The Changing Relationship of Obesity and Disability, 1988-2004

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Context Recent studies suggest that the obese population may have been growing healthier since the 1960s, as indicated by a decrease in mortality and cardiovascular risk factors. However, whether these improvements have conferred decreased risk for disability is unknown. The obese population may be living longer with better-controlled risk factors but paradoxically experiencing more disability.

Objective To determine whether the association between obesity and disability has changed over time.

Design, Setting, and Participants Adults aged 60 years and older (N=9928) with measured body mass index from 2 waves of the nationally representative National Health and Nutrition Examination Surveys (NHANES III [1988-1994] and NHANES 1999-2004).

Main Outcome Measures Reports of much difficulty or inability to perform tasks in 2 disability domains: functional limitations (walking one-fourth mile, walking up 10 steps, stooping, lifting 10 lb, walking between rooms, and standing from an armless chair) and activities of daily living (ADL) limitations (transferring, eating, and dressing).

Results Among obese individuals, the prevalence of functional impairment increased 5.4% (from 36.8%-42.2%; $P=.03$) between the 2 surveys, and ADL impairment did not change. At time 1 (1988-1994), the odds of functional impairment for obese individuals were 1.78 times greater than for normal-weight individuals (95% confidence interval [CI], 1.47-2.16). At time 2 (1999-2004), this odds ratio increased to 2.75 (95% CI, 2.39-3.17), because the odds of functional impairment increased by 43% (OR 1.43; 95% CI, 1.18-1.75) among obese individuals during this period, but did not change among nonobese individuals. With respect to ADL impairment, odds for obese individuals were not significantly greater than for individuals with normal weight (OR, 1.31; 95% CI, 0.92-1.88) at time 1, but increased to 2.05 (95% CI, 1.45-2.88) at time 2. This was because the odds of ADL impairment did not change for obese individuals but decreased by 34% among nonobese individuals (OR, 0.66; 95% CI, 0.50-0.88).

Conclusions Recent cardiovascular improvements have not been accompanied by reduced disability within the obese older population. Rather, obese participants surveyed during 1999-2004 were more likely to report functional impairments than obese participants surveyed during 1988-1994, and reductions in ADL impairment observed for nonobese older individuals did not occur in those who were obese. Over time, declines in obesity-related mortality, along with a younger age at onset of obesity, could lead to an increased burden of disability within the obese older population.

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OBESITY IS ASSOCIATED WITH A variety of poor health outcomes including an increased risk for cardiovascular disease, diabetes, disability, and mortality.[1-5] Recent studies, however, suggest that the obese population may have grown healthier since the 1960s. For example, the prevalence of high cholesterol and high blood pressure has declined among obese individuals.[4] Additionally, the influence of obesity on all-cause mortality may have decreased.[2] However, not all studies have supported this finding,[6] and obesity continues to be associated with excess mortality.[2,6-9]

These changes may be mediated, in part, by improvements in medical care, particularly for cardiovascular disease. Increases in the use of antihypertensive and lipid-lowering medications have occurred across weight groups but have been especially large within the obese population.[4] If the physiological manifestations of obesity are increasingly treatable, some of the negative health effects of obesity may be in decline.

It is unclear, however, whether improvements in cardiovascular risk factors and mortality have been accompanied by improvements in other health outcomes. For example, the increased risk for diabetes associated with obesity has not changed[4] and obesity continues to be associated with an excess burden of disabling conditions.[10,11] If improvements in the health of the obese population are due to primary prevention efforts that reduce the burden of disease, then obesity could become less disabling over time. However, if improvements have been due to secondary or tertiary prevention efforts, allowing people to live longer with disease, the association between obesity and disability may be increasing.

See also p 2066 and Patient Page.

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Furthermore, new cohorts of older individuals may have experienced a longer duration of obesity relative to previous cohorts. The increases in weight have occurred since the 1980s across all age groups[12]; those entering old age (≥60 years) with obesity today are likely to have had a longer exposure to excess weight than older people in previous cohorts. The disability risk associated with obesity may be related to cumulative exposure,[1] because obesity affects disability risk not only through cardiovascular disease burden, but also through conditions like arthritis.

Our objective was to determine whether the association between obesity and disability changed between 1988-1994 and 1999-2004 among individuals aged 60 years and older. A previous analysis of trends in obesity and disability showed a constant effect of obesity on disability over time, with disability increasing in both obese and nonobese populations.[13] This analysis, however, was based on an earlier period when disability appeared to be increasing in the older population. It is important to know whether recent declines in old age disability[14] have occurred for all older individuals or have been confined to nonobese individuals. Disability in this age group is of particular importance, given the current context of population aging[15] and an increasing prevalence of obesity among older-aged individuals.[12,16] Furthermore, obesity-associated disability is associated with significant burden in terms of both quality of life and health care costs in this age group.[17-19]

METHODS

The National Health and Nutrition Examination Surveys (NHANES) are cross-sectional studies of the noninstitutionalized US population including interviews and clinical examinations conducted by the National Center for Health Statistics.[20] In this analysis, data from NHANES III (1988-1994) and NHANES 1999-2004 were used to examine change in disability by body mass index (BMI [calculated as weight in kilograms divided by height in meters squared]) category. We do not examine NHANES waves prior to NHANES III because they did not include our measures of interest on disability. There were 5724 participants aged 60 years and older during 1988-1994 and 4984 during 1999-2004 who participated in the clinical examination component (87.7% of participants).

NHANES collected information on 2 types of disability indicators: functional limitations, which refer to restrictions in basic movement ability, and limitations in activities of daily living (ADLs), which represent the most severe disabilities and reflect an individual's ability to live independently. These domains are conceptually distinct, as functional limitations are intrinsic to the individual (eg, ability to stoop or kneel), while ADL limitations refer to an interaction with the physical and social environment to accomplish a task (eg, dressing).[21] For each question pertaining to disability-related tasks, participants were asked, "By yourself and without using any special equipment, how much difficulty do you have" with the particular task. Participants could report having no difficulty, some difficulty, much difficulty, or unable to do. In 2003-2004, a new response category, "don't do," was added. For each item, less than 1% of respondents selected the "don't do" category, and these responses were recoded as unable to do. Sensitivity analysis found that excluding don't do responses as missing did not change results.

Participants were considered to have a functional limitation if they reported much difficulty or inability to perform any of the following 6 tasks: walking one-fourth mile, walking up 10 steps without resting, stooping/crouching/kneeling, lifting or carrying 10 lb, walking between rooms on the same floor, and standing from an armless chair. Participants who reported using assistive devices to walk were assumed to have difficulty walking one-fourth mile and walking up 10 steps. Participants were considered to have an ADL limitation if they reported much difficulty or inability to perform any of the 3 tasks representing ADLs: getting in and out of bed, eating, and dressing. Participants were included if they answered at least 4 of the 6 functioning indicators and at least 2 of the 3 ADL indicators, which resulted in 43 participants who were excluded for missing data on disability measures. Sensitivity tests in which we excluded all participants with any missing data or assumed that all such individuals were disabled did not change results. Cronbach α for a summary scale of impairment items indicated high correlations among individual items and acceptable internal reliability ($\alpha = 0.85$ for functional limitations; $\alpha = 0.66$ for ADL limitations).

Unfortunately, NHANES includes questions on only 3 of the 5 ADLs typically used to define ADL impairment[22] and did not ask about bathing or toileting, leading to a slightly lower prevalence of observed ADL limitations in elderly individuals relative to other surveys.[14] Nevertheless, we include estimates of trends for the available ADL limitations as a comparison for trends in functional limitations.

Weight categories were based on measured height and weight: underweight (BMI <18.5), normal weight (BMI, 18.5-24.9), overweight (BMI, 25.0-29.9), and obese (BMI ≥30.0). Covariates included self-reported age, sex, race/ethnicity (determined by self-report and categorized as non-Hispanic black, Mexican American, and other compared with non-Hispanic white), education, income, the presence of chronic conditions, smoking, and health insurance status. Education was coded in 3 categories: low (<12 years), 12 years, and high (>12 years). Income was measured using the poverty income ratio to account for household size and inflation over time.[23] For 11% of the respondents with missing income data, poverty income ratio values were imputed using random regression imputation.[24] With respect to chronic conditions, participants were asked whether a physician had ever told

Table 1. Prevalence of Disability by BMI Group in NHANES III (1988-1994) and NHANES 1999-2004[a]

	1988-1994			1999-2004			Trend		
	Normal Weight[b]	Overweight[b]	Obese[b]	Normal Weight[b]	Overweight[b]	Obese[b]	*P* for Change in Normal Weight	*P* for Change in Overweight	*P* for Change in Obese
No. of participants	1865	2151	1262	1239	1801	1408			
Weighted %	35.4 (1.20)	38.7 (0.91)	23.5 (0.87)	28.0 (0.99)	39.0 (1.0)	31.7 (0.84)	<.001	.82	<.001
Mean BMI[b]	22.4 (0.06)	27.3 (0.04)	34.0 (0.13)	22.7 (0.06)	27.4 (0.04)	34.6 (0.15)	.007	.007	.001
Functional impairment[c]	26.7 (1.39)	27.4 (1.34)	36.8 (1.90)	26.6 (1.58)	25.8 (1.04)	42.2 (1.51)	.94	.35	.03
ADL impairment[d]	5.0 (0.72)	4.3 (0.51)	6.0 (0.82)	3.5 (0.60)	3.0 (0.46)	5.5 (0.64)	.13	.09	.63

Abbreviations: ADL, activities of daily living; BMI, body mass index; NHANES, National Health and Nutritional Examination Surveys.
[a] Results shown are % (SE) unless otherwise indicated; BMI is calculated as weight in kilograms divided by height in meters squared.
[b] Normal weight denotes a BMI of 18.5 to 24.9, overweight denotes a BMI of 25.0 to 29.9, and obese denotes a BMI of 30.0 or greater.
[c] Percentage of respondents reporting much difficulty or inability to do any of 6 functioning tasks: walking one-fourth mile, walking up 10 steps without resting, stooping/crouching/kneeling, lifting or carrying 10 lb, walking across a room, and standing from an armless chair.
[d] Percentage of respondents reporting much difficulty or inability to do any of 3 activities of daily living: getting in and out of bed, eating, and dressing.

them that they had arthritis, asthma, chronic bronchitis, emphysema, diabetes, congestive heart failure, a heart attack, cancer, or stroke. Smoking and health insurance were coded into 2 categories: current smokers vs nonsmokers and no health insurance vs any health insurance.

In the combined sample (N = 10 708), 326 participants were excluded for missing BMI, followed by 43 for missing disability data, and 411 for missing 1 or more other covariates, yielding a final analytic sample of 9928 participants from both surveys. Logistic regression was used to model the odds of having a functional or ADL limitation (in separate analyses). Because odds ratios (ORs) may overestimate risk in common outcomes, we also provide risk ratios computed as the ratio of the adjusted probability of disability in the exposed group to the adjusted probability of disability in the nonexposed group.

We examined the influence of weight status on functional and ADL limitations and the extent to which this relationship has changed from NHANES III (1988-1994) to NHANES 1999-2004. In addition, we examined potential explanations for observed changes over time. First, we considered whether demographic changes, such as differences in age, race, education, or income, accounted for trends in the association between obesity and disability. Next, we accounted for the changes in the distribution of BMI in the obese category by separating obesity into standard classes. Because the weight distribution shifted upward over this period,[12] it is possible that changes in the risk associated with obesity simply reflect an upward shift in the BMI distribution. We therefore estimated risk for disability using separate obesity weight categories (class I, BMI 30.0-34.9; class II, BMI 35.0-39.9; and class III, BMI $\geq$40.0). Finally, we examined whether changes in the prevalence of disabling chronic conditions, smoking, and health insurance coverage for participants accounted for trends in obesity and disability. The University of Pennsylvania Institutional Review Board approved this study. All analyses were conducted using STATA version 8.2 (StataCorp LP, College Station, Texas) to account for sample weighting and elements of survey design.

RESULTS

TABLE 1 provides the prevalence of normal weight, overweight, and obese in the respondents (after weighting) and the prevalence of functional limitations and ADL disability within BMI groups. The underweight group was omitted because of its small sample size (202), which precluded meaningful estimates. The prevalence of obesity increased by 8.2 percentage points over time ($P < .001$) from 23.5% of the population aged 60 years and older in 1988-1994 (time 1) to 31.7% in 1999-2004 (time 2). During both time ranges, obese individuals were more likely than normal-weight individuals to have a functional impairment ($P < .001$). During time 2, obese individuals were also more likely to have an ADL impairment ($P = .02$). Examining trends over time showed that the prevalence of functional impairment did not change significantly among normal-weight individuals, but increased among obese individuals from 36.8% to 42.2% ($P = .03$). ADL impairment declined marginally in normal-weight and overweight groups considered separately and declined significantly when those groups were combined ($P = .02$).

TABLE 2 provides characteristics of the obese and nonobese populations in NHANES III (1988-1994) and NHANES 1999-2004. Obese participants were younger, had fewer years of education, were more likely to be women, black, and to have arthritis and diabetes, and were less likely to smoke. Education levels and asthma prevalence increased in both the obese and nonobese groups, but diabetes prevalence increased only in the obese group.

TABLE 3 provides ORs based on logistic regression predicting the odds of having a functional impairment or an ADL impairment. The OR for the time coefficient indicates the odds of being impaired for a nonobese individual during 1999-2004 relative to 1988-1994. The OR for the obese coefficient indicates the odds of being impaired for an obese individual relative to one with normal weight at time 1. Finally, the OR for the obese-time interaction indicates change in the association between obesity and disability over time, or the change in the OR associated with being obese at time 2 relative to time 1.

Controlling for demographic characteristics in model 1, we see that the odds of being functionally impaired did not change for nonobese individuals from time 1 to time 2 (OR, 0.93; 95% CI, 0.81-1.07), but increased 43% among obese individuals (OR, 1.43; 95% CI, 1.18-1.75; OR=exp[ln(0.93)+ln(1.54)]=[0.93×1.54]). Accordingly, we find an increasing association between obesity and disability over time. At time 1, obese individuals had a 78% increased odds of functional impairment relative to those with normal weight (OR, 1.78; 95% CI, 1.47-2.16). At time 2, the odds of functional limitation for obese individuals were 2.75 times greater than for those with normal weight (OR, 2.75 [1.78 × 1.54]; 95% CI, 2.39-3.17). Hence, the OR for obesity between NHANES III (1988-1994) and NHANES 1999-2004 increased by a factor of 1.54 (95% CI, 1.25-1.91).

The predicted probabilities obtained from model 1 were adjusted for age, sex, race/ethnicity, education, and income (**Figure**). The adjusted probability of functional impairment did not change among normal-weight individuals (0.234 during 1988-1994 vs 0.221 during 1999-2004); the risk ratio of impairment for normal-weight individuals at time 2 relative to time 1 was 0.94. However, the probability of functional impairment increased among obese individuals from 0.352 to 0.438 for a risk ratio of 1.24 for obese individuals at time 2 relative to time 1. The effect of obesity relative to normal weight also increased over time; at time 1, the risk ratio of impairment for obesity vs normal weight was 1.50, and this risk increased to 1.98 at time 2.

Model 2 separates obese individuals into 3 obesity weight categories (class I, class II, and class III) to account for an upward shift in the BMI distribution and the increased prevalence of extreme obesity in the 1990s.[13] All 3 levels of obesity were significantly associated with functional impairment, and this association increased with increasing obesity class. Individuals with a BMI of 40 or greater had 8.68 times the odds of having functional impairment relative to those with normal weight (95% CI, 4.45-16.91). The effects of both class I and class II obesity increased between 1988-1994 and 1999-2004, with the effect of class I obesity increasing 1.31 times (OR, 1.31; 95% CI, 1.00-1.72; $P=.047$) and the effect of class II obesity increasing 2.24

Table 2. Characteristics of Obese and Nonobese Population in NHANES III (1988-1994) and NHANES 1999-2004[a]

	1988-1994			1999-2004			Trend	
	Nonobese (n = 4163)[b]	Obese (n = 1262)[b]	*P* for Difference	Nonobese (n = 3095)[b]	Obese (n = 1408)[b]	*P* for Difference	*P* for Change in Nonobese	*P* for Change in Obese
Weighted %	76.5 (0.87)	23.5 (0.87)		68.3 (0.84)	31.7 (0.84)		<.001	<.001
Demographic								
Mean age, y	71.0 (0.25)	69.1 (0.22)	<.001	71.6 (0.23)	69.0 (0.22)	<.001	.09	.82
Women	55.6 (0.70)	61.0 (1.87)	.02	55.1 (0.75)	58.8 (1.25)	.03	.62	.32
Race/ethnicity								
Black	7.2 (0.64)	11.1 (1.25)	<.001	6.9 (0.96)	11.2 (1.35)	<.001	.85	.98
Mexican American	2.0 (0.15)	2.6 (0.30)	.03	3.1 (0.71)	3.3 (0.75)	.44	.07	.35
Other	5.0 (0.86)	3.8 (1.15)	.26	7.3 (1.26)	4.4 (1.06)	.005	.12	.72
Low education (<12 y)	40.4 (1.75)	46.1 (2.35)	.006	29.1 (1.96)	29.9 (1.57)	.72	<.001	<.001
High education (≥12 y)	29.5 (1.62)	22.3 (1.99)	.005	43.2 (1.55)	38.5 (1.79)	.02	<.001	<.001
Poverty income ratio (0-5)[c]	2.7 (0.06)	2.5 (0.07)	.008	2.8 (0.07)	2.7 (0.06)	.16	.37	.07
Chronic conditions								
Arthritis	41.5 (0.99)	55.2 (1.60)	<.001	46.2 (0.96)	58.3 (1.46)	<.001	.001	.15
Asthma	6.7 (0.50)	8.8 (1.36)	.12	9.0 (0.76)	12.7 (1.06)	.003	.009	.04
Cancer	21.6 (1.11)	18.0 (1.42)	.047	22.6 (0.80)	19.3 (1.57)	.07	.48	.56
Chronic bronchitis	9.3 (0.56)	10.1 (0.91)	.46	7.6 (0.76)	9.8 (0.91)	.03	.09	.85
Congestive heart failure	6.7 (0.46)	8.6 (1.16)	.10	5.8 (0.39)	8.1 (0.80)	.004	.14	.74
Diabetes	10.4 (0.57)	19.0 (1.21)	<.001	11.3 (0.63)	25.0 (1.39)	<.001	.34	.002
Emphysema	6.0 (0.50)	5.2 (1.15)	.53	5.2 (0.52)	4.5 (0.80)	.46	.27	.61
Myocardial infarction	11.1 (0.78)	11.9 (1.37)	.49	9.8 (0.62)	11.1 (1.09)	.28	.21	.65
Stroke	6.6 (0.56)	7.1 (1.00)	.67	6.4 (0.51)	7.2 (0.83)	.33	.75	.91
Health behavior and access								
Current smoker	16.4 (0.91)	10.7 (1.68)	.005	13.1 (0.85)	9.2 (0.93)	.004	.011	.42
Uninsured	2.3 (0.36)	2.3 (0.49)	.90	3.9 (0.48)	4.3 (0.78)	.65	.008	.03

Abbreviation: NHANES, National Health and Nutritional Examination Survey.
[a] Results shown are % (SE) unless otherwise indicated.
[b] Nonobese denotes a body mass index of less than 30 (including underweight) and obese denotes a body mass index of 30 or greater (calculated as weight in kilograms divided by height in meters squared).
[c] Mean poverty income ratio is the ratio of household income to the family's appropriate poverty threshold (top coded at 5).

times (95% CI,1.48-3.38). However, the effect of morbid obesity did not change over time (OR, 0.93; 95% CI, 0.40-2.17).

Adjusting for chronic conditions, availability of health insurance, and smoking (model 3) reduced the OR for class I obesity so that it was no longer significant (OR, 1.24; 95% CI, 0.97-1.58). Class II and class III obesity continued to be associated with increased odds of disability. Even after adjusting for potential differences in other health characteristics over time, the OR for class I obesity increased by a factor of 1.37 (OR, 1.37, 95% CI, 1.02-1.84) and the OR for class II obesity more than doubled (OR, 2.04; 95% CI, 1.29-3.24). All chronic conditions were significantly associated with functional impairment except asthma and cancer. Arthritis, stroke, and congestive heart failure were the most disabling chronic conditions, each more than doubling the odds of functional impairment. Smoking was associated with increased odds of functional impairment (OR, 1.44; 95% CI, 1.17-1.77), but being uninsured at the time of the interview was not (OR, 0.96; 95% CI, 0.67-1.38).

In terms of ADL limitations, model 1 shows that risk of ADL impairment in obese older individuals was not significantly different from normal weight during time 1 (OR, 1.31; 95% CI, 0.92-1.88). Between 1988-1994 and 1999-2004, the odds of ADL impairment decreased by 34% within the nonobese population (OR, 0.66; 95% CI, 0.50-0.88), but did not change in the obese population (OR, 1.03 [0.66 × 1.56]; 95% CI, 0.71-1.51. Accordingly, the OR for obese (vs normal weight) increased by a factor of 1.56 between time 1 and time 2 (OR, 1.56; 95% CI, 1.03-2.36). At time 2, the odds of ADL impairment for obese individuals were 2.05 times greater than for those with normal weight (OR, 2.05 [1.31 × 1.56]; 95% CI, 1.45-2.88).

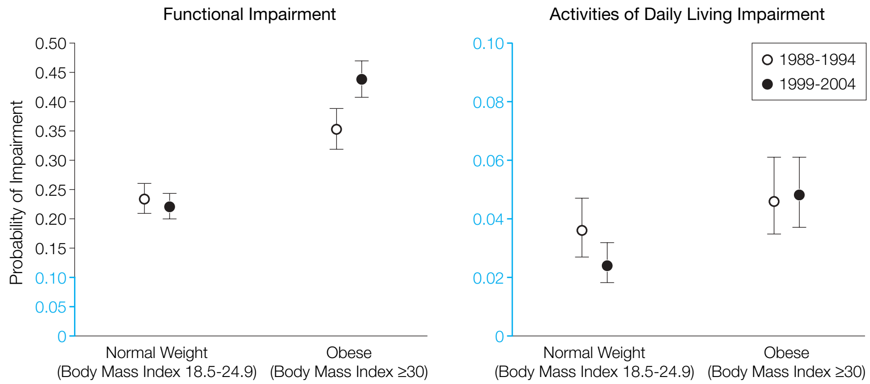
Table 3. Relative Odds of Functional and ADL Impairment in NHANES 1999-2004 Relative to NHANES III (1988-1994) Among Individuals Aged 60 Years and Older (N = 9928)[a]

	Odds Ratio (95% Confidence Interval)					
	Presence of Functional Impairment			Presence of Activities of Daily Living Impairment		
	Model 1	Model 2[b]	Model 3[c]	Model 1	Model 2[b]	Model 3[c]
Underweight	1.53 (1.02-2.30)	1.54 (1.02-2.31)	1.48 (0.97-2.25)	1.55 (0.87-2.75)	1.56 (0.87-2.78)	1.66 (0.87-3.17)
Normal weight	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]	1 [Reference]
Overweight	1.12 (0.98-1.29)	1.13 (0.98-1.29)	1.09 (0.95-1.26)	0.94 (0.68-1.28)	0.94 (0.69-1.28)	0.85 (0.62-1.17)
Time[d]	0.93 (0.81-1.07)	0.92 (0.80-1.06)	0.88 (0.76-1.02)	0.66 (0.50-0.88)	0.66 (0.50-0.87)	0.63 (0.47-0.85)
Obese	1.78 (1.47-2.16)			1.31 (0.92-1.88)		
Obese × time	1.54 (1.25-1.91)			1.56 (1.03-2.36)		
Obesity weight categories[e]						
Class I obese		1.38 (1.10-1.73)	1.24 (0.97-1.58)		0.82 (0.44-1.51)	0.71 (0.38-1.32)
Class II obese		2.20 (1.64-2.94)	1.94 (1.40-2.70)		2.11 (1.15-3.86)	1.76 (0.91-3.41)
Class III obese		8.68 (4.45-16.91)	5.64 (2.51-12.67)		3.97 (1.79-8.79)	2.32 (1.09-4.93)
Weight-time interaction[f]						
Class I obese × time		1.31 (1.00-1.72)	1.37 (1.02-1.84)		1.70 (0.83-3.45)	1.68 (0.82-3.46)
Class II obese × time		2.24 (1.48-3.38)	2.04 (1.29-3.24)		1.41 (0.66-3.00)	1.19 (0.53-2.66)
Class III obese × time		0.93 (0.40-2.17)	1.13 (0.43-3.00)		1.14 (0.37-3.50)	1.33 (0.45-3.93)
Chronic conditions						
Arthritis			2.68 (2.35-3.06)			2.43 (1.95-3.03)
Asthma			1.17 (0.91-1.49)			1.35 (0.95-1.92)
Cancer			1.10 (0.94-1.28)			1.08 (0.81-1.44)
Chronic bronchitis			1.34 (1.02-1.76)			1.03 (0.71-1.49)
Congestive heart failure			2.16 (1.67-2.80)			1.54 (1.03-2.29)
Diabetes			1.56 (1.28-1.90)			1.62 (1.26-2.07)
Emphysema			1.92 (1.38-2.66)			0.83 (0.51-1.33)
Myocardial infarction			1.41 (1.15-1.74)			1.33 (1.00-1.78)
Stroke			2.25 (1.71-2.95)			3.06 (2.24-4.17)
Health behavior and access						
Smoking			1.44 (1.17-1.77)			1.30 (0.87-1.95)
Uninsured			0.96 (0.67-1.38)			1.31 (0.66-2.61)

Abbreviations: ADL, activities of daily living; NHANES, National Health and Nutritional Examination Survey.
[a] All models control for age, sex, race/ethnicity, education, and income.
[b] Model 2 includes classes of obesity in addition to the parameters in model 1.
[c] Model 3 includes chronic conditions, smoking, and insurance status in addition to parameters in model 2.
[d] Time = 1 if NHANES 1999-2004 and time = 0 if NHANES III (1988-1994).
[e] Obesity weight categories: class I, body mass index 30.0 to 34.9; class II, body mass index 35.0 to 39.9; class III, body mass index 40.0 or greater.
[f] The odds ratio for the obese-time interaction indicates change in the association between obesity and disability over time or the change in the odds ratio associated with being obese at time 2 relative to time 1.

The adjusted probability of ADL impairment declined marginally in the normal-weight population from 0.036 to 0.024, yielding a risk ratio of ADL impairment of 0.67 for normal-weight individuals at time 2 relative to time 1 (Figure). The probability of ADL impairment did not change among obese individuals for a risk ratio of 1.04. Because the probability of impairment decreased within the normal-weight population but increased within the obese population, the risk ratio of obesity vs normal weight increased, from a risk ratio of 1.28 at time 1 to 2.00 at time 2.

Figure. Predicted Probability of Impairment by Obesity and Time



Values are adjusted for age, sex, race/ethnicity, education, and income. Error bars represent 95% confidence intervals. Blue color of y-axes indicate probability range from 0 to 0.10.

After dividing obesity into 3 categories (model 2), only class II and class III obesity were related to increased odds of ADL impairment within the obese population, and the time trend was not significant in any obesity category. Class II obesity was associated with twice the odds of ADL impairment relative to normal weight (OR, 2.11; 95% CI, 1.15-3.86), and class III obesity was associated with nearly 4 times the odds of ADL impairment (OR, 3.96; 95% CI, 1.79-8.79; model 2). Adjusting for confounders further attenuated the relationships between obesity and impairment. Of the health conditions considered in this study, arthritis, diabetes, congestive heart failure, myocardial infarction, and stroke were significantly associated with ADL impairment.

In additional analyses (results available from authors by request), we examined changes in individual functional impairment and ADL disability items. We do not include these results because the amount of missing data vary across items, requiring analysis of different analytic samples or exclusion of 654 cases to identify a sample with complete data. Furthermore, these items are highly correlated, contributing to our confidence in using a summary score. For functional impairment items, the largest increase in reported difficulty was in walking one-fourth mile, but difficulties increased in 4 of the 6 items within the obese population and decreased in each item within the nonobese population. Although the largest increase in functional impairment was in walking one-fourth mile, results are similar even if this item is excluded. For ADL impairment items, difficulties decreased slightly or were similar for each of the items within the obese population and decreased in each item within the nonobese population.

COMMENT

Our objective was to examine whether the association between obesity and disability has changed over time in the US elderly population. Despite recent improvements in cardiovascular health among obese adults,[4] it appears that obesity-associated disability did not decrease during the 1990s. Using 2 different indicators of disability, we found that the disparity between obese and normal-weight individuals has increased over time. The odds of functional impairment did not change between NHANES III (1988-1994) and NHANES 1999-2004 among nonobese participants, but increased by 43% among obese participants. Furthermore, while the odds of ADL disability declined significantly over the 1990s for nonobese older individuals, it did not change among obese older individuals.

For functional impairment, the change in obesity-associated disability risk was not explained by an increased prevalence of extreme obesity, as the effects of both class I and class II obesity increased over time. The association between class III obesity and functional impairment did not change over time. This group already had very high disability levels in NHANES III and it is possible that given the small sample and limited power in this analysis, we were not able to detect changes. For ADL impairment, the change in obesity-associated disability risk was partially explained by increases in the severity of obesity. Obese-time interactions were no longer significant after separating obesity into severity classes. Although controlling for chronic conditions had little effect on obese-time interactions for either outcome, it did reduce the main effects of obesity on disability.

Consistent with previous research, we found a decline in ADL disability throughout the 1990s.[14,25] These declines are important because the small percentage of individuals with extreme disability accounts for a disproportionate share of health expenditures.[26] However, ADL declines observed in this study were confined to the nonobese population, suggesting that obesity may be slowing disability decline at the population level and that obese individuals may not be benefiting as greatly from broader health improvements. There has been significant debate about the effects of obesity on trends in life expectancy,[27] but understanding its effects on trends in disability is important in light of the impact of disability on both quality of life and health care spending late in life.[17-19]

It is worth noting that the strength of the association between obesity and disability observed in this and other studies[1,13,16,18,19] is similar in magnitude to the associations between chronic conditions and disability. In contrast, we find no effect of overweight on disability, which is consistent with other research suggesting small effects of overweight on health in old age.[2] We tested for an interaction between overweight and time to determine whether trends in disability differed for overweight vs normal-weight participants, and this interaction was not significant.

Two demographic trends deserve further consideration. First, it is often argued that increasing education has led to disability decline in the older population.[28,29] In this study, education levels increased over time among those with obesity even more than among individuals with nonobesity. The proportion of the obese population with fewer than 12 years of education decreased by 16.2% in the period observed in this study ($P<.001$), compared with only an 11.3% decrease in the nonobese population ($P<.001$). Hence, controlling for education showed an even larger change in the risk for disability associated with obesity. This suggests that prevalence of disability within the obese population may have increased even more without accompanying increases in education.

Second, more research is needed on age and cohort differences in obesity and the associated health effects. An increased burden of comorbidity and disability among obese individuals at older ages could arise from an increase in individual lifetime exposure to obesity, leading to an expansion of disability among obese individuals at older ages. It could also arise from a decline in the mortality risk associated with obesity, which would lead to a higher prevalence of obesity at older ages. Recent research finds that the prevalence of obesity increased by 5.0 percentage points in the Medicare population between 1997 and 2002.[16] In our data covering 1988-2004, the prevalence of obesity increased by 10.9 percentage points in adults aged 60 to 69 years and by 5.9 percentage points among those aged 70 years and older. In addition to an increasing prevalence of obesity, we find an increase in both the prevalence and relative risk of functional impairment in the obese elderly population. In additional analysis, we stratified the older than 60-year age group into 2 groups: aged 60 to 69 years and aged 70 years and older. The effect of obesity on disability increased over time in both age groups for both functional and ADL impairment, but not all increases were significant, perhaps due to the loss of power associated with age-stratified analysis (available on request from the authors).

Furthermore, we find that the most severe type of disability (ADL limitations) is decreasing among nonobese older individuals but not in the obese population. Thus, despite increases in education and medical interventions, higher levels of obesity in subsequent cohorts of older individuals raise concerns about the disability burden in the future.

In interpreting these findings, it is important to recognize certain limitations. First, although we attempted to account for an upward shift in the BMI distribution by disaggregating obesity by class, this approach cannot account for increases in BMI within obesity classes, which may be driving observed increases in disability within the obese population. Second, we rely on self-reported difficulties in physical functioning and ADLs rather than objective measures of strength or performance. Unfortunately, these were the only measures that could be compared because NHANES performance measures of physical ability were not comparable across surveys. Although reliance on self-reported measures may underestimate prevalence differences between demographic groups (eg, black-white differences), it seems unlikely to account for time trends in disability by obesity. Additionally, NHANES did not include additional ADL measures (bathing, toileting), meaning that we are likely to underestimate ADL disability in the population. The ADL disability levels of 4% to 5% observed in this study are lower than the estimates of 7% to 8% observed in the National Health Interview Survey for a slightly older age group[30]; therefore, NHANES is likely to have missed 2% to 3% of ADL disability. However, because we are observing trends, missing ADL items are unlikely to affect our results unless the obese group experienced changes in bathing and toileting difficulty not experienced by other weight groups. Some studies have included difficulty walking across a room as an indicator of ADL limitations.[14] If we include difficulty walking between rooms on the same floor as an ADL limitation rather than a functional limitation, we observe similar increases in the effect of obesity on both functional impairment and ADL impairment over time.

Our results differ somewhat from some other surveys that have reported declines in functional impairment for the elderly population[31]; this may be due to differences in interview mode (NHANES interviews are conducted in person) or to the particular time period considered. A recent analysis of Medicare data found that the total level of disability was constant from 1992 to 2003, with a decline in Medicare beneficiaries with ADL disability and an increase in beneficiaries with functional impairment.[32] Finally, screening questions relating to walking and stair climbing changed slightly between NHANES III (1988-1994) and NHANES 1999-2004; however, results do not change in direction or significance if we exclude these items. In general, further research including more extensive measures of disability, multiple cohorts, and longer time periods is warranted.

CONCLUSION

Obese participants in NHANES 1999-2004 were more likely to report functional impairments than obese participants in NHANES III (1988-1994), which suggests an increasing risk of disability in the obese population. Furthermore, reductions in ADL disability observed among nonobese older individuals did not occur among obese individuals. Taken together, these findings suggest that recent improvements in cardiovascular health have not been accompanied by a reduction in disability burden among obese individuals; instead, the risk of some types of disability is actually increasing.

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Study concept and design: Alley, Chang.
Analysis and interpretation of data: Alley, Chang.
Drafting of the manuscript: Alley, Chang.
Critical revision of the manuscript for important intellectual content: Chang.
Statistical analysis: Alley, Chang.
Obtained funding: Chang.
Study supervision: Chang.

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