Economics and Human Biology 24 (2017) 164–183

Contents lists available at ScienceDirect

Economics and Human Biology

journal homepage: http://www.elsevier.com/locate/ehb

The effects of prospective mate quality on investments in healthy body weight among single women[☆]

Matthew C. Harris[a,*], Christopher J. Cronin[b]

[a] University of Tennessee, Department of Economics and Center for Business and Economic Research, 722A Stokely Management Center, 916 Volunteer Boulevard, Knoxville, TN 37996-0570, United States
[b] University of Notre Dame, Department of Economics, United States

ARTICLE INFO

Article history:
Received 19 May 2016
Received in revised form 7 December 2016
Accepted 12 December 2016
Available online 21 December 2016

JEL classification:
I14
I12
J12
J15

Keywords:
Obesity
Physical activity
Marriage
Matching
Human capital

ABSTRACT

This paper examines how a single female's investment in healthy body weight is affected by the quality of single males in her marriage market. A principle concern in estimation is the presence of market-level unobserved heterogeneity that may be correlated with changes in single male quality, measured as earning potential. To address this concern, we employ a differencing strategy that normalizes the exercise behaviors of single women to those of their married counterparts. Our main results suggest that when potential mate quality in a marriage market decreases, single black women invest less in healthy body weight. For example, we find that a 10 percentage point increase in the proportion of low quality single black males leads to a 5–10% decrease in vigorous exercise taken by single black females. Results for single white women are qualitatively similar, but not consistent across specifications. These results highlight the relationship between male and female human capital acquisition that is driven by participation in the marriage market. Our results suggest that programs designed to improve the economic prospects of single males may yield positive externalities in the form of improved health behaviors, such as more exercise, particularly for single black females.

1. Introduction

The obesity rate in the United States grew from 15% in 1980 to 34% in 2008. In addition to the obvious health implications, this growth generated significant economic costs (Flegal et al., 2010). Reuters estimates that obesity contributed \$190 billion to annual health care costs in the United States in 2012, a figure that exceeds the costs attributable to smoking (Begley, 2012). Obesity is linked to increased hypertension, heart disease, stroke, disability, diabetes, and non-health factors such as decreased productivity in the workplace and stunted human capital formation. The Brookings Institution estimates the aggregate economic costs of obesity to be \$215 billion per year, or 1.4% of GDP (Hammond and Levine, 2010).

While the incidence of obesity among all demographic groups in the United States has risen considerably since the 1980s, some groups have been disproportionately affected (see Fig. 1). The CDC reports that 58.5% of black women over the age of 20 are obese, compared to a population average of 33.9% (Flegal et al., 2010).[1] The demographic discrepancy in severe (grade 2) obesity is even larger. Black

☆ We thank Jason Fletcher, Scott Gilpatric, Meghan Skira, Forrest Spence, David Bradford, Kitt Carpenter, Guy David, Josh Pinkston, Gabriel Picone, Melayne McInnes, the Economics Department at University of South Carolina and the Southeastern Health Economics Study Group, and others for their comments on this manuscript. We also thank our editor, Inas Kelly, and two anonymous referees. All errors are ours.

* Corresponding author.
E-mail address: mharris@utk.edu (M.C. Harris).

[1] Obesity is generally defined using the body mass index (BMI), which is calculated as BMI = [weight (lb)/height (in)^2] * 703. The Centers for Disease Control define obesity as a BMI greater than or equal to 30. Severe (grade 2) obesity is defined as a BMI greater than or equal to 35.

http://dx.doi.org/10.1016/j.ehb.2016.12.002
1570-677X/

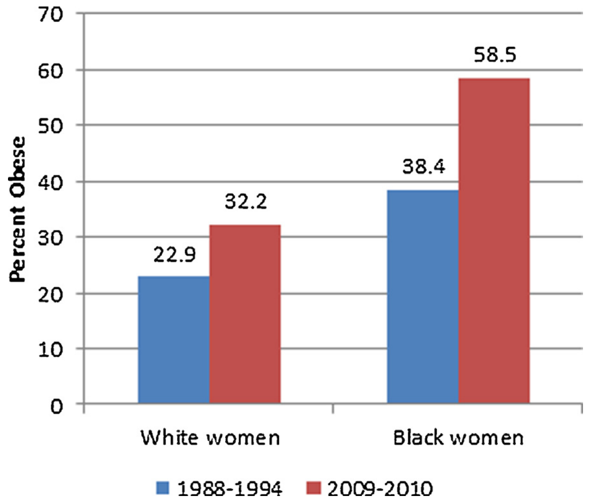

Fig. 1. Obesity rates among women by race; 1998–1994 and 2009–2010.

women have a severe obesity rate of 27.9% compared to a rate of 14.3% for the total population. While the obesity rate (particularly severe obesity) is highest among black women, the obesity rate among single white women has exhibited the largest growth rate (45% from 1999 to 2011) of any demographic group in recent years. According to the Behavioral Risk Factor Surveillance System, the obesity rate for single black women under age 45 increased by 27% over the same period.

Biologically, body weight is a function of calories ingested and expended. Economically, the individual's decision to consume net calories is a function of her incentives to invest in healthy eating and exercise. Philipson (2001) posits that an unfavorable marriage market for women may reduce the marginal benefit of premarital investment in fitness and therefore contribute to the high rate of obesity. Black women have exhibited greater obesity rates and faced less favorable marriage prospects than white women since the 1970s (Wilson and Neckerman, 1986). The U.S. Bureau of Justice Statistics (BJS) reports that black males are incarcerated at nearly seven times the rate of white males. Estimates place the proportion of black males with a felony conviction as high as one-third. Black men exhibit 100% greater high school dropout rates and 40% lower college completion rates than white men.[2] The unemployment rate among black men has been approximately twice that of white men since the 1960s and black men are also 45% more likely than white men to not participate in the labor force.[3] Conditional on being employed, median wages are 27% lower for black men than white men.[4] These observed disparities in human capital, employment, wages, and incarceration rates are clearly not independent. For example, Western (2002) finds that incarceration decreases earnings by between 10% and 30%, increases search costs when seeking employment, and limits the set of attainable occupations.

In this paper, we study the effect of single male quality on a single female's investment in healthy body weight.[5] Our analysis is empirical. Using panel data from the Behavioral Risk Factor Surveillance System – Selected Metropolitan/Micropolitan Area Risk Trends (BRFSS-SMART) we measure premarital investment in healthy body weight by minutes of moderate and vigorous exercise per week. As suggested by Becker (1974), we measure a male's quality by his earning potential.[6] Thus, defining marriage markets by MSA, race, and age group, we measure single male quality within a given marriage market using education, employment, income, and arrests rates.[7] Ideally, we would observe the entire distribution of male quality, which would allow us to analyze the behavioral responses of single females to shifts in the entire male quality distribution. However, the data allow us to measure only the proportion of low quality single males within a marriage market (i.e. we observe high school graduation rates, the unemployment rate, percent with low income, and arrest rate). We assume that this measure of the proportion of low quality males reflects a shortage of quality mates (for women) in the marriage market.

We estimate the effect of the proportion of low quality males on the body weight investment decisions of the average single female in a marriage market. Our regressions include year and marriage-market fixed effects, which control for unobservables that vary by time period (e.g. nationwide economic conditions) and marriage market (e.g. persistent economic, cultural, and geographic factors) that may be correlated with the characteristics of single males. However, there are additional unobservables that vary by both time period and marriage market (e.g. chemical dependency rates, poverty rates, local economic shocks) that may be correlated with single male quality. Ignored, this correlation between male quality and unobservables would bias our results. We address the potential omitted variable bias by differencing the average health investments of married women from single women in the same marriage market. We also include differenced control variables and market-level fixed effects in these regressions to account for time-variant observable and time-invariant unobservable compositional differences

[2] Source: National Center for Education Statistics.
[3] Source: Bureau of Labor Statistics, Current Population Survey.
[4] Source: American Community Survey.

[5] Throughout this paper we will reference the "quality" of males and females participating in the marriage market. In all instances, an individual's quality refers to their value to potential mates. (Burdett and Coles (2001) use the term "pizazz" to describe a similar value.) In theory, single females receive greater utility from matching to a high quality male than a low quality male and vice versa.

[6] In a similar vein, Wilson and Neckerman (1986) proxies for quality, which he refers to as the "marriageablity", of black men using employment. Wood (1995) measures marriageablity using full-time or military employment and various own-income thresholds. Brien (1997) adds student status and education to Wood's measures.

[7] The Pew Research Center reports that black-white interracial marriage rates are less than 5% of all black and white marriages. As such, throughout our analysis we treat marriage markets separately for each race.

between single and married women respectively at the market level.

Our results suggest that low quality among single males in a marriage market reduces females' incentives for premarital investment in healthy body weight. In our first model (i.e. using single women only), we find that single black women exercise less in response to a decrease in single male quality; a 10 percentage point increase in the proportion of low quality single black males (roughly equivalent to decreasing the quality of single black men in Orlando, FL to that of the single black men in Indianapolis, IN) leads to a 10% decrease in vigorous exercise taken by single black females.[8] The results for white marriage markets vary in significance and magnitude according to model specification. In our differencing specification, we find that a 10 percentage point increase in the proportion of low quality single black males leads to a 5% decrease in vigorous exercise taken by single black females. Therefore, our econometric correction for time-varying market level unobservables halves the marginal effect of male quality on premarital female investment in healthy body weight. Our results are robust to marriage markets defined at the state level. We rule out (empirically) any cross-race effects (i.e. the effect of single male quality of one race on single female health investment of another race) and show that single male quality does not affect the health investments of married women. These results validate our race-specific definitions of marriage markets and differencing strategy.

As an extension, we consider how the effects of male quality may vary over the distribution of female quality. To that end, we regress individual-level single female investment in healthy body weight on the proportion of low quality single males in the marriage-market, control variables, and MSA-level fixed effects. We allow estimated coefficients to vary over the distribution of single female quality. We find evidence that the health behavioral responses of single women to changes in single male quality are strongest among females with less education, less income, and higher body weight.

This paper merges several related literatures. Prior work has examined the effects of mate quality on racial differences in marriage formation (Brien, 1997; Wood, 1995; Wilson and Neckerman, 1986). A separate, more recent literature has examined the spillover effects of marriage-market imbalance, particularly for black women (Mechoulan, 2011; Finlay and Neumark, 2010; Lin et al., 2014). While Mechoulan (2011) finds that black females facing an unfavorable imbalance in the marriage market invest in more human capital (e.g. education), it is not clear whether these spillover effects are the result of increased or decreased competition for mates. Women facing a lack of quality mates may invest in more education either to increase their mating capital or in preparation for financial independence. Our analysis indicates that an unfavorable marriage-market imbalance leads the average single female to decrease her investment in healthy body weight. This reduction would suggest a decrease in competition, as an increase in body weight cannot be interpreted as increasing mating capital. Additionally, this paper is the first to link marriage-market conditions directly to premarital investment in healthy body weight. There has been research on the effects of obesity on marriage-market prospects (Oreffice and Quintana-Domeque, 2010; Averett et al., 2008), but very little on how marriage-market prospects affect investment in healthy body weight.

The rest of the paper is organized as follows: Section 2 reviews the existing literature. Section 3 describes the data and sample construction. Section 4 contains empirical results. Section 5 concludes with a summary of our results, the limitations of our analysis, and directions for future work.

2. Related literature

2.1. Empirical literature

We are not the first to consider the relationship between marriage-market conditions and premarital investments. The theoretical models of Burdett and Coles (2001), Iyigun and Walsh (2007), and Chiappori et al. (2009) describe the premarital investments of forward-looking singles. There is less empirical work on the subject and researchers have focused primarily on educational investments. Boulier and Rosenzweig (1984) estimate a model of female schooling, (spousal) search, and (spousal) selection. Using data from the Philippines, they find evidence that single women facing higher sex ratios (men to women) and higher single male unemployment rates invest less in their educations. Lafortune (2013) studies how sex ratios impact premarital investments in education and the educational characteristics of selected occupations of second generation Americans born between 1885 and 1915. She finds that men and women who face a shortage of potential mates invest in more years of schooling.

Our work also relates to a number of empirical papers suggesting that bodyweight impacts marriage formation differently for men and women. Mukhopadhyay (2007) finds that both black and white obese women are less likely to enter into cohabitation or marriage, but that obesity does not affect the incidence of marriage for men.[9] Oreffice and Quintana-Domeque (2010) find positive assortative mating among spouses in the United States on weight, height, and BMI. Consistent with Mukhopadhyay, they also find significant penalties for obese women. Female BMI is found to be negatively correlated with husband's income, height, and education. Furthermore, Becker (1974) hypothesizes and numerous studies (e.g.

[8] We refer to exercise as "investment in health body weight" throughout the paper. However, it is important to recognize that our results may not generalize to all health investment decisions. We would not necessarily expect a similar relationship to exist between single male quality and single female consumption of the influenza vaccine.

[9] In a related paper, Ali et al. (2014) finds that overweight white female teens are less likely to have engaged in intercourse than their skinnier white peers. However, they find no difference in sexual behaviors of overweight black female teens and their healthy-weight counterparts.

Lichter et al., 1991, 1992; Wilson and Neckerman, 1986) show that while males are evaluated in a marriage market by their wages and material possessions, women are typically sought after for non-monetary attributes, such as appearance and education. Chiappori et al. (2012) found that women must compensate for an additional two units of BMI with an additional year of education.

This paper also joins a growing literature that seeks to understand how changes in the number of "marriageable" black men in the United States, particularly since the 1970s, has altered the marriage trends and behaviors of black women. Researchers have studied how changes in the marriageability of single black men has affected both marriage rates (Wood, 1995) and marriage timing (Brien, 1997) in black populations. Recent work by Mechoulan (2011) and Lin et al. (2014) examines how the increase in the incarceration of black men, and the sex ratio imbalance it causes, affects the behavior of black women. Mechoulan (2011) finds that young black women have responded with greater investment in human capital (e.g. higher educational attainment, increased early employment, and lower teenage fertility rates). This paper is closely related to Lin et al. (2014), who find that as much as 18% of the growth in obesity among black females over the 1990s was due to mate shortages attributable to increases in the incarceration of black males. However, incarceration rates should not only affect sex ratios, but the quality of available mates in future periods as well. By showing that mate quality affects single female investment in healthy body weight, we argue that Lin et al. understate the negative health externalities from the expansion of the penal system.

2.2. Theoretical literature

Becker (1974) was among the first to study marriage formation as the optimizing behavior of rational economic agents. In Becker's model, which assumed transferable utility, an individual chose to marry if the utility from marriage was greater than the utility from remaining single. In this frictionless setting, Becker showed that assortative matching would arise if everyone preferred higher quality partners. To account for incomplete information, more recent matching models have allowed for search frictions, while assuming both transferable (Becker, 1981) and non-transferable (Burdett and Coles, 1997; Smith, 2006) utility. Much like job seekers in a labor market with frictions, single individuals in these models are assumed to set a reservation mate quality and accept the first offer that exceeds the threshold. More recent models have amended this earlier work by allowing for premarital investments, which increase an individual's value in the marriage market (Burdett and Coles, 2001; Iyigun and Walsh, 2007; Chiappori et al., 2009; Lafortune, 2013).

While we do not contribute to the theoretical literature on marriage markets or matching models, our empirical work is motivated by Burdett and Coles (2001) equilibrium model of self-improvement. In their model, vertically differentiated singles enter the marriage market endowed with a particular level of quality or "pizazz." An individual's utility from marriage equals their partner's pizazz (i.e. non-transferable utility). A single is able to invest, at a cost, in his/her own pizazz, which may increase the expected value of a match. A female's investment decision is thus influenced by the distribution of both male and female pizazz, as well as the cost of investment.[10] Depending on these factors, the model would predict that some women engage in costly investment, while other women choose to enter the marriage market with their original pizazz endowment. In our empirical work, we will measure how the average female's body weight investment decision is affected by the proportion of males in the left tail of the quality, or pizazz, distribution. We abstract from the equilibrium effects of the women's behavior (i.e. changes in female body weight and subsequent single male behavioral responses to these changes), leaving this for future work.[11]

3. Data

The primary data source used in our empirical analysis is the Center for Disease Control's Behavioral Risk Factor Surveillance System (BRFSS). The BRFSS has been conducted annually since the 1980s and is the world's largest telephone health survey.[12] The survey is a repeated cross section, designed to identify trends in health behaviors at the state level to help state health agencies efficiently allocate resources. Beginning in 2002, the BRFSS began tracking local trends from metropolitan and micropolitan areas with 500+ respondents. Our estimation samples are drawn from these data, which are known as BRFSS-SMART (Selected Metropolitan/Micropolitan Area Risk Trends).

While BRFSS is a repeated cross section, we use sample weights to construct a panel at the marriage-market level. A total of 227 MSAs are included in our four-year panel. We define marriage markets using a race (black/white) and age category combinations within each MSA.[13] The age categories are [18–25), [25–35), [35–45), [45–55), [55–65),

[10] In our paper, a woman's investment in healthy body weight is akin to investing in her pizazz. Our measure of low male quality within a marriage market provides some measure of the proportion of males to the left of some arbitrarily low threshold in the male pizazz distribution.

[11] Our data and empirical specification are well suited to capture the contemporaneous effects of mate quality on investment decisions. By contrast, an individual's body weight should evolve gradually as the effects of these investment decisions accrue over time, which is beyond the scope of our data.

[12] Although the Current Population Survey (CPS) is not a health survey, many of our MSA-level economic measures could be calculated using the March Supplement of the CPS. While both are designed to be representative at the state level, we prefer BRFSS due to its large sample size, which is necessary to compute aggregate statistics within a MSA-age-race-year bin. During our sample period, BRFSS contains an average of 385,000 observations per year, which is approximately 1.6 times the size of the March Supplement of the CPS. That said, there are tradeoffs in this decision. As BRFSS is a telephone survey, random digit dialing techniques are used on landlines and cell phones to identify survey participants. CPS, on the other hand, selects households based on address, which may ensure a more representative sample. Moreover, Schneider (2011) report a median response rate of 48% for the 2000 BRFSS compared to 67% in the 2000 Decennial Census.

[13] We abstract from cohabitation in our analysis as cohabitation is a very small part of the sample. In the 2009 BRFSS, for example, 2.15% of the sample reports being "part of an unmarried couple."

Table 1
MSAs, markets, and respondents by wave.

Year	No. of MSAs	No. of markets	No. of respondents
2003	102	1019	129,779
2005	148	1400	201,539
2007	177	1700	253,071
2009	173	1638	250,584
N		5757	700,583

Table 2
Observations per market.

Observations per market	No. of markets
1	693
2	360
3	264
4	888

and [65, ∞). In Section 4.1.2, we show that our results are robust to alternative definitions of marriage markets that allow for interracial marriage and overlapping age bands.

Table 1 displays the number of MSAs tracked for each year, the total number of marriage markets constructed, and the total number of individual respondents (single and married) for each year of the BRFSS-SMART used to compose these marriage markets. Of the 5757 marriage market observations defined by MSA, age group, race, and time, there are 2130 black observations and 3627 white observations. The BRFSS-SMART only reports results for MSAs with at least 500 respondents. Some MSAs are either insufficiently diverse to form marriage-market estimates for blacks or had an insufficient number of black respondents to form reliable estimates. Our MSA-level markets form an unbalanced panel. Table 2 displays the number of markets with 1, 2, 3, or 4 observations.

Our estimation sample includes marriage markets with at least five single men and five single women satisfying the MSA-race-age criteria.[14] Given our precise definition of a marriage market, increasing this threshold rapidly decreases the number of markets we can include in the sample. Admittedly, the presence of these small markets calls into question the representativeness of our results; to which we have two comments. First, including markets with small numbers of observations is likely to increase the noise in our data. Because these individuals are randomly sampled from the population, observations with small numbers of individuals should create classical measurement error, which will result in an attenuation bias of our estimates. To test for such bias, we repeat our analysis with marriage markets defined at the state-level. Our key results increase in magnitude and significance when we aggregate to the state level, which is consistent with alleviating classical measurement error in the MSA-defined markets.

The dependent variables in our empirical analysis are minutes of moderate and vigorous exercise per week by single females. After the 2002 initiation of the BRFSS-SMART, questionnaires in odd years (2003, 2005, 2007, 2009) elicited information on behaviors related to changes in body weight, including minutes of moderate and vigorous exercise taken.[15,16] According to BRFSS, moderate exercise "causes small increases in breathing or heart rate." Survey participants are provided with examples, such as "brisk walking, bicycling, vacuuming, and gardening." Vigorous exercise induces "large increases in breathing or heart rate (e.g. running, aerobics, and heavy yard work)." Our dependent variables of average minutes of moderate or vigorous exercise per week are formed by averaging over individual reports in each market. We use post-stratification weights in constructing these measures. Summary statistics for our dependent variables are found in the top two rows of Table 3. On average, single white women engage in more moderate and vigorous exercise than single black women.

In each market, we also form measures of male quality, our explanatory variable of interest. In addition to health information, the BRFSS asks respondents about their highest degree attained in school, a very coarse categorical income measure, and employment status. From these reports, we use post-stratification weights to construct three measures of male quality in each market: the proportion of single males who are high school dropouts, the proportion of single males who earn less than $20,000 per year,[17] and the proportion of single males who are unemployed for greater than six months or not in the labor force. We supplement this information with average arrest rates by marriage market, which are compiled from the Bureau of Justice Statistics, Uniform Crime Reports (UCR) Annual Summary.[18] While related works have measured the impact of the penal system on males using incarceration rates, we suspect that arrest rates provide a better contemporaneous measure of the corrections aspect of mate quality. Incarceration rates alone are likely to understate to impact of the penal system on marriage markets. While incarceration removes an individual from participating in the market, arrests increase the likelihood of conviction, which lowers an individual's economic

[14] Women and men are categorized as *single* if it is reported that their marital status is never married, divorced, widowed, or separated (roughly 2% of the sample). Members of an unmarried couple (roughly 3% of the sample) are excluded from analysis.

[15] BRFSS also contains information about healthy food intake, such as 'servings of fruits and vegetables per day.' In considering investment in healthy body weight, we are equally (if not more) concerned with 'unhealthy food abstinence' as we are 'healthy food intake.' These are two entirely separate behaviors, one does not imply the other. In previous versions of the paper, we have considered fruit and vegetable intake. The results were mixed. We are happy to share them as asked.

[16] BRFSS-SMART responses after 2010 are not directly comparable to responses from 2003 to 2009.

[17] The $20,000 threshold was selected because it is the closest to the U.S. Census Bureau's poverty line for a family of four. Under the assumption that males are valued in the marriage market as providers for the family, the federal poverty line for a family of four provides an objective threshold for insufficient earnings.

[18] The Bureau of Justice Statistics does not report the marital status of arrestees. We are therefore unable to separately identify arrest rates for single versus married men.

Table 3
Market-level descriptive statistics by race.

Variable	White			Black		
	Mean	S.D.	Max	Mean	S.D.	Max
Health markers – single females						
Minutes of moderate exercise per week	46.16	18.91	180.00	39.75	33.23	180.00
Minutes of vigorous exercise per week	24.68	14.93	109.00	18.10	22.09	117.00
Low income rate	0.24	0.14	0.75	0.33	0.25	0.80
Joblessness rate	0.14	0.12	0.65	0.20	0.21	0.72
H.S. dropout rate	0.10	0.10	0.55	0.14	0.17	0.57
Average number of children	0.59	0.51	2.5	0.84	0.75	2.5
Mate quality rate variables – single males						
Arrests per capita	0.03	0.04	0.33	0.08	0.08	0.38
Low income rate	0.19	0.14	0.69	0.26	0.28	0.70
Joblessness rate	0.15	0.14	0.59	0.20	0.24	0.75
H.S. dropout rate	0.11	0.11	0.57	0.14	0.20	0.61

prospects. As such, arrests probabilistically diminish an individual's value in the marriage market. Given that roughly 52% of American males will be arrested at some point in their life (Tillman, 1987), while only 9.0% will ever be incarcerated (Bonczar and Beck, 1997), identifying externalities of high arrest rates is important. Note also that incarcerated males are not included in the non-institutionalized population we consider.

The UCR reports offenses at the Original Reporting agency Identifier (ORI; e.g. Knoxville Police Department), both by race and by age-sex, but not by race-age-sex. Thus, we assume that for a given ORI, the race proportion is constant for each age-by-sex cell. In other words, if we observe that 20% of the arrestees in a given MSA were black, and we observe that 1000 27-year-old men are arrested, then we assume that 200 of those 27-year-old arrested men are black. We measure the criminal aspect of mate quality as felony arrests per-capita among men in the marriage market, as felony arrests are most likely to have long term economic consequences. Summary statistics for our measures of low male quality are in the bottom panel of Table 3. On average, single black males have lower quality measures than single white males.

In each market, we also construct control variables to characterize the population of single females. We construct market averages that parallel our measures of low quality males: high school dropout rates, low income rates, and joblessness rates. We do not use arrest rates among females, which are less than 1% in the median marriage market, and we add the average number of children per single woman in each market. Summary statistics for these market average rates are also in Table 3.

Our econometric technique requires market-level variation in male quality over time. Table 4 shows the variance of each measure of male quality and the share of that variance within and between each MSA. The table shows that roughly 45% of the total variation for our economic measures of male quality comes from within each MSA-level market. Approximately 25–40% of the total variation in white male quality at the state level comes from within-market variation, as does nearly 50% of the variation in black male quality. A much lower proportion of the variance in arrests per capita comes from variation within markets. While this may be attributable to properties of this specific variable, the UCR is true population data whereas the BRFSS is (albeit very large) sample data. Overall, the shares of variance at the MSA-level and state-level BRFSS provide evidence that our market-level data has adequate variation to study the relationship between single male quality and female health investment decisions.

4. Empirical analysis

We empirically evaluate how a single female's investment in healthy body weight (i.e. exercise) responds to a change in the proportion of low quality single males within her marriage market. In Section 4.1, we outline our empirical strategy, discuss the primary sources of bias with which we are concerned, and make explicit the conditions under which our estimates are unbiased. In Section 4.1.1, we present our primary findings. In

Table 4
Variance of male quality measures within and between markets.

Variable	Total Variance	Proportion Between	Proportion Within
White marriage markets			
Markets defined at MSA geographic level			
H.S. dropout rate	0.013	0.531	0.469
Low income rate	0.020	0.554	0.446
Joblessness rate	0.019	0.542	0.458
Arrests per capita	0.002	0.887	0.113
Markets defined at state geographic level			
H.S. dropout rate	0.006	0.737	0.267
Low income rate	0.010	0.741	0.259
Joblessness rate	0.010	0.600	0.400
Arrests per capita	0.001	0.890	0.110
Black marriage markets			
Markets defined at MSA geographic level			
H.S. dropout rate	0.042	0.531	0.469
Low income rate	0.075	0.536	0.464
Joblessness rate	0.057	0.510	0.490
Arrests per capita	0.007	0.809	0.191
Markets defined at state geographic level			
H.S. dropout rate	0.042	0.518	0.482
Low income rate	0.064	0.441	0.559
Joblessness rate	0.052	0.441	0.559
Arrests per capita	0.011	0.851	0.149

Section 4.1.2 we conduct a series of falsification tests. In Section 4.2.1 we extend our empirical analysis to control for sex ratios, demonstrating that our main result can be interpreted as a quality-based mate shortage. In Section 4.2.2 we replicate our preferred specification at the state level to alleviate concerns about non-representativeness in MSA-markets. Finally, in Section 4.2.3, we use individual-level, cross-sectional data to consider how the effect of male quality on female premarital investment in healthy body weight varies over the distribution of female quality.

4.1. Market-level empirical strategy

Let us assume that the average weekly minutes of exercise among single women in marriage market j and time t can be written as

$$E_{jt} = \beta_1 Q_{jt} + \beta_2 X_{jt} + \alpha_t + \gamma_j + \epsilon_{jt} \quad (1)$$

where Q_{jt} measures the proportion of low quality single males and X_{jt} measures average single female characteristics in the same marriage market and time period. Our parameter of interest is β_1. To produce an unbiased estimate, we must control for three types of unobservables which are likely correlated with Q_{jt}. Unobservables that vary by time period, α_t, and unobservables that vary by marriage market, γ_j, are easily controlled for using separate time and marriage-market fixed effects. However, we are not able to control for unobservables that vary by both time period and marriage market, ϵ_{jt}, using fixed effects. We include control variables, X_{jt}, which vary by market and time to reduce some of the potential bias caused by these unobservables, but additional work is needed to reduce this bias further.

For expository purposes, we rewrite ϵ_{jt} as

$$\epsilon_{jt} = \lambda_{jt} + \eta_{jt} \quad (2)$$

where $corr(\lambda_{jt}, Q_{jt}) \neq 0$ and $corr(\eta_{jt}, Q_{jt}) = 0$; our endogeneity problem stems from the first of these two conditions. The standard procedure for addressing this unwanted correlation is to employ an instrumental variables method; however, we think it unlikely that any variable that is correlated with Q_{jt} has no other effect on E_{jt}. Investments in healthy body weight are made by individuals maximizing their utility, subject to a constraint, while interacting with the built environment in which they live. Any local variation which affects the economic characteristics of single males is likely to affect the outcome of a single woman's optimization problem by altering either her constraint or the built environment. Therefore, we opt for a different strategy, which reduces the correlation between Q_{jt} and ϵ_{jt} by differencing the outcomes of married women from those of single women in the same time period and marriage market.

To describe this strategy, we first rewrite Eq. (1) for *married* women as

$$\tilde{E}_{jt} = \tilde{\beta}_1 Q_{jt} + \tilde{\beta}_2 \tilde{X}_{jt} + \tilde{\alpha}_t + \tilde{\gamma}_j + \tilde{\epsilon}_{jt} \quad (3)$$

where all variables and parameters are redefined for married women, except Q_{jt}, which still defines the quality of single males in market j and time period t. Subtracting (3) from (1) yields

$$E_{jt} - \tilde{E}_{jt} = (\beta_1 - \tilde{\beta}_1)Q_{jt} + \beta_2(X_{jt} - \tilde{X}_{jt}) + \hat{\beta}_2 \tilde{X}_{jt} + (\alpha_t - \tilde{\alpha}_t) + (\gamma_j - \tilde{\gamma}_j) + (\epsilon_{jt} - \tilde{\epsilon}_{jt}) \quad (4)$$

where $\hat{\beta}_2 = \tilde{\beta}_2 - \beta_2$. We then make the following two assumptions

1. $\tilde{\beta}_1 = 0$
2. $E(Q_{jt}(\lambda_{jt} - \tilde{\lambda}_{jt})) = 0$.

Under these assumptions, Eq. (4) reduces to

$$E_{jt} - \tilde{E}_{jt} = \beta_1 Q_{jt} + \beta_2(X_{jt} - \tilde{X}_{jt}) + \hat{\beta}_2 \tilde{X}_{jt} + \hat{\alpha}_t + \hat{\gamma}_j + \hat{\epsilon}_{jt} \quad (5)$$

where $\hat{\alpha}_t = (\alpha_t - \tilde{\alpha}_t)$, a time fixed effect; $\hat{\gamma}_j = (\gamma_j - \tilde{\gamma}_j)$, a market fixed-effect, and $\hat{\epsilon}_{jt} = \epsilon_{jt} - \tilde{\epsilon}_{jt}$ is an *i.i.d.* random shock. We estimate Eq. (5).[19]

Our identification technique relies on assumptions (1) and (2) above. The first assumption implies that the proportion of low quality single males has no effect on the health investments of married females; this is tested in Section 4.1.2. The second assumption implies that Q_{jt} is exogenous to $(E_{jt} - \tilde{E}_{jt})$, or that unobserved factors that are correlated with single male quality have an equal effect on the health behaviors of single and married females, on average over marriage markets, j, and time periods, t.[20] While no statistical test can validate this assumption, single and married females should be equally affected by the time- and market-varying unobservables that we consider most likely to be correlated with Q_{jt} (e.g. chemical dependency rates, poverty rates, local economic shocks). Even if the condition $E(Q_{jt}(\lambda_{jt} - \tilde{\lambda}_{jt})) = 0$ is not met, the endogeneity of Q_{jt} (and, therefore, the bias in β_1) decreases with greater correlation between λ_{jt} and $\tilde{\lambda}_{jt}$. Therefore, any correlation between λ_{jt} and $\tilde{\lambda}_{jt}$ should reduce bias in β_1.

The above should also clarify why our analysis is conducted using market-level (rather than individual-level) data. First, since our data are a repeated cross section, we cannot observe the same individual in more than one period. Therefore, we cannot evaluate how that individual will change her investment in healthy body weight as male quality changes. We can evaluate how the market average investment changes as male quality changes. Second, our differencing strategy cannot be conducted using individual-level data. The inability to empirically address λ_{jt} at the individual level motivates our use of a market panel.

[19] Including married females' characteristics, $\tilde{X}_{jt}$, has virtually no effect on the parameters of interest, yet it reduces the adjusted R^2 and, therefore, the efficiency of our estimates. As a result, $\hat{\beta}_2 \tilde{X}_{jt}$ is not included in the differencing results presented in Table 7. Supplementary results are available from the authors upon request.

[20] If $E(Q_{jt}(\lambda_{jt} - \tilde{\lambda}_{jt})) = 0$ is satisfied, then Q_{jt} is exogenous by definition. The assumption $\lambda_{jt} = \tilde{\lambda}_{jt} \;\; \forall \;\; j, t$ (i.e. that unobserved factors that are correlated with single male quality have an equal effect on the health behaviors of single and married females *for every* marriage market and time period), is a stronger assumption, which is not necessary for the exogeneity of Q_{jt}.

Table 5
Market level results: average minutes of vigorous exercise, single women.

Simulated marginal effects	All races	White only	Black only
Panel A: multivariate measure of male quality			
(10 pct point increase in low quality)	−11.2%	−29.5%	−9.8%
p-Value	0.009	0.001	0.086
(10 % increase in low quality)	−1.4%	−1.2%	−1.6%
p-Value	0.002	0.002	0.039
F-statistic	2.58	3.55	1.98
p-Value	0.036	0.006	0.096
Joint significance	1%	1%	10%
Panel B: principle component measure of male quality			
First component	−0.97	−0.53	−1.25
Standard error	(0.38)	(0.51)	(0.54)
Significance	5%	None	5%
Controls for female quality			
Number of children per female	Yes	Yes	Yes
Female H.S. dropout rate	Yes	Yes	Yes
Female joblessness rate	Yes	Yes	Yes
Female low income rate	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes
N	4525	3004	1521

Regressions include marriage-market fixed effects and time fixed effects. Standard errors are clustered at the MSA level. Simulated marginal effects are calculated using 10,000 bootstrap draws from the covariance matrix of the estimates for the multivariate measure of male quality. See Table A.III for point estimates.

Table 6
Market level results: average minutes of moderate exercise, single women.

Simulated marginal effects	All races	White only	Black only
Panel A: multivariate measure of male quality			
(10 pct point increase in low quality)	−2.8%	−5.4%	−1.5%
p-Value	−0.453	0.423	0.772
(10 % increase in low quality)	−0.3%	−0.4%	−0.3%
p-Value	0.160	0.131	0.542
F-statistic	0.97	1.20	0.86
p-Value	0.422	0.309	0.488
Joint significance	None	None	None
Panel B: principle component measure of male quality			
First component	−0.82	−1.15	−0.58
Standard error	(0.50)	(0.58)	(0.73)
Significance	10%	5%	None
Controls for female quality			
Number of children per female	Yes	Yes	Yes
Female H.S. dropout rate	Yes	Yes	Yes
Female joblessness rate	Yes	Yes	Yes
Female low income rate	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes
N	4525	3004	1521

Regressions include marriage-market fixed effects and time fixed effects. Standard errors are clustered at the MSA level. Simulated marginal effects are calculated using 10,000 bootstrap draws from the covariance matrix of the estimates for the multivariate measure of male quality. See Table A.III for point estimates.

4.1.1. Market-level results

Before discussing the results of our differencing regressions, which can be found in Table 7, we present market-level results for single females (Eq. (1)) for comparison purposes. Tables 5 and 6 contain these base results. The dependent variables are average minutes of vigorous exercise per week and average minutes of moderate exercise per week, respectively. For both black and white women, we regress these dependent variables on the proportion of low quality single males in the market, while controlling for market-average single female characteristics.

We estimate each model twice, utilizing different strategies to measure single male quality. Our first strategy allows the four market-level measures of single male quality discussed above to enter as separate independent regressors. The advantage of this strategy is that it enables us to examine which specific characteristics of quality are most important. However, the joint effect of the multiple measures can be difficult to interpret and sometimes yields mixed results (see appendix Tables A.III–A.IV). One solution to this problem is to simulate the marginal effect of a proportional increase in all four measures of low male quality, which yields a single marginal effect. Our second strategy uses a single-index measure of male quality from the first principal component of the four market-level measures. In contrast to the multivariate approach, this strategy yields a marginal effect that is easily interpreted. However, nearly half the information available in the four measures of single male quality is discarded when we use only the first principal component (Kaiser–Meyer–Olkin (KMO) statistic of 0.531).[21] Given the strengths and weaknesses of each method, we conduct analysis using both. We believe each method provides insight on whether the quality of single males affects single females' health investment, but find neither method to be strictly preferable.

Tables 5 (vigorous exercise) and 6 (moderate exercise) contain the results of our panel data regressions for the full sample (Column 1), for white women (Column 2), and black women (Column 3). Panel A results are found using multiple measures of low male quality, while Panel B results use the single-index measure of low male quality. For ease of interpretation, we report simulated marginal effects for our multivariate (Panel A) results throughout. Individual parameter estimates for each quality measure are shown in Appendix A. To generate this marginal effect, we first take 10,000 draws from the covariance matrix of our estimates. Using these draws, we simulate single female behavior once using observed single male quality, a second time with a 10% increase in all four (low) single male quality measures, and a third time with a 10 percentage point increase in the same four measures of (low) single male quality. We calculate the average minutes of weekly exercise within each marriage market for each simulation and report the average percentage change in exercise behavior. Directly below each marginal effect, we report its *p*-value (i.e. the probability that we would obtain this marginal effect if the true effect were zero). Also in Panel A, we report the *F*-statistic and *p*-value for the joint significance of the multivariate measure of mate quality, which are derived from analytical tests of the joint significance of the male quality parameter estimates. In the discussion that follows, we will use the latter definition of statistical significance (i.e. *F*-test on the joint significance of the male quality parameter estimates) to evaluate marginal effects, as this metric is common to the 10% and 10 percentage point simulations. All regressions control for marriage-market and year fixed effects and include single female control variables. In all specifications, standard errors have been clustered at the MSA level.

The results of our vigorous exercise regressions can be observed in Table 5. Results in Panel A indicate that the effect of low male quality on single females' vigorous exercise is significant at the 1% level for white women and 10% level for black women. The simulations suggest that the marginal effect of a 10% increase in the proportion of low quality males leads single black (white) women to decrease their vigorous exercise by 1.6% (1.2%), while a 10 percentage point increase in the proportion of low quality males leads single black (white) women to decrease their vigorous exercise by 9.8% (29.5%). Note that while it is reasonable to assume that policy or other economic shocks could cause a 10% change in either black or white male quality in most marriage markets, a 10 percentage point change in the proportion of low quality white males is implausible. The observed proportion of low quality males is considerably higher in black marriage markets than in white ones; the difference is most notable with arrest rates. For black men there are an average of 0.12 arrests per capita per year, a figure four times that of white men (0.03). Thus, the predicted decrease in vigorous exercise for single white women in response to the 10 percentage point change in male quality is driven almost entirely by the quadrupling of the arrest rate. For this reason, little attention should be paid to the 10 percentage point result for white women. This marginal change, however, is consistent with the data on black males. Marginal effects are included for both groups for completeness. The PCA results in Panel B confirm the multivariate results. While the effect of low male quality on market-average vigorous exercise by single females is still significant for the full sample and for single black women (a 10 percentage point increase in our (low) quality measure decreases average vigorous exercise for single women and single black women by 3.0% and 8.4%, respectively), it is no longer significant for white women. This result is intuitive; lack of variation in arrest rates causes the PCA index to place lower weight on arrest rates than the other economic measures. The result suggests that arrest rates are the primary driver of joint significance for white women in the multivariate model.

Our results for moderate exercise can be found in Table 6. Unlike the results for vigorous exercise, none of the multivariate regressions yield estimates in which the four coefficients on low male quality are jointly significant. For white women, we find that an increase in the proportion of low quality single males correlates with a decrease in moderate exercise (with 5% significance) when using the index from the first principal component. This result suggests that a 10% increase in the proportion of low quality single white males leads to a 3% decrease in moderate exercise by single white women. For black women, we find no effect on moderate exercise.

Briefly summarizing the results from our market-level regressions so far, an increase in the proportion of low quality males leads to a decrease in market-average vigorous exercise by single black women. The evidence that a greater proportion of low quality males decreases exercise among single white women is mixed for both exercise type and male quality specifications.

The results from our differencing regressions (Eq. (5)) are presented in Table 7. Recall that the dependent variables are the difference in average investment in healthy body weight between single and married women in a given marriage market and time period. We regress these differenced variables on our previously defined

[21] The Kaiser–Meyer–Olkin statistic is a measure of sampling adequacy. The principle component analysis literature suggests that a KMO statistic below 0.5 is "unacceptable" (i.e. one should not factor).

Table 7
Market level differencing regression: single-married women.

	White women		Black women	
	Mod. Ex.	Vig. Ex.	Mod. Ex.	Vig. Ex.
Panel A: multivariate measure of male quality				
Simulated marginal effects				
(10 pct point increase in low quality)	4.6%	−26.3 %	−1.8%	−5.0%
p-Value	0.348	0.355	0.780	0.070
(10 % increase in low quality)	0.3%	−1.0%	−0.4%	−1.3%
p-Value	0.575	0.624	0.130	0.089
F-statistic	0.59	1.16	0.81	2.10
p-Value	0.671	0.327	0.52	0.079
Joint significance	None	None	None	10%
Panel B: principle component measure of male quality				
First component	0.52	−0.04	−0.94	−1.68
Standard error	(0.92)	(0.64)	(1.36)	(0.85)
Significance	None	None	None	5%
Controls for female quality	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes
N	3004	3004	1521	1521

All regressions include controls for differenced market characteristics of females, including high school dropout rate, number of children per female, joblessness rate and low income rate. Regressions also include time fixed effects, marriage-market fixed effects, and clustered standard errors. Simulated marginal effects are calculated using 10,000 bootstrap draws from the covariance matrix of the estimates for multivariate measure of male quality. See Table A.IV for point estimates. Percentage change calculated with average exercise among *single females* as the base, rather than the difference. Ultimately, the exercise of single females, not the spread, is the outcome of interest.

market-level measures of low male quality and differenced market-level female characteristics. Using both multivariate and single-index measures of male quality, we find no statistically significant effect of low quality single white males on single white female health investments. For black women, we find that the joint effect of the multivariate measure of low quality males is statistically significant at the 10% level for vigorous exercise. A 10 percentage point increase in the proportion of low quality males leads to a 5% decrease in vigorous exercise taken by single black women. We find a negative, but insignificant, effect on moderate exercise for single black women. We find similar results when estimation is conducted with the single-index measure of male quality. An increase in the proportion of low quality males decreases average vigorous exercise among single black women in the population (at a 5% level of significance) and has a negative, though insignificant, effect on average moderate exercise. This marginal effect can be interpreted as follows: If the quality of males in a given marriage market deteriorates from median quality to the 25th percentile, single black women will decrease their vigorous exercise by 10%.

There are at least two plausible candidate explanations for why we find statistically significant results for vigorous exercise, but not moderate exercise. In the questionnaire, respondents are given examples of moderate and vigorous exercise when asked about their typical behavior. While most of the examples provided for moderate activity (walking, vacuuming, gardening) are activities that people do as part of their normal routines, the examples included for vigorous exercise (running, aerobics, heavy yard work) are activities that people do with the specific intent of becoming more fit. Therefore, one reason that male quality may affect vigorous, but not moderate, exercise may be that individuals respond to decreases in mate quality by reducing their intentional fitness activity, but do not alter their home or yard maintenance. Alternatively, the non-result for moderate exercise may be driven by substitution between types of exercise. If decreased mate quality lowers the returns to physical fitness, individuals may decrease their exercise time or intensity – i.e. some vigorous exercisers may substitute to moderate exercise, while some moderate exercisers may substitute to sedentary leisure. The effect of decreased mate quality on average moderate exercise is therefore ambiguous. While we view both of these explanations as plausible, we cannot specifically identify the reason that male quality has a significant impact on vigorous exercise, but moderate exercise.

For both races, the simulated marginal effect of a 10% increase in low male quality on vigorous exercise under our differencing specification is roughly 20% lower than our results in Table 5. Furthermore, the marginal effect of a 10 percentage point increase on vigorous exercise is approximately halved for black women when we difference the married women from the single women. These results are fairly consistent with the findings from the single-index model. For black women, the marginal effect of an increase in low male quality on vigorous exercise is negative and 35% lower in the differencing model than in the base model. These results suggest that an increase in the proportion of low quality single black males decreases the vigorous exercise taken by single black women within a marriage market. Furthermore, differencing married women from single women is effective at reducing bias from time- and market-varying unobserved heterogeneity. Recall that the differencing regression results can be interpreted as unbiased estimates of the effect of low male quality on single female investment in health body weight only if the effect of low single male quality on *married* female investment in healthy body weight is zero. We test that assumption in the next section.

Table 8
Falsification test: results for married women.

	White women	Black women
Vigorous exercise	−0.37	0.58
Standard error	(0.37)	(0.72)
Moderate exercise	−1.52	0.19
Standard error	**(0.76)	(1.15)
Controls for female quality	Yes	Yes
Fixed effects	Yes	Yes
N	3004	1521

Control variables for female quality include high school dropout rate, number of children per female, joblessness rate and low income rate. Regressions include time fixed effects, marriage-market fixed effects, and clustered standard errors.
** $p < 0.05$.

4.1.2. Market-level falsification checks

We subject the MSA-level results to a series of falsification tests. Given the consistency of PCA and multivariate regressions in the previous section, we conduct all subsequent analyses using the single-index measure of male quality only for ease of interpretation. We first test the validity of the assumptions underlying our differencing regressions, namely that single male quality does not affect post-marital investment in healthy body weight. To do this, we regress marriage-market level average investment in healthy body weight by married women on the proportion of low quality single males and the usual set of control variables (i.e. high school dropout rate, kids per capita, low income rates, and joblessness rates). Results are found in Table 8. We find that the effect of the proportion of low quality single males on black married female investment and white married female vigorous exercise is insignificantly different from zero. In general, these results support our differencing strategy as an effective means to control for time- and market-varying unobserved heterogeneity.[22] We do find that married white women's moderate exercise behavior is significantly increasing in single white male quality (i.e. an increase in the proportion of low quality single males leads married white women to exercise less). While this violates our assumption of no relationship, the impact of this result on the differenced marginal effect is straightforward. Returning to Eq. (4), our differencing specification allows us to estimate $(\beta_1 - \tilde{\beta}_1)$, though our interest lies in β_1. Finding that $\tilde{\beta}_1$ is non-zero suggests that we should interpret our differencing result for white women's moderate exercise as the effect of a change in single male quality on single female exercise relative to married females, rather than as the pure effect on single females. This explains why low male quality decreased moderate exercise for single white women in our level specification but not when differenced against the married women.

Our next set of tests addresses the concern that our definition of marriage markets, which limits women to searching for mates within their own race, is too restrictive. Among reported marriages in the CPS from 2000 to 2010, 97.5 (92.3) percent of white (black) people were married to someone of their same race. However, a recent report from the Pew Foundation (2015) indicates that interracial marriage rates are increasing: approximately 12% of new marriages in 2013 were between spouses of different races. Therefore, we test for the importance of interracial mating using several falsification tests. First, we regress the average vigorous and moderate exercise taken by single females on the proportion of low quality single males from the other (i.e. black/white) race in the same MSA-age marriage market. Results are found in Panel A of Table 9. All effects are statistically indistinguishable from zero. Second, we repeat this regression, but interact the cross-race single-male quality variable with an

[22] This falsification test is not perfect. Just as potential correlation between unobserved heterogeneity and single male quality motivated the differencing strategy, the same correlation (though likely weaker) could bias the results of this falsification test. None-the-less, this test does establish that, controlling for market and time fixed effects, there is no statistical relationship between single male quality and married female exercise behaviors. An alternative identification strategy was suggested by an anonymous referee, which does not rely on the single male quality/married female behavior relationship. The strategy is to include MSA-time and marriage-market fixed effects in our market-level specification described in Section 4.1. Thus, the differencing strategy described in Eq. (5) identifies off of variation in the difference in exercise between married and single women within a marriage market over time. This new strategy identifies off of variation in the exercise behaviors of single women within a marriage market over time across age groups. The results of this alternative identification strategy are reported in Appendix A, Table A.V. The results from the two identification strategies are strikingly similar.

Table 9
Falsification: cross-race estimation.

	Single white women		**Single black women**	
	Moderate	Vigorous	Moderate	Vigorous
Panel A: baseline				
Cross-race men	−0.10	−0.03	0.69	0.02
Standard error	(0.33)	(0.26)	(1.30)	(0.78)
Panel B: differential effects by interracial marriage rates				
Cross-race men	0.01	−0.07	1.07	−0.16
Standard error	(0.79)	(0.45)	(1.92)	(1.04)
Cross-race men* high IRM rate	0.42	−0.01	−1.25	0.394
Standard error	(0.78)	(0.58)	(2.94)	(1.79)
Panel C: inclusion of quality of non-white non-black single men				
Cross-race men	−1.02	0.06	4.35	0.48
Standard error	(1.10)	(0.74)	(8.01)	(4.38)
Non-White non-Black men	2.30	−0.47	−1.25	4.11
Standard error	(1.79)	(1.31)	(4.74)	(5.46)
Controls for female quality	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes
N	3004	3004	1521	1521

Control variables for female quality include high school dropout rate, number of children per female, joblessness rate and low income rate. Regressions include time fixed effects, marriage-market fixed effects, and clustered standard errors. Estimates in Panel C are much less precise as the number of MSA*Age defined markets that contain the requisite numbers of Non-White Non-Black individuals in a given age band in the sample are much smaller ($N \equiv 400$) than the numbers for white/black individuals alone.
* $p < 0.1$.

Table 10
Sensitivity analysis: age considerations.

	Single white women		Single black women	
	Moderate	Vigorous	Moderate	Vigorous
Panel A: interacted effects of age and male quality				
Male quality	−1.93	−0.70	−0.50	−1.44
Standard error	**(0.76)	(0.59)	(1.00)	**(0.72)
Male quality* $\mathbf{1}[Age \leq 35]$	1.13	0.22	1.26	0.69
Standard error	(1.35)	(1.18)	(2.50)	(1.39)
Male quality* $\mathbf{1}[Age \geq 55]$	1.91	0.47	−0.25	0.53
Standard error	*(1.04)	(0.79)	(1.24)	(1.04)
Panel B: expanded age bands for males matched to females				
Male quality	0.50	−2.32	−0.93	−1.78
Standard error	(1.45)	**(1.07)	1.93	*(1.07)
Controls for female quality	Yes	Yes	Yes	Yes
MSA*year fixed effects	Yes	Yes	Yes	Yes
Marriage-market fixed effects	Yes	Yes	Yes	Yes
N	3004	3004	1521	1521

Control variables for female quality include high school dropout rate, number of children per female, joblessness rate and low income rate. Regressions include time fixed effects, marriage-market fixed effects, and clustered standard errors.
* $p < 0.1$.
** $p < 0.05$.

indicator variable that takes the value of one if the proportion of interracial marriages in the MSA is greater than the median for all MSAs.[23] This regression addresses the concern that cross-race effects may only be found in MSAs where interracial marriage rates are high. Results are found in Panel B of Table 9. We find no evidence that single females respond to the quality of single males of other races, even in MSAs with high rates of interracial marriage. Third, acknowledging the fact that most interracial marriages occur not between blacks and whites, but between blacks and non-whites and whites and non-blacks, we allow the quality of non-black non-white single males to impact the behaviors of single females.[24] Results are found in Panel B of Table 9. Again, we find no evidence that single females respond to the quality of single males of other races.

Next, we conduct sensitivity analysis on the treatment of age in our model. Results are presented in Table 10. First, our model assumes that the effect of mate quality on physical activity is homogeneous across all age groups. However, if single women are more or less likely to match at different ages, the effect of male quality may be concentrated in a few age groups. In Panel A of Table 10, we amend our market-level analysis from Section 4.1.1 by interacting our index of male quality with indicators for being in the youngest age markets and the oldest age markets. For vigorous exercise among single black women, the overall effect of low male quality is negative and significant. Neither interaction term of age and male quality is statistically significant. This result stands in contrast to the results for moderate exercise among single white women. While low male quality appears to have a negative effect overall, the effect is completely offset among older white women. However, the main result regarding vigorous exercise among single black women is not substantially altered by allowing for heterogeneous effects by age group. Second, we define marriage markets by assuming that individuals search for mates within an age band – for example, we assume that 25–35-year-old women only are concerned with the quality of 25–35-year-old men. In actuality, data from the CPS suggests that women, on average, marry men four years their senior. Technically, we could redefine marriage-market age bands to cover the full support of non-zero age-match probabilities for all age groups; however, such a strategy would eliminate all within MSA-time variation in male quality. Instead we check that our results are robust to looser age restrictions on males. Panel B of Table 10 reports a specification where, for example, 25–35-year-old women consider 23–39-year-old men. For the 30-year-old women at the center of the age band, these bands cover 90% of the empirical distribution of age of husbands in the CPS. As our results show, vigorous exercise among single black women is still negatively affected by the proportion of low quality males. The results for vigorous exercise among white women are now significant. We therefore conclude that our age restrictions, while necessary, if anything, understate our results.

Finally, while BRFSS provides survey participants with definitions and examples of moderate and vigorous exercise, respondent interpretation is somewhat subjective (see Section 3 for details). Furthermore, there is some question as to what a decrease in moderate exercise implies, as an individual could transition to either no exercise or more vigorous exercise. Thus, we estimate the effect of single male quality on single female *total* exercise (i.e. moderate exercise minutes plus vigorous exercise minutes). Results are found in Table 11. When analysis is conducted at the market level, we find that an increase in

[23] Interracial marriage rates by MSA were calculated by averaging rates across the 2000–2010 CPS.
[24] According to the CPS from 2000 to 2010, whites were over 3.5 times as likely to report a non-black non-white spouse than a black spouse. Similarly, blacks reported having a non-black non-white spouse at 3 times the rate they reported having a white spouse.

Table 11
Robustness check: total exercise (moderate + vigorous).

	Single women		Single-married difference	
	White women	Black women	White women	Black women
Minutes of total exercise				
PCA male quality	−1.68	−1.83	0.52	−3.06
Standard error	**(0.87)	*(0.99)	(1.11)	**(1.49)
Controls for female quality	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes
N	3004	1521	3004	1521

Control variables for female quality include high school dropout rate, number of children per female, joblessness rate and low income rate. Regressions include time fixed effects, marriage-market fixed effects, and clustered standard errors.
* $p < 0.1$.
** $p < 0.05$.

the proportion of low quality single males has a significant, negative impact on single female total exercise for both whites and blacks. Using our differencing specification, we find a significant effect for blacks only. These results are largely consistent with our results from Tables 5–7.

Several additional potential sources of bias must be considered. For example, location may be endogenous. If individuals who are competitive in the marriage market (and presumably investing in healthy body weight) move to areas with higher concentrations of mate quality, our results would be biased away from zero. CPS data from 2000 to 2010 can partially address these concerns. Approximately 2.5% of individuals move between different states per year over that decade. While it is true that higher educated individuals are more likely to move (approximately 6.5% migration rate among single individuals with a college degree compared to 3.5% of single individuals with a high school diploma only), this pattern is less pronounced among blacks (4.7% migration rate among single college educated individuals vs. 2.5% among single individuals with a high school degree), and therefore less likely to explain our main results. Furthermore, when controlling for decade of age, propensity to move between states is nearly orthogonal to income. Correlation coefficients between migration and income are −0.001, −0.001, and −0.006 for individuals in their 20s, 30s, and 40s, respectively. Evidence from the Decennial Census suggests that women do not mass migrate to cities with high quality potential mates. Using 2000 and 2010 Decennial Census Data, we find that the proportion of low quality men (as defined in this paper) in 2000 is positively correlated with increased proportion of female population from 2000 to 2010 ($\rho = 0.08$).[25] Additionally, much of the migration among single people is from rural areas to cities. Our analysis is already restricted to cities. Empirically, we control for changing characteristics of the single female population of an MSA by including variables for single females' high school dropout rates, joblessness rates, low income status rates, and number of children. To the extent that migration by single females changes the composition of the area, changing proportions of 'low quality' females should reflect that change.

Selection into marriage creates another potential concern. In each time period, the composition of single women in a marriage market changes as the result of 4 factors: (i) migration (discussed above), (ii) aging out of a particular market, (iii) aging into a particular market, and (iv) selection into marriage. Presumably, selection into marriage is problematic if young, high-quality single women in a particular MSA-age range (e.g. age 35–45) decide to marry, leaving only low-quality older single women in the same MSA-age range in future periods. However, between each period for each MSA-age combination, the oldest single women in the marriage market (i.e. aged within 2 years of the upper age threshold) age out, and the oldest single women from the younger marriage market (e.g. age 25–35) age in. Thus, so long as the non-randomness governing selection into marriage is constant over time, our marriage-market fixed effect will address selection concerns. If, however, changes in male quality alter the properties of women selecting into marriage for a particular market, our results could still be affected. We address this concern by controlling for education, income, and joblessness rates among single women. While these variables ostensibly control for selection-on-observables, they are also correlated with motivation and other latent factors that are likely to influence physical activity.

4.2. Empirical extension

4.2.1. Controlling for differences in sex-ratio

While our analysis is focused on the effects of low quality single males, a related literature has examined the effect of market-level sex ratios on investment in human capital (Mechoulan, 2011; Lafortune, 2013; Lin et al., 2014). For example, Lin et al. find that unfavorable sex ratios induced by the expansion of the criminal justice system contribute to obesity among single black females. It has been suggested that sex ratios may be a problematic omitted variable as the same factors that reduce male quality may also lead to greater numbers of males being extracted from the populace into prisons. In this section, we repeat our market-level (non-differencing) analysis using our single-index measure of the proportion of low quality males, while controlling for sex-ratio at the

[25] We thank an anonymous referee for this suggestion.

Table 12
Market level regressions – by race and sex ratio.

Variable	Principal component	
	Measure of male quality	
	FMR < 1	FMR > 1
Black women		
Vigorous exercise	−0.35	***−1.66
Standard error	(0.99)	(0.62)
Moderate exercise	−0.15	−0.82
Standard error	(1.62)	(0.78)
Controls for female quality	Yes	Yes
Fixed effects	Yes	Yes
N	450	1071
White women		
Vigorous exercise	−1.07	0.04
Standard error	(0.80)	(0.59)
Moderate exercise	−1.11	*−1.23
Standard error	(0.95)	(0.69)
Controls for female quality	Yes	Yes
Fixed effects	Yes	Yes
N	1364	1640

Control variables for female quality include high school dropout rate, number of children per female, joblessness rate and low income rate. Regressions include time fixed effects, marriage-market fixed effects, and clustered standard errors. FMR is the ratio of Females/Males in a given market.
* $p < 0.1$.
*** $p < 0.01$.

marriage-market level to verify that our previous results hold under a mate shortage.[26]

Table 12 contains our results. Denoting the female-to-male ratio FMR, we split the sample on whether there is a shortage of males ($FMR > 1$) or a surplus of males ($FMR < 1$). We find that the effect of an increased proportion of low quality males on single female investment in healthy body weight persists when we control for sex ratio; therefore our results are not driven by unobserved correlation between sex ratio and male quality. Furthermore, the effect increases when there is already a shortage of males. For single black women facing a mate shortage, the additional effect of a high proportion of low quality mates on vigorous exercise is negative and significant at the 1% level. For white women, the larger effect is on moderate exercise for women facing a mate shortage (10% significance). This result is intuitive. In a market already characterized by a shortage of males, an increase in the proportion of low quality males will increase the number of women who cannot find a suitable mate, potentially leading these women to quit the marriage market. In contrast, a market with a surplus of males provides some buffer for women facing a downward shift in male quality.

4.2.2. State-level analysis

Brien (1997) finds evidence that even using large data sets (i.e. decennial census, sample A) that MSA-level measures of economic indicators are troubled by measurement error. If classical measurement error is present in our market-level estimates, these estimates should understate the true effect of low quality single males on female health behaviors. To verify that our results are not driven entirely by some endogenous measurement error, we repeat our preferred differencing specification using state-level data from BRFSS. While BRFSS-SMART is weighted to increase representativeness at the MSA level, it is fundamentally designed to be representative only at the state level. While we view the MSA as the correct geographic definition of a marriage market, we do view these state-level results as validation of our findings at the MSA level.[27] Furthermore, these results may be seen as a robustness check against any problems related to small numbers of observed individuals in a marriage market.

The results of the differencing regressions (married from single women) of health investment on the market-level measures of single men are found in Table 13. In using the multivariate approach, none of the estimated coefficients are jointly significant for white women. Single black women are shown to decrease moderate and vigorous exercise by 2.2% and 3.6% in response to a 10% increase in the proportion of low quality males; coefficients are jointly significant at the 5% level. This compares to respective decreases of 0.4% and 1.3% at the MSA level, suggesting that our MSA-level results may suffer from classical measurement error due to attenuation bias. Similar to our previous specifications, we also conduct regressions with a PCA-created single-index measure of male quality.[28] With this measure, our results for the effect of mate quality on vigorous exercise for black women are negative and significant at the 5% level. The point estimate is very close to the estimate found when marriage markets were defined at the MSA level (Table 7, column 6). Further supporting the notion that our MSA-level results are understated, we find that increased proportions of low quality males negatively effect (1% level of significance) moderate exercise among single black females. This effect was insignificant at the MSA level.

4.2.3. Heterogeneous investment: variation over the female quality distribution

Thus far, we have conducted our analysis using market averages over single women. However, it is probable that the response of single females' investment in healthy body weight to changes in male quality varies over the distribution of female quality. To evaluate whether the response in female premarital investment in healthy body weight varies by female quality, we must move to individual level data.[29]

[26] We measure sex ratio at the MSA level using data from the 2010 Decennial Census. Prior work such as Lin et al. (2014) instrument for sex ratios using incarceration rates, which are not available at the MSA level.

[27] Brien (1997) finds that state-level marriage-market variables outperform indicators of "marriageability" defined at the local level due to considerable measurement error at the local level.

[28] (KMO = 0.515).

[29] In nearly all MSAs, we do not have enough observations to split the market into quality-quintiles by market. The move to individual data, along with the cross sectional nature of the data, also prevents us from utilizing the differencing methodology employed above. We discuss the implications of this limitation below.

Table 13
Differencing regression – single vs. married women, state level.

	White women		Black women	
	Moderate	Vigorous	Moderate	Vigorous
Panel A: multivariate measure of male quality				
Simulated marginal effects				
(10 pct point increase in low quality)	32.2%	−17.6%	−9.6%	−22.3%
p-Value	0.531	0.340	0.092	0.115
(10 % increase in low quality)	1.6%	−0.8%	−2.2%	−3.6%
p-Value	0.166	0.246	0.017	0.002
F-statistic	1.71	0.91	2.98	2.94
p-Value	0.147	0.457	0.020	0.022
Joint significance	None	None	5%	5%
Panel B: principle component measure of male quality				
First component	−0.59	−1.47	−2.93	−1.50
Standard error	(1.58)	(1.29)	(1.13)	(0.70)
Significance	None	None	1%	5%
Controls for female quality	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes
N	1256	1255	877	879

Control variables for female quality include high school dropout rate, number of children per female, joblessness rate and low income rate. Regressions include time fixed effects, marriage-market fixed effects, and clustered standard errors. Simulated marginal effects are calculated using 10,000 bootstrap draws from the covariance matrix of the estimates for the multivariate measure of male quality.

To assess the effects of prospective mate quality on individual single female health behaviors, we use individual-level data from females in the BRFSS-SMART and the calculated market-level characteristics for single men. To split the sample on the basis of female quality, we use multiple correspondence analysis (MCA) to rotate the individual female categorical reports of income, education, and body weight into a single, continuous index of female quality.[30] We then split the sample into quintiles of female quality. As in our market-level regressions, we consider two specific health investment behaviors: minutes of moderate exercise per week and minutes of vigorous exercise per week. We use an ordered probit specification for each behavior.[31] In all regressions, we control for a female education, income, employment, number of children, age-category fixed effects, MSA-level fixed effects, and a time-trend variable for each MSA. Mirroring our market-level analysis, we employ a multivariate specification with simulated marginal effects and analytical tests for joint significance, and a single-index measure of male quality constructed from the first principal component. For each quintile of female quality we regress single female investment in healthy body weight on the multivariate (or PCA) measure of male quality with aforementioned controls and fixed effects.

Table 14 contains the results of our regressions using hours of vigorous exercise as the dependent variable. Panel A contains the results from our multivariate specification of low male quality. We find jointly significant effects (at the 1% level) of male quality on hours of vigorous exercise for only single black women in the lowest quintile of female quality. To calculate the marginal effect of a change in the proportion of low quality males we increase each measure of low male quality by both 10 percentage points (top row) and 10% (second row). Among single black females in the lowest quality quintile, the only subset for which the estimated coefficients are jointly significant, a 10 percentage point increase in the proportion of low quality single males decreases vigorous exercise by 15.8%. A 10% increase in the proportion of low quality single males decreases vigorous exercise by 3.4%. Parameter estimates are available in Table A.I. Panel B contains our findings from the PCA-derived single index specification. For black women in the bottom quintile of the quality distribution, an increase in low male quality decreases the amount of vigorous exercise undertaken. A 10% increase in the proportion of low quality single males decreases vigorous exercise by 3.6%. This result is significant at the 5% level.

Table 15 contains the results for our regressions using hours of moderate exercise as the dependent variable. Similar to the Panel A results for vigorous exercise, we find jointly significant effects (at the 10% level) of low male quality on hours of moderate exercise for only single black women in the lowest quintile of quality. Increasing each of the four measures of low male quality by 10% and 10 percentage points leads to a decrease in moderate exercise by low quality black women; 2% and 10.6%, respectively. An important finding from this table is that the decrease in vigorous exercise for single black women in the lowest quality quintile is being compounded by, rather than offset by, responses in moderate exercise. Parameter estimates are available in Table A.II. In Panel B, we find that the effect of the single-index measure of male quality on

[30] MCA and principal components analysis (PCA) both are data reduction tools, used for transforming multi-variate measures into a single measure. Whereas PCA is used to transform continuous variables into a single-index variable, MCA is used to transform discrete categorical variables into a single-index variable. The variables for males are market-level averages and, as such, are continuous. The female variables are at the individual level and are categorical, hence the need to use different techniques for male and female quality.

[31] While both exercise variables are continuous, the distribution of responses is multi-modal with considerable mass at each hour mark. We therefore discretize the individual reports of exercise using a floor function with hours as units.

Table 14
Individual-level results, ordered probit: weekly hours of vigorous exercise.

	Lowest	Second	Middle	Fourth	Highest
Panel A: multivariate measure of male quality – marginal effects					
Black women					
(10 pct point increase in low quality)	−15.8%	2.8%	10.2%	−8.8%	1.2%
(10 % increase in low quality)	−3.4%	−0.2%	2.9%	−1.6%	0.1%
χ^2 value (joint sig. of parameters)	15.73	3.84	7.74	3.79	2.48
p-Value	.003	0.428	0.101	0.436	0.648
Joint significance	1%	None	None	None	None
White women					
(10 pct point increase in low quality)	−17.2%	5.1%	−5.9%	−3.9%	0.3%
(10 % increase in low quality)	−0.1%	−0.1%	−0.4%	−0.0%	0.2%
χ^2 value (joint sig. of parameters)	6.63	2.87	5.94	1.83	2.80
p-Value	0.156	0.579	0.203	0.766	0.591
Joint significance	None	None	None	None	None
Panel B: univariate measure (first principal component) by female quality quintile					
Black women					
PCA index	−0.02	−0.01	0.02	−0.02	0.01
Standard error	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Significance	5%	None	None	None	None
White women					
PCA index	0.001	−0.00	−0.00	−0.01	0.01
Standard error	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Significance	None	None	None	None	None
Controls for female quality	Yes	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes	Yes

Control variables for female quality include number of children, education, and income. All regressions include MSA fixed effects, MSA fixed effects interacted with a time trend, and clustered standard errors. Simulated marginal effects are calculated using 10,000 bootstrap draws from the covariance matrix of the estimates for the multivariate measure of male quality.

Table 15
Individual-level results, ordered probit: weekly hours of moderate exercise.

	Lowest	Second	Middle	Fourth	Highest
Panel A: multivariate measure of male quality – marginal effects					
Black women					
(10 pct point increase in low quality)	−10.6%	2.8%	1.7%	1.0%	1.8%
(10 % increase in low quality)	−2.0%	−0.0%	0.1%	0.1%	0.6%
χ^2 value (joint sig. of parameters)	7.91	3.76	0.76	0.81	1.29
p-Value	.090	0.439	0.943	0.937	0.8626
Joint significance	10%	None	None	None	None
White women					
(10 pct point increase in low quality)	7.8%	−4.7%	−2.0%	1.0%	−2.6%
(10 % increase in low quality)	0.8%	−0.4%	−0.6%	−0.1%	−0.2%
χ^2 value (joint sig. of parameters)	3.72	3.77	1.51	6.83	2.95
p-Value	0.445	0.437	0.825	0.145	0.567
Joint significance	None	None	None	None	None
Panel B: univariate measure (first principal component) by female quality quintile					
Black women					
PCA index	−0.02	−0.01	0.01	0.00	−0.01
Standard error	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Significance	5%	None	None	None	None
White women					
PCA index	0.00	−0.01	−0.01	−0.03	0.00
Standard error	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Significance	None	None	None	1%	None
Controls for female quality	Yes	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes	Yes

Control variables for female quality include number of children, education, and income. All regressions include MSA fixed effects, MSA fixed effects interacted with a time trend, and clustered standard errors. Simulated marginal effects are calculated using 10,000 bootstrap draws from the covariance matrix of the estimates for the multivariate measure of male quality.

single black females' moderate exercise is negative and significant at the 5% level for women in the lowest quintile of quality. For these women, a 10% increase in the proportion of low quality males leads to a 1.6% decrease in moderate exercise. Counter to our primary results for black females, Panel B shows that an increased proportion of low quality single males leads to decreased exercise by high quality (4th quintile) white females.

In summary, our individual-level cross-sectional analysis produces two primary results. First, we consistently find that single black women at the low end of the quality distribution exercise less when there is a greater proportion of low quality males. This result holds for vigorous and moderate exercise, under multivariate and single index measures of male quality. Second, we find mixed evidence on whether single white women change their investment in healthy body weight in response to a change in the proportion of low quality males in the market. Note that these results are only suggestive of a causal relationship between single male quality and single female health investment that varies over the female quality distribution. While we have controlled for MSA-level fixed effects and MSA-specific time trends, it is possible that time specific MSA-shocks can cause both a deterioration in single male quality and a decrease in single female investment in health body weight. Furthermore, we recognize that BMI is endogenous to exercise decisions in the PCA/MCA analysis. As higher body weight lowers mate quality, the women in the lowest quintile typically do not exercise very much. As such, if there is any bias from subdividing the sample partially on the basis of BMI, it is towards zero. Additionally, since exercise is discrete and bounded below by zero, the variation in exercise behavior for those women in the bottom quintile is primarily on the extensive margin.

5. Discussion

This paper examines how a single female's investment in healthy body weight is affected by the quality of single males in her marriage market. We find that a greater proportion of low quality mates in a marriage market leads to decreased investment in healthy body weight by single females, particularly for black females. This result holds when marriage markets are defined at both the MSA and state level. Additional empirical analysis suggests that the impact of low male quality is strongest in marriage markets with a shortage of males and on single black women who are less educated, low income, and heavy.

None of our results suggest increased competition for mates in response to a reduction in mate quality. Previous work on the effects of mate shortage on human capital investment (Mechoulan, 2011; Lafortune, 2013) have found that a shortage of mates yields increased investment. By contrast, our results are consistent with Lin et al. (2014), who find that mate shortage is associated with increased obesity rates among single females. In fact, when we control for sex ratios, we find that the negative effects of low quality males are strongest for black women in the presence of a mate shortage. These inconsistencies in premarital investment behavior can be explained by either of the following two conditions: (1) investing in education/labor market human capital is more cost effective than investing in healthy body weight, or (2) the increased investment in education under shortage conditions reflects preparation for financial independence.

On the source of racial differences in mate quality, previous studies have examined the relationship between incarceration rates and female investment in human capital and obesity. Our results show that conditional on an observed mate shortage (induced by incarceration or not), low quality among the remaining candidates matters. We believe that abstracting from mate quality and focusing purely on mate shortage understates the impact of incarceration on premarital investment in body weight and family formation. While sentences are often short (BJS estimates expected time served for a drug trafficking conviction at 28 months), felony convictions carry severe consequences for earning potential for the balance of the individual's life. Insofar as women value marriage as a means of financial support, while the expansion of the corrections system in the United States increased in the proportion of males of all races with low economic value, black males have been disproportionately affected. Charles and Luoh (2010) find that a 1% increase in incarceration rates decreases the proportion of women who marry by 2.4%.

There are several avenues for future research on this topic. One open question is whether single females respond differently to changes in single male quality depending on the source of the change. For example, are structural or cyclical changes in average single male quality more likely to induce changes in single female behavior? This is particularly interesting because cyclical changes are more feasibly altered/induced by policy. Separating the effect of these changes could be done in a manner similar to Black et al. (2003). This research also calls to question whether other single female behaviors are impacted by the quality of single males. Mechoulan (2011) and Lin et al. (2014) study how single female education and body weight outcomes respond to the marriage-market conditions; however, employment decisions, for example, have not been studied to our knowledge.

Appendix A

Tables A.I–A.VI

Table A.I
Parameter estimates from multivariate approach: Table 14.

Individual vigorous exercise on multivariate measure of mate quality					
	Lowest	Second	Middle	Fourth	Highest
Black women					
H.S. dropout rate – single males	−0.21	−0.17	0.23	−0.13	0.29
	(0.27)	(0.24)	(0.18)	(0.18)	(0.19)
Low income rate – single males	0.06	−0.22	0.23	−0.17	0.22
	(0.16)	(0.16)	(0.14)	(0.16)	(0.20)
Arrest rate – single males	−0.58	0.54	1.00	−0.47	−0.19
	(0.92)	(0.80)	(0.65)	(0.74)	(0.62)
Jobless rate – single males	−0.54	−0.10	0.09	−0.11	−0.21
	***(0.18)	(0.19)	(0.16)	(0.14)	(0.19)
White women					
H.S. dropout rate – single males	0.07	0.06	−0.11	−0.03	0.09
	(0.13)	(0.14)	(0.12)	(0.12)	(0.14)
Low income rate – single males	0.13	0.09	0.14	−0.12	−0.05
	(0.13)	(0.13)	(0.11)	(0.11)	(0.12)
Arrest rate – single males	−1.62	0.54	−0.42	−0.36	−0.18
	**(0.80)	(0.87)	(0.85)	(0.61)	(0.80)
Jobless rate – single males	−0.03	−0.20	−0.11	0.06	0.18
	(0.12)	(0.13)	(0.12)	(0.11)	(0.13)

All regressions include individual controls, MSA fixed effects, MSA fixed effects interacted with a time trend, and clustered standard errors.
** $p < 0.05$.
*** $p < 0.01$.

Table A.II
Parameter estimates from multivariate approach: Table 15.

Individual moderate exercise on multivariate measure of mate quality.					
	Lowest	Second	Middle	Fourth	Highest
Black women					
H.S. dropout rate – single males	0.16	−0.15	0.04	0.09	0.05
	(0.22)	(0.19)	(0.17)	(0.19)	(0.15)
Low income rate – single males	−0.08	−0.12	−0.08	−0.05	−0.02
	(0.14)	(0.14)	(0.13)	(0.14)	(0.13)
Arrest rate – single males	−0.94	0.72	0.25	0.17	0.06
	(0.69)	(0.58)	(0.68)	(0.68)	(0.57)
Jobless rate – single males	−0.29	−0.13	−0.00	−0.08	0.14
	**(0.14)	(0.14)	(0.14)	(0.15)	(0.15)
White women					
H.S. dropout rate – single males	−0.03	−0.08	−0.08	−0.26	0.19
	(0.13)	(0.13)	(0.13)	**(0.13)	(0.14)
Low income rate – single males	0.03	0.02	−0.04	−0.16	0.01
	(0.12)	(0.12)	(0.11)	(0.14)	(0.13)
Arrest rate – single males	0.78	−0.37	−0.06	0.53	−0.47
	(0.74)	(0.75)	(0.76)	(0.67)	(0.79)
Jobless rate – single males	0.18	−0.22	−0.09	0.08	−0.14
	(0.12)	*(0.13)	(0.10)	(0.10)	(0.13)

All regressions include individual controls, MSA fixed effects, MSA fixed effects interacted with a time trend, and clustered standard errors.
* $p < 0.1$.
** $p < 0.05$.

Table A.III
Parameter estimates: multivariate approach for Tables 5 and 6.

	All races	White only	Black only
Panel A: multivariate measure of male quality – vigorous exercise			
H.S. dropout rate – single males	−2.40	−6.31	−0.11
	(2.85)	*(3.47)	(4.27)
Low income rate – single males	−5.01	−1.57	−6.62
	**(2.12)	(3.10)	**(2.80)
Arrest rate – single males	−20.86	−72.47	−8.03
	*(11.66)	***(24.81)	(12.91)

Table A.III (*Continued*)

	All races	White only	Black only
Jobless rate – single males	−1.59	0.73	−3.30
	(2.17)	(3.10)	(2.98)
Panel B: multivariate measure of male quality – moderate exercise			
H.S. dropout rate – single males	0.47	−6.21	4.52
	(3.16)	(4.36)	(6.18)
Low income rate – single males	−5.23	−1.44	−7.91
	*(3.23)	(3.72)	*(4.68)
Arrest rate – single males	−6.37	−13.54	−4.19
	(17.67)	(31.38)	(20.82)
Jobless rate – single males	−1.09	−4.39	1.48
	(3.04)	(3.39)	(4.70)

All regressions include controls for market characteristics of single females and clustered standard errors.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Table A.IV
Market-level differencing regression parameter estimates, Table 7.

	White women		Black women	
	Moderate	Vigorous	Moderate	Vigorous
Panel A: multivariate estimates – differencing regressions (MSA level)				
H.S. dropout rate – single males	0.63	−2.31	−4.88	−3.33
	(6.71)	(4.43)	(8.07)	(6.24)
Low income rate – single males	6.43	−1.12	−11.97	−13.32
	(0.08)	(4.50)	*(7.54)	***(4.93)
Arrest rate – single males	16.58	−70.18	−3.03	5.24
	(54.71)	*(39.91)	(36.39)	(23.87)
Jobless rate – single males	−2.87	2.73	2.06	5.99
	(4.71)	(3.72)	(7.79)	(5.43)
N	3561	3561	1611	1611
Panel B: multivariate estimates – differencing regressions (state level)				
H.S. dropout rate – single males	−7.65	−8.25	13.04	−1.30
	(10.02)	(7.73)	(9.59)	(5.35)
Low income rate – single males	17.23	2.44	−12.44	−5.26
	*(8.84)	(6.05)	(8.87)	(5.14)
Arrest rate – single males	141.52	−36.86	−21.56	−30.25
	(94.49)	(62.30)	(29.22)	*(16.87)
Jobless rate – single males	3.95	−4.15	−19.10	−7.08
	(7.69)	(4.79)	**(9.33)	*(4.57)
N	1256	1255	877	879

All regressions include controls for differenced market characteristics of females, time fixed effects, marriage-market fixed effects, and clustered standard errors.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Table A.V
Robustness check: MSA*age and MSA*year fixed effects.

	White women		Black women	
	Moderate	Vigorous	Moderate	Vigorous
	Minutes of exercise			
PCA male quality	−0.94	−0.63	−0.93	−1.42
Standard error	(0.79)	(0.62)	(0.83)	**(0.73)
Controls for female quality	Yes	Yes	Yes	Yes
MSA*year fixed effects	Yes	Yes	Yes	Yes
Marriage-market fixed effects	Yes	Yes	Yes	Yes
N	3004	3004	1521	1521

Control variables for female quality include high school dropout rate, number of children per female, joblessness rate and low income rate. Regressions include time fixed effects, marriage-market fixed effects, and clustered standard errors.
* $p < 0.1$.
** $p < 0.05$.

Table A.VI
Symmetry of changes in male quality, first differencing specification.

	White women		Black women	
	Moderate	Vigorous	Moderate	Vigorous
Panel A: interacted effects of age and male quality				
Male quality	−0.83	−1.01	−0.48	−1.66
Standard error	(0.68)	*(0.58)	(0.70)	***(0.55)
Male quality*$\mathbf{1}[Q_t > Q_{t-1}]$	−0.96	1.20	1.30	3.17
Standard error	(1.21)	(1.00)	(1.99)	***(1.09)
Controls for female quality	Yes	Yes	Yes	Yes
MSA* year fixed effects	Yes	Yes	Yes	Yes
Marriage-market fixed effects	Yes	Yes	Yes	Yes
N	1840	1840	771	771

Control variables for female quality include high school dropout rate, number of children per female, joblessness rate and low income rate. Regressions include time fixed effects, marriage-market fixed effects, and clustered standard errors.
* $p < 0.1$.
*** $p < 0.01$.

Appendix B. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ehb.2016.12.002.

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