Epidemiology of Gestational Weight Gain and Body Weight Changes After Pregnancy

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INTRODUCTION

Women are universally concerned about whether pregnancy will have a lasting impact on their body weight. Anecdotal reports and studies of severely obese women have pointed to pregnancy as a cause of their obesity. In a Stockholm obesity clinic, 40–50 percent of women (mean age 47.8 ± 10.7 years) attributed the onset of their obesity to childbearing, and 73 percent reported a retention of 10 kg after pregnancy (1, 2). However, most of the evidence from observational studies about the influence of pregnancy on postpartum body weight does not support these perceptions. For the majority of women, body weight at 6–18 months postpartum is no more than 1–2 kg greater than preconceptional weight (3–9). Yet, at least 14–20 percent of women in national surveys were more than 5 kg heavier by 6–18 months postpartum (3, 4, 6–8). This evidence suggests that pregnancy may substantially increase postpartum body weight for subgroups of women, such as those with high gestational weight gain (6). A more recent study found an increased risk of becoming overweight among women who had a single pregnancy compared with nongravid women (10). Thus, estimates of average body weight change do not reflect the excess weight increases experienced by a sizable number of women; this may be further compounded over subsequent pregnancies and contribute to the development of obesity.

Factors suspected of influencing postpartum body weight include gestational weight gain, pregravid weight, race/ethnicity, parity, and lactation. Body weight at conception may be particularly important among race/ethnic groups in which the prevalence of obesity is high (8). Both mean gestational weight gain and prevalence of overweight women in the US population have increased over the past two decades (8, 11–13). It has not been established whether increased gestational weight gain is responsible for part of the increasing prevalence of overweight women. The questions that have arisen from the current evidence are: "Does pregnancy increase the risk of becoming overweight or excess weight increases?", and "Which factors predict the pregnancy-associated changes in body weight?" The purpose of this review is twofold: to examine the evidence relating to the influence of pregnancy, particularly gestational weight gain, on changes in the body weight of women and their risk of becoming overweight after pregnancy, and to comment on what further research is needed. The review is organized in several sections as follows:

1. Background on the current epidemic of overweight in the United States and its health consequences, as well as trends in recommended and actual gestational weight gain over the past decades.
2. Design considerations in studies of the influence of pregnancy on postpartum body weight, and accuracy of the weight data.
3. Findings from longitudinal studies including average change in body weight, prevalence of excess weight increases after pregnancy, and the risk of becoming overweight associated with pregnancy.
4. Findings from multivariable linear regression models regarding the risk factors (pregravid weight-for-height, gestational weight gain, parity, race/ethnicity, dietary intake, lactation, and social factors) which predict increased postpartum body weight, as well as the statistical bias issues related to gestational weight gain.
5. Biologic mechanisms which may influence the relation between gestational weight gain and postpartum weight changes.

Finally, we will summarize the conclusions based on these findings and propose directions for future research. In this review we examine American or European prospective studies that include well-nourished adult women of reproductive age in order to ascertain the effect of pregnancy on postpartum body weight apart from weight changes related to adolescent growth or menopause.

BACKGROUND

The epidemic of overweight and its health effects and economic costs

The epidemic of overweight adults in the United States has continued unabated despite the estimated $30 to $50 billion spent each year on weight loss or weight-control treat-
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ments (14, 15). Thirty years ago the percentage of overweight women in the population aged 20–74 years remained stable at 24 percent (11). Over the last two decades the prevalence has increased sharply from 26 to 36 percent of all women (11, 16). In 1994, an estimated 30 million women were overweight as defined by a body mass index (BMI) (calculated by dividing weight in kilograms by height in meters squared) greater than 27.3 (11, 16). Minority ethnic groups show much higher prevalences of overweight, especially among women; 47 percent of Mexican-American women and 49 percent of black women are overweight (17). Today, more than 45 million US women (50 percent) are classified as overweight based on a revised definition of overweight as having a BMI more than or equal to 25.0 (12). The contribution of childbearing to the development of obesity among women is important in light of the latest US statistics that show the greatest increases in prevalence of overweight among reproductive age women (11). Between 1960 and 1991, the percentage of overweight women aged 20–29 years doubled from 10 to 20 percent, and among women aged 30–39 years increased from 22 to 34 percent (11). These increases may partly reflect secular trends in childhood obesity rates, or other factors such as higher gestational weight gains.

The adverse health effects and economic costs of obesity and comorbid conditions related to excess body fat are second only to smoking (18). About 300,000 deaths in the United States each year are attributed to dietary behaviors and physical activity patterns that are “too sedentary” (18). This lack of physical fitness is often associated with obesity or moderate degrees of excess adiposity that adversely affect health status by leading to comorbid conditions. Obesity (a BMI > 29) is associated with a two- to threefold increased mortality risk among women, and is a major risk factor for chronic diseases that are the leading causes of death in the United States; these diseases include coronary artery disease, stroke, hypertension, and diabetes mellitus, as well as certain cancers (19–23). Obesity among women is also a cause of reduced fertility, endometrial cancer, and osteoarthritis of the spine and knee (19). In addition, excess adiposity may lead to gout, dyslipidemia, osteoarthritis, cholelithiasis, and obstructive apnea (19, 24).

Moderate degrees of overweight and weight increases during adulthood are also associated with increased risks of mortality and morbidity. In the Nurses’ Health Study, a prospective study of US middle-aged women, overall mortality was substantially higher among women who were overweight (BMI ≥ 27.0) and among women with a weight gain of 10 kg or more from the age of 18 years (21). Other studies have reported an increased risk of coronary heart disease among moderately overweight women (BMI = 25–28.9) (20) and a 50 percent increase in the incidence of diabetes associated with modest weight gain (25).

The health care costs of treating illnesses associated with obesity are substantial (14, 26, 27). It is estimated that obesity accounts for almost 6 percent of all US direct health care expenditures, and nearly $100 billion annually in direct and indirect costs (27). Obesity affects the health status and quality of life of women disproportionately; 63 percent of cases of type II diabetes were diagnosed in obese women (27). The future health care costs for treating morbidities among women who remain overweight after 40 years of age are estimated at $16 billion over the next 25 years (28). Thus, current obesity prevention efforts are targeted at women of reproductive age.

Gestational weight gain: recommendations and population trends

Upward trends in both actual and recommended gestational weight gains occurred during the same period as the increase in body weight among American women (11, 13). Actual gestational weight gain increased from an average of 10 kg in the 1960s to 15 kg by the late 1980s (13). These higher gestational weight gains coincided with the 50 to 100 percent increase in the prevalence of overweight women of reproductive age from the 1960s to the 1990s (11). These population data support a possible link between higher gestational weight gain and maternal body weight, and are important from the standpoint of obesity prevention.

Recommended gestational weight gains have increased largely based on the potential benefits to infant health. Prior to 1970, it was standard obstetric practice to restrict prenatal weight gain to between 6.8 and 9 kg. In 1970, the Committee on Maternal Nutrition recommended a higher gestational weight gain (10.9 kg) based on the evidence that maternal weight restriction had a deleterious effect on infant morbidity and mortality rates (29). By 1990, even higher gestational weight gain (11.4–15.9 kg for normal pregravid weight) was encouraged, since the published evidence suggested that adequate maternal weight gain during pregnancy reduced rates of low birth weight (13). The Institute of Medicine recommended gains that were somewhat higher for underweight women and lower for overweight women. At that time, there was insufficient data available to conclude whether the higher gestational weight gains would result in increased maternal body weight or influence the risk of becoming overweight.

STUDY DESIGN ISSUES

A variety of study design issues influence measures of the impact of pregnancy on maternal postpartum body weight. First, we list the study types and sources of subjects; next, we identify the important study design features and limitations; and finally, in the sections to follow, we explain how these aspects of the study designs influence the estimates of body weight change.

Observational studies of European or American women provide estimates of average body weight changes from baseline (preconception) and risk of becoming overweight after pregnancy (tables 1 and 2). Study subjects come from three sources: 1) hospital/clinic-based samples of pregnant women, 2) population/community-based samples of pregnant women, and 3) population-based samples of pregnant women with comparison groups of nulliparous or non-gravid women. Other important study design features include sample size, age ranges, race/ethnicity, measured
versus self-reported weight data, time postpartum and length of follow-up period, nonresponse or lost-to-follow-up, and average gestational weight gain (where available).

Studies without comparison groups (hospital/clinic- or population-based) estimate weight change from baseline (preconception) until 6–18 months postpartum, or between consecutive pregnancies. However, several limitations affect the accuracy and validity of the estimates including lack of comparison groups of non-gravid women, inclusion of teenagers, exclusion of women with more than one pregnancy during the study period, use of self-reported pre-gravid or postpartum weights, lost-to-follow-up, and relatively short follow-up periods. Yet, these studies constitute the only source of information about gestational weight gain and maternal body weight (3, 4, 6–9, 30, 31).

Studies with comparison groups estimate weight changes for women giving birth, compared with nulliparous or non-gravid women, over extended follow-up periods (5, 10, 32, 33). These studies provide the most accurate estimates of weight changes and risk of overweight since they rely on measured pregravid weights and control for weight increases due to aging or secular trends. Finally, the findings from these studies are generalizable since they are derived from population-based samples (10, 32, 33). The weaknesses of these studies include variable postpartum time period, small sample sizes, exclusion of women who became pregnant more than once over the study period, and lack of data on gestational weight gain.

The majority of the studies (tables 1 and 2) rely on self-reported pregravid weights, and over half have relatively small sample sizes (< 500 pregnant women). A third of the studies have relatively large lost-to-follow-up or nonresponse rates (> 20 percent) or include teenagers (aged < 18 years). Several studies provide no information on the number of adolescents or the age range of the subjects. Finally, temporal effects may be responsible for the lower weight change estimates related to the emphasis on restriction of gestational weight gain in the 1950s and 1960s. Many of these factors affect the accuracy of the estimates or induce biases.

**Comparison groups of non-gravid women help isolate the effects of pregnancy on body weight changes**

Appropriate comparison groups of non-gravid or nulliparous women are important to account for age-related weight increases and the individual variability in weight changes apart from pregnancy. Only four prospective studies included non-gravid comparison groups to account for weight changes due to aging and other factors unrelated to pregnancy (5, 10, 32, 33). These studies provide the most accurate estimates of maternal postpartum weight change since they also include measured preconception weights. The Coronary Artery Risk Development in Young Adults (CARDIA) study followed women who had one birth and nulliparous women of similar age range (18–30 years) over 5 years (32). This study provides the most valid information about weight increases directly due to pregnancy, because the age-related weight increases are based on comparison with a group of nulliparous women of reproductive age. The First National Health and Nutrition Examination Survey (NHANES I) Epidemiologic Follow-Up Study (NHEFS) included a much wider age range (25–45 years) at baseline, and the non-gravid comparison group would have included many women aged 55 years by the end of the 10-year follow-up period (10, 33). Therefore, the weight increases attributed to pregnancy would have been underestimated, since 1–2 kg average weight increases also occur around menopause (34).

**Inclusion of pregnant adolescents may overestimate postpartum weight changes**

Inclusion of women under the age of 18 years is likely to provide biased estimates of average body weight increases due to pregnancy since maternal growth accounts for some of the weight increase. Four out of 13 studies (4, 7, 8, 31) included adolescents (aged less than 18 years), and two other studies (3, 30) did not state the age range of the subjects (table 1). Longitudinal studies of incremental growth among adolescents have found that at least 50 percent of young white women have not attained adult height by the chronological age of 17 years (35). Body weight changes among growing teenagers may reflect deposition of lean body mass for completion of linear growth as well as increased adipose tissue (36). In the Camden Study, differences in body composition after 28 weeks gestation were reported among growing gravidas compared with non-growing gravidas and mature control subjects (36). In contrast to mature pregnant women who accrue maternal fat during the first and second trimesters and mobilize it during the third, growing teenagers continued to gain fat throughout gestation. They also retained more weight postpartum than mature control subjects (36). Pregnancy during adolescence may alter normal growth processes and increase the risk of becoming overweight or obese (37).

Therefore, inclusion of a large numbers of pregnant adolescents may overestimate postpartum weight changes or the risk of becoming overweight, and thus bias estimates for adult women. The bias would depend on the proportion of young teenagers in the sample. In one study (not shown), more than 60 percent of the sample were teenagers (38). The large sample sizes of the population-based studies (n > 1,000) may lessen the impact from inclusion of adolescents, but none provide data on the number of adolescents. Boardley et al. (9) and Parker and Abrams (6), as well as all studies with comparison groups (5, 10, 32, 33), excluded adolescents from the samples.

**Time postpartum may reflect spacing of pregnancies and maternal weight change**

Very little data are available about the influence of pregnancy spacing on maternal weight changes, or the optimal time necessary to return to preconception weight. It is reasonable to hypothesize that women who became pregnant more than once during the follow-up period were either excluded or lost to follow-up in all but three studies (7, 10, 33). Women who become pregnant within a short period of

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<table>
<thead>
<tr>
<th>Study reference no.</th>
<th>Country, time period, study cohort</th>
<th>Sample size (n)</th>
<th>Race (%)</th>
<th>Gestational weight gain (kg)</th>
<th>Postpartum weight change (kg) from preconception</th>
<th>Postpartum interval*</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscati et al. (31), 1996</td>
<td>Canada, 1979–1989</td>
<td>371</td>
<td>100 White 0 Black 0 Hispanic</td>
<td>16.1 Low Medical records</td>
<td>6 weeks Blacks gained 2.9 kg more than whites</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boardley et al. (9), 1995</td>
<td>United States, not stated</td>
<td>345</td>
<td>35 White 65 Black 0 Hispanic</td>
<td>14.1 B: 14.4, W: 14.4</td>
<td>7–12 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schaubirger et al. (3), 1992</td>
<td>United States, 1989–1990</td>
<td>795</td>
<td>97 White 0 Black 0 Hispanic</td>
<td>13.0 First prenatal visit</td>
<td>6 weeks 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parker and Abrams (6), 1993</td>
<td>United States, 1986, NMIHS†</td>
<td>1,129</td>
<td>12 White 53 Black 47 Hispanic</td>
<td>35% gained &gt;15.9 kg Self-report BMI &lt;26</td>
<td>Self-report 10–24 months % &gt;9 kg; W: 18.2%, B: 48.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kappel and Taffel (8), 1993</td>
<td>United States, 1988, NMIHS</td>
<td>1,599</td>
<td>54 White 46 Black 0 Hispanic</td>
<td>14.4 Not stated US population</td>
<td>Self-report 12 months Medians: W: 1, B: 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ohlin and Rossner (4), 1990</td>
<td>Sweden, not stated</td>
<td>1,423</td>
<td>100 White 0 Black 0 Hispanic</td>
<td>17–49 Mixed Self-report</td>
<td>6 months 1.5 ±3.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greens et al. (7), 1988</td>
<td>United States, 1959–1965, PCS†</td>
<td>7,116</td>
<td>None White 45 Black 50 Hispanic</td>
<td>9.5 ±9.1 Self-report, variable</td>
<td>1.5 median 0.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Billewicz (39), 1970</td>
<td>Aberdeen, Scotland, 1949–1964</td>
<td>5,579</td>
<td>100 White 0 Black 0 Hispanic</td>
<td>Not available Not available</td>
<td>Variable Not available 10-year follow-up O: 2.4 ±0.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Note: Unless otherwise specified, postpartum body weight was measured.
† SD, standard deviation; SE, standard error; U, underweight; N, normal weight; O, overweight; B, black; W, white; BMI, body mass index; NMIHS, National Maternal and Infant Health Survey; PCS, Perinatal Collaborative Study; adj, adjusted for age-related weight change.
Body Weight Changes After Pregnancy

Body Weight Changes After Pregnancy

The optimal amount of time needed to return to preconception weight is not known. The time required may depend on both the amount and composition of the gestational weight gain. Postpartum weight loss at serial points in time has been measured in only a few studies. Two studies that included serial weight measurements reported that 75–80 percent of gestational weight gain (including infant birthweight) is lost by 2–6 weeks postpartum (3, 4). Schauberger et al. (3) found that postpartum weight loss continued to increase up to the 6-month visit, and differed significantly from the 6-week visit (3). A few studies have provided evidence of a positive association between the increased time interval between consecutive pregnancies and increased body weight; however, none adjusted for age-related weight changes (7, 39). Studies with age-appropriate comparison groups measured postpartum weight at variable intervals (≥12 months) over extended follow-up periods (10, 32, 33). In summary, data on pregnancy-related weight changes at specific postpartum intervals are limited.

Accuracy of pregravid weight data and how this affects various outcome parameters

The most reliable estimates of changes in body weight or BMI category come from four studies (table 2) with comparison groups that measured weights before conception and at postpartum follow-up (5, 10, 32, 33). Only one study without a comparison group (table 1) obtained measured pregravid weight data from medical records (31). The remaining studies obtained self-reported pregravid weight or weight at first prenatal visit, and obtained a variety of measured or self-reported weights at delivery and postpartum periods (3, 4, 6–9, 30). While self-reported weight data may be sufficient to classify individuals by BMI group, a substantial bias may result when it is used to estimate average body weight change over time. The size of the error varies according to pregravid body size (which increases with actual body weight) among other factors.

Self-reported pregravid body weights (r = 0.98) correlate very well with current measured body weights in women of reproductive age (r = 0.96) (40–44). But, the reporting error ranges from an average of −0.5 kg among white women (35–44 years) to −1.95 ± 5.42 (standard deviation) kg among low-income black pregnant women (40, 41, 45). The error is even greater among overweight women, as much as −5.0 ± 6.0 kg (41). An error of 1–5 kg may overestimate postpartum weight change by more than 100–200 percent. Therefore, measured weights at preconception, delivery, and postpartum are necessary to obtain accurate estimates of average body weight change as well as gestational weight gain, especially among overweight women. Only Muscati et al. (31) used measured pregravid weights to estimate gesta-
tional weight gain. Given these inherent weaknesses in the data, reporting bias may exert an important influence on maternal characteristics related to postpartum body weight change.

A second outcome, change in BMI category, may be less subject to bias from reporting errors, compared with average postpartum weight change. Self-reported weights provide reasonable estimates of BMI category since the reporting error (1–2 kg) is a small percentage of total body weight, and age-related changes in height are not a factor for prenatal populations. The error in self-reported weight and height (1.1 cm) would result in lower BMI estimates as compared with measured values. Yet, estimates of the risk of becoming overweight would not be greatly altered by use of self-reported pregravid weight among non-overweight women of reproductive age. Though some moderately overweight women may be incorrectly classified as normal weight, this misclassification error would tend to bias the risk ratio toward the null for becoming overweight after pregnancy. The good correlation between reported and measured preconception body weights is likely to minimize misclassification bias by BMI category. In large epidemiologic studies where measured pregravid weights are not available, the most appropriate outcome measure may change in BMI category rather than absolute change in body weight. Furthermore, large increases in BMI may have greater relevance to health status than absolute weight retention. For example, a normal-weight woman who moves into the overweight BMI category may experience more detrimental health effects than an underweight woman whose weight increases by several kilograms, but falls within the normal-weight BMI group.

Nonresponse/lost to follow-up and generalizability of findings

The percentage of women who were nonrespondents, missing data, or lost to follow-up in the studies ranged from 12 to 38 percent. Most of the studies had percentages below 15 percent. However, the few studies which included serial weight measurements beyond 6 months postpartum often reported higher drop-out rates. Therefore, the generalizability of these findings may be limited since the drop-outs may have differed from the women at follow-up. For example, Ohlin and Rossner (4) measured weights at 2.5, 6, and 12 months postpartum. By 12 months postpartum, a total of 38 percent were lost to follow-up; 15 percent dropped out at 6 months, and 23 percent over the subsequent 6 months. Schaubinger et al. (3) lost 30 and 41 percent of their sample at 6 weeks and 3 months, respectively (3). Complete data on the pattern of weight change beyond 6 weeks after delivery appears to be unavailable.

Period effects

Period effects are not discernible in the mean or median postpartum weight change estimates between studies without comparison groups. Differences in the average gestational weight gain are noticeable between one study from the 1960s and studies conducted in the 1980s. The mean gestational weight gain ranged from 13.0 ± 4.8 to 16.0 ± 6.1 kg for the more recent studies, while the mean gain in the Perinatal Collaborative Study was only 9.5 ± 9.1 kg (7). However, other factors such as differences in study design or initiation and duration of lactation, lack of comparison groups, variability in pregravid BMI, or inclusion of adolescents may be responsible for the similarity in the estimates of postpartum weight change.

Conclusions

Considering the limitations in study designs, 10 of the 13 studies provide reasonably valid estimates of pregnancy-related weight changes among adult women (3, 4, 6–10, 31–33). Of these studies, three (10, 32, 33) provide the most accurate data on average weight change from preconception to postpartum. The strengths of these two study designs are 1) use of measured pregravid and postpartum weights, 2) comparison groups of nulliparous or nongravid women, 3) sizable population-based samples, 4) exclusion of adolescents, and 5) lost-to-follow-up rates below 20 percent. Smith et al. (32) also provided a comparison of weight changes for blacks versus whites according to parity, and Williamson et al. (10) examined the risk of becoming overweight associated with a single pregnancy. The limitations of the study designs are 1) small sample sizes of pregnant women, 2) variable time postpartum, and 3) lack of data on gestational weight gain.

Seven other studies provide potentially biased or inaccurate estimates of average postpartum weight change since they lack measured pregravid weight and comparison groups to account for age-related weight changes. However, these studies are important because they have relatively large sample sizes, provide data on gestational weight gain, and include black women (3, 4, 6–9). Three studies are excluded from the discussion of the findings because of substantial study design weaknesses, high proportion of teenagers, high rates of nonresponse or lost-to-follow-up, and limited sample sizes (5, 30, 38).

FINDINGS: PARAMETERS OF BODY WEIGHT CHANGE

Three parameters of body weight change from preconception to postpartum have been estimated; average body weight or BMI change, prevalence of excess weight increases, and the risk of becoming overweight (tables 1–3). Most studies have focused on average change in body weight from preconception. Estimates range from a 0.5–3 kg increase in body weight beyond 6 or 12 months postpar- tum. The variability (standard deviation ranges from 4 to 8 kg) of the estimates is large, particularly in the 1960s cohort where the coefficient of variation is 333 percent (7). The differences may be related to the duration of observation, use of self-reported pregravid weight and/or postpartum weights, secular trends, age-related changes for studies without comparison groups, or other factors. We found only one study that examined the risk of becoming overweight due to a single pregnancy among adult women (10) (see
Average body weight changes in reference to comparison groups

Two studies reported that women who had a single birth experienced higher mean weight increases (2–3 kg) during the 5-year or 10-year study periods compared with nulliparous or nongravid women (10, 32). Smith et al. (32) found that white and black primaparas were 1.8 and 3 kg heavier, respectively, compared with nulliparas, and the weight change for multipartas did not differ from nulliparas within each racial group. The NHEF study provides similar, although somewhat biased estimates of pregnancy-related weight changes since subjects were older at baseline (25–45 years). The mean weight increases reported after 10 years, 1.7 ± 8.0 kg (10) and 0.5 kg for a single pregnancy (33), may be underestimates since peri- or postmenopausal women can experience weight increases related to menopause (34). Lastly, a fourth study (n = 49) found a mean change in BMI of 0.15 ± 0.21 (standard error), or 0.4 kg from preconception until 9 or more months postpartum (5). These studies provide evidence that having a child results in higher long-term weight increases, but it is unknown whether the weight increases are caused by childbearing (pregnancy) rather than changes in behaviors and activities related to child rearing.

Average body weight changes without comparison groups

The majority of epidemiologic research provides data on average body weight increase among pregnant women without comparison groups. The estimates range from 1.4 ± 4.8 to 1.5 ± 3.6 kg (mean ± standard deviation) by 6- to 12-months postpartum, or 1.5 ± 5 kg between two consecutive pregnancies (3, 4, 7). The 1988 National Maternal and Infant Health Survey (NMIHS), a US representative sample, reported a median weight change of 1 kg at 10-18 months postpartum, or 1.5 ± 3.6 kg (mean ± standard deviation) by 6- to 12-months postpartum (8). The annualized estimates represent an increase in body weight of between 0.5 and 1.1 kg per year. If we take into account the 0.4–0.7 kg per year increase due to aging among women of reproductive age, (17, 46, 47), and the 0.5 kg error from use of self-reported weights, the short-term (under 1 year) increases in body weight due to pregnancy are practically nonexistent.

Prevalence and risk of excess weight increases

The relatively small average maternal weight increases observed for populations conceal the significant impact of pregnancy on body weight for a sizable percentage of women. A weight increase of 1.5 kg, or even 3 kg, will not result in obesity for an individual. However, for up to 20 percent of the women studied, pregnancy resulted in excessive weight increases (3, 4, 7, 32). Therefore, use of the mean or median values to assess body weight increases following pregnancy fails to adequately reflect the population at risk.

Many women experienced excess weight increases at the postpartum follow-up (table 3). Between 14 and 20 percent of women experienced a 5-kg or greater weight increase following pregnancy (3, 4, 7, 8). In the NMIHS, 15.7 percent of women were more than 6.4 kg heavier by 10–18 months postpartum. The risk of very high weight increases (> 9 kg) occurred three times more often among black women (22 percent) compared with white women (7–8 percent) (6–8). The NHEFS reported that 7.3 percent of nulliparas, versus 11.6 percent of those with one birth, gained more than 13 kg over 10 years (10). Within the population, a subgroup of women are prone to excess weight retention and/or postpartum weight increases.

Risk of becoming overweight after pregnancy

The risk of becoming overweight associated with pregnancy may have more relevance to health risks for women than estimates of average body weight change related to pregnancy. Few studies evaluate this risk, and none provide

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TABLE 3. Percentage of women losing weight, returning to preconception weight, and retaining more than 5 kg at postpartum follow-up

<table>
<thead>
<tr>
<th>Study (reference no.) year</th>
<th>Sample size (n)</th>
<th>Age range (years)</th>
<th>Postpartum period</th>
<th>Net weight loss (%)</th>
<th>Retained 0 to &lt;5 kg (%)</th>
<th>Retained 5 or more kg (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schauberger et al. (3), 1992</td>
<td>795</td>
<td>Not stated</td>
<td>6 weeks</td>
<td>22*</td>
<td>N/A†</td>
<td>&gt;16</td>
</tr>
<tr>
<td>Ohlin and Rosner (4), 1990</td>
<td>463</td>
<td>17–49</td>
<td>6 months</td>
<td>37*</td>
<td>56</td>
<td>14</td>
</tr>
<tr>
<td>Keppel and Taffel (8), 1993‡</td>
<td>1,423</td>
<td>&gt;15</td>
<td>12 months</td>
<td>30</td>
<td>&gt;50</td>
<td>&gt;20</td>
</tr>
<tr>
<td>Greene et al. (7), 1988‡</td>
<td>2,944</td>
<td>Variable (between two pregnancies)</td>
<td>10–18 months</td>
<td>27</td>
<td>&gt;50</td>
<td>&lt;20</td>
</tr>
</tbody>
</table>

Note: Categories do not sum to 100% because of overlapping in some studies.
* Includes women who returned to preconception weight.
† N/A, not available.
‡ Sample includes adolescents.

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identification on gestational weight gain among adult women. Ohlin and Rossner (4) reported that the percentage of overweight women (defined as BMI ≥ 23.9) increased from 13 to 21 percent by 12 months postpartum. In the NHEFS, the risk of becoming moderately overweight (BMI ≥ 27.3) or severely overweight (BMI ≥ 30.0) increased by 60 and 110 percent, respectively, among women aged 25–45 years at baseline who had one birth versus women who did not give birth during the 10-year follow-up (10). This study could not evaluate gestational weight gain as a predictor of risk of becoming overweight since the variable would not apply to nongravid women.

Other study groups—obese women

Numerous anecdotal reports cite pregnancy and childbearing as a cause of obesity (48). High percentages of severely obese (BMI > 30) women reported large excess body weight increases after pregnancy; 40–50 percent of women treated for obesity at a Stockholm hospital traced the onset of their obesity to the childbearing years, and 73 percent reported retaining more than 10 kg following pregnancy (1, 2). A case-control study of obese women and randomly selected non-obese women from a population-based sample in Utah found 4 kg higher weights at 6 weeks postpartum and 1.6 kg per pregnancy among obese women (49). Some women may be especially prone to developing obesity following pregnancy because of the natural process of weight cycling, a predisposition for excess fat accumulation, or alternations in maternal metabolism which persist into the postpartum period. Identification of risk factors that predict excess postpartum weight increases is important to the prevention of obesity among young women.

TABLE 4. Factors influencing weight changes from baseline until study follow-up for parous women (after one birth during study period) compared with nulliparous or nongravid women

<table>
<thead>
<tr>
<th>Study (reference no.), year (dependent variable)</th>
<th>Gestational weight gain (total/rate)</th>
<th>Pregravid body mass index</th>
<th>Smoking habit</th>
<th>Socio-economic status</th>
<th>Parity</th>
<th>Lactation</th>
<th>Maternal age</th>
<th>Race</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wolfe et al. (33), 1997 (weight change by 10-year follow-up; minimum 12 months postpartum)</td>
<td>N/A*</td>
<td>W*: + B*: (small n*)</td>
<td>W: + B: (small n)</td>
<td>N/A</td>
<td>C*</td>
<td>N/A</td>
<td>W: – B: (small n)</td>
<td>N/A</td>
</tr>
<tr>
<td>Williamson et al. (10), 1994 (risk of becoming overweight by 10-year follow-up)</td>
<td>N/A</td>
<td>C</td>
<td>C</td>
<td>N/A</td>
<td>+</td>
<td>N/A</td>
<td>C</td>
<td>N/A</td>
</tr>
<tr>
<td>Smith et al. (32), 1994 (mean weight change at 5-year follow-up; minimum 12 months postpartum)</td>
<td>N/A</td>
<td>C</td>
<td>C</td>
<td>N/A</td>
<td>Primip:+ Multip:0</td>
<td>N/A</td>
<td>C</td>
<td>0</td>
</tr>
<tr>
<td>Rookus et al. (5), 1987 (change in body mass index)</td>
<td>N/A</td>
<td>Not applicable</td>
<td>C</td>
<td>C</td>
<td>(Education)</td>
<td>C</td>
<td>+</td>
<td>C</td>
</tr>
</tbody>
</table>

Key: ++ = strong positive association, + = weak positive association, – = weak negative association, 0 = no association.

* C, confounder (associated, but no coefficient given); N/A, not available; W, whites; B, blacks; Primip, primiparous; Multip, multiparous; small n, insufficient sample size with only one birth during the follow-up period.

FINDINGS: GESTATIONAL WEIGHT GAIN AND OTHER RISK FACTORS

The most important determinants of weight change from preconception to postpartum include gestational weight gain, pregravid weight for height, race/ethnicity, and parity. Tables 4 and 5 summarize the evidence from multivariable regression analyses for a variety of factors hypothesized to influence weight changes following pregnancy. Wide variability in the weight changes has been consistently observed (8), indicating that some women are at greater risk for excess weight gain during the reproductive years. Potential sources of this variability across studies may include differences in subject characteristics (e.g., age, parity, race/ethnicity, social class), length of time over which weight change was measured, and cohort effects (e.g., pregnancy weight gain was routinely restricted in the 1960s, but not today). The variability for individuals within populations may be related to risk factors such as gestational weight gain, parity, pregravid body size, age at first birth, infant feeding practices, smoking habit, and/or other lifestyle behaviors influencing the weight status of women (e.g., diet and physical activity). Other factors, such as time interval at postpartum follow-up, number of pregnancy losses (miscarriages or therapeutic abortions) during the postpartum period, age at menarche, and changes in employment have not been considered in many studies.

Gestational weight gain—statistical bias issues

Pregnancy is the only normal physiologic process for an adult where body weight increases by 20 percent or more, and additional fat stores for lactation are deposited in a short 9-month period (50). Gestational weight gain has been
reported to be the primary and most important determinant of weight change from preconception to postpartum (postpartum weight change). At least six previous studies have reported a statistically significant positive relation between gestational weight gain and postpartum weight change using multivariable linear regression techniques (3, 4, 7, 9, 31, 38). For example, Greene et al. (7) found that for every kilogram of weight gain during pregnancy, a 0.45 kg weight retention is expected. In linear regression models, gestational weight gain has accounted for practically all the variability in postpartum weight change "explained by the linear model".

Many previous studies have only three weights available, 1) pregravid weight, 2) weight at delivery, and 3) postpartum weight, to derive two weight change variables, gestational weight gain and weight change from preconception to postpartum. The same baseline measurement, pregravid weight, is used to construct each variable. Thus, postpartum weight change is made up of the sum of gestational weight gain and the post-delivery weight loss. The relation between gestational weight gain and postpartum weight change is subject to a "structural bias" since gestational weight gain is an inherent part of postpartum weight change. The bias is due to the "part-whole" correlation between the variables that is similar to correlation between total gestational weight gain and infant birthweight (51). This correlation is necessarily influenced by the structural overlap. A bias in the regression analysis results from the "part-whole" correlation in which gestational weight gain is part of the dependent variable, postpartum weight change. Both the estimates of the coefficient for gestational weight gain (total or rate) and the squared multiple correlation coefficient may be biased in studies that used linear regression techniques. However, no studies to date have considered this issue. Thus, the role of gestational weight gain in determining the variability of postpartum weight change (from preconception) may be overestimated due to the structural bias.

Studies have reported regression coefficients for total gestational weight gain ranging from 0.44 to 0.49, and squared multiple correlations of 0.21 to 0.40 (3, 4, 7, 9). Although these values are probably inflated, studies consistently report a strong positive association between gestational weight gain and postpartum weight change (3, 4, 6, 7, 9, 31, 38). Given this evidence, it is likely that a true relation between gestational weight gain and postpartum body weight exists, but the magnitude may be smaller than estimated. Unfortunately, a solution is not yet apparent to overcome the statistical bias that is present in the correlation between gestational weight gain and postpartum weight change.

Prepregnancy weight-for-height

Women who are overweight before pregnancy generally gain less weight during pregnancy and on average have larger babies (13), although postpartum body weight increases are greater and more variable in these women (6, 8, 13, 28, 52). In the first longitudinal study on postpartum weight, McKeown and Record (52) concluded that weight change during the 12 months postpartum was largely influenced by the woman's weight prior to pregnancy; the heavier the woman, the larger the increment of the mean weight "retained". Overweight women in a 1960s Aberdeen (Scotland) cohort showed a greater increase in body weight by the second pregnancy (39), and in the 1988 NMIHS were more likely to retain more than 6 kg by 10–18 months postpartum than other BMI groups (8). Among overweight women, the average body weight increases may be explained by the larger reporting error in pregravid weight (44). Early postpartum (at 2 days) weight retention was lower for overweight women; however, this is probably related to their lower gestational weight gain (30).

More recent studies, all of which used self-reported pregravid weights, have shown inconsistent findings regarding the influence of pregravid weight or BMI on postpartum body weight (table 4). Three studies found a positive association (6, 7, 9), two did not find any association between pregravid weight and postpartum weight increases (4, 31), and a few studies adjusted for pregravid weight in the multivariable regression, but did not report a coefficient (3, 5). The lack of association with postpartum weight change may be related to effect modification by gestational weight gain according to pregravid BMI group. For example, gestational weight gain may be unrelated to postpartum weight among overweight women, but strongly related among normal-weight women.

Longitudinal studies with measured pregravid weights and non-gravid comparison groups have not provided specific estimates for overweight women or other BMI groups. Therefore, sufficiently large samples with accurate data are not available to evaluate the impact of pregravid weight on postpartum body weight.

Race/ethnicity differences

Several studies report larger postpartum weight increases among black women compared with white women (6–9). The NMIHS reported a three times higher median weight change (3 kg versus 1 kg), and almost a two times higher percentage retaining more than 4 kg at 10–18 months postpartum for black women compared with white women (8). Among non-overweight women in the NMIHS, black mothers were twice as likely than white mothers to retain 9 kg or more by 10–24 months postpartum (6). Non-gravid comparison groups were not available; thus, higher body postpartum weight increases may reflect weight increases that are unrelated to pregnancy.

The only definitive data about race/ethnicity differences in body weight change associated with pregnancy comes from the CARDIA study (32). Similar (2–3 kg) higher average weight increase for primiparas compared with nulliparas occurred for both black women and white women (32). Yet, black women were more likely to be overweight at baseline, and, irrespective of parity, gained more weight than white women (8.8 kg versus 4.5 kg among primiparas) over the 5-year study period (32, 53). The higher prevalence of obesity was explained, in part, by the earlier age at menarche and the earlier age at first birth for black women compared with white women (53). The greater weight increases among black women probably reflect other differences in genetic,
social, cultural, and behavioral factors which are reflected in trends for the general population (11, 54). During a 10-year longitudinal period in a population-based sample (NHANES I, 1970s), black women were 50 percent more likely than white women to experience a weight gain of 10 kg or more, and 60 percent more likely to become obese (47). The black-white difference in the secular changes in BMI among young women was not explained entirely by differences in either income or education (55). These findings suggest that the black-white difference in body weight change among reproductive age women cannot be attributed to pregnancy itself, but, rather, differences in child-bearing patterns and, possibly, gestational weight gain among other factors.

Parity

Pregnancy's influence on maternal weight status may be greatest after the first pregnancy. The CARDIA study found differences in net weight increases according to parity (32). Primiparas gained about 2–3 kg more than nulliparas, but multiparas did not differ from nulliparas after adjustment for several covariates (32). These findings suggest that weight increases related to pregnancy occur after the first pregnancy, but not after subsequent pregnancies. Similar findings were reported in a cohort of Aberdeen mothers followed from 1954 to 1964. A majority of women who gained more than 7.5 kg between pregnancies did so after the first pregnancy (39).

Other studies without comparison groups or measured pregravid weights have found greater mean weight increases among multiparas compared with primiparas (3, 9). These studies report a higher mean postpartum body weight of 1.3–1.5 kg for multiparas compared with primiparas (3, 9). Among non-overweight women from the NMIHS, high multiparity among black women was associated with twice the risk of retaining 9 or more kg, but no association for parity was found among white women (6). The inconsistent findings with respect to parity may be attributed to error in self-reported weights or uncontrolled confounding by other characteristics associated with parity and weight increases. For example, differences in education, maternal age, lactation, age at first birth, or employment status may be influenced by parity and, in turn, may affect postpartum weight change.

Lactation

Both duration and intensity of lactation exert important influences on the demand for maternal nutrients and energy for milk production. Body fat is stored during pregnancy partially in preparation for fetal growth during late gestation and production of human milk during early infancy (56). Several studies have included information on lactation in multivariable regression models (3–7, 9, 38). Three of seven studies in tables 4 and 5 (4, 5, 7) found differences in post-

TABLE 5. Factors influencing body weight changes from preconception to postpartum follow-up, or after delivery among pregnant women (no comparison groups)

<table>
<thead>
<tr>
<th>Study (reference no.), year (dependent variable)</th>
<th>Gestational weight gain</th>
<th>Pregravid body mass index</th>
<th>Smoking habit</th>
<th>Socio-economic status</th>
<th>Parity</th>
<th>Lactation</th>
<th>Maternal age</th>
<th>Race</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muscati et al. (31), 1996 (weight change at 6 weeks postpartum)</td>
<td>++</td>
<td>0</td>
<td>N/A</td>
<td>N/A</td>
<td>0</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Boardley et al. (9), 1995 (weight change at 7–12 months postpartum)</td>
<td>++</td>
<td>+ (Weight)</td>
<td>N/A</td>
<td>N/A</td>
<td>+</td>
<td>0</td>
<td>N/A</td>
<td>B+</td>
</tr>
<tr>
<td>Schaubberger et al. (3), 1992 (weight loss from delivery to 6 months postpartum)</td>
<td>++</td>
<td>C*</td>
<td>–</td>
<td>N/A</td>
<td>–</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Parker and Abrams (6), 1993 (weight increase &gt;9 kg at 10–18 months postpartum)</td>
<td>+</td>
<td>+</td>
<td>N/A</td>
<td>–</td>
<td>B+</td>
<td>0</td>
<td>0</td>
<td>B+</td>
</tr>
<tr>
<td>Ohlin and Rossner (4), 1990 (weight change at 1 year postpartum)</td>
<td>++</td>
<td>0</td>
<td>+ (Cessation)</td>
<td>0</td>
<td>0</td>
<td>–</td>
<td>+</td>
<td>N/A</td>
</tr>
<tr>
<td>Greene et al. (7), 1988 (weight change between two pregnancies)</td>
<td>++</td>
<td>+</td>
<td>–</td>
<td>0</td>
<td>0</td>
<td>–</td>
<td>0</td>
<td>+</td>
</tr>
</tbody>
</table>

Key: ++ = strong positive association, + = weak positive association, – = weak negative association, 0 = no association.

* C, confounder (associated, but no coefficient given); N/A, not available (where N/A homogenous study groups).
partum weight change according to infant feeding method, but the findings were not consistent. Two studies found a very weak negative association between lactation and weight retention (4, 7). The third study (which measured weights at preconception) found a positive association between lactation and weight retention (5). Women who breastfed longer than 2 months gained more body mass over the postpartum period than nonpregnant women. In addition, women who used medication to stop lactation actually lost more body mass (-0.5 kg/m²) by 9 months postpartum compared with the nonpregnant group (5).

Similarly, inconsistent findings about the influence of lactation on postpartum weight changes have been reported in studies using early postpartum lactation status to classify women as breastfeeding or bottle-feeding. In a 1960s cohort, the initiation of lactation following delivery was associated with 0.55 kg lower mean weight retention compared with women who did not initiate lactation in the hospital (7). Another later study (n = 411) found that women who bottle-fed their infants lost more weight by 6 weeks postpartum than women who were still either partially or fully breastfeeding by 6 weeks postpartum (57).

Studies which have used more accurate measures of lactation status and duration have yielded more consistent results. A higher lactation score, as measured by a summary score of duration and intensity, was related to a higher mean weight loss between 2.5 and 6 months postpartum, but mean weight loss was not different from the groups with lower scores by 12 months postpartum (4). Dewey et al. (58) found that breastfeeding women (n = 46) lost an average of 2 kg more than formula-feeding women (n = 39), but most of the differences in weight loss occurred from 3 to 6 months postpartum. Janney et al. (59) recruited women (n = 110) from birthing education classes or obstetric practices and classified them as fully breastfeeding, partly breastfeeding, or bottle-feeding at each of six different points in time. Women who were older, unmarried, or had a higher gestational weight gain retained more weight according to the mixed-effects longitudinal regression models. Lactating women lost more weight during the early postpartum period as compared with women who were still breastfeeding or bottle-feeding. However, the magnitude of these differences was relatively small, and the authors concluded that the impact of lactation was minimal compared with the influence of age, marital status, and gestational weight gain (59). These studies provide more accurate measures of lactation over time than most previous studies; however, both pregravid weight and pregnancy weight gain were self-reported, and selection biases may have influenced the validity of the studies (58, 59).

The failure of most studies to find any association with lactation may reflect the absence of a relation between lactation and postpartum weight loss. Alternatively, these findings may be due to inadequate measures of lactation duration and intensity (any breastfeeding versus no breastfeeding), small sample sizes, significant drop-out rates over time, inclusion of women in the nonlactating group who restricted their dietary intake to achieve intentional weight loss, and failure to control for confounding by maternal characteristics. Misclassification of women who provided both formula and breast milk to infants with women who exclusively breastfed may result in lack of an association despite accurate information on duration. Better indicators of lactation intensity and duration, and larger study samples with longitudinal weight measures, are needed to study the impact of lactation on maternal body weight status.

Other risk factors influencing postpartum body weight

A variety of other factors are likely to influence maternal weight status including, social class, employment, maternal age, birth control methods, physical activity, dietary intake, smoking cessation, and other postpartum behaviors (4, 7, 9, 60). However, few studies have assessed the influence of these factors on postpartum weight changes, and most associations between these factors and weight changes were absent or weak. Maternal age among white women was inversely associated with postpartum weight changes (33). Higher weight "retention" was associated with irregular eating habits after delivery after controlling for physical activity among other factors (4), and increased leisure time physical activity was associated with lower retention. The same study found smoking cessation to result in higher weight retention at 1 year postpartum (4). Others researchers have found no association between self-reported physical activity and postpartum weight change (3), although returning to work by 2 weeks postpartum was associated with a larger weight loss at 6 months postpartum compared with those who returned later or did not return to work (3). Pregnancy-related increases in dietary intakes may persist into the postpartum period. In a nationally representative survey of black and white low-income US women who were not lactating, postpartum energy intakes remained higher than preconception levels among black women (61). Alterations in lifestyle and eating habits are difficult to measure reliably; however, these factors cannot be ruled out as important influences on postpartum weight changes.

BIOLGIC MECHANISMS INFLUENCING BODY WEIGHT CHANGES DURING AND AFTER PREGNANCY

Behavioral and genetic factors influencing fat metabolism regulation, both during and after pregnancy, may contribute to the sustained body weight increases related to child-bearing and child-rearing. Progesterone levels during pregnancy are responsible for fat accumulation during the first and second trimesters, and fat mobilization during the third trimester. New evidence suggests that leptin may also play a role in gestational weight gain and postpartum weight retention. Leptin is a hormone secreted by adipose tissue and regulated by the obesity (ob) gene. It is also produced in the placenta, suggesting an important role in pregnancy (62). Leptin levels are elevated during the pregnancy and postpartum periods, and positively correlate with gestational weight gain (63). Thus, both higher gestational weight gain and excess postpartum weight increases may be related to a genetic pre-
disposition to accumulate excess adipose tissue during reproduction. The large variability in weight changes subsequent to pregnancy within the population may be related to a combination of biologic and environmental factors.

High gestational weight gain is reported to result in both higher fat and lean tissues gains for adult women, and that fat gain varies by pregravid weight (64). Average gestational weight gains of 16.6 kg and 12.5 kg resulted in estimated fat gains of 4 ± 3.5 kg and 2.1 ± 1.9 kg, respectively, among 15 Swedish women aged 23–37 years (64). Women with higher gestational weight gains also increased their lean tissue, although between person variability for all measures was large (64). Gestational fat gain was estimated in a larger cohort (n = 200) of women aged 18–36 years whose weight gains were within the Institute of Medicine’s recommendations according to pregravid weight-for-height groups based on a measure of body composition at 14 weeks gestation (65). The gestational fat gains were 6.0 ± 2.6, 3.8 ± 3.4, 3.5 ± 4.1, and -0.6 ± 4.6 kg for underweight, normal, overweight, and obese groups, respectively, but no differences in body water gain were found (65). The actual fat gain may be underestimated using late first trimester baseline measures since body fat increases begin early in pregnancy (66). These findings may reflect differences in total gestational weight gain, but indicate that the fat gain varies greatly, particularly among overweight and obese pregnant women. Postpartum fat losses may vary as well; well-nourished lactating women during the first 6 months after delivery lost between 1 and 2.5 kg (67, 68). Among white women gaining within the Institute of Medicine’s recommended range, the median amount retained was 0.7 kg, versus a median of 2.2 kg among white women gaining more than recommended in the NMIHS (8). The variability in the adipose tissue gains by pregravid BMI suggests a mechanism of biologic regulation to limit fat deposition via gestational weight gain among overweight or obese pregnant women.

CONCLUSIONS

Body weight change during the postpartum period is probably a combination of retention of gestational weight gain, and weight change caused by the lifestyle alterations associated with child-rearing. To our knowledge, no studies have been designed to assess these separate contributions to maternal postpartum weight changes. However, it is likely that the influence of gestational weight gain may be greatest during the immediate postpartum period (less than 1 year), and that other factors may be more important to long-term weight changes. Current epidemiologic evidence suggests that a single birth results in a 2–3 kg higher average body weight, and increases the risk of becoming overweight within 12 months to several years after delivery. In large cohorts of pregnant women, the effect of pregnancy on average body weight within 1–1.5 years of delivery appears to be negligible (less than 0.5 kg) after adjustment for age-related increases and reporting errors. However, about 15–20 percent of these pregnant women were found to sustain significant weight increases after delivery. Therefore, identification of maternal characteristics associated with the risk of obesity and excess weight increases after pregnancy remains an important area for future research. Studies have consistently reported that gestational weight gain exerts the strongest influence. However, this finding is probably overstated due to a “part-whole” correlation bias between gestational weight gain and postpartum weight change (from preconception). There is sufficient evidence to suggest that increased postpartum body weight is more likely after the first pregnancy (primiparous women). The evidence is inconsistent or insufficient for most other factors: pregravid BMI or weight, lactation, young maternal age, smoking, social class, and race/ethnicity. Carefully designed studies are needed to evaluate these risk factors.

Estimates of average postpartum weight change could be improved in future study designs by use of comparison groups of reproductive-age women, measured pregravid weight and gestational weight gain, weight measurements at multiple postpartum intervals, and sufficient numbers of pregnant women. Such studies would provide accurate information on the pattern of weight changes over time as well as estimates of average weight change expected at specific time points. However, studies of this sort would pose significant challenges for investigators to carry out. Large epidemiologic studies where self-reported weight is available are still important since they may identify predictors of the risk of becoming overweight or excess weight change postpartum among normal-weight women. These studies could be improved by use of appropriate comparison groups of non-gravid women. In general, the major challenge for future research is to ascertain changes in body weight that are linked to pregnancy (childbearing) from lifestyle alterations related to child-rearing, as well as genetic factors related to weight increases associated with pregnancy.

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