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CLINICAL RESEARCH STUDY

# Increasing Trends in Incidence of Overweight and Obesity over 5 Decades

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## ABSTRACT

**PURPOSE:** We evaluated trends in the incidence of overweight and obesity over the past 50 years.

**METHODS:** We evaluated trends in the incidence of overweight ( $25 \leq$  body mass index [BMI]  $< 30$  kg/m<sup>2</sup>), obesity (BMI  $\geq 30$  kg/m<sup>2</sup>) and stage 2 obesity (BMI  $\geq 35$  kg/m<sup>2</sup>) from 1950 to 2000 in Framingham Study participants (n = 6798, 54% women). Individuals aged 40-55 years who attended 2 examinations 8 years apart in each decade were eligible.

**RESULTS:** The incidences of overweight, obesity, and stage 2 obesity increased across the decades in both sexes (*P* for trend  $< .001$ ). For men, the incidence of overweight rose from 21.8% (95% confidence interval [CI], 17.6-26.5) in the 1950s to 35.2% (95% CI, 28.6-42.5) in the 1990s; of obesity from 5.8% (95% CI, 4.4-7.6) to 14.8% (95% CI, 12.2-17.9); and of stage 2 obesity from 0.2% (95% CI, 0.1-0.9) to 5.4% (95% CI, 4.0-7.2). For women, incidence rates of overweight increased from 15.0% (95% CI, 12.3-18.1) to 33.1% (95% CI, 29.0-37.4); of obesity from 3.9% (95% CI, 2.9-5.3) to 14% (95% CI, 11.6-16.7); and of stage 2 obesity from 1.7% (95% CI, 1.1-2.6) to 4.4% (95% CI, 3.2-6.0). Overall, incidence rates of overweight increased 2-fold and that of obesity more than 3-fold over 5 decades, findings that remained robust upon additional adjustment for baseline BMI in each decade.

**CONCLUSIONS:** The incidence of overweight and obesity increased progressively over the last 5 decades, suggesting that the rising trend in prevalence is not a recent phenomenon. © 2007 Elsevier Inc. All rights reserved.

**KEYWORDS:** Body mass index; Obesity; Overweight; Trends; Epidemiology

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The epidemic of obesity in the United States is a major public health problem. Excess adiposity increases risk of diabetes, hypertension, cardiovascular diseases, and certain types of cancers.<sup>1-4</sup> Furthermore, obesity is associated with elevated mortality risks due to cardiovascular disease<sup>5</sup> and all-causes.<sup>6-9</sup>

The increasing prevalence of overweight and obesity underscores the need to better understand this epidemic. Data from the National Health Examination Survey (NHES I, 1960-1962) and National Health and Nutritional Examination Surveys (NHANES I, 1971-1974; NHANES II, 1976-1980; NHANES III, 1988-1994; NHANES 1999-2000) indicate that the prevalence of obesity (body mass

index [BMI]  $\geq 30$  kg/m<sup>2</sup>) in the United States was relatively stable from 1960-1980, at which point rates escalated.<sup>10</sup> In comparison, studies have suggested a stable prevalence of overweight ( $25 \leq \text{BMI} < 30$  kg/m<sup>2</sup>) until the 1990s (with the exception of women between the ages of 20 and 29 years in whom overweight prevalence increased before the 1990s).<sup>11</sup> In this context, it is important to note that parallel data on temporal trends in the incidence of overweight and obesity in the community are lacking. Such incidence data are critical for understanding reasons underlying rising prevalence trends and for making projections about future burden of obesity. Additionally, an analysis of incidence trends may help clarify the apparent paradox of rising obesity prevalence despite stable overweight prevalence in the 1980s.

We examined temporal trends in the incidence of overweight and obesity among Framingham Study participants over a 50-year period from 1950 to 2000. We hypothesized that the current epidemic of obesity was paralleled by an epidemic of overweight, which may have been unapparent in the absence of data on incidence trends. We also postulated that the rising trend of excess adiposity is not a recent phenomenon.

## METHODS

### Sample

The Framingham Heart Study, a community-based prospective cohort study, began in 1948, with enrollment of 5209 participants (original cohort).<sup>12,13</sup> In 1971, 5124 individuals who were children of the original cohort (and their spouses) were enrolled into the Framingham Offspring Study. Participants in the original cohort are examined biennially, whereas the offspring cohort is evaluated quadriennially.<sup>14,15</sup>

For the present investigation, we chose 2 examinations within each calendar decade from 1950 up to 2000 that were approximately 8 years apart (Figure). The availability of only 2 offspring cohort examinations in the 1970s that were 8 years apart constrained us to using observations from only 2 examinations within each decade. Individuals were eligible if they: were between ages 40 and 55 years at the first of the 2 examinations in a given decade; attended a follow-up examination 8 years later; and were not underweight (BMI  $< 18.5$  kg/m<sup>2</sup>) at the baseline examination. For primary analyses we excluded underweight individuals because such persons may have had illnesses that prevent weight gain. We chose the 40-55 years group because adequate numbers of individuals for this age range were available in each of

the 5 decades. All participants gave informed consent and the study protocol was approved by the Institutional Review Board of the Boston Medical Center.

## Body Mass Index and Risk Factors

### Measurement

At each Framingham study examination, height and weight are measured using standardized protocols.<sup>16,17</sup> BMI was calculated as the weight in kilograms divided by the square of height in meters.

Participants underwent assessment of vascular risk factors at each examination.<sup>17</sup> Current smoking was defined as regular cigarette smoking in the year preceding the examination. Smoking cessation was defined as a history of quitting smoking subsequent to the baseline examination. A physical activity index<sup>18,19</sup> was calculated based on responses to a physical activity questionnaire for offspring cohort attendees at examinations 2 (1980s) and 4 (1990s). Dietary daily caloric intake

was calculated based on 3-day dietary recall information obtained for the offspring cohort in the 1980s and the 1990s.<sup>20</sup>

### BMI on Follow-Up: Definitions of Overweight and Obesity

All eligible participants within a given decade were followed for 8 years to assess the development of the BMI outcomes (see below). Categories of BMI were defined according to established guidelines<sup>21,22</sup>: normal weight ( $18.5$  to  $< 25$  kg/m<sup>2</sup>), overweight ( $25 \leq \text{BMI} < 30$  kg/m<sup>2</sup>), overweight or more ( $\geq 25$  kg/m<sup>2</sup>), obesity ( $\geq 30$  kg/m<sup>2</sup>), and stage 2 obesity ( $\geq 35$  kg/m<sup>2</sup>).

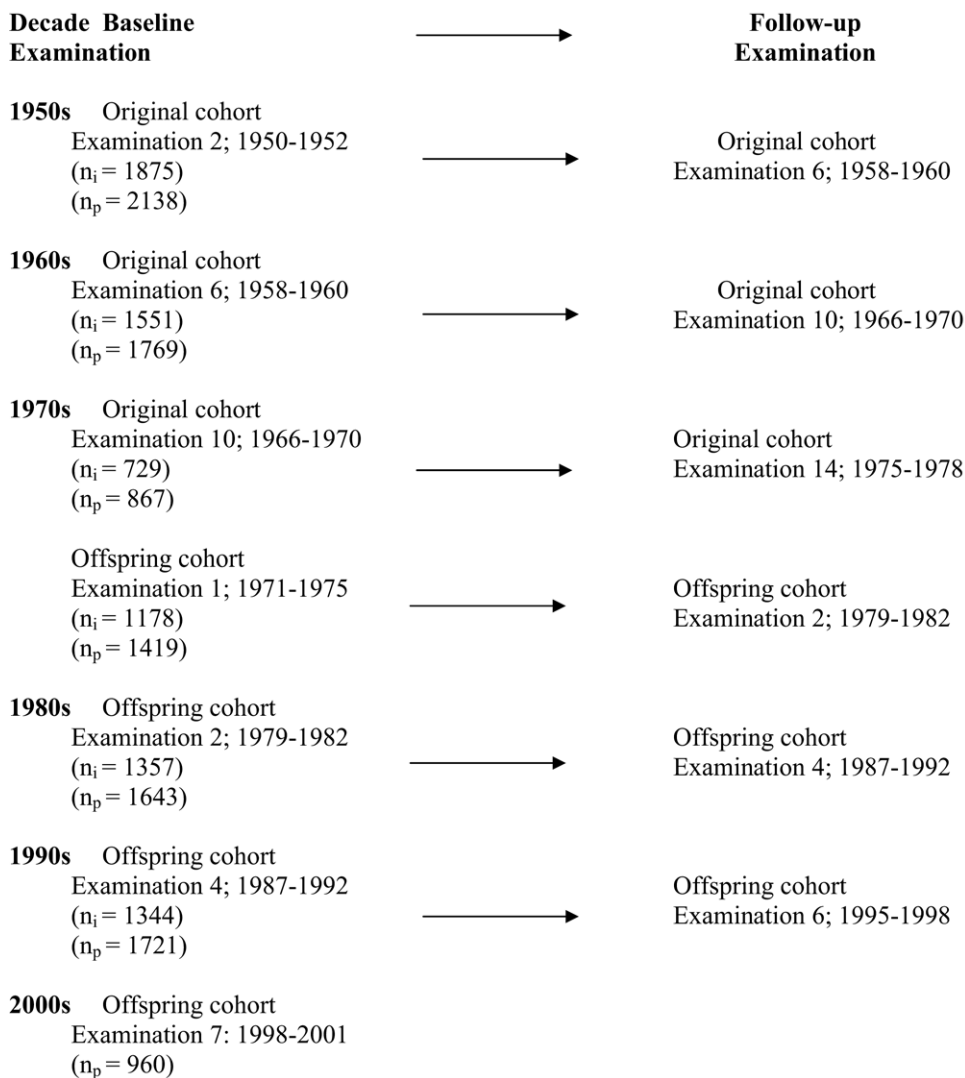
### Statistical Methods

For each decade from 1950 to 2000, we evaluated the prevalence of BMI categories at the baseline examination in that decade, and assessed trends in prevalence (with generalized estimating equations to account for individuals contributing to more than one decade, 1950s serving as referent). Next, we evaluated the sex-specific 8-year incidence of the following BMI outcomes (eligibility defined by BMI at first examination in each decade):

- Overweight* defined as ' $25 \leq \text{BMI} < 30$  kg/m<sup>2</sup>'; participants with BMI  $< 25$  kg/m<sup>2</sup> were eligible for these analyses. Individuals with BMI  $> 30$  kg/m<sup>2</sup> at follow-up examination were excluded for estimating incidence of overweight alone.

### CLINICAL SIGNIFICANCE

- Incidence rates of overweight increased 2-fold and that of obesity more than 3-fold over the past 5 decades.
- The rising trend of excess adiposity is not a recent phenomenon.
- Over the 50-year period, there was a decline in the proportion of overweight or obese people who were able to achieve normal or nonobese BMI, respectively.
- Long-term data provided by our study can help in estimating the future burden of excess adiposity.



**Figure** Baseline and follow-up examination years for the original and offspring cohorts of the Framingham Study that were used for determining the prevalence and the incidence of obesity by decade of observation (from 1950s to 2000s); n<sub>i</sub> and n<sub>p</sub> indicate the numbers of individuals between ages 40 and 55 years available in each of the decades for the calculations of prevalence and incidence rates.

- b. *Overweight or more* defined as a BMI ≥25 kg/m<sup>2</sup>; participants with BMI <25 kg/m<sup>2</sup> were eligible for these analyses.
- c. *Obesity* defined as a BMI ≥30 kg/m<sup>2</sup>; participants with BMI <30 kg/m<sup>2</sup> were eligible for these analyses.
- d. *Stage 2 obesity* defined as a BMI ≥35 kg/m<sup>2</sup>; participants with BMI <35 kg/m<sup>2</sup> were eligible for these analyses.

We evaluated trends in incidence of BMI outcomes using sex-specific multivariable pooled logistic regression adjusting for age and smoking cessation, the latter 2 being major confounders. In additional analyses, we adjusted for baseline BMI. The 1950s served as referent. Because individuals who developed an outcome of interest could not contribute to future decades, generalized estimating equations were not necessary for these analyses. We repeated analyses to examine trends in incidence of obesity among nonsmokers; trends in overweight among nonsmokers were not analyzed

because there were too few people eligible in the referent decade. We analyzed nonsmokers to determine if our results were influenced by the striking decreases in smoking rates across decades in our cohorts. Likewise, we did not analyze trends in incidence of stage 2 obesity among nonsmokers because there were no events (development of BMI ≥35 kg/m<sup>2</sup>) observed in the 1950s in nonsmokers. We repeated analyses including individuals who were underweight to see if this altered our incidence estimates.

Finally, we studied temporal trends in decade-specific incidence rates of weight loss by examining:

- a. *Overweight individuals who lost weight*: proportion of individuals with BMI ≥25 kg/m<sup>2</sup> during a decade who subsequently became normal weight (18.5 kg/m<sup>2</sup> < BMI <25 kg/m<sup>2</sup>).
- b. *Obese individuals who lost weight*: the proportion of individuals with BMI ≥30 kg/m<sup>2</sup> during the decade who

**Table 1** Baseline Characteristics of All Participants and Prevalence Rates for Body Mass Index (BMI) Categories in Each Decade

	Men						Women					
	1950s	1960s	1970s	1980s	1990s	2000s	1950s	1960s	1970s	1980s	1990s	2000s
n	921	799	1103	804	822	431	1217	970	1183	839	899	529
Age, years	47.1	47.5	48.3	47.2	47.6	50.6	47.0	47.7	48.3	47.2	47.3	50.6
BMI, kg/m <sup>2</sup> *	26.2	26.6	27.4	27.4	27.9	28.9	25.8	25.0	25.5	25.5	26.1	27.3
Overweight or more (BMI ≥25 kg/m <sup>2</sup> ), %*	64.0	66.3	75.1	74.9	77.9	81.4	51.0	40.3	44.5	42.0	45.9	58.0
Obesity (BMI ≥30 kg/m <sup>2</sup> ), %*	10.2	13.4	19.6	20.8	25.4	32.3	13.9	11.4	13.8	14.2	18.7	24.8
Stage 2 obesity (BMI ≥35 kg/m <sup>2</sup> ), %*	0.5	1.6	3.0	2.4	5.6	10.0	3.9	2.9	4.1	5.6	6.2	11.2
Weight, kg*	77.5	79.6	82.0	83.8	87.0	90.4	64.9	63.7	64.9	65.7	69.1	72.9
Height, m*	1.72	1.73	1.73	1.75	1.76	1.77	1.59	1.60	1.59	1.61	1.63	1.63
Smoking, %*	76.3	66.7	43.6	44.3	26.5	19.5	37.7	49.2	40.5	32.6	23.9	19.5

Values are means, unless indicated otherwise.

\**P*-values <.01 for trend across decades in both sexes (with the exception of BMI ≥25 kg/m<sup>2</sup> in women); *P*-values are age-adjusted and based on generalized estimating equations to account for participants contributing to more than one decade.

subsequently became normal weight or overweight (18.5 kg/m<sup>2</sup> < BMI <30 kg/m<sup>2</sup>).

A 2-tailed *P* value <.05 was considered statistically significant.

## RESULTS

### Baseline Characteristics

In our sample, the prevalence of obesity, stage 2 obesity, mean values of height, and weight increased across the decades from the 1950s to 2000 in both sexes (Table 1;

*P* for trend <.001). Over this period, mean BMI increased by about 2.7 kg/m<sup>2</sup> in men and 1.5 kg/m<sup>2</sup> in women. Smoking rates decreased in men more substantially than in women (*P* for trend <.001).

Table 2 displays the baseline characteristics of study participants eligible for analyses in each decade. Among eligible individuals from the 1950s to the 1990s, mean weight and height increased, while smoking rates decreased (*P* <.01).

Among non-overweight offspring study participants, the physical activity index increased from the 1980s to the

**Table 2** Baseline Characteristics of Persons Aged 40-55 Years Eligible in Each Calendar Decade

	Men					Women				
	1950s	1960s	1970s	1980s	1990s	1950s	1960s	1970s	1980s	1990s
Persons with BMI <30 kg/m <sup>2</sup>										
n	827	692	887	637	613	1048	859	1020	720	731
Age, years	47.2	47.5	48.3	47.1	47.4	46.8	47.6	48.3	47.0	47.3
BMI, kg/m <sup>2</sup>	25.5	25.7	26.1	26.0	26.1	24.5	23.9	24.2	23.9	24.0
Weight, kg*	75.7	77.2	78.6	79.8	81.5	62.2	61.1	61.5	61.7	63.8
Height, m*	1.72	1.73	1.73	1.75	1.76	1.59	1.60	1.60	1.61	1.63
Smoking, %*	77.5	67.8	44.1	43.9	26.3	39.9	51.1	41.0	33.7	24.8
Persons with BMI <25 kg/m <sup>2</sup>										
n	332	269	275	202	182	596	579	656	487	486
Age, years	46.9	47.4	48.6	46.7	47.4	46.2	47.3	48.0	46.7	46.8
BMI, kg/m <sup>2</sup>	22.9	23.1	23.4	23.3	23.3	22.5	22.4	22.6	22.4	22.4
Weight, kg*	68.2	69.8	70.9	72.5	73.3	57.6	57.7	58.1	58.4	59.6
Height, m*	1.72	1.74	1.74	1.76	1.77	1.60	1.60	1.60	1.61	1.63
Smoking, %*	82.8	71.8	54.7	50.0	26.9	46.0	58.2	45.5	32.9	24.1

Values are means, unless indicated otherwise.

\**P*-values <.01 for trend across decades in both sexes; *P*-values are age-adjusted and based on generalized estimating equations to account for participants contributing to more than 1 decade.

1990s (from 36.0 to 37.5 in men, and from 33.9 to 36.8 in women,  $P < .001$  for both) paralleled by increases in reported daily caloric intake (2206 to 2363 kilocalories in men and 1549 to 1676 kilocalories in women,  $P < .001$  for both).

### Incidence of BMI Outcomes

The incidences of overweight, overweight or more, obesity and stage 2 obesity increased from 1950 to 1990 in both sexes (Table 3). In women, the incidence rates of BMI outcomes rose across the 5 decades in a step-wise fashion. In men, incidence rate increases across decades were less graded; rates rose in the 1960s (relative to the 1950s) but then decreased in the 1970s, only to escalate again in the 1980s.

Table 4 displays adjusted trends in incidence of BMI outcomes with rates in the 1950s as referent. Overall, incidence rates of overweight increased over 2-fold and that of obesity more than 3-fold over the 5-decade period in both sexes. In models fitting a linear trend across decades, in women there was a 25% (95% confidence interval [CI], 17%-34%) increase in incidence of overweight per decade, a 34% (95% CI, 24%-46%) increase in incidence of obesity per decade, and a 31% (95% CI, 16%-49%) increase in incidence of stage 2 obesity per decade. In men, there was a 20% (95% CI, 10%-32%) increase in incidence of overweight per decade, a 29% (95% CI, 18%-40%) increase in incidence of obesity per decade, and a 97% (95% CI, 63%-138%) increase in incidence of stage 2 obesity per decade. These results remained robust upon additional adjustment for baseline BMI ( $P = .004$  for trend across decades for overweight or more incidence in men;  $P < .001$  for all other BMI outcomes in both sexes). These trends were consistent when we limited our analysis to nonsmokers (Appendix 1).

### Cohort-Specific Incidence Rates in the 1970s

In order to investigate if differences in incidence rates across decades were influenced by cohort effects (original cohort contributing data for the 1950s and 1960s, and offspring cohort for 1980s and 1990s), we assessed incidence rates separately for eligible participants in the 2 cohorts in the 1970s (the decade at which individuals between ages 40 and 55 years were available in both cohorts; Appendix 2). The incidence rates of BMI outcomes were similar in the 2 cohorts; whereas point estimates in rates varied for the 2 samples, the 95% CI overlapped. Analyses that included underweight individuals did not materially change incidence rates for overweight, obesity and stage 2 obesity (Appendixes 3, 4).

### Temporal Trends in Weight Loss

The proportions of overweight or more individuals who achieved normal weight status and of obese individuals who became nonobese have steadily decreased over the past 50 years (Tables 5, 6).

**Table 3** 8-Year Crude Incidence Rates\* of Overweight, Obesity and Stage 2 Obesity in Each Calendar Decade

	Men					Women				
	1950s	1960s	1970s	1980s	1990s	1950s	1960s	1970s	1980s	1990s
Incidence of overweight ( $25 \leq \text{BMI} < 30 \text{ kg/m}^2$ )†										
Events/no. at risk	72/331	81/268	56/273	75/199	63/179	89/595	124/574	133/653	122/480	156/472
Incidence rate (95% CI)†	21.8 (17.6-26.5)	30.2 (25.0-36.0)	20.5 (16.1-25.7)	37.7 (31.2-44.6)	35.2 (28.6-42.5)	15.0 (12.3-18.1)	21.6 (18.4-25.2)	20.4 (17.5-23.6)	25.4 (21.7-29.5)	33.1 (29.0-37.4)
Incidence of overweight or more (BMI $\geq 25 \text{ kg/m}^2$ )										
Events/no. at risk	73/332	82/269	58/275	78/202	66/182	90/596	129/579	136/656	129/487	170/486
Incidence rate (95% CI)	22.0 (17.9-26.8)	30.5 (25.3-36.2)	21.1 (16.7-26.3)	38.6 (32.2-45.5)	36.3 (29.6-43.5)	15.1 (12.4-18.2)	22.3 (19.1-25.9)	20.7 (17.8-24.0)	26.5 (22.8-30.6)	35.0 (30.9-39.3)
Incidence of obesity (BMI $\geq 30 \text{ kg/m}^2$ )										
Events/no. at risk	48/827	67/692	61/887	75/637	91/613	41/1048	60/859	71/1020	58/720	102/731
Incidence rate (95% CI)	5.8 (4.4-7.6)	9.7 (7.7-12.1)	6.9 (5.4-8.7)	11.8 (9.5-14.5)	14.8 (12.2-17.9)	3.9 (2.9-5.3)	7.0 (5.5-8.9)	7.0 (5.6-8.7)	8.1 (6.3-10.3)	14.0 (11.6-16.7)
Incidence of stage 2 obesity (BMI $\geq 35 \text{ kg/m}^2$ )										
Events/no. at risk	2/916	11/786	12/1070	26/785	42/776	20/1170	15/942	31/1134	27/792	37/843
Incidence rate (95% CI)	0.2 (0.1-0.9)	1.4 (0.8-2.5)	1.1 (0.6-2.0)	3.3 (2.3-4.8)	5.4 (4.0-7.2)	1.7 (1.1-2.6)	1.6 (1.0-2.6)	2.7 (1.9-3.9)	3.4 (2.3-4.9)	4.4 (3.2-6.0)

\*Incidence rate per 100 persons.

†Individuals with BMI  $< 25 \text{ kg/m}^2$  at baseline but with BMI  $> 30 \text{ kg/m}^2$  at the follow-up examination were excluded for estimating incidence of overweight alone.



**Table 4** Trends in Incidence of BMI Outcomes Across Decades (1950s to 1990s): Results of Age- and Smoking Cessation-Adjusted Models

Odds Ratio (95% CI)											
Men						Women					
1950s	1960s	1970s	1980s	1990s	<i>P</i> for trend	1950s	1960s	1970s	1980s	1990s	<i>P</i> for trend
Incidence of overweight ( $25 \leq \text{BMI} < 30 \text{ kg/m}^2$ )											
Referent	1.53* (1.04-2.26)	0.99 (0.66-1.50)	2.13‡ (1.43-3.18)	2.13‡ (1.41-3.22)	<.001	Referent	1.49† (1.10-2.02)	1.38* (1.02-1.86)	1.86‡ (1.37-2.53)	2.72‡ (2.02-3.66)	<.001
Incidence of overweight or more ( $\text{BMI} \geq 25 \text{ kg/m}^2$ )											
Referent	1.53* (1.04-2.24)	1.02 (0.68-1.53)	2.17‡ (1.46-3.23)	2.19‡ (1.46-3.30)	<.001	Referent	1.54† (1.14-2.07)	1.40* (1.04-1.89)	1.95‡ (1.44-2.63)	2.94‡ (2.19-3.94)	<.001
Incidence of obesity ( $\text{BMI} \geq 30 \text{ kg/m}^2$ )											
Referent	1.67* (1.11-2.51)	1.23 (0.82-1.85)	2.11‡ (1.42-3.12)	3.01‡ (2.06-4.41)	<.001	Referent	1.80† (1.20-2.72)	1.80† (1.21-2.68)	2.10‡ (1.39-3.17)	3.91‡ (2.68-5.70)	<.001
Incidence of stage 2 obesity ( $\text{BMI} \geq 35 \text{ kg/m}^2$ )											
Referent	5.60* (1.22-25.66)§	4.51 (1.00-20.45)§	13.92‡ (3.29-58.92)§	24.57‡ (5.93-101.92)§	<.001	Referent	0.93 (0.47-1.83)	1.61 (0.91-2.85)	2.04* (1.13-3.67)	2.64‡ (1.52-4.58)	<.001

\**P* <.05.  
†*P* <.01.  
‡*P* <.001.  
§Wide 95% CI are the result of the small n in the referent group (2 events in 916 men at risk in 1950s, Table 3).

**Table 5** Incidence Rates of Losing Weight

BMI Outcome	Men					Women				
	1950s	1960s	1970s	1980s	1990s	1950s	1960s	1970s	1980s	1990s
Normal BMI on follow-up*										
Events/no. at risk	58/589	31/530	72/828	38/602	32/640	78/621	40/391	65/527	25/352	17/413
Incidence rate (95% CI)	9.8 (7.7-12.5)	5.8 (4.1-8.2)	8.7 (7.0-10.8)	6.3 (4.6-8.6)	5.0 (3.6-7.0)	12.6 (10.2-15.4)	10.2 (7.6-13.6)	12.3 (9.8-15.4)	7.1 (4.8-10.3)	4.1 (2.6-6.5)
BMI <30 on follow-up†										
Events/no. at risk	32/94	20/107	49/216	33/167	23/209	30/169	21/111	25/163	12/119	18/168
Incidence rate (95% CI)	34.0 (25.2-44.2)	18.7 (12.4-27.2)	22.7 (17.6-28.7)	19.8 (14.4-26.5)	11.0 (7.4-16.0)	17.8 (12.7-24.3)	18.9 (12.7-27.3)	15.3 (10.6-21.7)	10.1 (5.8-16.9)	10.7 (6.9-16.4)

\*Refers to individuals overweight or more ( $\text{BMI} \geq 25 \text{ kg/m}^2$ ) during the referent decade who subsequently became normal weight ( $18.5 \text{ kg/m}^2 < \text{BMI} < 25 \text{ kg/m}^2$ ).  
†Refers to those individuals obese or more ( $\text{BMI} \geq 30 \text{ kg/m}^2$ ) during the referent decade who subsequently became normal weight or overweight ( $18.5 \text{ kg/m}^2 < \text{BMI} < 30 \text{ kg/m}^2$ ).

**Table 6** Trend across Decades (1950s to 1990s): Age and Smoking Cessation Adjusted Incidence of Losing Weight

Odds Ratio (95% CI)		Women											
Men		1950s	1960s	1970s	1980s	1990s	P for trend	1950s	1960s	1970s	1980s	1990s	P for trend
Incidence of normal weight on follow-up for persons with BMI $\geq 25$ kg/m <sup>2</sup> at baseline*													
Referent	0.55† (0.34-0.88)	0.81	0.55-1.18	0.63† (0.41-0.98)	0.46§ (0.29-0.72)	0.004	Referent	0.80 (0.53-1.20)	0.98 (0.69-1.39)	0.54† (0.34-0.87)	0.30§ (0.17-0.52)	<.001	
Incidence of BMI < 30 kg/m <sup>2</sup> on follow-up for persons with BMI $\geq 30$ kg/m <sup>2</sup> at baseline													
Referent	0.41‡ (0.21-0.81)	0.53† (0.31-0.92)	0.42‡ (0.24-0.76)	0.22§ (0.12-0.41)	<.001	<.001	Referent	1.17 (0.63-2.18)	0.87 (0.48-1.55)	0.54 (0.26-1.10)	0.59 (0.31-1.11)	.024	

\*Refers to individuals overweight or more (BMI  $\geq 25$  kg/m<sup>2</sup>) during the referent decade who subsequently became normal weight (18.5 kg/m<sup>2</sup> < BMI < 25 kg/m<sup>2</sup>).  
 †P < .05.  
 ‡P < .01.  
 §P < .001.  
 ||Refers to individuals obese or more (BMI  $\geq 30$  kg/m<sup>2</sup>) during the referent decade who subsequently became normal weight or overweight (18.5 kg/m<sup>2</sup> < BMI < 30 kg/m<sup>2</sup>).

**DISCUSSION**

It is estimated that the lifetime risk of being overweight exceeds 70% and that for obesity it exceeds 35%.<sup>23</sup> In the present investigation we assessed if the rising prevalence of overweight and obesity in national cross-sectional surveys was a recent trend or a gradual phenomenon accruing over decades. Our principal findings are 3-fold. First, incidence rates of overweight and obesity increased 2- to more than 3-fold over the last 5 decades in our community-based sample. Second, the incidence rates increased across decades in a fairly monotonic fashion in women. However, incidence rates in men demonstrated a biphasic pattern of increase, with an initial increase in the 1960s and a subsequent one in the 1980s. The reasons for these differing patterns in the 2 sexes are not clear. Third, we noted a striking increase in the prevalence of stage 2 obesity in the 1990s and 2000s, and observed a rising incidence in the 1990s, a matter of great concern.

The reasons for the increases in obesity over the past several decades are likely manifold. Our data demonstrate a decrease in incidence rates of weight loss among both overweight and obese individuals over the past 50 years. Smoking cessation among adults has been related to an increased prevalence of overweight.<sup>24</sup> Indeed, smoking rates decreased considerably in our study cohort over the past 50 years. However, adjusting for smoking cessation did not significantly alter the incidence trends in our investigation. Increased mean energy intake among adults between 1970 and 2000 has also been implicated as a potential cause for the growing obesity epidemic.<sup>25,26</sup> Such increases in energy intake have been attributed to increases in mean food and beverage portion sizes,<sup>27</sup> and consumption of energy-dense fast foods.<sup>28</sup> Consistent with these data, the self-reported mean energy intake in our cohort increased between the 1980s and the 1990s.

Decreased physical activity in the United States population has been suggested as a causal factor for greater obesity prevalence. Data from the Behavioral Risk Factor Surveillance System (BRFSS), as well as from our cohort indicate that self-reported physical activity has actually increased moderately from the 1980s into the 2000s.<sup>29,30</sup> One explanation for the rising incidence in obesity in the face of higher physical activity may be that increases in caloric intake may have been greater relative to increases in physical activity. An alternative explanation is that the physical activity questionnaire in BFRSS and our study may not have captured adequately overall increases in sedentary lifestyle among adults. Factors contributing to a sedentary lifestyle include less physically demanding occupations,<sup>31</sup> changing land-use patterns (eg, urban sprawl<sup>32</sup>), and increased automotive travel.<sup>33</sup>

**Temporal Trends in BMI Prevalence and Incidence: Comparison with Published Literature**

The baseline prevalence of overweight (or more), obesity, and stage 2 obesity in our sample in each decade closely resembles that for corresponding age groups in the

NHANES data.<sup>10,11,34,35</sup> However, our estimates of prevalence of overweight (or more) and obesity were higher in the 1990s and 2000s than those reported for comparable age groups in BRFSS.<sup>36-38</sup> Lower prevalence estimates in BRFSS may be due to self-reported height and weight ascertainment. Previous studies of self-reported weight and height report that overweight participants tend to underestimate their true weight, whereas most participants overestimate their height.<sup>39,40</sup> Also, inaccurate height reporting increases after age 45 years.<sup>40</sup>

Previous longitudinal studies of BMI and weight categories<sup>41-45</sup> have not focused on temporal trends in incidence of overweight and obesity during the past 5 decades; therefore, we are unable to compare our results with other studies. Our incidence data complement available information on the prevalence of overweight and obesity from national surveys. The substantial incidence rates of overweight, obesity, and stage 2 obesity in our study population in the 1990s are consistent with a parallel increase in the prevalence of obesity nationwide. Overall, our longitudinal observations over 50 years suggest that the increase in prevalence of overweight and obesity was accompanied by increasing incidence rates for both.

## Strengths and Limitations

The strengths of our investigation include the use of prospectively collected data over a 50-year period in a community-based study, and the standardized measurements of BMI over this period. Nonetheless, several limitations should be acknowledged. We evaluated only participants aged 40-55 years (an unavoidable constraint of studying BMI trends for participants in a similar age range over 5 decades) that limits the generalizability of our results to persons older or younger, and limits the comparison of our findings with observations in the NHANES samples. Our sample consisted of 2 separate cohorts—original cohort participants contributed observations in the earlier decades (1950s and 1960s), whereas offspring cohort members provided information during the later decades (1980s and 1990s). Birth cohort effects have been described with later birth cohorts demonstrating a greater propensity for obesity.<sup>41</sup> We found no clear-cut evidence of cohort-related differences in incidence of overweight and obesity. Our study cohort is overwhelmingly white, and our results may not be generalizable to nonwhites. Physical activity and dietary caloric intake measurements were available only for recent decades; consequently, we were unable to assess the contributions of these factors to the rising incidences of obesity. We did not account for temporal changes in the incidence of chronic diseases (like cancer) that may influence BMI trends. Lastly, we were unable to examine trends in the incidence of central adiposity because waist measurements were not obtained at early examinations. NHANES data suggest that the prevalence of abdominal adiposity has increased from 1960-1962 to 1999-2000.<sup>46</sup>

## Implications

To our knowledge, the present investigation is the first systematic analysis of the incidence of overweight, obesity, and stage 2 obesity over 5 decades in a community-based sample in the United States. Increased incidences of overweight and obesity over the last 50 years suggests that the rising trend of excess adiposity is not a recent phenomenon, although rates have escalated in the last decade. If these patterns of rising incidence continue unabated, the community burden of overweight and obesity may continue to increase over the next decade. Data provided by our study can help in the estimation of the future burden of excess adiposity combining the trajectory of incidence rates over 50 years (average increase per decade of 20%-30% for overweight and 30%-35% for obesity) with the incidence rates observed in the last decade.

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**Appendix 1:** Incidence Rates of Obesity (BMI  $\geq 30$  kg/m<sup>2</sup>) in Nonsmokers

	Men					<i>P</i> for trend	Women					<i>P</i> for trend
	1950s	1960s	1970s	1980s	1990s		1950s	1960s	1970s	1980s	1990s	
Events/no. at risk	10/164	19/197	20/409	34/345	53/441		28/588	45/407	47/571	34/467	73/540	
Incidence rate (95% CI)	6.1 (3.3-11.0)	9.6 (6.2-14.6)	4.9 (3.2-7.5)	9.9 (7.1-13.5)	12.0 (9.3-15.4)		4.8 (3.3-6.8)	11.1 (8.4-14.5)	8.2 (6.2-10.8)	7.3 (5.2-10.0)	13.5 (10.9-16.7)	
Odds ratio (95% CI)	Referent	1.65 (0.75-3.66)	0.81 (0.37-1.76)	1.69 (0.81-3.51)	2.11* (1.05-4.26)	.007	Referent	2.50‡ (1.53-4.09)	1.80* (1.11-2.93)	1.56 (0.93-2.62)	3.12‡ (1.99-4.91)	<.001

†*P* < .01.\**P* < .05.‡*P* < .001.**Appendix 2:** Cohort-Specific 8-year Crude Incidence Rates\* of Overweight, Obesity and Stage 2 Obesity in the 1970s

	Men	Women
Original cohort		
Incidence rate of overweight (95% CI)	17.8 (11.6-26.2)	23.9 (19.0-29.6)
Incidence rate of overweight or more (95% CI)	17.8 (11.6-26.2)	24.5 (19.6-30.2)
Incidence rate of obesity (95% CI)	7.4 (5.0-10.8)	6.4 (4.4-9.3)
Incidence rate of stage 2 obesity (95% CI)	1.3 (0.5-3.0)	2.7 (1.5-4.7)
Offspring cohort		
Incidence rate of overweight (95% CI)	22.3 (16.6-29.3)	18.2 (14.7-22.2)
Incidence rate of overweight or more (95% CI)	23.2 (17.4-30.2)	18.4 (14.9-22.4)
Incidence rate of obesity (95% CI)	6.6 (4.8-8.9)	7.3 (5.5-9.7)
Incidence rate of stage 2 obesity (95% CI)	1.0 (0.5-2.1)	2.8 (1.8-4.3)

\*Incidence rate per 100 persons.

**Appendix 3:** Incidence Rates of Overweight, Obesity, and Stage 2 Obesity (for Sample that Included Individuals with BMI <18.5 mg/kg<sup>2</sup>)

BMI Outcome	Men					Women				
	1950s	1960s	1970s	1980s	1990s	1950s	1960s	1970s	1980s	1990s
Overweight or more										
Events/no. at risk	73/342	82/277	58/282	78/208	66/184	90/617	129/599	136/670	129/500	170/500
Incidence rate (95% CI)	21.3 (17.3-26.0)	29.6 (24.5-35.2)	20.6 (16.2-25.7)	37.5 (31.2-44.3)	35.9 (29.3-43.1)	14.6 (12.0-17.6)	21.5 (18.4-25.0)	20.3 (17.4-23.5)	25.8 (22.2-29.8)	34.0 (30.0-38.3)
Obesity										
Events/no. at risk	48/837	67/700	61/894	75/643	91/615	41/1069	60/879	71/1034	58/733	102/745
Incidence rate (95% CI)	5.7 (4.3-7.5)	9.6 (7.6-12.0)	6.8 (5.3-8.7)	11.7 (9.4-14.4)	14.8 (12.2-17.8)	3.8 (2.8-5.2)	6.8 (5.3-8.7)	6.9 (5.5-8.6)	7.9 (6.2-10.1)	13.7 (11.4-16.4)
Stage 2 obesity										
Events/no. at risk	2/926	11/794	12/1077	26/791	42/778	20/1191	15/962	31/1148	27/805	37/857
Incidence rate (95% CI)	0.2 (0.1-0.9)	1.4 (0.8-2.5)	1.1 (0.6-2.0)	3.3 (2.2-4.8)	5.4 (4.0-7.2)	1.7 (1.1-2.6)	1.6 (0.9-2.6)	2.7 (1.9-3.8)	3.4 (2.3-4.8)	4.3 (3.1-5.9)

**Appendix 4:** Trend across Decades (1950s to 1990s): Age and Smoking Cessation Adjusted Incidence of Adiposity Outcomes (for Sample that Included Individuals with BMI <18.5 mg/kg<sup>2</sup>)

Odds Ratio (95% CI)											
Men						Women					
1950s	1960s	1970s	1980s	1990s	P for trend	1950s	1960s	1970s	1980s	1990s	P for trend
Incidence of overweight											
Referent	1.53*	1.03	2.18†	2.26‡	<.001	Referent	1.53†	1.42*	1.95‡	2.93‡	<.001
	(1.04-2.25)	(0.69-1.55)	(1.47-3.23)	(1.50-3.41)			(1.14-2.07)	(1.05-1.90)	(1.44-2.64)	(2.19-3.92)	
Incidence of obesity											
Referent	1.68*	1.24	2.12†	3.05‡	<.001	Referent	1.80†	1.81†	2.10‡	3.90‡	<.001
	(1.12-2.52)	(0.82-1.86)	(1.43-3.15)	(2.09-4.47)			(1.19-2.70)	(1.22-2.69)	(1.39-3.17)	(2.68-5.69)	
Incidence of stage 2 obesity											
Referent	5.61*	4.54*	14.00‡	24.85‡	<.001	Referent	0.93	1.61	2.04*	2.64‡	<.001
	(1.22-25.72)	(1.00-20.58)	(3.31-59.24)	(5.99-103.05)			(0.47-1.82)	(0.91-2.86)	(1.14-3.67)	(1.52-4.59)	

\*P &lt;.05.

†P &lt;.01.

‡P &lt;.001