Importance  Associations have been documented between physical activity and depressive symptoms, but the direction of this association is unclear.

Objective  To examine whether depressive symptoms are concurrent with physical activity and to examine the direction of the relationship from 23 to 50 years of age.

Design, Setting, and Participants  Participants included members of the 1958 British Birth Cohort, a general population sample of all persons born in England, Scotland, and Wales in a single week in March 1958 who were followed up to 50 years of age (2008). We included approximately 11,000 cohort members with information on depressive symptoms or frequency of physical activity at 23, 33, 42, or 50 years of age.

Exposures  Depressive symptoms were measured using the Psychological subscale of the Malaise Inventory; frequency of physical activity, by questionnaire.

Main Outcomes and Measures  Number of depressive symptoms (on a scale of 0 to 15 items), depression (defined as being in the top 10% for symptoms at 23, 33, 42, or 50 years of age), and frequency of physical activity (times per week).

Results  At most ages, we found a trend of fewer depressive symptoms with more frequent activity; for example, per higher frequency of activity per week at 50 years of age, the mean number of symptoms was lower by 0.06 (95% CI, −0.09 to −0.04). In longitudinal analyses, activity was associated with fewer symptoms from 23 to 50 years of age (per higher frequency of activity per week, symptoms were lower by 0.06 [95% CI, −0.07 to −0.05]), and the magnitude of association did not vary with age (P = .21 for interaction). Those who were inactive at 23 years of age and remained inactive 5 years later showed no change in symptom level (mean difference, −0.01 [95% CI, −0.04 to 0.02]); those increasing activity to 3 times/wk had a lower mean number of symptoms (mean difference, −0.18 [95% CI, −0.22 to −0.15]). Such differences equate to estimated reductions in odds of depression by 19%. A longitudinal relationship observed between symptoms and activity weakened with age (P < .001 for interaction). Mean activity among those with no symptoms at 23 years of age and 5 years later was higher by 0.60 (95% CI, 0.57-0.64) times/wk; in those with 1 additional depressive symptom, 0.53 (95% CI, 0.49-0.56) times/wk. Activity frequency did not differ among those with no symptoms at 43 years of age who subsequently had 0 or 1 symptom at 48 years of age. Associations for depression were generally similar to those for the full symptom spectrum.

Conclusions and Relevance  The relationship between activity and depressive symptoms was bidirectional, albeit more persistent during adult life in the direction from activity to depressive symptoms. Findings suggest that activity may alleviate depressive symptoms in the general population and, in turn, depressive symptoms in early adulthood may be a barrier to activity.

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beneficial effects of physical activity include reduced rates of all-cause mortality, stroke, and some cancers. Several studies, but not all, suggest that activity reduces the risk for depressive symptoms. If activity could prevent and/or alleviate depressive symptoms, it would represent a low-risk, low-cost population-level intervention with auxiliary somatic health benefits. However, evidence to date on activity and depression has several limitations. Most studies have been cross-sectional, from which the direction of the relationship cannot be disentangled, and from the few prospective studies, findings have been inconsistent. Some studies, particularly in adulthood, combine wide age groups, which can lead to biased results. Although a Cochrane review of intervention studies found that exercise improved symptoms in people with depression, a recent trial of depressed adults found no improvement in mood or use of antidepressants for activity facilitation compared with usual care. Such studies focus on assessing the effects of activity as a treatment for depression; however, activity may also be able to prevent the onset of depression. Also, at the general population level, people with depressive symptoms may be less likely to engage in activity than their counterparts; however, this potential explanation for observed cross-sectional associations has received little attention. Few studies examine the possibility of a bidirectional association, and to date findings have been inconclusive. To shed light on the direction of the association in the general population and determine whether relationships vary with age, we aimed to establish (1) whether depressive symptoms are concurrent with physical activity levels, and (2) whether activity influences the level of depressive symptoms and the level of depressive symptoms influences activity from early to middle adulthood.

Methods

The 1958 British Birth Cohort consists of all persons born during a single week in March 1958 across Great Britain. From the 18,558 participants ever enrolled in the study, 76.1% of the eligible sample participated at 23 years of age, and 9790 of the 15,936 alive and still living in Britain (61.4%) participated at 50 years of age. Participants in middle adulthood were broadly representative of the total surviving cohort. Our study uses data on activity and depressive symptoms collected at 23, 33, 42, and 50 years of age. The maximum sample available for longitudinal analysis was 11,135 persons (details are given below). Ethical approval was given by the South East Multi-Centre Research Ethics Committee; written informed consent was obtained from the participants.

Measures

Depressive symptoms were measured at 23, 33, and 42 years of age using 15 yes/no items from the Psychological subscale of the Malaise Inventory assessing common symptoms of depression and anxiety (eg, depressed mood, sleep disturbance, fatigue, irritability, and anxiety). A shorter version (8 items) administered at 50 years of age was prorated to a scale of 0 to 15 items (ie, the number of symptoms was divided by 8 and multiplied by 15 [Table 1]). Therefore, the full-symptom spectrum is represented at all ages by a scale of 0 to 15 items. Participants in the top (sex-specific) 10% of symptoms at each age were identified as having elevated symptom levels. Our measures do not allow identification of individuals with clinical depression, but we refer henceforth to elevated symptom levels as depression.

Leisure-time physical activity at 23 years of age was assessed by a question on the frequency of exercise in the last 4 weeks; response categories were assigned a midpoint value for the range (given in parenthesis) as at least 5 times/wk (6.00), 3 to 4 times/wk (3.50), 1 to 2 times/wk (1.50), 2 to 3 times in the last 4 weeks (0.63), 1 time in the last 4 weeks (0.25), and 0 times in the last 4 weeks (0). At 33, 42, and 50 years of age, participants were asked about regular activity frequency for most of the year with a list of examples (eg, swimming and going for walks) to aid recall. We cued the following response categories (with midpoint value for the range given in parenthesis): every day (7.00), 4 to 5 d/wk (4.50), 2 to 3 d/wk (2.50), 1 d/wk (1.00), 2 to 3 d/mo (0.63), less often (0.25), and no exercise (0).

Covariates

Potential covariates at different life stages were identified a priori from the literature (details are given in the footnotes to Table 2). At birth, information was collected on maternal age and birth order; at 11 years of age, family size and general cognitive ability using a test standardized for age in months at test administration; and in adulthood, educational qualifications, socioeconomic position (categorized using the 1990 Registrar General’s Social Classification of Occupations), number of children in the household, smoking status (self-reported), and physically limiting health conditions (identified from reported longstanding limiting illness, excluding mental illness). Body mass index (calculated as weight in kilograms divided by height in meters squared) was calculated from measurements (at 33 years of age) and self-reports (at 23, 42, and 50 years of age). Depressive symptoms at 16 years of age were assessed using a validated teacher-rated questionnaire including internalizing symptoms; for physical activity at 16 years of age, participants reported how often they were active (defined as a 4-category variable).

Statistical Analysis

Cross-sectional Analysis
We tested whether associations of activity with depressive symptoms differed by sex by including an interaction term (activity by sex). We found little evidence of interaction; hence results are reported for both sexes combined. Using linear and logistic regression, we examined relationships of activity with the full symptom spectrum (range, 0-15) and depression (binary outcome), respectively, adjusting for sex. Associations were examined with and without adjustment for life stage–appropriate covariates (given in the footnotes to Table 2).
Abbreviation: OR, odds ratio.

### Table 1. Depressive Symptoms and Physical Activity by Sex

<table>
<thead>
<tr>
<th>Covariate</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>23</td>
<td>33</td>
</tr>
<tr>
<td>Depression, No. (%) of participants(a)</td>
<td>728 (11.7)</td>
<td>610 (11.0)</td>
</tr>
<tr>
<td>No. of depressive symptoms, mean (SD)(b)</td>
<td>1.40 (1.85)</td>
<td>1.28 (1.95)</td>
</tr>
<tr>
<td>Frequency of physical activity, mean (SD) times/wk</td>
<td>1.37 (1.86)</td>
<td>2.34 (2.43)</td>
</tr>
</tbody>
</table>

\(a\) Indicates participants with the highest 10% of symptoms (sex specific) at each age.

\(b\) Determined using the Psychological subscale of the Malaise Inventory: mean of 15 items, except 8 items at 50 years of age (prorated to the 15-item scale). If 1 or 2 items from the Malaise Inventory were not completed, total scores were prorated on the basis of the answered items (ie, the mean was calculated on the basis of available items and multiplied by 15 for 118 participants at 23 years of age; 118 at 33 years of age, 10 at 42 years of age, and 15 [by 8 items] at 50 years of age). If more than 2 items were incomplete, the Malaise Inventory score was considered to be missing.

### Table 2. Cross-Sectional Associations of Mean Difference in Number of Depressive Symptoms and Odds for Depression\(a\) by Physical Activity

<table>
<thead>
<tr>
<th>Age at Physical Activity Measurement, y</th>
<th>No. of Participants</th>
<th>No. of Depressive Symptoms, Mean Difference (95% CI)</th>
<th>OR for Depression (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Unadjusted(b) Adjusted(c) Unadjusted(b) Adjusted(c)</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>12 466</td>
<td>−0.13 (−0.16 to −0.11) −0.08 (−0.10 to −0.05) 0.84 (0.80 to 0.87) 0.90 (0.86 to 0.94)</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>11 304</td>
<td>−0.02 (−0.03 to 0.001) −0.01 (−0.02 to 0.01) 0.97 (0.95 to 0.99) 0.98 (0.95 to 1.00)</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>11 274</td>
<td>−0.07 (−0.09 to −0.05) −0.06 (−0.08 to −0.04) 0.93 (0.91 to 0.96) 0.94 (0.92 to 0.96)</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>9633</td>
<td>−0.06 (−0.09 to −0.04) −0.05 (−0.08 to −0.02) 0.96 (0.93 to 0.98) 0.97 (0.95 to 0.99)</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: OR, odds ratio.

\(a\) Top 10% of symptoms (sex specific) at each age.

\(b\) Adjusted for sex.

\(c\) Adjusted for sex, maternal age at birth (range, 14-48 years), birth order (first, second to fourth, or fifth or greater), cognitive ability at 11 years of age, family size (number of children younger than 21 years living in the house, <3 or ≥3) at 11 years of age, concurrent body mass index and social class I (professional) or II, III nonmanual, III manual, and IV or V (unskilled). Analyses at 23, 33, and 42 years of age were also adjusted for concurrent educational level, smoking status, number of children in the household, and physical disability at 42 years of age.

### Longitudinal Analysis

We used multilevel regression to model the association of physical activity with depressive symptoms (23–50 years of age) to account for repeated observations of depressive symptoms in the same individual over time. Thus, at 23 to 50 years of age, depressive symptoms constituted the outcome and physical activity (frequency per week) constituted the time-varying exposure of interest. The modeled regression slope represents the change in number of symptoms per year. Random effects at the individual level were included, allowing the intercept and slope to vary between individuals. Therefore, an individual’s symptoms were distributed around their person-specific regression line, and, in turn, person-specific regression lines were distributed around the population-level regression line. The association was adjusted for sex and depressive symptoms at 16 years of age. We tested whether the association between activity and depressive symptoms at 23 to 50 years of age varied by sex with an interaction term (activity by age). We examined whether the relationship between depressive symptoms and age was nonlinear by including an age-squared term. Next, the association between activity and symptoms was adjusted for factors occurring by 23 years of age (detailed in the footnotes to Table 3). For illustrative purposes we report estimated mean change in the number of depressive symptoms associated with changing activity during a 5-year period (eg, for those active 0 times/wk at 23 years of age and 3 times/wk at 28 years of age). Analyses were repeated for the binary outcome, depression, using a random intercept logistic regression model because depression was set at 10% for each age.

We examined depressive symptoms and physical activity from 23 to 50 years of age in a similar manner to that described above with activity (frequency per week) as the outcome and depressive symptoms as the time-varying exposure of interest. In sensitivity analysis, all analyses were repeated using a 0- to 8-item Malaise Inventory scale (similar to that used at 50 years of age) at all ages.

When we used all available data, sample sizes ranged from 12 466 at 23 years of age to 9633 at 50 years of age for the cross-sectional analyses. Sample sizes ranged from 10 947 to 11 135 for longitudinal analyses. Multilevel modeling allows for missing outcome data, so that participants with one age of measurement for depressive symptoms or for activity were included in respective analyses. To minimize data loss, missing covariates were imputed using multiple imputation chained equations; imputation models included all model variables plus previously identified key predictors of missingness, that is, cognitive ability and socioemotional behavior at 7 years of age and social class at birth and in adulthood. Regression analyses were run across 10 imputed data sets. Imputed results were broadly similar to those using observed values; the former are presented herein.
Results

Mean activity frequency varied at 23 to 50 years of age from 1.37 to 2.65 times/wk in men and 0.63 to 2.85 times/wk in women (Table 1). Mean (SD) number of depressive symptoms also varied at 23 to 50 years of age, from 1.40 (1.85) to 2.13 (3.07) for men and from 2.50 (2.49) to 3.14 (3.60) for women (Table 1).

Cross-sectional Associations

At all ages except 33 years, we found a trend of fewer depressive symptoms with more frequent activity; the mean number of symptoms was lower by 0.06 (95% CI, −0.09 to −0.04) per higher frequency per week in activity at 50 years of age and by 0.13 (95% CI, −0.16 to −0.11) at 23 years of age (Table 2). The odds ratio for depression was lower by 3% (at 33 years of age) to 16% (at 23 years of age) per higher activity frequency per week. Generally, associations attenuated but remained after adjustment.

Longitudinal Associations

Depressive Symptoms and Depression as Outcome

The relationship of physical activity with depressive symptoms from 23 to 50 years of age did not vary with age (P = .21 for interaction); that is, at all ages, symptoms were lower by approximately 0.06 per increase in activity frequency compared with those remaining inactive (Table 3). The estimated change in the mean number of symptoms varied with age (ie, the relationship between depressive symptoms and age was nonlinear [for age2, P < .001]), but this did not affect the association between activity frequency and symptoms. To illustrate, among those participants who were inactive at 23 years of age and became active 1 time/wk 5 years later, the mean symptom level was lower by 0.07 (95% CI, −0.09 to −0.04) compared with 0.01 (95% CI, −0.04 to 0.02) had they remained inactive. Among the inactive participants at 43 years of age who became active 1 time/wk 5 years later, mean symptom level was 0.31 (95% CI, 0.29-0.34) compared with 0.37 (95% CI, 0.35-0.40) had they remained inactive (ie, in both cases, the reduction was approximately 0.06 symptoms per increase in activity frequency). Results were little altered after adjustment.

<table>
<thead>
<tr>
<th>Physical Activity</th>
<th>No. of Depressive Symptoms, Mean Difference (95% CI)</th>
<th>OR for Depression (95% CI)*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadjusted</td>
<td>Adjusted</td>
</tr>
<tr>
<td>Any age 23-50 y, activity times per week</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>1</td>
<td>−0.06 (−0.07 to −0.05)</td>
<td>−0.05 (−0.06 to −0.04)</td>
</tr>
<tr>
<td>3</td>
<td>−0.17 (−0.20 to −0.14)</td>
<td>−0.15 (−0.18 to −0.12)</td>
</tr>
<tr>
<td>5</td>
<td>−0.29 (−0.34 to −0.24)</td>
<td>−0.26 (−0.31 to −0.21)</td>
</tr>
<tr>
<td>Inactive at age 23 y, activity times per week 5 y later</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>−0.01 (−0.04 to 0.02)</td>
<td>−0.02 (−0.04 to 0.01)</td>
</tr>
<tr>
<td>1</td>
<td>−0.07 (−0.09 to −0.04)</td>
<td>−0.07 (−0.10 to −0.04)</td>
</tr>
<tr>
<td>3</td>
<td>−0.18 (−0.22 to −0.15)</td>
<td>−0.17 (−0.21 to −0.13)</td>
</tr>
<tr>
<td>5</td>
<td>−0.30 (−0.35 to −0.25)</td>
<td>−0.27 (−0.32 to −0.22)</td>
</tr>
<tr>
<td>Inactive at age 33 y, activity times per week 5 y later</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0.18 (0.17 to 0.19)</td>
<td>0.18 (0.16 to 0.19)</td>
</tr>
<tr>
<td>1</td>
<td>0.12 (0.11 to 0.14)</td>
<td>0.13 (0.11 to 0.14)</td>
</tr>
<tr>
<td>3</td>
<td>0.01 (−0.02 to 0.04)</td>
<td>0.02 (−0.01 to 0.05)</td>
</tr>
<tr>
<td>5</td>
<td>−0.11 (−0.16 to −0.06)</td>
<td>−0.08 (−0.13 to −0.03)</td>
</tr>
<tr>
<td>Inactive at age 43 y, activity times per week 5 y later</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0.37 (0.35 to 0.40)</td>
<td>0.37 (0.35 to 0.40)</td>
</tr>
<tr>
<td>1</td>
<td>0.31 (0.29 to 0.34)</td>
<td>0.32 (0.29 to 0.35)</td>
</tr>
<tr>
<td>3</td>
<td>0.20 (0.16 to 0.24)</td>
<td>0.22 (0.18 to 0.26)</td>
</tr>
<tr>
<td>5</td>
<td>0.08 (0.03 to 0.14)</td>
<td>0.12 (0.06 to 0.17)</td>
</tr>
</tbody>
</table>

Abbreviation: OR, odds ratio.

* Includes 11 135 participants.

† Top 10% of symptoms (sex specific) at each age.

‡ Adjusted for sex and depressive symptoms at 16 years of age.

§ Additionally adjusted for maternal age at birth, birth order, family size, cognitive ability, body mass index, social class, educational level, smoking status, number of children, and physical disability.
Physical Activity as Outcome
The relationship between depressive symptom level and physical activity from 23 to 50 years of age weakened with age ($P < .001$ for interaction). One higher symptom was associated with lower activity by $0.09 (95\% \text{ CI}, -0.10$ to $-0.07)$ times/wk at 23 years of age and by $0.05 (95\% \text{ CI}, -0.06$ to $-0.03)$ times/wk at 43 years of age (Table 4). For those with no symptoms at 23 years of age who remained symptom free at 28 years of age, mean increase in activity was $0.60 (95\% \text{ CI}, 0.57$ to $0.64)$ times/wk, whereas for those with an increase of 1 depressive symptom at 28 years of age, the mean increase in activity was lower ($0.53 (95\% \text{ CI}, 0.50$ to $0.56)$ times/wk). Corresponding mean increases in activity at 33 and 43 years of age were $0.31 (95\% \text{ CI}, 0.29$ to $0.33)$ and $0.25 (95\% \text{ CI}, 0.23$ to $0.27)$ times/wk, respectively. Because the relationship between symptoms and activity weakened with age by 43 years among those with no symptoms, we found no difference in activity frequency between those who remained symptom free by 48 years of age or who had an increase of 1 symptom. Results were little altered after adjustment. However, the relationship between depression and activity did not vary with age ($P = .24$ for interaction); across all ages, those participants with depression were less active by $0.27 (95\% \text{ CI}, -0.35$ to $-0.19)$ times/wk. To illustrate, among the nondepressed participants at 23 years of age, the mean increase in activity 5 years later was $0.63 (95\% \text{ CI}, 0.60$ to $0.66)$ times/wk for those who remained depression free, but $0.36 (95\% \text{ CI}, 0.28$ to $0.44)$ times/wk for those with depression (Table 4).

Discussion
In a general population sample, we found associations between physical activity and level of depressive symptoms across multiple decades of adult life and that the association is bidirectional. Greater activity frequency predicted a lower number of depressive symptoms; increasing activity from 0 to 3 times/wk predicted fewer symptoms, by $0.17$ of a symptom, equating to a $19\%$ reduction in the odds of depression. Higher levels of depressive symptoms predicted less frequent physical activity, but this association was strongest in young adulthood and diminished with increasing age, such that it was no longer evident in middle adulthood. In general, associations observed across the full spectrum of symptoms were similar to those observed for depression.

Methodological Considerations
Study strengths include the availability of prospectively measured covariates, enabling adjustment for life stage-appropriate socioeconomic and lifestyle characteristics, including body mass index. The main study strength is the repeated measurement of activity and depressive symptoms assessed using the same or similar survey instruments (ie, frequency per week, Malaise Inventory); few other studies have comparable data. The Malaise Inventory allowed examination of the full symptom spectrum and those participants with
elevated levels of depressive symptoms. We focused on concurrent associations because of lengthy intervals in our study and the low stability of activity in adulthood.25

We acknowledge some study limitations. Activity was measured using questionnaires and lacked information on intensity and duration. Questionnaire-based activity measures may be prone to misclassification, although they are considered to be adequate for the purpose of ranking individuals by activity levels for assessing associations.26 Questionnaires are less intrusive, intensive, and expensive than more objective measures. Therefore, large numbers of people can undergo measurement, people are less likely to change their habits during measurement, and patterns during long periods can be captured. However, we cannot discount the possibility of differential reporting of activity among depressed and nondepressed participants. At all ages except 23 years, a list of examples was provided to aid activity recall. This recall aid may, in part, explain the trend in activity with age, although a similar trend of an increasing percentage of activity has been noted across all age groups from 1997 to 2008 in the Health Survey for England.27 As in previous work,2-6 our mental health measure does not provide a clinical diagnosis, and our arbitrary cutoff identifies those with the most elevated levels of depressive symptoms at each age. A sex-specific cutoff was used to avoid the possibility of artificial trends between depression and age (particularly in men). Despite its limitations, the Malaise Inventory is commonly used in epidemiological studies to screen for depressive tendencies28 and has good reliability and external validity consistent with the clinical assessment of depression and antidepressant use.24 The 8-item scale measure for 50 years of age was prorated to a 0- to 15-item scale similar to other ages; sensitivity analyses using an 8-item scale at all ages confirmed findings reported herein. We used the Psychological subscale of the Malaise Inventory rather than the full scale to overcome the problem of higher somatic scores with increasing age owing to physical rather than mental ill health.29 The study is observational; thus, despite adjustment for multiple factors, residual confounding (eg, due to limitations of measures, such as self-reported body mass index, at some ages) or uncontrolled covariates could account for some of the associations. Finally, sample attrition has occurred over the decades of follow-up. Although participants in middle adulthood are broadly representative of the surviving cohort, those with internalizing or externalizing problems at 7 years of age were more likely to be lost to follow-up.30 This selective dropout could result in underestimation of associations between physical activity and depressive symptoms with increasing age. Our analyses were designed to minimize susceptibility to bias (eg, related to selective dropout) in that multilevel models maximize the available data by including participants with at least 1 outcome measure (depressive symptoms or physical activity at 23-50 years of age). Provided that given their observed data, the reason for dropout does not depend on unseen responses (ie, the data are missing at random), parameter estimates from multilevel models are likely to be valid. Because complete observations (on outcome) were not required, longitudinal analyses were based on approximately 11 000 participants, and we used multiple imputation to avoid sample reductions owing to missing information on covariates.

Interpretation and Comparison With Other Studies
Our cross-sectional findings agree with previous work across the full spectrum of depressive symptoms3 and for participants with depression.5,9 Our longitudinal analyses suggest that bidirectional associations agree with most15,17,18 but not all16 previous studies examining both directions of association. We estimate that increasing activity from 0 to 3 times/wk predicts a mean decrease of 0.17 symptoms. Such a shift in the population symptom distribution could result in substantial benefits, with a reduction in the odds of depression by 19%. A reduction in the prevalence of depression in working-aged adults is important because poor mental health increases absence due to sickness, labor turnover, and accidents, thereby also reducing economic productivity.29 The reverse association from symptoms to activity diminished with age. For example, women with no symptoms exercised a mean of 1 time per week, whereas those with 3 and 7 symptoms exercised a mean of 0.8 and 0.4 times per week, respectively, at 23 years of age, with differences also at 33 years of age (2.1, 1.9, and 1.6 times per week, respectively). Such bidirectional associations have been suggested for depression and obesity.30 Adiposity could mediate between activity and depressive symptoms; if depression is causally related to obesity, obesity in turn may reduce the likelihood of being active. Alternatively, lack of activity may contribute to obesity, which in turn may be causally related to depression. However, other explanations may be involved because we show that the association is independent of body mass index.

Our longitudinal finding of a beneficial association of activity with symptoms agrees with previous work in young2,9 and older adults.17,18 However, our study is novel because we can demonstrate consistent associations at different adult life stages for the full symptom spectrum and for those with depression. Some studies fail to find any association,3,10 but discrepant findings may be the result of small sample sizes,3 focus on a depressed population,10 or wide intervals between measures.2 Activity could confer a protective effect against depression through several potential mechanisms. Distraction from stressful stimuli, as opposed to activity per se, may improve mental health,19 and/or activity may affect other factors, such as dietary patterns, exposure to sunlight, and associated vitamin D levels that have potential benefits for mental health.30-33 Activity also presents opportunities for greater social interaction, connectedness, and development of social skills.8,15 Whether activity affects mental health more directly is not well understood, with much of the available evidence coming from animal studies.34 However, various pathways have been hypothesized, including the involvement of endocannabinoids.34 Activity may be beneficial because of neurotransmitters and neurotrophic factors (eg, brain-derived neurotrophic factors). Neurotrophic factors are synthesized in response to exercise and can cross the blood-brain barrier to act directly on brain structures.34 Activity might also affect mental health via an endorphin mechanism.30 A further possibility is that factors, such as the brain-derived neurotrophic fac-
tor genotype, moderate the relationship between activity and depressive symptoms.36 Yet another hypothesis is that genetic factors predict activity and depressive symptoms.37,38 Although we cannot rule out this possibility, how it could explain the time-varying, bidirectional association seen in our study remains unclear.

With regard to our finding of an inverse diminishing relationship between symptoms and activity, our work spanning several decades puts into context previous studies from which the diminishing association is difficult to detect. To our knowledge, the only other longitudinal study in young adulthood found no association, but that study was in a smaller sample with a wider age range.39 Our findings identify depressive symptoms in young adults as a potential barrier to activity. This context is important because an understanding of modifiable factors associated with activity initiation is relevant to developing effective (age group-specific) interventions.39 Mechanisms through which depressive symptoms could reduce activity include anhedonia and psychomotor retardation,15 low energy levels or apathy,40 or social isolation that reduces the motivation to be active.41 Why the relationship would diminish with age is not clear. One possibility is statistical artifact from regression to the mean (i.e., the most active or inactive at younger ages tends to move toward the mean activity level at subsequent ages). Alternatively, symptoms may have little association with activity at older ages, as supported by a study in an elderly population.17

Conclusions

Our findings emphasize the potential importance of activity to prevent and alleviate depressive symptoms in adulthood and, in turn, depressive symptoms before midlife could be a barrier to activity. From a public health perspective, evidence to date suggests that even low levels of activity can protect against depression.42 Given the effect of inactivity on heart disease, diabetes mellitus, and some cancers,1 our findings highlight its wider relevance for depressive symptoms. From a clinical perspective, our study suggests that practitioners helping patients to recover from depression might address activity within their treatment plan for lifestyle factors.43 Strategies to maintain and promote physical activity at all ages are warranted, whereas depressive symptoms could be considered a potential barrier to activity.
Research Original Investigation


