Assortative mating for obesity

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ABSTRACT
Background: Assortative mating is the nonrandom mating of individuals with respect to phenotype and cultural factors. Previous studies of assortative mating for obesity have indicated that it may have contributed to the obesity epidemic. However, those studies used BMI or skinfold thicknesses to measure obesity and did not always account for potential confounding factors.

Objective: We aimed to assess the level of assortative mating for obesity by using dual-energy X-ray absorptiometry to characterize body composition.

Design: This was a cross-sectional study of 42 couples.

Results: Raw spousal correlations showed assortative mating for age, weight, body mass index, lean mass, and fat mass. Removing the effect of age on fat mass strengthened the spousal correlation (r = 0.405). Social homogamy did not appear to be important, because in this sample there was no significant effect of area of origin on age-corrected fat and lean tissue masses for either sex. Regional body-composition analysis showed that subjects with disproportionately large arms (both fat and lean) assortatively mated with partners with the same trait. However, both men and women with high lean tissue in their arms assortatively mated with partners that had a disproportionately low fat content in their legs.

Conclusions: These data confirm that assortative mating for obesity exists when dual-energy X-ray absorptiometry is used to evaluate adiposity. We hypothesize that assortative mating may have contributed to the obesity epidemic because the time course of obesity development has shifted progressively earlier, allowing singles in their late teens and early twenties to more easily distinguish partners with obese and lean phenotypes.

INTRODUCTION
Assortative mating occurs when men and women do not mate at random with respect to phenotypic and cultural traits. Assortative mating has been shown for height (1, 2), attitude domain of personality (3), education (4–6), religion (4, 6), politics (7), age (7–9), smoking habits (10, 11), and antisocial behavior (12). Assortative mating for obesity has also been inferred in previous studies (6, 9, 13–17), although other studies failed to detect it (18, 19). Assortative mating may have contributed to the obesity epidemic because it increases homozygosity and the likelihood of exposing harmful recessive traits (9). It is impossible to rigorously quantify this contribution unless the exact genetic contribution to the trait in question and the proportion of contributing genes that are recessive are known. These parameters are not yet available for obesity. Nevertheless, we can make some crude estimates of its theoretical effect (Appendix A), which suggests that all things being equal, a switch from random to complete assortative mating would increase the prevalence of obesity in a baseline population from 5% to between 6.6% and 12.6% in just 2 generations. Additionally, assortative mating can result in spurious indications of the role of shared environmental factors in models that attempt to partition the causality of variability in phenotype (13, 16, 20, 21).

There are, however, several problems with previous assessments of assortative mating for obesity. First, almost all previous studies used BMI as a measure of obesity. An exception is the study of Ginsburg et al (15), which used skinfold thicknesses and circumferences. The inadequacies of BMI as a measure of obesity at the individual level are well known (22–27), and these problems may lead either to spurious inferences of assortative mating or underestimates of its significance. Second, the main method for inferring assortative mating is to examine the correlation of given traits between mates (spousal correlation). The spousal correlation, however, is influenced by several other factors that need to be accounted for. Spurious positive associations may occur because obesity is related to other traits that are themselves subject to assortative mating. The most obvious of these is age (13). Because people generally get fatter as they get older (28), and people tend to form relationships with people of their own age (7, 8), taking a cross-section of couples of various ages will generate a spousal correlation in obesity because older persons are generally more obese. Another problem is social homogamy, that is, the tendency for persons to assortatively mate with partners from their own social setting. Because obesity also correlates with social class (29–31), assortative mating may be primarily a consequence of social homogamy. Not all previous studies accounted for these effects. A
further difficulty is that couples generally share a common environment for much of their lives. Any spousal correlation in obesity-related traits may then reflect a shared environmental effect (17, 19, 32).

In the present study, we examined assortative mating for obesity and attempted to overcome some of these difficulties. We used dual-energy X-ray absorptiometry (DXA) to measure body composition, thereby overcoming the inadequacies of using BMI. Moreover we accounted for the effects brought about by assortative mating for age, and social homogamy, and the similarity between couples because of the duration occupying a shared environment.

SUBJECTS AND METHODS

Study subjects

The project was part of a larger cohort observation (Rascal—Rowett assessment of childhood appetite and metabolism) in which families were recruited from the northeast of Scotland, United Kingdom (Aberdeen), through poster and newspaper advertisements to take part in a study investigating familial nutrition. As part of the study, body composition was assessed in 42 couples by use of DXA (Norland XR-26, Mark II high-speed pencil beam scanner; Norland Corporation, Fort Atkinson, WI, equipped with dynamic filtration, with version 2.5.2 of the Norland software). Height was measured with a stadiometer (Holtain Ltd, Crymych, Dyfed, United Kingdom). Weight was measured, with the subjects wearing light clothes, to the nearest 0.1 kg, by using a digital weighing scale (Ohaus, Pine Brook, NJ). All measurements of the family were conducted in the morning after the subjects had fasted overnight. Weekly quality-control checks performed with a phantom over a period of 7 mo indicated CVs of 0.94% and 1.52% for bone mineral density and bone mineral content, respectively. The subjects gave verbal and written consent, and the project was approved by the Grampian local research ethics committee.

Statistical analysis

All data were analyzed by using MINITAB 14 (Minitab Inc, State College, PA). To explore the association between phenotypes of men and women, we used the square of the spousal correlation ($r^2$). We assessed the significance of the associations between men and women for each phenotype by fitting ordinary least-squares regressions and deriving the resultant significance from the $F$ test in the regression analysis of variance. We also derived the gradients of reduced major axis regressions, which are more appropriate for these data for which the $x$ and $y$ traits have equal error variance. In our data set, there was strong assortative mating for age. Because body composition potentially varies with age, spousal associations for body composition might emerge because of the correlation of fatness with age. We therefore explored the effects of age and sex on body composition by using generalized linear modeling. This showed that age was not a significant associate of body composition in our sample. Nevertheless, a weak but not significant association of fatness with age might contribute to a spousal correlation when there is strong assortative mating for age. We therefore fitted regressions of body fatness against age for each sex and derived the residual body fatness corrected for the age of the person. We then examined the spousal correlation in the body fatness corrected for age to establish whether the spousal correlation had been generated because of the strong assortative mating for age in our sample.

In the United Kingdom, geographical areas are classified into postal codes, very much like zip codes in the United States but covering smaller areas. The UK census, which provides comprehensive social information, has been analyzed for each postal code region and these data are available in the public domain. These data show enormous differences in social class between different postal codes over even very small spatial distances. We therefore used postal codes to indicate the social class of the couples. The sample of couples in this study was drawn from 4 different postal code areas. To explore the possibility that we had detected associations because of social homogamy, we examined whether couples varied significantly across these areas of origin with respect to the phenotypes of interest by using one-way analysis of variance with area of origin as the factor.

Finally, we examined the regional body-composition data derived from DXA to explore whether assortative mating for regional body fatness and leanness existed. To explore this possibility, we used the regional lean and fat masses by DXA for the trunk, abdomen, arms, and legs, thus generating 8 traits for each partner. Obviously, subjects that have high total body fat tend to also have high levels of fat in each of their body regions (with such correlations generally having $r$ values around 0.8—0.95), and the same is true of total lean tissue and regional lean tissue masses. Spurious spousal correlations might then emerge because of the overall spousal correlations for total body fat and total-body lean tissue. To eliminate these potential artifacts, we regressed the lean tissue of each region onto the total lean tissue for subjects of each sex and then calculated the residual values to the fitted regression. We repeated this for all 4 body regions in each sex, for both lean and fat tissue (regressing fat tissue mass of each region on total fat tissue mass). These residual values express the extent to which a subject has disproportionate fat or lean tissue amounts in the region of interest. For example, a person with a positive value for leg fat on this scale would have disproportionately large amounts of fat tissue in their legs relative to their overall body fatness. We used these variables to assess whether a person with each characteristic might be involved assortatively in relationships with partners who had similar (or other) regional composition traits. All effects were considered significant when $P < 0.05$.

RESULTS

Total body composition

The mean characteristics of the men and women in the sample are shown in Table 1. The subjects were typical of the UK population and Western societies in general and included many overweight and obese subjects [the mean BMI (in kg/m$^2$) of the men was 26.2 (range: 20.3—45) and that of the women was 24.6 (range: 20.6—43)]. Simple spousal correlations for the raw traits showed significant positive associations in age, weight, BMI, and total-body lean tissue content and total-body fat tissue content by DXA but not in height or bone mineral content by DXA (Table 2 and Figure 1). The relation between ages included an outlier (male age of 55 y and female age of 30 y; Figure 1a); when this point was excluded, the $r$ was increased considerably to 0.84. Even including this outlier, there was strong assortative mating with respect to age in this population. Because weight, BMI, and
lean and fat mass by DXA are all traits that potentially increase with age, the spousal correlations in these instances may have occurred because of the associated age effect. In fact, however, for weight and lean tissue mass by DXA, there were significant effects of sex but not of age and no significant sex-by-age interactions; for BMI, neither age or sex nor their interaction was statistically significant, the weak positive association could still contribute to the spousal correlation of fat mass (Figure 1d and 2). With the age effect removed from fat mass, the spousal correlation became stronger ($r = 0.405; \text{df} = 1,40; P < 0.008$). Persons who were fat for their age tended to be in relationships with other persons who were fat for their age.

To explore the possible role of social homogamy, we examined the extent to which couples might converge because of their shared environment, we examined the difference between their residual fat masses, accounting for the effects of age, against the time that they had been in a relationship and the time that they had been living together. If convergence occurred, the difference between partners would be expected to decline as these durations increased. In both cases, these relations were not significant (time together in the relationship: $\text{df} = 1,30$ and $P = 0.210$). Because only 32 of the 42 couples provided information on the durations of their relationships, the failure to detect such an effect might have been a consequence of reduced power because of the lower sample size. There were strong correlations for these 32 couples between their average ages and both the time they had been in a relationship ($r = 0.847$) and the time they had been living together ($r = 0.886$). In the entire data set of 42, therefore, we examined whether there was a relation between their average age and the difference in their residual fat masses. As their average age increased, we would predict the difference in their residual fat masses to get smaller if environmental factors were important. There was a significant relation (Figure 3; $\text{df} = 1,40$; $P = 0.011$), but the trend was positive rather than negative. However, one data point (indicated by an arrow in Figure 3) had a high leverage on the regression (Cook’s distance $= 0.45$), and

### TABLE 1

Subject characteristics of 42 couples in long-term partnerships recruited into the present study

<table>
<thead>
<tr>
<th>Variable</th>
<th>$\bar{x}$</th>
<th>SE mean</th>
<th>SD</th>
<th>Paired $r^2$</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>37.026</td>
<td>0.851</td>
<td>5.517</td>
<td>2.75</td>
<td>0.009</td>
</tr>
<tr>
<td>Women</td>
<td>35.118</td>
<td>0.691</td>
<td>4.480</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>83.73</td>
<td>2.22</td>
<td>14.36</td>
<td>5.71</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Women</td>
<td>69.23</td>
<td>2.50</td>
<td>16.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>1.7838</td>
<td>0.0107</td>
<td>0.0692</td>
<td>7.70</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Women</td>
<td>1.6751</td>
<td>0.0115</td>
<td>0.0743</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI (kg/m(^2))</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>26.249</td>
<td>0.568</td>
<td>3.683</td>
<td>1.92</td>
<td>0.062</td>
</tr>
<tr>
<td>Women</td>
<td>24.642</td>
<td>0.834</td>
<td>5.404</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TBMC (kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>3.31</td>
<td>0.068</td>
<td>0.440</td>
<td>5.77</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Women</td>
<td>2.85</td>
<td>0.052</td>
<td>0.339</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total lean mass (kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>60.44</td>
<td>1.274</td>
<td>8.26</td>
<td>14.50</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Women</td>
<td>41.78</td>
<td>0.977</td>
<td>6.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total fat mass (kg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>19.77</td>
<td>1.391</td>
<td>9.01</td>
<td>$-2.96$</td>
<td>0.005</td>
</tr>
<tr>
<td>Women</td>
<td>25.14</td>
<td>1.819</td>
<td>11.79</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^1\) TBMC, total bone mineral content. Total lean and total fat masses were determined by dual-energy X-ray absorptiometry.

\(^2\) Paired $t$ values show comparisons of men with women for all traits with the significance value ($P$).

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To explore the possible role of social homogamy, we examined whether the lean and fat masses corrected for age were significantly associated with the area of origin (postal code area) of the couples. In this sample, there were no significant effects of the area of origin of the subjects on the age-corrected fat masses of either the women ($\text{df} = 3,38$; $P = 0.704$) or the men ($\text{df} = 3,38$, $P = 0.467$) or in the age-corrected lean masses of the women ($\text{df} = 3,38$; $P = 0.264$). An effect of area of origin on the age-corrected lean masses of the men approached significance ($\text{df} = 3,38$; $P = 0.061$).

To assess the extent to which couples might converge because of their shared environment, we examined the difference between their residual fat masses, accounting for the effects of age, against the time that they had been in a relationship and the time that they had been living together. If convergence occurred, the difference between partners would be expected to decline as these durations increased. In both cases, these relations were not significant (time together in the relationship: $\text{df} = 1,30$ and $P = 0.432$; time living together: $\text{df} = 1,30$ and $P = 0.210$). Because only 32 of the 42 couples provided information on the durations of their relationships, the failure to detect such an effect might have been a consequence of reduced power because of the lowered sample size. There were strong correlations for these 32 couples between their average ages and both the time they had been in a relationship ($r = 0.847$) and the time they had been living together ($r = 0.886$). In the entire data set of 42, therefore, we examined whether there was a relation between their average age and the difference in their residual fat masses. As their average age increased, we would predict the difference in their residual fat masses to get smaller if environmental factors were important. There was a significant relation (Figure 3; $\text{df} = 1,40$; $P = 0.011$), but the trend was positive rather than negative. However, one data point (indicated by an arrow in Figure 3) had a high leverage on the regression (Cook’s distance $= 0.45$), and

### TABLE 2

Raw spousal correlations ($r$) and significance ($P$) with the gradient of the reduced major axis regression (bRMA) for significant relations of various phenotypic traits measured in 42 couples from northeast of Scotland

<table>
<thead>
<tr>
<th>Trait</th>
<th>$r$</th>
<th>$P$</th>
<th>bRMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.613</td>
<td>$&lt;0.001$</td>
<td>1.232</td>
</tr>
<tr>
<td>Weight</td>
<td>0.425</td>
<td>$&lt;0.005$</td>
<td>0.886</td>
</tr>
<tr>
<td>Height</td>
<td>0.187</td>
<td>NS</td>
<td>-</td>
</tr>
<tr>
<td>BMI</td>
<td>0.332</td>
<td>0.032</td>
<td>0.681</td>
</tr>
<tr>
<td>Fat mass</td>
<td>0.386</td>
<td>0.012</td>
<td>0.634</td>
</tr>
<tr>
<td>Lean mass</td>
<td>0.370</td>
<td>0.016</td>
<td>1.304</td>
</tr>
<tr>
<td>Bone mineral content</td>
<td>0.130</td>
<td>NS</td>
<td>-</td>
</tr>
</tbody>
</table>

\(^1\) In all cases, df for the analysis was (1, 40).
eliminating this point resulted in the regression losing significance ($P = 0.099$).

**Regional body composition**

Having shown that persons assortatively mate for total body fatness, even after age effects were allowed for, we used the regional analysis by DXA to explore whether there is additional assortative mating based on particular body regions. Regional body composition did not vary significantly with age for any trait included in the analysis ($P > 0.05$). For trunk and abdomen with the use of both lean and fat masses, there were no significant spousal correlations, and these traits were also not related to the residual lean and fat masses of the limbs. However, when examining the residual limb values, we found several significant correlations (Table 4 and Figure 4). In particular, we found that there were positive associations between both the residual arm fat tissue and lean tissue contents between men and women. In other words, men and women with arms that contained disproportionately large amounts of fat or lean tissue, relative to total body fat and lean tissue levels, were assortatively mated with partners who had similar disproportionately increased arm fat and lean tissue levels relative to their total body fat and lean tissue levels. That is, persons with disproportionately heavy arms—whether lean or fat—tend to assortatively mate with one another.

There were also significant negative spousal correlations between the residual amounts of lean tissue in the arms and the residual amounts of fat tissue in a partner’s legs. This was true for both men and women. Hence, if a man or a woman had disproportionately large amounts of lean tissue in his or her arms, he or she tended to be assortatively mated with a partner who had disproportionately low amounts of fat in his or her legs (Table 4 and Figure 5). Clearly, multiple testing is involved in this matrix of correlations. If the Bonferroni correction is applied, only the correlation between disproportionate arm fatness in both men and women remained significant at $P < 0.05$, but this may be an overly conservative correction.

**DISCUSSION**

Significant raw spousal correlations were found for age, BMI, and body weight in accord with many previous studies. Despite previous indications that humans also assortatively mate for height (1, 2), we did not confirm this relation in our sample. Previous studies based on relatively small samples like our own

**TABLE 3**

<table>
<thead>
<tr>
<th>Trait</th>
<th>Age</th>
<th>Sex</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>0.341</td>
<td>&lt;0.001</td>
<td>0.781</td>
</tr>
<tr>
<td>BMI</td>
<td>0.289</td>
<td>0.175</td>
<td>0.891</td>
</tr>
<tr>
<td>Lean mass</td>
<td>0.84</td>
<td>&lt;0.001</td>
<td>0.906</td>
</tr>
<tr>
<td>Fat mass</td>
<td>0.162</td>
<td>0.012</td>
<td>0.687</td>
</tr>
</tbody>
</table>

1 df in all cases was (1, 80).
also failed to confirm assortative mating for height (4, 9). The strong assortative mating for age occurs primarily because most persons form their first long-term relationships during their late teens and early twenties. At this stage, the potential pool of unattached partners is dominated by persons of the same age. Because we selected for this study couples who were in long-term relationships, the couples involved predominantly met at similar ages and then grew older together, which led to a spousal correlation for age. Undoubtedly, there is probably also assortative mating with respect to age, even in persons who become available during later years after divorce or spousal death, which maintains a strong spousal correlation for age, despite a relatively high divorce rate in Western societies. Clearly, however, these trends can be broken, as illustrated by the outlying couple in our own sample (Figure 1a) and the reduced degree of age correlation among divorced and remarried couples (8). Some degree of assortative mating for age in humans is clearly evolutionarily advantageous because it allows significant biparental care over the protracted developmental period of offspring.

Our data also confirm previous suggestions of assortative mating for body weight and BMI on the basis of the raw spousal correlations (6, 9, 13–17). Consequently, despite the limitations of using BMI as an index of obesity, measures of lean body tissue and fat tissue by DXA support the suggestion that assortative mating for obesity exists. Because, in general, older persons get heavier and fatter, the highly significant assortative mating for age can generate spurious illusions of assortative mating for these other traits. Some (13) but not all previous studies accounted for age effects. In our sample, there were no significant effects of age on weight, BMI, or lean or fat mass, so the raw spousal correlations we observed could not have been due to an age artifact. Indeed, when we corrected for age with respect to fat mass, which

TABLE 4
Spousal correlations between fat and lean tissue amounts in the limbs (corrected for total body fat and lean tissue, respectively) across 42 couples from northeast Scotland

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th></th>
<th>Legs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arms</td>
<td></td>
<td>Legs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LM</td>
<td>FM</td>
<td>LM</td>
<td>FM</td>
</tr>
<tr>
<td></td>
<td>r</td>
<td></td>
<td>r</td>
<td></td>
</tr>
<tr>
<td></td>
<td>p</td>
<td></td>
<td>p</td>
<td></td>
</tr>
<tr>
<td>Arms</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r</td>
<td>0.378</td>
<td>0.336</td>
<td>0.050</td>
<td>-0.346</td>
</tr>
<tr>
<td>p</td>
<td>0.014</td>
<td>0.029</td>
<td>0.653</td>
<td>0.025</td>
</tr>
<tr>
<td>FM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r</td>
<td>0.406</td>
<td>0.463</td>
<td>0.002</td>
<td>0.264</td>
</tr>
<tr>
<td>p</td>
<td>0.008</td>
<td>0.002</td>
<td>0.986</td>
<td>0.092</td>
</tr>
<tr>
<td>Legs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r</td>
<td>0.030</td>
<td>0.070</td>
<td>0.002</td>
<td>0.151</td>
</tr>
<tr>
<td>p</td>
<td>0.721</td>
<td>0.603</td>
<td>0.988</td>
<td>0.338</td>
</tr>
<tr>
<td>FM</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r</td>
<td>-0.340</td>
<td>0.296</td>
<td>0.035</td>
<td>0.293</td>
</tr>
<tr>
<td>p</td>
<td>0.028</td>
<td>0.056</td>
<td>0.961</td>
<td>0.060</td>
</tr>
</tbody>
</table>

FIGURE 3. The absolute difference between male residual fat mass with age effects removed and the same trait in their partners, plotted against the average age of the couple. The relation was significant and positive, but significance was lost if the arrowed point (which had a high Cooks distance) was removed.

FIGURE 4. Interrelations between arm fat tissue mass relative to the expectation from total body fat and arm lean tissue mass relative to the expectation from total lean tissue in both men and women in long-term partnerships. All 4 relations were significant. Men and women with disproportionately large arms assortatively mate with partners with similarly large arms. (Note that the scale for female residual arm fatness is expanded to reflect the greater variance relative to that in men.)

FIGURE 5. Interrelations between arm lean tissue content relative to total lean tissue of both men and women and the leg fat tissue of their partners relative to their total body fatness. For both sexes, persons with disproportionately large amounts of lean tissue in their arms were assortatively mated with persons who had disproportionately low amounts of fat in their legs.
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REFERENCES


APPENDIX A

Theoretical quantification of assortative mating effects on the prevalence of obesity

In theory, assortative mating for any polygenically determined trait will have an effect on the prevalence of that trait because bringing persons with the trait together will increase the likelihood that recessive genes of large effect are exposed as homozygotes (9). However, it is impossible to rigorously quantify this effect unless (1) the exact genetic contributions to the trait and (2)
the proportion of genes contributing to the trait that are recessive and their individual effects are known. These parameters are not yet available for obesity. We can, however, make some very crude estimates of its theoretical effect in the limiting situations where mating is completely random or mating is completely assortative and where contributory genes are predominantly recessive or dominant.

Consider obesity as a binary trait: persons are either obese or nonobese. The proportion that is nonobese in generation \( x \) is \( P_{\text{nonob}} \), and the proportion that is obese (\( P_{\text{ob}} \)) is by definition \( 1 - P_{\text{nonob}} \). In the situation where mating is random, the proportion of obese persons in generation \( x + 1 \) can be defined as

\[
P_{\text{ob}x+1} = (P_{\text{nonob}})^2 \times P_{\text{off1}} + 2 \times (P_{\text{nonob}} \times P_{\text{ob}}) \times P_{\text{off2}} + (P_{\text{ob}})^2 \times P_{\text{off3}} \]  

(A1)

Where \( P_{\text{off1}} \) is the probability of an offspring from a mating of 2 nonobese persons being obese, \( P_{\text{off2}} \) is the probability of an offspring from a mating of a nonobese person with an obese person being obese, and \( P_{\text{off3}} \) is the probability of an offspring from a mating of 2 obese persons being obese. When mating is completely assortative, the proportion of matings reflects only the proportion of each type in the population. Hence, the proportion of obese persons in generation \( x + 1 \) can be defined as

\[
P_{\text{ob}x+1} = P_{\text{nonob}} \times P_{\text{off1}} + P_{\text{ob}} \times P_{\text{off3}} \]  

(A2)

Consider a starting population (generation \( x = 0 \)) with an obesity prevalence \( P_{\text{ob}} \) of 0.05, and hence \( P_{\text{nonob}} = 0.95 \). For the scenario where most genes contributing to obesity are recessive, we will set the probability of producing obese offspring (\( P_{\text{off1}} \) and \( P_{\text{off2}} \)) at 0.05. We will set the probability of producing an obese offspring resulting from an obese person mating with another obese person (\( P_{\text{off3}} \)) at 0.75 because of exposure of recessive obesity genes. The prevalence of obesity over 3 generations 1 to 3 in a random mating situation using Equation A1 would be 0.0517 in generation 1, 0.0519 in generation 2, and 0.0519 in generation 3. In contrast, if there was complete assortative mating, the prevalence using equation A2 would increase from 0.05 over the 3 generations to 0.085, 0.109, and 0.126. In the 2 generations that have spanned the current obesity epidemic, a large assortative mating effect of this type could result in a doubling of the prevalence of obesity. In contrast, when most genes are dominant, the respective probabilities of producing obese offspring can be set at \( P_{\text{off1}} = 0.03, P_{\text{off2}} = 0.23, \) and \( P_{\text{off3}} = 0.60 \) (ie, obese \( \times \) nonobese matings have a probability of producing obese offspring midway between the obese \( \times \) obese and nonobese \( \times \) nonobese matings). In this situation in the population, where there is random mating, obesity prevalence over the 3 generations from equation A1 is 0.0504, 0.0506, and 0.0507, whereas the increase in the assortatively mated population is 0.0585, 0.063, and 0.066.