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Long-Term Physical Activity Patterns and Health-Related Quality of Life in U.S. Women

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Abstract

Background—Despite studies showing that physically active individuals report higher quality of life scores, few data exist on the impact of changing physical activity levels on subsequent changes in quality of life.

Methods—Subjects were 63,152 women in the Nurses' Health Study aged 40–67 years in 1986. Women reported their physical activity on questionnaires in 1986, 1988, 1992, 1994 and 1996, and were grouped according to quartile of change in activity from 1986–1996. Women also reported seven health-related quality of life dimensions in 1996 and 2000 using the Medical Outcomes Study Short-Form 36 Health Status Survey. The main outcome measures were scores for each of these seven dimensions in 1996, as well as changes in each of these dimensions from 1996 to 2000. Data were analyzed in 2006.

Results—In age and baseline activity adjusted analyses, compared to women whose physical activity was relatively stable from 1986 to 1996, women who saw any increase in physical activity levels had higher quality of life scores in 1996. Among women with a clear increase in physical activity, the increase in quality of life scores ranged from 2.23 (95% CI 1.94, 2.52) for mental health to 8.23 (95% CI 7.49, 8.97) for role limitations due to physical problems. Increasing physical activity also was associated with greater increases in quality of life scores from 1996 to 2000 compared to women whose physical activity level was stable. The strongest association was for role limitations due to physical problems, where women with a clear increase in physical activity had a significant improvement in (1.81, 95% CI 1.09, 2.53) in the outcome.

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Conclusion—Long-term physical activity patterns are an important determinant of health-related quality of life.

BACKGROUND

Physical inactivity is associated with increased risk of many adverse health conditions, including obesity, cardiovascular disease, diabetes and certain cancers.¹ In addition, active individuals often report higher health-related quality of life scores, an association that is supported by a conceptual model proposed by Stewart and King.^{2, 3} Short-term intervention studies have found increases in physical activity to be associated with improved quality of life.^{4, 5} However, no longitudinal study has investigated the relationship between long-term change in physical activity and subsequent change in health-related quality of life.

Cross-sectional analyses have found that higher levels of physical activity were positively associated with physical functioning, vitality, and mental health in women.^{6–9} In other cross-sectional analyses, physically active individuals reported fewer unhealthy days (physical or mental),^{10–12} though this finding is not universal.¹³ Cross-sectional research also suggests physical activity is associated with greater well-being, successful aging and improved global quality of life,^{4, 14–16} though some studies have found no association.^{17, 18} The equivocal results may be due to differences in research design and the small sample sizes employed in some studies.

Longitudinal research has consistently found that physical activity is associated with better well-being and physical functioning.^{5, 19–22} Physical activity has also predicted decreased risk of declining self rated health,²⁰ improved social functioning,²³ less difficulty with activities of daily living,¹⁹ and successful aging.²⁴ Only one longitudinal study has examined the influence of change in physical activity,²³ but it employed simultaneous assessments of change in physical activity and change in quality of life raising the possibility that changes in quality of life preceded change in activity or that underlying conditions caused both changes.

Other research investigating change in physical activity has consisted primarily of short-term exercise intervention studies with mixed results; some find exercise programs improve quality of life, but many find no relationship.^{2, 4, 5, 25–28} These equivocal results may be due to varying population demographics and intervention designs, small sample sizes or study design limitations (such as the post hoc grouping of subjects by intervention adherence or lack of a control group). Furthermore, the changes made in these intervention studies may not reflect sustained change over the long term.

While research has examined the relationship between physical activity and health-related quality of life at single time points, longitudinal research on the impact of changing physical activity, especially over the long term, on quality of life is limited and reverse causation cannot be ruled out. Exercise training programs provide suggestive data about improved quality of life with in the short term, but we have limited data on the long term impact. With only half of U.S. adults meeting recommended physical activity levels and an additional 26% considered inactive,²⁹ it is important to understand the effect that changing physical activity patterns may have on health-related quality of life. Thus, we sought to examine the relation between activity and quality of life in a large population of healthy women.

METHODS

Study Population

The Nurses' Health Study was established in 1976 when 121,700 U.S. female registered nurses between the ages of 30 and 55 completed a self-administered questionnaire on their health

behaviors, lifestyle and medical histories. Subsequent follow-up surveys were sent to the women on a biennial basis to obtain updated information on lifestyle factors and health outcomes. This study was approved by the human subjects' protection committee at Brigham and Women's Hospital.

Health-Related Quality of Life

In 1996 and 2000, the Medical Outcomes Study Short-Form 36 Health Status Survey (SF-36) was administered to the cohort.³⁰ The SF-36 is a self-administered 36-item questionnaire that measures health-related quality of life in eight domains: physical functioning, role limitations due to physical problems, role limitations due to emotional problems, vitality, bodily pain, social functioning, mental health, and general health perception. Each domain is scored separately with values ranging from zero to 100 (lowest to highest level of functioning). The validity and reliability of the SF-36 has been established.^{30, 31} The general health perceptions scale of the SF-36 was not included in these analyses due to the omission of one item from the 1996 questionnaire. We initially considered 1996 SF-36 scores as the outcome of interest. We then examined change in SF-36 subscale scores between 1996 and 2000. Change in SF-36 subscale was modeled by taking the difference of each continuous variable (2000 minus 1996 scores).

Physical Activity

Physical activity was assessed in 1986, 1988, 1992, 1994, and 1996. In 1986 women were asked to report the average time per week spent in each of eight common leisure-time activities: walking or hiking outdoors, jogging, running, bicycling, lap swimming, playing tennis, playing squash or racquetball, and participating in calisthenics, aerobics, aerobic dance, or use of a rowing machine. Individuals also reported their usual walking pace and number of flights of stairs climbed daily. These data were used to derive a weekly physical activity score expressed in MET hours.³² This assessment of physical activity was found to be reliable and valid in a similar cohort of younger nurses with good correlation with weekly recalls ($r=0.79$) and activity diaries ($r=0.62$).³³

The physical activity questions changed slightly between 1986 and 1996 as items were added and example activities were modified to account for changing physical activity trends. The addition of two items in 1992 changed the mean MET hours per week from 15.5 in 1988 to 19.1 in 1992. Other questionnaire changes resulted in smaller changes in mean MET hours per week. Thus, we took the Z-score of each participant's physical activity at each time point by subtracting the mean for that year and dividing by the standard deviation. Women had to have physical activity information for at least three of the five time points between 1986 and 1996 to be included. This resulted in the exclusion of 31,488 women.

To examine change in activity over the ten-year period from 1986 to 1996, we employed a linear regression of physical activity Z-scores on time. The slope of the line represents change over the 10-year period. We then grouped the coefficients of the slopes into quartiles: (1) slope less than or equal to -0.075 , (2) greater than -0.075 but less than or equal to -0.003 , (3) greater than -0.003 but less than or equal to 0.073 and 4) greater than 0.073 . Women in quartile one had a median activity level of 22.7 MET hours per week in 1986, which decreased to a median of 7.9 MET hours per week in 1996. In contrast, women in quartile 4 had a median activity level of 6.4 MET hours per week in 1986 and a median of 30.2 MET hours per week in 1996. Women in quartile one generally represent women who declined in physical activity over time, while women in quartile four tended to increase their physical activity over time. In contrast, women in the second quartile had a relatively stable physical activity level and women in the third quartile had some increase in physical activity. Women in the second quartile, who had no change in physical activity, were the reference group.

The “baseline” physical activity level for each woman was also assessed. For women who reported their physical activity data in 1986, these values were used as the baseline. For women without physical activity information in 1986 but with data in 1988, the 1988 values were used as “baseline.” For women reporting neither 1986 nor 1988 physical activity information, “baseline” physical activity was taken as the value reported in 1992.

Covariates

Body mass index (BMI) was calculated using height from the 1976 questionnaire and weight as reported on the 1986 questionnaire. If weight was not reported in 1986 we used the closest available weight from those reported in 1984, 1982 or 1980. The validity of self-reported weight in this cohort has been established, where questionnaire weights were highly correlated with measured weights (Spearman $r=0.96$) in a sub-sample of the cohort.³⁴ Smoking was self-reported as never, past or current use in 1986. Women also reported a diagnosis of arthritis (except in 1994 and 1998), hypertension, diabetes and hypercholesterolemia biennially from 1986 through 2000.

Data Analyses

We excluded women missing more than 50% of the responses within each quality of life outcome scale. If a participant had missing information on less than half of the responses we used an imputation procedure where missing values are replaced with the mean of the responses from the other items in the same sub-scale.³⁰ This approach will not underestimate the variance when the inter-item correlation is high and non response is low as is the case here. Based on previous work in this cohort, women not completing the health-related quality of life assessment tended to be older, heavier, and more sedentary.⁸ A total of 10,826 women did not have values for any 1996 SF-36 subscale. To control for underlying illness as confounder we also excluded women who reported a diagnosis of cancer other than non-melanoma skin cancer ($n=10155$) or heart disease (angina or myocardial infarction) ($n=6079$) through the 1996 survey. 63,152 women met all necessary criteria.

Ordinary least squares regression was used to estimate the effect of quartile of change in long-term physical activity on 1996 SF-36 scores, treated as categorical variables, adjusting for age and baseline physical activity level. Analyses were conducted in 2006. We also estimated the association between quartiles of long-term physical activity and change in SF-36 scores from 1996 to 2000 adjusting for baseline SF-36 score (1996), baseline physical activity and age. Baseline SF-36 score and baseline physical activity were included as continuous variables. Age was divided into seven categories. The coefficients from ordinary least squares regression represent the differences between exposure groups in the value of the outcome (either 1996 SF-36 score or change in SF-36 score), adjusted for the other variables in the model; as a result, the null value is 0.

In multivariate analyses, we adjusted for BMI (in four categories: normal ($BMI < 25$), overweight ($25 \leq BMI < 30$), Class I Obese ($30 \leq BMI < 35$) and Class II Obese ($BMI \geq 35$)) and smoking. Additionally, we adjusted for chronic conditions by creating a variable for four conditions related to quality of life (arthritis, hypertension, diabetes and hypercholesterolemia). The chronic conditions variable was computed as the sum of the number of conditions reported in 1986 ranging from zero to four and was modeled as a categorical variable.

In an attempt to evaluate variation in the association by risk factor strata, we stratified analyses by level of BMI, quartile of baseline physical activity, smoking status and development of chronic conditions (arthritis, hypertension, diabetes or hypercholesterolemia) through 2000.

RESULTS

The mean age of the study population was 52 years (range, 40 to 67) in 1986. The median physical activity level in 1986 was 7.8 MET hours per week. In accordance with the changes in the questionnaire described above, the median activity level rose in 1988 to 9.0 MET hours per week, in 1992 to 12.2 MET hours per week, and in 1994 to 12.7 MET hours per week. In 1996, the median declined slightly to 11.0 MET hours per week. Physical activity change slopes ranged from -6.3 to 13.9 with a mean of 0.003. The mean BMI in 1986 was 24.5 kg/m². While 20 percent of participants were current smokers in 1986, 45 percent had never smoked.

Women whose activity decreased had the highest median level of physical activity in 1986 (Table 1). Women whose activity increased had the highest median levels of physical activity in 1996. Mean BMI did not vary substantially across quartiles of physical activity change. With the possible exception of hypertension, the prevalence of the four chronic conditions did not markedly vary across quartiles of physical activity change.

In general, women reported high scores on all dimensions of health-related quality of life. All scales had median scores of 70 or above. Social functioning, role limitations due to physical problems and role limitations due to social problems all had a median score of 100. The mean change in SF-36 scores from 1996 to 2000 was generally not large, but there was a wide range indicating that women both increased and decreased scores during this time (Figure 1).

Compared to women who did not change their physical activity, women who had some or substantial increases in physical activity from 1986 to 1996 had higher 1996 SF-36 scores. (Table 2) Women whose activity increased had an eight-unit higher score in physical functioning (8.19, 95% CI 7.76, 8.62) and role limitations due to physical problems (8.23, 95% CI 7.49, 8.97) scores than women whose activity was stable. The smallest improvement was on the mental health scale where increasing physical activity was associated with a 2.23 (95% CI 1.94, 2.52) unit higher score compared to women with a stable physical activity level.

Improvement in physical activity profile was also associated with a subsequent increase in SF-36 scores. Women who increased their activity saw over a two unit (2.64, 95% CI 1.90, 3.38) greater improvement in role limitations due to physical problems from 1996 to 2000 as compared to women with stable physical activity from 1986 to 1996. Long-term physical activity patterns had the smallest impact on mental health, where the increases in SF-36 score change were small for all groups of physical activity change, including women who increased their physical activity (0.35, 95% CI 0.12, 0.58).

Further adjustment for smoking, BMI and chronic conditions slightly attenuated change in SF-36 scores. The greatest attenuations occurred for role limitations due to physical problems, where, among women who increased their physical activity, the adjusted score fell from 2.64 (95% CI 1.90, 3.38) to 1.81 (95% CI 1.09, 2.53), and bodily pain, which decreased from 1.20 (95% CI 0.81, 1.59) to 0.75 (95% CI 0.38, 1.12).

When evaluating relations within strata of baseline BMI, the findings remained quite consistent across the three categories of BMI less than 35 (Table 3). However, in Class II obese women, increasing physical activity was associated with larger improvements in both social functioning and role limitations due to emotional problems, while having little impact on vitality as compared to women whose physical activity was stable. In analyses stratified by baseline smoking status (Table 4), the association appeared to differ only for role limitations due to emotional problems and vitality.

Women who developed chronic conditions (arthritis, hypertension, diabetes, hypercholesterolemia) between 1986 and 2000 had the greatest improvements for all domains

except bodily pain and role limitations due to physical problems when comparing women who increased their activity to women whose activity was stable (Table 5). Women who developed chronic conditions before 1986 had slightly higher coefficients, comparing women who increased activity to those with stable activity, than women who remained free of chronic conditions through 2000, with the exception of physical functioning (1.57 vs. 1.56) and social functioning (0.47 vs. 0.43). In analyses by quartile of baseline physical activity there was no substantial variation across strata with the possible exception of role limitations due to physical problems (data not shown).

DISCUSSION

In this large prospective study, long-term physical activity patterns appeared to play an important role in determining health-related quality of life among women. Women with stable physical activity over a 10-year period, did not experience the increases in quality of life experienced by women who increased their physical activity. The improvements in quality of life were observed after adjusting for potential confounders and remained across strata of BMI, smoking, chronic conditions and baseline physical activity. These data support the current emphasis on increasing physical activity levels among U.S. women, who are largely sedentary.³⁵ In the present study, women in quartile three, who did not meet current physical activity recommendations in 1986 (median, 4.2 MET-hrs/week), but increased their activity levels so that they met them in 1992 (10.9 MET-hrs/week), experienced improvements in scores in several quality of life domains. These findings may also highlight that particular concern needs to be paid to the quality of life concerns of women whose physical activity levels may be declining for a number of reasons.

The magnitude of improvement in quality-of-life associated with improvements in physical activity was substantial. We observed at least an eight-point difference in 1996 SF-36 scores associated comparing women with stable physical activity to those who increased their physical activity for physical functioning and role limitations due to physical problems. A three-point difference on the mental health subscale is thought to be equivalent to the impact of being fired or laid off.³⁶ The improvements in social functioning score associated with increasing physical activity suggest that a physically active lifestyle has benefits beyond those associated with fitness and weight. Physically active individuals may also benefit from the social interactions associated with their activities.

Our exposure choice has certain limitations. Using quartiles based on the change in activity regression coefficient as our measure of change implies that differences exist at the cutpoints which may not reflect true thresholds in the effect. However, our change measure is more comprehensive than those used previously as we are able to look at activity measured prospectively at five time points. The use of more physical activity measures than any previous assessment of physical activity change suggests any change in physical activity reported by our measure is more likely to reflect true change and not compounded measurement error as may occur when using only two time points. Modifications to the physical activity questionnaire between survey administrations may result in variation in reported physical activity levels even when true levels remain unchanged, as individuals' reported activity level may change depending on the number of activities requested.³⁷ We accounted for this by taking the Z-score of each participant's level and using those scores to create the change in physical activity measure, normalizing for the change in mean activity induced by the questionnaire. We note that women in quartile one had a decline in physical activity over the 10 year period which may be due to unmeasured comorbidities. We chose to use quartile two (women with no change in physical activity) as our reference group in part to address this concern. We also adjusted for several comorbidities and still found a significant association.

Opportunity for change in our health-related quality of life measures may have been somewhat limited in our analyses as baseline scores were high. However, change in SF-36 scores had a wide range. We did adjust for baseline SF-36 score to account for the potential ceiling effect. We found a significant positive association of change in physical activity with change in quality of life when adjusting for the high baseline SF-36 scores, but found a smaller significant inverse association when we did not account for the high baseline SF-36 scores (data not shown). We believe this is likely due to regression to the mean due to the ceiling effects in SF-36 scores. Cross-sectional analyses of the 2000 SF-36 scores showed similar findings to the 1996 cross-sectional results presented (data not shown). We believe this lends further support to our conclusion that increasing physical activity is associated with increases in quality of life. However, our results are sensitive to the analytic approach employed.

Finally, incomplete control for underlying health status may confound our results. We addressed this by adjusting for four chronic conditions and baseline SF-36 score. Despite this, the possibility remains that the association we found may be a function of some other factor like onset of undiagnosed disease. We used ordinary least squares regression despite the ceiling effects present in the data. Ordinary least squares regression does well in large samples, as we have here, and has been used in analyses of quality of life elsewhere.^{23, 38}

Debate exists regarding adjustment for baseline values of the dependent variable in analyses of change.³⁹ However, we believe baseline adjustment was appropriate given the strong ceiling effect present in this study; three of the SF-36 scales (role emotional, role physical and social functioning) had median scores of 100 (the scale maximum) and two others (mental health and physical functioning) had median scores over 80. These high median scores indicate that many subjects could not increase their scores between 1996 and 2000. Thus, our analyses may be subject to regression to the mean. If this were the case, and if the exposure were correlated with the outcome at time 1 (as was the case in the present study, where change in physical activity between 1986 and 1996 was related to 1996 SF-36 scores), then a spurious negative relation may be observed between the exposure (i.e., change in physical activity between 1986 and 1996) and change in the outcome from time 1 to time 2 (i.e., change in SF-36 scores between 1996 and 2000). An added rationale for adjustment for baseline values of physical activity is that this is consistent with other analyses that have examined change in SF-36 scores.⁴⁰ Analyses without adjustment for baseline physical activity yielded effects that were of greater magnitude and were more likely to be statistically significant, indicating our approach was more conservative.

In previous analyses of SF-36 change from 1992 to 1996 in this population, higher BMI was associated with decreased physical function, decreased well-being, increased pain, decreased vitality and increased risk of limitations.⁸ The association between change in physical activity and health-related quality of life remained after adjusting for BMI and across strata of BMI indicating that the association is independent of weight. To address concerns that BMI might mediate the association between physical activity and quality of life, we also examined the association without adjustment for BMI and found that the effects did not change.

The Nurses' Health Study cohort is a highly motivated and well-informed population providing high quality information. The longitudinal design of the study allows prospective assessment of variables in our analyses, while the large number of subjects and data collected allowed us to examine whether the observed associations varied across previously identified modifiers like BMI⁴¹ and chronic conditions.⁴² Our sample is not a random sample of U.S. women, and thus, our results may lack generalizability. The generalizability of our sample may be further limited by our exclusion criteria. Of particular concern may be the worse health status of those who did not complete sufficient physical activity questionnaires and the likelihood that those who did not complete the SF-36 may also have worse health. However, the 1992 quality of life

scores in this cohort were similar to a general population sample of similar age.⁴³ Exclusion of non-respondents creates bias if the relationship between physical activity and quality of life is different in the non-responders. The question under study in our analyses is novel and has important implications for public health. This is the first study to examine the relationship between long-term change in physical activity and subsequent changes in health related quality of life. The study design allows us to exclude the possibility that the changes in quality of life seen led to changes in activity.

Our findings provide strong evidence for an association between long-term changes in physical activity and several aspects of health-related quality of life. The present study extends previous cross-sectional findings showing an association between physical activity and health-related quality of life. Our findings support current U.S. guidelines that encourage all women to be physically active⁴⁴ and add to the body of evidence on the benefit to older and middle aged women increasing their physical activity.

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Figure 1.
Mean change and standard deviation in SF-36 score from 1996 to 2000

Table 1
 Characteristics of women by quartile of long-term physical activity change from 1986 to 1996

	Long term physical activity quartile			
	1 (decrease) slope ≤ -0.075	2 (no change) $-0.075 < \text{slope} \leq -0.003$	3 (some increase) $-0.003 < \text{slope} \leq 0.073$	4 (increase) slope > 0.073
No of subjects	15854	17147	13209	16942
Median physical activity 1986, MET hrs per week	22.7	4.3	4.2	6.4
Median physical activity 1992, MET hrs per week	15.0	6.4	10.9	20.9
Median physical activity 1996, MET hrs per week	7.9	3.9	10.4	30.2
1986 mean BMI, kg/m ^{2a}	24.5	25.2	24.6	24.0
Mean age in 1986, years	52.6	52.3	52.1	51.9
Baseline prevalence, % ^a				
Current smoker	19.5	21.3	20.2	20.5
Never smoker	43.0	45.2	46.5	45.4
Hypertension	12.8	14.6	12.8	10.9
High cholesterol	6.5	6.8	6.1	6.0
Diabetes	1.5	2.1	1.4	1.1
Arthritis	13.3	14.8	13.5	12.5
1996 median score, IQR				
Physical functioning	90, 23	85, 30	90, 20	94, 20
Role limitations, emotional	100, 33	100, 33	100, 33	100, 0
Role limitations, physical	100, 50	100, 50	100, 50	100, 25
Bodily pain	74, 22	74, 23	74, 22	84, 22
Vitality	70, 25	65, 25	70, 25	75, 20
Social functioning	100, 12	100, 12	100, 12	100, 0
Mental health	84, 16	80, 16	84, 16	84, 14
2000 median score, IQR				
Physical functioning	85, 30	85, 35	85, 25	90, 20
Role limitations, emotional	100, 33	100, 33	100, 0	100, 0
Role limitations, physical	100, 50	100, 75	100, 50	100, 50
Bodily pain	74, 23	72, 32	74, 23	74, 22
Vitality	70, 25	65, 30	70, 25	70, 20
Social functioning	100, 12	100, 12	100, 12	100, 12
Mental health	84, 16	84, 18	84, 16	84, 16

^a age standardized

BMI, body mass index; IQR, interquartile range; MET, metabolic equivalent

Table 2

Coefficient (95% confidence interval) for quality of life measures associated with quartiles of change in physical activity, 1986 to 1996, Nurses Health Study

	1996 SF-36 ^a	Change in SF-36 score from 1996 to 2000 ^b	Change in SF-36 score from 1996 to 2000 ^c
Physical functioning			
No change in physical activity	reference	reference	reference
Decrease in physical activity	0.31 (−0.16, 0.78)	−0.33 (−0.76, 0.10)	−0.39 (−0.80, 0.02)
Some increase in physical activity	5.01 (4.56, 5.46)	1.10 (0.69, 1.51)	0.91 (0.50, 1.32)
Increase in physical activity	8.19 (7.76, 8.62)	2.14 (1.75, 2.53)	1.82 (1.45, 2.19)
Role limitations due to emotional problems			
No change in physical activity	reference	reference	reference
Decrease in physical activity	−0.14 (−0.78, 0.50)	0.14 (−0.48, 0.76)	0.10 (−0.52, 0.72)
Some increase in physical activity	2.32 (1.70, 2.94)	1.04 (0.44, 1.65)	0.79 (0.19, 1.40)
Increase in physical activity	4.44 (3.86, 5.03)	1.45 (0.88, 2.02)	1.03 (0.47, 1.60)
Role limitations due to physical problems			
No change in physical activity	reference	reference	reference
Decrease in physical activity	0.06 (−0.76, 0.88)	0.08 (−0.74, 0.90)	0.01 (−0.79, 0.81)
Some increase in physical activity	4.23 (3.43, 5.03)	1.48 (0.70, 2.26)	0.97 (0.19, 1.75)
Increase in physical activity	8.23 (7.49, 8.97)	2.64 (1.90, 3.38)	1.81 (1.09, 2.53)
Bodily pain			
No change in physical activity	reference	reference	reference
Decrease in physical activity	−0.39 (−0.86, 0.08)	0.19 (−0.24, 0.62)	0.14 (−0.29, 0.57)
Some increase in physical activity	2.23 (1.78, 2.68)	0.58 (0.17, 0.99)	0.32 (−0.09, 0.73)
Increase in physical activity	3.99 (3.56, 4.42)	1.20 (0.81, 1.59)	0.75 (0.38, 1.12)
Vitality			
No change in physical activity	reference	reference	reference
Decrease in physical activity	0.49 (0.08, 0.90)	0.06 (−0.29, 0.41)	0.05 (−0.30, 0.40)
Some increase in physical activity	2.23 (1.78, 2.68)	0.33 (−0.002, 0.66)	0.20 (−0.13, 0.53)
Increase in physical activity	3.99 (3.56, 4.42)	1.00 (0.69, 1.31)	0.77 (0.46, 1.08)
Social functioning			
No change in physical activity	reference	reference	reference
Decrease in physical activity	−0.19 (−0.60, 0.22)	−0.07 (−0.46, 0.32)	−0.14 (−0.53, 0.25)
Some increase in physical activity	2.39 (2.00, 2.78)	0.90 (0.51, 1.29)	0.68 (0.31, 1.05)
Increase in physical activity	3.69 (3.32, 4.06)	1.28 (0.93, 1.63)	0.92 (0.57, 1.27)
Mental health			
No change in physical activity	reference	reference	reference
Decrease in physical activity	−0.007 (−0.32, 0.31)	0.20 (−0.05, 0.45)	0.20 (−0.05, 0.45)
Some increase in physical activity	1.30 (0.99, 1.61)	0.22 (−0.03, 0.47)	0.17 (−0.08, 0.42)
Increase in physical activity	2.23 (1.94, 2.52)	0.35 (0.12, 0.58)	0.28 (0.05, 0.51)

^a Age and baseline physical activity adjusted

^b Age, baseline physical activity and baseline SF-36 adjusted

^c Age, baseline physical activity, baseline SF-36, smoking, BMI and chronic conditions (arthritis, hypertension, diabetes, hypercholesterolemia) adjusted

SF-36, Medical Outcomes Study Short-Form 36 Health Status Survey

Table 3

Coefficients (95% confidence interval) by baseline BMI for change in quality-of-life measures, 1996–2000, associated with a quartile of change in physical activity, 1986 to 1996, Nurses Health Study ^a

	Normal (BMI<25) <i>n</i> =36291	Pre-obese (25≤BMI<30) <i>n</i> =16633	Class I Obese (30≤BMI<35) <i>n</i> =5490	Class II Obese (BMI≥35) <i>n</i> =2389
Physical functioning				
No change in physical activity	reference	Reference	reference	reference
Decrease in physical activity	−0.37 (−0.90, 0.16)	−0.83 (−1.69, 0.03)	−0.10 (−1.66, 1.46)	−0.81 (−3.35, 1.73)
Some increase in physical activity	0.93 (0.42, 1.44)	0.90 (0.10, 1.70)	0.25 (−1.19, 1.69)	1.85 (−0.43, 4.13)
Increase in physical activity	1.90 (1.43, 2.37)	1.54 (0.76, 2.32)	1.67 (0.23, 3.11)	2.32 (−0.08, 4.72)
Role limitations due to emotional problems				
No change in physical activity	reference	Reference	reference	reference
Decrease in physical activity	0.35 (−0.45, 1.15)	−0.27 (−1.54, 1.00)	−0.90 (−3.36, 1.56)	−2.79 (−6.61, 1.03)
Some increase in physical activity	0.92 (0.16, 1.68)	1.29 (0.10, 2.48)	−0.19 (−2.37, 1.99)	−0.61 (−4.00, 2.78)
Increase in physical activity	1.29 (0.59, 1.99)	0.61 (−0.54, 1.76)	0.98 (−1.20, 3.16)	1.70 (−1.83, 5.23)
Role limitations due to physical problems				
No change in physical activity	reference	Reference	reference	reference
Decrease in physical activity	0.53 (−0.50, 1.56)	−0.63 (−2.27, 1.01)	−2.62 (−5.60, 0.36)	−2.23 (−6.95, 2.49)
Some increase in physical activity	0.93 (−0.06, 1.93)	0.18 (−1.38, 1.74)	0.33 (−2.42, 3.08)	0.40 (−3.83, 4.63)
Increase in physical activity	1.97 (1.05, 2.89)	2.00 (0.50, 3.50)	1.27 (−1.50, 4.04)	3.06 (−1.33, 7.45)
Bodily pain				
No change in physical activity	reference	Reference	reference	reference
Decrease in physical activity	0.64 (0.09, 1.19)	0.07 (−0.77, 0.91)	−1.95 (−3.45, −0.45)	−3.17 (−5.55, −0.79)
Some increase in physical activity	0.66 (0.13, 1.19)	0.34 (−0.46, 1.14)	0.16 (−1.23, 1.55)	−1.69 (−3.82, 0.44)
Increase in physical activity	1.20 (0.71, 1.69)	0.55 (−0.21, 1.31)	−0.29 (−1.68, 1.10)	0.44 (−1.76, 2.64)
Vitality				
No change in physical activity	reference	Reference	reference	reference
Decrease in physical activity	0.07 (−0.38, 0.52)	−0.002 (−0.67, 0.66)	−0.12 (−1.33, 1.09)	−1.02 (−3.03, 0.99)
Some increase in physical activity	0.27 (−0.16, 0.70)	0.31 (−0.33, 0.95)	0.35 (−0.76, 1.46)	−1.05 (−2.84, 0.74)
Increase in physical activity	0.90 (0.51, 1.29)	0.71 (0.09, 1.33)	0.64 (−0.49, 1.77)	−0.32 (−2.21, 1.57)
Social functioning				
No change in physical activity	reference	Reference	reference	reference
Decrease in physical activity	−0.15 (−0.64, 0.34)	−0.15 (−0.95, 0.65)	−0.50 (−2.00, 1.00)	−1.95 (−4.76, 0.86)
Some increase in physical activity	0.53 (0.06, 1.00)	0.82 (0.06, 1.58)	0.62 (−0.77, 2.01)	2.04 (−0.48, 4.56)
Increase in physical activity	0.90 (0.47, 1.33)	0.95 (0.23, 1.67)	0.96 (−0.43, 2.35)	4.51 (1.92, 7.10)
Mental health				
No change in physical activity	reference	Reference	reference	reference
Decrease in physical activity	0.32 (−0.01, 0.65)	−0.06 (−0.57, 0.45)	−0.12 (−1.02, 0.78)	0.21 (−1.29, 1.71)

	Normal (BMI<25)	Pre-obese (25≤BMI<30)	Class I Obese (30≤BMI<35)	Class II Obese (BMI≥35)
	<i>n</i> =36291	<i>n</i> =16633	<i>n</i> =5490	<i>n</i> =2389
Some increase in physical activity	0.29 (−0.04, 0.62)	−0.05 (−0.52, 0.42)	0.70 (−0.14, 1.54)	−0.81 (−2.16, 0.54)
Increase in physical activity	0.33 (0.04, 0.62)	0.44 (−0.03, 0.91)	−0.08 (−0.92, 0.76)	1.00 (−0.39, 2.39)

^a Age, baseline physical activity, baseline SF-36 score adjusted

SF-36, Medical Outcomes Study Short-Form 36 Health Status Survey

Table 4

Coefficients (95% confidence interval) by baseline smoking status for change in quality-of-life measures, 1996–2000, associated quartile of change in physical activity, 1986 to 1996, Nurses Health Study ^a

	Never smokers <i>n</i> =28,327	Past smokers <i>n</i> =21,833	Current smokers <i>n</i> =12,868
Physical functioning			
No change in physical activity	Reference	Reference	Reference
Decrease in physical activity	−0.51 (−1.13, 0.11)	−0.55 (−1.25, 0.15)	0.65 (−0.36, 1.66)
Some increase in physical activity	0.87 (−.29, 1.46)	1.14 (0.44, 1.84)	1.58 (0.63, 2.54)
Increase in physical activity	1.88 (1.32, 2.45)	2.38 (1.72, 3.04)	2.49 (1.59, 3.39)
Role limitations due to emotional problems			
No change in physical activity	Reference	Reference	Reference
Decrease in physical activity	0.06 (−0.86, 0.98)	0.18 (−0.87, 1.23)	0.08 (−1.46, 1.62)
Some increase in physical activity	1.48 (0.62, 2.34)	0.73 (−0.30, 1.76)	0.47 (−0.99, 1.93)
Increase in physical activity	1.68 (0.88, 2.48)	1.51 (0.54, 2.49)	0.70 (−0.67, 2.07)
Role limitations due to physical problems			
No change in physical activity	Reference	Reference	Reference
Decrease in physical activity	−0.56 (−1.77, 0.65)	0.98 (−0.39, 2.35)	0.07 (−1.82, 1.96)
Some increase in physical activity	0.95 (−0.18, 2.08)	1.78 (0.42, 3.15)	2.50 (0.71, 4.29)
Increase in physical activity	2.06 (0.99, 3.13)	3.40 (2.13, 4.67)	2.80 (1.14, 4.46)
Bodily pain			
No change in physical activity	Reference	Reference	Reference
Decrease in physical activity	0.03 (−0.59, 0.65)	0.20 (−0.50, 0.90)	0.66 (−0.34, 1.66)
Some increase in physical activity	0.57 (−0.02, 1.16)	0.52 (−0.18, 1.22)	0.77 (−0.17, 1.71)
Increase in physical activity	1.18 (0.62, 1.75)	1.20 (0.54, 1.86)	1.34 (0.46, 2.22)
Vitality			
No change in physical activity	Reference	Reference	Reference
Decrease in physical activity	−0.23 (−0.74, 0.28)	0.37 (−0.20, 0.94)	0.25 (−0.55, 1.05)
Some increase in physical activity	0.32 (−0.15, 0.79)	0.19 (−0.38, 0.76)	0.69 (−0.07, 1.45)
Increase in physical activity	0.69 (0.24, 1.14)	1.22 (0.69, 1.75)	1.38 (0.66, 2.10)
Social Functioning			
No change in physical activity	Reference	Reference	Reference
Decrease in physical activity	−0.24 (−0.83, 0.35)	−0.13 (−0.77, 0.51)	0.35 (−0.65, 1.35)
Some increase in physical activity	0.95 (0.40, 1.50)	0.64 (−0.003, 1.28)	1.20 (0.26, 2.14)
Increase in physical activity	1.06 (0.55, 1.57)	1.35 (0.75, 1.96)	1.64 (0.76, 2.52)
Mental Health			
No change in physical activity	Reference	Reference	Reference
Decrease in physical activity	0.08 (−0.31, 0.47)	0.23 (−0.20, 0.66)	0.46 (−0.18, 1.10)
Some increase in physical activity	0.39 (0.04, 0.74)	0.12 (−0.31, 0.55)	−0.01 (−0.62, 0.60)
Increase in physical activity	0.47 (0.14, 0.80)	0.24 (−0.15, 0.63)	0.30 (−0.27, 0.87)

^a Age, baseline physical activity, baseline SF-36 score adjusted

SF-36, Medical Outcomes Study Short-Form 36 Health Status Survey

Table 5

Coefficients (95% confidence interval) by presence of chronic conditions (arthritis, hypertension, diabetes, hypercholesterolemia) for change in quality-of-life measures, 1996–2000, associated with quartile of change in physical activity, 1986 to 1996, Nurses Health Study ^a

	Condition developed before 1986 n=28350	Condition developed between 1986 and 2000 n=10084	Free of conditions through 2000 n=24718
Physical Functioning			
No change in physical activity	reference	Reference	reference
Decrease in physical activity	0.15 (−0.77, 1.07)	−0.34 (−1.00, 0.32)	−0.48 (−1.12, 0.16)
Some increase in physical activity	0.76 (−0.12, 1.64)	1.31 (0.67, 1.95)	0.56 (−0.06, 1.18)
Increase in physical activity	1.56 (0.76, 2.36)	2.15 (1.55, 2.76)	1.57 (0.99, 2.16)
Role limitations due to emotional problems			
No change in physical activity	reference	Reference	reference
Decrease in physical activity	−0.66 (−1.95, 0.63)	−0.13 (−1.16, 0.90)	0.75 (−0.21, 1.71)
Some increase in physical activity	1.13 (−0.12, 2.38)	0.85 (−0.15, 1.85)	0.59 (−0.31, 1.49)
Increase in physical activity	0.94 (−0.19, 2.07)	1.27 (0.33, 2.21)	0.76 (−0.10, 1.62)
Role limitations due to physical problems			
No change in physical activity	reference	Reference	reference
Decrease in physical activity	−0.36 (−1.96, 1.24)	−0.45 (−1.74, 0.84)	0.88 (−0.39, 2.15)
Some increase in physical activity	2.36 (0.82, 3.90)	1.27 (0.02, 2.52)	0.14 (−1.07, 1.35)
Increase in physical activity	2.16 (0.78, 3.55)	2.10 (0.92, 3.29)	1.29 (0.16, 2.42)
Bodily pain			
No change in physical activity	reference	Reference	reference
Decrease in physical activity	−0.13 (−1.07, 0.81)	0.53 (−0.11, 1.17)	−0.03 (−0.69, 0.63)
Some increase in physical activity	0.96 (0.06, 1.86)	0.73 (0.11, 1.35)	−0.34 (−0.96, 0.28)
Increase in physical activity	0.90 (0.08, 1.72)	0.86 (0.26, 1.47)	0.49 (−0.10, 1.08)
Vitality			
No change in physical activity	reference	Reference	reference
Decrease in physical activity	−0.21 (−1.01, 0.59)	0.04 (−0.49, 0.57)	0.22 (−0.33, 0.77)
Some increase in physical activity	0.51 (−0.27, 1.29)	0.54 (0.03, 1.05)	−0.26 (−0.77, 0.25)
Increase in physical activity	0.63 (−0.07, 1.33)	1.03 (0.54, 1.52)	0.58 (0.09, 1.07)
Social functioning			
No change in physical activity	reference	Reference	reference
Decrease in physical activity	0.13 (−0.63, 0.89)	−0.51 (−1.17, 0.15)	0.24 (−0.35, 0.83)
Some increase in physical activity	0.40 (−0.34, 1.14)	1.21 (0.57, 1.85)	0.19 (−0.36, 0.74)
Increase in physical activity	0.43 (−0.23, 1.09)	1.49 (0.89, 2.10)	0.47 (−0.06, 1.00)
Mental health			
No change in physical activity	reference	Reference	reference
Decrease in physical activity	0.32 (−0.30, 0.94)	0.17 (−0.22, 0.56)	0.22 (−0.19, 0.63)
Some increase in physical activity	0.29 (−0.31, 0.90)	0.35 (−0.04, 0.74)	−0.07 (−0.46, 0.32)
Increase in physical activity	0.39 (−0.16, 0.94)	0.48 (0.11, 0.85)	0.02 (−0.35, 0.39)

^a Age, baseline physical activity, baseline SF-36 score, smoking and BMI adjusted

SF-36, Medical Outcomes Study Short-Form 36 Health Status Survey