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Fitness and Body Mass Index During Adolescence and Disability Later in Life:

A Cohort Study

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Abstract

Background: Low physical fitness, obesity, and the combination of the two in adolescence may be related to risk for disability in adulthood, but this has rarely been studied.

Objective: To examine individual and combined associations of cardiorespiratory fitness and obesity in male adolescents with later receipt of a disability pension due to all and specific causes.

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Design: Population-based cohort study.

Setting: Sweden.

Participants: 1 079 128 Swedish adolescents aged 16 to 19 years who were conscripted into the military between 1972 and 1994.

Measurements: Cardiorespiratory fitness and body mass index (BMI) were measured at conscription and were related to information on later receipt of a disability pension obtained from the Social Insurance Agency.

Results: Over a median follow-up of 28.3 years, 54 304 men were granted a disability pension. Low cardiorespiratory fitness was strongly associated with later receipt of a disability pension due to all causes (hazard ratio, 3.74 [95% CI, 3.55 to 3.95] for lowest vs. highest fitness decile) and specific causes (psychiatric, musculoskeletal, injuries, nervous system, circulatory, and tumors). Obesity was associated with greater risk for receipt of a disability pension due to all and specific causes, with the greatest risks observed for class II and III obesity. Compared with being unfit, being moderately or highly fit was associated with attenuated risk for receipt of a disability pension across BMI categories.

Limitation: The cohort did not include women, had data on smoking and alcohol intake only in a subsample, and lacked repeated measures of exposures and covariates.

Conclusion: Low cardiorespiratory fitness, obesity, and the combination of the two were strongly associated with later chronic disability due to a wide range of diseases and causes. Although additional well-designed studies are required, these findings support the importance of high cardiorespiratory fitness and healthy body weight during adolescence to prevent later chronic disease.

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Noncommunicable diseases are global public health issues that lead to premature death and disability (1, 2). Psychiatric and musculoskeletal disorders, cardiovascular diseases, cancer, and injuries are a major burden on societies (1, 3–5). Thus, identification of early and potentially modifiable risk factors for later chronic disease is of great public health importance. An objective approach to studying severe chronic diseases is to use receipt of a disability pension as a health outcome. In many countries, disability pensions are granted to working-aged persons who are likely to never work full-time again because of a chronic disease or injury diagnosed by a physician. In addition to serving as an important indicator of chronic disease, disability pensions are associated with high societal costs (6) and thus have not only clinical but also economic consequences.

Low cardiorespiratory fitness in childhood and adolescence has been associated with increased risk for death and disability later in life (7–9). However, few studies have examined associations of cardiorespiratory fitness in youth with later receipt of a disability pension. A study of 49 321 Swedish military conscripts aged 18 to 20 years showed that low cardiorespiratory fitness was associated with higher risk for receipt of a disability pension due to all causes, although it did not examine specific causes (10). Therefore, large studies that are powered to examine the association of cardiorespiratory fitness with receipt of a disability pension for specific causes are needed.

Obesity in youth has been found to be related to impaired health and premature death (11). Although previous studies have reported that obesity is associated with increased risk for receipt of a disability pension (6, 12), the association between severe obesity (body mass index [BMI] ≥40.0 kg/m^2) in youth and later chronic disability (as indicated by receipt of a disability pension) is unknown. High cardiorespiratory fitness has been shown to potentially attenuate the negative effects of obesity (13, 14). However, the combined association of cardiorespiratory fitness and obesity with receipt of a disability pension has yet to be examined.

The aim of this study was to examine the associations of cardiorespiratory fitness and obesity with receipt of a disability pension in a large sample (>1 million) of Swedish male adolescents. Given the high power of the study, we examined individual and combined associations of cardiorespiratory fitness and obesity with receipt of a disability pension due to all and specific causes.

METHODS

Study Design and Population

This prospective cohort study used data from the Swedish Military Service Conscription Registry, which was linked to several other national registries using the men’s unique personal identification numbers as described previously (12). The Cause of Death Register and the Registry of the Total Population were used to identify men who died or emigrated during follow-up. The study was approved by the Regional Ethical Review Board, Stockholm, Sweden.

The cohort comprised male adolescents who were born in Sweden between 1951 and 1976, were conscripted into the military between 1972 and 1994, and were followed until 31 December 2012. Military conscription was mandatory for the study participants; only 2% to 3% of Swedish adolescents were exempted from conscription because of incarceration or severe medical conditions (15). In this study, we included male adolescents who were aged 16 to 19 years at conscription and had complete data on the exposures, outcomes, and covariates. In accordance with previous studies (12), we excluded males with extreme values for height (≤150 or ≥210 cm), weight (≤40 or ≥150 kg), or BMI (≤15 or ≥60 kg/m^2). The overall cohort consisted of 1 125 739 adolescents, of whom 1 083 561 had complete data on cardiorespiratory fitness (the primary exposure). Another 4433 had missing or extreme values for the other exposures, outcomes, and covariates, leaving 1 079 128 adolescents (95.9%) for the analyses.

Cardiorespiratory Fitness, BMI, and Covariates

Cardiorespiratory fitness was measured in conscripts with a normal electrocardiogram using an electrically braked ergometer cycle test, as described previously (16). The initial resistance was determined by weight and was increased by 25 W for men who reported regular exercise. After a 5-minute warm-up period with a pulse between 120 and 170 beats/

min, the resistance was further increased by 25 W/min until volitional exhaustion. The final work rate was retained and used in the analysis. Weight was measured using analogue or digital scales, and height was assessed using wall-mounted stadiometers according to standardized procedures (7). Body mass index was calculated as weight in kilograms divided by height in meters squared and was classified according to World Health Organization criteria (17). Year of conscription, conscription center (6 centers), and age at conscription were obtained from the Military Service Conscription Registry, and information on the occupations of participants' parents was retrieved from the Population Housing Censuses. Childhood socioeconomic status was defined as the highest-level occupation of either parent.

Disability Pension

Data on the date and cause of receipt of a disability pension were retrieved from the Social Insurance Agency for 1972 to 2012. During the study years, the cause of receipt of a disability pension had to be confirmed by a certificate from a physician using International Classification of Diseases (ICD) codes (ICD-8, ICD-9, or ICD-10), and the work capacity had to be reduced by at least 25%. The codes were then used to classify the cause as psychiatric (for example, affective and nonaffective disorders), musculoskeletal (for example, dorsalgia and soft tissue disorders), nervous system (for example, multiple sclerosis), circulatory (for example, cerebrovascular and ischemic heart diseases), injuries, or tumors (Appendix Table 1, available at Annals.org).

Statistical Analysis

We used Cox proportional hazards regression models to calculate hazard ratios (HRs) with 95% CIs and to estimate cumulative incidences. Men were followed until they were granted a disability pension, died, or emigrated or until the end of follow-up (31 December 2012), whichever occurred first.

We first analyzed the associations of cardiorespiratory fitness and BMI with later receipt of a disability pension due to all and specific causes. We created 2 models: the first included basic covariates (conscription year, conscription center, age at conscription, and childhood socioeconomic status), and the second included these covariates plus BMI or cardiorespiratory fitness. Analyses involving receipt of a disability pension due to all and psychiatric causes were also adjusted for any mental hospitalization before conscription and any psychiatric diagnosis at conscription. In the analyses that included BMI categories, we examined the association of severe obesity with receipt of a disability pension due to all causes as well as psychiatric and musculoskeletal causes (which were most prevalent) because there were too few cases for the remaining causes.

We also assessed the combined association of cardiorespiratory fitness and BMI categories with later receipt of a disability pension, with adjustment for the aforementioned basic covariates. In these analyses, we investigated receipt of a disability pension due to all, psychiatric, and musculoskeletal causes. Adolescents in the first 2 deciles were classified as unfit, and fit adolescents were further divided into moderately fit (deciles 3 to 8) and highly fit (deciles 9 and 10) categories. The proportional hazards assumption for the exposures (fitness, BMI, and both combined) in the Cox regression was examined using a log-minus-log plot, and we found no evidence that the assumption was violated.

Statistical analyses were conducted using SPSS Statistics, version 22 (IBM).

Role of the Funding Source

Karolinska Institutet had no role in the design or conduct of the study, management of the data, interpretation of the results, or the decision to submit the manuscript for publication.

RESULTS

Descriptive Statistics

The Table shows descriptive data on the 1 079 128 participants. Over a median follow-up of 28.3 years (30.6 million person-years), 54 304 men were granted a disability pension. Figure 1 shows the unadjusted cumulative incidences of receipt of a disability pension due to all causes by cardiorespiratory fitness level (*left panel*) and BMI category (*right panel*). The cumulative incidence was consistently higher in adolescents with lower cardiorespiratory fitness and a higher BMI during follow-up. Additional data on cumulative incidences by cardiorespiratory fitness level and BMI category are shown in Appendix Figures 1 to 6 and Appendix Tables 2 and 3 (available at Annals.org).

Cardiorespiratory Fitness and Receipt of a Disability Pension

Figure 2 shows the associations of cardiorespiratory fitness with receipt of a disability pension due to all causes and specific causes. Higher cardiorespiratory fitness was associated with lower risk for receipt of a disability pension in a dose-response manner, although there was a steep decrease in risk between the first and second deciles. In the fully adjusted models, compared with adolescents in the highest decile, those in the lowest decile had a 3.74-fold (95% CI, 3.55- to 3.95-fold) higher risk for receipt of a disability pension due to all causes. They also had a statistically significantly increased risk for receipt of a disability pension due to all specific causes (psychiatric: HR, 4.01 [CI, 3.72 to 4.32]; musculoskeletal: HR, 3.72 [CI, 3.29 to 4.20]; injuries: HR, 2.74 [CI, 2.35 to 3.18]; nervous system: HR, 2.86 [CI, 2.35 to 3.48]; circulatory: HR, 4.87 [CI, 3.58 to 6.61]; tumors: HR, 1.89 [CI, 1.31 to 2.73]).

BMI and Receipt of a Disability Pension

Overall, there were J-shaped associations between BMI categories and risk for receipt of a disability pension in the models that were adjusted for basic covariates. However, these associations were more linear when they were also adjusted for cardiorespiratory fitness (Figure 3). In the adjusted analyses, compared with normal weight, severe obesity was associated with greater risk for receipt of a disability pension due to all causes (HR, 3.21 [CI, 2.49 to 4.15]), psychiatric causes (HR, 1.63 [CI, 1.00 to 2.67]), and musculoskeletal causes (HR, 4.11 [CI, 2.48 to 6.82]).

Combined Association of Cardiorespiratory Fitness and BMI With Receipt of a Disability Pension

Figure 4 shows the combined associations of cardiorespiratory fitness and BMI with receipt of a disability pension due to all, psychiatric, and musculoskeletal causes. Higher cardiorespiratory fitness attenuated risk for receipt of a disability pension in all BMI categories. For example, highly fit adolescents with obesity had similar risk for receipt of a disability pension due to all causes (HR, 2.27 [CI, 1.94 to 2.66]) compared with unfit adolescents with normal weight (HR, 2.64 [CI, 2.53 to 2.76]), whereas the risk was considerably higher for unfit adolescents with obesity (HR, 4.67 [CI, 4.21 to 5.17]). Furthermore, highly fit adolescents with obesity had lower risk for receipt of a disability pension due to psychiatric causes (HR, 1.86 [CI, 1.45 to 2.39]) than unfit adolescents with either obesity (HR, 4.34 [CI, 3.63 to 5.19]) or normal weight (HR, 3.59 [CI, 3.38 to 3.80]).

Sensitivity Analyses

We performed a sensitivity analysis in a subset of males (n = 34 966) with data on smoking and alcohol consumption, which were available in the early years of the Swedish Military Service Conscription Registry (Appendix Table 4, available at Annals.org). Low cardiorespiratory fitness and obesity remained strong risk factors for receipt of a disability pension due to all causes, even after adjustment for smoking and alcohol consumption at conscription.

We then examined the robustness of our findings to unmeasured confounding by calculating E-values for our main outcomes (Appendix Table 5, available at Annals.org), as described by VanderWeele and Ding (18). Values were generally high, and the E-value for the association of cardiorespiratory fitness with receipt of a disability pension due to all causes was 6.94.

We also examined the association of cardiorespiratory fitness and BMI with receipt of a disability pension due to specific psychiatric causes (substance abuse, nonaffective disorders, affective disorders, and personality disorders) (Appendix Table 6, available at Annals.org). Higher cardiorespiratory fitness was strongly associated with lower risk for receipt of a disability pension for all psychiatric causes, although the association with substance abuse was particularly strong.

Finally, in 2 sensitivity analyses, we excluded participants with a prior mental hospitalization and psychiatric diagnosis at conscription and excluded those who were granted a disability pension within the first 10 years of follow-up. Both analyses yielded estimates that were similar to our main results. For example, in fully adjusted models comparing the lowest and highest fitness deciles, HRs were 3.92 (CI, 3.71 to 4.15) and 3.67 (CI, 3.47 to 3.88), respectively, compared with 3.74 (CI, 3.55 to 3.95) in our main analysis.

DISCUSSION

In this population-based cohort study of more than 1 million male adolescents, low cardiorespiratory fitness was a strong risk factor for later chronic disability, as indicated by receipt of a disability pension. Higher cardiorespiratory fitness was associated with lower risk for receipt of a disability pension for all examined causes, particularly all causes, psychiatric causes, musculoskeletal causes, and circulatory diseases. Another novel finding was that severe obesity was strongly related to increased risk for receipt of a disability pension, especially due to all and musculoskeletal causes. Finally, higher cardiorespiratory fitness attenuated risk for receipt of a disability pension in all BMI categories. Of note, highly fit adolescents with obesity had lower risk for disability due to psychiatric causes than unfit adolescents with normal weight.

Previous studies have examined the association between cardiorespiratory fitness and disability. A relatively small Finnish study (*n* = 1307) reported that low cardiorespiratory fitness in middle age was associated with increased risk for receipt of a disability pension (19), and low cardiorespiratory fitness has also been found to be a risk factor for future absence from work due to illness (20–22). Of note, the largest study to date (*n* = 49 321) showed that low cardiorespiratory fitness in adolescence was a risk factor for receipt of a disability pension due to all causes but did not examine specific causes (10). We expand the literature by demonstrating in a cohort of more than 1 million male adolescents that low cardiorespiratory fitness in youth is a strong risk factor for later disability due to a wide range of diseases and causes, regardless of BMI.

Our results may also be compared with those of studies that analyzed cardiorespiratory fitness in relation to mortality and other indicators of morbidity besides receipt of a disability pension (7–9, 15, 23–29). These studies, some of which also used data from the Swedish Military Service Conscription Registry (7, 15, 23–25), have shown that low cardiorespiratory fitness is associated with increased mortality and morbidity due to a wide variety of diseases, such as cardiovascular disease, type 2 diabetes, cancer, and depression. This is consistent with our finding that low cardiorespiratory fitness is associated with receipt of a disability pension due to a wide range of diseases and causes, including circulatory and psychiatric diseases as well as tumors. Although the mechanisms by which cardiorespiratory fitness may influence health are not fully understood, higher cardiorespiratory fitness has been linked to more favorable cardiometabolic risk profiles (lower blood pressure, insulin resistance, and healthier lipid profile), lower concentrations of inflammatory markers, and better cognitive function, which may influence both physical and mental health (28, 30).

Studies have consistently identified obesity as a risk factor for receipt of a disability pension (6, 12). However, the association between severe obesity and later receipt of a disability pension has not been previously assessed. In our study, the risk for receipt of a disability pension associated with severe obesity was considerably higher than for moderate and mild obesity, highlighting the importance of severe obesity as a strong risk factor for later chronic disability. Although obesity in youth (11, 31) and adulthood (32) is recognized to be associated with impaired health, evidence suggests that the negative effects of obesity can be attenuated by being fit (the “fat but fit” paradox) (13, 14). Indeed, fit adolescents with obesity had lower risk for receipt of a disability pension than unfit adolescents with obesity in the current study. This study also showed that being moderately or highly fit attenuated risk for receipt of a disability pension in all BMI categories. Therefore, our results indicate that cardiorespiratory fitness is an important marker for later health, regardless of BMI.

This study has several strengths, including a long follow-up and a population-based sample of more than 1 million male adolescents that enabled analysis of specific causes of receipt of a disability pension as well as combined analyses of cardiorespiratory fitness and BMI. Furthermore, the main study variables (cardiorespiratory fitness, BMI, and receipt of a disability pension) were measured using objective and standardized procedures. Finally, the use of a young cohort with little preexisting disease decreases risk for reverse causation (low cardiorespiratory fitness due to disease) while also providing support for early prevention of chronic disease.

A major limitation of this study is that we did not have data on smoking status and alcohol intake for all adolescents and lacked repeated measures of covariates, cardiorespiratory fitness, and BMI during follow-up. This, coupled with the fact that the determinants of fitness in adolescents are not fully understood, led to considerable risk for residual confounding by such factors as socioeconomic status. To address this risk, we conducted 2 sensitivity analyses. The first showed that low cardiorespiratory fitness and obesity remained strong risk factors for receipt of a disability pension after additional adjustment for smoking and alcohol consumption in a subset of adolescents (Appendix Table 4). In the second, we calculated E-values to assess the robustness of our main results to unmeasured confounding (Appendix Table 5). Values were generally high, and the E-value for the association of cardiorespiratory fitness with receipt of a disability pension due to all causes was 6.94. This indicates that an unmeasured confounder would have to be associated with both cardiorespiratory fitness and receipt of a disability pension by a risk ratio of 6.94 to fully explain away the association of cardiorespiratory fitness (lowest vs. highest fitness decile) with receipt of a disability pension (18). Although a single confounder of that magnitude is unlikely, we cannot exclude the possibility of residual confounding. Therefore, it is important for future studies to consider repeated measures of key variables, such as socioeconomic status, smoking, alcohol consumption, physical activity, other health behaviors, fitness, and BMI, to further elucidate the role of cardiorespiratory fitness and BMI in receipt of a disability pension. Another limitation of this study is that it included only male adolescents, which limits the generalizability of the results to female adolescents. Although a previous study in women indicated that low cardiorespiratory fitness is related to later absence from work due to illness (33), additional studies are needed in women. Finally, it should be noted that although our study outcome is receipt of a disability pension, the underlying cause of the disability must be diagnosed and certified by a physician.

Our study has implications for public health and clinical care. We found evidence of a strong association between physical fitness and risk for later receipt of a disability pension due to a wide range of diseases and causes. However, it should be noted that cardiorespiratory fitness is influenced by not only physical activity but also other environmental factors and genetics (34–36), with the latter having been found to be a strong influence in a previous study that used data from the Swedish Military Service Conscription Registry (36). Nevertheless, our findings indicate that promoting fitness in adolescence may be important to counteract later chronic disabilities. The findings showed that adolescents classified as unfit (those in the first quintile) had the greatest risk for later receipt of a disability pension. Although cardiorespiratory fitness data are available only as the final work rate (in watts achieved), a crude estimation of the corresponding maximum oxygen consumption (VO_2max) values can be calculated using the cutoff for work rate (229 W) and the average weight in the first quintile (37). Of note, the estimated cutoff for being unfit in our data (VO_2max approximately 41 mL/kg per minute) is very similar to the cutoff (42 mL/kg per minute for male adolescents) proposed in a recent meta-analysis to identify children and adolescents with increased cardiovascular disease risk (38). Furthermore, our results underscore a recent position of the American Heart Association that cardiorespiratory fitness should be considered a clinical vital sign that is easily measurable in clinical settings (28). Therefore, increasing cardiorespiratory fitness in youth may have a large effect on public health and thus should be an important focus during clinical care.

In addition to low cardiorespiratory fitness, obesity (especially severe obesity) was a strong risk factor for later disability, and adolescents who were obese and unfit had the greatest risk. Our data indicated that such high-risk persons may benefit from improved cardiorespiratory fitness and/or decreased body weight. Most adolescents in this study were conscripted at a time when obesity was uncommon. However, the secular increases in pediatric obesity (39) and decreases in cardiorespiratory fitness (40, 41) are likely to result in later impaired health and, consequently, greater prevalence of disability in contemporary adolescents. Thus, although additional well-designed studies are required, our results show the importance of high cardiorespiratory fitness and a healthy body weight in all adolescents.

In conclusion, this population-based cohort study of more than 1 million male adolescents indicated that low cardiorespiratory fitness and obesity are strongly associated with receipt of a disability pension due to a wide range of diseases and causes later in life. Although additional well-designed studies are required to provide further evidence, these findings emphasize the importance of high cardiorespiratory fitness and healthy body weight during adolescence.

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Appendix

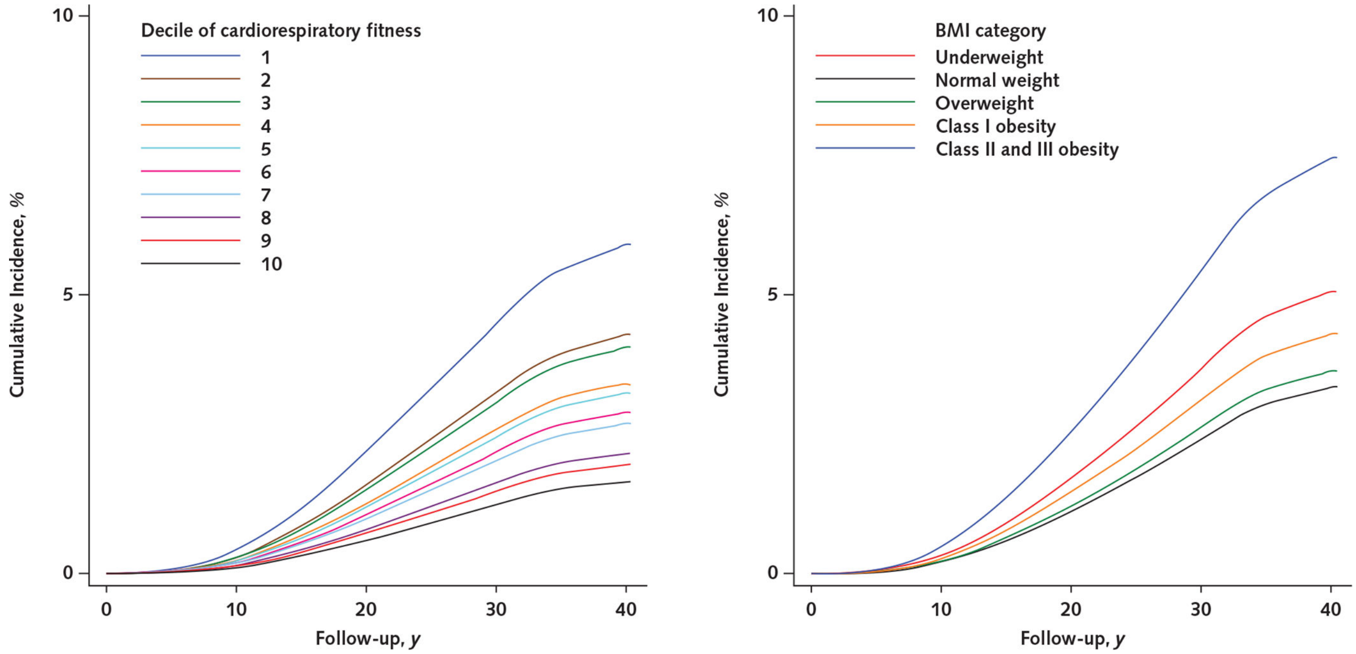
Appendix Table 1.

ICD Codes Used in the Study

Category	ICD-10	ICD-9	ICD-8
Circulatory	Chapter I	390 to 398, 401 to 405, 410 to 417, 420 to 438, 440 to 448, 451 to 459	390 to 392, 400 to 404, 410 to 414, 420 to 429, 430 to 438, 440 to 448, 450 to 458

Category	ICD-10	ICD-9	ICD-8
Psychiatric	Chapter F	290 to 319	290 to 315
Musculoskeletal	Chapter M	710 to 739	710 to 718, 720 to 738
Nervous system	Chapter G	320 to 326, 330 to 337, 340 to 359	320 to 324, 330 to 358
Tumors	Chapter C; D00 to 48	140 to 165, 170 to 176, 179 to 208, 210 to 239	140 to 163, 170 to 174, 180 to 228, 230 to 239
Injuries	Chapters S, T, V, W, X, and Y	800 to 848, 850 to 854, 860 to 887, 890 to 897, 900 to 999, Chapter E	Chapters E and N

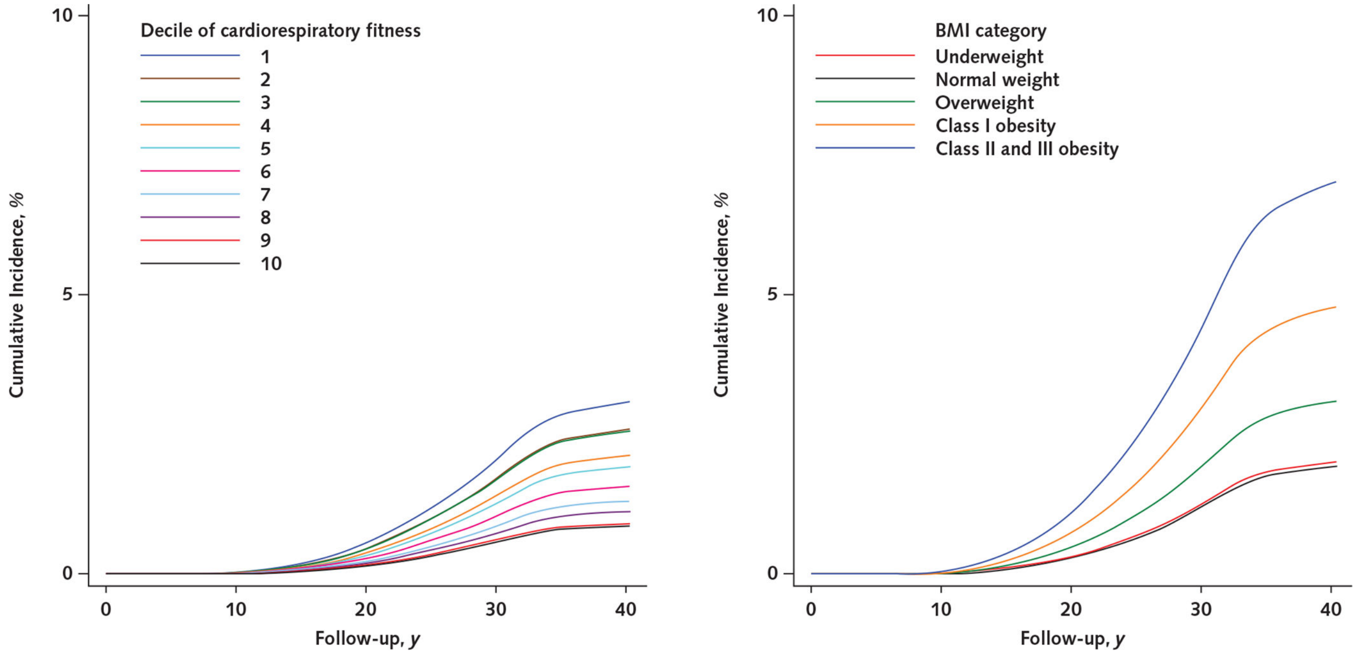
ICD = International Classification of Diseases.



Appendix Figure 1.

Unadjusted cumulative incidences of receipt of a disability pension due to psychiatric causes, by cardiorespiratory fitness level (*left*) and BMI category (*right*).

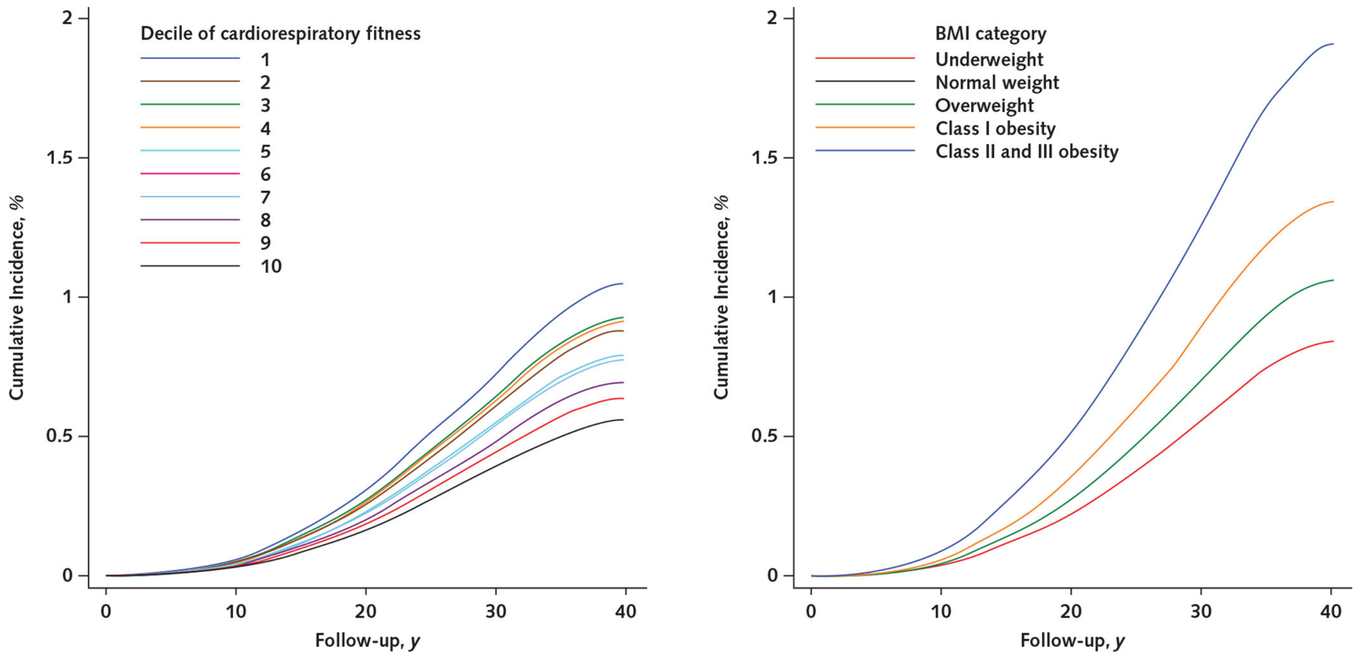
Cumulative incidences were estimated from unadjusted Cox regression models. BMI = body mass index.



Appendix Figure 2.

Unadjusted cumulative incidences of receipt of a disability pension due to musculoskeletal causes, by cardiorespiratory fitness level (*left*) and BMI category (*right*).

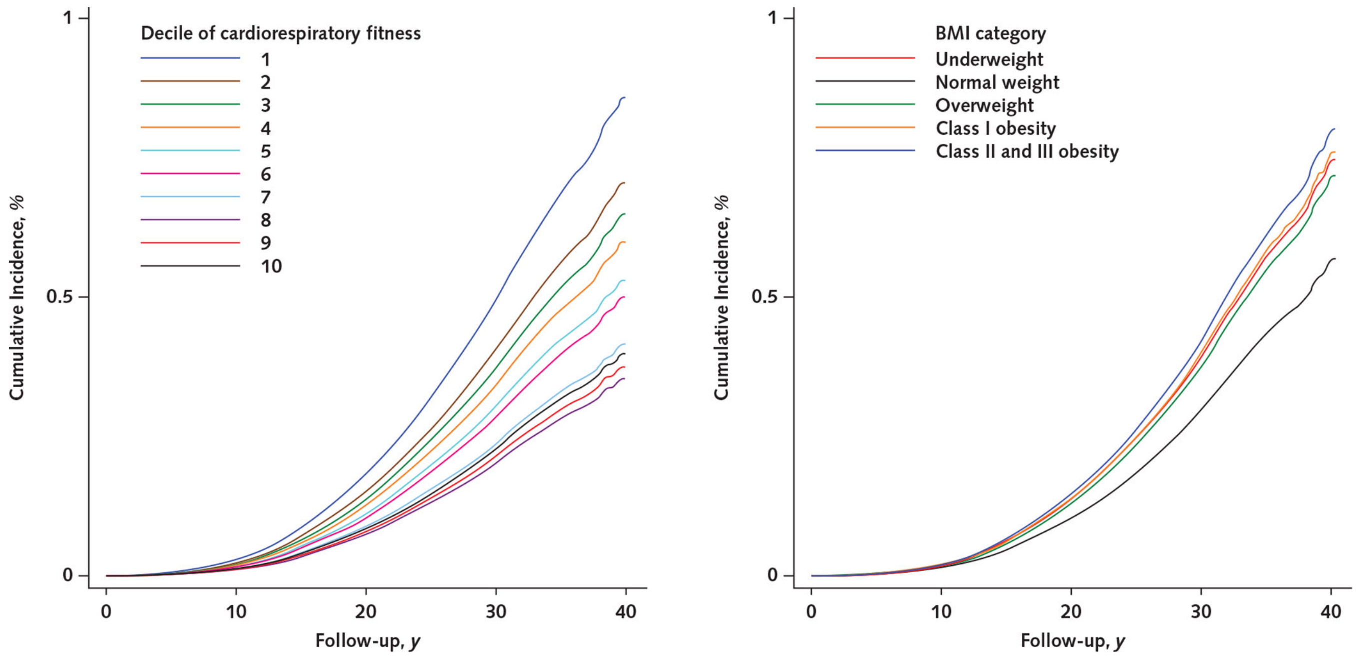
Cumulative incidences were estimated from unadjusted Cox regression models. BMI = body mass index.



Appendix Figure 3.

Unadjusted cumulative incidences of receipt of a disability pension due to injuries, by cardiorespiratory fitness level (*left*) and BMI category (*right*).

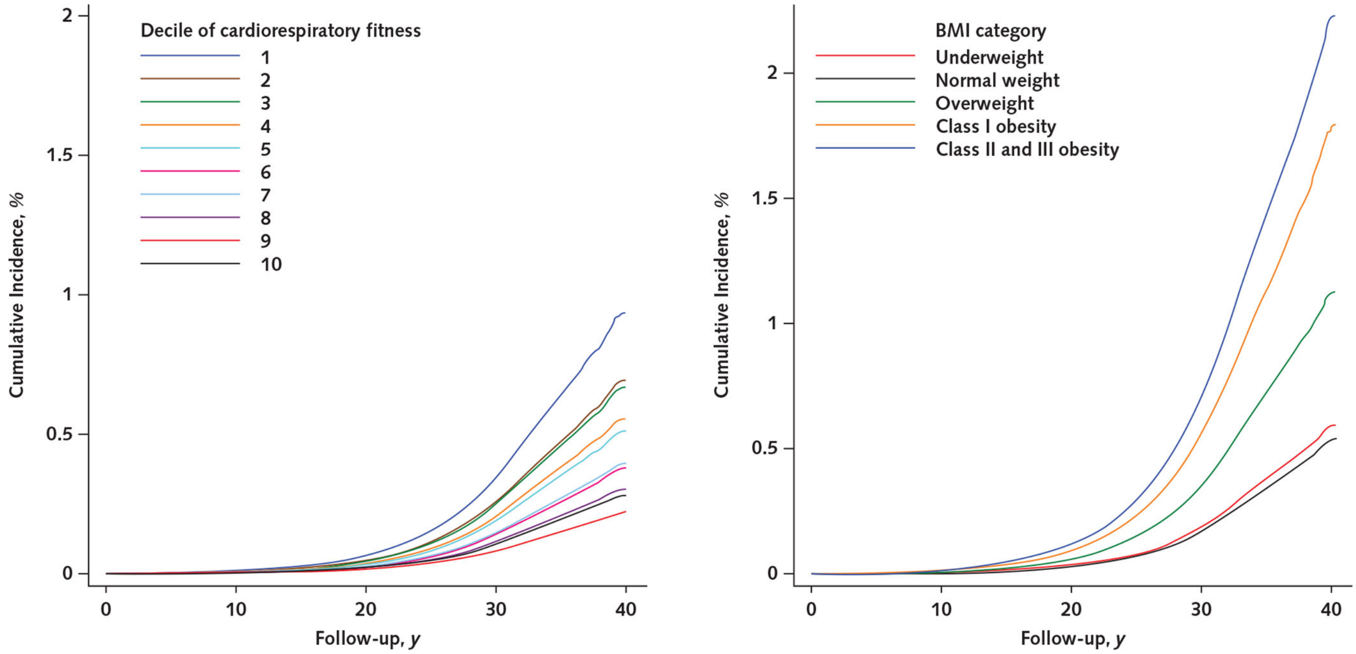
Cumulative incidences were estimated from unadjusted Cox regression models. BMI = body mass index.



Appendix Figure 4.

Unadjusted cumulative incidences of receipt of a disability pension due to nervous system causes, by cardiorespiratory fitness level (*left*) and BMI category (*right*).

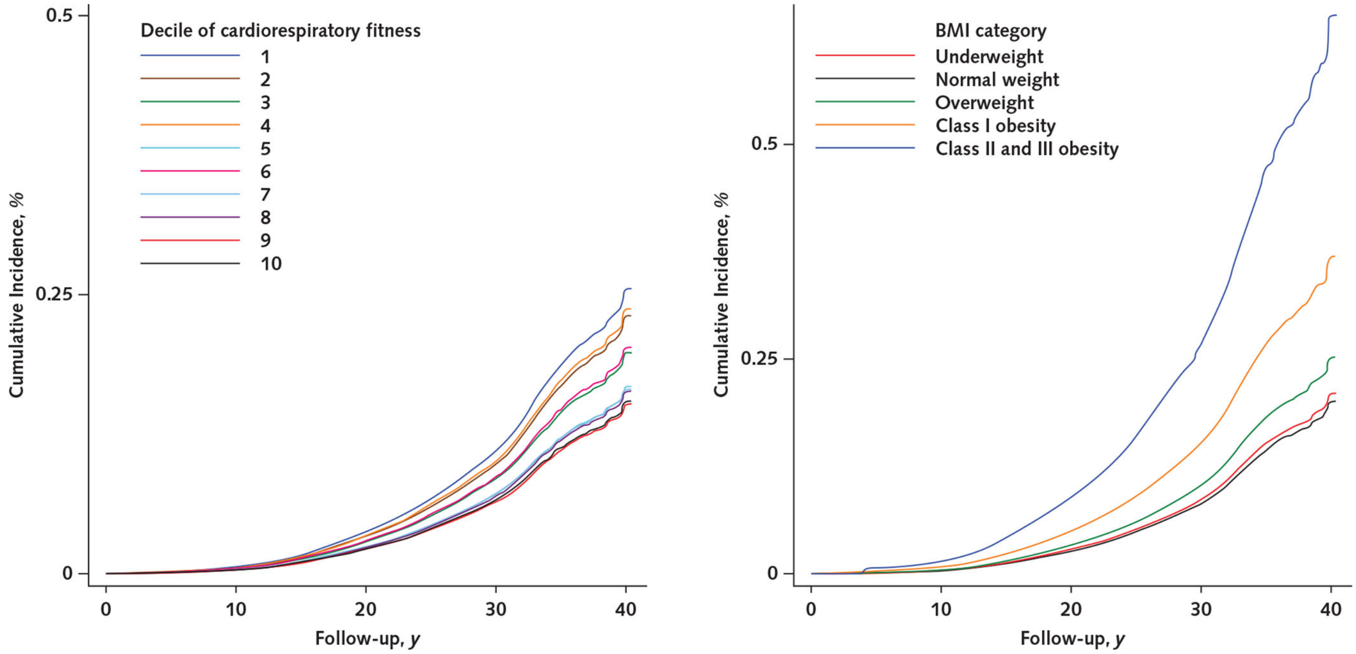
Cumulative incidences were estimated from unadjusted Cox regression models. BMI = body mass index.



Appendix Figure 5.

Unadjusted cumulative incidences of receipt of a disability pension due to circulatory causes, by cardiorespiratory fitness level (*left*) and BMI category (*right*).

Cumulative incidences were estimated from unadjusted Cox regression models. BMI = body mass index.



Appendix Figure 6.

Unadjusted cumulative incidences of receipt of a disability pension due to tumors, by cardiorespiratory fitness level (*left*) and BMI category (*right*).

Cumulative incidences were estimated from unadjusted Cox regression models. BMI = body mass index.

Appendix Table 2.

Unadjusted Cumulative Incidence of Receipt of a Disability Pension, by Decile of Cardiorespiratory Fitness

Disability Cause	Decile of Cardiorespiratory Fitness									
	1	2	3	4	5	6	7	8	9	10
All										
Cases, *n*	12 009	8471	7217	6286	5668	4242	3378	3021	2139	1873
Incidence per 10 000 person-years	31.7	24.7	23.0	19.5	16.8	14.8	12.3	10.3	8.4	7.2
Cumulative incidence per 1000 persons during follow-up										
10 y	4.9	2.9	3.6	3.0	3.8	3.2	3.3	2.8	3.0	2.6
20 y	31.8	22.3	24.4	21.3	22.1	20.3	19.9	16.3	15.7	13.6
30 y	88.2	68.6	66.7	57.9	52.0	45.7	39.1	32.9	26.0	22.1
40 y	144.6	113.5	105.6	90.2	78.5	70.2	58.7	49.2	42.2	39.6
Psychiatric										
Cases, *n*	5689	3737	3193	2738	2638	2001	1701	1465	1103	935
Incidence per 10 000 person-years	15.0	10.9	10.2	8.5	7.8	7.0	6.2	5.0	4.3	3.6
Cumulative incidence per 1000 persons during follow-up										

Disability Cause	Decile of Cardiorespiratory Fitness									
	1	2	3	4	5	6	7	8	9	10
10 y	3.7	2.2	2.5	2.1	2.5	2.3	2.3	2.0	2.0	1.5
20 y	20.4	13.5	14.3	12.3	12.6	11.9	11.6	9.1	8.8	7.1
30 y	45.6	32.6	31.8	26.6	25.0	21.9	19.6	15.9	13.3	10.9
40 y	65.3	48.2	43.6	36.6	33.6	30.2	26.2	21.1	18.0	17.3
Musculoskeletal										
Cases, *n*	2720	2099	1826	1514	1329	914	641	593	362	339
Incidence per 10 000 person-years	7.2	6.1	5.8	4.7	3.9	3.2	2.3	2.0	1.4	1.3
Cumulative incidence per 1000 persons during follow-up										
10 y	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.2	0.2
20 y	4.6	3.6	4.2	3.4	3.6	3.2	3.0	2.6	2.3	2.2
30 y	20.3	17.4	17.2	14.2	12.8	10.5	7.9	6.9	4.6	4.3
40 y	36.6	30.2	29.3	23.8	20.3	16.4	12.9	10.7	9.7	8.5
Injuries										
Cases, *n*	931	714	670	667	576	429	425	409	302	264
Incidence per 10 000 person-years	2.5	2.1	2.1	2.1	1.7	1.5	1.6	1.4	1.2	1.0
Cumulative incidence per 1000 persons during follow-up										
10 y	0.3	0.2	0.3	0.3	0.5	0.4	0.4	0.4	0.4	0.5
20 y	2.3	1.7	2.3	2.2	2.5	2.2	2.7	2.3	2.3	2.1
30 y	7.0	5.9	6.3	6.5	5.5	4.9	5.0	4.5	3.7	3.1
40 y	12.2	10.3	10.4	9.8	7.8	6.8	7.0	6.4	5.3	3.9
Nervous system										
Cases, *n*	679	508	411	381	330	262	188	172	142	149
Incidence per 10 000 person-years	1.8	1.5	1.3	1.2	1.0	0.9	0.7	0.6	0.6	0.6
Cumulative incidence per 1000 persons during follow-up										
10 y	0.2	0.1	0.3	0.2	0.2	0.1	0.2	0.1	0.2	0.2
20 y	1.5	1.5	1.2	1.3	1.2	1.1	0.9	0.8	1.0	1.0
30 y	4.8	4.0	3.8	3.4	3.0	2.8	2.2	1.9	1.8	1.9
40 y	9.4	7.5	6.7	6.1	5.1	5.0	4.1	3.5	3.5	2.5
Circulatory										
Cases, *n*	609	411	334	272	228	139	111	90	44	51
Incidence per 10 000 person-years	1.6	1.2	1.1	0.8	0.7	0.5	0.4	0.3	0.2	0.2
Cumulative incidence per 1000 persons during follow-up										
10 y	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
20 y	0.4	0.3	0.4	0.4	0.5	0.2	0.4	0.3	0.2	0.3
30 y	3.1	2.5	2.3	2.0	1.7	1.3	1.1	0.9	0.6	0.6
40 y	10.6	7.3	6.8	5.4	4.6	3.6	3.6	2.2	1.9	3.1

Disability Cause	**Decile of Cardiorespiratory Fitness**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Tumors										
Cases, *n*	182	150	111	132	89	90	61	64	45	44
Incidence per 10 000 person-years	0.5	0.4	0.4	0.4	0.3	0.3	0.2	0.2	0.2	0.2
Cumulative incidence per 1000 persons during follow-up										
10 y	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0	0.1
20 y	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.3
30 y	1.2	1.0	0.8	1.1	0.8	0.7	0.7	0.6	0.6	0.5
40 y	2.7	2.5	2.2	2.3	1.4	2.3	1.4	1.5	0.9	1.1

Appendix Table 3.

Unadjusted Cumulative Incidence of Receipt of a Disability Pension, by BMI Category

Disability Cause	**BMI Category**					
	Underweight	**Normal Weight**	**Overweight**	**Class I Obesity**	**Class II Obesity***	**Class III Obesity***
All						
Cases, *n*	5763	41 560	5480	1158	284	59
Incidence per 10 000 person-years	22.5	16.6	21.2	29.0	44.2	61.3
Cumulative incidence per 1000 persons during follow-up						
10 y	4.6	3.1	3.8	5.3	10.0	12.9
20 y	27.7	19.4	25.0	36.1	60.1	90.2
30 y	66.2	50.2	64.9	88.8	135.8	174.1
40 y	109.5	84.8	109.8	149.0	213.4	298.5
Psychiatric						
Cases, *n*	3091	19 459	2143	385	122	
Incidence per 10 000 person-years	12.1	7.8	8.3	9.6	16.5	
Cumulative incidence per 1000 persons during follow-up						
10 y	3.5	2.2	2.5	3.4	6.9	
20 y	18.3	11.5	13.0	16.1	30.7	
30 y	37.2	24.5	26.3	30.2	49.5	
40 y	54.4	36.0	37.7	43.8	72.9	
Musculoskeletal						
Cases, *n*	1041	9393	1477	339	87	
Incidence per 10 000 person-years	4.1	3.8	5.7	8.5	11.8	
Cumulative incidence per 1000 persons during follow-up						

Disability Cause	BMI Category					
	Underweight	Normal Weight	Overweight	Class I Obesity	Class II Obesity*	Class III Obesity*
10 y	0.2	0.1	0.4	0.3	1.4	
20 y	3.3	3.0	5.1	8.7	14.0	
30 y	12.4	11.8	18.4	28.1	36.9	
40 y	22.5	21.5	32.9	47.4	73.5	
Injuries						
Cases, *n*	468	4223	562	107	27	
Incidence per 10 000 person-years	1.8	1.7	2.2	2.7	3.7	
Cumulative incidence per 1000 persons during follow-up						
10 y	0.4	0.4	0.5	0.9	0.7	
20 y	2.1	2.2	3.0	4.1	5.7	
30 y	5.7	5.3	6.9	8.2	13.4	
40 y	9.4	8.6	11.0	14.1	13.4	
Nervous system						
Cases, *n*	350	2502	312	49	9	
Incidence per 10 000 person-years	1.4	1.0	1.2	1.2	1.2	
Cumulative incidence per 1000 persons during follow-up						
10 y	0.2	0.2	0.2	0.1	0.0	
20 y	1.5	1.1	1.3	1.5	1.5	
30 y	3.9	3.0	3.8	3.7	4.1	
40 y	7.7	5.7	7.0	7.5	6.9	
Circulatory						
Cases, *n*	204	1668	328	74	15	
Incidence per 10 000 person-years	0.8	0.7	1.3	1.9	2.0	
Cumulative incidence per 1000 persons during follow-up						
10 y	0.0	0.0	0.1	0.1	0.3	
20 y	0.3	0.3	0.6	1.6	1.5	
30 y	1.6	1.6	3.4	5.2	7.4	
40 y	6.4	5.3	10.1	14.0	12.8	
Tumors						
Cases, *n*	86	763	93	20	6	
Incidence per 10 000 person-years	0.3	0.3	0.4	0.5	0.8	
Cumulative incidence per 1000 persons during follow-up						
10 y	0.1	0.1	0.0	0.1	0.3	
20 y	0.3	0.3	0.4	0.6	1.5	

Disability Cause	BMI Category					
	Underweight	Normal Weight	Overweight	Class I Obesity	Class II Obesity*	Class III Obesity*
30 y	0.9	0.8	1.0	1.5	2.2	
40 y	2.1	2.0	2.3	3.2	4.9	

BMI = body mass index.

*Data on class II and III obesity are combined for all specific causes.

Appendix Table 4.

Associations of Cardiorespiratory Fitness and BMI With Later Receipt of a Disability Pension due to All Causes, With Adjustment for Smoking and Alcohol Consumption*

Variable	Hazard Ratio (95% CI)		
	Basic Adjustment‡	**Basic Adjustment + BMI**	**Basic Adjustment + BMI + Smoking + Alcohol Consumption**
Cardiorespiratory fitness level†			
1	3.40 (1.61–7.17)	4.36 (2.06–9.21)	4.70 (2.22–9.93)
2	1.82 (1.24–2.66)	2.20 (1.50–3.22)	2.03 (1.38–2.97)
3	1.55 (1.35–1.79)	1.82 (1.58–2.11)	1.62 (1.40–1.87)
4	1.48 (1.33–1.65)	1.68 (1.50–1.88)	1.52 (1.36–1.70)
5	1.39 (1.25–1.53)	1.52 (1.37–1.69)	1.37 (1.23–1.52)
6	1.27 (1.14–1.42)	1.34 (1.20–1.49)	1.22 (1.10–1.36)
7	1.10 (0.97–1.25)	1.14 (1.00–1.29)	1.06 (0.93–1.20)
8	1.12 (0.99–1.28)	1.16 (1.01–1.32)	1.10 (0.96–1.25)
9	Reference	Reference	Reference
	Basic Adjustment	**Basic Adjustment + Fitness**	**Basic Adjustment + Fitness + Smoking + Alcohol Consumption**
BMI category			
Class II or III obesity	2.88 (1.44–5.76)	2.71 (1.35–5.43)	2.75 (1.37–5.50)
Class I obesity	1.55 (1.17–2.07)	1.55 (1.16–2.06)	1.55 (1.17–2.07)
Overweight	1.39 (1.24–1.55)	1.44 (1.29–1.61)	1.43 (1.28–1.59)
Normal weight	Reference	Reference	Reference
Underweight	1.06 (0.97–1.15)	0.93 (0.85–1.02)	0.95 (0.87–1.04)

BMI = body mass index.

*Analyses were performed in a subset of adolescents (*n* = 34 966) who were conscripted between 1969 and 1973 because data on smoking and alcohol consumption were collected only during these years. These adolescents had complete data on cardiorespiratory fitness, BMI, and basic confounders as well as smoking (0, 1 to 5, 6 to 10, 11 to 20, or >20 cigarettes per day) and alcohol consumption (yes vs. no), as described in a previous study that used data from the Swedish Military Service Conscription Registry (10).

†Presented as stanine (standard nine) scores, as described previously (10).

‡Basic adjusted models included conscription year, conscription center, age at conscription, and childhood socioeconomic status as covariates.

Appendix Table 5.

Robustness to Unmeasured Confounding (Reported as E-Values) for Assessment of the Association of Cardiorespiratory Fitness and BMI With Receipt of a Disability Pension*

Disability Cause	Cardiorespiratory Fitness		BMI	
	For Effect Estimate†	For CI Limit Closest to Null‡	For Effect Estimate†	For CI Limit Closest to Null‡
All	6.94	6.56	5.87	4.42
Psychiatric	7.48	6.90	2.64	1.00
Musculoskeletal	6.90	6.03	7.69	4.40
Injuries	4.92	4.13	3.33	2.01
Nervous system	5.17	4.13	1.79	1.00
Circulatory	9.21	6.62	7.08	4.01
Tumors	3.19	1.95	5.59	2.08

BMI = body mass index.

*E-values are for the associations of cardiorespiratory fitness (decile 1 vs. decile 10) and BMI (class III obesity vs. normal weight for all causes and psychiatric and musculoskeletal causes, and class II and III obesity vs. normal weight for remaining causes) with receipt of a disability pension due to all or specific causes and were calculated according to the method of VanderWeele and Ding (18).

†The E-value for the effect estimate is the minimum strength of the association on the risk scale that an unmeasured confounder would need to have with both the exposure and the outcome to fully explain away the observed association.

‡The E-value for the 95% CI limit closest to the null is the minimum strength of the association on the risk scale that an unmeasured confounder would need to have with both the exposure and the outcome in order for the CI of the observed association to include the null value.

Appendix Table 6.

Associations of Cardiorespiratory Fitness and BMI With Later Receipt of a Disability Pension due to Specific Psychiatric Causes (*n* = 1 079 128)*

Variable	Hazard Ratio (95% CI)				
	All Psychiatric Causes (n = 25 200)	Substance Abuse† (*n* = 2592)	Nonaffective Disorders† (*n* = 4475)	Affective Disorders† (*n* = 11 761)	Personality Disorders† (*n* = 3313)
Decile of cardiorespiratory fitness					
1	4.01 (3.72–4.32)	9.28 (6.42–13.40)	2.08 (1.77–2.44)	3.55 (3.18–3.97)	5.82 (4.64–7.30)
2	3.18 (2.95–3.44)	7.04 (4.86–10.19)	1.83 (1.55–2.15)	2.82 (2.52–3.16)	4.34 (3.45–5.47)
3	2.93 (2.71–3.16)	5.65 (3.89–8.20)	1.86 (1.59–2.18)	2.68 (2.39–3.00)	3.91 (3.10–4.92)
4	2.48 (2.30–2.68)	4.69 (3.22–6.82)	1.66 (1.41–1.94)	2.30 (2.05–2.57)	3.18 (2.52–4.02)
5	2.24 (2.07–2.41)	3.96 (2.72–5.77)	1.50 (1.28–1.75)	2.12 (1.90–2.37)	2.86 (2.27–3.61)
6	2.00 (1.84–2.16)	3.57 (2.43–5.24)	1.34 (1.14–1.58)	1.89 (1.69–2.12)	2.41 (1.89–3.01)
7	1.73 (1.60–1.88)	2.54 (1.70–3.78)	1.36 (1.16–1.60)	1.70 (1.51–1.91)	1.96 (1.54–2.51)
8	1.43 (1.31–1.55)	1.79 (1.18–2.72)	1.22 (1.04–1.44)	1.36 (1.20–1.53)	1.55 (1.20–1.99)

Variable	Hazard Ratio (95% CI)				
	All Psychiatric Causes (n = 25 200)	**Substance Abuse† (*n* = 2592)**	**Nonaffective Disorders† (*n* = 4475)**	**Affective Disorders† (*n* = 11 761)**	**Personality Disorders† (*n* = 3313)**
9	1.21 (1.11–1.32)	1.94 (1.27–2.96)	1.05 (0.88–1.24)	1.19 (1.05–1.35)	1.47 (1.14–1.91)
10	Reference	Reference	Reference	Reference	Reference
BMI categories					
Class II or III obesity	1.81 (1.52–2.17)	0.74 (0.31–1.78)	0.57 (0.27–1.20)	2.53 (2.00–3.18)	1.13 (0.63–2.05)
Class I obesity	1.15 (1.04–1.27)	1.09 (0.79–1.51)	0.62 (0.45–0.85)	1.24 (1.07–1.43)	1.48 (1.16–1.88)
Overweight	1.13 (1.08–1.18)	1.12 (0.97–1.29)	0.86 (0.76–0.96)	1.20 (1.13–1.28)	1.13 (1.00–1.28)
Normal weight	Reference	Reference	Reference	Reference	Reference
Underweight	1.08 (1.04–1.13)	1.00 (0.89–1.13)	1.13 (1.03–1.25)	1.08 (1.01–1.14)	1.09 (0.98–1.21)

BMI = body mass index; ICD = International Classification of Diseases.

*Models were adjusted for conscription year, conscription center, age at conscription, childhood socioeconomic status, any mental hospitalization before conscription, and any psychiatric diagnosis at conscription. Models with cardiorespiratory fitness as the exposure were further adjusted for BMI, and models with BMI as the exposure were further adjusted for cardiorespiratory fitness.

†Use of ICD codes for specific psychiatric causes of receipt of a disability pension was based on Kark and colleagues (42) (substance abuse: ICD-8 codes 291 and 303 to 304, ICD-9 codes 291 to 292 and 303 to 305, and ICD-10 codes F10 to F19; nonaffective disorders [including schizophrenia]: ICD-8 codes 295 and 297, ICD-9 codes 295 and 297, and ICD-10 codes F20 to F29; affective disorders: ICD-8 codes 296, 298, 300, and 305, ICD-9 codes 296, 298, 300, 306, 308 to 309, and 311, and ICD-10 codes F30 to F49; personality disorders: ICD-8 codes 301 to 302, ICD-9 codes 301 to 302, and ICD-10 codes F60 to F69).

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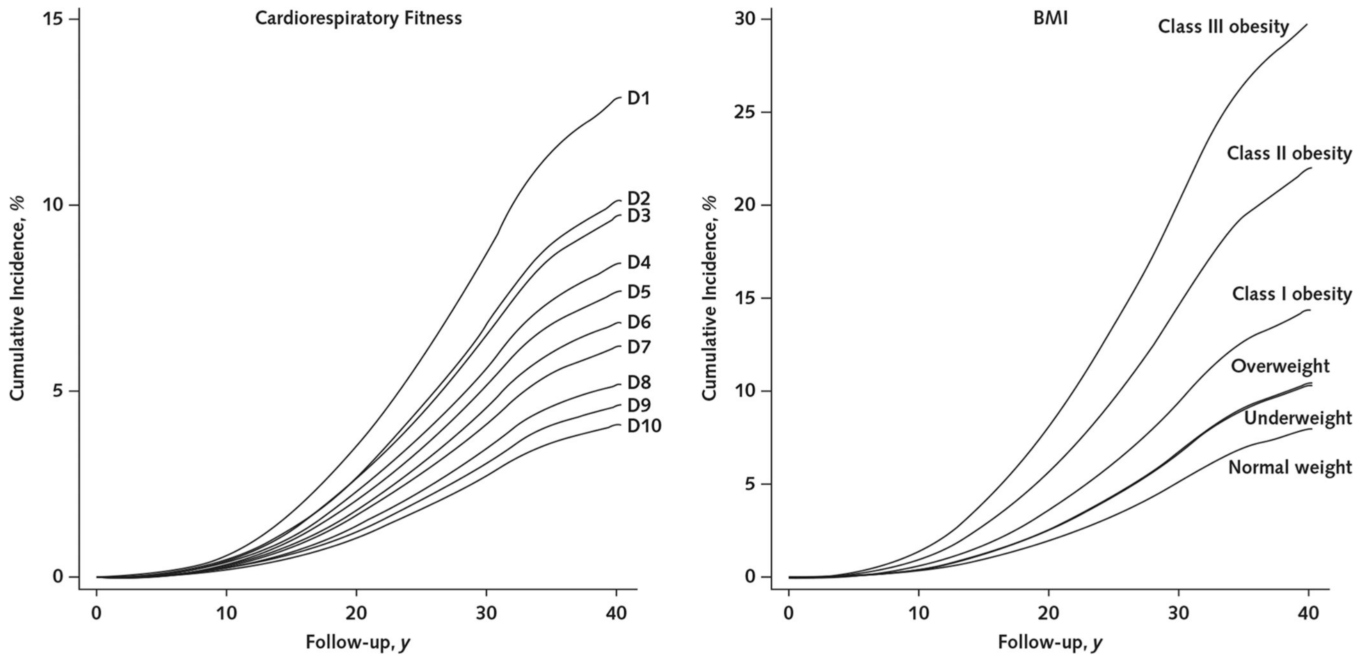

Figure 1.

Unadjusted cumulative incidences of receipt of a disability pension due to all causes, by cardiorespiratory fitness level (*left*) and BMI category (*right*).

Cumulative incidences were estimated from unadjusted Cox regression models. BMI = body mass index; D = decile.

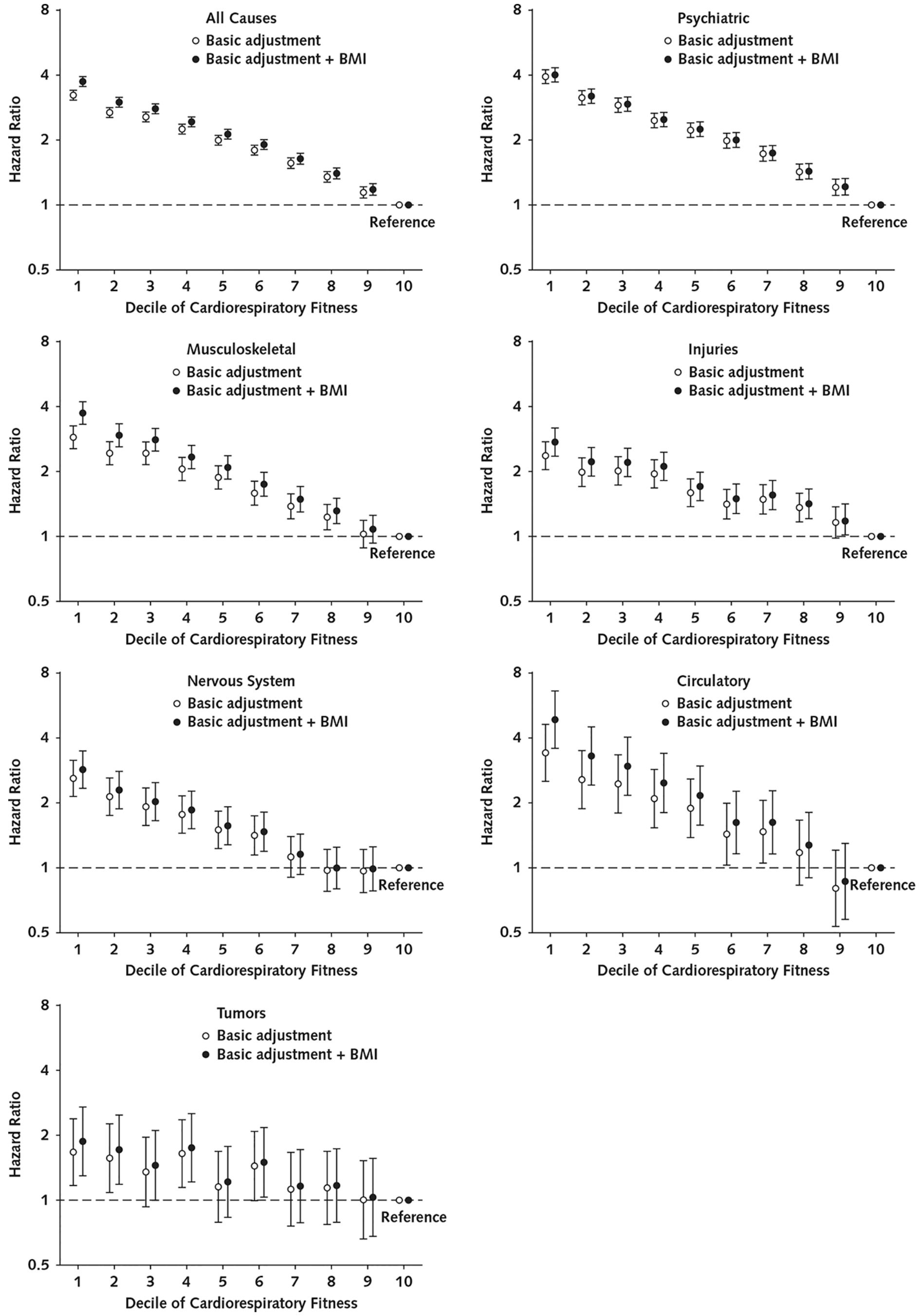

Figure 2.

Association of cardiorespiratory fitness with later receipt of a disability pension due to all and specific causes (*n* = 1 079 128).

Cox proportional hazards regression models were used to estimate hazard ratios with 95% CIs. Basic adjusted models included conscription year, conscription center, age at conscription, and childhood socioeconomic status as covariates. Models for receipt of a disability pension due to all or psychiatric causes were also adjusted for any mental hospitalization before conscription and for any psychiatric diagnosis at conscription. Error bars indicate 95% CIs. BMI = body mass index.

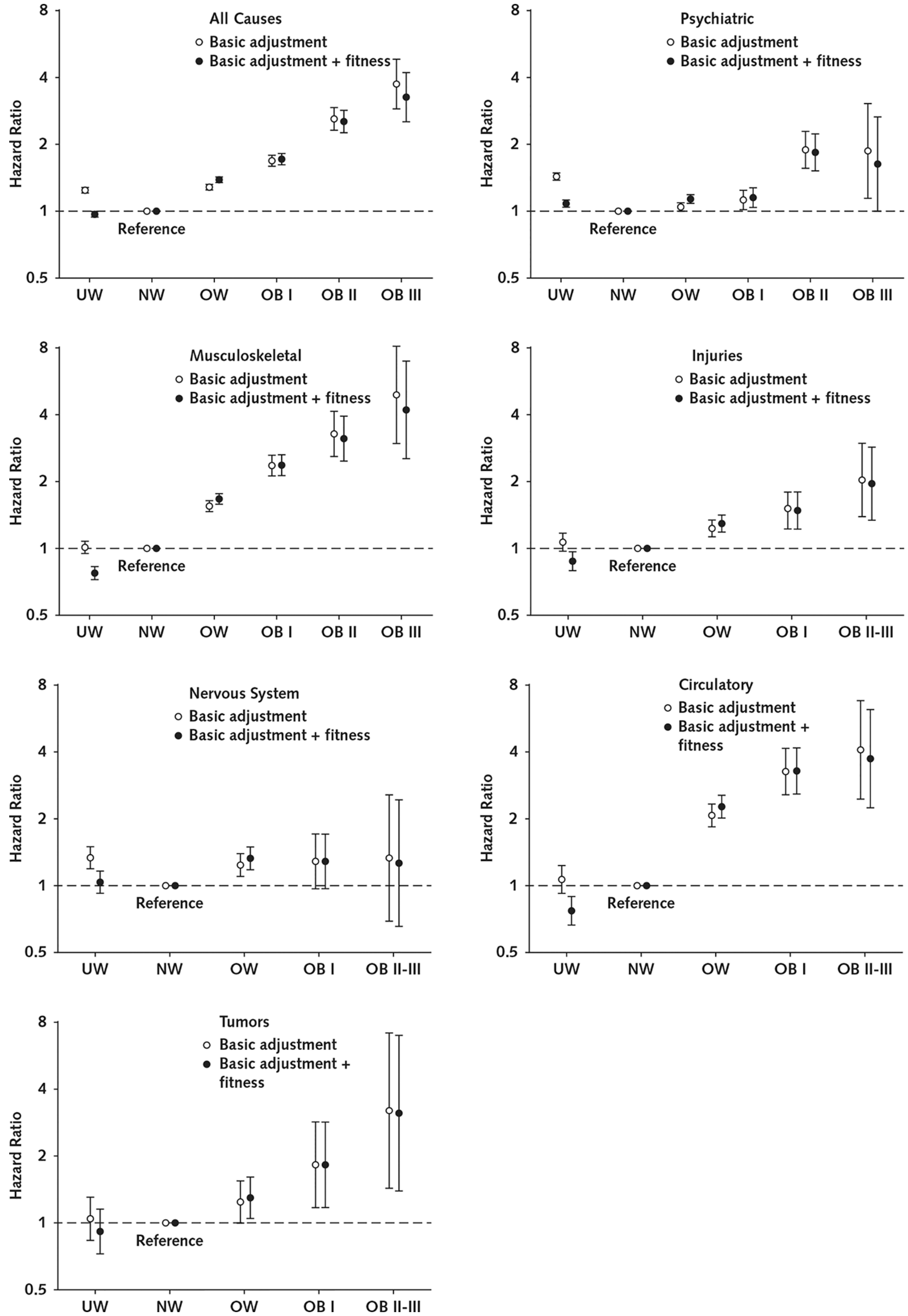

Figure 3.

Association of BMI with later receipt of a disability pension due to all and specific causes (*n* = 1 079 128).

Cox proportional hazards regression models were used to estimate hazard ratios with 95% CIs. Basic adjusted models included conscription year, conscription center, age at conscription, and childhood socioeconomic status as covariates. Models for receipt of a disability pension due to all or psychiatric causes were also adjusted for any mental hospitalization before conscription and for any psychiatric diagnosis at conscription. Error bars indicate 95% CIs. BMI = body mass index; OB I = class I obesity; OB II = class II obesity; OB III = class III obesity; NW = normal weight; OW = overweight; UW = underweight.

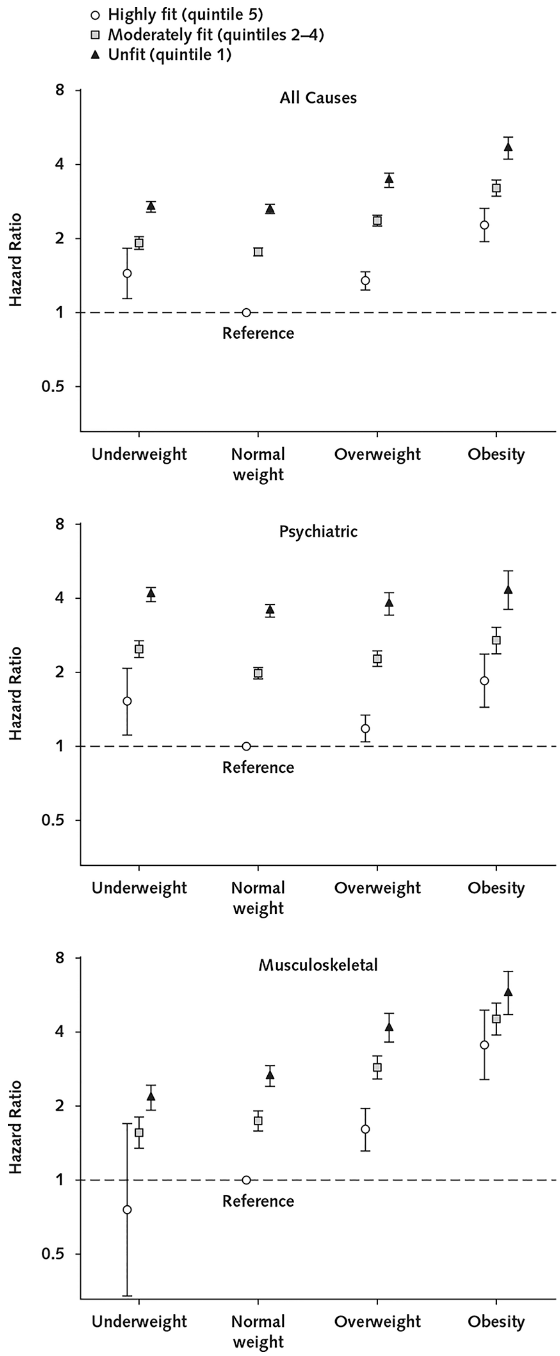

Figure 4.

Combined associations of cardiorespiratory fitness and BMI with later receipt of a disability pension due to all causes and the 2 most prevalent causes (psychiatric and musculoskeletal). Cox proportional hazards regression models were used to estimate hazard ratios with 95% CIs. Models were adjusted for conscription year, conscription center, age at conscription, and childhood socioeconomic status as covariates. Models for receipt of a disability pension due to all or psychiatric causes were also adjusted for any mental hospitalization before conscription and for any psychiatric diagnosis at conscription. Error bars indicate 95% CIs. BMI = body mass index.

Table.

Descriptive Data on Study Participants (*n* = 1 079 128)

Characteristic	Value
Mean age at conscription (SD), *y*	18.32 (0.44)
Mean height (SD), *cm*	179.3 (6.5)
Mean weight (SD), *kg*	69.9 (10.3)
Mean cardiorespiratory fitness (SD), *W**	275.2 (52.0)
BMI at conscription (SD), kg/m^2	21.7 (2.8)
BMI category, *n (%)*	
Underweight (<18.5 kg/m^2)	87 575 (8.1)
Normal weight (18.5–24.9 kg/m^2)	879 367 (81.5)
Overweight (25.0–29.9 kg/m^2)	94 253 (8.7)
Mild (class I) obesity (30.0–34.9 kg/m^2)	15 027 (1.4)
Moderate (class II) obesity (35.0–39.9 kg/m^2)	2517 (0.2)
Severe (class III) obesity (≥40.0 kg/m^2)	389 (<0.01)
Childhood socioeconomic status, *n (%)*†	
High-level nonmanual workers	92 361 (8.6)
Intermediate-level nonmanual workers	228 669 (21.2)
Low-level nonmanual workers	166 293 (15.4)
Self-employed or farmers	79 483 (7.4)
Skilled workers	352 448 (32.7)
Unskilled workers	129 429 (12.0)
Other	30 445 (2.8)
Cause of receipt of disability pension, *n (%)*	
All	54 304 (5.0)
Psychiatric	25 200 (2.3)
Musculoskeletal	12 337 (1.1)
Injuries	5387 (0.5)
Nervous system	3222 (0.3)
Circulatory	2289 (0.2)
Tumors	968 (0.1)
Other	4901 (0.5)
Mental hospitalization before conscription, *n (%)*	9337 (0.9)
Psychiatric diagnosis at conscription, *n (%)*‡	53 126 (4.9)

BMI = body mass index; ICD = International Classification of Diseases.

*Measured by ergometer cycle test. Decile 1 = ≤211 W, decile 2 = 212 to 229 W, decile 3 = 230 to 241 W, decile 4 = 242 to 254 W, decile 5 = 255 to 270 W, decile 6 = 271 to 284 W, decile 7 = 285 to 300 W, decile 8 = 301 to 320 W, decile 9 = 321 to 343 W, and decile 10 = ≥344 W.

†Based on highest-level occupation of parents.

‡Any diagnosis in psychiatric chapter of ICD (ICD-10: Chapter F; ICD-9: 290 to 319; ICD-8: 290 to 315).