The Impact of Obesity and Arthritis on Active Life Expectancy in Older Americans

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This article examines the relationship of obesity and arthritis to length of life and length of disabled life in older American men and women. Secondary data analysis is conducted on three waves of the Asset and Health Dynamics Among the Oldest Old (AHEAD) survey (*n* = 7,381). Using integrated Markov chains, total, active, and disabled life expectancy in Americans aged ≥70 is estimated, with and without obesity and arthritis. Results indicate that neither obesity nor arthritis is related to the length of life for older men and women, alone or in combination. However, both conditions are significantly individually associated with increased length of disabled life in older men (1.4 years attributable to obesity; 1.2 years to arthritis at age 70; *P* < 0.05) and women (1.7 years attributable to obesity; 2.1 years to arthritis at age 70; *P* < 0.05). In addition, the combination of the two is significantly related to decreased active life, with nearly 50 and 60% of remaining life for 70-year-old men and women lived with disability, respectively (*P* < 0.05). Coupled with the fact that both obesity and arthritis are growing in prevalence, these findings represent one of the few clearly negative health trends in older adults today. These results should provide incentives for health-care professionals to make concerted efforts to address both conditions in clinical settings.

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INTRODUCTION

In spite of generally improving health in older adults toward the end of the past century (1,2), there are two clearly negative trends in the health of older Americans. One is the increase in obesity at all ages (3); the other is the increase in the prevalence of arthritis, particularly in older adults (4,5). These two negative health trends suggest a higher level of disability in older baby boomers than policy makers and the health-care industry are prepared to confront.

Obesity, mortality, and disability

Although many researchers find increased death rates in the obese (6), those focusing on adults in middle-age or old age find little relationship between obesity and mortality (7–9). In contrast, evidence is clear that obesity is strongly linked to increased levels of disability, whether measured by mobility limitations, activities of daily living (ADLs), or instrumental ADLs (7,10–12). Current estimates of the direct economic cost associated with obesity range between $75.1 billion (13) and $79.8 billion (14). Another $42.9 billion represents indirect costs of lost economic output (15), 68% from presentee-ism (lost productivity of obese workers) and 32% from absenteeism.

Arthritis, mortality, and disability

Arthritis is generally not associated with premature death, although some types of arthritis such as rheumatoid arthritis (RA) are associated with higher mortality rates and early death (16). It is fairly clear, however, that arthritis often negatively affects adults' physical and mental health (17), health-related quality of life (18), and ability to perform ADLs and instrumental ADLs (19). From a societal viewpoint, arthritis and other rheumatic conditions accounted for $128 billion in lost wages and medical costs in 2003 (ref. 20).

Obesity and arthritis

There is also evidence that obesity and arthritis may be linked (21), and that persons with both conditions may be at extra risk for disability and other negative health consequences (22,23). However, few studies have examined the combined effects of obesity and arthritis in terms of disability, and few have focused specifically on older adults. With the aging of the baby boomers in the coming decades and the potential impact of obesity and arthritis on quality of life for older individuals, the link between obesity, arthritis, and disability merits further examination.

In a prior study, Reynolds and colleagues (7) found no evidence of a relationship between obesity on total life expectancy, but a strong negative relationship with active life expectancy. The current study builds on those findings by examining arthritis in addition to obesity as these illnesses are likely to co-occur and together represent an increasing threat to older adults' health and quality of life. Our hypotheses are: (i) The presence

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of obesity and/or arthritis will not be associated with the length of life for older adults; but (ii) the presence of obesity and/or arthritis, will be associated with significantly longer disabled life for older men and women.

METHODS AND PROCEDURES

We use the first three waves of the Asset and Health Dynamics Among the Oldest Old (AHEAD) data, collected by the University of Michigan in 1993, 1995, and 1998 (ref. 24). At baseline (1993), AHEAD surveyed 8,222 adults aged ≥70, including spouses/partners regardless of age. When we eliminate the age-ineligible spouses/partners, we are left with a sample of 7,381 adults aged ≥70. Subsequent waves were collected in 1995 and 1998, leaving us with between-wave intervals of ~2 and 2½ years.

The baseline sample was followed through the third wave, by which time 1,894 had died. Deaths and dates of death were determined through the National Death Index link, as well as by reports of survivors. The date of death provided by the National Death Index was used when available; when no date was available from the National Death Index, the survivor-provided date of death was used. All results are weighted to reflect the 70+ population. Details on the AHEAD survey design and procedures are readily available and are not repeated here (25).

Measures

Active and disabled life. Active life is defined as self-reporting no difficulty with performing any of six ADLs, including bathing, eating, dressing, toileting, transferring, and walking around the home. Disabled life is defined as having self-reported difficulty with any of the ADLs. Although several different definitions of disability are available, the use of ADL difficulty or dependency has considerable support in the literature (26,27).

Obesity. Obesity is measured at baseline by self-reported weight and height, in pounds and inches. BMI is then calculated by converting to weight in kilograms and height in meters, and applying the formula, weight divided by height (squared). Obesity is defined as having a BMI of ≥30, in accordance with the World Health Organization categories (28). Although self-reported BMI is not the ideal measure of adiposity, because of typical under-reporting of weight and over-reporting of height, it is the only measure available in the AHEAD data. As the result of reporting bias, results on obesity are likely to be somewhat underestimated.

Arthritis. Having arthritis at baseline is determined by the answer to the question, "has a doctor ever told you that you have arthritis?" Similar self-report questions are used frequently in public health surveillance research on arthritis and are found to be an acceptable and valid means of assessing arthritis (4,29). A doctor's diagnosis from clinical records would be preferable, but that is not available in the data.

Based on the respondents' answers to these questions, four groups are constructed. The first group reports having neither obesity nor arthritis (henceforth, the Neither group). The second group reports having obesity but not arthritis (obesity only), the third group reports arthritis but not obesity (arthritis only), and those reporting both are the Both group.

Statistical analysis. We use a multistate life table method to estimate total and active life expectancy appropriate for use with longitudinal data. Estimates of active and disabled life expectancy are derived from age-specific transition rates for the four types of health events that can occur (**Figure 1**): (i) from active (no difficulty with six ADLs) to disabled (difficulty with at least 1 ADL); (ii) from disabled to active, (iii) from active to dead, and (iv) from disabled to dead. The method, therefore takes into consideration the fact that individuals experience both declines and improvements in disability; it also allows different mortality profiles by disability state (30).

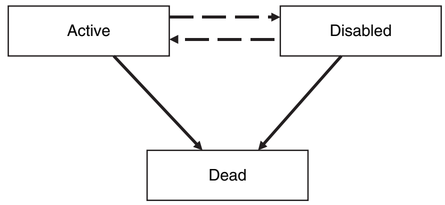

Figure 1 Multistate lifetable model. Broken arrow, live state; continuous arrow, absorbing state.

Interpolation of Markov Chains (IMaCh) assumes only one transition between data collections waves, so it is almost certain that some transitions are overlooked.

We use the IMaCh software to estimate transition schedules and life expectancy (30,31). The IMaCh software also provides standard errors for the transition probabilities as well as the estimates of total, active, and disabled life expectancy, from which 95% confidence intervals are calculated. This approach allows multiple waves of data and different interval lengths between survey waves. Health expectancies are computed from the transitions observed between waves for each of the health states. The first step is the estimation of the set of the parameters of a model for the transition probabilities between an initial state (e.g., active) and a final state (e.g., disabled or dead), again, assuming there has been only one transition between waves. The simplest model for the transition probabilities is the multinomial logistic model where *pij* is the probability of being in state *j* (active, disabled, dead) at a subsequent wave conditioned on being observed in state *i* (active, disabled) at a prior wave. Therefore the simple model used in this study is: $\log(pij/pii) = aij + bij \times age + cij \times obesity + dij \times arthritis$, where "*age*" is continuous age, and "*obesity*" and "*arthritis*" are covariates. Output includes estimates for the four combinations of obesity and arthritis presence that correspond to four groups mentioned above. We also tested for interaction effects between obesity and arthritis, finding nothing significant; we therefore omit these results. It is important to remember that these estimates relate only to the presence of ADL difficulties, and do not address the presence or absence of other potentially confounding conditions. Active life, thus, becomes the remaining life without ADL difficulty, and not a general statement about overall good health.

We first present descriptive statistics on transitions from an initial active/disabled state to activity, disability, or death 5 years later. We then present 2-year transition probabilities in graphic form. Because of the four groups and the number of data points, inclusion of the lines showing the 95% confidence intervals would make the graphs unreadable, so we display the transition probabilities only (the full set of graphs is available from the corresponding author). Finally, we present estimates of average total, active, and disabled life expectancy in tabular form for older adults in each of the four groups, with 95% confidence intervals. Non-overlap of the confidence intervals indicates differences significant at $P < 0.05$. This research protocol was approved by the Institutional Review Board of the University of South Florida.

RESULTS

Table 1 presents the percent of males and females making the various transitions from active and disabled status at baseline to activity, disability, and death 5 years later, based on presence or absence of obesity and arthritis. In both males and females, a majority of those who are active in 1993 remain so in 1998. Among those who are initially disabled, the most likely transition is to death in 1998, more so for males than females. Generally, for both males and females who were active and disabled in 1993, the Neither group are least likely to become disabled and the Both group are most likely to become disabled.

Table 1 Number (percent) of transitions between 1993 and 1998: AHEAD respondents age ≥70 (n = 7,381)

	Status in 1998		
	Active	Disabled	Dead
Males			
All males (n = 2,882)			
Status in 1993			
Active	1,310 (54.7)	296 (12.4)	788 (32.9)
Disabled	65 (13.3)	133 (27.3)	290 (59.4)
Arthritis only (n = 500)			
Status in 1993			
Active	164 (45.8)	61 (17.0)	133 (37.2)
Disabled	22 (15.5)	48 (33.8)	72 (50.7)
Obese only (n = 201)			
Status in 1993			
Active	99 (57.2)	29 (16.8)	45 (26.0)
Disabled	3 (10.7)	10 (35.7)	15 (53.6)
Both (n = 93)			
Status in 1993			
Active	25 (44.6)	16 (28.6)	15 (26.8)
Disabled	8 (21.6)	16 (43.2)	13 (35.1)
Neither (n = 2,088)			
Status in 1993			
Active	1,022 (56.6)	190 (10.5)	595 (32.9)
Disabled	32 (11.4)	59 (21.0)	190 (67.6)
Females			
All females (n = 4,499)			
Status in 1993			
Active	1,868 (53.9)	682 (19.7)	917 (26.5)
Disabled	152 (14.7)	417 (40.4)	463 (44.9)
Arthritis only (n = 1,043)			
Status in 1993			
Active	307 (46.2)	173 (26.1)	184 (27.7)
Disabled	49 (12.9)	163 (43.0)	167 (44.1)
Obese only (n = 391)			
Status in 1993			
Active	152 (50.2)	62 (20.5)	89 (19.4)
Disabled	15 (17.1)	47 (53.4)	26 (29.6)
Both (n = 288)			
Status in 1993			
Active	71 (45.8)	55 (35.5)	29 (18.7)
Disabled	22 (16.5)	68 (51.1)	43 (32.3)
Neither (n = 2,777)			
Status in 1993			
Active	1,338 (57.1)	392 (16.7)	615 (26.2)
Disabled	66 (15.3)	139 (32.2)	227 (52.6)

Transition probabilities

Figures 2, 3, and 4 present 2-year transition probabilities for the three types of possible movements between states by gender. In Figure 2a,b, the lack of any differentiation between the lines indicates that there is no significant difference in the 2-year probability of dying for males or females, based on the presence or absence of obesity and/or arthritis. Figure 3a,b, however, shows some clear differences. For the males (Figure 3a), those with arthritis only and obesity only have a higher probability of becoming disabled than those with neither condition, and males with both conditions have a higher probability of

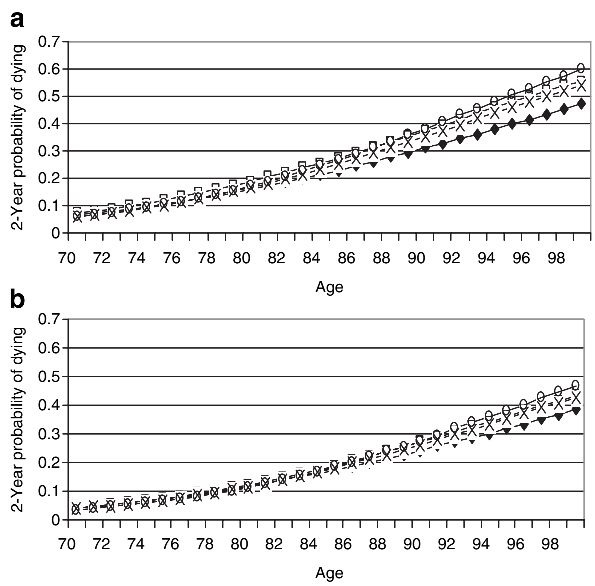

Figure 2 Two-year transition probabilities of dying for (**a**) males and (**b**) females: AHEAD, 1993–1998. Circles, neither condition; squares, arthritis only, crossout, obese only; diamond, both conditions.

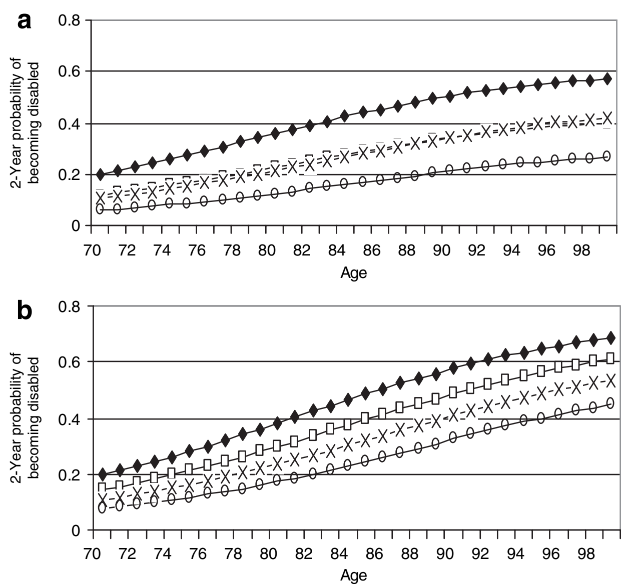

Figure 3 Two-year transition probabilities of becoming disabled for (**a**) males and (**b**) females: AHEAD, 1993–1998. Circles, neither condition; squares, arthritis only, crossout, obese only; diamond, both conditions.

becoming disabled compared to those with either condition, up to the ages of 88 (arthritis) and 86 (obese). Those with both conditions are more likely to become disabled at all ages, compared to males with neither condition.

Results for the females are slightly different. Females with arthritis only have a higher probability of becoming disabled, compared to females with neither condition, but there is no significant difference between females who are obese and females with neither condition. In addition, females with both conditions are more likely to become disabled than those who are obese only up to the age of 94; there is no relationship between having both conditions and having just arthritis. However, females at all ages with both conditions have a higher probability of becoming disabled than females with neither condition.

Finally, as with mortality, **Figure 3** shows little differentiation between the probability of recovering from disability within any 2 years in the study period. This is true for both males and females.

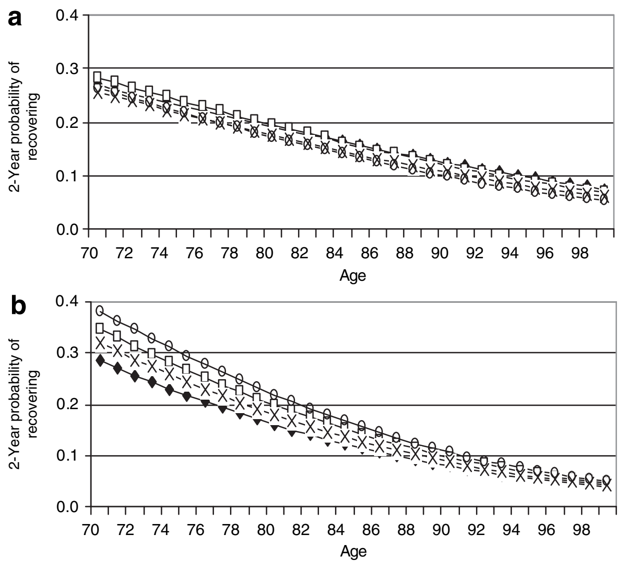

Figure 4 Two-year transition probabilities of recovering from disability for (**a**) males and (**b**) females: AHEAD, 1993–1998. Circles, neither condition; squares, arthritis only, crossout, obese only; diamond, both conditions.

Total, active, and disabled life expectancy

In addition to the results of the 2-year probabilities, small differences in transition rates can lead to interesting differences in the length and quality of life remaining. **Table 2** presents estimates of total (TLE), active (ALE), and disabled life expectancy for men at ages 70, 80, and 90, along with the percent of remaining life spent disabled. Unless otherwise indicated, all results discussed are significant at the $P < 0.05$ level. The average 70-year-old male with neither obesity nor arthritis can expect to live another 12.3 years, of which 10.0 will be free of ADL disability, or active, and 2.3 will be disabled. Examination of the overlapping confidence intervals for TLE reveals no differences between the four condition groups in 70-year-old men. In contrast, one observes a steady decline in ALE, from 10 for the Neither group to 6.3 for the Both group. These results are generally the same for men at age 80, with little difference in TLE, but a steady decline in ALE, based on the condition groups. At age 90, we observe little difference in either TLE or ALE; only 90-year-old men with obesity significantly lose further active years.

These results are further shown in the percent of remaining life that men can expect to live with disability. For 70-year-old men with neither condition, disability constitutes 18.4% of remaining life. That percent increases similarly in the presence

Table 2 Total, active, and disabled life expectancy with 95% confidence intervals (CI) in years, and percent remaining life lived with disability: AHEAD, 1993–1998 for males

	Total	Lower, upper CI	Active	Lower, upper CI	Disabled	Lower, upper CI	% Disabled
Age 70							
Neither	12.3	11.8–12.8	10.0	9.5–10.5	2.3	2.0–2.5	18.4
Obesity only	13.0	11.5–14.5	9.3	8.1–10.5	3.7	2.8–4.6	28.4
Arthritis only	11.9	10.8–12.9	8.3	7.5–9.1	3.5	2.9–4.1	29.8
Both	12.6	10.6–14.5	6.3	5.2–7.4	6.3	4.8–7.7	49.9
Age 80							
Neither	6.8	6.4–7.2	4.9	4.6–5.2	1.9	1.7–2.1	28.1
Obesity only	7.1	6.0–8.2	3.8	3.2–4.5	3.3	2.5–4.0	45.9
Arthritis only	6.5	5.8–7.2	3.4	2.9–3.8	3.2	2.7–3.7	48.5
Both	7.6	6.0–9.1	2.7	2.1–3.4	4.8	3.6–6.1	63.8
Age 90							
Neither	3.8	3.4–4.2	2.3	2.1–2.6	1.5	1.2–1.7	38.8
Obesity only	3.4	2.4–4.3	0.5	0.2–0.9	2.8	2.0–3.6	45.9
Arthritis only	4.0	3.5–4.6	1.9	1.6–2.1	2.2	1.7–2.6	53.8
Both	5.2	4.1–6.3	2.2	1.8–2.5	3.0	2.1–4.0	58.5

Table 3 Total, active, and disabled life expectancy with 95% confidence intervals (CI) in years, and percent remaining life lived with disability: AHEAD, 1993–1998 for females

	Total	Lower, Upper CI	Active	Lower, Upper CI	Disabled	Lower, Upper CI	% Disabled
Age 70							
Neither	15.4	14.8–16.0	11.2	10.7–11.6	4.2	3.9–4.6	27.6
Obesity only	15.2	13.9–16.5	9.3	8.4–10.2	5.9	4.9–6.8	38.7
Arthritis only	14.8	14.0–15.7	8.5	7.9–9.1	6.3	5.7–7.0	42.8
Both	14.9	13.4–16.5	6.3	5.5–7.1	8.7	7.4–9.9	57.9
Age 80							
Neither	9.1	8.7–9.5	5.4	5.1–5.7	3.7	3.4–4.0	40.4
Obesity only	9.3	8.3–10.3	4.5	4.0–5.0	4.8	4.0–5.6	51.8
Arthritis only	8.5	7.9–9.2	3.0	2.7–3.3	5.5	5.0–6.0	64.4
Both	9.4	8.2–10.7	2.7	2.4–3.1	6.7	5.6–7.8	70.8
Age 90							
Neither	5.2	4.8–5.6	2.3	2.1–2.5	2.9	2.6–3.3	56.2
Obesity only	5.5	4.7–6.3	1.8	1.5–2.0	3.7	3.0–4.5	67.8
Arthritis only	5.2	4.6–5.8	1.3	1.1–1.4	3.9	3.4–4.4	75.1
Both	5.9	4.9–7.0	1.2	1.0–1.4	4.7	3.8–5.7	80.1

of either obesity or arthritis, and increases substantially more when obesity and arthritis are combined. These increases are even more dramatic at ages 80 and 90.

Table 3 presents the results of the same estimates for women age 70, 80, and 90. If anything, the results for women are even more consistent than the men. The average 70-year-old female with neither obesity nor arthritis can expect to live another 15.4 years, 11.2 of which will be active, and 4.2 disabled. In no case does the addition of obesity and arthritis, alone or together, change TLE significantly. However, obesity and arthritis, alone and together, decrease ALE at all ages. Compared to the 11.2 years of activity experienced by the 70-year-old female with neither condition, the average 70-year-old female with obesity can expect 9.3 active years; if she has arthritis or both conditions, she can expect to live 8.5 or 6.3 active years, respectively. This pattern is similar for 80- and 90-year-old females, although the numbers are smaller.

In terms of the percent of remaining life that women can expect to live with disability, for 70-year-old women with neither condition, disability constitutes 27.6% of remaining life. The presence of obesity or arthritis individually increase this percent, but the combination of obesity and arthritis increase remaining disabled life even more, to 57.9%. Both 80- and 90-year-old women show the same pattern of increased percent of remaining life disabled, reaching a high of 80.1% for 90-year-old women with both conditions.

DISCUSSION

In this article, we examine the association between obesity, arthritis, and length and quality of life in older Americans. We find little evidence to suggest that either obesity or arthritis is related to mortality for those who have already survived to the age of 70, confirming our first hypothesis. Our second hypothesis is also confirmed, as we find that people with both obesity alone and arthritis alone are more likely to become disabled in comparison to those with neither condition. In addition, our findings suggest that the combination of obesity and arthritis in older adults is a potent one, with the years of disability for 70-year olds with both conditions nearly threefold for men (6.3 vs. 2.3 years) and more than twofold for women (8.7 vs. 4.2 years), compared to those with neither condition. In contrast, the years of disability with obesity alone increases 1.4 years for men and 1.7 years for women. The disability years with arthritis alone, compared to those with neither condition, increase by 1.2 years for men and 2.1 years for women.

In addition to the increased risk of becoming disabled, our findings suggest that a typical 70-year-old man with both obesity and arthritis can expect to live at least half of his remaining years disabled. This is even worse for older women, as a 70-year-old woman with both obesity and arthritis is likely to live nearly 60% of her remaining life disabled. These two conditions, which are known to be growing in the older population, represent a significant threat to the quality of life in old age. To better understand the population impact of obesity and arthritis, we estimated the excess disabled years in the 1995 population associated with being obese and/or having arthritis by weighting the average number of years lived in disability among the four groups by their representation in the population. If we assume that each condition group lived the same number of years in disability as the Neither group, the total number of years lived with ADL disability in the 70+ population would be reduced by 16.8% among older women and 16.3% among older men. This extends our prior work, in which we determined that a similar comparison between obese and nonobese older men and women would result in 5.4 and 8% reductions in disability, respectively (7). These findings are important in light of the projected increase in prevalence rates for arthritis and obesity in the coming decades along with the baby boomers reaching old age. The confluence of these three events is likely to negatively affect the ability of many older adults to live independently as well as the quality of life of older adults and the family members who care for them.

On a positive note, both obesity and arthritis are amenable to intervention. Health-care providers and public health efforts can stress that both conditions are indeed treatable and preventable early on, and can encourage healthy behaviors such as weight loss and exercise (32) that we know can alleviate the symptoms of arthritis. These kinds of programs have the potential to reduce the number of years older men and women will live with disability due to obesity and/or arthritis and will ultimately increase quality of life.

While researchers generally agree on the value of both weight loss and exercise in decreasing the negative health effects of obesity, some caution is merited in regard to weight loss in the elderly. Weight loss in older adults can be a marker for decreased reserves and potential frailty (33,34), with a host of potentially harmful effects on older adults' health (35), including loss of lean body mass (36). However, several researchers have also found that moderate weight loss combined with exercise therapy, particularly weight-bearing exercise, can not only be efficacious in older adults, but also cost-effective (37,38).

Limitations to this study include the use of BMI as a measure of adiposity, although it is considered to be an appropriate measure of obesity, particularly in population research (39). In addition, some researchers suggest that the problem of measuring BMI in children (i.e., the developmental factor) should be mirrored at the oldest ages, particularly for women, who often lose height in old age, which would bias the measure of BMI upward. Of course, there is also the issue of the accuracy of self-reported vs. measured height and weight. In one of the few population studies that includes both measures, Kuczmarski and colleagues found that self-reported BMI was lower than calculated BMI by 1 unit for adults over the age of 70 (ref. 40), although this bias tends to be higher for women and in particular, minority women (41).

We are also limited to the self-reported arthritis in the AHEAD data, which is one of few available that surveys sufficient numbers of older adults to generate stable mortality and disability rates. A doctor's diagnosis of arthritis (e.g., osteoarthritis or RA) would be preferable, and we are not able to separate out osteoarthritis from RA; this may actually have the effect of overestimating the mortality effect due to the higher mortality rate for those with RA (16). Research examining the validity of self-reports of arthritis show mixed results, with Simpson and colleagues finding less agreement between diagnosis and self-report of arthritis compared to hip fracture, diabetes, and stroke (42). On the other hand, Barlow and colleagues (43) reported that most of their study subjects with arthritis were able to distinguish between having osteo- or RA. Any bias relating to discrepancy in self-report is likely to reflect undiagnosed arthritis.

The AHEAD data allow us to examine effects of obesity and arthritis on disabled life expectancy in a nationally representative sample of older adults thus increasing the generalizability of our findings. Finally, the IMaCh procedure is relatively new and the software currently limits us to consideration of only two covariates, in this case, obesity and arthritis. Other factors that would potentially moderate our findings could include the presence of diabetes and other potentially disabling conditions, instrumental ADL difficulties, and cognitive impairment, among others. Future research clearly should aim to provide more information on the impact of moderating and/or mediating variables in the disability process by improving the technique to allow more covariates.

Validation of the accuracy of self-reports of ADL difficulties is difficult. However, the Principal Investigators for the AHEAD survey examined the correlations between the ADL questions and a variety of health measures, and found strong relationships between the two, ranging from $r = 0.198$ for the number of reported doctor visits to $r = 0.364$ for the number of self-reported chronic conditions (44). In any case, for a population study such as this, the more important issue is the consistent definition of ADL difficulty across data collection waves.

Our results suggest a future increase in disability in older adults with both obesity and arthritis which makes this an important public health issue. Since 1998, the prevalence of obesity in adults ≥60 has remained somewhat stable overall, declining from two percentage points between 1999–2000 and 2003–2004 (45). This is not true, however, for African Americans or Hispanics whose obesity rates in the same period have increased 4.7 and 1.3 percentage points, respectively (45). Considering the increasing diversity of the older population, this trend bears watching.

Clinicians working with older patients have the opportunity to make a major impact on the shape of these trends. General, Family, and Internal Medicine practitioners should be encouraged to address weight issues with their patients, taking care to balance the need for moderate weight loss with an appropriate level of weight-bearing exercise. Pediatricians should also be encouraged to counsel parents on proper weight, diet, and physical activity for children, as the most alarming increase in obesity is in America's children—tomorrow's older adults. Public health efforts also need to continue to educate individuals across the life span that both arthritis and obesity are treatable conditions and that remaining physically active and maintaining a healthy weight and physical activity level are critical in minimizing disability in older adults.

DISCLOSURE

The authors declared no conflict of interest.

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