Gender and Body Weight Status over the Life Course in China

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Abstract:

Developing countries are in the midst of emerging obesity epidemics. Men and women are disproportionately affected by obesity regarding psychological, socioeconomic, and health outcomes. It is unclear how gender differences in body weight change and vary by important moderators over the life course. Previous findings from western societies may not apply to developing countries that are at different stages of the nutrition transition. We draw on longitudinal data that covers the period of 1991-2009 in China, a country that has experienced enormous social changes and a rapid increase in obesity in recent years. We examine how gender differences in body mass index(BMI) change under the influences of SES and socio-environmental context over the life course and across different cohorts. We find men have higher BMI during young adulthood, but women gain greater weight in subsequent years. Women's average BMI exceeds men's around midlife, and the gap widens in later life.

INTRODUCTION

Increased prevalence of overweight and obesity at the population level has been observed in both developed (Flegal, Carroll, Kuczmarski, and Johnson 1998; Prentice and Jebb 1995; Sundquist and Johansson 1998) and developing countries (Popkin 2002; Popkin and Gordon-Larsen 2004) for both adults and children (Wang, Ge, and Popkin 2000; Wang, Monteiro, and Popkin 2002). Overweight and obesity are associated with increased risks of developing insulin resistance, hypertension, diabetes, and cardiovascular disease (Sowers 2003; Wilson, D'Agostino, Sullivan, Parise, and Kannel 2002). In the U.S., obesity has been related to more excess deaths than underweight between 1999 and 2002 (Flegal, Graubard, Wiliamson, and Gail 2005) and a potential decline in life expectancy in the 21st century (Olshansky, Passaro, Hershow, Layden, Carnes, Brody, Hayflick, Butler, Allison, and Ludwig 2005).

Considerable research has demonstrated that men and women are disproportionately affected by excessive body weight with respect to psychological, socioeconomic, and health outcomes in western societies. Women are far more likely than men to be stigmatized and discriminated for being overweight and obese (Harris and Walters 1991; Palinkas, Wingard, and Barrett-Connor 1996; Sobal and Stunkard 1989). Longitudinal studies have shown that overweight and obese women completed fewer years of school, had lower household incomes and hourly earnings, and maintained higher rates of household poverty compared to normal weight women, but these relationships were not found in men (Gortmaker, Must, Perrin, Sobol, and Dietz 1993; Sargent and Blanchflower 1994). Moreover, women tend to bear more burden of disease attributable to overweight and obesity compared to men. For example, the associations between body weight status and clinical depression, suicide ideation, and suicide attempts were positive for women, but negative for men in the U.S. (Carpenter, Hasin, Allison, and Faith 2000). Estimates from nationally representative samples indicated that overweight and obese women lost about 6.7 and 1.8 times respectively as many quality-adjusted life years as overweight and obese men in the U.S. (Muennig, Lubetkin, Jia, and Franks 2005).

Men are generally more likely than women to be overweight and obese, but women tend to experience faster rate of weight gain over time. For example, the gender difference in the increase of body weight (averaged 7.5 kg for men and 10.6 kg for women) led to a 2-point increase in the average BMI for men and a 4-point increase for women between 1971 and 2000 in the U.S. (Zhang and Wang 2004b). Men and women also differ in the relationships between risk factors and excessive weight gain. In particular, an inverse association between socioeconomic status (SES) and body weight has been well documented in women, but findings for men have been much more mixed in many Western countries (Sobal and Stunkard 1989; Wardle and Griffith 2001). Drawing on data from both cross-sectional and longitudinal surveys, Garn and colleagues found the so-called "socioeconomic reversal of fatness" in females. Compared to their peers of high family SES, girls of low family SES were thinner in childhood but began to gain more excess weight during adolescence and eventually became fatter in adulthood (Garn, Clark, Lowe, Forbes, Garn, Owen, Smith, Weil Jr., Nichaman, Johansen, and Rowe 1976; Garn, Hopkin, and Ryan 1981). More recent studies also suggested that the inverse relationship between SES and obesity gradually emerged as girls grow up to be women (Sobal and Stunkard 1989; Wardle and Griffith 2001; Zhang and Wang 2004a). On the other hand, a secular trend of diminishing SES disparities in obesity from the 1970s to 2000 was also found to be more pronounced in female than in male adults in the U.S. (Zhang and Wang 2004b).

Many of these studies rely on successive cross-sectional data or longitudinal data that cover only a small sample of very limited age groups (e.g. Garn et al. 1981), which hinders our understanding of how gender differences in body weight change and get moderated over the life course. Moreover, previous research focused on variations by gender in the association between SES and weight gain. A hitherto less examined but important dimension concerning the gender differences in body weight status is how they vary by family and social-environmental factors over the life course. Given that men and women may differ in their susceptibilities and behaviors in response to social-environmental changes that influence individual's weight changes (Zhang and Wang 2004b), an investigation of changing effects of these factors on men and women is in need to achieve a full understanding of gender differences in body weight status.

Finally, much research has focused on western societies and in particular the U.S., but these findings may not be applicable to developing countries that are at different stages of the nutrition transition. For example, in developing countries where people of low SES do not have adequate access to sufficient food supplies, overweight and obesity may signify wealth and health (Sobal and Stunkard 1989), and hence fat body shapes are highly valued rather than stigmatized. A good understanding of how gender differences in body weight status vary by SES and other factors among populations in developing societies is required to inform public health policy targeted at obesity epidemics.

In this study, we draw on data from a longitudinal survey over the period 1991 to 2009 in China, a country that experienced enormous social change and recent increases in overweight and obesity. We examine the relationship between gender and body weight status over the life course. A life course approach embeds individual experiences within broad socioeconomic and historic contexts (Elder, Johnson, and Crosnoe 2003). It contends that exposures to biological, psychological, behavioral, and social risk factors for health may develop over time and accumulate across an individual's lifespan (Ben-Shlomo and Kuh 2002; Kuh, Ben-Shlomo, Lynch, Hallqvist, and Power 2003). With respect to chronic disease like obesity, a life course approach recognizes the importance of time and timing in that both individual and contextual determinants can differentially influence health trajectories when they are experienced at different life stages at different times (Lynch and Smith 2005). Therefore, gender differences in body weight status are hypothesized to be dynamic within an individual life course and across generations as socioeconomic, environmental, and historical contexts change together with individuals' response strategies over time (Kuh et al. 2003).

This study contributes new knowledge to the growing research on life course and health by providing one of the first systematic investigations on how gender differences in body weight status are manifested over the life course under the influences of SES, family condition, health behaviors, and social environmental context. With its focus on China, this study contributes to the ongoing research efforts to fully understand the rapid nutrition transition and widened health inequality in developing countries which differ from the past experience in developed countries (Popkin 2002).

OVERWEIGHT AND OBESITY IN CHINA

China's rapid economic growth, social development, and urbanization in the last three decades has led itself to entering a new stage of the nutrition transition characterized by long-term shifts towards a high-fat, high-energy-density and low-fiber diet and increased physical inactivity at work and leisure, and hence reduced energy consumption (Du, Lu, Zhai, and Popkin 2002). The prevalence of overweight and obesity surged by nearly 50 percent in one decade from 14.6 percent in 1992 to 21.8 percent in 2002, accompanied by increased prevalence of obesity- and diet-related chronic diseases including hypertension, cardiovascular disease, and type-2 diabetes during the similar period (Wang, Mi, Shan, Wang, and Ge 2007). The indirect economic costs of obesity and obesity-related health conditions were estimated to range between 3.58 and 8.73% of China's gross national product (GNP) in 2000 and 2025 respectively (Popkin, Kim, Rusev, Du, and Zizza 2006).

Gender difference in the secular trend of weight gain in China is somewhat different from that in western societies in that men tend to gain excessive weight at a faster rate compared to women. In a population-based study of Chinese adults aged 20-45 in 1989, the prevalence of overweight and obesity doubled in women and almost tripled in men by 1997 (Bell, Ge, and Popkin 2001). Wang et al. (2007) reported that the average BMI was significantly higher for women than for men in 1989. However, the gender difference became insignificant by 2000 since the rate of increased weight gain was faster in men than in women during the 1990s (Wang, Du, Zhai, and Popkin 2007). Similarly, a meta-analysis based on nationally representative data has shown that Chinese men had experienced a greater increase in the prevalence of overweight and obesity than women between the early 1990s and the early 21st century, although such an increase was found in both men and women, across all age groups, and in both rural and urban regions (Wang et al. 2007).

A number of studies have examined the relationships between body weight status and several individual-level demographic, socioeconomic, and health-related variables among Chinese adults. Some of them have found gender differences in the correlates of body weight status through separate analyses for men and women. For example, using the 2000 CHNS data, Hou (2008) found positive relationships between overweight and age, female gender, being married, household income, and urban residence. However, urban residence was no longer significantly related to overweight after controlling for lifestyle variables (Hou 2008). Among the lifestyle variables, Hou (2008) found that smoking and heavy work activity reduced the risk of overweight, whereas frequent alcohol consumption increased the risk. Du et al. (2004) suggested that rapid income growth in China had allowed animal foods and edible oil affordable to even low income families, although high income individuals continued to consume more high-fat and low-fiber foods from 1989 to 1997, resulting in a positive relationship between income and prevalence of overweight and obesity. They further suggested a shift in the burden of obesity from the rich toward the poor as the latter would experience a faster increase in weight gain given future income growth (Du, Mroz, Zhai, and Popkin 2004).

Some research has revealed variations in the associations between SES and body weight status by gender in China. In a study of weight change among Chinese adults between 1989 and 1997, Bell and colleagues (2001) found the association between college education (versus primary school education) at baseline and subsequent weight gain was positive in men but negative in women. They also reported a significant correlation of the highest income tertile at baseline with weight gain in women but not in men (Bell, Ge, and Popkin 2001), a finding consistent with those in the U.S. (Flegal, Harlan, and Landis 1988) and Brazil (Monteiro, Conde, and Popkin 2001). In a study of body composition change among older Chinese adults aged 50-70 years, household income significantly differentiated between the respondents who lost both arm muscle and body fat and those who lost muscle but gained body fat for women, but not for men (Stookey, Adair, Stevens, and Popkin 2001).

In addition to individual-level factors, urbanization has been found as an important community-level predictor of reduced physical activity among Chinese adults which in turn contributes to excessive weight gain (Bell, Ge, and Popkin 2001; Monda, Adair, Zhai, and Popkin 2008; Paeratakul, Popkin, Ge, Adair, and Salonen 1998). Using the longitudinal CHNS data, Monda and colleagues (2007) found that the average increase in community-level urbanization between 1991 and 1997 predicted 68 and 51 percent increases for men and women respectively in the odds of engaging light versus heavy occupational activity. They further showed that urbanization explained more variance in occupational activity for men (54%) and for women (40%) through simulations (Monda, Gordon-Larsen, Stevens, and Popkin 2007). Using the 1991-2006 CHNS data, Ng and colleagues (2009) extended the measure of physical activity to incorporate both intensity of activities and time spent on activities at work, home, leisure, and transportation. They found that the association between urbanization and decline in average weekly physical activity was stronger in men than in women, although women experienced a faster decline compared to men (Ng, Norton, and Popkin 2009). Moreover, urban population experienced greater changes in the diet pattern characterized by a shift from the high-carbohydrate food consumption toward high-fat, high-energy density food consumption, compared to rural population between 1981 and 2001 (Wang, Du, Zhai, and Popkin 2007).

On the other hand, urbanization implies modernization which includes embracing westernized cultural values in favor of thin body shapes (especially among women) instead of fat body shapes viewed traditionally as signs of health and wealth in developing countries (Chen and Meltzer 2008). For example, adolescent girls in Fiji, a society that traditionally valued a robust body habitus rather than thinness as an aesthetic ideal, developed an interest in weight loss as a means of emulating television characters after 3-year exposure to Western television (Becker 2004; Becker, Burwell, Herzog, Hamburg, and Gilman 2002). These Fijian girls also perceived intergenerational disparities with their parents regarding weight loss behaviors that are contradictory to the traditional norms (Becker et al. 2002). A similar shift toward westernized ideal body shape may be taking place in Chinese society (Lau 2006).

Drawing on previous research, this study examines both individual and contextual dimensions of gender difference in body weight status among Chinese adults. A key contribution of this paper is its summary of gender-specific weight changes over the life course and across cohorts in China. Moderators of these patterns, including SES and urbanization, are also examined.

DATA AND METHOD

The data are drawn from the China Health and Nutrition Survey (CHNS), a longitudinal project following the same respondents over time and gathering data on health, nutrition, socioeconomic, and demographic characteristics at the individual, household, and community levels in nine provinces in China. The CHNS data are not nationally representative, but the surveyed areas reflect substantial demographic, socioeconomic, and geographic variation. Moreover, trends in the distribution of BMI revealed by the CHNS data are similar to those from nationally representative surveys (Ge, Weisell, Guo, Cheng, Ma, Zhai, and Popkin 1994; Wang et al. 2007; Wang, Monteiro, and Popkin 2002). For this analysis we draw on seven waves of data (1991, 1993, 1997, 2000, 2004, 2006, and 2009). Thus, we have repeated measures for adults age 21 and older across nearly two decades, providing opportunity to analyze patterns of BMI over the life course across multiple cohorts. Details on the survey design, sampling, coverage, and attrition of CHNS has been described elsewhere (Popkin, Du, Zhai, and Zhang 2010).

The sample in this study is limited to adults aged 21 years or above, excluding pregnant women at the time of survey (251 person-year records). The sample includes 7,650 individuals in 1991, 7,199 in 1993, 7,512 in 1997, 8,088 in 2000, 7,878 in 2004, 8,135 in 2006, and 8,286 in 2009. All together, the male and female respondents contribute 28,753 and 25,995 person-year records respectively.

The dependent variable BMI, defined as weight in kilograms divided by squared height in meters, is calculated from the weight and height measured through physical examination. Age is a continuous variable measured in years. Following previous research that examines cohort patterns in China (Chen, Yang, and Liu 2010), cohort is coded as a continuous variable to capture 10-year birth cohorts with the exception of 1950s cohort. Two 5-year cohort, 1951-1955 and 1956-1959, are created to capture the distinct influences of the two nation-wide historical events, the Great leap Forward and Three-Year Famine, on the individuals born in the 1950s. SES is measured by educational attainment coded into three categories (some/complete primary schooling or less, some/complete junior high, and some/complete senior high or technical school or above), household per capita income inflated to 2009, and occupation coded into three categories (unemployed or other, manual labor, and professional). Family context is captured by a dichotomous variable indicating currently married or not. Health behaviors are controlled by including dichotomous variables indicating whether one ever drank in past year or smoked in life time to date. Level of urbanization is measured by an urbanicity index constructed from the household- and community-level data from CHNS. The urbanicity index captures ten dimensions concerning the degree of urbanization in a community, including population, density, access to markets for household goods, economic wellbeing, transportation, communications, educational institutions, health facilities, sanitation, and housing infrastructure. The construction of the urbanicity index has been described elsewhere (Monda, Gordon-Larsen, Stevens, and Popkin 2007). All the continuous variables, except age, are standardized into z-scores before entering a regression to facilitate model predictions and interpretations. Age is centered at cohort-specific medians to reduce its collinearity with cohort and then divided by 10 to rescale its regression coefficient for easy interpretation. Finally, to control for selection bias due to mortality, a dichotomous variable for death is included in all the models. Table 1 presents descriptive statistics for the dependent and independent variables used in this analysis.

[Table 1 about here]

Two-level hierarchical models are employed to estimate age trajectories of BMI and gender variations in these trajectories. For the BMI of individual *i* at time *t*, the level-1 model estimates individual growth trajectories with age in the following form:

$$y_{it} = \beta_{0i} + \beta_{1i}Age_{it} + \beta_{2j}Age_{it}^2 + e_{it} \quad (1)$$

The quadratic rate of growth (β_{2i}) in captures potential curvilinear growth in BMI with age. The mean level (β_{0i}) of BMI is modeled as

$$\beta_{0i} = \gamma_{00} + \gamma_{01}Gender_i + \gamma_{02}X_i + \gamma_{03}Gender_i \cdot X_i + \gamma_{04}Z_i + u_{0i} \quad (2)$$

where X denotes the moderating variables of particular interests in this analysis, including SES, marital status, and urbanization, and Z denotes the control variables including smoking, drinking, and mortality. Within-individual correlations over time is captured by the random effects u_{0i}.

The linear rate of growth in BMI (β_{1i}) is modeled in a similar form

$$\beta_{1i} = \gamma_{10} + \gamma_{11}Gender_i + \gamma_{12}X_i + \gamma_{13}Gender_i \cdot X_i + \gamma_{14}Z_i + u_{1i} \quad (3)$$

where the heterogeneity in growth trajectories in BMI with age across individuals is captured by the random effects u_{1i}.

PRELIMINARY RESULTS

Figure 1 plots secular trend of the mean BMI and the associated 95% confidence interval for men and women separately. Both men and women experienced weight gain over the period 1991 to 2009. Women had a significantly higher average BMI compared to men between 1991 and 2000. However, men's BMI grew at a faster rate such that the gender difference was no longer significant by 2004 and continued to decline afterwards.

[Figure 1 about here]

In the preliminary analysis, we focused on the mean level and linear growth effects of all the independent variables. The only moderating effect on gender (i.e. interactions with gender) we have explored so far is cohort. Table 2 shows parameter estimates of two regression models as specified above. Model 1 includes only gender, age, cohort, and their interactions and controls for mortality. The average BMI among men was about 0.65 lower than that among women. Younger cohorts had a lower average BMI compared to older cohorts. The positive coefficient of the gender interaction with cohort indicates that the gap between men's and women's BMI grew larger in more recent cohorts. As for the linear growth rate, the positive coefficient of the intercept suggests an increase in BMI as people age. The linear growth rate coefficient is not significant for gender, but highly significant for cohort, indicating more rapid weight gain over the life course for more recent cohorts. The significant gender interaction with cohort in the linear growth rate implies more pronounced weight gain among males compared to females for more recent cohorts. The rate of increase in BMI tended to decline as indicated by the significant negative coefficient of the quadratic growth rate.

[Table 2 about here]

Model 2 added the variables of SES, marital status, and urbanization in the intercept and linear growth rate, and controlled for health behaviors in addition to mortality. The main change in Model 2 as compared to Model 1 is that the aging effect is no longer significant, whereas the gender effect in the linear growth rate is significant. To summarize the trajectories of the gender difference in BMI over age and across different cohorts, we plotted predicted values for three illustrative cohorts (1931-1940, 1951-1955, and 1971-1979) in Figure 2. Several findings are noteworthy. First, the average gender-specific BMI was larger for the 1951-1955 cohort than for the 1931-1940 cohort at early 50s, and much greater for the 1971-1979 cohort than for the 1951-1955 cohort at late 30s. This pattern is consistent with the emerging obesity epidemic in China found in previous secular trend analysis (Wang et al. 2007). Second, during young adulthood, men have a higher BMI compared to women, but in subsequent years, women gain weight faster than men closing this gap. As a result, the average BMI of women exceeded that of men around midlife. The gender difference in BMI continued to widen in late life. This growth pattern implies potentially elevated disease burdens attributed to obesity in women at the onset of middle age. Nevertheless, among the more recent cohort (1971-1979), the gender difference in the growth of BMI was fairly stable from early 20s to the early 40s, suggesting that the gender crossover in BMI at middle life may be delayed. This pattern could well reflect the increased awareness and practice of weight control among females in the younger generation.

[Figure 2 about here]

As for other predictors, education did not show a significant influence, but household per capita income was positively related to BMI. However, the coefficient of income in the linear growth rate was negative, indicating higher income individuals gain weight at a slower rate over the life course. Compared to manual labors, those who were unemployed or worked as professionals had a significantly greater BMI, although these differences did not change with age. Marriage was also positively associated with BMI and the relationship did not vary by age. The effect of urbanization is similar to that of income. Urbanization was positively associated with BMI, but those who lived in more urbanized areas experienced a slower weight gain over the life course. Finally, both smoking and mortality were negatively related to BMI, but no significant effect of drinking was found. The negative relationship between rate of weight gain and income and urbanization over the life course may suggest that the high SES people living in more developed communities are more likely to adopt health-conscious behavioral changes (Popkin, Siega-Riz, and Haines 1996) to reduce obesity-related diseases as they age.

NEXT STEP

Next, we will perform stepwise analysis of interaction effects with gender with respect to their main effects and linear growth rates. This will allow us to assess how socioeconomic, family, and community contexts help to reduce or exaggerate gender differences in BMI, and how these variations change over the life course, resulting in cumulative advantage or disadvantage as men and women age. This analysis will provide one of the first systematic examinations of gender differences in BMI across different life stages and birth cohorts during rapid socioeconomic and health transitions in a country in the midst of the nutrition transition.

Table 1.Descriptive Statistics of All Variables in the Analysis

	Whole Sample (N = 54748)		Rural (N = 36995)		Urban (N = 17753)	
	Mean	SD	Mean	SD	Mean	SD
Body Mass Index	22.75	3.26	22.50	3.16	23.25936	3.39
Age (years)	47.36	14.65	46.46	14.17	49.23444	15.43
Sex (male = 1, female = 0)	0.47	0.50	0.48	0.50	0.468034	0.50
Birth Cohort (0 to 6)	3.22	1.84	3.33	1.80	2.996733	1.92
Education						
No/Primary school (yes = 1, no = 0)	0.49	0.50	0.56	0.50	0.331324	0.47
Junior high school (yes = 1, no = 0)	0.30	0.46	0.31	0.46	0.277812	0.45
Senior high school or above (yes = 1, no = 0)	0.21	0.41	0.13	0.33	0.390864	0.49
Household per capita income (RMB inflated to 2009)	6194.40	8471.46	5555.54	7619.45	7525.69	9885.16
Currentally Married (yes = 1, no = 0)	0.85	0.35	0.87	0.34	0.830113	0.38
Smoking (ever smoked = 1, no = 0)	0.31	0.46	0.33	0.47	0.280798	0.45
Drinking (drank in last year = 1, no = 0)	0.35	0.48	0.35	0.48	0.355377	0.48
Died (died = 1, not died = 0)	0.06	0.23	0.06	0.24	0.052442	0.22
Urbanicity Index (0 to 100)	57.97	20.09	49.47	17.21	75.69967	12.75

Table 2. Growth Curve Models of Aging, Gender, and Cohort Effects on BMI in China

	Model 1			Model 2		
	Coef.	SE		Coef.	SE	
For Intercept						
Intercept	23.688	0.067	***	23.449	0.071	***
Male (ref=female)	-0.652	0.094	***	-0.657	0.095	***
Cohort	-0.203	0.017	***	-0.219	0.017	***
Education (ref=no/primary sch)						
Junior high				0.054	0.034	
Senior high				0.069	0.045	
Income (z-score)				0.072	0.014	***
Currenly married (ref=no)				0.286	0.033	***
Urbanicity (z-score)				0.233	0.017	***
Male x Cohort	0.172	0.024	***	0.201	0.024	***
For Linear Growth Rate						
Intercept	0.099	0.048	*	-0.019	0.058	
Male (ref=female)	-0.112	0.069		-0.187	0.070	*
Cohort	0.248	0.013	***	0.226	0.014	***
Education (ref=no/primary sch)						
Junior high				0.022	0.038	
Senior high				0.021	0.047	
Income (z-score)				-0.094	0.019	***
Currenly married (ref=no)				0.020	0.042	
Urbanicity (z-score)				-0.096	0.018	***
Male x Cohort	0.042	0.019	*	0.051	0.019	**
For Quadratic Growth Rate						
Intercept	-0.282	0.018	***	-0.180	0.022	***
Control Variables						
Smoking (ref = no)				-0.247	0.027	***
Drinking (ref = no)				0.027	0.021	
Died	-1.297	0.092	***	-1.120	0.091	***
Random-Effects Variance Components						
Level-1: within-person	1.260	0.005		1.262	0.005	
Level-2: Intercept	2.855	0.017		2.816	0.017	
Level-2: Linear growth rate	1.193	0.018		1.189	0.018	
Goodness-of-fit						
AIC	233166			232819		
BIC	233290			233050		

Note: ***P<.001; **p<.01; *p<.05; +p<.1

Figure 1. Secular Trend in Gender Gap in BMI

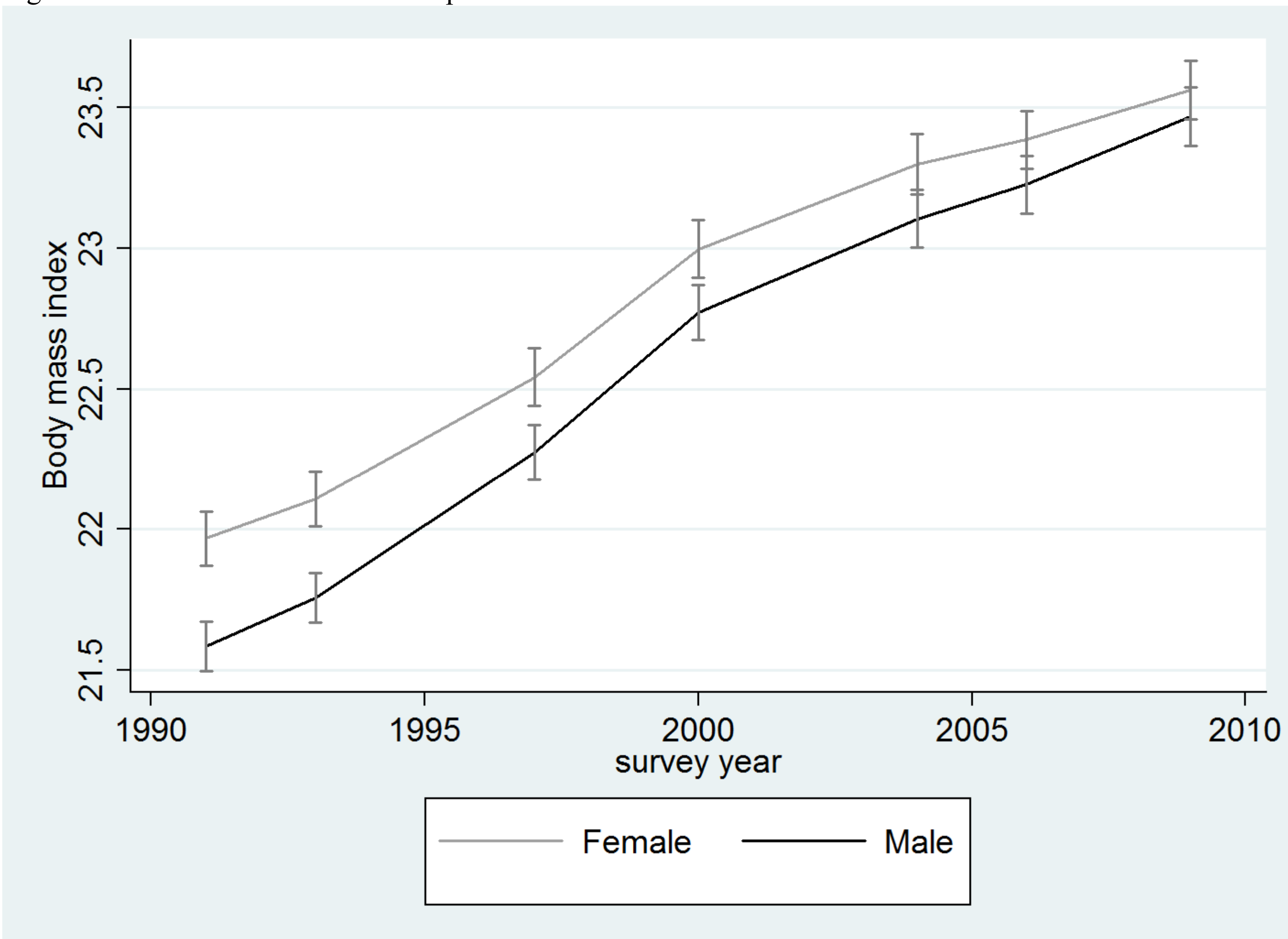
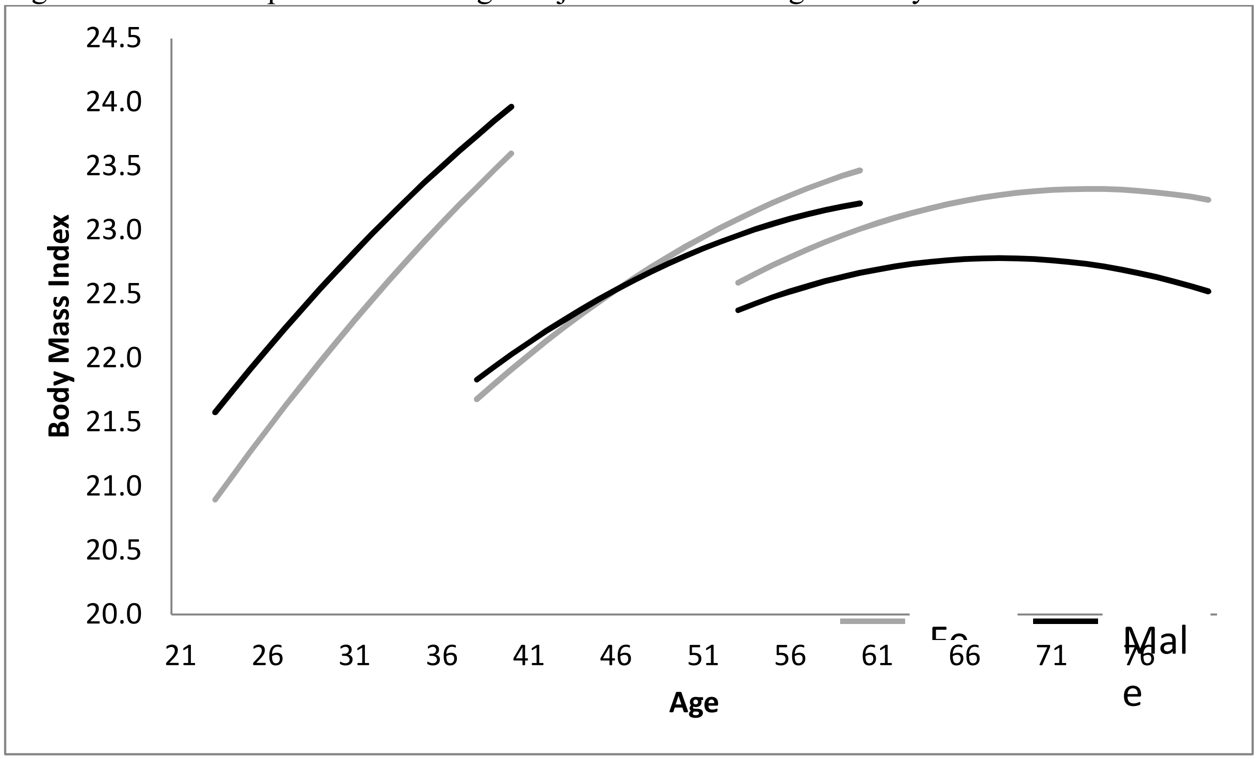


Figure 2. Gender Gap in Predicted Age Trajectories of Average BMI by Birth Cohort



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