representative sample and the use of survey-weighted analyses that enhance the generalizability of the findings to the U.S. adult population. The findings suggest that strength training and adequate sleep were more consistently associated with favorable emotional health outcomes than moderate-intensity physical activity alone. Future longitudinal and intervention studies are needed to clarify causal pathways and determine whether interventions targeting strength training and healthy sleep behaviors can reduce depression, anxiety, and loneliness among U.S. adults.

CONCLUSIONS

In this nationally representative sample of U.S. adults, strength training and adequate sleep were more consistently associated with favorable emotional health outcomes than moderate-intensity physical activity alone. Meeting strength-training recommendations was associated with lower odds of depression and loneliness, whereas obtaining

the recommended sleep duration was associated with lower odds of depression, anxiety, and both social and emotional loneliness. Younger adults and individuals with lower household incomes had higher odds of adverse emotional health outcomes. These findings highlight the potential value of promoting strength training and healthy sleep behaviors as modifiable strategies to support mental and social well-being. Longitudinal studies are needed to clarify causal relationships and inform targeted interventions.

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Keywords: *physical activity; sleep; depression; anxiety; loneliness*