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## THE FIRST SERIATIM STUDY INTO OLD AGE FOR WEIGHT, STATURE AND BMI: THE FELS LONGITUDINAL STUDY

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### Abstract

**Purpose**—To document the serial status of measures of weight, stature and BMI from birth into old age.

**Methods**—Longitudinal measures of weight, stature and BMI were taken from birth to 76 years of age for 5 men and 7 women as part of the Fels Longitudinal Study.

**Results**—Sex-specific plots of means for weight, stature and BMI are presented that describe the changes and sex differences in these measurements between birth (or the first year of life) into old age. These serial data demonstrate a continuous increase in body weight through much of adulthood and a small decline in stature starting in late middle age. The plots for BMI indicate the early onset of overweight and subsequent obesity early in adulthood and its continuance into old age for men and women.

**Conclusions**—These are the first plots of serial means for weight, stature and BMI measured from the same group of individuals from birth into old age. These findings demonstrate the changes in these measurements through childhood and maturity into old age. Similar data are needed for individuals from other racial/ethnic groups and countries in order to understand the aging process better.

### Introduction

The two most common measures of the human body are weight and stature, which are recorded frequently throughout the lifespan for health and identification purposes. There are well-documented descriptions of the status and changes that occur in weight and stature during childhood, and growth charts are available to record these measures for children up to 18 years of age (1). With maturity, weight is the most common clinical measurement for a variety of health associations, and weight stability, based on cross-sectional data during adulthood, is an emerging health indicator (2). During adulthood, a stature measurement is used more for identification purposes (e.g. driver's license) than for health reasons because stature remains stable until a decline in old age (3). In recent decades, stature measurements of adults have attained health importance for the calculation of the body mass index or BMI for which there are significant morbidity and mortality relationships (4). Despite the frequency that weight and stature are recorded in adulthood, these measures are rarely

available for an individual over more than a few years of life, much less for a group of individuals over 70 or more years of life.

There have been only two previous reports of long-term measures of stature for an individual. The initial report covered the first 18 years of life for one child between 1759 and 1777 (5). The second report covered the first 50 years of life for one of the individuals with data in this report (6). These two previous studies reported data for recumbent length and stature only. The present paper is the first to report longitudinal measures of weight, stature and BMI for over 70+ years of life for a small group of adults who are participants in the ongoing Fels Longitudinal Study (7, 8).

## Sample and Methods

The study sample consisted of 5 white men all of whom were measured at birth for weight and within the first year of life for recumbent length. The most recent weight and stature measurements of them were taken when they were between 63 and 74 years of age. The sample also includes 7 white women all of whom were measured at birth for weight and within the first year of life for recumbent length, and the most recent weight and stature measurements of them were taken when they were between 73 and 76 years of age.

These 5 men and 7 women are among the oldest active participants in the ongoing Fels Longitudinal Study with extensive long-term records for weight, stature and BMI, and they were observed between April 1930 and December 2006. They (and the younger 1300 participants currently in the Fels Longitudinal Study) were not selected for the study based on any specific disease or other criteria. Most participants were recruited either in utero or at birth (8).

Current data collection protocols for the Fels Longitudinal Study specify that participant visits occur at birth and at 3, 6, 9 and 12 months of age; then every 6 months at birthdays and half-birthdays until age 18 years; and then every two to five years afterwards. This schedule has been adhered to over the past 78 years for children, but the interval between visits for adults was greater before 1976 (8). Weight has always been measured using a calibrated beam-balance scale or an electronic digital scale. Recumbent length was recorded for these and all children in the Fels Longitudinal Study before 2 years of age and stature was recorded after age 2 years. Stature and recumbent length have always been measured with calibrated stadiometers (wall mounted or horizontal) or electronic digital stadiometers. There is a continuous record of measurement reliability for equipment and observers (8).

Measurement protocols for recumbent length, stature and weight have remained standardized over the past 78 years and conform to current recommendations in the Anthropometric Standardization Reference Manual (9). There are known small differences between recumbent length and stature, but these are ignored for this presentation since recumbent length was only measured up to two years of age. BMI was calculated as weight in kilograms divided by the square of stature (or recumbent length) in meters. After the passage of the National Research Act by the United States Congress in 1974, that required institutional review and approval of all federally funded research involving human participants, all Fels participants have signed an informed consent statement approved by the Institutional Review Board of Wright State University.

## Results

Sex-specific mean values for weight, stature and BMI are plotted at annual ages in Figures 1 to 3. For men and women, there is a rapid increase in weight and stature during the first 18 years of life, with men having larger average values than women reflecting basic sex

differences in body size (Figures 1-2). The positive slope for weight in childhood flattens during the teenage years and into adulthood, but overall the slope for weight remains positive for both men and women indicating a continuous increase in mean weight of about 10 or more kilograms from maturity up to 74 years of age (Figure 1). There is greater variability in the mean weights of men as compared to women, which may be a function of the small sample sizes.

The slopes for stature also start to flatten during the teenage years (Figure 2). There is less variability in mean statures across age because it is not as affected by diet or lifestyle as is body weight in healthy adults. In the mid-40s for women and the mid-50s for men, the means for stature start to decline slightly in value to a small degree which continues into old age.

The plots of BMI in Figure 3 are the first using longitudinal values for this index from childhood into old age. After early childhood, there is a variable but continuous increase in BMI values for these men and women to about 70 years of age. This increase corresponds to the similar increase in body weight seen in Figure 1. The mean values for men attain the current cut-point for overweight of 25 by about the late 20's and attain the current cut-point for obesity of 30 at close to 70 years of age. The means for the women do not reach the marker for overweight until about 56 years of age.

## Discussion

Today, investigators collect a cornucopia of health and genetic variables from study participants, but the knowledge and technology to collect such data have only existed in the last 30 plus years of the 20th Century. It is difficult to collect data from groups of individuals for long periods of time without significant attrition, but loss to follow-up in the Fels Longitudinal Study is low with participation sustained at approximately 90%. Longitudinal studies are rare and outside of the historic Harvard, Berkeley, Denver and Guidance childhood growth studies (10), to date, there are only a few studies of adults that have continued to collect data for more than two decades. The Fels Longitudinal Study is approaching its 80th year of continuous operation and data collection. This length of sustained work is required if plots such as those presented herein are to be available, and the number of participants represented in these plots will only increase as will the ages at observation as data collection and analyses continue.

To the best of our knowledge, these are the only plots of longitudinal data for a group of individuals over such a long span of life. These serial data reflect the trends reported previously from cross-sectional data with a continuous increase in body weight through much of adulthood, and a small decline in stature starting in late middle age (3). However, the plots for BMI for these few men indicate the early onset of overweight but subsequent obesity later in old age, at least for this small group of men and women. In comparison to national reference data for non-Hispanic whites from the NHANES III (1), the means for weight and BMI for these older men are between the corresponding 50th and 85th percentiles (75th percentile for BMI) between 50 and 69 years of age but above the 85th percentile after 70 years of age. The means for weight and BMI for these older women are slightly below the corresponding 50th percentiles between 50 and 59 years of age, close to the 50th percentiles between 60 and 69 years of age and between the 50th and 85th percentile (75th percentile for BMI) after 70 years of age. These few Fels participants spent much of their lives before the current "obesity epidemic" yet it appears that the men had, on average, attained the current cut-point for overweight about 1960, and the women attained this cut point about 1980. The level of overweight approaching obesity has continued to increase in these individuals into their mid-70's in age. Admittedly, these results and their

interpretation reflect a very small number of individuals, but it has taken 78 years of data collection by four generations of scientists to collect, analyze and document these longitudinal findings.

## Conclusion

These are the first plots of means for weight, stature and BMI measured from the same group of individuals from their birth into old age. These findings demonstrate the natural changes that occur in these measurements as individuals progress through childhood and maturity into old age. Similar data are needed for individuals from other racial/ethnic groups and countries if we are to understand the aging process better. In addition, it appears that some individuals were becoming overweight decades before our recognition of the obesity epidemic in the 1990's.

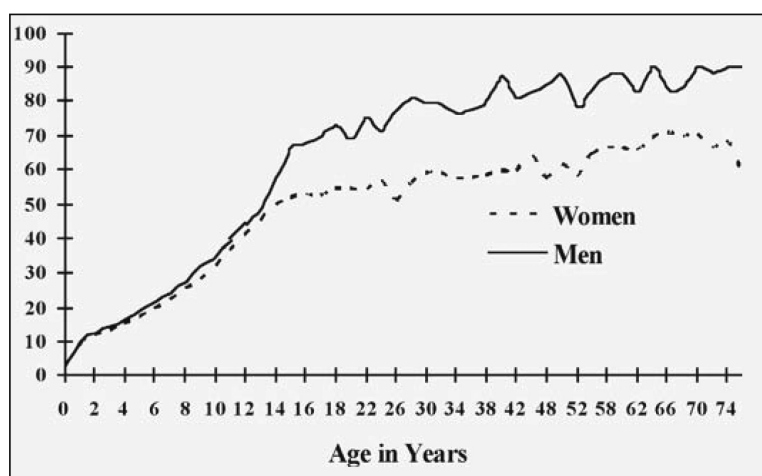
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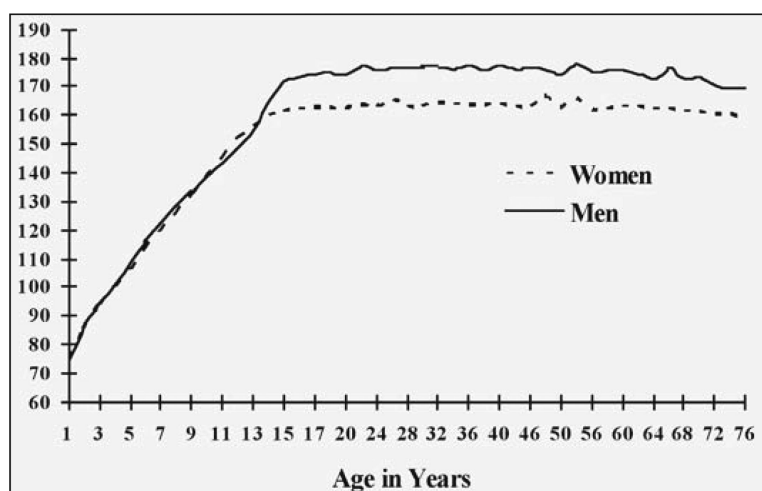
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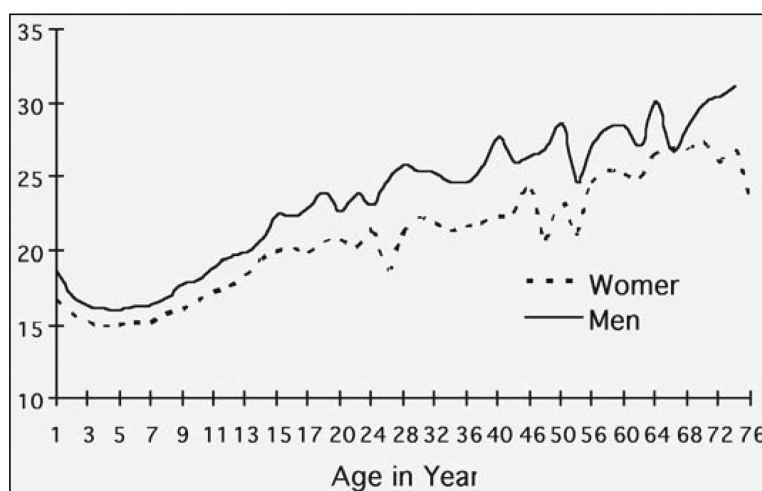
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**Figure 1.**  
Mean Weight for Men and Women from Birth to 76 Years of Age



**Figure 2.**  
Mean Stature for Men and Women from 1 to 76 Years of Age



**Figure 3.**  
Mean BMI for Men and Women from 1 to 76 Years of Age