# Health Assets in the Family and Maintaining Optimal Weight Across the Lifespan

# Health Assets in the Family and Maintaining Optimal Weight across the Lifespan

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## ABSTRACT

Family health research has been dominated by the deficit-based perspective, which focused on studying the detrimental effects of risky family environment. In comparison, the possible health benefits of positive family relationships remain less understood. To help address the knowledge gap, the present study took an asset-based perspective to investigate the association between parenting styles and offspring body weight, and the association between marital quality and adult body weight based on data from the Midlife in the United States Study. It also used data from the Nurses' Health Study II and the Growing Up Today Study to examine the association between maternal marital history and offspring body weight.

Study 1 found a protective effect of the authoritative parenting style on offspring weight gain in mid-life, compared to the authoritarian and the uninvolved style. The association was partly mediated by the elevated rate of depression in offspring of the authoritarian and uninvolved styles. There was also evidence that it was likely the interactive effects between parental warmth and parental control that matters for offspring body weight. Study 2 revealed that maternal marital stability was protective for offspring body weight. Moreover, the analyses on multiple facets of maternal marital history suggested that higher frequency of maternal marital transitions, longer duration of mother being unmarried, and occurrence of the first maternal marital transition in offspring's adolescence or young adulthood were each associated

with higher risk of offspring being overweight or obese. Contrary to our expectation that nurturing marital relationships may provide an exception to the general pattern that positive family relationships are protective for body weight, Study 3 showed that higher marital quality was associated with lower risk of incident obesity and less subsequent weight gain in mid-life. It also found an effect of marital support independent from marital strain.

In conclusion, this study added to the evidence that nurturing family relationships may be a health asset. It also highlighted the importance of taking a lifecourse perspective. This line of research may help identify and mobilize positive attributes within the family for promoting healthy states, and open new avenues for obesity prevention and control.

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## Introduction

The prevalence of obesity has increased substantially since 1990 in the U.S.[1] Obesity has been identified as a public health crisis,[2-4] and is linked to an increased risk of numerous chronic diseases.[5] In 2008, the annual medical cost related to obesity was estimated to be $147 billion.[6] Most research to date has focused on identifying risk factors for obesity, with the goal of developing interventions to ameliorate these risk factors. Established risk factors for obesity include family history[7] and sedentary lifestyles;[8,9] recent evidence has increasingly suggested that poor social relationships may also contribute to the obesity epidemic.[10,11] In comparison, what factors may be protective for maintaining optimal weight remains less understood.

Historically, public health research has focused on studying needs, problems and deficits – such as risky behaviors and illness. This problem-based deficit approach does not fully reflect the true meaning of health, and may communicate to the public a sense that deterioration is inevitable with age and that prevention science primarily revolves around delaying disease and disability and is less about promoting healthy states. In response, a strength-based asset approach has been introduced to help shift the paradigm from "what individuals need (deficits)" to "what individuals have (assets)". A health asset is defined as "the resources that individuals and communities have at their disposal, which protect against negative health outcomes and /or promote health status".[12] The asset-based approach is concerned with enhancing positive attributes or resources that promote achieving and maintaining healthy states. It acknowledges individuals as active agents and fully respects their potential for creating health rather than just staving off illness.[13-15] However, it is worth noticing that what is a health asset may not be uniform across health outcomes and social groups. A resource or attribute that promotes cardiovascular health for example, may have no effect or may even be detrimental in relation to

another health outcome (e.g., cancer) in the same population or in another population.[16,17] Therefore, health assets may need to be considered in relation to specific outcomes and for clearly specified social groups.

The family environment represents individuals' immediate social surroundings, and it is potentially a critical source of health assets.[18] However, the field of family health research has long been dominated by the deficit perspective, focused on health risks imposed by exposure to high levels of chaos and conflict and low levels of nurturing within the family environment. A more asset-based approach to the family environment was introduced recently to understand factors that characterize families that are stronger and more supportive, and to assess if these factors can protect health.[19] Evidence to date suggested that having a nurturing relationship with family members is generally protective for health.[20] Other research has further suggested that two relationships within the family in particular may have the strongest effects on lifelong health: the relationship with one's spouse/partner, and the relationship between parent and offspring.[21] Specifically, a positive relationship with one's spouse/partner has been observed with better health for both spouses;[22] moreover individuals who have a good relationship with their spouse/partner are also more likely to report successful parenting experiences and healthy offspring.[23] In addition, having a positive relationship with one's parents is associated with better psychosocial development in offspring and may serve as a resilience factor in the face of adversity.[24-26] Relative to detrimental effects of a risky family environment on health, significantly less work has considered possible health benefits of positive family relationships. Not only is research on whether and what aspects of family relationships are health protective much needed, but so too is any exploration of mechanisms that might account for these effects.[27]

To address some of the knowledge gaps, the overall objective of this proposed research is to investigate effects of nurturing family relationships - particularly positive relationships with spouse/partner and positive parenting styles - on body weight. Specifically, Study 1 aims to examine the association between parenting styles and offspring's body weight. Prior research has primarily focused on evaluating effects of parenting styles on offspring's body weight in childhood and adolescence. Existing evidence generally suggests that the authoritative style may be associated with greater likelihood that offspring will maintain healthier body weight during childhood and adolescence, compared to other parenting styles.[28] However, whether the protective effect of the authoritative style on offspring's body weight extends beyond adolescence has seldom been examined. In addition, little prior work has examined potential pathways through which parenting styles may affect offspring body weight, although particular parenting styles have been linked to a number of identified risk factors for obesity such as depression[29-31], poor social integration[40,41] and low educational attainment [32,33]. This study investigates the effects of parenting styles on offspring's body weight in mid to late adulthood, and examines three potential mediators of the relationship including depression, social support and educational attainment of the offspring, based on data from the Midlife in the United States Study.

Study 2 aims to examine the association between maternal marital history and offspring risk of overweight or obesity. Evidence to date has linked parents' marital history to a number of offspring health outcomes that are closely related to body weight such as diabetes and heart diseases.[34] The findings generally suggest that parents' marital stability (i.e., being consistently married) was protective,[34] and specific dimensions of marital history such as the frequency and timing of marital transitions might exert different effects through different mechanisms.

However, much of the prior work has been cross-sectional, investigating the association between parents' current marital status and offspring health. Assessing marital status at a single point in time may not capture the cumulative effects of marital experiences throughout the life course,[35] and similarly it may be parent's marital history over time that matters for offspring health.[36,37] However, to our knowledge no study has ever examined whether or how parents' marital history might be associated with offspring's body weight over time. To help fill in the knowledge gaps, this study uses data from the Nurses' Health Study II (NHSII) and the Growing Up Today Study (GUTS) to investigate the longitudinal association between maternal marital history and offspring's risk of overweight or obesity across adolescence and young adulthood, and examine the effects of specific dimensions of maternal marital trajectory including the frequency of marital transitions, duration of being unmarried, and timing of the first marital transition.

Study 3 aims to examine the association between marital quality and body weight in mid-life. Evidence to date suggests that the effect of being married on body weight may provide an exception to the general pattern of findings that being married is a health asset. Specifically, prior work has found that entering marriage is associated with subsequent weight gain whereas marital dissolution is often associated with subsequent weight loss.[38] Recent research has increasingly suggested that having a high quality marital relationship rather than the mere presence of a spouse or partner is the essential ingredient providing health benefits.[39] However, few studies have gone beyond studying marital status to examine effects of marital quality on body weight. To help address the knowledge gaps, this study examines the association between marital quality and body weight in mid-life, based on data from the Midlife in the United States Study. It also differentiates effects of positive and negative components of marital quality

including marital support and marital strain. In addition, it investigates whether the potential association may be modified by gender.

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## STUDY 1. Parenting Styles and Offspring Body Weight

**Title:** Does optimal parenting style help offspring maintain healthy weight in mid-life?

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## Abstract

The authoritative parenting style was associated with healthier offspring body weight in children and adolescents, compared to other parenting styles. However, whether this protective effect of the authoritative style extends beyond adolescence was seldom investigated. Moreover, the potential pathways underlying the association remain largely unknown.

This study investigated effects of parenting styles on offspring's change in body mass index (BMI) in mid-life, based on data from the Midlife in the United States Study. It also examined three potential mediators of the relationship including depression, social support and educational attainment of the offspring. In addition, this study also evaluated models that considered the separate effects of parental warmth and parental control, and then also a model that included them simultaneously along with an interaction term.

Compared to the authoritative style, the authoritarian style was associated with greater offspring BMI increase (β=0.43, 95% CI: 0.06, 0.80 in the fully-adjusted model). The uninvolved style was also associated with higher offspring BMI increase compared to the authoritative style in the minimally-adjusted model (β=0.31, 95% CI: 0.01, 0.61). The association was still evident albeit somewhat attenuated in the fully-adjusted model (β=0.27, 95% CI: -0.04, 0.58). However, the difference between the permissive versus authoritative style was not statistically significant. The individual parenting dimensions of parental warmth, parental control or the interaction term between them were not associated with offspring's change in BMI. However, the stratified analyses suggested that high parental warmth was associated with lower offspring BMI increase when parental control was high (β=-0.44, 95% CI: -0.82, -0.06), whereas no significant associations were evident when parental control was low.

The mediation analyses suggested that the higher offspring BMI increase associated with the authoritarian and uninvolved styles was partly explained by the elevated rate of depression in offspring of these parenting styles.

In conclusion, this study demonstrated a protective effect of the authoritative style on offspring's BMI change in mid-life, compared to the authoritarian and the uninvolved styles. It helped with our understanding of the possible pathways underlying the association, and added to the evidence that early life family environment may exert effects on offspring's life-long health.

**Introduction**

The prevalence of obesity has increased substantially over the past three decades in the U.S..[1] Over 30% of children and adolescents and 68% of adults in the US were overweight or obese in 2012.[2] Obesity has been identified as a public health crisis,[3-5] portending a substantial increase in the burden of chronic diseases into the future.[6] Previous research has sought to identify risk factors of obesity such as genetic predisposition,[7,8] unhealthy lifestyles,[9-11] depression,[12] low socioeconomic status (SES)[1] and poor social relationships.[13,14] However, as evidenced by ongoing high rates of obesity, a deficit-oriented approach focused exclusively on identifying risk factors for obesity may not be sufficient for controlling the epidemic. As a result, an asset-based approach focusing on positive attributes and resources to promote healthy states has been proposed.[13-15] This asset perspective may help open new avenues of addressing the obesity epidemic, through improving understanding of protective factors that promote the maintenance of optimal weight.

A health asset is defined as "…a resource that individuals and communities have at their disposal, which protects against negative health outcomes and/or promotes health status".[16] Family environment represents an individual's immediate social surroundings and is potentially a critical source of health assets. Prior evidence has suggested that nurturing relationships within the family are protective for general health.[17,18] In particular, a number of studies have demonstrated positive parenting behaviors are associated with more optimal outcomes in offspring such as better psychosocial development in early life and healthier metabolic profiles in adulthood.[19-21]

The most extensively examined dimensions of parenting behaviors are parental warmth and control. Specifically, parental warmth is defined as support, care, and comfort that parents

express towards offspring.[22] Parental control refers to the demands and rules that parents use to discourage misbehaviors or gain compliance from offspring.[22,23] The concept of *parenting style* refers more specifically to the quality of parenting, and is defined as "a constellation of attitudes toward offspring that creates the emotional climate in which parents' behaviors are expressed".[23] Based on the levels of parental warmth and control, Maccoby and Martin[24] identified four major parenting styles adapted from typologies originally proposed by Baumrind,[25,26] which were the authoritative (high in both warmth and control), authoritarian (low in warmth and high in control), permissive (high in warmth and low in control) and uninvolved styles (low in both warmth and control). Existing evidence generally suggests that an authoritative parenting style may serve as a health asset, as it has often been observed with better outcomes in offspring such as higher academic and psychosocial competencies, compared to other parenting styles.[23] In comparison, children raised by authoritarian parents are more likely to show high levels of depressive symptoms and poor peer acceptance;[23,27] those growing up in permissive families often lack self-control,[23] while children raised with an uninvolved parenting style more often exhibit low academic achievement.[23] However, work linking parenting style to offspring physical health outcomes over the life course is still limited.

Recent research has begun to consider parenting styles in relation to childhood obesity, and has suggested that compared to the authoritarian and uninvolved style, the authoritative style may be associated with greater likelihood that offspring will maintain healthier body weight and gain less weight during childhood and adolescence. Inconsistent effects of the permissive style have been demonstrated. For instance, one study of 2,516 U.S. adolescents from diverse socioeconomic backgrounds found that young adolescent boys and girls raised by authoritative parents had lower risk of unhealthy body weight 5 years later compared to adolescents of

authoritarian and uninvolved parents, but no differences with children of permissive parents were evident.[28] In contrast, a prospective study of 872 first-grade children showed that compared to children of authoritative mothers, those raised by authoritarian mothers had a four-fold higher risk of becoming overweight, while those of permissive and uninvolved mothers were twice as likely to become overweight in two years.[29]

A limited number of studies have explored whether the possible protective effects of the authoritative parenting style on maintaining healthy body weight persist beyond adolescence. However, existing evidence also suggests a lingering beneficial influence on body weight and weight change into young adulthood. For example, one longitudinal study based on data from the U.S. National Longitudinal Study of Adolescent Health found that offspring of authoritative parents had a lower increase in body mass index (BMI) during the transition from adolescence to young adulthood, compared to offspring of authoritarian and uninvolved parents.[30] Another prospective study using data from the 1958 British Birth Cohort found that experiences of strict upbringing, parental neglect and abuse in childhood were associated with higher offspring BMI in mid-life, although the effects of parental warmth and the overall parenting style were not directly investigated.[31] To our knowledge, no research to date has examined whether the protective effect of authoritative parenting style on offspring's body weight or weight change extends into middle adulthood or beyond.

The majority of prior studies on parenting styles and offspring body weight adjusted only for a handful of childhood familial factors as potential confounders, although a number of additional family environment factors have been documented as risk factors for obesity among children and adolescents. The most extensively studied familial factors related both to parenting style and to offspring body weight include parental SES, family welfare receipt, and family

structure (defined as intact versus single-parent family) during childhood. However, existing evidence generally suggests that taking account of parental education, family income, father's occupation, family welfare status or family structure did not substantially attenuate the protective effects of the authoritative versus non-authoritative style on offspring body weight.[29-31] In comparison, evidence on possible confounding effects of other childhood familial factors remains limited. For example, although parental abuse and parental substance abuse have been observed with both less effective parenting and higher risk of obesity in children and adult offspring,[32-34] whether they may account for the association between parenting style and offspring body weight remains unknown. Similarly, residential mobility and family religiousness in childhood were found to be associated with parent-child relationship, offspring diet, physical activity, and general health.[35-37] However, existing research on parenting styles and offspring body weight has rarely taken family religion or residential characteristics into account. Taken together, the interplay between the broader family environment, parenting style and offspring body weight remains poorly understood.

Moreover, little prior work has examined potential pathways through which parenting styles may affect offspring body weight. Prior evidence has suggested associations between parenting styles and a number of identified risk factors for obesity such as depression,[23,25,38] anxiety,[39] poor social integration,[40,41] low educational attainment,[42,43] emotional eating[44] and sedentary life styles,[45] with evidence most consistent for depression, social integration and educational attainment as pathways. Specifically, the authoritative parenting style has often been observed with fewer depressive symptoms in offspring during adolescence and adulthood, compared to the authoritarian and uninvolved styles. Authoritative parenting style has also been found to be associated with higher social integration in offspring such as greater peer acceptance

and more effective communication, compared to other parenting styles.[46-48] The authoritative parenting style has also consistently been linked with higher educational achievement in youth compared to the uninvolved style in particular.[42,43,49] Meanwhile, fewer depressive symptoms, greater social support and higher educational attainment have consistently been found to be associated with lower risk of obesity in prior work.[25,27,40,40-43] Taken together, existing evidence suggests that depression, social support and educational attainment may lie on the pathway between parenting style and offspring body weight, but to our knowledge no study has yet directly tested if they may serve as mediators.

To address these knowledge gaps, this study aimed to investigate effects of parenting styles on offspring's body weight in mid to late adulthood adjusting for other childhood family environment factors, and examining three potential mediators of the relationship including depression, social support and educational attainment of the offspring. We hypothesized that the authoritative parenting style would be associated with lower BMI increase in offspring compared to other parenting style. We considered effects of parenting style accounting for not only potential confounders that have commonly been considered in prior work in this area (e.g., offspring childhood SES and family structure), but also those that other research has suggested may be relevant but are less commonly considered (e.g. childhood residential stability and family religiousness). We further hypothesized that the elevated BMI increase associated with the non-authoritative styles may be at least partly explained by offspring of these parenting styles experiencing more depressive symptoms, less social support and lower educational attainment.

In addition, to assess whether any observed effects of parenting style are primarily due to a single parenting dimension, we also evaluated models that each considered the separate effects of parental warmth and parental control, and then also a model that included them

simultaneously along with the interaction between them. We hypothesized that the dimensions of low parental warmth and high control may each be associated with higher BMI increase in offspring, and that there may be interactive effects between parental warmth and control. We posited that low parental warmth will be associated with particularly high increase in offspring BMI when parental control is high.

## Methods

### Sample and Study Design

The present study used existing data from the Midlife in the United States (MIDUS) study. The MIDUS study was initiated between 1994 and 1995 to investigate the interrelations between psychosocial factors, behaviors, health and well-being in mid-life. At the first wave (MIDUS I), 7,108 non-institutionalized individuals aged between 25 to 74 years were enrolled through random digit dialing from 48 states of the US. Participants included 950 siblings and 957 pairs of twins.[50] A second wave of the study (MIDUS II) took place in 2004-2005, which followed up around 70% (N=4,963) of the original participants and newly recruited a sample of 592 African Americans from Milwaukee.[51] A subgroup of the respondents (N=1,255) who completed the MIDUS II psychosocial survey and were healthy enough to travel participated in a biomarker project. Participants of the biomarker project did not differ from those who did not participate in sex, age, race, marital status, income or biomedical conditions, but were more highly educated.[52]

Participants recalled their parents' parenting styles during childhood at the MIDUS I psychosocial assessment. At this time respondents also self-reported depressive symptoms, social

support and educational attainment. Measures of body weight were obtained via self-report at both MIDUS I and MIDUS II.

The analytic sample for the present study were drawn from respondents who participated in both waves of the MIDUS study (N=4963). Among the initial sample, 308 respondents who were missing data on parents' parenting style were first excluded. Next, 1,036 participants with missing information on either MIDUS I or MIDUS II BMI were excluded. Another 236 participants with missing values on covariates or hypothesized mediators were further excluded, which yielded the final analytic sample of 3,383 participants with 984 of these either siblings or twins. Compared to participants excluded from the analytic sample, those who were included were more likely to gain weight during follow-up, and tended to be older, white, highly educated, report more social support, and were less likely to be on welfare in childhood, from non-intact families, experience residential instability or have alcoholics residing in home during childhood (Table S1.1). The study was approved by Institutional Review Boards at participating institutions, and all participants provided written informed consent.

**Measures**

Exposures

*Parental warmth.* Following prior work,[38] parental warmth was assessed with a six-item Parental Support Scale[53] administered at MIDUS I, referring to experiences of parental warmth during the years of growing up. Maternal and paternal warmth were queried separately, with items such as: "How much did your mother/father understand your problems and worries?" Response options ranged from 1 (a lot) to 4 (not at all). Responses were reverse coded so that a higher score represents higher level of warmth. Maternal and paternal warmth scores were

calculated for participants with valid data on at least half of the scale items, and were created separately by averaging responses across items of the maternal and paternal warmth subscales. An overall parental warmth score was calculated as the average of maternal and paternal warmth scores.[38,49,54] The internal consistency reliability of the maternal warmth subscale (α = .89), the paternal warmth subscale (α = .91), and the overall parental warmth scale were high (α = .91).

*Parental control*. Following prior work,[38] experience of parental control during the years of growing up was assessed with a three-item Parental Control Scale[53] administered at MIDUS I. Maternal and paternal control were queried separately, with items such as: "How much did your mother/father stop you from doing things that other kids of your age were allowed to do?". Response options ranged from 1 (a lot) to 4 (not at all). Responses were reverse coded so that a higher score represents higher level of control. Maternal and paternal control scores were calculated for participants with valid data on at least half of the scale items, and were created separately by averaging responses across items of the maternal and paternal control subscales. An overall parental control score was calculated as the average of maternal and paternal control scores.[33,54] The internal consistency reliability of the maternal control subscale (α = .74), the paternal control subscale (α = .74), and the overall parental control scale were good (α = .79).

*Parenting style*. Four parenting style categories were created based on distinct constellations of parental warmth and control following prior work in this area.[24] Tertiles for the parental warmth and control scales were created separately according to the distribution in the sample. The top tertile on each scale was used as the cutoff to define high versus lower levels of parental warmth and control. Specifically, the authoritative style included participants with scores in the top tertile of both warmth and control (13.71%); the authoritarian style included respondents with scores in the bottom and middle tertiles of warmth but in the top tertile of

control (18.00%); the permissive style included those with scores in the top tertile of warmth but in the bottom and middle tertiles of control (18.14%); and the uninvolved style included those with scores in the bottom and middle tertiles of both warmth and control (50.15%) (Figure S1.1). Given the generally high levels of parental warmth (mean=2.97) and parental control (mean=2.99) reported in this sample, we used the top tertile split on each scale as the cutoff so as to capture distinctively high levels of warmth and control. Although there was no standard cutoff available on each scale to define high versus low levels of warmth and control, the median split was most often used in prior studies.[38] Compared to existing studies which used the median split, there was a smaller proportion of participants categorized as having authoritative parents and a larger percentage as having uninvolved parents in our study.

For sensitivity analyses, we also followed another categorization approach from prior child development literature[38] to create more distinct parenting styles, which were based on both the top and the bottom tertile splits of parental warmth and control. Specifically, the top tertile on each scale was considered as high levels of parental warmth and control, the bottom tertile was considered as low levels of warmth and control, whereas participants falling into the middle tertile of parental warmth or control were excluded from further analyses. This yielded an analytic sample of 1440 participants. In this approach, the authoritative parenting style included participants with scores in the top tertile of both warm and control (32.08%); the authoritarian style included respondents with scores in the bottom tertile of warmth but in the top tertile of control (16.94%); the permissive style included those with scores in the top tertile of warmth but in the bottom tertile of control (14.65%); and the uninvolved style included those with scores in the bottom tertile of both warmth and control (36.32%).

Outcomes

*Body weight measures*. At both waves participants self-reported their current height (in inches) and weight (in pounds), used to calculate body mass index (BMI, $kg/m^2$). As the biomarker project participants (N=1255) received a physical exam, their self-reported BMI was compared with the measured BMI, and demonstrated good concordance (r=0.92). BMI was winsorized at the 1st and 99th percentiles to minimize possible influence of extreme outliers. BMI $\geq 30$ $kg/m^2$ is defined as obese, and BMI $< 30$ $kg/m^2$ is defined as non-obese.[55] Change in BMI between waves was calculated by subtracting BMI at wave I from BMI at wave II and was considered as a continuous score (mean=1.27 $kg/m^2$, SD=3.08).

Potential mediators

*Major depression.* Past-year major depression was assessed with the 19-item Composite International Diagnostic Interview Short Form (CIDI-SF)[56,57] administered at MIDUS II. The diagnosis of major depression was based on criteria specified in DSM-III-R, which requires report of either depressed affect or anhedonia at least most of the day, nearly every day for two weeks, and the presence of four or more accompanying symptoms (including loss of interests, fatigue, changes in appetite, sleeping problems, trouble concentrating, low self-esteem, and suicidal ideation). Prior work has demonstrated high test-retest reliability and clinical validity of CIDI-S.[58,59]

*Social support*. Perceived emotional support from spouse/partner (if applicable), friends and families (other than spouse/partners) were queried separately at MIDUS I with a four-item Supportive Interaction Scale.[60,61] Two additional items[60,61] were also used to measure support from spouse/partner, including "how much does he or she appreciate you?" and "how much can you relax and be yourself around him or her?". Response options ranged from 1 (a lot) to 4 (not

at all). Responses were reverse coded so that a higher score represents more support. Support from each source was calculated for participants with valid data on at least half of the subscale items. Following prior work,[62] responses on support from all sources (spouse/partner, friends, and families) were averaged to create an overall score of social support, ranging from 1 to 4. The internal consistency reliability of each subscale and the overall social support scale was high: $\alpha$ = .91 (support from spouse/partner), 0.88 (support from friends), 0.83 (support from families), and 0.86 (the overall social support).

*Educational attainment*. Respondent's highest grade of school or year of college completed was queried at MIDUS I, and response options ranged from 1 (no school/some grade school) to 12 (completion of a professional degree). Following prior work,[20] educational attainment was grouped into four categories: less than high school, high school graduate, some college, and college or more.

Covariates

*Socio-demographic characteristics.* Participants self-reported their age, sex (male, female), race (white, black, other races) at MIDUS I. Respondents' childhood socioeconomic status (SES) was assessed using two measures (included in models as separate variables): the highest education level attained by parents and family welfare status in childhood. Specifically, participants self-reported their mother and father's educational attainment at MIDUS I. Following prior work,[20] parents' highest education level was defined as the education level of the most highly educated parent, and grouped into four categories: less than high school, high school, some college and college or more. In addition, participants were asked whether their family was ever on welfare for at least six months during childhood and adolescence (yes/no).

*Severe physical abuse by parents in childhood*. Severe physical abuse by mother and father in childhood were queried separately at MIDUS I with items from the Conflict Tactics Inventory[63]: "During your childhood, how often did your mother/father kick, bit, or hit you with a fist or an object, beat you up, choked, burned or scalded you", with response options ranging from 1 (often) to 4 (never). Responses on abuse by mother and father were reverse coded so that a higher score represents higher level of abuse, and abuse levels across mother and father were averaged to create an overall score.[64]

*Other childhood family environment factors.* Childhood family structure was assessed with a single question at MIDUS I: "Did you live with both biological parents up until you were 16?". Participants who responded affirmatively were considered as coming from intact families. Participants' residential stability at early life was queried at MIDUS I: "How many times during your childhood did you move to a totally new neighborhood or town?", with responses ranging from 0 to 60 times (mean=1.84, SD=2.86). Following prior work,[65] participants who reported less than 3 residential moves were considered as having residential stability in childhood. Whether participants lived with alcoholics in early life was measured with a single questionnaire item at MIDUS II: "When you were growing up, did you live with anyone who was a problem drinker or alcoholic?" (yes/no). Family religiousness during childhood was assessed at MIDUSI with a single question: "How important was religion in your home when you were growing up?", with response options ranged from 1: very important to 4: not at all important. Respondents who reported the highest level of importance (i.e., "1: very important") were considered as having family religiousness in childhood.

**Statistical Analyses**

All statistical analyses were performed in SAS 9.3. Inverse probability weighting was used in all models to account for attrition at MIDUS II. The inverse probability weights (IPWs) were calculated based on covariates available to predict attrition including participants' sex, age, race, educational attainment, history of chronic conditions, depression and parents' parenting styles. Chi-square tests and analysis of variance tests were used to examine distribution of participants' characteristics by parenting styles in childhood.

To test whether parenting styles were associated with offspring's change in BMI during mid-life adjusting for covariates, generalized estimating equations (GEE) were used to model participants' change in BMI between waves as the dependent variable with parenting styles in childhood as the independent variable, while adjusting for potential clustering by family. A series of these GEE models were used to investigate the effect of confounders. First, the base model adjusted for demographic factors including participants' age, sex, and race. In a second model, respondents' childhood SES was taken into account by adding parents' highest education level and participants' family welfare status in childhood to the base model. To examine if the absence of parental abuse is a confounder, a third model additionally adjusted for severe physical abuse by parents in childhood. A fourth and fully adjusted model further controlled for other childhood family environment factors that might confound the association of interest (or serve as a prior cause of parenting style) including family structure, residential stability, living with an alcoholic, and family religiousness during childhood. Sensitivity analyses reanalyzed the primary sets of models using the more distinct parenting styles which were created based on both the top and bottom tertile splits of parental warmth and control as the independent variable.

Secondary analyses examined the effect of individual parenting dimensions. Parental warmth and control were first entered as the independent variable in separate models, adjusting

for demographics, childhood SES, childhood physical abuse by parents and other childhood familial environment factors. Then, the fully-adjusted model was reanalyzed with parental warmth, parental control, and an interaction term between warmth and control included simultaneously in the model.

Next, we examined whether an association between parenting styles and offspring's change in BMI were accounted for by our hypothesized mediators. Specifically, the model adjusted for demographics, childhood SES, childhood physical abuse by parents and other childhood family environment factors was considered as the base model. A series of GEE models were first used to examine whether parenting styles was associated with each of the hypothesized mediators and then whether the mediators would predict change in BMI. Next, we entered the hypothesized mediators to the base model both separately and simultaneously to examine the attenuation in effect estimates of parenting styles. The proportion of the association explained by each mediator was calculated as: 100*[1- (exposure coefficient estimate with intermediary/exposure coefficient estimate without intermediary)].[66]

## Results

*Descriptive Analyses*

Participants were predominantly white (94.41%) and slightly higher percentage female (51.42%), with the mean age of 46.96 years (SD=12.29) at MIDUS I. The prevalence of obesity increased from 20.20% to 28.06% across the two waves, and the mean increase in BMI was 1.27 (SD=3.08) $kg/m^2$ (Table S1.1). In bivariate analyses, participants who were older, male, Black, not on welfare in childhood, from intact families, experienced little parental physical abuse,

reported childhood residential stability, had no alcoholics residing in home at early life, grew up in religious families, reported no major depression and had high social support were generally more likely to recall being raised by authoritative or permissive parents ($p<0.05$, Table 1.1).

**Table 1.1 Distribution of participant characteristics according to parenting styles in childhood (N=3382)**

| Characteristic | | Parenting styles in childhood | | | | *p* |
|---|---|---|---|---|---|---|
| | | Authoritative *n* = 462 | Authoritarian *n* = 610 | Permissive n =617 | Uninvolved *n* = 1693 | |
| *Body weight* | | | | | | |
| **BMI at baseline** | Mean (SD) | 26.58 | 26.76 | 26.28 | 26.44 | 0.34 |
| **BMI at follow-up** | Mean (SD) | 27.63 | 28.25 | 27.37 | 27.77 | 0.04 |
| *Socio-demographic characteristics* | | | | | | |
| **Age at baseline, years** | Mean (SD) | 47.18 (12.76) | 46.46 (11.63) | 48.24 (13.65) | 46.61 (11.84) | 0.03 |
| **Sex** | | | | | | 0.005 |
| Male | % | 14.47 | 15.50 | 18.35 | 51.68 | |
| Female | % | 12.98 | 20.17 | 18.16 | 48.69 | |
| **Race** | | | | | | 0.02 |
| White | % | 13.31 | 17.76 | 18.23 | 50.70 | |
| Black | % | 22.55 | 23.53 | 19.61 | 34.31 | |
| Others | % | 16.09 | 21.84 | 17.24 | 44.83 | |
| **Highest parental education** | | | | | | 0.07 |
| Less than high school | % | 14.32 | 20.05 | 15.87 | 49.76 | |
| High school degree | % | 12.51 | 18.06 | 18.64 | 50.79 | |
| Some college | % | 17.31 | 16.57 | 18.23 | 47.88 | |
| 4-year college degree or higher | % | 12.22 | 16.88 | 20.15 | 50.76 | |
| **Family ever on welfare in childhood** | | | | | | <0.001 |
| Yes | % | 8.62 | 18.39 | 5.17 | 67.82 | |
| No | % | 13.93 | 18.02 | 18.95 | 49.10 | |
| *Severe physical abuse by parents* | Mean (SD) | 1.11 (0.34) | 1.45 (0.72) | 1.07 (0.25) | 1.27 (0.55) | <0.001 |
| *Other childhood family environment factors* | | | | | | |
| **Intact family structure in childhood** | | | | | | 0.004 |

**Table 1.1 (Continued)**

| | | | | | | |
|---|---|---|---|---|---|---|
| Yes | % | 14.31 | 18.30 | 18.73 | 48.67 | |
| No | % | 10.67 | 16.83 | 16.00 | 56.50 | |
| **Residential stability in childhood** | | | | | | 0.0006 |
| Yes | % | 14.68 | 17.43 | 19.08 | 48.80 | |
| No | % | 10.54 | 19.88 | 15.69 | 53.89 | |
| **Alcoholics in family in childhood** | | | | | | <0.001 |
| Yes | % | 6.40 | 15.44 | 12.17 | 65.99 | |
| No | % | 15.36 | 18.64 | 19.66 | 46.33 | |
| **Family was religious in childhood** | | | | | | <0.001 |
| Yes | % | 20.16 | 20.56 | 20.83 | 38.45 | |
| No | % | 8.49 | 16.03 | 16.19 | 59.29 | |
| *Hypothesized mediators* | | | | | | |
| **Major depression** | | | | | | <0.001 |
| Yes | % | 7.65 | 24.69 | 10.86 | 56.79 | |
| No | % | 14.48 | 17.13 | 19.25 | 49.14 | |
| **Social support score** | Mean (SD) | 3.62 (0.38) | 3.35 (0.47) | 3.59 (0.35) | 3.34 (0.46) | <0.001 |
| **Educational attainment** | | | | | | 0.24 |
| Less than high school | % | 14.04 | 21.91 | 14.61 | 49.44 | |
| High school degree | % | 13.80 | 19.21 | 18.87 | 48.12 | |
| Some college | % | 14.67 | 17.89 | 16.18 | 51.26 | |
| 4-year college degree or higher | % | 12.74 | 16.81 | 19.88 | 50.58 | |

Note: Percentages refer to the proportion of individuals within each parenting style category with that characteristic. *p* comes from $\chi^2$ or analysis of variance tests.

*Parenting styles and offspring change in BMI during mid-life*

Compared to the authoritative style, the authoritarian style was associated with greater increase in offspring BMI over the 9-year follow-up, controlling for participants' age, sex and race (β=0.45, 95% CI: 0.08, 0.82) (Table 1.2, model 1) (The observed BMI increase of 0.45 $kg/m^2$ on average would translate to an excess weight gain of 2.3 pounds for a participant who is 5-feet tall). The association remained robust after further adjustment for childhood SES, physical abuse by parents, and other childhood family environment factors (β=0.43, 95% CI: 0.06, 0.80) (Table 1.2, models 2-4). Moreover, uninvolved parenting style was also associated with higher BMI increase in offspring compared to the authoritative style, adjusting for participants' age, sex and race (β=0.31, 95% CI: 0.01, 0.61) (Table 1.2, model 1). The association was still evident albeit somewhat attenuated after additional adjustment for childhood SES, physical abuse by parents and other childhood family environment factors (β=0.27, 95% CI: -0.04, 0.58) (Table 1.2, models 2-4). However, the associations of permissive versus authoritative style on BMI change in offspring did not differ significantly. Sensitivity analyses with the more distinct parenting styles as the independent variable produced similar results. Specifically, compared to the authoritative style, the authoritarian and the uninvolved style were both associated with greater increase in BMI adjusting for age, sex and race (β=0.52, 95% CI: -0.01, 1.05 for the authoritarian style, β=0.47, 95% CI: 0.09, 0.84 for the uninvolved style). However, the associations were attenuated in the fully adjusted model (β=0.42, 95% CI: -0.13, 0.96 for the authoritarian style, β=0.29, 95% CI: -0.13, 0.71 for the uninvolved style). There was still no evident difference in the effect of the permissive versus authoritative style on offspring BMI change (data not shown).

**Table 1.2 Parenting styles in childhood and the change in BMI over the follow-up in offspring during mid-life (N = 3382)**

| | Model 1 : Base model [a] | Model 2: model 1 + Childhood SES | Model 3: model 2 + childhood physical abuse by parents | Model 4: model 3 + childhood family environment |
|---|---|---|---|---|
| | β (95% CI) | β (95% CI) | β (95% CI) | β (95% CI) |
| **Parenting styles** | | | | |
| Authoritative style (ref) | | | | |
| Authoritarian style | 0.45 (0.08, 0.82)* | 0.44 (0.07, 0.81)* | 0.44 (0.07, 0.81)* | 0.43 (0.06, 0.80)* |
| Permissive style | 0.18 (-0.18, 0.54) | 0.20 (-0.16, 0.56) | 0.20 (-0.16, 0.56) | 0.19 (-0.17, 0.55) |
| Uninvolved style | 0.31 (0.01, 0.61)* | 0.30 (0.01, 0.60)* | 0.30 (0.01, 0.60)* | 0.27 (-0.04, 0.58)~ |
| **Highest parental education** | | | | |
| Less than high school (ref) | | | | |
| High school | | 0.07 (-0.24, 0.37) | 0.07 (-0.23, 0.38) | 0.07 (-0.24, 0.37) |
| Some college | | 0.004 (-0.34, 0.35) | 0.01 (-0.33, 0.36) | 0.01 (-0.33, 0.36) |
| College or more | | -0.37 (-0.70, -0.04)* | -0.35 (-0.68, -0.02)* | -0.34 (-0.68, -0.01)* |
| **Family not on welfare in childhood** | | -0.35 (-0.85, 0.16) | -0.31(-0.82, 0.20) | -0.24 (-0.75, 0.27) |
| **Physical abuse by parents (residual)** [b] | | | 0.14 (-0.08, 0.37) | 0.12 (-0.10, 0.35) |
| **Intact family structure in childhood** | | | | -0.02 (-0.32, 0.28) |
| **Childhood residential stability** | | | | -0.04 (-0.29, 0.21) |
| **No alcoholics in family in childhood** | | | | -0.29 (-0.57, -0.01)* |
| **Childhood family religiousness** | | | | 0.05 (-0.17, 0.27) |

Note: Generalized estimating equations with normal distribution and identity link were used in all models to estimate the mean change in offspring BMI over the follow-up, adjusting for clustering by family. Inverse probability weighting was used in all models to account for loss to follow up.

[a] The base model adjusted for participants' age, gender and race.

[b] Since parental abuse was correlated with parenting styles, the residual of severe physical abuse by parents not accounted for by parenting styles was calculated and was adjusted as a covariate in the model.

$\sim p \leq .10$, $^{*} p \leq .05$, $^{**} p \leq .01$, $^{***} p \leq .001$

To assess whether the primary finding is that authoritative styles are more health beneficial relative to all other styles versus only relative to an authoritarian style, we dichotomized parenting styles into authoritative versus all other non-authoritative styles. Compared to the non-authoritative styles, the authoritative style was associated with lower BMI increase in offspring (β=-0.31, 95% CI: -0.59, -0.03 minimally-adjusted; β=-0.29, 95% CI: -0.58, 0.004 fully-adjusted), suggesting that the authoritative style might be health beneficial relative to other parenting styles beyond simply the authoritarian style.

*Parenting dimensions and offspring change in BMI during mid-life*

When considered separately, the individual dimensions of parenting were not associated with offspring's change in BMI later in life. Specifically, neither parental warmth nor parental control was associated with offspring's change in BMI in the fully-adjusted model, when they were entered as the independent variable in separate models (data not shown). Similarly, when parental warmth, parental control and an interaction term were included simultaneously in the fully-adjusted model, there were no association between parental warmth or parental control and offspring's change in BMI (Table 1.3). Contrary to our expectation, the interaction terms between parental warmth and control were not statistically significant either in association with offspring BMI change (Table 1.3). However, stratified analyses of parenting dimensions in context of one another provided suggestive evidence for possible interactive effects between parental warmth and control. Specifically, high parental warmth was associated with lower BMI increase in offspring when there was high parental control (β=-0.44, 95% CI: -0.82, -0.06, Table 1.3), whereas no significant associations were evident when parental control was low.

**Table 1.3 Interactions between parental warmth and parental control in childhood and offspring's change in BMI during mid-life (N = 3382)**

| | BMI change β (95% CI) |
|---|---|
| **Parental warmth** | |
| Low (ref) | |
| High | -0.08 (-0.37, 0.21) |
| **Parental control** | |
| Low (ref) | |
| High | 0.16 (-0.15, 0.47) |
| **The interaction term** | -0.35 (-0.82, 0.12) |

| ***Stratified associations*** | **BMI change β (95% CI)** | |
|---|---|---|
| **Parental warmth** | **Low parental control** | **High parental control** |
| Low (ref) | | |
| High | -0.09 (-0.38, 0.20) | -0.44 (-0.82, -0.06)* |
| **Parental control** | **Low parental warmth** | **High parental warmth** |
| Low (ref) | | |
| High | 0.17 (-0.14, 0.48) | -0.23 (-0.60, 0.13) |

Note: Generalized estimating equations with normal distribution and identity link were used to estimate the mean change in offspring BMI over the follow-up, adjusting for clustering by family. All models adjusted for participants' age, gender, race, childhood SES, severe physical abuse by parents in childhood and other childhood family environment factors. Inverse probability weighting was used in all models to account for loss to follow-up.
$\sim p \leq .10$, $^{*} p \leq .05$

*Mediation Analyses*

The mediation analyses generally suggested that depression may lie on the pathway between parenting styles and offspring's change in BMI, but there was no evidence that social support or educational attainment may mediate the association of interest. Specifically, as suggested by the bivariate analyses presented in Table 1.1, parenting styles were associated with depression in offspring, even after adjusting for age, sex, race, childhood SES, parental severe physical abuse and other childhood familial factors (e.g., $RR_{depression}$=2.21, 95% CI: 1.50, 3.24 for the authoritarian versus the authoritative style; $RR_{depression}$=1.80, 95% CI: 1.24, 2.60 for the uninvolved versus the authoritative style). Depression was also significantly associated with offspring's change in BMI even after covariate adjustment (β=0.58, 95% CI: 0.20, 0.95). When depression was subsequently included in the base model with parenting styles, the effects of the authoritarian and the uninvolved styles versus the authoritative style were attenuated (Table 1.4, model 2). Depression explained 11.36% and 11.30% of the BMI increase associated with the authoritarian and the uninvolved styles. In comparison, there was no evident association between social support and change in BMI in this sample either without or with parenting styles in the model (data not shown). Moreover, parenting styles were not associated with offspring educational attainment in this sample after covariate adjustment (data not shown). Therefore, social support and educational attainment were not considered in further analyses as potential mediators for the association of interest.

**Table 1.4 Test of mediation - the association between parenting styles in childhood and offspring's change in BMI during mid-life mediated by offspring's major depression (N = 3382)**

| | Model 1: Base model [a] | Model 2: model 1 + depression |
|---|---|---|
| | β (95% CI) | β (95% CI) |
| **Parenting style in childhood** | | |
| Authoritative style (ref) | | |
| Authoritarian style | 0.43 (0.06, 0.80)* | 0.38 (0.01, 0.75)* |
| Permissive style | 0.19 (-0.17, 0.55) | 0.19 (-0.17, 0.55) |
| Uninvolved style | 0.27 (-0.04, 0.58)~ | 0.24 (-0.07, 0.55) |
| **Major depression** | | 0.55 (0.18, 0.92)** |

Note: Generalized estimating equations with normal distribution and identity link were used to estimate the mean change in offspring BMI over the follow-up, adjusting for clustering by family. Inverse probability weighting was used in all models to account for loss to follow-up.

[a] The base models adjusted for participants' age, gender, race, childhood SES, severe physical abuse by parents in childhood and other childhood family environment factors. Subsequent models added the hypothesized mediators to the base model.

~ $p \leq .10$, * $p \leq .05$, ** $p \leq .01$, *** $p \leq .001$

**Discussion**

This study is the first to demonstrate a protective effect of the authoritative parenting style on offspring body weight beyond adolescence and young adulthood. Compared to the authoritative style, the authoritarian style was associated with higher BMI increase of 0.45 $kg/m^2$ on average over the 9-year follow up period in middle-aged offspring, adjusting for offspring's age, sex and race. Similarly, the uninvolved parenting style was found to be associated with higher BMI increase in offspring by 0.31 $kg/m^2$ on average compared to the authoritative style. The patterns were generally maintained after additional adjustment for a series of potential confounders including childhood SES, severe physical abuse by parents and a broad range of other childhood family environment factors. Sensitivity analyses based on more distinct parenting styles which were created with more stringent cutoffs yielded similar results as the primary analyses. Secondary analyses on individual parenting dimensions showed that neither parental warmth nor control alone was predictive of offspring change in BMI. The stratified analyses considering effects of parental warmth and control in context of one another were consistent with the analyses using the typology, suggesting that it is likely the interactive dynamics between parenting dimension that matters. The mediation analyses suggested that the higher BMI increase in offspring associated with the authoritarian and uninvolved parenting styles compared to the authoritative style was partly explained by the elevated rate of major depression in offspring of authoritarian and uninvolved parents.

Findings in this study were largely consistent with prior findings among children and adolescents,[28,29,45,67] although it is worth noting that the magnitude of the elevated risk of unhealthy body weight associated with non-authoritative styles was less substantial compared to the effect size observed in earlier life that was documented in prior work.[29,30] This may reflect

the elasticity of human development over the life course: childhood experiences set the developmental trajectory, whereas experiences in later life may open up opportunities for redirecting the course.[38,68] Specifically, children are most likely to model weight-related attitudes and behaviors from their parents, and the substantial influences from the home environment in early life could persist through one's weight trajectories.[69] However, as individuals transition into adolescence and young adulthood, they may gain increasing educational opportunities and experience expansions in social network. The newly developed social relationships and other accumulated resources that promote resilience could open up the possibility of reshaping individuals' health perceptions and behavioral patterns,[70,71] and may help offset less than optimal parental influences experienced in early life.

Compared to the authoritative style, the elevated BMI increase in offspring associated with the authoritarian style was particularly pronounced. It may be attributable to the synergistic effects of low parental warmth and high parental control which have been observed with increased risk of obesity separately among children.[29,72] Investigation on individual parenting dimensions in this study also suggested that the lack of parental warmth was particularly detrimental for offspring body weight when parental control was high, although the interaction term between parental warmth and control did not reach statistical significance. In prior studies, researchers hypothesized that low parental warmth may results in higher emotional distress and low self-efficacy,[73] whereas high parental control may lead to lack of abilities in reasoning and self-regulation among children,[73,74] which may both increase the risk of adopting unhealthy weight-related behaviors such as binge eating to cope with the stress.[73,74] Consistent with some prior studies,[28] our study did not find elevated risk of unhealthy body weight in offspring associated with the permissive style. Prior researchers[38] hypothesized that high parental warmth

may serve as a buffer against the lack of parental control. Specifically, children may tend to model their supportive parents' healthy life styles and prosocial ways even in the absence of parental discipline, and they may develop self-regulation in other non-familial settings later in life that require disciplines such as in school.[38]

Somewhat unexpectedly, the uninvolved parenting style was only moderately associated with higher BMI increase in offspring and was not associated with offspring risk of obesity, compared to the authoritative style. This might be due in part to the specific cutoff used to create parenting style in this study. More specifically, participants in this sample generally reported high levels of parental warmth and control. To capture high levels of warmth and control and utilize all possible data, we compared the top tertile of parental warmth and control to the middle and low tertiles. Therefore, the uninvolved parenting style created in this approach may not capture distinctively low levels of warmth and control, and any effects of this style may be muted as a result. This hypothesis was supported by evidence from the sensitivity analyses in this study. Specifically, when we reanalyzed the association of interest with more distinct parenting styles that compared the top tertile of parental warmth and control to the bottom tertile, the uninvolved style created in this approach showed a more pronounced association with BMI increase in offspring compared to the authoritative style.

This study provides somewhat inconclusive evidence as to whether the authoritative parenting style is a health asset per se in relation to offspring body weight. Specifically, the authoritative style was related to lower BMI increase in offspring compared to the authoritarian and uninvolved styles, but not to the permissive style. Prior studies have most often evaluated health assets on a continuous scale, and posited that health would improve with each incremental increase in the amount of the positive attribute or resource.[75] However, this method of comparing

effects of have more versus less of an attribute is not appropriate when considering a categorical variable. With a categorical variable, effects of having one type of attribute are compared to effects of having another type of attribute; whether this attribute is protective for health depends largely on the other attribute to which it is being compared. To our knowledge there is no agreed-upon definition as to whether a categorical attribute can be considered as a health asset only if it is related with better health outcomes compared to *all* other typologies or if it needs to improve only on a subset of alternative attributes. In fact, a more comprehensive definition of health assets may be needed, so as to provide clear rubrics and standards for evaluating categorical attributes or resources as potential health assets.

The association between parenting styles and offspring body weight was partly mediated by our hypothesized mediator major depression. This is in line with prior findings that the authoritarian and uninvolved parenting style were related to higher risk of depression in offspring compared to the authoritative style,[25,38] while depression has also been repeatedly documented as a risk factor for obesity.[12] Contrary to our expectation, we did not find that social support was associated with offspring change in BMI. This may be due to the fact that social support was queried during participants' mid-life, and prior work has suggested that levels of emotional support remained rather stable in later life.[76] Therefore, it is possible that social support may have already exerted its effects on body weight at the time when participants' BMI was first queried. Moreover, the mean change in BMI was minimal in this sample, thus it may be hard to capture the effect of social support on BMI change, if effects are small. Further, parenting style was not associated with offspring educational attainment, perhaps because participants included in this study were more highly educated on average than those excluded from the analyses (Table S1.1).

This study has several limitations to consider. First, parenting style and other childhood family environment factors were retrospectively reported by participants in their mid-life, which may be subject to recall bias. However, prior studies have documented evidence for the validity of recalled parenting style.[77,78] Moreover, parenting style was reported 10 years prior to the second assessment of BMI and participants were not aware that linkages between parenting styles and BMI might be considered. Second, the hypothesized mediators such as depression in mid-life were assessed concurrently with parenting styles in childhood and other early life experiences, which may be subject to information bias. Therefore, the mediation analyses performed in this study were exploratory, due to the lack of temporality in the assessment of the independent variable and the hypothesized mediators. There was no information available on participants' weight control behaviors such as eating disorders or body image perception during adolescence, which are also potentially important mediators for the association of interest. Next, there may be residual confounding by other prenatal or childhood factors for which information was unavailable in in this study such as parental body weight, parental depression, offspring body weight and general health status in childhood. In addition, participants in both waves of the MIDUS study did not comprise a nationally representative sample, and there was some evidence that participants included in the analyses were different from those excluded. Therefore, results of this study may not be generalizable to other populations.

This study has a number of important strengths. It is the first study with detailed data to examine whether protective effects of the authoritative parenting style on offspring body weight may extend beyond young adulthood, while taking into account of a wide range of important early life familial factors as potential confounders. In addition, it adds to the evidence that early life family environment may exert effects on offspring's life-long health, and contributes to our

understanding of resiliency and plasticity over the life course trajectory. Moreover, it lends further support to the notion that the presence of parental nurturance is more than the mere absence of social adversity or parental maltreatment. Furthermore, this is the first study that begins to explore potential mechanisms underlying possible links between parenting styles and offspring body weight.

Important next steps following this study include replicating this research with prospectively measured parenting style in a more generalizable study sample, considering what other resources may help buffer negative effects of less than optimal parental influences, as well as examining other potential pathways linking parenting style with offspring body weight such as weight control behaviors during critical developmental stages. Prior work has suggested that interventions on positive parenting are possible. Such programs aim at addressing children's weight problems through intervening on parents' general parenting styles (such as reducing parents' coercive or permissive discipline practice) and specific parenting practices (such as improving parents' skills in communicating about health and nutrition),[79] and have been shown to be effective in improving children's weight-related health behaviors.[80] The current study further suggests that the beneficial effect of such programs on offspring's body weight and weight-related behaviors may persist into later life. Previous studies have shown that interventions on childhood obesity were most effective when the family was engaged, and the American Heart Association called for involving parents as "agents of change" in treating obese children. Further research on parenting styles and the broader family environment may help inform more targeted interventions in this area, and help identify resources and attributes within the family that may be targeted for obesity prevention and control.

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**Supplementary Materials**

| | | **Parental Control** | |
|---|---|---|---|
| | | High (top tertile in the distribution) | Low (bottom and middle tertiles in the distribution) |
| **Parental Warmth** | High (top tertile in the distribution) | **Authoritative style** | **Permissive style** |
| | Low (bottom and middle tertiles in the distribution) | **Authoritarian style** | **Uninvolved style** |

**Figure S1.1 Categorization of parenting styles in this study**

Note: The top tertile on each scale were used as the cutoffs to define high versus low levels of parental warmth and control.

**Table S1.1 Comparison of participant characteristics between those included in and excluded from the analyses**

| Characteristic | Included n=3382 | Excluded n=1581 | *p* |
|---|---|---|---|
| **Obese at baseline, %** | 20.20 | 22.77 | 0.07 |
| **Obese at follow-up, %** | 28.06 | 30.56 | 0.26 |
| **Change in BMI over follow-up, mean (SD)** | 1.27 (3.08) | 0.75 (3.93) | 0.01 |
| **Parenting style, %** | | | 0.24 |
| Authoritative | 13.66 | 14.72 | |
| Authoritarian | 18.04 | 16.61 | |
| Permissive | 18.24 | 20.24 | |
| Uninvolved | 50.06 | 48.43 | |
| **Age at baseline, mean (SD), years** | 46.96 (12.29) | 45.38 (12.92) | 0.001 |
| **Sex, %** | | | 0.07 |
| Male | 48.58 | 45.77 | |
| Female | 51.42 | 54.23 | |
| **Race, %** | | | <0.0001 |
| White | 94.41 | 85.37 | |
| Black | 3.02 | 8.99 | |
| Others | 2.57 | 5.64 | |
| **Highest parental education, %** | | | 0.48 |
| Less than high school | 24.78 | 25.42 | |
| High school degree | 35.69 | 37.43 | |
| Some college | 16.06 | 15.24 | |
| 4-year college degree or higher | 23.48 | 21.91 | |
| **Family never on welfare in childhood, %** | 94.86 | 92.74 | 0.003 |
| **Severe physical abuse score, mean (SD)** | 1.25 (0.54) | 1.27 (0.60) | 0.15 |
| **Intact family structure in childhood, %** | 82.26 | 74.60 | <0.0001 |
| **Residential stability in childhood, %** | 75.31 | 71.34 | 0.006 |
| **No alcoholics in family in childhood, %** | 81.05 | 75.73 | <0.0001 |
| **Family was religious in childhood, %** | 44.29 | 45.52 | 0.45 |

**Table S1.1 (Continued).**

| | | | |
|---|---|---|---|
| **Major depression, %** | 11.98 | 12.84 | 0.39 |
| **Social support, mean (SD)** | 3.42 (0.45) | 3.38 (0.47) | 0.008 |
| **Educational attainment, %** | | | <0.0001 |
| Less than high school | 5.26 | 11.26 | |
| High school degree | 26.79 | 29.92 | |
| Some college | 29.42 | 32.26 | |
| 4-year college degree or higher | 38.53 | 26.57 | |

Note: Percentages refer to the proportion of individuals within each inclusion category with that characteristic. *p* comes from $\chi^2$ or t-tests.

**Table S1. 1 Individual items of the parental warmth and parental discipline scales**

| |
|---|
| The parental warmth scale (α=0.91). |
| Q1. How much did your mother/father understand your problems and worries? |
| Q2. How much could you confide in her/him about things that were bothering you? |
| Q3. How much love and affection did your mother/father give you? |
| Q4. How much time and attention did your mother/father give you when you needed it? |
| Q5. How much effort did your mother/father put into watching over you and making sure you had a good upbringing? |
| Q6. How much did your mother/father teach you about life? |
| Response options ranged from 1: a lot to 4: not at all, and were reverse-coded so that a higher score represented greater parental warmth. |
| The parental discipline scale (α=0.79). |
| Q1. How strict was your mother/father with her/his rules for you? |
| Q2. How consistent was she/he about the rules? |
| Q3. How much did she/he stop you from doing things that other kids your age were allowed to do? |
| Response options ranged from 1: a lot to 4: not at all, and were reverse-coded so that a higher score represented greater parental control. |

Note: Factor analyses confirmed the one common factor structure of the parental warmth scale and the parental discipline scale.

## STUDY 2. Maternal Marital History and Offspring Body Weight

**Title:** Mother's Marital History and Their Offspring's Body Weight across Adolescence and Young Adulthood: A 21-year Longitudinal Study

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**Abstract**

Prior work has linked parents' marital history to a number of offspring health outcomes such as hypertension and diabetes. The findings suggest that parents' marital stability was protective. However, no study has examined whether or how parents' marital history might be associated with offspring's body weight.

This study investigated the association between mother's marital history and offspring's risk of being or becoming overweight or obese across adolescence and young adulthood, based on data from the Nurses' Health Study II (NHSII) and the Growing Up Today Study (GUTS). It also examined whether offspring BMI trajectory would rise at an accelerated rate after versus before their mother's first marital transition. In addition, this study also examined effects of different dimensions of maternal marital trajectory including frequency of marital transitions, duration of being unmarried, and timing of the first marital transition.

Compared to offspring with consistently married mothers, those whose mothers were divorced or separated were at higher risk of being overweight or obese (RR=1.12, 95% CI: 1.04, 1.21 in the fully-adjusted model). In addition, offspring with remarried mothers also had higher risk of being (RR=1.11, 95% CI: 1.00, 1.23) or becoming (HR=1.26, 95% CI: 1.06, 1.49) overweight or obese. There was also evidence that maternal widowhood was associated with higher offspring risk of being overweight or obese, but the association was attenuated after adjustment for maternal baseline BMI. Among offspring who ever experienced maternal marital transition, their BMI trajectory rose at an accelerated rate after versus before their mother's first marital transition (p for change in the slope <0.001). Higher frequency of maternal marital transitions, longer duration of mothering being unmarried, and occurrence of first maternal

marital transition during offspring's adolescence or young adulthood was each associated with higher risk of offspring being overweight or obese.

This study demonstrated that having a consistently married mother was associated with healthier body weight. It also suggested that every facet of maternal marital history exerted different effects. This study paves the way for future studies on potential pathways underlying the association, and highlights the importance of providing support for children experiencing family structure changes.

## Introduction

Obesity in youth has been identified as a public-health crisis, and numerous interventions have sought to control the childhood obesity epidemic.[1] In 2011 to 2012, around 17% of the children and adolescents aged 2 to 19 years old were obese in the U.S.[2] Obesity in youth has been linked to a wide array of adverse health outcomes such as increased risk of chronic conditions and premature mortality.[1,3,4] A number of risk factors for obesity have been identified including genetic factors, being sedentary, as well as some perinatal factors such as not being breast fed.[1,5] In addition, evidence has increasingly suggested that social environmental factors – the family environment in particular –also contribute significantly to the obesity epidemic in youth.[1] For instance, studies have consistently demonstrated parental neglect, parental abuse and other household dysfunctions are associated with offspring's binge eating,[6,7] lack of physical activity,[8] and rapid weight gain in childhood throughout young adulthood. [9-11] Early childhood poverty has also been linked to accelerated weight gain and higher body weight in later life.[12,13]

Beyond parenting practices and family socioeconomic status (SES), there is evidence to suggest that another aspect of the home environment - parents' marital status - may also exert effects on offspring's body weight[14]. For instance, one cross-sectional study of 5,147 young adolescents found that offspring of married parents generally had lower body weight compared to offspring of divorced, widowed or never married parents.[15] Researchers posited that single parents, and single mothers in particular, were more likely to encounter financial hardship,[16] loss of educational and employment opportunities,[17] and develop depressive symptoms[18] compared to married parents. Therefore, marital dissolution may distract parents from providing effective parenting or modeling healthy behaviors for their children, which may lead to increased risk of unhealthy weight in offspring.[19] In fact, the adverse consequences associated with single

motherhood may be particularly pronounced in the U.S. where the social safety nets are relatively weak compared to most European countries.[20]

Prior work has investigated the health risks in offspring associated with parents' current marital status, although it is important to note that most of these studies were cross-sectional.[21] However, patterns in family structures have changed considerably over the past five decades in the U.S., as multiple changes in marital status for each individual have become increasingly common. Currently, it is estimated that by age 50 around one third of adults in the U.S. will have been divorced, and approximately one fourth will have been married for two or more times.[22,23] Evidence is beginning to suggest that assessing marital status at a single point in time may not capture the cumulative effects of marital experiences throughout the lifecourse,[23] and similarly it may be parent's marital history over time that matters for offspring health.[24,25] Marital history is defined as "the course of marital status over time",[26] and has generally been categorized into the following typologies: consistently married, divorced/separated, widowed, remarried.[23] Based on findings to date, researchers have argued we need to consider marital history from a lifecourse perspective and move beyond taking a static view of potential effects of marital status at any given time on the partners or the offspring.[26] For example, a few empirical studies on marital trajectories posited that marital history may be more likely to capture offspring's exposure to chronic stress as a function of parents' marital dissolution and reunions;[21,27] understanding marital history can facilitate our understanding of the different effects of various aspects of marital trajectories such as frequency and timing of marital transitions and duration of marriage.[18]

To date, empirical evidence has linked parents' marital history to a number of offspring health outcomes that are closely related to body weight. Findings generally suggest that parents'

marital stability (i.e., being consistently married) was protective.[26] For instance, a longitudinal study of 12,424 adolescents found that compared to those whose mothers were consistently married, offspring with mothers of other marital history typologies had more depressive symptoms and a greater number of physician-diagnosed physical illnesses such as high blood pressure, diabetes and heart diseases over the 13-year follow-up.[26] A cross-sectional study of 1,364 primary school children showed that those who ever experienced parents' marital status change were more likely to have psychosocial problems such as externalizing behaviors, loneliness and low peer competency.[28] However, to our knowledge no study has ever examined whether or how parents' marital history might be associated with offspring's body weight over time.

Wickrama and colleagues have proposed a theoretical framework – the Family Process Model[26] – to help understand how parents' marital history may affect offspring's health. It suggests that when parents change their marital status (hereafter called marital transition), this can result in chaotic family processes such as economic hardships and ineffective parenting. The stressful family environment may compromise offspring's psychosocial development, increase emotional insecurity, adjustment problems and risky behaviors, leading to mental and physical health problems in later life. The model has been supported by empirical evidence. For instance, prospective studies have repeatedly documented a higher risk of financial hardship related to marital dissolution. [29-31] Financial hardship has also been shown to increase parental depression and ineffective parenting, and ultimately lead to offspring adjustment problems.[32]

The Family Process model also posits that different dimensions of marital history such as the frequency and timing of marital transitions may exert specific effects on offspring health.[33] For instance, a few cross-sectional studies of children and young adolescents have reported a

dose-response relationship between the number of parental marital transitions and offspring's psychosocial problems.[34,35] Moreover, timing may be an important moderating factor for the effect of marital history on offspring health. For instance, a longitudinal study of 1,364 elementary school students found that children who experienced the first occurrence of parents' marital transition in early childhood were at higher risk of psychosocial problems compared to children of consistently married parents, but risk was not elevated in those who experienced the first transition in middle childhood.[28] Some empirical work also suggests that another dimension of marital trajectory – duration of staying in single-parent family –might also adversely affect offspring development.[36,37] For instance, a cross-sectional study of 2,544 black and white men and women showed that the longer the participants spent in single-parent family, the fewer years of schooling they completed.[36] However, we know of no prior work that has linked these specific dimensions of marital history to offspring body weight.

To help address these knowledge gaps, this study aimed to investigate the longitudinal association between mother's marital history and offspring's body weight across adolescence and young adulthood, adjusting for covariates that have previously been identified as relevant.[26,38] We hypothesized that compared to offspring whose mothers remained consistently married, those whose mothers were divorced/separated, widowed or remarried would have increased risk of being overweight/obese as well as higher likelihood of becoming overweight/obese over the follow-up period. We also expected that among offspring who ever experienced mother's marital transition, BMI trajectory would rise at an accelerated rate after their mother's first marital transition compared to prior to the transition. As secondary analyses, we examined effects on offspring's body weight of different dimensions of mother's marital trajectory including frequency of mother's marital transitions, duration of mother being

unmarried, and timing of mother's first marital transition. We posited that higher frequency of mother's marital transition, longer duration of mother being unmarried and earlier occurrence of mother's first marital transition might all be associated with higher risk of being overweight or obese in offspring.

## Methods

### Sample and study design

Data for the present study were drawn from the Nurses' Health Study II (NHSII) and the Growing Up Today Study (GUTS). NHSII was initiated in 1989 to study effects of oral contraceptives, diet and lifestyle factors on health. It recruited 116,430 nurses aged 25 to 42 years at baseline, and followed them biennially with mailed or web-based questionnaires. GUTS enrolled 16,882 of their offspring in 1996, and followed them annually or biennially with mailed or web-based questionnaires. Specifically, 34,174 NHSII participants with children aged 9-14 years were invited in 1996 to participate in GUTS, and 54% of them provided maternal consent to have their children participate (n=18,526). Among the children who agreed to participate, around 58% of the boys (n=7,843) and 68% of the girls (n=9,039) returned their self-completed questionnaires. This study was approved by the Partners' Institutional Review Board.

NHSII participants reported their current marital status quadrennially between year 1989 and 2009. GUTS respondents also self-reported their height and weight annually or biennially between year 1996 and 2010, based on which their body mass index (BMI) was calculated.

The analytic sample for the present study was drawn from GUTS participants whose mother was ever married prior to enrollment (N=16,825) (i.e., those whose mother was never

married by year 1989 were excluded, n=50). Respondents were additionally excluded for the following reasons: missing data on mother's marital status at one or more waves (n=4,657); missing data on participants' body weight at all waves (n=13); missing information on any covariates (n=105). This yielded a final analytic sample of 12,050 offspring participants (N mothers=9,015), of which 3,036 were siblings.

**Measures**

Exposures

*Mother's marital history.* Current marital status was self-reported in NHSII quadrennially between 1989 and 2009. Response options included married or in domestic partnership, divorced or separated, widowed and never married. Marital history was considered as a time-varying variable[23]. Specifically, women who had consistently reported being married or in domestic partnership by the current wave were considered as "consistently married"; those who reported being divorced/separated were considered as "divorced or separated"; participants who reported being widowed were coded as "widowed"; and respondents who were unmarried (divorced, separated, or widowed) at the prior wave and reported being married or in domestic partnership in the current wave were considered as "remarried' at that wave and onwards until occurrence of the next change in marital status.[23]

*Frequency of mother's marital transition.* In NHSII, participants whose reported marital status changed compared to the previous assessment were considered as having marital transition at that wave. Due to the small number of participants who experienced marital transition in this sample, we did not differentiate transition into (i.e., became remarried) and out (i.e., became

divorced/separated or widowed) of marriage. Frequency of marital transition was calculated as the total number of marital transitions the respondent's mother reported,[23] and was considered as a time-varying variable. Following prior work,[23] responses were grouped into three categories: 0 transition, 1 and 2 or more marital transitions.

*Duration of mother being unmarried.* Among NHSII participants who experienced change in marital status, the specific timing of the occurrence of the marital transition was not queried. For the purposes of this study, we assume that the transition occurred halfway between the prior wave and the current wave. Duration of being unmarried was calculated as the sum of years when the respondent was divorced/separated or widowed,[20] and was considered as a time-varying variable. Responses were grouped into four categories: 0 years, 1-8 years, 9-12 years, and >12 years.

*Timing of mother's first marital transition.* Among NHSII participants who ever experienced change in marital status, timing of first marital transition was established according to their offspring's age when the first change in marital status occurred. Responses were grouped into four categories: never experienced mother's marital transition, aged 1-12 years (in childhood), aged 13-18 years (in adolescence), and aged >18 years (in adulthood).

Outcome

*Offspring body weight*. Participants in GUTS self-reported their height (in inches) and weight (in pounds) annually or biennially between 1996 and 2010, based on which their BMI (kg/m2) was calculated. BMI>25kg/$m^2$ was defined as overweight and BMI >30kg/$m^2$ as obese for respondents aged 18 years or over.[39] Among participants under age of 18 years, the International Obesity Task Force standards were used to determine the age-and-sex-specific BMI

cutoffs for overweight and obesity.[40] Previous studies in other cohorts have shown high validity of self-reported height and weight in children and adolescents, compared to measured height and weight.[41,42]

Covariates

*Sociodemographic characteristics*. Mother's age (years), offspring's age (years), offspring sex (male, female), and maternal and offspring race (white, non-white) were all self-reported by participants in NHSII and GUTS. Mother's socioeconomic status (SES) was evaluated in several ways. Mothers' subjective social standing in adulthood was assessed in NHSII in 2001 with two validated scales in the form of a 10-rung ladder, which asked participants to place themselves in comparison to others in the community and in the U.S.[43] Response options ranged from 1: the top rung to 10: the bottom rung. The responses were used as continuous scores, and were reverse coded so that a higher score represented higher subjective social standing. Following prior work,[44] mothers' childhood SES was assessed with their parents' highest educational level (i.e., the offspring's grandparents' highest education level) recalled by the NHSII respondents in 2005. Responses were grouped into the following categories: 1: high school or less, 2: some college and 3: college or more.

*Mother's BMI at baseline*. NHSII Participants self-reported their height (in inches) and weight (in pounds) initially in 1989, from which their BMI (kg/m2) was derived. In NHSII this measure of self-reported body weight was validated against measured weight in a subset of participants who participated in a physical examination (N=140), and the measures had high concordance (r=0.97).[45] Mother's BMI was winsorized at the 1$^{st}$ and 99$^{th}$ percentiles to minimize possible influence of extreme outliers, and was considered as a continuous variable.

**Statistical Analyses**

All statistical analyses were performed in SAS 9.3. The frequency distribution of offspring participants within each category of mother's marital history characteristics over the course of the study was first examined. Chi-square test and analysis of variance test were then used to examine the distribution of participant characteristics across categories of mother's marital history across the follow-up period. We also plotted the mean values of offspring BMI at each year by their mother's marital history category (time-varying).

To investigate whether mother's marital history (time-varying) was associated with offspring's risk of being overweight or obese over the course of the study, generalized estimating equations (GEE) were used adjusting for clustering by family. To account for possible confounders, a series of the GEE models were used. Specifically, the base model controlled for demographic characteristics including offspring's age, sex, race, and the mother's age and race. The second model further adjusted for maternal socioeconomic status including the mother's adulthood subjective social standing and her childhood SES. A third, fully adjusted model additionally took into account the mother's BMI at baseline (i.e., in year 1989). We also reanalyzed the primary fully-adjusted model with frequency of mother's marital transition, duration of mother being unmarried and timing of mother's first marital transition as the independent variable in separate models.

In offspring participants who had normal weight ($BMI \leq 25 kg/m^2$) at baseline (i.e., in year 1996), cox proportional hazard models were used to estimate the hazard of becoming overweight or obese over the follow up with mother's marital history (time-varying) as the independent variable. A series of cox models similar to the models described above were increasingly

adjusted to account for possible confounding by demographic characteristics, maternal SES and mother's baseline BMI.

To test the hypothesis that offspring BMI trajectory would rise at an accelerated rate after mother's transition either from being married to unmarried or vice versa, we used piecewise regression models. These analyses were conducted only among offspring who ever experienced mother's change in marital status during the follow-up (n=2,067), and we examined offspring BMI trajectory before and after the onset of their mother's first marital transition. In these models, an inflection was imposed at the time of mother's first marital transition. We also examined possible non-linearity in offspring BMI trajectory both before and after maternal marital transition by including the squared terms of the slope. A set of increasingly adjusted piecewise regression models similar to the models described above were used to investigate possible confounding by demographic characteristics, maternal SES and mother's baseline BMI.

## Results

### *Descriptive Analyses*

The majority of offspring had mothers who were consistently married (79.11%). Among offspring with mothers who were ever unmarried (n=2,355), half of these had mothers who did (9.63%) versus did not (9.92%) become remarried. A small number of offspring had mothers who were consistently unmarried (1.34%). Among offspring who ever experienced mother's marital transition (n=2,355, 19.54%), the majority of them experienced only one transition, had mothers with a duration of being unmarried of no more than 8 years, and experienced the first maternal marital transition in their childhood (Table S2.1).

Offspring with mothers who were consistently married throughout the study period were more likely to be younger and white. In addition, younger mothers and mothers with healthier body weight at baseline were more likely to remain consistently married or become remarried after getting divorced/separated or becoming widowed during the follow-up (Table 2.1).

**Table 2.1 Participant characteristics by mother's marital history over the follow-up, Nurses' Health Study II (1989-2009) and Growing Up Today Study (1996-2010), N mothers = 9,015, N offspring = 12,050**

| Participant characteristics | | Full sample N offspring =12,050 | Mother's marital history over the follow-up: Consistently Married n = 9533 | Consistently Unmarried n = 162 | Ever unmarried and never remarried n = 1195 | Ever unmarried but then remarried n=1160 | p |
|---|---|---|---|---|---|---|---|
| **Offspring age at baseline** [a] | Mean (SD) | 11.55 (1.64) | 11.54 (1.64) | 11.98 (1.52) | 11.53 (1.65) | 11.65 (1.60) | 0.001 |
| **Offspring sex** | | | | | | | 0.28 |
| Male | % | 46.58 | 46.69 | 50.62 | 44.35 | 47.41 | |
| Female | % | 53.42 | 53.31 | 49.38 | 55.65 | 52.59 | |
| **Offspring race** | | | | | | | 0.01 |
| White | % | 93.83 | 93.95 | 87.65 | 93.81 | 93.71 | |
| Non-white | % | 6.17 | 6.05 | 12.35 | 6.19 | 6.29 | |
| **Mother's age at baseline** [b] | Mean (SD) | 34.12 (3.52) | 34.10 (3.47) | 36.02 (3.44) | 34.78 (3.58) | 33.39 (3.65) | <0.0001 |
| **Mother's race** | | | | | | | 0.26 |
| White | % | 98.01 | 98.02 | 96.30 | 98.45 | 97.74 | |
| Non-white | % | 1.99 | 1.98 | 3.70 | 1.55 | 2.26 | |
| **Mother's adulthood SES** [c] | | | | | | | |
| US social standing | Mean (SD) | 7.15 (1.29) | 7.21 (1.26) | 6.59 (1.34) | 6.96 (1.38) | 6.90 (1.35) | <0.0001 |
| Community social standing | Mean (SD) | 7.01 (1.53) | 7.09 (1.49) | 6.45 (1.70) | 6.72 (1.65) | 6.73 (1.63) | <0.0001 |
| **Mother's childhood SES** [d] | | | | | | | 0.46 |
| High school or less | % | 48.02 | 48.10 | 51.85 | 48.62 | 46.21 | |
| Some college | % | 25.55 | 25.70 | 26.54 | 24.18 | 25.60 | |
| College or more | % | 26.43 | 26.20 | 21.60 | 27.20 | 28.19 | |
| **Mother's BMI at baseline** [e] | Mean (SD) | 23.29 (4.17) | 23.25 (4.09) | 25.41 (5.86) | 23.77 (4.56) | 22.86 (4.05) | <0.0001 |

Note: Percentages refer to the proportion of individuals with that characteristic within each category of mother's marital history. P comes from $\chi 2$ tests or ANOVA.

[a] Offspring age at baseline refers to participants' age in year 1996 in the Growing Up Today Study.

[b] Mother's age at baseline refers to participants' age in year 1989 in the Nurses' Health Study II.

[c] Mother's adulthood SES refers to participants' self-reported subjective SES in the US and in the community in year 2001 in the Nurses' Health Study II.

[d] Mother's childhood SES was assessed with parents' highest education level (i.e., offspring's grandparents' education level) recalled in the Nurses' Health Study II.

[e] Mother's BMI at baseline refers to participants' self-reported BMI in year 1989 in the Nurses' Health Study II.

Compared to offspring whose mothers remained consistently married, those with mothers who were divorced/separated, widowed or remarried had higher mean values of BMI at each assessment year, unadjusted for covariates. The disparities persisted throughout offspring's adolescence and young adulthood (Figure 2.1).

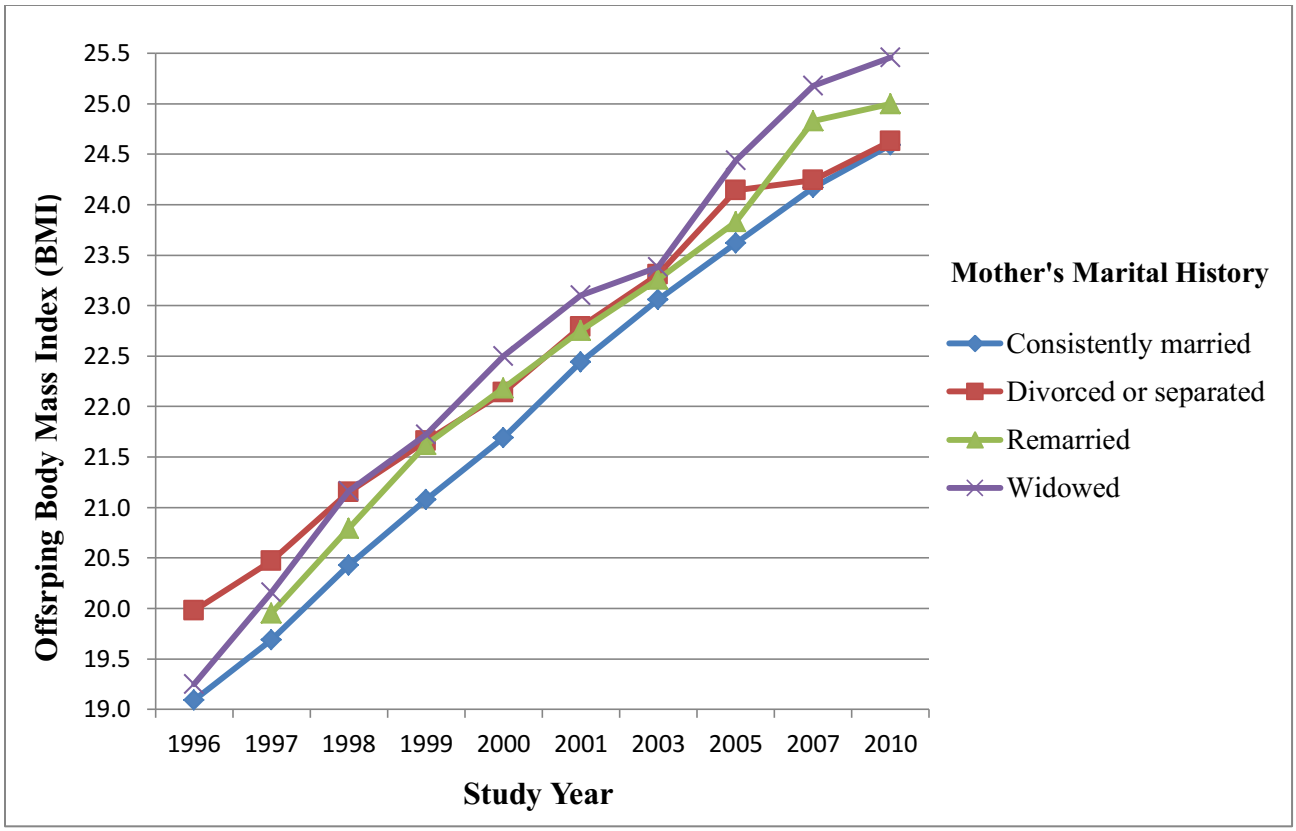


**Figure 2.1 Unadjusted offspring mean body mass index trajectory across adolescence and young adulthood by mother's marital history (time-varying), Nurses' Health Study II (1989-2009) and Growing Up Today Study (1996-2010), N offspring=12,050, N observations (offspring) =87,323**

*Offspring risk of being overweight or obese in relation to their mother's marital history*

Compared to offspring with consistently married mothers, those whose mothers were divorced/separated (RR=1.16, 95% CI: 1.07, 1.26) or widowed (RR=1.31, 95% CI: 1.06, 1.62) were at higher risk of being overweight or obese across the follow-up, adjusting for demographic characteristics. There was also weak evidence that mother's remarriage was associated with higher risk of overweight or obesity in offspring, but the association did not reach statistical significance (Table 2.2, model 1). The elevated risk associated with mothers being divorced or separated remained robust after further adjustment for maternal SES and baseline maternal BMI. The effect of mother being widowed still held after additional adjustment for maternal SES, but was attenuated after further adjustment for maternal BMI. In comparison, the increased risk of overweight or obesity in offspring associated with mother's remarriage became pronounced in the fully-adjusted model (RR=1.11, 95% CI: 1.00, 1.23) (Table 2.2, models 2-3).

**Table 2.2 Mother's marital history and offspring's risk of being overweight or obese across adolescence and young adulthood, Nurses' Health Study II (1989-2009) and Growing Up Today Study (1996-2010), N offspring=12,050, N observations (offspring)=87,323**

| | Risk of being overweight or obese in offspring | | |
|---|---|---|---|
| | Model 1 | Model 2 | Model 3 |
| | RR (95% CI) | RR (95% CI) | RR (95% CI) |
| **Mother's marital history (time-varying)**[a] | | | |
| Consistently married (ref) | | | |
| Divorced or separated | 1.16 (1.07, 1.26)*** | 1.14 (1.05, 1.24)** | 1.12 (1.04, 1.21)** |
| Widowed | 1.31 (1.06, 1.62)* | 1.28 (1.04, 1.59)* | 1.09 (0.89, 1.34) |
| Remarried | 1.08 (0.96, 1.20) | 1.06 (0.95, 1.19) | 1.11 (1.00, 1.23)* |
| **Offspring age** | 1.04 (1.04, 1.05)*** | 1.04 (1.04, 1.05)*** | 1.04 (1.04, 1.05)*** |
| **Offspring sex (**male vs. female**)** | 1.48 (1.40, 1.56)*** | 1.48 (1.41, 1.56)*** | 1.48 (1.40, 1.55)*** |
| **Offspring race (**white vs. non-white**)** | 0.99 (0.87, 1.13) | 1.00 (0.88, 1.13) | 1.04 (0.92, 1.18) |
| **Mother's age at baseline** [b] | 0.99 (0.99, 1.00) | 1.00 (0.99, 1.00) | 0.99 (0.98, 1.00)* |
| **Mother's race (**white vs. non-white**)** | 1.00 (0.78, 1.27) | 1.00 (0.79, 1.27) | 0.92 (0.74, 1.15) |
| **Mother's US social standing in adulthood** | | 0.96 (0.93, 0.98)** | 0.98 (0.95, 1.00)~ |
| **Mother's community social standing in adulthood** | | 0.99 (0.97, 1.01) | 1.00 (0.98, 1.03) |
| **Mother's childhood SES** [c] | | | |
| High school or less (ref) | | | |
| Some college | | 0.90 (0.84, 0.97)** | 0.91 (0.85, 0.97)** |
| College or more | | 0.85 (0.79, 0.91)*** | 0.89 (0.83, 0.95)*** |
| **Mother's BMI at baseline** [d] | | | 1.08 (1.07, 1.08)*** |

Note: Generalized estimating equations with Poisson distributions and log link were used in all models to estimate the risk ratio of overweight or obesity in offspring while adjusting for clustering by family, calculated using SAS PROC GENMOD.

[a] Mother's marital history was considered as a time-varying variable.

[b] Mother's age at baseline refers to participants' age in year 1989 in the Nurses' Health Study II.

[c] Mother's childhood SES was assessed with parents' highest education level recalled in the Nurses' Health Study II.

[d] Mother's BMI at baseline refers to participants' self-reported BMI in year 1989 in the Nurses' Health Study.

~ p≤ 0.10; * p≤ 0.05; **p≤ 0.01; ***p≤ 0.001;

In secondary analyses that examined specific dimensions of mother's marital history, frequency of mother's marital transitions, duration of mother being unmarried, and timing of mother's marital transition were all associated with offspring body weight in the fully-adjusted model (Table 2.3). Specifically, compared to those who never experienced maternal marital transition, offspring who experienced two or more transitions were at elevated risk of being overweight or obese (RR=1.13, 95% CI: 1.00, 1.28). There was also a modest (but not statistically significant) association with experiencing mother's marital transition one time. Next, compared to offspring with mothers who were consistently married, those whose mothers stayed unmarried for ≤ 8 years, 9-12 years or >12 years over the follow-up all had higher risk of being overweight or obese (e.g., $RR_{>12\ years}$=1.15, 95% CI: 1.01, 1.31). Contrary to our expectation, compared to offspring who never experienced mother's marital transition, those who experienced the first maternal marital transition in adolescence (RR=1.14, 95% CI: 1.01, 1.30) or adulthood (RR=1.13, 95% CI: 0.98, 1.30) had higher risk of being overweight or obese over the follow-up. However, experiencing mother's first marital transition in childhood did not seem to be associated with increased risk of unhealthy body weight in offspring (Table 2.3).

**Table 2.3 Specific dimensions of mother's marital history and offspring's risk of being overweight or obese across adolescence and young adulthood, Nurses' Health Study II (1989-2009) and Growing Up Today Study (1996-2010), N offspring=12,050, N observations (offspring)=87,323**

| | Risk ratio (95% CI) of being overweight or obese in offspring |
|---|---|
| **Frequency of mother's marital transition** [a] **(including both transition out of and into marriage)** | |
| Never experienced mother's marital transitions | Ref |
| Once | 1.06 (0.98, 1.15) |
| Two or more times | 1.13 (1.00, 1.28)* |
| **Duration of mother being unmarried** [a] | |
| 0 years (mother were consistently married) | Ref |
| ≤ 8 years | 1.10 (1.02, 1.18)* |
| 9-12 years | 1.18 (1.05, 1.31)** |
| >12 years | 1.15 (1.01, 1.31)* |
| **Timing of mother's first marital transition (offspring's age at mother's first marital transition)** | |
| Never experienced mother's marital transition | Ref |
| ≤ 12 years | 1.06 (0.95, 1.17) |
| 13-18 years | 1.14 (1.01, 1.30)* |
| >18 years | 1.13 (0.98, 1.30)~ |

Note: Generalized estimating equations with Poisson distributions and log link were used in all models to estimate the odds ratios of overweight and obesity in offspring while adjusting for clustering by family, calculated using SAS PROC GENMOD. All models adjusted for offspring's age, sex, race, mother's age, race, adulthood subjective SES, childhood SES, and BMI at baseline.

[a] Frequency of mother's marital transition and duration of mother being unmarried were both considered as time-varying variables.

~ p≤ 0.10; * p≤ 0.05; **p≤ 0.01; ***p≤ 0.001;

*Offspring risk of becoming overweight or obese in relation to mother's marital history*

A total of 8,911 offspring had normal body weight at baseline (i.e., in year 1996), and 2879 of them became overweight or obese during follow-up. Among offspring with normal weight at baseline, those whose mothers got remarried were at increased risk of becoming overweight or obese (HR=1.19, 95% CI: 1.00, 1.41) over the follow-up adjusting for demographics, compared to those whose mothers remained consistently married (Table 2.4, model 1). The association remained robust after further adjustment for maternal SES and baseline maternal BMI (Table 2.4, models 2-3). There was also a modest (but not statistically significant) association between maternal divorce/separation and increased risk of offspring becoming overweight or obese. However, there was no evidence of an association between mother's widowhood and offspring risk of becoming overweight or obese (Table 2.4), but it is worth noticing that the sample size of mothers who were ever-widowed in this sample was small (n=316).

**Table 2.4 Mother's marital history and the risk of becoming overweight or obese in offspring across adolescence and young adulthood among offspring with normal weight at baseline, Nurses' Health Study II (1989-2009) and Growing Up Today Study (1996-2010), N offspring=8,911, N observations (offspring)=67, 303**

| | The hazard ratio of incident overweight or obesity in offspring | | |
|---|---|---|---|
| | **Model 1** HR (95% CI) | **Model 2** HR (95% CI) | **Model 3** HR (95% CI) |
| **Mother's marital history (time-varying)**[a] | | | |
| Consistently married (ref) | | | |
| Divorced or separated | 1.08 (0.94, 1.23) | 1.06 (0.93, 1.21) | 1.08 (0.95, 1.23) |
| Widowed | 0.94 (0.60, 1.47) | 0.92 (0.59, 1.45) | 0.80 (0.51, 1.25) |
| Remarried | 1.19 (1.00, 1.41)* | 1.18 (1.00, 1.40)~ | 1.26 (1.06, 1.49)** |
| **Offspring age** | 1.07 (1.05, 1.09)*** | 1.07 (1.04, 1.09)*** | 1.06 (1.04, 1.09)*** |
| **Offspring sex (**male vs. female**)** | 1.86 (1.73, 2.01)*** | 1.87 (1.74, 2.02)*** | 1.88 (1.74, 2.02)*** |
| **Offspring race (**white vs. non-white**)** | 1.01 (0.85, 1.20) | 1.01 (0.85, 1.19) | 1.05 (0.88, 1.24) |
| **Mother's age at baseline** [b] | 0.99 (0.98, 1.00)* | 0.99 (0.98, 1.00)* | 0.98 (0.97, 1.00)** |
| **Mother's race (**white vs. non-white**)** | 1.19 (0.86, 1.65) | 1.20 (0.87, 1.66) | 1.07 (0.78, 1.48) |
| **Mother's US social standing in adulthood** | | 0.97 (0.94, 1.01) | 0.99 (0.95, 1.02) |
| **Mother's community social standing in adulthood** | | 0.99 (0.96, 1.02) | 1.00 (0.97, 1.03) |
| **Mother's childhood SES** [c] | | | |
| High school or less (ref) | | | |
| Some college | | 0.99 (0.91, 1.09) | 0.99 (0.91, 1.09) |
| College or more | | 0.88 (0.81, 0.97)** | 0.91 (0.83, 1.00)* |
| **Mother's BMI at baseline** [d] | | | 1.08 (1.07, 1.09)*** |

Note: All analyses were restricted to offspring participants with normal weight at baseline in year 1996 and with valid data on body weight at one or more waves during the follow up between years 1997 to 2010. Hazard ratios of incident overweight or obesity in offspring were estimated using Cox proportional hazard model, calculated using SAS PROC PHREG. There were 2879 events of incident overweight or obesity in offspring occurred during the follow-up.

[a] Mother's marital history was considered as a time-varying variable.

[b] Mother's age at baseline refers to participants' age in year 1989 in the Nurses' Health Study II.

[c] Mother's childhood SES was assessed with parents' highest education level recalled in the Nurses' Health Study II.

[d] Mother's BMI at baseline refers to participants' self-reported BMI in year 1989 in the Nurses' Health Study.

~ $p \leq 0.10$; * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$

*Discontinuity in offspring BMI trajectory before and after the onset of their mother's marital transition*

There were 2,067 offspring participants who ever experienced maternal martial transition over the course of this study. Prior to mother's marital transition, offspring BMI generally increased with time and the trend was nonlinear ($\beta_{time}$=0.84, 95% CI: 0.63, 1.06; $\beta_{time}^2$=-0.031, 95% CI: -0.032, -0.030) in the minimally-adjusted model (Table 2.5, model 1). After the onset of mother's first marital transition, offspring BMI rose at an even faster rate ($\beta_{time}$=1.67, 95% CI: 1.10, 2.23; $\beta_{time}^2$=-0.019, 95% CI: -0.020, -0.018) compared with the rate of change prior to the transition (Table 2.5, model 1). The association remained robust after further adjustment for maternal SES and baseline maternal BMI (Table 2.5, models 2-3).

**Table 2.5 Spline models of the relationship between mother's marital transition and offspring BMI trajectory across adolescence and young adulthood among offspring who experienced at least one maternal marital transition, Nurses' Health Study II (1989-2009) and Growing Up Today Study (1996-2010), N offspring=2,067, N observations (offspring)=174,130**

| | Offspring BMI | | |
|---|---|---|---|
| | Model 1 [a] | Model 2 [b] | Model 3 [c] |
| | β (95% CI) | β (95% CI) | β (95% CI) |
| **Intercept** | 15.19 (12.55, 17.83)*** | 14.24 (11.34, 17.14)*** | 10.24 (7.08, 13.39)*** |
| **Slope** | | | |
| Before onset of mother's marital transition | | | |
| The linear term | 0.84 (0.63, 1.05)*** | 0.85 (0.62, 1.08)*** | 0.66 (0.40, 0.91)*** |
| The squared term | -0.031 (-0.032, -0.030)*** | -0.031 (-0.032, -0.030)*** | -0.031 (-0.032, -0.030)*** |
| After onset of mother's marital transition | | | |
| The linear term | 1.67 (1.10, 2.23)*** | 1.64 (1.02, 2.26)*** | 1.59 (0.91, 2.27)*** |
| The squared term | -0.019 (-0.020, -0.018)*** | -0.019 (-0.020, -0.018)*** | -0.019 (-0.020, -0.018)*** |

Note: All analyses only included offspring participants who ever experienced mother's marital transitions (including both transition out of and into marriage) during the time from year 1996 through 2010. Inflection is set at the onset of mother's marital transition.

a. Model 1 included mother's marital transition, offspring age, sex, race, mother's age and race as covariates.

b. Model 2 further adjusted for mother's adulthood subjective SES and mother's childhood SES.

c. Model 3 additionally adjusted for mother's BMI at baseline in year 1989.

~ p≤ 0.10; * p≤ 0.05; **p≤ 0.01; ***p≤ 0.001

**Discussion**

The present study found that offspring whose mothers were divorced/separated or remarried had increased risk of being overweight/obese compared to offspring whose mothers was consistently married, adjusting for demographic characteristics, mother's SES and baseline BMI. There was also some evidence of an increased risk of offspring being overweight or obese associated with mother's being widowed, but the association was attenuated after adjustment for mother's baseline BMI. We also found that among offspring with normal weight at baseline, those whose mothers remarried had increased risk of becoming overweight or obese during follow-up compared to offspring whose mothers remained consistently married. In addition, among offspring who ever experienced a maternal marital transition, their BMI rose at a faster rate after the onset of their mother's first marital transition compared to rate of BMI increase prior to the transition. In secondary analyses that examined specific dimensions of mother's marital history, offspring who experienced two or more maternal marital transitions or those who experienced mother's first marital transition in adolescence or young adulthood all had increased risk of being overweight/obese, compared to their peers who never experienced a maternal marital transition. Moreover, offspring whose mother was unmarried for less than 8 years, 9-12 years or more than 12 years all had elevated risk of being overweight/obese over the follow-up, compared to their counterparts whose mother remained consistently married.

Consistent with prior work,[26,28] having a mother who was consistently married was associated with better offspring health outcomes compared to other types of maternal marital history. Researchers posited that offspring who grow up in households with parents who are consistently married tend to have stable financial conditions, observe positive social exchanges, receive effective parenting, and therefore are more likely to develop social competency and

healthy behaviors.[26,28] In contrast, any type of marital instability – be it marital dissolution or reunion – may introduce stress into the mother's life that could trickle down to the offspring.[46] For instance, marital dissolution is often preceded by family conflict and chaos, and then followed by parental distress, financial hardships and coercive or neglectful parenting.[47,48] Offspring's chronic exposure to these family dysfunctional processes has been linked to decreased sense of emotional security, and increased risk of internalizing disorders (e.g., depression), externalizing behaviors (e.g., lack of self-regulation), less frequent family meals and longer hours of screening time, each of which has been identified as a risk factor for childhood obesity.[48] In terms of marital reunion, prior evidence showed that remarriage may not necessarily offset the elevated health risks associated with marital dissolution.[49,50] Maternal remarriage can lead to changes in family environment, which may entail repeated negotiations and adjustment to new family rules and expectations that in turn disrupt offspring health.[26] In the present study we sought to capture potentially acute responses among offspring to maternal marital transition via the piecewise regression analyses. These findings indicated that offspring do seem to have acute changes in BMI directly after maternal transition, demonstrating more rapid weight gain after versus before a maternal marital transition. In these models, maternal marital transitions included both marital dissolution and reunion.

Contrary to our expectation, we did not observe substantially increased risk of offspring overweight or obesity associated with maternal widowhood. It may be that there were only a small number of ever widowed mother in our sample (n=316) and if effects are small, we had only limited statistical power to observe an association. It is also possible that divorce/separation is often accompanied by long term marital distress and family dysfunctions before and after the marital dissolution, whereas widowhood is more likely to entail acute short-term stress.[49] It was

also unexpected that among offspring with normal weight at baseline, those whose mothers remarried had higher risk of becoming overweight or obese, but those whose mothers divorced or separated were not at elevated risk compared to offspring of consistently married mothers. One possible reason is that a considerable proportion (22.98%) of the mothers who were ever divorced/separated (n=2,250) during the entire study period reported being divorced/separated at baseline (n=517). The maternal divorce/separation reported at baseline may have exerted effects on offspring body weight by the time offspring was recruited into the study. In comparison, maternal remarriage was only assessed during the follow-up period. Therefore, we may be more likely to observe effects of maternal remarriage compared to maternal divorce/separation.

Findings in this study suggested that every facet of maternal marital trajectory exerted effects on offspring body weight. For instance, the increased risk of unhealthy body weight was particularly pronounced in offspring who experienced multiple maternal marital transitions. This is consistent with prior findings that offspring who experienced multiple family structure changes were more likely to have compromised well-being, compared to those who experienced no family structure change or only one change.[28,51] Also, adverse effects that follow marital dissolution and reunion may dissipate over time. However, families that undergo structure changes multiple times may fail to restore to adaptive functioning states, thus creating a family environment characterized by perpetual chaos and unpredictability.[52] We also found evidence that longer duration of staying in single-parent family was associated with higher risk of being overweight or obese in a nearly monotonic fashion. The household production theory[36,53] posits that households headed by single mothers have fewer economic and parenting resources available for offspring development, and the magnitude of the adverse effects may increase with the duration of household resource scarcity. In the absence of the father, single mothers' labor

market roles would compete with their childrearing responsibility, which may impede providing effective child care and monitoring.

Contrary to our expectation, experiencing a first maternal marital transition in childhood was not associated with elevated risk of overweight or obesity in offspring, but experiencing mother's first marital transition in adolescence or young adulthood was. In fact, this is consistent with some prior evidence that potential adverse effects of parental marital dissolution occurring in offspring's childhood may not manifest until adolescence or young adulthood,[54] and adjusting to parents' remarriage might be more challenging for adolescents than young children.[55] Adolescence is a critical period of emerging autonomy and independence.[28] Changes in family structure during this period may be particularly disruptive for offspring's development.[47] Potentially weakened parental monitoring may also account for the increased unhealthy stress-coping behaviors in adolescents and young adults, compared to young children. We also speculate that parents in unsatisfactory marriage may withhold their dissolution until their offspring reached late adolescence or young adulthood, hoping to minimize the negative effects on young children. In this case, those offspring experiencing marital dissolution in adolescence or later may have experienced a stressful marital relationship earlier in life that exposes them to long-term distress and conflicts, which may lead to even more adverse consequences.

This study has several limitations to consider. First, mother's current marital status was queried every four years. We may not capture multiple marital changes occurred between assessment if any, and we did not have information on the specific timing of the occurrence of the transitions, which may lead to misclassifications in mother's marital history. Second, findings may not be generalizable as the NHSII cohort along with their offspring does is

comprised of mostly white nurses. Moreover, participants in this study may have more stable marriage and better health compared to the general population.

The study also has some important strengths. It is the first study that links maternal marital history to offspring body weight, and we investigated the association using prospective data and a number of rigorous analytic approaches. The long follow-up period allows us to examine the long-term effects of maternal marital history from a lifecourse perspective across offspring's late childhood throughout young adulthood. Second, our study examined effects of multiple facets of maternal marital trajectories on offspring body weight from a life course perspective, and moved beyond taking a static view of marital status at a single time point.

Important next steps following this study include studying potential pathways linking maternal marital history to offspring body weight, investigate whether and how parental marital history may affect other health outcomes in offspring, and examining potential resources that may help buffer adverse effects of family dysfunctions on offspring development. This line of research may help pediatricians identify vulnerable groups at high risk of developing childhood obesity and other adverse health outcomes, and inform the development of targeted interventions. It is imperative to implement effective family policies to provide economic security and social support for children experiencing family structure changes,[47] which may open new avenues of controlling the obesity epidemic and help reduce health disparities.

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**Supplementary Materials**

**Table S2.1 Characteristics of mother's marital history over the follow-up, Nurses' Health Study II (1989-2009) and Growing Up Today Study (1996-2010), N mothers = 9,015, N offspring = 12,050**

| Characteristics | N offspring (%) |
|---|---|
| **Mother marital history** | |
| Consistently married | 9533 (79.11) |
| Consistently unmarried | 162 (1.34) |
| Ever unmarried and never remarried | 1195 (9.92) |
| Ever unmarried but then remarried | 1160 (9.63) |
| **Frequency of mother's marital transitions (including both transition into and out of marriage)** | |
| 0 times (consistently married or consistently unmarried) | 9695 (80.46) |
| 1 time | 1452 (12.05) |
| 2 times | 765 (6.35) |
| 3+ times | 138 (1.15) |
| **Frequency of mother's marital transitions into marriage** | |
| 0 times (consistently married or unmarried, or become unmarried but never remarried) | 10866 (90.17) |
| 1 time | 1126 (9.34) |
| 2 + times | 58 (0.48) |
| **Frequency of mother's marital transitions out of marriage** | |
| 0 times (consistently married or unmarried, or unmarried at baseline but then remarried) | 9974 (82.77) |
| 1 time | 1952 (16.20) |
| 2 + times | 124 (1.03) |
| **Duration of mother being unmarried** | |
| 0 years (consistently married) | 9533 (79.11) |
| <=8 years | 1447 (12.01) |
| 9-12 years | 413 (3.43) |
| >12 years | 657 (5.45) |
| **Timing of mother's first marital transition (offspring participant's age at his/her mother's first marital transition)** | |
| Never experienced mother's marital transition | 9695 (80.46) |
| <=12 years | 1068 (8.86) |
| 13-18 years | 703 (5.83) |
| >18 years | 584 (4.85) |

Note: Percentages refer to the proportion of the offspring participants within each category of mother's marital history characteristics.

## STUDY 3. Marital Quality and Body Weight

**Title:** Marital Quality and Body Weight in Mid-life: A 10-year Prospective Study

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**Abstract**

Prior evidence suggested that the effect of being married on body weight may provide an exception to the general pattern that being married is health protective. Recent research has begun to suggest that the nurturing aspect of the relationship is what provides the critical health protective component. However, few studies have gone beyond studying marital status to examine effects of marital quality on body weight.

This study examined the prospective association between marital quality and body weight in mid-life, based on data from the Midlife in the United States (MIDUS) study. In addition, it sought to differentiate effects of positive and negative components of marital quality including the overall marital quality, marital support (positive component) and marital strain (negative component). It also investigated possible interaction between marital quality and gender.

The lowest versus highest level of baseline overall marital quality was associated with higher obesity incidence in the base model (RR=1.33, 95% CI: 1.00, 1.76). However, the association was attenuated in the fully-adjusted model (RR=1.25, 95% CI: 0.94, 1.67). The analyses on weight change yielded similar results. Each lower quartile of baseline marital support was associated with higher obesity incidence compared to the top quartile (e.g., RR=1.56, 95% CI: 1.17, 2.08 for the lowest versus highest quartile of marital support). There was also an inverse association between marital support and subsequent weight change. Sensitivity analyses with the continuous marital support score yielded similar results. This study did not find an association between marital strain and obesity incidence or weight change. There was no evidence of an interaction between marital quality and gender.

Contrary to our expectation, this study demonstrated that a nurturing marital relationship was associated with healthier weight in mid-life. It adds to the evidence that nurturing social

relationships may serve as a health asset. It differentiated multiple aspects of marital quality, and suggested that marital support and marital strain are not simply two measures of the same construct. This study paves the way for future studies on potential pathways underlying the association, and highlights the importance of involving the spouse/partner in obesity prevention and control.

## Introduction

Numerous public health interventions have sought to control the obesity epidemic, but the prevalence of obesity remains high. In 2011-2012, 34.9% of the adults in the U.S. were obese.[1] A number of biological, behavioral, and psychosocial risk factors for obesity have been identified including genetic predisposition,[2,3] unhealthy life styles,[4,5] depression[6] and low socioeconomic status (SES).[7] In addition, evidence has increasingly suggested that poor social relationships may also contribute to unhealthy body weight.[8] For instance, a prospective study of 227 young African Americans found an association between low maternal support reported in adolescence and greater increase in BMI over the 12-year follow-up in women.[9]

Being nurtured and having positive social relationships have been linked to better health outcomes generally. As a result, investigators have begun to consider having positive social relationships as a health asset, a protective factor that reduces risk of adverse health outcomes across a range of endpoints.[10] The marital relationship, the primary and most intimate social relationship for most adults,[11] represents a critical source for health assets of this nature in adulthood. While much of the work in this area has examined effects of marital status per se, some research has focused on marital quality, arguing that the nurturing aspect of the relationship rather than status is what provides the critical health protective component. Empirical evidence examining status and quality suggests that being married and having nurturing marital relationship confer benefits on a number of health outcomes such as lower mortality and lower risk of developing metabolic syndromes.[12-14]

Based on these prior findings, we might expect that such relationships would also increase likelihood of maintaining a healthy body weight. However, evidence to date suggests that the effect of being married on body weight may provide an exception to the general pattern

of findings (i.e., being married is a health asset). Specifically, prior work has found that entering marriage is associated with subsequent weight gain whereas marital dissolution is often associated with subsequent weight loss.[15] For example, a prospective study of 80,944 initially married women with a 4-year follow-up showed that those who got divorced or became widowed had greater weight loss and increased physical activity compared to women who remained married.[16] Another prospective study of 38,865 men found that marital dissolution was associated with weight loss, whereas remarriage was related to weight gain and decreased physical activity over the 4-year follow-up.[17] Researchers proposed the following pathways to understand the surprising negative associations: 1) transition into marital roles encourages regular meals, which may increase food intake;[18] 2) Marital obligations compete with opportunities for individual activities leading to reduced physical activity;[19] 3) Married individuals tend to quit smoking, which leads to weight gain;[20] 4) Individuals ending a marriage pay more attention to weight control as they return to the mating market.[21,22]

Recent research has begun to suggest that having a high quality marital relationship rather than the mere presence of a spouse or partner is the essential ingredient providing health benefits.[23] However, few studies have gone beyond studying marital status to examine effects of marital quality on body weight. Marital quality is defined as "subjective evaluation of the relation with spouse/partner".[24] In prior research, factor analysis of items describing a variety of aspects of marital quality suggested marital quality is a two-dimensional construct comprised of positive (such as marital support and marital communication) and negative (such as marital strain and marital disagreement) components. [25] Other work has also found that the positive and negative components of marital quality appear to be orthogonal, [26] and therefore studies of marital quality must consider both.[12] The most extensively studied positive aspect of marital

quality is marital support defined as "the perceived availability of support and empathy from one's spouse or partner".[27] Marital support has been linked to better health outcomes such as less depressive symptoms[28] and lower levels of inflammation in women.[29] The most studied negative component of marital quality is marital strain defined as "experience of psychological distress caused by the negative behaviors or demands from one's spouse/partner".[30] Higher marital strain has been linked with adverse health outcomes such as higher risk of incident coronary heart disease[31] and lower self-rated health.[32]

Competing hypotheses have been proposed to predict the association between marital quality and body weight, although they have seldom been tested in empirical data. One hypothesis is derived from a health regulation model, and suggests that a nurturing marital relationship facilitates a behavioral regulatory function of marriage – spouses tend to encourage each other to engage in healthy behaviors and avoid unhealthy practices,[33] which in turn leads to healthier weight.[24,34] In a non-nurturing marriage, marital strain can lead to increased stress, interfering with behavioral regulation, and this would likely result in weight gain.[21,34] In contrast, there is a mating market model which posits maintaining healthy weight is primarily driven by the motivation to attract a mate. Following this reasoning, individuals who are satisfied with their marriage will relax efforts to maintain a healthy diet and exercise, since they already have a desirable mate. By extension, those in a stressful marital relationship may prioritize weight maintenance as a result of an underlying sense that the marriage may not survive and therefore they may subsequently need to attract a new mate.[24,25]

To our knowledge, only one empirical study has examined the association between marital quality and body weight, and the findings supported the mating market model. This study recruited 169 newlywed couples (most were graduate students) who were followed biannually

for 4 years.[21] Growth curve analyses showed that marital satisfaction was positively associated with weight gain over time. However, the study had several limitations. First, the sample size was small, and participants were newlywed young couples who generally had healthy body weight. It is possible that the association of interest may differ across life stages, and findings of the study may not apply to other age groups. For instance, evidence from other studies showed that the marital relationship becomes more salient to individuals as they age,[35] and patterns of weight change may also vary across the life course.[36] Second, the study considered marital quality as a one-dimensional construct, and did not differentiate effects of different aspects of marital quality. Prior research has suggested that different components of marital quality may exert independent effects on health through different mechanisms.[12] Also, body weight was self-reported and was not validated against measured weights. It is possible that participants underreported their body weight due to social desirability.

A number of clinical studies suggested that marital quality may exert greater effects in women than men on some health outcomes such as survival from heart failure.[37] Based on prior studies finding that relative to men women exhibited greater emotional and physiological responses in marital disputes, investigators have posited that women may be more sensitive than men are to quality of the marital relationship.[38] However, to our knowledge whether gender may also modify the association between marital quality and body weight has never been investigated.

To address these knowledge gaps, this study aimed to investigate the prospective association between marital quality and body weight in mid-life. Using data from the Midlife in the United States (MIDUS) study, this study sought to differentiate effects of positive and negative components of marital quality including the overall marital quality, marital support (positive component) and marital strain (negative component). We accounted for potential

confounders that have been previously linked to marital quality and/or body weight including sociodemographic characteristics,[21] baseline chronic health conditions,[44,45] depression,[28,39] and health behaviors.[21,40] We note that baseline health conditions and health behaviors may lie on the pathways from marital quality to body weight.[21] However, we considered them as confounders rather than mediators since health conditions and health behaviors were assessed concurrently with marital quality in this study. To account for the possibility that baseline marital quality may be a proxy for subsequent marital status change, we further adjusted for marital status change over the course of follow-up as a covariate in sensitivity analyses.

Following the mating market model, we hypothesized that overall marital quality and marital support would be each associated with weight gain and higher risk of incident obesity, whereas marital strain would be related to weight loss and lower risk of incident obesity, and the effects of marital support and strain would be independent of each other. We also examined possible interaction between marital quality and gender in relation to body weight as a secondary analysis. We further hypothesized that the association between marital quality and body weight would be stronger in women than men.

## Methods

### Sample and study design

Data are from the Midlife in the United States (MIDUS) study. The MIDUS study is an ongoing prospective study, initiated between 1994 and 1995 to examine effects of psychosocial factors on health and well-being in a middle-aged population of U.S. adults. At the first phase (MIDUS I), 7,108 non-institutionalized individuals between 25 and 74 years old were recruited

through random digit dialing from across the U.S. Participants included 950 siblings and 957 twin pairs.[41] The second phase of the study (MIDUS II) was conducted between 2004 and 2005, and around 70% (N=4,963) of the original participants were followed up.[42] Compared to those who were lost to follow-up at MIDUS II, participants who remained in the cohort were more likely to be female, white, highly-educated and have high income. A subgroup of the respondents (N=1,255) who were healthy enough to travel participated in a biomarker project during this second phase. These participants had similar sociodemographic characteristics to non-participants, except they were more highly educated.[43]

At MIDUS I, participants reported their marital status. Those who were currently married or in a marriage-like relationship further answered questions about quality of the relationship with their spouse/partner. Measures of body weight were obtained through self-reports at both phases of the study.

The analytic sample for this study was drawn from respondents who participated in both phases of the MIDUS study (N=4,963). Since marital quality was only queried in participants who reported being married or in a marriage-like relationship, those who reported being unmarried and not in a relationship at MIDUS I were excluded (N=1,261). Participants were additionally excluded for the following reasons: missing data on any baseline marital quality measures (N=242); missing data on body weight measures at either MIDUS I or MIDUS II (n=754); missing information on any covariates (n=39). This resulted in a final analytic sample of 2,667 respondents with 195 of them either siblings or twins. Compared to participants excluded from the analytic sample, those who were included tended to be older, male, white, highly-educated, have higher income, and were less likely to be depressed, heavy drinkers,

current smokers, or physically inactive (Table S3.1). The study was approved by Institutional Review Boards at participating institutions, and participants provided written informed consent.

**Measures**

Exposures

*Overall marital quality.* Following prior work,[44] overall marital quality was assessed with a single question at MIDUS I which requested participants to rate the relationship with their spouse/partner. Response options ranged from 1: excellent to 5: poor. Responses were reverse coded so that a higher score represents higher marital quality.

*Marital support.* Following prior work,[29,44,45] marital support was measured with a validated six-item Spouse/Partner Support Scale[46] (Table S3.2) at MIDUS I. The scale assessed helpful and caring behaviors from the spouse/partner (e.g., "How much does your spouse or partner really care about you?"). Response options ranged from 1: a lot to 4: not at all. Responses were reverse coded so that a higher score represented greater support. An overall marital support score was calculated as the mean across the six items, and quartiles of the marital support score were also created. The internal consistency reliability of the scale was high ($\alpha = .90$).

*Marital strain.* Following prior work,[29,44,45] marital strain was measured with a validated six-item Spouse/Partner Strain Scale[46] (Table S3.2) at MIDUS I that queried demands and negative behaviors from the spouse/partner (e.g., "How often does your spouse or partner make too many demands on you?"). Response options ranged from 1: often to 4: never. Responses were reverse coded so that a higher score represented greater strain. An overall marital strain score was calculated as the mean of the six items, and quartiles of the marital strain score were

also created based on the distribution of scores in the sample. The internal consistency reliability of the scale was good ($\alpha = .87$).

Outcomes

*Body weight measures*. At both waves participants self-reported their current height (in inches) and weight (in pounds). Body mass index (BMI, $kg/m^2$) was calculated at both waves based on self-reported height and weight. BMI $\geq 30$ $kg/m^2$ was defined as obese, and BMI $< 30$ $kg/m^2$ as non-obese.[47] Weight change between waves was calculated by subtracting weight at wave I from weight at wave II, and was considered as a continuous score (mean=6.47 pounds, SD=16.59). As the biomarker project participants (N=1255) received a physical exam, their self-reported weight was compared with the measured weight, and demonstrated good concordance (r=0.95). Weight change was winsorized at the 1st and 99th percentiles to minimize possible influence of extreme outliers.

Covariates

*Sociodemographic characteristics.* At MIDUS I, participants self-reported their age (in years), gender (male, female), race (white, black, other races), highest education level (less than high school, high school, some college and college or more), household income (in U.S. dollars, income greater than $300,000 was winsorized as $300,000 to minimize risk of deductive disclosure, quartiles of household income were created), and relationship status (married, in partnership).

*Health conditions.* Past-year major depression was measured with the 19-item Composite International Diagnostic Interview Short Form (CIDI-SF)[48,49] at MIDUS I. Diagnosis of major depression requires presence of either depressed affect or anhedonia at least most of the day,

nearly every day for two weeks, and report of four or more accompanying symptoms (such as loss of interests, fatigue, changes in appetite and sleep problems). Test-retest reliability and clinical validity of the CIDI-SF has been demonstrated in prior work.[50,51] Participants' medical history was also queried at MIDUS I. Those who reported at least one of the following conditions were considered as having chronic conditions: ever had cancer, heart attack, stroke, diabetes, or taking medications for controlling heart problems or diabetes.

*Health behaviors.* Current smoking and drinking status were queried at MIDUS I. Participants who reported smoking cigarettes regularly at the time of assessment were considered as current smokers. Respondents who ever regularly had at least one drink for three or more days per week were considered as heavy drinkers. Frequency of moderate physical activity (e.g., bowling or using a vacuum cleaner) and vigorous physical activity (e.g., running or lifting heavy objects) were also reported at MIDUS I. Responses ranged from 0 to 14 times/month, and were considered as continuous variables.

**Statistical Analyses**

All statistical analyses were performed in SAS 9.3. Generalized linear models were first used to examine the distribution of baseline levels of marital support and marital strain by participant characteristics.

To investigate whether baseline marital quality was associated with incidence of obesity over the follow-up among participants who were non-obese at baseline (n=2124), generalized estimating equations (GEE) with binomial distribution and log link were used. Tertiles of baseline overall marital quality, quartiles of marital support and marital strain were considered as independent variables in separate models, and all models adjusted for clustering by family. A

series of these GEE models were used to investigate the effect of confounders. The base model controlled for sociodemographic factors including participants' age, sex, race, educational attainment, household income and initial relationship status (married or in partnership). A second model further adjusted for baseline health conditions including major depression and other weight-related chronic conditions. A third, fully adjusted model additionally took into account baseline health behaviors including heavy drinking, current smoking, and moderate and vigorous physical activity. The primary sets of models were reanalyzed with the continuous scores of baseline overall marital quality, marital support, and marital strain as the independent variables. We also followed a similar modeling strategy but with normal distribution and identity link, considering weight change as the dependent variable and adjusting for height in the full analytic sample (n=2667). To account for the possibility that baseline marital quality may be a proxy for subsequent marital status change (remained married or in partnership vs. become unmarried or exit the partnership), marital status change was further added as a covariate to the fully-adjusted model as a sensitivity analysis.

To investigate whether gender would modify the association between marital quality and weight change, we examined interaction terms of gender with baseline overall marital quality, marital support and marital strain in separate fully-adjusted GEE models.

## Results

### *Descriptive Analyses*

The prevalence of obesity increased from 20.36% to 27.56% over the follow-up, and the average weight change was 6.47 pounds (SD=16.59). At baseline, participants generally reported

high levels of overall marital quality (mean=3.98, SD=0.98), marital support (mean=3.64, SD=0.52) and low levels of marital strain (mean=2.20, SD=0.59). Participants were predominantly white (95.28%), higher percentage female (51.56%), and most had at least a high school degree (65.88%). Around 10.12% of the participants (N=270) became unmarried or had exited the marriage-like relationship at follow up.

Participants who were older, male and white were more likely to report higher marital support and lower marital strain at baseline. In comparison, those who were depressed, current smokers, heavy drinkers and physically inactive tended to report lower baseline marital support and/or greater marital strain. There was no clear association between socioeconomic indicators and baseline marital quality (Table 3.1).

**Table 3.1 Participant marital quality by socio-demographic and health-related characteristics in the full sample (N=2667)**

| | Marital support | | Marital strain | |
|---|---|---|---|---|
| | Mean (SE) | p | Mean (SE) | p |
| **Age (years)** | | 0.02 | | 0.01 |
| 20-39 | 3.63 (0.48) | | 2.21 (0.58) | |
| 40-49 | 3.56 (0.54) | | 2.25 (0.59) | |
| 50-59 | 3.62 (0.54) | | 2.15 (0.60) | |
| 60-69 | 3.66 (0.52) | | 2.16 (0.61) | |
| 70+ | 3.64 (0.59) | | 2.17 (0.57) | |
| **Gender** | | <0.001 | | 0.003 |
| Male | 3.68 (0.46) | | 2.17 (0.55) | |
| Female | 3.56 (0.55) | | 2.23 (0.63) | |
| **Race** | | 0.08 | | 0.31 |
| White | 3.62 (0.52) | | 2.20 (0.59) | |
| Black | 3.52 (0.65) | | 2.29 (0.70) | |
| Other races | 3.50 (0.64) | | 2.13 (0.61) | |
| **Education level** | | 0.42 | | 0.85 |
| <HS | 3.63 (0.52) | | 2.17 (0.64) | |
| HS | 3.59 (0.56) | | 2.20 (0.62) | |
| Some College | 3.61 (0.51) | | 2.21 (0.58) | |
| ≥ College | 3.63 (0.50) | | 2.20 (0.57) | |
| **Income** | | 0.51 | | 0.99 |
| Bottom quartile | 3.58 (0.59) | | 2.20 (0.65) | |
| Second quartile | 3.60 (0.54) | | 2.20 (0.60) | |
| Third quartile | 3.63 (0.50) | | 2.19 (0.57) | |
| Top quartile | 3.62 (0.50) | | 2.20 (0.58) | |

**Table 3.1 (Continued).**

| | | | | |
|---|---|---|---|---|
| **Relationship status** | | 0.09 | | 0.67 |
| Married | 3.61 (0.53) | | 2.20 (0.59) | |
| In partnership | 3.69 (0.43) | | 2.18 (0.64) | |
| **Depression** | | 0.0002 | | <0.001 |
| Yes | 3.50 (0.57) | | 2.39 (0.64) | |
| No | 3.63 (0.52) | | 2.18 (0.58) | |
| **Chronic condition** | | 0.31 | | 0.62 |
| Yes | 3.59 (0.57) | | 2.21 (0.65) | |
| No | 3.62 (0.51) | | 2.20 (0.58) | |
| **Current smoker** | | 0.04 | | 0.93 |
| Yes | 3.57 (0.59) | | 2.20 (0.65) | |
| No | 3.62 (0.51) | | 2.20 (0.58) | |
| **Heavy drinker** | | 0.28 | | 0.002 |
| Yes | 3.60 (0.52) | | 2.24 (0.59) | |
| No | 3.62 (0.52) | | 2.17 (0.59) | |
| **Moderate activity** | | 0.0003 | | 0.09 |
| Bottom tertile | 3.56 (0.57) | | 2.23 (0.61) | |
| Middle tertile | 3.60 (0.54) | | 2.20 (0.61) | |
| Top tertile | 3.65 (0.49) | | 2.18 (0.58) | |
| **Vigorous activity** | | <.0001 | | 0.001 |
| Bottom tertile | 3.54 (0.57) | | 2.25 (0.61) | |
| Middle tertile | 3.60 (0.52) | | 2.20 (0.61) | |
| Top tertile | 3.68 (0.47) | | 2.15 (0.55) | |

Note: generalized linear models were used to calculate the mean values of marital quality by categories of participant characteristics.

*Baseline overall marital quality and body weight over follow-up*

The lowest versus highest level of baseline overall marital quality was associated with higher risk of incident obesity in the base model (RR=1.33, 95% CI: 1.00, 1.76). However, the association was attenuated after further adjustment for health conditions and then additionally adding health behaviors (RR=1.25, 95% CI: 0.94, 1.67). There was no evidence of elevated risk of incident obesity associated with the middle tertile of overall marital quality compared to the top tertile. When considering continuous overall marital quality score, a one unit increase in overall marital quality was associated with a 10% reduced risk of becoming obese over follow-up in the base model (RR=0.90, 95% CI: 0.81, 1.00). However, the association was slightly attenuated in the fully-adjusted model (RR=0.92, 95% CI: 0.82, 1.03).

Similar to findings with incident obesity, there was weak evidence that the lowest versus highest level of baseline overall marital quality was associated with greater weight gain over follow-up in the fully-adjusted model (β=1.42, 95% CI: -0.15, 2.98). There was no evidence that the middle tertile of overall marital quality was associated with greater weight gain compared to the top tertile in any model. Analyses with the continuous overall marital quality score yielded similar results (e.g., β=-0.59, 95% CI: -1.25, 0.08 in the fully-adjusted model).

*Baseline marital support and body weight over follow-up*

Compared to the top quartile, each lower quartile of baseline marital support was associated with 47%-63% higher risk of incident obesity in the base model (table 3.2, model 1). The association remained robust after further adjustment for health conditions and then additionally adding health behaviors (Table 3.2, models 2-3). The effect of marital support was maintained when marital status change was included as a covariate (RR=1.64, 95% CI: 1.23,

2.19 for the lowest versus highest level of marital support; p for trend: 0.002). Analyses with the continuous marital support score yielded similar results. Specifically, a one unit increase in marital support was associated with 21% reduced risk of incident obesity in the base model (RR=0.79, 95% CI: 0.66, 0.95). The association remained unchanged after further adjustment for health conditions and then additionally adding health behaviors (RR=0.81, 95% CI: 0.67, 0.98). When baseline marital support and marital strain were simultaneously included in the model, there was still an independent effect of marital support (RR=0.81, 95% CI: 0.67, 0.98).

**Table 3.2 Marital support at baseline and incidence of obesity at follow-up among initially non-obese participants (N=2124)**

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| | RR (95% CI) | RR (95% CI) | RR (95% CI) |
| **Marital support** | | | |
| Bottom quartile (vs. top quartile) | 1.63 (1.23, 2.17)*** | 1.61 (1.21, 2.14)** | 1.56 (1.17, 2.08)** |
| Second quartile (vs. top quartile) | 1.42 (1.05, 1.92)* | 1.40 (1.03, 1.90)* | 1.35 (0.99, 1.83)~ |
| Third quartile (vs. top quartile) | 1.47 (1.07, 2.01)* | 1.47 (1.07, 2.01)* | 1.45 (1.06, 1.97)* |
| *p for trend* | 0.002 | 0.003 | 0.008 |
| **Age** (years) | 0.98 (0.97, 0.99)*** | 0.98 (0.97, 0.99)*** | 0.98 (0.97, 0.99)*** |
| **Female** (vs. male) | 0.94 (0.75, 1.18) | 0.92 (0.73, 1.16) | 0.91 (0.72, 1.15) |
| **Race** | | | |
| Black (vs. white) | 1.25 (0.62, 2.54) | 1.27 (0.62, 2.60) | 1.23 (0.61, 2.45) |
| Other races (vs. white) | 1.20 (0.61, 2.34) | 1.21 (0.61, 2.38) | 1.13 (0.56, 2.27) |
| **Education level** | | | |
| HS (vs. <HS) | 0.91 (0.69, 1.19) | 0.90 (0.69, 1.19) | 0.76 (0.49, 1.19) |
| Some College (vs. <HS) | 0.55 (0.40, 0.75)*** | 0.55 (0.40, 0.76)*** | 0.67 (0.43, 1.06)~ |
| ≥ College (vs. <HS) | 1.34 (0.87, 2.07) | 1.29 (0.83, 2.01) | 0.40 (0.24, 0.64)*** |
| **Income** | | | |
| Second vs. bottom quartile | 0.81 (0.54, 1.22) | 0.80 (0.53, 1.20) | 1.23 (0.81, 1.86) |
| Third vs. bottom quartile | 0.96 (0.71, 1.31) | 0.96 (0.70, 1.30) | 1.31 (0.87, 1.98) |
| Top vs. bottom quartile | 1.00 (0.76, 1.33) | 1.00 (0.75, 1.33) | 1.30 (0.86, 1.96) |

**Table 3.2 (Continued).**

| | | | |
|---|---|---|---|
| **Married** (vs. in partnership) | 0.75 (0.49, 1.15) | 0.77 (0.50, 1.20) | 0.71 (0.46, 1.09) |
| **Depressed** (yes vs. no) | | 1.17 (0.83, 1.64) | 1.20 (0.86, 1.67) |
| **Chronic condition** (vs. no) | | 1.44 (1.06, 1.96)* | 1.44 (1.05, 1.96)* |
| **Current smoker** (vs. no) | | | 0.64 (0.46, 0.89)** |
| **Heavy drinker** (yes vs. no) | | | 1.02 (0.81, 1.29) |
| **Moderate activity** (times/m) | | | 0.99 (0.96, 1.02) |
| **Vigorous activity** (times/m) | | | 0.99 (0.97, 1.02) |

Note: Generalized estimating equations with binomial distribution and log link were used in all models to estimate the risk ratio of obesity by marital support at baseline, adjusting for clustering by family. Model 1 adjusted for socio-demographic factors. Model 2 additionally adjusted for health conditions. Model 3 further controlled for health behaviors. ***p<0.001; **p<0.01; *p<0.05; ~P<0.10.

There was weaker evidence of an inverse association between levels of baseline marital support and subsequent weight change. Specifically, the bottom and second quartile of baseline marital support was associated with marginally increased weight gain compared to the top quartile across all models (Table 3.3, models 1-3). When marital status change between waves was included as a covariate, the effect of baseline marital support became slightly stronger (β=1.67, 95% CI: 0.005, 3.34 for the lowest versus highest level of marital support; p for trend: 0.07). In comparison, the analyses with the continuous marital support score revealed a strong inverse association between baseline marital support and subsequent weight change in the base model (β=-1.50, 95% CI: -2.76, -0.23). The association remained robust after further adjustment for health conditions and then additionally adding health behaviors (β=-1.43, 95% CI: -2.72, -0.15). When baseline marital support and marital strain were simultaneously included in the model, the effect of marital support on weight change remained unchanged (β=-1.43, 95% CI: -2.72, -0.15).

**Table 3.3 Marital support at baseline and weight change (in pounds) over the follow-up period (N=2667)**

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| | β (95% CI) | β (95% CI) | β (95% CI) |
| **Marital support** | | | |
| Bottom quartile (vs. top quartile) | 1.55 (-0.07, 3.18)~ | 1.44 (-0.19, 3.07)~ | 1.49 (-0.16, 3.13)~ |
| Second quartile (vs. top quartile) | 1.53 (-0.13, 3.20)~ | 1.43 (-0.24, 3.11)~ | 1.43 (-0.25, 3.11)~ |
| Third quartile (vs. top quartile) | 0.97 (-0.66, 2.60) | 0.91 (-0.72, 2.54) | 0.96 (-0.67, 2.59) |
| *p for trend* | 0.08 | 0.11 | 0.10 |
| **Age** (years) | -0.34 (-0.39, -0.29)*** | -0.33 (-0.39, -0.28)*** | -0.33 (-0.38, -0.28)*** |
| **Height** (inch) | 0.08 (-0.17, 0.34) | 0.09 (-0.17, 0.34) | 0.08 (-0.18, 0.33) |
| **Female** (vs. male) | 0.36 (-1.59, 2.31) | -0.30 (-2.24, 1.64) | 0.57 (-1.41, 2.54) |
| **Race** | | | |
| Black (vs. white) | 1.97 (-2.62, 6.56) | 2.02 (-2.56, 6.60) | 2.05 (-2.52, 6.63) |
| Other races (vs. white) | 1.22 (-3.56, 6.00) | 1.15 (-3.63, 5.94) | 1.16 (-3.64, 5.96) |
| **Education level** | | | |
| HS (vs. <HS) | 0.39 (-2.70, 3.48) | 0.47 (-2.61, 3.55) | 0.55 (-2.53, 3.63) |
| Some College (vs. <HS) | -1.71 (-4.88, 1.46) | -1.63 (-4.50, 1.53) | -1.53 (-4.70, 1.64) |
| ≥ College (vs. <HS) | -2.93 (-6.08, 0.21)~ | -2.78 (-5.91, 0.35)~ | -2.67 (-5.83, 0.50)~ |
| **Income** | | | |
| Second vs. bottom quartile | 2.74 (0.55, 4.94)* | 2.75 (0.45, 4.94)* | 2.75 (0.56, 4.93)* |
| Third vs. bottom quartile | 3.55 (1.44, 5.66)** | 3.60 (1.49, 5.71)*** | 3.56 (1.45, 5.67)*** |

**Table 3.3 (Continued).**

| | | | |
|---|---|---|---|
| Top vs. bottom quartile | 3.23 (1.08, 5.39)** | 3.25 (1.10, 5.40)** | 3.19 (1.05, 5.34)** |
| **Married** (vs. in partnership) | -4.18 (-7.52, -0.85)* | -4.13 (-7.45, -0.82)* | -4.03 (-7.38, 0.68)* |
| **Depressed** (yes vs. no) | | 2.29 (-0.24, 4.81)~ | 2.30 (-0.23, 4.82)~ |
| **Chronic condition** (vs. no) | | -0.03 (-1.94, 1.88) | -0.03 (-1.94, 1.87) |
| **Current smoker** (vs. no) | | | 0.38 (-1.47, 2.22) |
| **Heavy drinker** (yes vs. no) | | | 0.34 (-0.91, 1.59) |
| **Moderate activity** (times/m) | | | -0.05 (-0.20, 0.11) |
| **Vigorous activity** (times/m) | | | 0.10 (-0.23, 0.03) |

Note: Generalized estimating equations with normal distribution and identity link were used in all models to estimate the mean change in weight by marital support at baseline, adjusting for clustering by family. Model 1 adjusted for socio-demographic factors. Model 2 additionally adjusted for health conditions. Model 3 further controlled for health behaviors. ***p<0.001; **p<0.01; *p<0.05; ~P<0.10.

*Baseline marital strain and body weight over follow-up*

No statistically significant associations were evident when comparing the highest versus lower levels of baseline marital strain in relation to the incidence of obesity over follow-up (Table 3.4, models 1-3). Associations were unaltered after adding marital status change between waves as a covariate to the model. Associations with the continuous marital strain score were similarly null. When considering weight change as the dependent variable findings were also null (Table 3.5, models 1-3), and unchanged regardless of including marital status change or use of continuous marital strain score in the models.

*Interaction between baseline marital quality and gender in relation to weight change over the follow-up*

There was no evidence of interaction between baseline marital quality and gender in association with weight change over the follow-up. Specifically, the interaction terms of gender with baseline overall marital quality (β=-0.69, 95% CI: -2.00, 0.62), marital support (β=0.32, 95% CI: -2.28, 2.93) and marital strain (β=0.09, 95% CI: -2.07, 2.26) were not statistically significant in any models.

**Table 3.4 Marital strain at baseline and incidence of obesity at follow-up among initially non-obese participants (N=2124)**

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| | RR (95% CI) | RR (95% CI) | RR (95% CI) |
| **Marital strain** | | | |
| Bottom quartile (vs. top quartile) | 0.82 (0.59, 1.14) | 0.83 (0.60, 1.16) | 0.86 (0.62, 1.20) |
| Second quartile (vs. top quartile) | 0.92 (0.68, 1.26) | 0.94 (0.69, 1.29) | 0.96 (0.70, 1.32) |
| Third quartile (vs. top quartile) | 1.12 (0.84, 1.49) | 1.14 (0.85, 1.52) | 1.16 (0.86, 1.55) |
| *p for trend* | 0.14 | 0.18 | 0.26 |
| **Age** (years) | 0.98 (0.97, 0.99)*** | 0.98 (0.97, 0.99)*** | 0.98 (0.97, 0.99)*** |
| **Female** (vs. male) | 0.96 (0.77, 1.21) | 0.95 (0.75, 1.19) | 0.93 (0.73, 1.18) |
| **Race** | | | |
| Black (vs. white) | 1.30 (0.64, 2.64) | 1.33 (0.65, 2.71) | 1.28 (0.64, 2.57) |
| Other races (vs. white) | 1.23 (0.63, 2.38) | 1.23 (0.63, 2.42) | 1.15 (0.58, 2.31) |
| **Education level** | | | |
| HS (vs. <HS) | 0.89 (0.68, 1.18) | 0.89 (0.68, 1.17) | 0.76 (0.49, 1.20) |
| Some College (vs. <HS) | 0.54 (0.39, 0.74)*** | 0.54 (0.40, 0.75)*** | 0.67 (0.42, 1.05)~ |
| ≥ College (vs. <HS) | 1.34 (0.87, 2.07) | 1.29 (0.83, 2.01) | 0.39 (0.24, 0.63)*** |
| **Income** | | | |
| Second vs. bottom quartile | 0.79 (0.53, 1.19) | 0.78 (0.52, 1.18) | 1.25 (0.82, 1.90) |
| Third vs. bottom quartile | 0.97 (0.71, 1.32) | 0.96 (0.70, 1.31) | 1.33 (0.88, 2.01) |
| Top vs. bottom quartile | 1.00 (0.75, 1.32) | 1.00 (0.75, 1.32) | 1.32 (0.87, 2.00) |

**Table 3.4 (Continued).**

| | | | |
|---|---|---|---|
| **Married** (vs. in partnership) | 0.78 (0.50, 1.21) | 0.80 (0.51, 1.25) | 0.74 (0.47, 1.17) |
| **Depressed** (yes vs. no) | | 1.20 (0.86, 1.68) | 1.22 (0.87, 1.70) |
| **Chronic condition** (vs. no) | | 1.46 (1.07, 1.99)* | 1.45 (1.06, 1.99)* |
| **Current smoker** (vs. no) | | | 0.63 (0.46, 0.88)** |
| **Heavy drinker** (yes vs. no) | | | 1.05 (0.83, 1.33) |
| **Moderate activity** (times/m) | | | 0.99 (0.96, 1.02) |
| **Vigorous activity** (times/m) | | | 0.99 (0.96, 1.01) |

Note: Generalized estimating equations with binomial distribution and log link were used in all models to estimate the risk ratio of obesity by marital strain at baseline, adjusting for clustering by family. Model 1 adjusted for socio-demographic factors. Model 2 additionally adjusted for health conditions. Model 3 further controlled for health behaviors. ***p<0.001; **p<0.01; *p<0.05; ~P<0.10.

**Table 3.5 Marital strain at baseline and weight change (in pounds) over the follow-up period (N=2667)**

| | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| | β (95% CI) | β (95% CI) | β (95% CI) |
| **Marital strain** | | | |
| Bottom quartile (vs. top quartile) | -1.14 (-2.91, 0.62) | -0.99 (-2.75, 0.78) | -1.00 (-2.78, 0.78) |
| Second quartile (vs. top quartile) | -1.08 (-2.83, 0.68) | -0.95 (-2.69, 0.80) | -0.92 (-2.67, 0.83) |
| Third quartile (vs. top quartile) | -0.12 (-1.83, 1.59) | -0.06 (-1.77, 1.65) | -0.09 (-1.81, 1.63) |
| *p for trend* | 0.13 | 0.19 | 0.19 |
| **Age** (years) | -0.34 (-0.39, -0.29)*** | -0.34 (-0.39, -0.28)*** | -0.33 (-0.39, -0.28)*** |
| **Height** (inch) | 0.09 (-0.17, 0.34) | 0.09 (-0.17, 0.34) | 0.08 (-0.17, 0.33) |
| **Female** (vs. male) | 0.43 (-1.51, 2.37) | 0.37 (-1.57, 2.31) | 0.64 (-1.33, 2.61) |
| **Race** | | | |
| Black (vs. white) | 1.98 (-2.61, 6.57) | 2.03 (-2.55, 6.61) | 2.05 (-2.53, 6.63) |
| Other races (vs. white) | 1.24 (-3.53, 6.00) | 1.16 (-3.61, 5.94) | 1.16 (-3.63, 5.94) |
| **Education level** | | | |
| HS (vs. <HS) | 0.35 (-2.76, 3.46) | 0.43 (-2.66, 3.52) | 0.52 (-2.57, 3.61) |
| Some College (vs. <HS) | -1.78 (-4.97, 1.41) | -1.70 (-4.88, 1.48) | -1.59 (-4.77, 1.60) |
| ≥ College (vs. <HS) | -3.00 (-6.16, 0.17)~ | -2.84 (-5.99, 0.31)~ | -2.71 (-5.89, 0.47)~ |
| **Income** | | | |
| Second vs. bottom quartile | 2.78 (0.58, 4.98)* | 2.78 (0.60, 4.98)* | 2.78 (0.59, 4.97)* |
| Third vs. bottom quartile | 3.57 (1.46, 5.69)*** | 3.62 (1.51, 5.73)*** | 3.58 (1.47, 5.69)*** |

**Table 3.5 (Continued).**

| | | | |
|---|---|---|---|
| Top vs. bottom quartile | 3.29 (1.13, 5.45)** | 3.30 (1.14, 5.45)** | 3.24 (1.09, 5.40)** |
| **Married** (vs. in partnership) | -4.10 (-7.44, -0.75)* | -4.05 (-7.37, -0.73)* | -3.94 (-7.30, 0.58)* |
| **Depressed** (yes vs. no) | | 2.32 (-0.21, 4.84)~ | 2.32 (-0.21, 4.85)~ |
| **Chronic condition** (vs. no) | | -0.06 (-1.96, 1.84) | -0.07 (-1.96, 1.83) |
| **Current smoker** (vs. no) | | | 0.36 (-1.48, 2.20) |
| **Heavy drinker** (yes vs. no) | | | 0.39 (-0.87, 1.64) |
| **Moderate activity** (times/m) | | | -0.05 (-0.21, 0.11) |
| **Vigorous activity** (times/m) | | | 0.09 (-0.04, 0.23) |

Note: Generalized estimating equations with normal distribution and identity link were used in all models to estimate the mean change in weight by marital strain at baseline, adjusting for clustering by family. Model 1 adjusted for socio-demographic factors. Model 2 additionally adjusted for health conditions. Model 3 further controlled for health behaviors. ***p<0.001; **p<0.01; *p<0.05; ~P<0.10.

**Discussion**

The present study is the first to examine the prospective association between marital quality and body weight in mid-life, and to differentiate effects of both positive and negative aspects of marital quality. In this study, each lower quartile of baseline marital support was associated with substantially higher risk of incident obesity and marginally increased weight gain over follow-up compared to the top quartile. A 19% reduced risk of becoming obese and significantly lower level of weight gain was associated with each one unit increase in baseline marital support levels in the fully-adjusted model. The association remained robust when marital status change between waves was further included as a covariate and when marital strain was simultaneously included in the model. In addition, there was also some evidence of an inverse association between overall marital quality and incidence of obesity in the base model, but this association was attenuated when additional covariates were included. However, the study did not find an association between marital strain and body weight in any model. Moreover, there was no evidence of effect modification by gender for the association between baseline marital quality and subsequent weight change.

Contrary to our expectation, results of this study provide stronger support for the health regulation than for the mating market model and suggest that a nurturing marital relationship may in fact serve as a health asset. Our findings are at odds with those in the one prior study in this area[21] which observed a positive association between marital satisfaction and weight gain in newlywed young couples. We speculate the different findings may be due in part to varying effects of marital quality on body weight across life stages. Specifically, according to the mating market model, the maintenance of healthy weight in young adulthood is primarily motivated by a desire to appear attractive. Therefore, individuals who are satisfied with their marriage may relax

efforts toward maintaining their appearance since they have already obtained a desirable mate. However, as individuals age, they may prioritize the benefits of maintaining healthy weight on health over appearance.[52] Following the health regulation model, the presence of a supportive and caring spouse/partner may thus facilitate the behavioral regulation function of marriage to help the couples to keep healthy weight in their mid-life. Another possibility is that marital characteristics differ in young adulthood and in mid-life. Specifically, newlywed couples are still adjusting to the transition into marital roles, and may experience frequent fluctuations in perceived marital quality.[53] In comparison, marital quality may tend to be more stable and have more visible effects as individuals age.

Findings in this study added to the growing evidence that positive and negative aspects of marital quality can have different effects on health, and a nurturing marital relationship may have effects over and beyond simply the mere absence of martial strain. According to Burman's theory of how marital factors influence health,[24] positive experiences in the marital relationship such as support from one's spouse/partner may help reduce emotional problems such as depression and decrease risk of unhealthy behaviors such as sedentary lifestyles, which in turn promote the maintenance of healthy weight. Results of the present study are consistent with findings in prior MIDUS research that marital support was associated with reduced risk of other health problems such as inflammation[44] and chronic conditions.[29] Contrary to our expectation, the present study did not find an independent association between marital strain and body weight. It is possible that middle-aged individuals have greater economic resources and social support from outside the family to help buffer stress associated with marital strain, compared to other age groups. Another possibility is that because this study was conducted in participants who were married or in a marriage-like relationship at mid-life, the sample was primarily

comprised of individuals with low levels of marital strain, since those in stressful marital relationships may have ended their marriage in earlier life and were not eligible to be in the sample. Unlike prior work in clinical samples, we did not find interactions between marital quality and gender in relation to weight change. It is possible that participants in clinical studies were generally older and sicker, and women were more likely to play the role of caregivers for their spouses in later life. Therefore, the greater vulnerability to negative effects of marital distress among women observed in clinical studies may be partly explained by their greater exposure to stress associated with caregiving for spouses.[54]

This study has several limitations to consider. First, marital quality was self-reported in this study, and the reports of marital quality may be affected by participants' current body weight. However, the prospective assessment of marital quality 10 years prior to body weight reported at follow-up provides some reassurance that findings are not solely due to self-report bias. Moreover, although body weight measures were also obtained through self-reports, the self-reported body weight was validated against measured weight in a subset of participants and demonstrated high concordance. Second, no formal mediation analysis could be performed due to the lack of temporality in the measurement of primary predictors and possible mediators. This study considered baseline health conditions and health behaviors as confounders, but they might be potential mediators as well. Third, there may be residual confounding by factors for which information was unavailable in in this study such as past marital history, duration of the current marriage or relationship, and health status of the spouse/partner. The study did not measure spouse's perception of marital quality, and therefore could not assess the joint effects of couple rating of marital quality. In addition, participants in the present study did not comprise a nationally representative sample, and there was evidence that participants included and excluded

from the analyses differed on a number of sociodemographic characteristics. Therefore, results of this study may not be generalizable to other populations.

This study has a number of important strengths. It is the first study to examine the prospective association between marital quality and body weight in mid-life. It adds to the growing evidence that nurturing social relationships may serve as a health asset. Second, marital support and marital strain were measured with previously validated scales, and the measure of marital quality has been linked to a number of health outcomes such as self-rated health, inflammation, cardiovascular function and bone density in prior MIDUS studies. Next, the study made efforts to differentiate effects of multiple aspects of marital quality on body weight. It helped add to the evidence that marital support and marital strain are not simply two measures of the same construct. Moreover, the present study adjusted for a wide range of potential confounders which have been linked to marital quality and/or body weight in prior research. In addition, the long follow-up period in this study makes it possible to investigate the long-term cumulative effects of marital quality on body weight.

Important next steps following this study include replicating this research in a more representative sample, examining potential interaction between marital quality and age in a sample with a wider age range, investigating potential mediators for the association of interest, and studying effects of other marital quality components on body weight. Marital therapy has been shown to be an effective means for improving marital satisfaction and reducing marital distress,[55-57] and has been linked to better health outcomes such as reduced depressive symptoms.[55] There is also evidence that obesity treatment and weight loss programs are more likely to be effective when the spouse/partner is involved.[58] Further research on marital quality

and body weight may help understand the underlying mechanisms of the relationship, inform more targeted interventions, and introduce new avenues of controlling the obesity epidemic.

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**Supplementary Materials**

**Table S3.1 Comparison of participant characteristics between those included in and excluded from the analyses**

| Characteristic | | Included (n=2667) | Excluded (n=2296) | *p* |
|---|---|---|---|---|
| **Age, years** | **mean (SD)** | 47.23 (12.10) | 45.56 (12.93) | <0.0001 |
| **Male** | % | 48.44 | 44.60 | 0.007 |
| **Race** | | | | <0.0001 |
| White | % | 95.28 | 87.18 | |
| Black | % | 2.59 | 7.63 | |
| Other races | % | 2.14 | 5.19 | |
| **Highest parental education** | | | | <0.0001 |
| Less than high school | % | 5.74 | 8.84 | |
| High school | % | 28.37 | 27.09 | |
| Some college | % | 28.91 | 31.97 | |
| 4-year college or higher | % | 36.97 | 32.10 | |
| **Family income** | | | | <0.0001 |
| 1: Bottom quartile | % | 12.79 | 35.25 | |
| 2 | % | 23.28 | 25.53 | |
| 3 | % | 29.77 | 21.35 | |
| 4: Top quartile | % | 34.16 | 17.87 | |
| **Depression** | % | 9.60 | 15.33 | <0.0001 |
| **Chronic conditions** | % | 14.85 | 13.76 | 0.28 |
| **Heavy drinking** | % | 39.78 | 43.58 | 0.007 |
| **Current smoking** | % | 16.72 | 23.02 | <0.0001 |
| **Moderate physical activity, times/month** | **mean (SD)** | 9.75 (4.54) | 8.99 (4.88) | <0.0001 |
| **Vigorous physical activity, times/month** | **mean (SD)** | 6.38 (5.18) | 5.92 (5.27) | 0.003 |

Note: Percentages refer to the proportion of individuals within each inclusion category with that characteristic. p comes from $\chi 2$ or T-test.

**Table S3.2 Individual items of the marital quality scales**

| |
|---|
| Overall marital quality |
| Q1. Would you describe your relationship with S/P as… Excellent, Very good, Good, Fair or Poor? |
| Spouse/Partner Support Scale (α=0.90) |
| Q1. How much does your spouse or partner really care about you? |
| Q2. How much does he or she understand the way you feel about things? |
| Q3. How much does he or she appreciate you? |
| Q4. How much do you rely on him or her for help if you have a serious problem? |
| Q5. How much can you open up to him or her if you need to talk about your worries? |
| Q6. How much can you relax and be yourself around him or her? |
| Spouse/partner strain scale (α=0.87) |
| Q1. How often does your spouse or partner make too many demands on you? |
| Q2. How often does he or she argue with you? |
| Q3. How often does he or she make you feel tense? |
| Q4. How often does he or she criticize you? |
| Q5. How often does he or she let you down when you are counting on him or her? |
| Q6. How often does he or she get on your nerves? |

**Concluding Remarks**

This research adds to the growing evidence that nurturing family relationships are a critical source of health assets for both the couple and the offspring. The findings demonstrate the long-lasting effects of early life exposures on health across the lifespan, and highlight the importance of a lifecourse perspective. They also reveal some remaining challenges in the study of health assets and emphasize the need for further research.

Study 1 demonstrated a protective effect of the authoritative parenting style on offspring body weight beyond young adulthood, compared to the authoritarian and the uninvolved styles. The stratified analyses considering effects of parental warmth and control in context of one another were consistent with the analyses using the typology, suggesting that it is likely the interactive dynamics between parenting dimension that matters. The mediation analyses suggested that the higher BMI increase in offspring associated with the authoritarian and uninvolved parenting styles was partly explained by the elevated rate of major depression in offspring of these parenting styles, compared to the authoritative style. The findings were largely consistent with prior evidence in children and adolescents, and add to our understanding of the potential mechanisms underlying the association. However, the study could not provide conclusive evidence as to whether the authoritative parenting style is a *health asset* for offspring body weight, since the authoritative style was protective compared to some but not all other typologies of parenting styles.

Study 2 found that offspring whose mothers remained consistently married had lower risk of being or becoming overweight or obese across adolescence and young adulthood, compared to offspring whose mothers were divorced/separated or remarried. Among offspring who ever experienced a maternal marital transition, their BMI rose at a faster rate after the onset of their

mother's first marital transition compared to prior to the transition. In addition, higher frequency of maternal marital transitions, longer duration of mother being unmarried and earlier occurrence of mother's first marital transition all put the offspring at higher risk of being overweight or obese. The findings were consistent with existing evidence that being consistently married was protective for offspring health, compared to other types of parental marital history. This study moved beyond taking a static view of marital status at a single time point, and is the first study we know of that links maternal marital history to offspring body weight. It also furthered our understanding of the different effects of multiple facets of marital trajectory.

Study 3 revealed an association between a nurturing marital relationship and reduced risk of incident obesity as well as lower weight gain in mid-life. We differentiated effects of positive and negative components of marital quality, and found a protective effect of marital support but a null association between marital strain and body weight. The findings were inconsistent with one prior study in this area which observed a positive association between marital satisfaction and weight gain in newlywed young couples. We speculate that the association may vary across life stages, given that marital characteristics and individual's motivation for maintaining healthy weight may change with age. This study further adds to the evidence that positive family relationships can serve as a health asset, and suggests that a nurturing marital relationship may have effects over and beyond simply the mere absence of martial strain.

Taken together, this research paves the way for future studies on the potential mechanisms underlying the association between positive family relationships and health so as to inform targeted interventions. It also reveals some remaining challenges in the studies of health assets such as the need for a more comprehensive definition of a health asset to provide clear rubrics and standards for evaluating categorical attributes as potential assets. In addition, it

emphasizes the importance of implementing effective family policies to strengthen factors that characterize supportive families, and the need for providing social and economic support for children experiencing family structural changes. Overall, this line of research may help mobilize positive attributes within the family to promote healthy states and introduce new avenues for obesity prevention and control.