Weight Histories and Mortality among Finnish Adults: The Role of Duration and Peak BMI

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Abstract

Background—Many studies use information on weight histories to examine the association between body weight and mortality. A recent paper in EPIDEMIOLOGY (2013;24(1):158–166) developed a typology of the most common weight-history specifications.

Methods—We use data from a sample of Finnish adults to explore the associations of body weight and mortality, using existing specifications and also peak BMI, a new specification.

Results—We confirm earlier findings that longer time in a high BMI state is predictive of mortality. Peak BMI (the highest BMI attained in life or available in the data) is also positively associated with mortality.

Conclusions—The specifications of duration in a high BMI state and peak BMI are both valuable for understanding the relationship between lifetime weight dynamics and mortality. The collection of information on peak body weight may be useful when collection of more detailed weight histories is not feasible.

Preston et al.[1] recently outlined a typology for modeling the association between body mass index (BMI) and mortality when information on BMI is available at multiple ages. The authors identified four specifications most commonly employed in statistical models of BMI and mortality: additive (i.e., treating each BMI observation additively and independently), duration (i.e., counting the time spent with a high BMI), weight change, and interactive (i.e., including interaction terms among BMI observations). Using baseline and retrospectively reported weight at earlier ages in the U.S. National Health and Nutrition Examination Survey (NHANES), the authors evaluated each specification with respect to variance explained and ease of interpretation. They concluded that duration models were the best-performing models.

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Our objective was two-fold. The first was to replicate the analysis by Preston and colleagues[1] using an independent dataset from another developed country. The second was to examine the role of an additional specification of weight history not previously examined, namely peak BMI. Peak BMI refers to the highest BMI attained in life (or alternatively, the highest measure available in the data).

Methods

We used a nationally representative dataset from Finland, which, like NHANES, includes retrospective information on weight at earlier ages. We began by estimating duration models similar to those estimated by Preston et al.[1] and comparing our results to theirs. We then examined the association between peak BMI and mortality and assessed its role in explaining variation in death rates.

Data were from the Health 2000 Survey, a nationally representative cross-sectional survey of adults age 30 years and older carried out in Finland in 2000–2001.[2] Survey participants have been followed continuously in the Finnish Mortality Registry; we analyzed death record linkages through 31 December 2011.

Recalled weight was collected for ages 20, 30, 40, and 50 years. We used this information, along with weight measured at the time of the survey, to calculate BMI at the various ages. Measured height at the time of survey was used for all calculations of BMI. We included adults aged 50–74 years at the survey, the same age group used by Preston et al.[1] After excluding those with missing data (11%) and respondents who were underweight (BMI <18.5 kg/m^2) at the time of the survey (<1%), our analytical sample comprised 2,505 participants. There were 335 deaths during 26,424 person-years of follow-up.

We applied Cox proportional hazard models, with time in study as the underlying time metric, to data from a person-year file to estimate hazard ratios (HRs). Models were adjusted for attained age, sex, educational attainment (basic [0–9 years], intermediate [10–12 years], and higher [13+ years]), and cigarette smoking (current, former, never). Analyses were weighted to reduce bias due to non-response. Results were substantively similar for men and women, and so we combined both sexes in our analyses.

We defined a high BMI state as being at or above a BMI of 25.0 kg/m^2, the conventional threshold for overweight. Preliminary analyses showed similar results with a cut-point of 30.0, the threshold for obesity. We chose the lower threshold of 25.0 because the majority (79%) of time spent at a BMI >25.0 in this sample was spent between a BMI of 25.0 and 29.9.

Our duration variables were constructed based on the approach outlined by Preston et al.[1] and counted time spent in a high BMI state. The first duration measure was simply the number of years spent above a BMI of 25.0 kg/m^2. The second measure was a composite measure of duration and intensity, defined as BMI-Years above a BMI of 25.0 (i.e., the number of BMI units above 25.0). For example, a person with a BMI of 27.0 at both age 30 and age 40 would receive a value of 20 BMI-Years (2 BMI units×10 years) for this interval.

Both measures pertain to weight experiences between age 20 and age at survey. Those who had a BMI <25.0 at all ages received a value of 0 on both measures.

Peak BMI was based on the maximum reported BMI at ages 20, 30, 40, 50, or at the time of the survey and was assessed both categorically (BMI <25.0 kg/m^2, overweight [25.0–29.9], obese [30.0]) and continuously. Continuous variables were constructed by assigning a value of 0 to those with a peak BMI 25.0 and a value of (BMI – 25.0) for those with a peak BMI >25.0.

The eAppendix 3 provides details on acquiring Health 2000 data and Stata code used in this analysis.

Results

Descriptive characteristics of the various BMI measures are presented in Table 1. Table 2 shows results from the duration models. Mortality increased by 10% for every 10 years spent with a BMI 25.0 kg/m^2 (HR=1.10 [95% confidence interval (CI) = 1.02 – 1.18). The BMI-years variable was also positively associated with mortality. The HR associated with a 10-unit increment was 1.02 (95% CI = 1.01 – 1.03).

eTable 1 compares estimates from the duration models estimated in the Finnish Health 2000 survey with estimates from the U.S. NHANES data of Preston et al.[1] The variables shown in eTable 1 were constructed using BMI=30.0 kg/m^2 as a cut-point, as that was the threshold used by Preston and colleagues[1] The HRs associated with the two duration measures were similar in Finland and the United States. For example, a 1-unit increase in obesity duration was associated with a 2.0% increase in the hazard in Finland (HR=1.020 [95% CI = 1.008 – 1.032]) and 1.6% increase in the hazard (1.016 [1.010 – 1.022]) in the United States. We additionally show results for two other duration measures estimated by Preston et al.[1] (percent of years spent obese and years since becoming obese).

We next turn to the role of peak BMI. Table 3 presents results for the categorical specification of overall peak BMI. Overall peak BMI in Model 1 refers to the maximum BMI observed from the retrospective reports and at the time of the survey. In Model 2, we show results for categorical BMI assessed at the time of the survey, which has been the most commonly employed approach to examining the BMI-mortality association. In both models, we found that obesity (BMI 30.0 kg/m^2) was associated with an excess hazard of dying relative to a BMI <25.0. In Model 1, the HR for overall peak obesity was 1.42 (95% CI = 1.04 – 1.95). In Model 2, the HR for obesity at time of survey was 1.22 (95% CI = 0.91 – 1.65). There was little evidence that overweight was associated with an increased hazard of dying in either specification.

Table 4 shows results for continuous specifications. We examined two measures of peak BMI. As in Table 3, overall peak BMI takes the maximum observed BMI from both retrospective and survey information. Historical peak BMI excludes information from the time of the survey. The column labeled Models 1–3 shows results for each measure entered in a separate model and reflects the findings in Table 3—each measure was positively associated with the hazard, of dying.

A relevant clinical and public health concern is whether historical obesity contributes to mortality over-and-above the information on obesity collected at time of survey (or, for example, at the time of a healthcare visit). To examine this issue, Model 4 of Table 4 included both baseline BMI and historical peak BMI. (Historical peak BMI does not include BMI at the time of the survey.) Results from Model 4 indicate that historical peak BMI was positively associated with mortality (HR=1.06 for a 1-unit increment [95% CI = 1.02 – 1.11]). In contrast, BMI at the time of the survey was not associated with mortality in Model 4.

eAppendix 2 shows the cross-tabulation of BMI at time of survey and historical peak BMI. About one-quarter of the sample had been in a higher BMI category at some time prior to the survey.

Discussion

Like the United States, Finland experiences relatively high levels of overweight and obesity.[3] Our findings contribute to previous studies by highlighting the positive association between duration in a high BMI state and mortality at older ages.[4–9] Comparing our results with those of Preston et al.,[1] the magnitude of the association between obesity duration and mortality is very similar in Finland and the US. This cross-national comparability suggests that obesity is operating similarly on mortality across high-income countries with relatively advanced obesity epidemics.

In addition, we found that persons whose peak BMI categorized them as obese (BMI 30 kg/m^2) experienced higher mortality than those whose peak BMI did not reach 25.0 kg/m^2. We did not detect excess mortality among those whose peak was in the overweight range (25.0–29.9 kg/m^2) relative to those whose peak BMI was <25.0 kg/m^2. Preston et al.[1] found that obesity at earlier ages contributed to mortality independent of obesity at baseline in NHANES. Our findings using peak BMI are consistent with this finding. Historical peak BMI in our analysis contributed to death rates independent of BMI at the time of the survey when both were included in the same model. This finding suggests that collecting information on the highest BMI attained in life will contribute to a more complete assessment of mortality associated with obesity, even when information on current BMI is available.

A sizeable percent of participants in the survey had been in a higher BMI category at some time in the past, suggesting that weight loss during adulthood is not uncommon. While we could not measure the role of illness in contributing to this weight loss, a key strength of using peak BMI is that it may be more robust to reverse causality, compared with BMI measured at the time of the survey, because the peak can capture weight attainment prior to the onset of illness. (Reverse causality in this context refers to a downward bias of obesity's effect due to disease-induced weight loss.[10, 11]) Peak BMI can be efficiently ascertained in health surveys by asking a single question on the highest weight ever attained (in addition to information on height).

In our population, duration was positively correlated with peak BMI (rho=.62). This correlation and the relatively small number of deaths precluded us from assessing the relative importance of peak BMI versus duration of overweight/obesity in explaining mortality. A further limitation was that true peak BMI may have been underestimated because we had weight recorded retrospectively only at specific ages.

Both duration of obesity and peak BMI appear to be valuable to understanding the relationship between lifetime weight dynamics and mortality. We recommend peak body weight be routinely collected in health surveys even when the collection of more detailed weight histories is not feasible.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Descriptive characteristics of various BMI measures for study participants aged 50–74 years at survey (n=2,505)

Characteristic	
Continuous Duration-based Measures; mean (SD)	
Duration with BMI 25.0 kg/m^2 (years)	17.20 (14.73)
BMI-years above BMI 25.0 kg/m^2	53.23 (76.67)
Survey BM I (kg/m^2) %	
<25.0	28.1
25.0–29.9 (overweight)	43.6
30.0+ (obese)	28.3
Overall Peak BMI (kg/m^2) %	
<25.0	23.1
25.0–29.9 (overweight)	44.6
30.0+ (obese)	32.3
Other Continuous Measures; mean (SD)	
Survey BMI >25.0 kg/m^2	3.43 (3.91)
Overall peak BMI >25.0 kg/m^2	3.85 (4.04)
Historical peak BMI >25.0 kg/m^2	2.44 (3.23)

Note: BMI-years is a composite measure of duration in years above a BMI of 25.0 kg/m^2 and number of BMI units above a BMI of 25.0. Survey BMI is BMI at time of survey in 2000–2001. Overall peak BMI is the peak BMI from the retrospective reports of weight at earlier ages (ages 20, 30, 40, and 50 years) and survey BMI. Historical peak BMI identifies peak excluding information at survey. For the other continuous measures, those with a BMI 25 were coded 0 and those with a BMI>25 were coded as (BMI-25.0). Estimates reflect sample weighting. Persons who were underweight (< 18.5 kg/m^2) are excluded.

SD: Standard Deviation

Table 2

Hazard ratios for continuous duration-based measures, for participants ages 50–74 years at time of survey (n=2,505)

Continuous Duration Measures	HR (95% CI) Per 1-unit change		Coefficient/SE	HR (95% CI) per 1-unit change	
Duration with BMI 25.0 (kg/m^2) (years)	1.01	(1.00–1.02)	2.51	1.10	(1.02–1.18)
BMI-years above 25.0 kg/m^2	1.00[a]	(1.00–1.00)	3.87	1.02	(1.01–1.03)

Note: Each measure is entered into a separate model. HRs from Cox proportional hazard models adjusted for attained age, sex, educational attainment, and cigarette smoking. Estimates reflect sample weighting.

[a]Rounded to 3 significant digits, the HR is 1.002 (95% C=1.001–1.003)

[a]SE: Standard Error

Table 3

Hazard ratios for categorical overall peak BMI and BMI at time of survey, for participants aged 50–74 years at time of survey (n=2,505)

(kg/m^2) BMI Categories	Overall Peak BMI HR (95% CI)		Survey BMI HR (95% CI)	
<25.0[a]	1.00		1.00	
25.0–29.9 (Overweight)	1.08	(0.79–1.48)	1.08	(0.82–1.43)
30.0 (Obese)	1.42	(1.04–1.95)	1.22	(0.91–1.65)

Note: Each measure is entered into a separate model. Cox proportional hazard models adjusted for attained age, sex, educational attainment, and cigarette smoking. Estimates reflect sample weighting.

[a]Reference category

Table 4

Hazard ratios for continuous BMI at survey, overall peak BMI, and historical peak BMI, for participants aged 50–74 years at time of survey (n=2,505)

Continuous Measures	Models 1–3 (Separate) HR (95% CI)		Model 4 (Joint) HR (95% CI)	
Survey BMI	1.04	(1.01–1.07)	1.01	(0.97–1.05)
Overall Peak BMI	1.05	(1.02–1.08)	-	
Historical Peak BMI	1.07	(1.03–1.10)	1.06	(1.02–1.11)

Note: In Models 1–3, each measure is entered into a separate model For all measures, those with a BMI 25 were coded 0 and those with a BMI>25 were coded as (BMI-25.0). Estimates reflect sample weighting.