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13. Abstract ***(Maximum 200 Words)*** *(abstract should contain no proprietary or confidential information)*

This study enrolled more than 2500 new mothers attending the well-baby clinic at the Naval Medical Center, San Diego. Approximately 20% of the study participants are active duty women.

More than half of the study group retained more than 2kg at about a year postpartum. One in 5 who began pregnancy normal weight became overweight (BMI>25). Despite physical training and emphasis on meeting weight standards, weight retention was as common among active duty women as among military dependents. Multivariate analysis suggested that high level of maternal weight gain during pregnancy, history of weight cycling, postpartum depression, and financial insecurity were associated with increased weight after birth. Results were inconsistent and somewhat difficult to interpret for "healthy" dieting and physical activity, perhaps because women who have the most trouble losing weight are also those who may most consistently attempt to increase exercise and reduce food intake.

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Postpartum Maternal weight Changes: Implications for Military Women

Introduction

This study was designed to collect a series of cross-sectional measurements of maternal weight and information as part of routine well-baby care at the Pediatrics Clinic, Balboa Hospital of the Naval Medical Center, San Diego (NMCSD). Data collection was designed to be supplemented by computerized appointment records, abstraction of medical records and 2 questionnaires mailed to the mothers (one early in the postpartum year, one at the end of the study).

The major objectives of the study were to:

1) describe the pattern of weight loss during the first year after delivery in a large study group of active duty and military dependent women,
2) compare differences in weight loss by maternal characteristics, and identify characteristics of women who are most likely to become permanently overweight or obese as a result of childbearing.

Body

Summary of Study Results by Technical Objectives

Task1: *Hold advisory meeting. Finalize protocol, hire staff, field-test data collection methods. Begin recruiting women.* **Completed**

Task 2: a. *Collect data on 4000 women during the first year after birth. Recruit subjects, collect postpartum maternal weight measurements and questionnaires. Edit, code and enter data. b. Obtain/abstract prenatal medical records, enter data. Create a preliminary analytical data set by merging these data sources. Clean/edit data. Using this preliminary data set, begin programming data analyses for tasks 3-6.* **Completed**

Task 3: *Use parametric techniques to summarize the sequential measurements to provide estimates of the overall pattern of maternal weight gain during pregnancy and the pattern of maternal weight loss after birth.* **Completed**

Task 4: *Summarize the average maternal weight change at 3 days, 14 days, months 2,4,6,9 and 12 after birth and its distribution.*

Detailed tables of absolute maternal weight change over time are presented and discussed in the February 2002 report.

Table 1 below summarizes the unadjusted associations between maternal characteristics and postpartum weight retention for each cross section after birth. (0= no significant relationship, -- means negatively significant, + means positively significant.).

- .Income and education became significant over time; active duty women retained more than non-active duty women early on but then the difference disappeared until 12+ months (active duty 2.2 kg vs non-active duty 3.5 kg).

• Financial insecurity was consistently associated with increased weight retention and weight cycling was related in all but the 12 month cross-sections. Because the cross-sections

Table 1: Associations between Maternal Characteristics and Postpartum Weight Retention by Time

Characteristic	< 20 days	2 months	4 months	6 months`	9 months	12 months
	n=1000	n=1357	n =1292	n =1191	n =918	n =840
Mean retention (kg)	7.5 (6.4)	5.6 (5.8)	5.1 (6.0)	4.9 (6.3)	4.2 (6.1)	3.3 (6.5)
Income	0	0	--	--	--	--
Education	0	0	0	--	--	--
Active Duty	+	+	0	0	0	--
Race	0	0	0	+	0	+
Exercise	0	0	0	0	0	0
Breastfeeding	0	--	--	--	+	0
Prepregnancy BMI	_	--	--	--	0	0
Age	0	0	0	--	--	--
Financial insecurity	0	+	+	0	+	+
Depression	0	0	0	0	0	0
Weight Cycler	+	+	+	+	+	0

differ not only by time but also participants, one should use caution in comparing them.

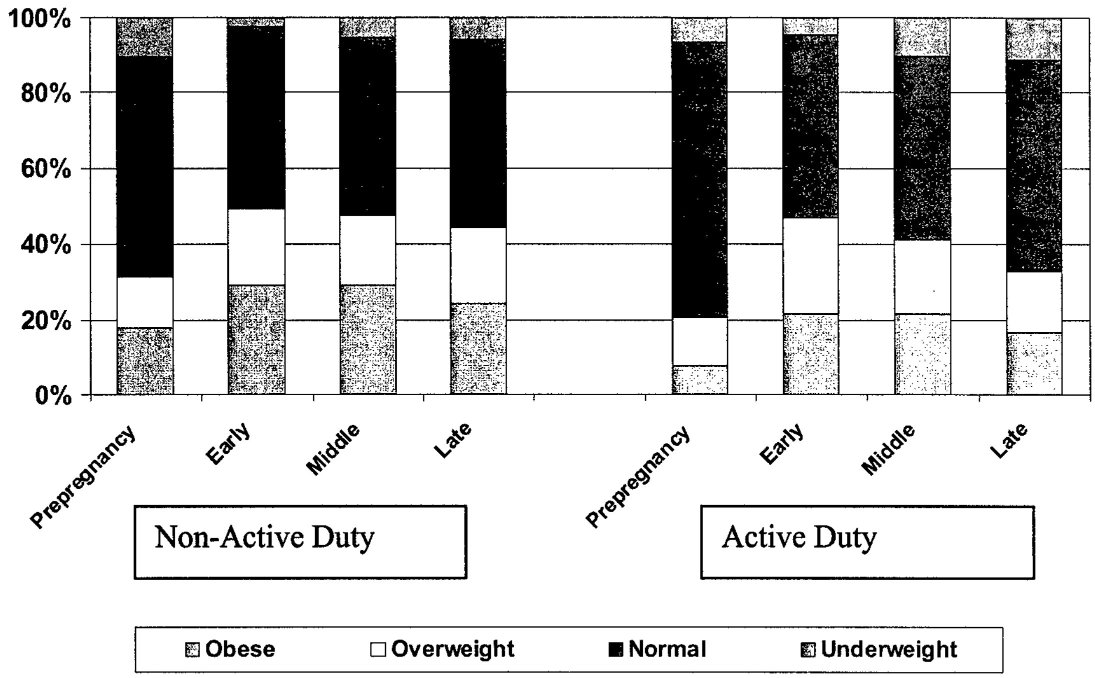
• The longitudinal analyses, though smaller in sample size (n=570), include the same women at each time point and therefore are more comparable. Mean BMI values for the entire longitudinal cohort were 24.6 (sd =4.6) before pregnancy, 26.7 (sd=4.8) at 2.5 months postpartum, 26.5 (sd=5.3) at 6 months postpartum and 25.9 (5.4) at about 9.5 months postpartum. This indicates that the average woman lost very little weight from the early to late postpartum periods. These women with longitudinal data were similar to the overall sample, though there were more white women and fewer minorities, fewer single mothers and a slightly lower proportion of active duty women (19%).

<u>Task 5</u>. Compare the average maternal weight change at 3 days, 14 days, 2,4,6,9 and 12 months after birth and its distribution by military status and by possible risk factors (including maternal race, parity, age, socioeconomic status, marital status, prepregnancy size, prenatal weight gain, method of delivery, breast feeding status, lifestyle behaviors).

• These data are presented in detail in the February 2002 report. Active duty women gained more weight during pregnancy and appeared to retain more early in the postpartum year and less weight at the end of the study.

• Figure 4 illustrates and compares the BMI categories over the postpartum year by active duty status for the longitudinal sample of 570 women. Active duty women had lower BMIs before pregnancy and at the end of the postpartum year compared to than wives of active service men.

Figure 4: Change in BMI category by time for Active Duty and Military Dependent Mothers

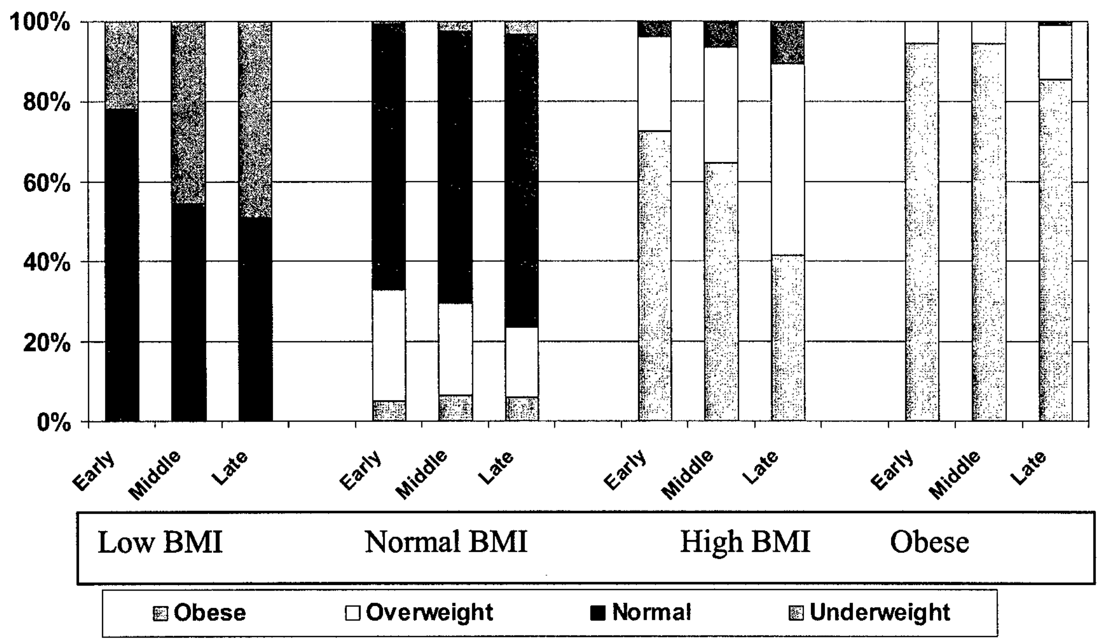


Thus, although active duty mothers retained less weight late in pregnancy than non-active duty women, 32% were overweight or obese by the end of the study. Furthermore, when other differences were controlled for in various multivariate models, active duty women's weight retention was no longer statistically significant. An exception is that African American active duty women retained much less weight than military dependent African American women. (See Kang et al manuscript in Appendix.)

Task 6. Describe the prevalence of excess postpartum weight retention at 14 days, 2, 4, 6, 9 and 12 months after delivery in the entire study group, by the risk factors listed in Technical Objective 5 and by military status. We will explore the use of several different definitions of excessive postpartum weight retention for these analyses.

Change in body size category for 570 women who contributed complete information during the early, middle and late postpartum year shown in the figure below. Each group of bars represents the distribution of BMI categories at the early (2.5 months), middle (5.5 months) and late (9.5 months) postpartum intervals. The first bar is women who began pregnancy underweight (BMI <19), the second is women who began with normal BMI(BMI 19-25); the third includes women who were overweight (BMI 26-29) and the last includes women who were obese (BMI >29) before pregnancy. The figure shows that the proportions of overweight women declined with time. None of the women who began pregnancy underweight became overweight postpartum, but 23% of those who were normal weight before pregnancy became overweight and 42% of those who began pregnancy overweight became obese.

Figure 3: Change in BMI category by time According to Institute of Medicine Prepregnancy BMI Group



- We have also examined weight retention in a variety of ways: absolute retention (prepregnancy weight – last postpartum weight), postpartum loss (delivery weight – last measured postpartum weight), postpartum BMI >26 (Institute of Medicine definition), postpartum weight >25 (definition used to define overweight status in the military). In the February 2002 report we describe our assessment of a variety of different weight outcomes before settling on weight retention (final postpartum weight before 551 days minus self-reported prepregnancy weight). Our statistician and I continue to work on a methodological paper to help sort out a "part-part" correlation problem that exists when regressing gestational weight gain on weight retention. In the meantime, we have validated our results using postpartum weight loss as well as weight retention as outcome and are confident that the findings we present here are reasonably good estimates of the relationship.

Task 7: If the pattern of postpartum weight loss or excessive weight retention differs by military status, compare the distribution of risk factors by military status. Conduct multivariate statistical models to examine whether there are differences in the postpartum weight loss pattern and excessive weight retention by military status, controlling for potentially confounding variables. Conduct additional analyses to investigate which factors might explain any differences discovered.

- We conducted extensive analyses in active duty women to attempt to define possible risk factors for weight retention in this group. They did not appear to differ much from the military dependents; physical training was expected to exert as strong influence but our data suggest otherwise. Those findings are found in the February 2002 report and extended in the manuscript by *Tujague et* al in the appendix.

Task 8: If the pattern of postpartum weight loss or excessive weight retention differs by maternal race, compare the distribution of risk factors between white, black, Asian, Hispanic and "other race" groups. Further explore the possibility that race is associated with differences in weight loss or weight retention, controlling for potentially confounding variables using multivariate models. If racial differences are confirmed, stratify by maternal race and conduct multivariate analysis to examine risk factors for postpartum weight change within maternal race groups.

- There were substantial differences in the distribution of weight during and after pregnancy by maternal race-ethnicity. Overall, white and Asian women tended to be less overweight and black and Hispanic women showed higher prevalence of BMI.
- There were differences in unadjusted postpartum weight retention by prepregnancy BMI. Among 734 women with BMI <26, mean postpartum weight retention (kg) was 2.8(5.4) for white, 4.2 (5.6) for black, 2.8 (4.0) for Asian and 4.1 (5.5) for Hispanic women. Retention was 4.2 (8.1), 2.0 (8.3), -0.3 (6.6) and 2.5 (8.9) kg for white, black, Asian and Hispanic mothers who began pregnancy overweight. (Table 8, 2002 report)
- When the data were adjusted for trimester weight gain, height, parity, age, weight cycling, income and time, black women retained 1.13 kg and Hispanic women retained 1.40 kg more than white women. Both findings were statistically significant. (Table 9, 2002 report)
- However, when we limited the sample to women who were not overweight at the beginning of pregnancy, black women who were military dependents retained significantly more weight than active duty black women. This finding was striking, but the multivariate model could not explain why it was so. (*Kang et al, Differences in postpartum weight loss between African American and White mothers in a Military Population of Normal Weight Women) in* Appendix.

- Table 2 shows the results of separate multivariate models predicting postpartum weight retention according to 4 maternal race-ethnicity groups.

Table 2: Comparision Of Factors Associated with Postpartum Weight Retention by Race-Ethnicity*				
	White (n=632)	Black (n=140)	Asian (n=139	Hispanic(n=156)
History of weight cycling	**1.19** (0.13, 2.3)	**2.8** (0.2,5.5)	-0.03 (-2.8,2.7)	-0.1 (-2.2, 2.4)
Prepregnancy weight	**0.01** (-0.13, -0.05)	**-0.17** (-0.26, -0.08)	**-0.08** (-0.19, 0.02)	**-0.10** (-0.18, -0.26)
College vs not	0.25 (-0.8, 1.3)	0.25 (-2.03, 2.53	0.68 (-1.59, 2.95)	**2.15** (0.14,4.17)
Parity	-0.73 (-2.10, 0.64)	0.89 (-2.05, 3.82)	**4.69** (1.35, 3.03)	2.23 (-0.53, 5.0)
Healthy Dieting	**-1.30** (-2.29, -0.31)	-1.14 (-3.60, 1.32)	-0.58 (-2.58, 1.42)	**-2.44** (-4.37,-0.52)
Physical Activity	0.15 (-0.88, 1.18)	**2.76** (0.35, 5.16)	0.44 (-1.65, 2.54)	0.09 (-1.79, 1.97)
Prenatal Gain				
<IOM	-1.0 (-2.5, 0.5)	-2.3 (-5.7, 1.0)	-0.3 (-2.5, 3.2)	-1.1 (-3.8,1.6)
>1OM	**3.2** (2.2, 4.3)	0.9 (-1.6, 3.5)	**3.8** (1.6, 6.0)	**1.3** (0, 4.4)
Financial insecurity				
Sometimes	**1.7 (0.5, 2.9)**	0.2 (-2.5,2.9)	-0.3 (-2.8,2.2)	-1.13 (-3.5,1.2)
Always	**2.6 (0.84, 4.4)**	1.6 (-1.5, 4.7)	1.0 (-2.2, 4.2)	1.3 (-2.18,4.7)
Breastfeeding	-0.2 (-1.0, 1.5)	-0.7 (-3.6, 2.2)	-1.10 (-3.5,1.3)	**-2.2** (-4.4, -0.04)

Results rom a separate multiple linear regression model for each group. All models adjusted for time since birth as well as the ; following variables which were not statistically significant for any group (maternal height, age, income, active duty status).

History of weight cycling was associated with increased weight retention for white and black women, but not for Asian or Hispanic women. College education was associated with increased weight retention for Hispanic women, but not other groups. Higher parity was associated with an almost 5 kg increase in weight retention among Asian women, but parity was unassociated in the other groups. "Healthy" dieting was negatively associated with weight retention in all the groups and was statistically significant in white and Hispanic women. Physical activity ("tried to be more physically active" was unassociated with retention in all groups except black mothers, where it was significantly associated with an almost 3 kg increase in weight retention. Gestational weight gain above the IOM recommended range was significantly associated with increases in weight retention for all groups except African Americans. Both "sometimes" and "always" financial insecurity were associated with significantly increased weight retention in white women. Financial insecurity was positively, but not significantly, associated with weight retention in the other groups. Finally, breastfeeding in the first year was associated with significantly reduced weight retention in Hispanics only.

These results suggest substantial heterogeneity by race-ethnicity in risk factors for weight retention postpartum.

Task 9: Use multivariate statistical methods to test the hypothesis that a high maternal weight gain during pregnancy, especially during the first and third trimesters, will be associated with excessive maternal weight retention, after adjusting for potentially confounding variables including military status, and risk factors.

Our data strongly suggest that as maternal weight gain during pregnancy increases, so does maternal postpartum weight retention. This was seen for trimester gain, for total weight gain and for weight gain above the Institute of Medicine's recommended ranges.

We analyzed various continuous maternal weight outcomes (retention over prepregnancy weight, loss since delivery and absolute BMI) at the end of the postpartum year and found that higher gestational weight gain was consistently associated with higher retention.

For example, Table 3 summarizes association between trimester gain and 2 outcomes: postpartum retention and became overweight for women who began pregnancy not overweight. (based on new data as well as studies reported in the February 2002 report). Adjusted results are shown for separate models in by prepregnancy weight status and active duty strata.

Table 3: Summary of Findings: Adjusted Associations between Trimester Weight Gain and Postpartum Weight

		Gain	(coefficient, 95% CI)
BMI<26	734	Trimester 1	0.47 (0.34, 0.6)
		Trimester 2	0.36 (0.24,0.48)
		Trimester 3	0.34 (0.24,0.44)
BMI > 26	317	Trimester 1	0.81 (.61, 1.02)
		Trimester 2	0.32 (0.08,0.56)
		Trimester 3	0.25 (0.24,0.70)
Active Duty	243	Trimester 1	0.71 0.5, 0.92)
		Trimester 2	0.37 (0.16,0.58)
		Trimester 3	0.53 (0.34,0.72)
Mil. Dependent	808	Trimester 1	0.64 (0.51, 0.76)
		Trimester 2	0.36 (0.24,0.49)
		Trimester 3	0.35 (0.23,0.46)
Development of Overweight in Women beginning pregnancy at normal weight			Odds Ratio (95% CI)
All	591	Trimester 1	1.15 (1.06, 1.25)
		Trimester 2	1.14 (1.05,1.22)
		Trimester 3	1.10 (1.03,1.17)
Active Duty	159	Trimester 1	1.17 (0.99, 1.37)
		Trimester 2	1.12 (0.96,1.31)
		Trimester 3	1.07 (0.93,1.24)
Mil. Dependent	432	Trimester 1	1.16 (1.06, 1.28)
		Trimester 2	1.13 (1.04,1.23)
		Trimester 3	1.11 (1.03,1.20)

Postpartum Weight Retention by Institute of Medicine Weight Guidelines, Prepregnancy BMI and Race-ethnicity

We conducted a series of analyses with the aim of examining the impact on weight retention by race and prepregnancy BMI of the 1990 Institute of Medicine (IOM) Guidelines for weight gain during pregnancy. Our analyses were meant, in part, to replicate an earlier examination of postpartum weight retention by weight gain categories, that was conducted prior to the implementation of the IOM guidelines (Keppel & Taffel, 1993). Inclusion criteria for this analysis included prepregnancy BMI of 29 or less; White, Black, Asian, or Hispanic race; a postpartum measured or self-reported weight between 9 and 18 months; and a gestation of 37 weeks or more.

Table 5. Median Weight Retention by Prepregnancy BMI sis

Race	
White	721 (56%)
Black	163 (13%)
Asian	195 (15%)
Hispanic	198 (16%)
IOM Pregnancy Gain Category	
Low	204 (16%)
Recommended	397 (31%)
High	676 (53%)
Prepregnancy BMI	
Underweight	178 (14%)
Normal Weight	896 (70%)
Overweight	203 (16%)
Marital/Partner Status	
Unmarried/Not living with a partner	89 (7%)
Married/living with a partner	1188 (93%)
Active Duty Status	
Military Dependant	1023 (80%)
Active Duty	254 (20%)
Education	
Less than high school	67 (6%)
High school graduate/GED	362 (30%)
Vocational or trade school	75 (6%)
College	602 (50%)
Graduate school	106 (9%)
Monthly Income	
$500 or less	9 (1%)
$501-$1000	68 (6%)
$1001-$1500	181 (15%)
$1501-$2000	226 (19%)
$2001-$2500	228 (19%)
$2501-$3000	163 (14%)
$3001-$6250	271 (23%)
$>$6250	45 (4%)
Maternal age (years)	26 ± 6
Parity	1 ± 1
Birthweight (g)	3443 ±488
Maternal height (cm)	162 ±7
Time of weight measurement (days postpartum)	390 ±58

Table 4 provides a description of demographic and anthropometric variables for the 1277 women included in this analysis.. Data here are presented in pounds to be

Mother's Body Mass Index and Weight Gain	**Number**	**Median (range)**
Total Median (lbs)	1277	5.2 (-43.9, 75.4)
Underweight		
Less than recommended	37	1.1 (-10.1, 11.9)
As recommended	72	5.1 (-9.0, 42.1)
More than recommended	69	9.0 (-8.8, 60.3)
Median (lbs)		5.2 (-10.1, 60.3)
Normal weight		
Less than recommended	153	1.2 (-30.9, 47.2)
As recommended	296	4.2 (-38.1, 38.1)
More than recommended	447	8.1 (-20.1, 75.4)
Median (lbs)		5.2 (-38.1, 75.4)
Overweight		
Less than recommended	14	-0.1 (-11.9, 10.0)
As recommended	29	0.2 (-26.9, 15.4)
More than recommended	160	10.0 (-43.9, 71.6)
Median (lbs)		6.6 (-43.9, 71.6)

consist ent with the units reported in the article by Keppel and Taffel. Overall, only 31% of the women gained within the IOM Recommended weight gain ranges; 53% gained more.

The median weight retention for the sample is presented in Table 5, both overall and by prepregnancy BMI and IOM pregnancy gain category. There was little variation by prepregnancy weight in median postpartum weight retention, both overall and when stratified by IOM gain category. In every prepregnancy weight group, there was increasing retention associated with increasing pregnancy gain.

The distribution of postpartum weight retention by IOM gestational weight gain category and by race is presented in Table 6. It is interesting to note that 26% of the women lost weight by their last postpartum visit, while 25% retained 14 lb or more. Again, there was a clear effect of increased pregnancy gain on increased postpartum retention. There were a number of differences between race groups on median retention stratified on pregnancy gain category. Hispanic women with a less than recommended gain had a somewhat higher retention than White, Black, and Asian women with a less than recommended gain. White women with a recommended gain had a slightly lower retention than Black, Asian, and Hispanic women with a recommended gain. A slightly lower median weight retention was observed for Asian women with a higher than recommended gain than for women in the other race groups.

Table 6: Weight Retention by Race and Pregnancy Weight Gain

Mother's Race and Weight Gain	Number	Lost weight	0-3	4-8	9-13	14 or more	Less than 4	9 or more	Median (range)
				All races					
Total	1277	26.2	15.6	19.9	13.2	25.1	41.8	38.3	5.2 (-43.9, 75.4)
Less than recommended	204	43.6	21.6	14.7	11.8	8.3	65.2	20.1	1.1 (-30.9, 47.2)
As recommended	397	31.2	15.9	24.4	14.6	13.9	47.1	28.5	4.1 (-38.1, 42.1)
More than recommended	676	18.1	13.6	18.8	12.9	36.7	31.7	49.6	8.3 (-43.9, 75.4)
Median (lbs)		-4.9	1.4	5.9	10.2	22.7	-1.9	17.0	
				White					
Total	721	29.1	15.0	20.0	11.7	24.3	44.1	35.9	5.0 (-30.9, 75.4)
Less than recommended	112	45.5	21.4	15.2	9.8	8.0	67.0	17.9	0.2 (-30.9, 47.2)
As recommended	217	37.3	17.1	25.4	10.6	9.7	54.4	20.3	2.9 (-24.9, 38.1)
More than recommended	392	19.9	12.0	18.4	12.8	37.0	31.9	49.7	8.4 (-20.1, 75.4)
Median (lbs)		-4.9	1.2	5.5	10.2	23.1	-2.1	18.1	
				Black					
Total	163	22.1	17.2	16.0	14.7	30.1	39.3	44.8	6.9 (-43.9, 71.6)
Less than recommended	30	50.0	20.0	6.7	13.3	10.0	70.0	23.3	0.2 (-16.8, 25.0)
As recommended	34	20.6	20.6	11.8	17.7	29.4	41.2	47.1	5.7 (-11.1, 42.1)
More than recommended	99	14.1	15.2	20.2	14.1	36.4	29.3	50.5	9.0 (-43.9, 71.6)
Median (lbs)		-4.9	1.1	6.0	10.3	23.0	-0.6	18.7	

Mother's Race and Weight Gain	Number	Lost weight	0-3	4-8	9-13	14 or more	Less than 4	9 or more	Median (range)
				Asian					
Total	195	23.1	17.4	25.1	15.4	19.0	40.5	34.4	5.2 (-38.1, 55.3)
Less than recommended	32	37.5	31.3	18.8	9.4	3.1	68.8	12.5	1.8 (-21.8, 23.2)
As recommended	76	29.0	10.5	29.0	19.7	11.8	39.5	31.6	5.2 (-38.1, 33.3)
More than recommended	87	12.6	18.4	24.1	13.8	31.0	31.0	44.8	7.0 (-14.9, 55.3)
Median (lbs)		-3.8	2.1	5.9	10.2	23.1	-0.9	14.3	
				Hispanic					
Total	198	22.2	14.7	17.7	15.7	29.8	36.9	45.5	7.2 (-15.3, 62.1)
Less than recommended	30	36.7	13.3	16.7	20.0	13.3	50.0	33.3	4.1 (-11.8, 30.2)
As recommended	70	20.0	15.7	22.9	20.0	21.4	35.7	41.4	6.8 (-12.0, 35.2)
More than recommended	98	19.4	14.3	14.3	11.2	40.8	33.7	52.0	9.6 (-15.3, 62.1)
Median (lbs)		-4.9	2.0	5.6	11.2	20.2	-1.9	15.6	

We used a multiple linear regression model to examine the impact of IOM pregnancy gain categories, race, and prepregnancy BMI on postpartum weight retention (Table 7).

Table 7: Multiple Linear Regression of Postpartum Weight Retention

This model confirmed that compared to women with lower than recommended pregnancy

	Coefficient Interval)	**(95% Confidence**
IOM Pregnancy Gain Category (vs. Less		
than recommended)	3.06	(0.73, 5.38)
Recommended	9.81	(7.64, 11.99)
More than recommended		
Race (vs. White)		
Black	0.85	(-1.56, 3.27)
Asian	1.14	(-1.04, 3.32)
Hispanic	1.81	(-0.34, 3.97)
Prepregnancy BMI (vs. Underweight)		
Normal Weight	-0.61	(-2.80, 1.57)
Overweight	-0.60	(-3.36, 2.15)
Active Duty (vs. Military Dependant)	-0.32	(-2.32, 1.68)
Parity	1.23	(0.31, 2.14)
Maternal Age	-0.10	(-0.27, 0.07)
Income	-0.001	(-0.002, -0.0004)
Education (vs. less than HS Grad)		
HS Grad/GED	-3.32	(-6.98, 0.34)
Trade School	-6.12	(-10.66, -1.57)
College	-4.09	(-7.70, -0.48)
Graduate School	-5.25	(-9.73, -0.76)
Time at measurement	-0.02	(-0.03, -0.01)
Constant	16.29	(9.09, 23.50)

gain, women with recommended and high gains had significantly higher weight retentions after controlling for sociodemographic differences. There were no significant effects of race or prepregnancy BMI on postpartum retention, controlling for demographic factors. The results of this multivariable model were used to obtain the predicted amount of postpartum weight retention by race, prepregnancy BMI, and pregnancy weight gain (Table 8). As with the uncontrolled analyses, increased pregnancy gain is associated with increased predicted postpartum weight retention.

Table 8: Predicted Weight Retention by Prepregnancy BMI, Pregnancy Weight Gain and Race*

	Race			
Mother's Body Mass Index and Weight Gain	**White**	**Black**	**Asian**	**Hispanic**
Underweight				
Less than recommended	1.0	1.9	2.2	2.9
As recommended	4.1	5.0	5.2	5.9
More than recommended	10.9	11.7	12.0	12.7
Normal weight				
Less than recommended	0.4	1.3	1.6	2.2
As recommended	3.5	4.3	4.6	5.3
More than recommended	10.2	11.1	11.4	12.1
Overweight				
Less than recommended	0.4	1.3	1.6	2.3
As recommended	3.5	4.3	4.6	5.3
More than recommended	10.3	11.1	11.4	12.1

*Controlling for active duty status, parity, age, income, education, and time of observation

Implications: This analysis underscores the importance of pregnancy weight gain in postpartum weight retention. Regardless of race and prepregnancy BMI, increasing weight gain during pregnancy was associated with increased weight retention postpartum. Importantly, even women who gained within the recommended range of weight during pregnancy retained a median of 4.1 pounds during the late postpartum period. While postpartum retention is only one of many factors considered in determining the appropriate amount of pregnancy weight gain, measures should be taken to ensure that women are educated about the consequences of excessive pregnancy weight gain to ensure optimal maternal and infant health.

Institute of Medicine Gestational Weight Gain Guidelines: Balance between maternal and infant outcomes

This analysis examined the relationship between maternal weight gain and 3 outcomes: infant birth weight, cesarean delivery and postpartum weight retention. The analytic sample was limited to White, Black, Asian and Hispanic women with normal pre-pregnancy BMI, singleton births, no pregnancy complications and complete data on prenatal weight gain, postpartum weight, and study covariates. Ninety percent were married, more than 50% were white, 22% were active duty, 20% had family incomes of > \$1500 per month. Mean maternal age was about 26 years; mean postpartum retention was 3.8 kg and 25% became overweight (BMI > 25) postpartum. Only 33% gained within the IOM recommended prenatal range, 50% gained more.

High prenatal gain associated with a significant increase in birthweight and tripled odds of cesarean delivery. After adjustment, no significant difference in any outcome between low gain and recommended gain. High gain associated with more weight retention for all races; recommended gain associated with high weight retention in Black women The complete manuscript (*Parthahasarathy et al, Do the Institute of Medicine guidelines for gestational weight gain provide an adequate balance between maternal and infant health outcomes?*) is ready to be submitted for publication and is included in Appendix XX

Predictors of weight gain during pregnancy

- Since gestational weight gain is consistently associated with postpartum retention, we attempted to identify risk factors for excessive gain, so that women might be identified early in pregnancy and supported to gain more appropriately. Taller mothers, women who began pregnancy overweight (BMI >26), those with hypertension in pregnancy and those with longer gestations were at significantly higher risk for gaining more than the IOM recommended weight gain goal for their pre-pregnancy body mass category. The complete manuscript is included in the appendix. *(Gerstein et al, Weight gain during pregnancy).*

Task 10: Using bivariate and multivariate statistical models, examine how maternal circumstances (e.g. education, socioeconomic status, marital status, work, social support), and lifestyle behaviors during the postpartum period (including method of infant feeding, reported physical activity, dieting behavior, attitudes toward body size, work hours, sleep) relate to maternal change and excessive weight retention.

- Results of the Table 9 suggest that history of weight cycling, financial insecurity, and Black and Hispanic race are potential risk factors. One of the major contributions of this study has been the identification of history of maternal weight cycling as a risk factor for excessive levels of both gestational weight gain and postpartum weight retention. (February 2002 report) Another interesting finding is the association between financial insecurity (self-perceived worry about the ability to pay bills at the end of the month) and increased weight retention.

- We conducted 2 studies examining the role of physical activity in postpartum weight loss. Both are included in the appendix: neither show strong or consistent evidence that women in this study who were physically active retained less weight after birth. (*Nadolny et al, Physical Activity and Postpartum Weight Retention, Eberle C et al, Prepregnancy Body Size, Physical Activity and Postpartum weight retention.* Appendix.) This may be due to problems obtaining precise measures of physical activity. It may also be due to the fact that women who wish to lose weight also attempt to increase their physical activity. As reviewed in the manuscripts, previous studies on this topic have also reported disappointing results.

Table 9 summarizes the results of multivariable analyses of the association between various maternal factors and postpartum weight retention.

Table 9: Risk Factors for Weight Retention for all and by Prepregnancy Body Mass Group

	All (n=1067)	Prepregnancy BMI <26 (n= 755)	Prepregnancy BMI ≥26 (n=312)
History of weight cycling	**1.19** (0.36, 2.0)	**1.08** (0.18,1.97)	1.22 (-0.60, 3.04)
Pre-pregnancy weight	**0.04** (-0.07, -0.01)	-0.01 (-0.05, 0.07)	-0.06 (-0.14, 0.03)
Height	-0.001 (-0.07, -0.01)	-0.03 (-0.1, 0.05)	-0.03 (-0.18,0.13)
Prenatal Gain			
<IOM recommended	-1.0 (-2.1, 0.9)	-2.3 (-5.7, 1.0)	-0.3 (-2.5, 3.2)
>IOM recommended	2.9 (2.1, 3.8)	0.9 (-1.6, 3.5)	3.8 (1.6, 6.0)
Age	-0.06 (-0.14, 0.02)	-0.04 (-0.12, 0.03)	-0.08 (-0.30,3.40)
Parity	-0.4 (-0.65, 0.45)	0.02 (-1.07, 1.12)	4.69 (1.35, 3.03)
College vs not	0.25 (-0.8, 1.3)	0.12 (-0.69, 0.93)	1.55 (-0.30, 3.40)
Active Duty vs not	-.10 (-1.0, 0.85)	-0.77 (-1.70, 0.15)	1.80 (-0.70,4.30)
Income			
Low	-0.6 (-1.5,0.4)	-0.8 (-1.8, 0.2)	-1.1 (-2.3,2.1)
High	**-0.9** (-1.8, 0.0)*	**-1.17** (-2.1,-0.3)	0.3 (-2.2,2.7)
Financial insecurity			
Sometimes	**0.7 (0.2, 1.6)**	0.1 (-0.8,1.1)	1.5 (-0.7,3.7)
Always	**1.7 (0.5, 3.0)**	**1.9 (0.6, 3.3)**	1.6 (-1.0, 4.3)
Healthy Dieting	**-1.4** (-2.1, -0.6)	-1.14 (-3.60, 1.32)	**- 2.27** (-4.12, -0.41)
Physical Activity	0.38 (-0.38, 1.15)	**0.78** (0.01, 1.54)	-0.94 (-2.87, 1.0)
Breastfeeding	-0.47 (-1.4, 0.46)	-0.35 (-1.30, 0.60)	-0.56 (-2.70,1.57)
Race/ethnicity (vs non-Hispanic white)			
Black	-0.2 (-1.3, 0.9)	**1.26** (0.09, 2.4)	**-2.83** (-5.39, -0.27)
Asian	-0.1 (-1.3, 1.1)	0.69 (-0.5, 1.9)	-2.58 (-6.09,0.94)
Hispanic	0.1 (-1.0,1.2)	**1.30** (0.2, 2.4)	**-2.42** (-4.94,0.10)

** p<0.06

- We also have found a positive link between maternal postpartum depression and weight retention. (*Altman et al, Is postpartum depression associated with maternal weight retention?* Appendix).

Task 11. Use the results of previous analyses to attempt to identify those women who are most likely to become overweight as a result of childbearing, and to identify when postpartum (or during pregnancy) such women might be detected.

We addressed this in the February 2002 report which presented models showing predictors of development of overweight/obesity among women who began their pregnancy within the "normal" BMI category defined by the Institute of Medicine. In the manuscript by

Tujague et al, included in the Appendix, we use the military cuo-ff of a BMI of 25 and examine additional variables such as physical training.

Study Limitations

As described in previous reports, this project was plagued with serious problems. Our subcontractor, Freeman Sullivan and Co (FSC), who was originally responsible for all aspects of fielding the study in San Diego (including screening, enrolling and following study participants, collecting, verifying and keying measurement and questionnaire data, and tracking and reporting the success of these activities) was unable to meet their contractual obligations. Particularly, they failed to successfully collect follow-up data after the enrollment visit (both in the clinic and by mailed questionnaire) and most importantly they were missing most of the women with infants aged between 9 month and 12 infants, the final endpoints for the postpartum year. FSC also failed to deliver timely progress reports, so it required 14 months into the project for Dr. Abrams to determine that only 12% of all women with 1-year-old infants had actually completed data collection.

To save the study, we renegotiated the subcontract, changed the study design and brought to Berkeley much of the follow-up data collection. This involved hiring, training and supervising a team of graduate students to collect data by mail and phone, the development of "mini" versions of the Follow-up/exit and Combination Baseline-Follow-up questionnaires that could be mailed in large batches and easily completed by study participants. Doing this allowed us to collect data at end of the postpartum year for over 1000 participants that would have otherwise been lost due to the virtual breach of contract. We were forced to exhaust funds originally intended for data analysis budget in order to complete data collection at Berkeley, but 2 years ago, the UC administration returned $165,000 from the study overhead to allow completion of data analysis.

However, the resulting data set differs from the original study plan in the following ways:

1) Measured versus self-reported weights Data collection via phone and mail yielded self-reported rather than measured maternal weights. When we limit the study sample to women with measured postpartum weights, the follow-up time is approximately 6 months after birth, while it is closer to a year for women who self-reported their weight. We found little evidence of a systematic difference by the way final postpartum weights were obtained in either raw or multivariate analyses, thus the final study sample includes women with both measured and self-reported postpartum weights.

2) Missing Data FSC was unable to recover Baseline and Follow-up Questionnaires from almost 33% of the enrolled women. Once the staff at Berkeley took over the data collection via mail, we were able to fill in many gaps by administering "mini" questionnaires. However, the longer questionnaires were unfortunately the sole source of data on many interesting exposures, including maternal smoking, body image, weight cycling and the depression scale. Thus, sample size for analyses including these variables are severely restricted in size. Furthermore, a proportion of women who did respond left some questions blank. However, comparisons of characteristics, including postpartum weight, of those women with and without missing data suggest little selection bias.

3) Sample and Follow-up We originally aimed to recruit more than 4000 mothers and follow a large proportion of them through the first year after birth. This estimate was based on advice from staff at the NMCSD Pediatrics Clinic who suggested that women would be eager to enroll in the study due to its objectives, that they would easily be able to complete the study instruments, and that follow-up would be possible because virtually all women who brought their infants for 2 months well-baby care could be expected to return to the NMCSD Pediatrics Clinic for further well-baby care. We believed that linking the data collection to routine, well-baby visits, would be the most efficient and inexpensive way to recruit and follow new mothers by reducing subject burden and number of staff members required. Furthermore, focus groups of new mothers in the Pediatric Clinics examined our instruments and agreed that completing them were feasible.

However, shortly after we began data collection, a "managed care" program was introduced into Pediatrics Clinic and the situation changed. Many women, confused about the future stability of their care (one of the eligibility requirements for this study), chose to delay enrolling. At the same time, the NMCSD opened several "satellite" pediatric clinics in remote locations and we had no study staff to collect data there. Some study participants switched to these other clinics and others alternated between several clinics, thus the "closed system" that we had counted on no longer existed and we could not collect all follow-up data as expected.

We also discovered that in addition to the expected loss of data from Active Duty women who were deployed, we also lost follow-up data from the wives of Active Duty servicemen. We had not anticipated that many study participants would leave San Diego and return to their families when their husbands were deployed. We were able to obtain some follow-up data by use of our mailed questionnaires, but many of these women simply disappeared after enrolling in the study.

3) Data entry errors It took 3 companies to get our data properly entered. We now have confidence in the quality of the data, which have been properly double-keyed, verified and most of the variables examined for unusual values and outliers. We have examined the pattern of maternal weight change by comparing all measurements over time and looking up inconsistent values for more than 500 individual women. This has increased our confidence in the data set, which was understandably shaken by the events described above. We have reanalyzed our study data reported in previous reports and in most, but not all cases, the original results have held.

Key Research Accomplishments

- Recruitment, data collection and data entry are complete for the study group of new mothers at the Naval Medical Center, San Diego.
- We enrolled more than 2500 women.
- Women in this study, on average, retained 3.8 kg at about a year postpartum.
- Major risk factors for high postpartum weight retention include excessive prenatal weight gain, history of weight cycling, financial insecurity and maternal depression after delivery.
- We found little evidence that physical activity, including physical training for Active Duty women, decreased postpartum weight loss.

Reportable Outcomes

Manuscripts and Presentations (new this year; see previous reports for past outcomes)

Kang MS, Abrams B, Selvin S. Differences in postpartum weight loss between African American and white mothers in a military population of normal weight women.

Parthahasarathy P, Abrams B, Selvin S. Do the Institute of Medicine guidelines for gestational weight gain provide an adequate balance between maternal and infant health outcomes?

Gerstein D, Abrams B, Selvin S. Weight gain during pregnancy.

Nadolny T, Selvin S, Abrams B. Physical activity and postpartum weight retention.

Eberle C, Diehl M, Abrams B. Prepregnancy body size, physical activity and postpartum weight retention.

Altman S, Abrams B, Selvin S. Is postpartum depression associated with maternal weight retention?

Tang T, Abrams B, Selvin S. Predictors of breastfeeding initiation and duration among races in a military population.

Abrams B. Dilemmas in prenatal weight gain. School of Public Health Research Symposium, October 2002.

Conclusions

The finding that women in this study retained almost 4 kg in the year after birth, rather than the 1 kg proposed by earlier researchers, suggest that weight retention may be a substantial problem for both active duty and non-active duty women after pregnancy. Indeed, the United States is facing an epidemic of obesity, thus this problem is neither limited to new mothers or to the military.

A recent study reported that women with excessive weight gain during pregnancy or those who had not lost their pregnancy weight gain by 6 months after birth were at increased risk for obesity 8-10 years later (Rooney and Schauberger, 2002). From a health perspective, obesity is a risk during a subsequent pregnancy and for long-term health.

We expected that the extra demands of physical readiness would cause active duty women to be less likely to retain weight after birth, but this was not the case, except for African American mothers. Nonetheless, weight retention in these women retained 3.5 kg. Some women became overweight postpartum. Unfortunately we do not know whether the gain in weight led to separations from the Navy as we did not ask this question and few women volunteered this information in passing.

Our finding that a history of weight cycling is a risk factor for both excessive gestational weight gain and postpartum retention holds some promise for identifying women who have lost weight repeatedly in the past and offering special services to them to try to support healthy pregnancy weight gain and weight loss after birth. Unfortunately, the published literature offers little guidance as to what kind of counseling or service would be effective in intervening to help women to control their weight. We also found that psychosocial factors, including financial stress and depression were risk factors. Thus, simply focusing on cutting calories and exercising may not be adequate. While "healthy dieting" did predict weight loss in some subgroups of the population, neither dieting nor physical activity emerged as a panacea.

This research was difficult to conduct. Postpartum women, particularly those who worked outside of the home, were very difficult to study. As a group, they were exhausted and preoccupied with the demands of caring for an infant and often more children, as well as juggling work out of the home. We believe that future studies are justified to assess how to intervene. If so, we recommend that active duty women be allowed to participate as part of their duty time or at home and that data be collected by interviewers rather than self-administered questionnaire. Unless health care is truly delivered in a "closed system" we do not recommend studying women in the Pediatric clinic setting.

Our results suggest that women cannot reliably report their physical activity, or that physical activity has a weak effect on postpartum weight. We were unable to measure energy balance; perhaps women who were physically active were also consuming more energy. Additional measurements of energy expenditure and intake would have been helpful, but impossible in a study this large.

It is also possible that exposures such as physical activity have a long-term effect that is not observed within the first year. In the 9-year follow-up study, Rooney and Schauberger reported that participation in postpartum exercise was not related to weight retention at 6 months postpartum, but was related to reduced weight change 8-10 years later.

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Appendix

Differences in Postpartum Weight Loss Between African American and White Mothers in a Military Population of Normal Weight Women

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Introduction

The prevalence of overweight and obese American women is increasing. The 1997 National Health Interview Survey showed that just under half of the women in the United States are overweight (body mass index (BMI) >=25 kg/m^2). The prevalence of overweight and obesity was also higher among African American women than among any other ethnic group surveyed[1]. There is evidence that higher body mass is associated with a variety of adverse health effects including heart disease, diabetes, hypertension, and osteoarthritis[2-4]. Jefferey et al. have also suggested obesity may impact on psychosocial outcomes. He discusses a potential negative impact of overweight and obesity on socioeconomic status[5]. Thus, the determinants of long term weight increase and the associated health and psychosocial consequences are an important public health concern [6].

Because pregnancy is a time of required weight gain, many studies have hypothesized that pregnancy is a risk factor for obesity in women[4, 7-12]. During an average human pregnancy, the mother is expected to increase her body weight by 20% or more[4, 13]. The mother's gain in weight has shown a consistent and strong association with the health of the infant in both African American and White populations[14-21]. Although a number of studies of pregnancy weight gain have focused on pregnancy complications and infant health, some studies have begun to address its impact on maternal weight change after delivery[4, 19, 20, 22-24]. From national survey information on women who were followed for 10 years Williamson et al. estimated the mean weight gain associated with pregnancy to range from 1.7kg to 2.2kg[10]. In another study, Smith et al found an increase in weight of 2-3kg over 5 years of follow up in primiparas compared to nulliparas. They also found that African American women were at significantly higher risk for adverse changes in adiposity due to pregnancy [9].

Three reviews of postpartum weight change have been published in the last 7 years. Lederman was the first to publish a review[11], and concluded that maternal weight increases were not a product of pregnancy per-se but of other lifestyle factors. The findings in Lederman's review are heavily based on the studies by Ohlin and Rossner in a Swedish population that may not be comparable to U.S. women[25]. Parker published a review one year later[12] looking at a wider range of factors. She found that higher pregnancy gain, African American racial group, and low socioeconomic status were associated with an increase in weight retention. She also concluded that cigarette smoking was consistently related to reduced weight retention and that other factors, such as exercise, dieting, mother's age, parity, and the inter-partum interval were still poorly understood.

Gunderson and Abrams recently reviewed the literature specifically with regard to gestational weight gain and its impact on weight change postpartum[4]. She examined a wide range of factors and considered several methodological issues in studying weight retention. Gunderson concluded that the change in body weight during the postpartum period is a complex interaction of maternal factors, gestational weight gain and lifestyle factors, with gestational gain playing a role primarily in the period of time most proximal to delivery with lifestyle factors such as physical activity and diet becoming more important as the endpoint of study moved further from birth. She also suggested heritable characteristics such as the proposed "obesity gene" as potential explanations for variation in postpartum weight patterns.

There has been a large variation in the choice of endpoints used across studies of postpartum weight. Timeframes range from 6 months as in Schauberger's study[26], to 5 years as in the CARDIA study[9], or even 10 years among studies such as Williamson's where National survey data were used[10]. With so few known determinants of retention, and such a range of time frames that have been studied, the normal pattern of maternal weight loss after birth and risk factors for long-term weight retention after pregnancy are poorly understood.

We conducted multivariable regression to answer two questions: (1) Is there a difference in postpartum weight retention between African American and White women in this population? (2) If differences exist, what factors might mediate or contribute to these differences? We were particularly interested in the role of Naval duty status in postpartum weight changes. Our study population consisted of military women or dependents of active military partners. For the remainder of this paper we will refer to these two groups as active and non-active duty. Those women who are of active duty status are required to achieve standards of physical readiness, including standards of weight for height, within a given time period after pregnancy. The time allowed to reach standards varies by branch of service, in the Navy it is usually 6 months. We hypothesized that pressure to meet physical goals might change women's behaviors and pattern of weight change postpartum.

Methods

The "After the Baby Comes" or ABC study was designed specifically to collect information on postpartum weight changes. Between 1997 and 1999, we enrolled more than 2900 postpartum women receiving well-baby care for their infants at the Pediatrics Clinic of Balboa Hospital, the U.S. Naval Medical Center, San Diego. Mothers' weight was measured at each clinic visit and mothers' height at the first clinic visit. Trained individuals collected weight and height measurements with standard methods. Measurements were taken twice at each visit and compared for accuracy. If measurements disagreed, a third measurement was taken. Mothers also filled out questionnaires on their current behaviors and conditions at each clinic visit. All women were given take home baseline and follow- up questionnaires requesting data on maternal demographic, behavioral, and social characteristics. Women who enrolled also consented to have their medical records abstracted.

For this analysis we were interested in assessing the differences or similarities in our results to those found previously in a nationally representative sample[27]. We therefore chose our exclusion criteria to match those used by Parker and Abrams in their analysis of the National Maternal and Infant Health Survey. From the full ABC study population, we selected all African American and White women at least 18 years of age delivering live singleton infants weighing at least 2500g. Women who were not of normal pre-pregnancy body mass index (BMI 19.8-26.0) according to the Institute of Medicine guidelines [13] were excluded because different associations may exist for pregnancy outcomes based on pre-pregnancy size[17]. Women who gained more than 70 pounds or who lost weight during pregnancy were also excluded. Because we wanted to understand the pattern of postpartum weight loss, women who became pregnant again during the follow-up period were also excluded.

As noted earlier, a wide variety of endpoints have been used to study postpartum weight change. We chose the same time window as Parker and Abrams to allow us to compare our results to theirs. We therefore examined women whose weight was measured or self reported between 10 and 24 months postpartum. This time window should allow enough time for a return to pre-pregnancy weight, but hopefully minimizes the effect of weight gain unrelated to pregnancy.

We calculated weight retained as the postpartum weight minus the pre-pregnancy weight of the mother in kilograms. Though there is evidence that the tendency to under-report of weight values increases with increasing body weight[28, 29], this potential bias should be less relevant among a study sample including only women with normal pre-pregnancy weights.

Racial or ethnic group used in this analysis was based on responses to the question "what race or ethnicity would you describe yourself as...(check all that apply)". Women who identified as white and no other ethnic or racial group were considered white. Women who self reported as black or African American were considered African American regardless of other racial/ethnic groups indicated. Women were considered active duty status if they reported being active duty at any point during the postpartum period, or if there was any indication in prenatal, hospital or naval records of active duty status. This approach erred in the direction of classifying women as active duty that may not have maintained their duty status through the entire postpartum period.

Data on dieting and exercise behaviors between 2 and 6 months postpartum were collected at well-baby clinic visits. Exercise in this study was reported as the number of times in the past 7 days a woman had participated in sports or exercise. For those women with more than one visit during this period, the average of her reported values for exercise was used. A woman was considered be dieting if she indicated (in a longer checklist of behaviors) that she was eating less, following a low calorie or low fat diet, trying to be more physically active, or reducing junk food in her diet. These behaviors constituted the majority of weight reduction strategies reported. All women who reported dieting between 2 and 6 months postpartum were considered dieters.

A repetitive pattern of loss and gain of weight has been suggested as a potential risk factor for retention although the one study examining this found inconclusive evidence [30].

History of weight cycling was a composite of two variables collected at baseline, but was missing for some women. We considered women to have a history of weight cycling if they answered that they had either lost 10 pounds or gained back 10 pounds of lost weight more than three times in their lives, excluding weight change due to pregnancy. Although the evidence for a relationship between postpartum weight and lactation is controversial, we examined models including the number of days a woman reported breastfeeding her infant.

Our main analysis was a linear regression of maternal factors on the amount of pregnancy weight gain that was retained. We initially considered factors shown in the literature to be potentially influential on weight retention. Maternal age, pre-pregnancy weight, parity, pregnancy weight gain, days since birth, mother's height, and infant birth weight were all entered into regression models continuously. Racial group and active duty status were entered as binary variables. Monthly household income and mother's education were considered as markers for socioeconomic status which has been suggested to be important in previous studies longitudinal weight change[31], of postpartum weight[23, 32, 33], and in several studies of birth outcomes[34]. Our study population was, in general, of relatively high education with almost all mothers having completed high school. As a result of this high education level, the education variable included was an indicator for mothers completing at least some college or graduate school.

Linear regressions were conducted on data stratified by race and by active duty status to look for potential interactions. Active duty status showed a different relationship with weight retention in African American mothers than in White mothers, therefore an interaction term for race and active duty status was entered into the full model. Factors were added and removed from the models manually.

Variables were retained in the main linear regression model if they were significantly associated with weight retention, if they changed the relationship between other variables and the outcome or if the removal of the factor negatively impacted the amount of variation explained by the model. For example, a model excluding age and parity explains only 5.6% of the variation in weight retention, whereas an identical model including these two variables explains 6.7% of the variation in retention. The number of days since birth was also retained in all models because we felt that the time window of measurements was too large to treat as one endpoint without controlling for differences in time since birth.

We conducted a second analysis in women who reported exercise and dieting behavior between 2 and 6 months postpartum, and provided information on weight cycling history. In this sub-analysis, dieting and exercise behaviors were retained, though neither was statistically significant alone. The two variables were included because they were confounders of each other, and because we felt that a discussion the impact of weight cycling necessitated some control for current dieting and energy expenditure. Income was retained in this model because it impacted the parameters for dieting, exercise, and weight cycling. Factors we studied that were not significant predictors of postpartum weight retention in any analyses of our population include mother's education, mother's height, mother's pre-pregnancy weight, infant's birth-weight, and length of breastfeeding.

Three additional analyses were conducted to allow us to compare our findings to those in the literature and to assess the impact of other methodological issues on our results.

Parker and Abrams reported odds ratios for differences in retention between African American and White mothers using national data[27].

Many studies have focused on gestational weight gain. The review by Gunderson and Abrams[4], raises serious issues of the statistical interpretation of gestational gain associations. Sufficient evidence has been presented in the literature to establish that there is a correlation between weight gain in pregnancy and weight retention postpartum. The amount of correlation that is a true finding, rather than one induced by the structural relationship between the two variables is unclear. We chose to focus our analysis and discussion on the differences between African American and White mothers and other less established potential risk factors. We were concerned, however, about potential biases created by removing maternal weight gain from the analyses. We therefore analyzed models including and excluding gestational gain. These models did not differ with regards to our study findings or their significance.

Some women in this analysis did not return to the clinic for a weight measurement between 10 and 24 months, but did mail in follow-up questionnaires with self-reported weight values. Concerned that this might affect our findings, we conducted a sub-analysis excluding self-reported postpartum weight values. The results of that regression were comparable to those in the full model. All analyses were conducted using Statistical Analysis Software[35].

Results

Our primary analysis consisted of 653 women, 121 African American mothers and 532 White mothers. When we compared them to all eligible women, the main analysis population was more likely to be slightly older, to be more highly educated, to be living with a partner, to be White, and to have a history of weight cycling. They were also less likely to be active duty themselves, and to report breastfeeding for a longer period of time. The women we included in the sub-analyses were even more likely than the women in the main sample to be

White, to have a higher income and level of education and to be living with a partner. Women included for analysis were also more likely to have reported a history of weight cycling.

A description of the main sample in our study by race and by active duty status can be found in Table 1. Whites in both duty categories had a higher mean income than African Americans. They were also slightly older, more likely to be primiparous and have graduate education, to be living with a partner, and to have a history of weight cycling. Of particular interest is the number of women in each study category that became overweight or obese as a result of pregnancy. The proportion becoming overweight or obese was highest among African American non-active duty women (52%) and lowest among White non-active duty women (24%).

The main linear regression showed a strong effect of active duty status on weight retention in African American mothers, but not in White mothers. Results of this analysis are in Table 2. After adjustment for marital status, parity, age, and time since birth, being active duty was associated with a 0.001 kg decrease in weight retention for White mothers. African American race was associated with a 3.57 kg increase in weight retention for non-active duty mothers and a -0.34 kg decrease in weight retention for active duty mothers with respect to White non-active duty mothers. Only the increase observed in African American non-active duty women was statistically significant at the $\alpha=0.05$ level.

The results of the sub-analysis including postpartum exercise, dieting and history of weight cycling are shown in Table 3. The increased risk of retention in African American non-active duty mothers is 3.05 kg for this model. Interestingly, even with the addition of the new behavioral factors to the model, the coefficient for African American active duty is –0.16 suggesting that after controlling for behavioral factors the African American active duty women are actually at less risk of retention than White active duty women with respect to White non-active duty mothers. Having a history of weight cycling was a risk factor for retention in this model.

Discussion

African Americans in the United States are at significantly higher risk of a wide range of negative health outcomes compared to Whites[36]. The use of racial categories is common in health research, but it is unclear what such categories are attempting to capture. The implication is that there are either social or biological consequences of membership in specific racial or ethnic groups [34, 37]. One common explanation for the disparities in health between African American and White individuals in the United States is that race is a marker for socioeconomic status[36].

The results of our analysis show that the differences in weight retention between African American mothers and White mothers are not explained by education nor by income, the two most commonly used markers for socioeconomic status[34]. Another common hypothesis that is presented to explain the differences in health between groups is access to care. All women in this study had equal access to care through their own, or their partners' military medical coverage. Thus the differences we observed are not explained by differences in access to medical care. The results of this study also suggest that genetic difference between races, another proposed explanation for health differences between African American and White mothers[34, 36] do not the explain the differences we observe in postpartum weight retention. If the difference were genetic, we would not expect the association to change by duty status. Our findings among the active duty servicewomen suggest that active duty status may serve as a marker for other influential and unstudied differences.

Of particular clinical interest is the number of women in our study that became classified as having a BMI considered overweight or obese (by Institute of Medicine standards[13]) as a result of pregnancy weight gains. Over half of the African American non-active duty women had moved into a higher weight category at 10-24 months postpartum. We found such a large difference that we consider it important even given some methodological concerns that BMI might not be an appropriate measure across groups[38, 39].

The percent of women lost to follow-up in this population (37%) is similar to that experienced by Ohlin and Rossner (38%) in their study of postpartum weight in Swedish women[25]. It is also comparable to that experienced by Rookus (30%-50%) in his study of women in The Netherlands[40]. These percentages indicate that new mothers are difficult to study in the year following delivery. Though Ohlin and Rossner state that differences in their analysis population and the women lost to follow-up were "minimal" they present no discussion of the differences that existed. Rookus does not include any discussion of the women who dropped out during his study. Our ability to assess the differences in our study population allows us to interpret our findings more carefully with respect to the target population.

More data are missing for income and weight cycling variables among those women who were lost to follow-up than among those included in analyses. This may be because those variables were not collected on all questionnaires. Income and weight history variables were collected only on baseline and follow-up questionnaires. We suspect that loss to follow-up is may be a result of differences in motivation to participate in a study. If this is true women who did not report information at all time points and were thus more likely to be lost to follow-up would also be expected to not complete the take home questionnaires asking for this information.

A larger percentage of women included for analysis reported a history of weight cycling compared to those who reported this variable but were not included for analysis. African American women were a smaller proportion of the sample and also less likely to diet than White women[2, 41]. This may have affected the percentages of women who reported weight cycling in our sample. The difference in proportion of women with a history of weight cycling may also indicate that women who have a history of weight problems or concerns are more motivated to participate in a study of weight changes.

Although previous research, including two studies that assessed the effects of race have suggested that large maternal pre-pregnancy size is an important risk factor for postpartum weight retention[7, 24, 27, 42], these factors were not significant in our results. We suspect that a relationship may exist, but in our population, we did not find evidence for such a relationship.

An association between pregnancy weight gain and post-pregnancy weight retention has been found consistently across other studies[14-21]. Higher pregnancy weight gains have been associated with better infant health, and with a possible negative impact on long-term maternal health. Health providers would like to be able to recommend weight gains that would maximize the health of both the infant and mother. Teasing out the delicate balance between weight gains that benefit infant health and weight gains that minimize maternal sequelae is difficult[43].

In their discussion of methodological issues, Gunderson and Abrams brought out a statistical complication of the study of pregnancy weight gain as it relates to postpartum weight change. She highlights an article by Selvin and Abrams[44] that discusses a "part-whole" correlation between pregnancy gain and birthweight variables. A similar "part-part" correlation exists for pregnancy gain and postpartum weight retention variables. Postpartum weight contains within it part of the gestational gain. This creates a "structural bias" in the analysis of the relationship. The two variables become statistically correlated because of this structural relationship. This makes it difficult to assess the true impact of gestational gain on postpartum weight change. Enough studies have found a consistently strong association that we can believe a true relationship exists, but its magnitude is unclear. To our knowledge no techniques for studying these variables in an unbiased fashion have been published in the literature. We found that while pregnancy gain may indeed be important, it does not impact the associations between postpartum weight change and the other factors we studied with regards to magnitude or significance.

Of those studies looking at lactation behaviors, some found a weak relationship between lactation and weight loss or body fat[45-47], though others have found no significant relationship[48]. The evidence looking across studies is inconclusive. There seems to be a modification of the relationship of lactation with weight and body fat patterns that depends both on the duration of breastfeeding and the intensity of feeding. There may be other factors involved in the relationship between lactation and weight change. Dewey et al. found that in a randomized trial of lactating mothers, those who were enrolled in a regular exercise program improved cardiovascular fitness but did not lose body fat or weight[48]. Thus it may be possible that lactation has an effect on the way that energy intake and expenditure is mediated during the postpartum period. We found no significant relationship between breastfeeding and postpartum weight. We considered only duration rather than a duration and intensity score, which may have decreased our ability to detect a difference, but our finding is consistent with existing scientific literature.

Our unique military population allowed us to assess the impact of several important factors not previously studied. Although Alexander et al. found some evidence of a narrower gap in birthweight and infant mortality outcomes between African Americans and Whites in military service[49], to our knowledge, this is the first study to examine the difference in postpartum weight loss between African Americans and Whites in a military population. We also had access to information on exercise, weight cycling and dieting behaviors collected before the weight outcome was measured.

Our findings may not be indicative of relationships in the general population of African American and White mothers in the U.S.. Our population was a military based one in which all women had access to prenatal, delivery and postnatal care. We also have little indication of what factors might account for a lack of racial difference in this outcome among active duty servicewomen. Women who enter the U.S. Navy must be free of a range of previous medical conditions, and must meet physical readiness standards to enter service. To maintain active duty status they must also maintain these physical standards. Active duty women may be more motivated to regain pre-pregnancy fitness than non-active duty women. This finding is confusing given the lack of difference between active duty and non-active duty women among White mothers. We were unable to find any factors that explained the differential impact of active duty status on African American mothers compared to White mothers.

Neither the dieting nor the exercise variables used in this study appeared to explain the differences in weight retention, and were not significantly different between active duty and non-active duty women in the two racial groups. This would seem to indicate that the difference found between active duty and non-active duty women is not due to self-reported dieting or exercise. Shauberger et al. found return to work to be protective against weight retention[26]. It may be that part of the impact of active duty status on weight is mediated by the return to work.

This possible relationship is one that should be considered in future studies of postpartum weight change.

Ohlin and Rossner have suggested that weight changes postpartum are a result of behavioral factors and of the effects of ageing rather than of pregnancy itself[25]. In our study maternal age was included but was not a statistically significant predictor of weight retention. Ohlin and Rossner's results may be different from those in this study because their population of White Swedish mothers was not comparable to the population studied here. Their population was racially homogenous, older, taller, and leaner than the women in this study.

The women Ohlin and Rossner studied also gained less weight during pregnancy and retained less weight after pregnancy that the women in our study. The mean weight gain in their study was 14.1kg (se=4.3kg) compared to a mean gain of 16.5kg (se=5.5kg) in our main analysis population. The mean weight retained by their mothers was 1.5kg(se=3.6) compared to 3.36kg(se=6.15) retained by our mothers. It may also be culturally inappropriate to generalize findings among Swedish Whites to African American and White women from a racially diverse military population. Rookus et al found a similar lack of difference in weight change associated with pregnancy beyond that expected due to age[40]. His results also represent the experience of a population that was different from that in our population, the 49 women he studied experienced a mean BMI increase of only 0.61kg/m^2 (se=0.15).

The scientific community has become increasingly interested in the possibility of genetic components to health outcomes. Harris et al. found evidence for a heritable predisposition to pregnancy related weight gain[50]. Stein et al. published results of a study in 1998 that suggest a possible impact of an 'obese gene' on pregnancy gain and postpartum weight retention through serum leptin levels. We did not collect information on this potential genetic risk factor for weight retention, though Stein et al. did not find an association between serum leptin and ethnic group [51] suggesting that a difference in leptin, a marker for genetic factors contributing to obesity, would not explain the difference between non-active duty African American and White mothers in our study.

Harris et al. also found evidence that negative body image postpartum was associated with long-term weight gains at 2.5 years after delivery[50]. These findings are based on the outcomes of 74 low risk women and have yet to be replicated. They do, however, raise an interesting possibility of psychological consequences of pregnancy and a relationship to weight retention. Future studies should examine the possibility that body image and other psychosocial factors mediate weight change in the postpartum period.

Conclusions

We found that for normal weight women, there was no increased risk, and possibly a decreased risk of weight retention among active duty African Americans with respect to Whites. This indicates that military duty status may be a marker for other unknown, and potentially modifiable, explanatory factors that mediate the differences in risk by racial group.

The importance of duty status was unchanged after controlling for education and income. Traditional markers for socioeconomic status, therefore, cannot explain its impact. We also could not explain the impact of duty status with indicators of physical activity or exercise. It may be that there are other behavioral or psychologic impacts of duty status that are particularly important to African American mothers.

Given the potentially large impact of body size on health, and the disproportionately high levels of African American women becoming overweight and obesity in the United States, it is important for future studies to try and understand what might be captured in the experience of active duty service that alleviates the difference in pregnancy weight retention between African American and White mothers.

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Table 1. Distribution of Characteristics by Study Group

Characteristic	African American active duty (n=63)	White active duty (n=121)	African American non-active duty (n=58)	White non-active duty (n=411)
Maternal Age: mean (se)	25.00 (5.13)	25.17 (5.70)	25.91 (5.08)	26.67 (5.72)
Pre-Pregnancy weight: mean(se)	61.39 (6.68)	62.01 (6.52)	61.55 (7.05)	61.29 (6.62)
Pregnancy weight gain (kg): mean(se)	16.52 (5.50)	18.23 (4.92)	16.27 (5.93)	16.65 (5.04)
Mother's height (cm): mean(se)	162.82 (6.96)	164.54 (6.48)	163.42 (5.91)	163.85 (6.28)
Weight retained (kg): mean(se)	3.53 (5.47)	3.91 (5.44)	7.48 (6.06)	3.86 (5.49)
BMI group postpartum: n(%)				
underweight	3 (4.76)	7 (5.79)	0	8 (1.95)
normal	38 (60.32)	77 (63.64)	28 (48.28)	305 (74.21)
overweight	17 (26.98)	27 (22.31)	19 (32.76)	72 (17.52)
obese	5 (7.94)	10 (8.26)	11 (18.97)	26 (6.33)
Parity: n (%)				
Primiparous	39 (61.90)	86 (71.07)	20 (34.48)	203 (49.39)
Multiparous	24 (38.10)	35 (28.93)	38 (65.52)	208 (50.61)
Maternal Education: n(%)**				
less than high school	0 (0.00)	1 (0.97)	2 (4.08)	18 (4.66)
high school/GED	23 (45.10)	47 (45.63)	13 (26.53)	104 (26.94)
vocational or trade school	3 (5.88)	7 (6.80)	4 (8.16)	20 (5.18)
some college	23 (45.10)	32 (31.07)	27 (55.10)	208 (53.89)
some graduate school	2 (3.92)	16 (15.53)	3 (6.12)	36 (9.33)
Living with Partner: n(%)				
yes	46 (73.02)	101 (83.47)	54 (93.10)	397 (96.59)
no	17 (26.98)	20 (16.53)	4 (6.90)	14 (3.41)
Estimated household monthly income: mean(se)**	2500.1(1193.7)	3456.5(1745.2)	2052.1(1024.4)	2959.6(1503.6)
History of weight cycling**				
yes	5 (10.87)	30 (32.61)	9 (19.15)	95 (27.86)
no	41 (89.13)	62 (67.39)	38 (80.85)	246 (72.14)
Days of breast feeding: mean(se)	110.29 (123.22)	121.22 (132.04)	131.64 (136.71)	155.26 (135.38)
Postpartum Dieting: n(%)**				
yes	37 (77.08)	80 (76.19)	38 (76.00)	282 (78.55)
no	11 (22.92)	25 (23.81)	12 (24.00)	77 (21.45)

*data on these variables were not available for all women

Table 2. Results for the Main Analysis Sample (n=676)

Characteristic	coefficient*	(se)	p-value
Living with partner	0.835	0.807	0.3014
Parity	0.161	0.272	0.5552
Age (years)	-0.136	0.041	0.0009
Days since birth	-0.005	0.002	0.0477
African American active duty status**	-0.343	0.771	0.6566
African American non-active duty status	3.569	0.782	0.0001
White active duty status	-0.001	0.585	0.9997

*coefficients correspond to the difference in kg of weight retention with respect to baseline

**coefficients for race and active duty categories are computed with respect to white non-active duty women

Table 3. Results for the Sub Analysis Sample (n=458)

Characteristic	coefficient*	(se)	p-value
Living with partner	1.968	1.147	0.0868
Parity	0.524	0.303	0.0847
Age (years)	-0.133	0.055	0.0153
Days since birth	-0.010	0.003	0.0012
African American active duty status**	-0.157	0.967	0.8714
African American non-active duty status	3.048	0.883	0.0006
White active duty status	0.319	0.680	0.6390
Household monthly income (per $100 dollars)	-0.032	0.019	0.1009
History of weight cycling	2.450	0.551	0.0001
Excercise (number of times)	-0.090	0.115	0.4332
Dieting	1.361	0.592	0.0220

*coefficients correspond to the difference in kg of weight retention with respect to baseline

**coefficients for race and active duty categories are computed with respect to white non-active duty women

Weight Gain during Pregnancy

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Abstract

Background: The 1990 Institute of Medicine's recommendations for weight gain during pregnancy aim to reduce adverse maternal and fetal health outcomes. However, only 30-40% of pregnant women in the United States gain weight within these recommended ranges. The objective of the present study was to determine the maternal characteristics of women who gain outside these recommendations. **Methods**: We used data from the After the Baby Comes (ABC) Study, which were collected prospectively between April 1997 and December 1999 at the United States Naval Medical Center in San Diego. Multivariable logistic regression was used to estimate the risk factors that lead to women gaining less than or greater than the IOM's recommendations. Because of limited statistical power in our analyses, we also used a multivariable linear regression model to identify predictors of total gestational gain and to assess for interactions between the covariates and gestational weight gain by maternal race and pre-pregnancy weight. **Results**: We found women with pre-pregnancy BMI > 26 to be at increased risk for gaining outside the recommended ranges. Tall women, women with prenatal hypertension, and women with greater gestational age were at increased risk for gaining above the recommended ranges. **Discussion**: Based on the results of this analysis and subsequent research and with the overall aim of ensuring the best possible health for mothers and their infants, future research should investigate other potential predictors of weight gain during pregnancy as many women are gaining more weight than is suggested by the recommendations.

Background

Recommendations for optimum weight gain during pregnancy have undergone significant transformations in the last century as research on maternal nutrition and pregnancy outcomes evolved. During the first half of the last century, American obstetricians restricted gestational weight gain to prevent preeclampsia, toxemia, labor and delivery complications, and maternal obesity. The accepted standard of medical practice at that time was to restrict weight gain during pregnancy to no more than 20 pounds (9.1 kg) (1-3). This practice was challenged in the 1960s by researchers who reported an association between low maternal weight gain and low birth weight, which in turn is a risk factor for infant mortality, disability, mental retardation, and low birth weight (2).

In 1970, the Committee of Maternal Nutrition of the National Academy of Sciences concluded that a weight gain of 24 pounds (10.9 kg), or a range of 20-25 pounds (9.1-11.4 kg), was associated with the most favorable pregnancy outcomes (4). Shortly after, the American College of Obstetricians and Gynecologists (ACOG) and the American Academy of Pediatricians (AAP) recommended a weight gain of 22-27 pounds (10-12.3 kg) during the course of a normal, singleton pregnancy (5,6).

In 1990, the research and recommendations were updated by the Institute of Medicine of the National Academy of Sciences' (IOM) report *Nutrition During Pregnancy,* which confirmed a strong association between pregnancy weight gain and infant size and provided recommendations tailored to individuals. The report recommends four ranges of weight gain based on women's pre-pregnancy

BMI rather than a single recommendation as seen in **Table 1** (7). The newest recommendations are intended to be guidelines for prenatal care providers and pregnant women throughout the US.

The IOM called for additional research to validate these recommendations. Studies published in the last 10 years have suggested that gestational weight gain within these ranges is indeed associated with more favorable health outcomes when compared to women whose weight gains fall outside of these recommendations (8-10); these favorable outcomes include a reduction in the prevalence of low-birth-weight or small-for-gestational age infants, large-for-gestational age or macrosomic infants, cesarean deliveries, and preterm deliveries (10-12). In their review of pregnancy weight gain, Abrams and Altman concluded that weight gains outside the IOM's recommended ranges are associated with twice as many poor pregnancy outcomes than are weight gains within these ranges (2).

Both gaining less than or greater than these recommended ranges have been shown to have several adverse health outcomes, but excessive weight gain during pregnancy is becoming an especially important problem and public health concern in the United States (13). Rossner reported a number of additional complications associated with excessive gestational weight gain in his review of weight gain in pregnancy. Among these other complications were fetal trauma, postpartum hemorrhage, and maternal obesity (14). For many women, pregnancy has resulted in pronounced and sustained weight gain (2,9,12,14-17).

Thus, controversy has recently arisen regarding the IOM's large increase in recommended gain from the previous recommendations (15).

Currently, only 30-40 percent of women actually gain gestational weight within the IOM's recommended ranges (18,19). Little is known about the factors that influence women to gain within these recommendations or the factors that increase women's risk of gaining outside these recommendations. Caulfield and colleagues studied a number of demographic and anthropometric risk factors for both gaining below and above the IOM's recommendations among a large cohort of black and white women in Baltimore, Maryland. They found that high maternal pre-pregnancy BMI, increased height, primiparity, prenatal smoking, prenatal hypertension, increased duration of pregnancy, and fetal sex were associated with increased risk of gaining above the recommendations. They also found black race and smoking to be associated with increased risk of gaining below the recommendations (18).

In the present study, we analyzed data from a study of active duty military and military dependent women in San Diego. We addressed the following research question in our analyses: what maternal characteristics predicted whether women were at increased risk for gaining outside the IOM's recommendations with an emphasis on maternal race and pre-pregnancy weight? We studied the same maternal characteristics as Caulfield and colleagues did in their analyses, in order to identify the most important demographic and anthropometric predictors of gestational weight gain among an ethnically diverse population. We studied the potential interaction between the maternal characteristics and gestational weight gain by race, as previous studies have found substantial differences among behaviors of women from different race/ethnic groups that ultimately lead to racial differences in gestational weight gain (7). We also assessed interaction between the maternal variables and gestational gain by pre-pregnancy BMI, because other reports have noted differences among normal weight and overweight women in the predictors of gestational weight gain and its associated outcomes (7).

Materials and Methods

Study Design

The ABC Study was a 32-month long prospective study conducted to investigate patterns of maternal weight changes in women during their first postpartum year. Data collection on maternal variables was integrated into the Balboa Pediatrics Clinic at the United States Naval Medical Center in San Diego (NMCSD) and followed the usual well-baby schedule of visits at 1-week, 2-weeks, 2, 4, 6, 9, and 12-months postpartum. As a result of the high-mobility nature of the military population, the study was designed to allow for data collection from both a series of cross-sectional samples and a smaller longitudinal cohort subsumed within the cross-sectional samples. While it was intended that women would be enrolled as soon after delivery as possible, the actual time of enrollment varied. By using this sequential design, we were able to increase the study population as routine military operations are such that personnel are transferred, on average, every 3 years.

The analyses conducted in this paper, utilized data collected from various questionnaires that were completed by the study participants at well-baby clinic visits and at home. Data were also abstracted from participants' medical records. The study was approved by the University of California at Berkeley's Committee for Protection of Human Subjects.

Study Population

Study participants consisted of women whom were either active duty military personnel, primarily from the Navy, or dependents of active duty servicemen who were receiving well-baby care for their infants at the NMCSD. Between April of 1997 and December of 1999, over 2800 postpartum women enrolled in the study. All women who were enrolled signed informed consent forms in order to participate and to allow data to be abstracted from their medical records. For this analysis, we included all women with complete information available on pre-pregnancy weight, height, total gestational weight gain, age, race, parity, years of education attained, prenatal smoking, pregnancy complications, fetal sex, and length of gestation. This yielded a total of 1228 women.

Measurements

Pre-pregnancy weight was self-reported. There is considerable evidence that shows a high correlation between actual-measured and self-reported weights in pregnant women (21,22). Though previous studies suggest underweight and normal weight women are more likely to over-estimate and overweight women are more likely to under-estimate their pre-pregnancy weight, the differences tend to be small (20). Virtually, all studies on pregnancy weight gain rely on self-reporting. Maternal height without shoes was measured on a stadiometer and recorded at study enrollment. If the two heights differed by more then 0.5 cm, a third measurement was taken. Pre-pregnancy body mass indices (BMI) were calculated by dividing self-reported pre-pregnancy weight in kilograms (kg) by height in meters^2. Pre-pregnancy BMI were then categorized into groups according to the cut-offs suggested by the IOM and shown in **Table 1**(7).

Total gestational weight gain was determined by subtracting the pre-pregnancy weight from the last weight recorded prior to delivery or by maternal self-report. The women's gestational weight gains were categorized as being low, within, or high in relation to the IOM's recommendations based on the women's pre-pregnancy BMI (7). Because the IOM does not specify an upper limit for recommended weight gain for obese women, for our analysis we considered 11.5 kg to be the upper limit of recommended gestational weight gain for this group.

Other variables that were collected and considered in our analyses included maternal self-reported race, age, parity prior to the most recent birth, years of education attended, prenatal smoking, specific complications of pregnancy, duration of pregnancy, and fetus sex. We modeled maternal race as a categorical variable; women were categorized as being white, black, Asian, or Hispanic. Women who reported being "other" race/ethnic group were dropped from the analyses due to the small numbers. Maternal age was modeled as a continuous variable, parity was categorized as primiparious, having had one previous birth, or more than one previous birth, and maternal education was categorized as < 12 years of education, 12 years of education (high school, trade school and/or vocational degree), or > 12 years of education (having attended or completed college and/or graduate school). Prenatal smoking, diabetes, and hypertension were treated as dichotomous variables. Gestational age was based on last menstrual period and often confirmed by early ultrasound, which was collected from the medical records. These variables were collected by questionnaire and were included in our final multivariable model to enable a comparison between our results and those generated by Caulfield and colleagues who addressed a similar research question in a different study population. Caulfield and colleagues included one additional variable in their model, provider type, which was not collected in our study (18).

Statistical Analysis

After describing the data, we used logistic regression to identify factors associated with gaining either less or more than the recommendations, while adjusting for other covariates. Two logistic regression models were generated; one model compared the women who gained less than the recommended weight with the women who gained within the recommended weight range, and the other model compared the women who gained over the recommended ranges with the same reference group of women who gained within the recommendations. The goal of these analyses was to identify the odds of low or high gestational gain as a function of the covariates (23). The two models first included all of the covariates; however, due to the small numbers, the pre-pregnancy BMI categories were collapsed into 2 categories. Not overweight women were defined as those women who had pre-pregnancy BMI less than or equal to 26, and overweight women were those women who had BMI greater than 26. Adjusted odds ratios and their 95% confidence intervals for low gain and high gain were estimated from the model. Variables were considered statistically significant at $P < .05$.

Because our sample size was substantially smaller than Caulfield and colleagues, we generated a multivariable linear regression model using gestational gain as a continuous outcome variable and the same covariates that were used in the logistic models in order to identify other significant predictors of total gestational gain. By using the continuous outcome in place of the categorical outcome, we were able to increase the statistical power in the model. Selvin and Abrams have previously shown that models containing continuous outcome variables have increased efficiency compared to models containing the same variable depicted as a discrete outcome variable (24).

To test for interaction between race and the other covariates as well as pre-pregnancy BMI and the covariates, we created interaction terms to incorporate into another multivariable linear regression model and used likelihood ratio testing to assess the interactions by comparing the full models with the restricted models. Interactions were considered statistically significant at $P < .10$. We found no evidence of interaction with maternal race; however we did find interactions with pre-pregnancy BMI. We then used multivariable linear models stratified by pre-pregnancy BMI to control for the different impact of pre-pregnancy BMI on the relationships between gestational weight gain and the other covariates.

Results

Table 2 compares the maternal characteristics of women with complete data to the total study population. No differences were noted between the two groups. **Table 2** additionally illustrates that 21% of women in the study sample were active duty military status. Approximately 1/5 of the women came from households that earned less than or equal to $1500/month, which is the 2002 US Health and Human Services marker of poverty for a family unit of four (25). This population was highly educated with most of the women having earned a high school degree and more than half having attended college and/or graduate school. Virtually all of our study women were married and/or lived with their spouse/partner.

Table 3 displays the maternal characteristics of the study population according to the IOM's gestational weight gain categories. About 1/3 of the women gained within the recommended ranges for weight gain during pregnancy, 29.8% of the white women, 25.8% of the black women, 36.7% of the Asian women and 34% of the Hispanic women. Of these women, 16.4% were underweight, 65.4% were normal weight, 6.6% were overweight, and 11.6% were obese prior to pregnancy. Over half of the study population gained more than the recommended ranges. Crude analysis suggests that women who gained less than the recommended range for their pre-pregnancy BMI category were shorter, less likely to be primiparous, to smoke during pregnancy, to have carried a male fetus, and to have had hypertension during pregnancy. They were also more likely to be Hispanic, have had diabetes during pregnancy and be overweight or obese prior to pregnancy. Women who gained more than the recommended amount of weight during pregnancy were taller and younger. They were also more likely to be primiparous, white, smoke during pregnancy, carry a male fetus, be hypertensive during pregnancy, and overweight or obese prior to pregnancy. The average duration of pregnancy increased from 38.7 $\pm$ 1.5 weeks for women gaining less than the recommended weight to 39.2 $\pm$ 1.4 weeks for the women gaining above the recommended weight.

Figures 1 & 2 illustrate the distributions of gestational weight gain by pre-pregnancy weight. Gestational weight gains were distributed approximately normally, with increasing variation among women with higher pre-pregnancy BMI. There were, however, a number of women who gained substantially greater amounts of weight than other women in their pre-pregnancy BMI category; these women are identified in **Figure 1** as the outliers or the points plotted above the whiskers of the boxplot. The mean gestational weight gains among the four pre-pregnancy BMI categories were 17.1, 16.6, 17.3 and 13.1 kg, respectively. With the exception of the mean gestational weight gain for the women in the underweight pre-pregnancy BMI category, the mean weight gains exceeded the upper limits of the recommended ranges. This suggests that women with pre-pregnancy BMI > 19.8 were likely to gain above the recommended ranges.

In order to observe how the covariates influenced the risk of gaining weight during pregnancy outside the recommended ranges, we generated two logistic regression models to estimate the influence of each variable on the risk of low gain and high gain compared to optimal gain. The adjusted odds ratios and corresponding 95% confidence intervals (CI) are presented in **Table 4.**

In the multivariable logistic analysis, maternal height and pre-pregnancy BMI were associated with gestational gain less than the IOM's recommendations. Shorter women were more likely to be low weight gainers, and women who were overweight pre-pregnancy were almost two times more likely to be low gainers rather than optimal gainers. Maternal height, pre-pregnancy BMI, prenatal hypertension, and gestational age had statistically significant associations with high gain. Taller women were at a slightly increased risk of gaining above the recommended ranges, and women who were overweight pre-pregnancy were at approximately 2.5 times increased risk of high gain than gaining within the recommendations. Increases in the length of gestation and reported hypertension during pregnancy were also associated with increased risk of high gain.

Table 5 presents the regression coefficients and the 95% confidence intervals estimated from the multivariable linear regression model, which used gestational gain as a continuous outcome variable to identify predictors of total gestational weight gain. This model's results were consistent with the logistic results, but also showed several other significant associations between the maternal characteristics and gestational weight gain. Multiparity, increased maternal age, and being overweight pre-pregnancy were shown to be negatively associated with total gain, and maternal height, prenatal smoking, and gestational age were associated with increases in total gestational gain.

We found no evidence of interaction between the maternal characteristics in the model and gestational weight gain by maternal race [likelihood-ratio test: chi-square = 33 with 29 degrees of freedom ($P < 0.28$)]. However, we did find interaction between the variables in the model and gestational gain by pre-pregnancy weight. The likelihood-ratio test for the saturated model verse the restricted model resulted in a chi-square of 47.61 with 14 degrees of freedom ($P < 0.00$). We then analyzed the data stratifying the multivariable linear regression model by pre-pregnancy BMI to illustrate the interactions, as seen in **Table 5**. We observed interactions with the variables age, height, and parity and total gestational weight gain by pre-pregnancy BMI.

Discussion

Our results were consistent with other studies that have used the IOM gestational weight gain categories, as less than 1/3 of the pregnant women studied gained weight within the IOM recommendations (3,11,18). Based on these results, it is evident that the majority of pregnant women are not gaining weight within these recommended ranges. Our results were further consistent with those from Caulfield's (18) and Siega-Ritz's (19) studies, which found primiparous women, taller women, and women with hypertension during pregnancy to be at increased risk for greater total gestational weight gain. Similar to Caulfield's study, we found these maternal characteristics increased women's risk of gaining above the recommended ranges, and pre-pregnancy BMI and gestational age to be influential in measuring the risk for gaining outside the recommendations.

The goal of our analyses was to identify maternal risk factors for gaining weight outside the IOM's recommendations. When comparing our results with those of Caulfield and colleagues (18), it was apparent that our small sample size was a limitation in our analysis. We had only a small percentage of women who had gained less than the recommended range, and the categorical nature of the outcome variable limited the power of our analysis. In order to increase this efficiency, we used gestational weight gain as a continuous outcome variable in a multivariable linear model. This model allowed us to identify a number of associations between maternal characteristics and gestational gain that were not previously significant in the logistic model but had been previously reported as significant predictors of gestational gain in other studies (11,18,19). These variables included maternal age, parity, and prenatal smoking.

One of the major strengths of our study was its capacity to address this research question among a range of racial groups despite the relatively small sample. Siega-Ritz and colleagues addressed a similar question among Hispanic women attending public prenatal clinics in West Los Angeles (19). However, few, if any, research has studied Asian women in this context. We were able to explore whether women from different racial groups had distinct predictors of gestational gain and found that race did not have any affect.

We found that women who entered pregnancy overweight were at higher risk of gaining outside of the IOM's recommendations. This finding is consistent with a report recently released by the March of Dimes Task Force on Nutrition and Optimal Development entitled *Nutrition Today Matters Tomorrow* (27). This report stated that pre-pregnancy weight matters more than health professionals realize. They noted birth defects, premature birth, and other severe health problems to be linked to the soaring rates of obesity among women of childbearing age (27). Most researchers have agreed that pregravid overweight increases maternal and fetal morbidity (12). In fact, pregravid overweight is one of the most common high-risk obstetric situations (12).

While gestational weight gain is an easy and noninvasive way to monitor the health of a pregnancy, health care professionals need to keep in mind that it has its limitations as a diagnostic tool to predict outcomes directly (8). Because total gestational weight gain is unknown until delivery, it is important that we monitor patterns of gestational weight gain throughout the duration of pregnancy and to identify key maternal characteristics that are associated with gestational weight gains outside the recommended ranges (8). By identifying these key maternal characteristics, clinicians could target nutritional, medical, and social services toward women with high risk of poor pregnancy outcomes.

Our study joined a growing body of literature that has examined several characteristics that are generally easy to obtain through medical records. This literature is consistent enough to indicate that it is time to explore other predictors of gestational weight gain. Though, Siega-Ritz and colleagues identified psychosocial factors that predicted poor maternal weight gain among a group of

Hispanic women (19) and Hickey and colleagues used socio-cultural and behavioral risk factors to predict low gain among a cohort of low-income black and white women (20), the literature on behavioral and psychosocial factors is fairly limited and should be expanded.

Statistics from the CDC suggest that most pregnant women are gaining more weight than is recommended (27) and our study's results confirm this phenomenon. With over half of our study population having gained above the recommended ranges, there is clearly a need for future research to study maternal predictors that have yet to be examined. We need to understand the context in which women are gaining weight in order to design interventions that will successfully decrease the number of women who gain weight outside of the IOM's recommendations. Future studies could be designed to collect data on variables such as frequency and forms of physical activity, dietary behaviors, body image, mental wellness, and environmental factors during pregnancy with the aim of understanding the causes of excessive gestational weight gain.

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Table 1. 1990 Institute of Medicine's (IOM) Recommendations for Weight Gain During Pregnancy Based on Pre-pregnancy Body Mass Index (BMI) (7).

Pre-pregnancy BMI Ranges for Classification	Pre-pregnancy BMI Classification	Recommended Weight Gain During Pregnancy (in pounds)	Recommended Weight Gain During Pregnancy (in kilograms)
< 19.8	Underweight	28-40	12.7-18.2
19.8-26	Normal weight	25-35	11.4-15.9
26.1-29	Overweight	15-25	6.8-11.4
>29	Obese	≥ 15	≥ 6.8

Table 2. A comparison of the maternal characteristics from the study subset (N=1228 women) with the entire study sample (N=2433).

Maternal Characteristic	*Study Subset*	*Total Study*
Active Duty Status (%):		
No – Military Dependant	78.6	78.0
Yes	21.4	22.0
Race (%):		
White	55.2	54.7
Black	14.5	15.3
Asian	13.8	14.0
Hispanic	16.5	16.1
Mean Age in years (range)	26.1 (22-30)	25.8 (21-29)
Pre-Pregnancy BMI Category (%):		
BMI $\leq$ 26	69.6	71.2
BMI > 26	30.4	28.8
Monthly Income (%):		
< $500	0.6	0.8
$501-1000	5.1	5.8
$1001-1500	15.5	15.9
$1501-2000	21.8	21.5
$2001-2500	19.0	19.2
$2501-3000	13.9	13.6
$3001-6250	21.0	20.6
> $6250	3.3	2.7
Highest level of Education Attained (%):		
Less than High School Degree	4.0	5.3
High School Degree/GED	31.8	31.5
Trade School/Vocational	7.7	7.6
Undergraduate Degree	49.3	48.4
Graduate School Degree	7.2	7.2
Parity (%):		
Primiparous	50.7	46.2
Multiparous	49.3	53.8
Mean Gestational Gain in Kilograms (range)	16.3 (12.3-19.9)	16.3 (12.1-20.3)

Figure 1. Boxplot: Distributions of Gestational Weight Gain Based on Women's Pre-pregnancy BMI - Unadjusted.

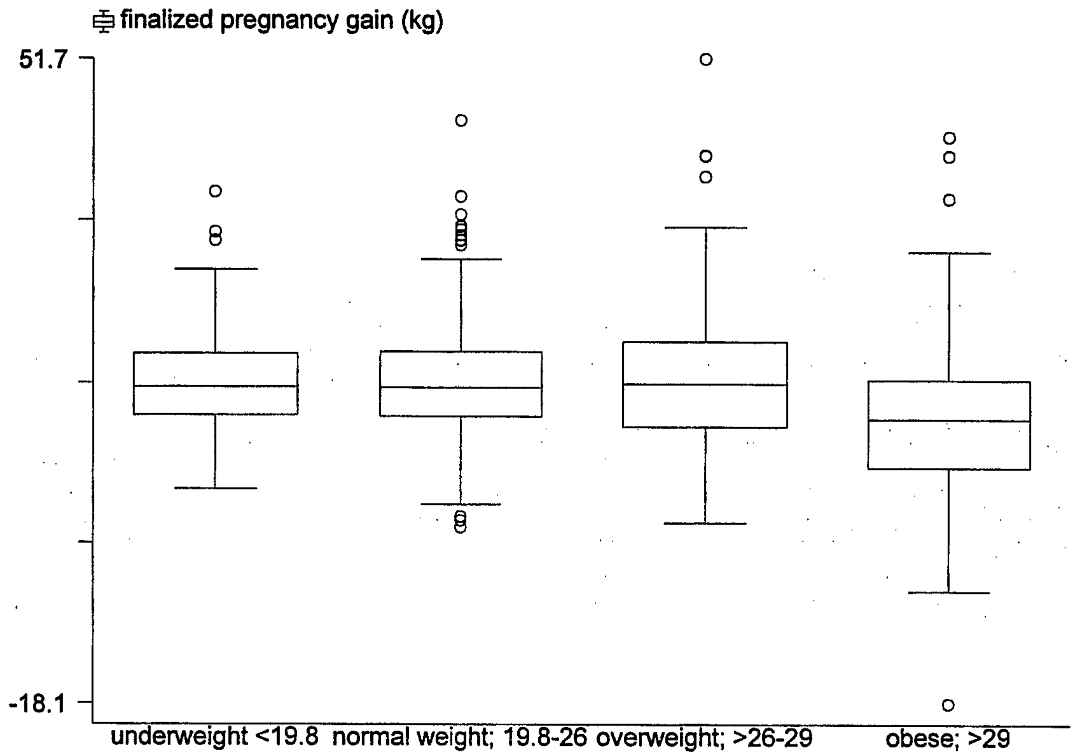
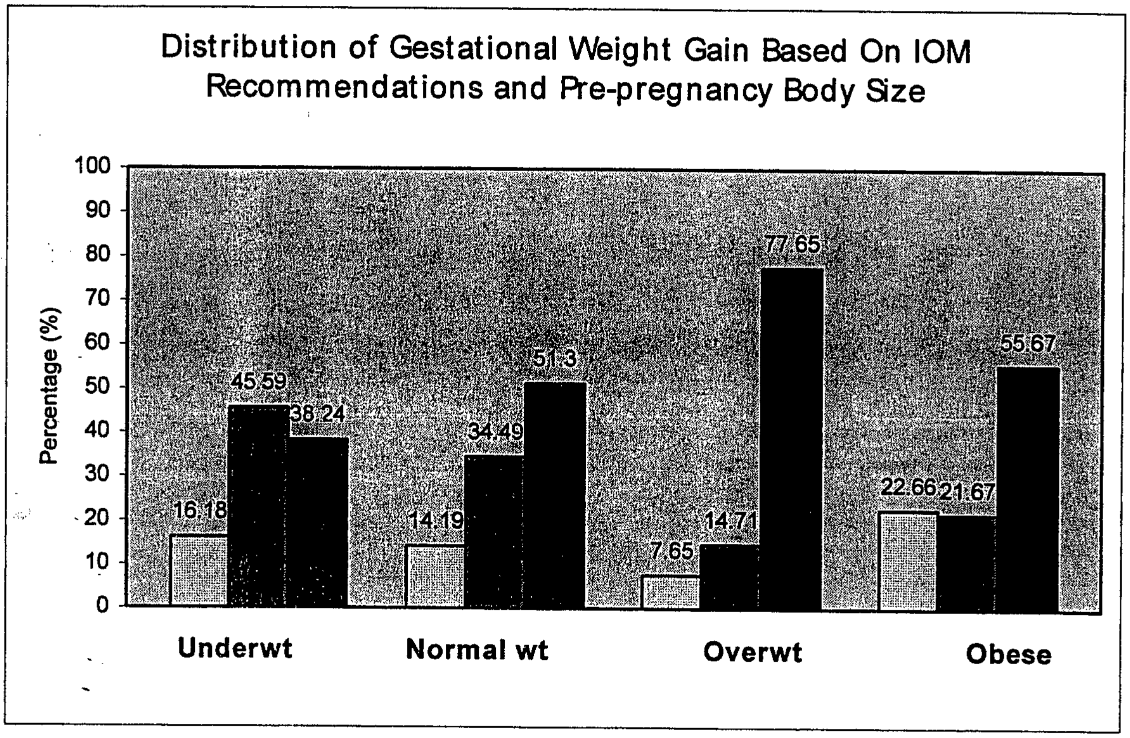


Figure 2. Graphical Presentation of the Gestational Weight Gain Distribution Based on the IOM's Recommended Ranges.



Key: Yellow = Low gain
Green = Recommended gain
Red = High gain

Table 3. Characteristics of the Study Population by Gestational Weight Gain Category.

Characteristics	*Weight gain category* Under-gain	Recommended gain	Over-gain
N	183	379	666
N *(%)*	14.9	30.9	54.2
Parity (%)			
0	39.3	48.0	55.4
1	42.6	35.1	30.6
≥ 2	18.0	16.9	14.0
Age (years)*	26.3 ± 5.6	26.5 ± 5.8	25.7 ± 5.2
White race (%)	50.3	53.3	57.7
Black race (%)	15.3	12.1	15.6
Hispanic race (%)	19.1	18.2	11.9
Asian race (%)	15.3	16.4	14.9
Years of education (%)			
< 12	4.9	3.7	3.9
12	44.8	37.5	39.3
> 12	50.3	58.8	56.8
Smoking (%)	9.3	10.8	13.7
Male Fetus	48.1	52.0	52.6
Gestational Age (weeks)*	38.7 ± 1.5	38.8 ± 1.5	39.2 ± 1.4
Hypertension (%)	2.2	2.4	5.9
Diabetes (%)	5.5	3.7	3.5
Height (cm)*	159.8 ± 7.4	161.1 ± 6.9	163.0 ± 7.0
Pre-pregnancy BMI (%)			
< 19.8	12.0	16.4	7.8
19.8-26.0	55.7	65.4	55.4
26.1-29.0	7.1	6.6	19.8
>29.0	25.1	11.6	17.0
Weight gain (kg) by BMI*			
< 19.8	10.3 ± 1.9	15.2 ± 1.7	22.3 ± 4.0
19.8 – 26.0	9.1 ± 2.1	13.9 ± 1.3	20.8 ± 4.0
26.1 – 29.0	5.2 ± 1.8	9.7 ± 1.4	20.0 ± 6.8
>29	2.9 ± 4.2	9.5 ± 1.3	18.6 ± 6.1

* Reported with the standard deviation.

Table 4. Adjusted* risk factors for gaining weight during pregnancy reported as odds ratios (95% confidence interval).

Maternal Characteristics	***Low Gain***	***High Gain***
Maternal Race:		
White	1.00	1.00
Black	1.24(.71,2.15)	1.30(.86,1.96)
Asian	0.83(.45,1.53)	1.04(.67,1.61)
Hispanic	0.85(.51,1.43)	0.88(.59,1.30)
Maternal Age (yr)	1.00(.96,1.04)	0.99(.96,1.02)
Parity:		
Primiparous	1.00	1.00
Second Delivery	1.42(.93,2.18)	0.77(.57,1.06)
Multiparous	1.18(.65,2.12)	0.74(.49,1.14)
Maternal Education:		
< 12 years of Education	1.10(.43,2.83)	0.99(.48,2.04)
High School/Trade School	1.00	1.00
Attended College/Grad. School	0.75(.50,1.12)	0.97(.73,1.31)
Prenatal Smoking:		
No	1.00	1.00
Yes	0.81(.43,1.51)	1.17(.76,1.79)
Maternal Height	**0.97(.94,1.00)**	**1.03(1.01,1.06)**
Pre-Pregnancy Weight:		
BMI $\leq$ 26	1.00	1.00
BMI **> 26**	**1.98(1.28,3.05)**	**2.61(1.89,3.59)**
Hypertension During Pregnancy:		
No	1.00	1.00
Yes	0.91(.27,3.10)	**2.59(1.19,5.62)**
Gestational Age	0.95(.84,1.08)	**1.21(1.10,1.32)**

* Adjusted for fetus sex and gestational diabetes in addition to the covariates reported.

Table 5. Adjusted* regression coefficients (95% confidence intervals) controlled for interaction by pre-pregnancy weight category.

Maternal Characteristics	***Normal Weight Women***	***Overweight Women***
Maternal Race:		
White	1.00	1.00
Black	0.30 (-0.79,1.39)	-0.31 (-2.54, 1.93)
Asian	0.79 (-0.35,1.92)	0.41 (-2.72, 3.53)
Hispanic	-0.15 (-1.21, 0.91)	-0.14 (-2.40, 2.12)
Maternal Age (yr)	**-0.08 (-0.15, 0.00)**	0.11 (-0.07, 0.28)
Parity:		
Primiparous	1.00	1.00
Second Delivery	**-0.85 (-1.69,-0.02)**	**-1.89 (-3.74, -0.04)**
Multiparous	0.16 (-1.02, 1.33)	**-4.50 (-6.85, -2.16)**
Maternal Education:		
< 12 years of Education	-0.13 (-1.99,1.73)	0.06 (-4.29, 4.40)
High School/Trade School	1.00	1.00
Attended College/Grad. School	0.03 (-0.76,0.82)	1.68 (-0.01, 3.37)
Prenatal Smoking:		
No	1.00	1.00
Yes	**1.31 (0.19,2.43)**	0.20 (-2.31, 2.70)
Maternal Height	**0.11 (0.05,0.16)**	**0.28 (0.16, 0.40)**
Hypertension During Pregnancy:		
No	1.00	1.00
Yes	**2.63 (0.66,4.61)**	**5.88 (2.54, 9.21)**
Gestational Age	**0.57 (0.32,0.82)**	**0.57 (0.04, 1.10)**

* Adjusted for fetus sex and gestational diabetes in addition to the covariates reported.

Do the Institute of Medicine guidelines for gestational weight gain provide an adequate balance between maternal and infant health outcomes?

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INTRODUCTION

Weight gain during pregnancy, or gestational weight gain, is a normal physiologic process that promotes maternal and fetal growth. Physiological studies from the 1960s suggest that a mother who "eats to appetite" gains 12.5 kg during pregnancy.[1] Less than half of this weight gain is composed of the fetus, placenta, and amniotic fluid; maternal reproductive tissues, fluid, blood and "stores" comprise the rest. "Maternal stores," mostly made up of body fat are activated by the high levels of progesterone that occur during pregnancy. This fat deposit serves as a reserve of calories for both pregnancy and lactation.[2] Gestational weight gain should foster optimal pregnancy outcomes for both mother and infant.

In the late 1960s and early 1970s, the Collaborative Perinatal Project produced the first studies showing strong relationships between maternal pre-pregnancy weight, weight gain during pregnancy, and birthweight.[3-6] Subsequent studies in the 1980s also showed relationships between weight gain and infant birthweight.[7-9]

In 1990, the Institute of Medicine (IOM) of the National Academy of Sciences released a report on weight gain during pregnancy that emphasized the association between weight gain and birthweight and recommended weight gain ranges for pregnancy based on women's pre-pregnancy body mass index (BMI = weight [kg]/height^2 [m^2])[10]. The IOM recommended that women who begin pregnancy with a normal BMI (19.8-26.0) gain 11.5-16 kg. They also recommended that underweight women (BMI less than 19.8) gain 12.5-18 kg, overweight women (BMI between 26.1 and 29.0) gain 7-11.5 kg, and obese women (BMI greater than 29.0) gain at least 6 kg. These recommendations were endorsed by the American College of Obstetricians and Gynecologists in 1993.[11]

In the decade since these guidelines were presented, researchers have been examining their appropriateness. Weight gain during pregnancy has continued to be associated with birthweight.[12] Parker and Abrams[13] validated the recommendations, finding that gestational weight gain outside the IOM ranges was associated with adverse pregnancy outcomes. They showed that women who gained below the recommended ranges had twice the risk of delivering a small-for-gestational age infant (less than 10th percentile), and women who gained above the recommended ranges had twice the risk of delivering a large-for-gestational age infant (above the 90th percentile). In addition, a recent review of literature on pregnancy weight gain concluded that gaining within the IOM's recommended ranges is beneficial to both mothers and their infants and that optimal outcomes for women who begin pregnancy with a normal BMI occur when they gain within the recommended range.[14]

However, the IOM report has also generated controversy. Some suggest that the recommended weight gain ranges should be higher than those proposed by the IOM. Bracero and Byrne[15] found that among women who were of average size before pregnancy, optimal perinatal and maternal outcomes occurred for those who gained between 14 and 18 kg. They also found that optimal outcomes occurred for underweight women who gained 16-18 kg and overweight women who gained 12-14 kg. Others have suggested that there is a lack of evidence that low weight gain plays a role in poor birth outcomes and have concluded that these recommendations are too high, possibly increasing risks to mothers and infants.[16] Feig and Naylor[17] recommended a weight gain or 7-11.5 kg for women who have a normal pre-pregnancy BMI.

Though high weight gain has been shown to benefit babies, it also has been shown to increase the risk of having macrosomic infants and resulting complications during delivery. A number of studies have demonstrated associations between increasing or excessive gestational weight gain and delivery of large infants.[12,13,18] Concerns exist that macrosomic infants may be at increased risk of birth injuries[19], brachial palsy[20], or brachial plexus injury[21]. Various studies have also shown that excessive weight gain during pregnancy is associated with an elevated risk of various complications of labor and delivery, including cesarean section.[13,18,22-24] Brost et al.[25] found that each unit increase in BMI at 27 to 31 weeks of gestation was significantly associated with a 7.8% increase in the odds of cesarean delivery. Though excessive weight gain is linked to both the birth of large infants and increased likelihood of cesarean section, Lederman[26] cautions that "It is an ecological fallacy to assume that additional cesarean sections associated with higher birthweight occur in the women who gain more weight" (p. 57).

A further consequence of high gestational weight gain is increased postpartum weight retention.[27-29] Schieve et al.[30] found that of a sample of 120,000 White, Black, and Hispanic women with singleton pregnancies, attending WIC in five different states from 1990 to 1996, more than 40% had gained excessively during pregnancy. If women gain excessively and then fail to lose the weight postpartum, they logically have a higher risk of becoming overweight postpartum[26].

A few studies have begun to examine the IOM recommendations' ability to provide a balance between maternal and birth outcomes. Luke et al.[31] described a "point of diminishing returns," a certain level of weight gain at which an increase in birthweight, presumably beneficial to the baby, begins to come at the expense of increasing postpartum obesity for women who have gained excessively. They found that for normal weight women, gaining above the IOM guideline increased birthweight by 6% but also increased postpartum weight retention by 6 kg. For such women, gaining below the guidelines also decreased birthweight by 5% and decreased weight retention by more than 6 kg.

Scholl et al.[32] reported similar results to those above. They showed that though normal BMI women with gestational weight gains below and within the recommended ranges did not differ significantly in their postpartum weight retention, women with low weight gains had smaller babies. Compared with women with recommended weight gain, those with excessive gain retained more weight and were twice as likely become overweight postpartum, however their infants were not significantly bigger than those born to women with recommended weight gain. Thus, they concluded that normal BMI women should gain within the IOM recommendation.

The present study sought to examine whether the IOM guideline for gestational weight gain in normal BMI women provides an adequate balance between maternal and infant health outcomes, using the analyses of Scholl et al.[32] as a template. In addition to birthweight, postpartum weight retention, and postpartum overweight, we included cesarean section as an outcome. Our analyses built upon these studies using more recent data and a much larger sample of women. We tested four hypotheses based on the results of Scholl et al.[32] We surmised that, among women who began pregnancy with a normal BMI, 1) women with gestational weight gains below the IOM recommendation had infants with birthweights that were significantly lower that those of women who gained in the recommended IOM range; 2) infant birthweights were not significantly different between women with recommended and high weight gains; 3) women with high weight gains were more likely to deliver their infants by cesarean section than women with recommended gains; 4) women with high weight gains retained more weight postpartum and were more likely to become overweight postpartum than women with recommended weight gains.

MATERIALS AND METHODS

Study Design & Sample

Data from the After the Baby Comes (ABC) Study, conducted at the Balboa Pediatrics Clinic (BPC) at the Naval Medical Center San Diego (NMCSD), were utilized to examine whether the IOM recommendations for gestational weight gain provide an adequate balance between maternal and infant health outcomes. The ABC Study was primarily designed to investigate the relationship between biological, lifestyle, and psychosocial factors and patterns of maternal weight changes in women during the first postpartum year. All mothers enrolled in the study were either active duty military personnel (primarily from the Navy) or dependents of active duty servicemen whose infants were receiving well-baby care at the BPC. The Institutional Review Board of the University of California, Berkeley, approved all study protocols.

Pediatric well-baby visits were scheduled to take place at 1 week, 2 weeks, 2 months, 6 months, 9 months, and 12 months postpartum. The study design was adapted to this health care schedule to optimize data collection. In addition, to accommodate the high mobility of the military population, the study design included both a series of cross-sectional samples and a longitudinal cohort nested within the cross-sectional samples. Study participants' duration of enrollment in the study varied due to their mobility.

Between April 1997 and December 1999, 7,723 women received well-baby care at the BPC, and 4,321 of these were invited to participate study. Some women were not approached for a variety of reasons: 1) a woman's scheduled well-baby visit occurred outside of the study recruiter's hours; 2) the biological mother did not bring in the infant for care; 3) many well-baby appointments were scheduled at one time that we could not approach all women.

Of all the 4,321 women approached, 2,433 (56%) met the eligibility requirements, which included: 1) she was not currently pregnant; 2) she did not have multiple births; 3) her infant was in the Neonatal Intensive Care Unit for less than four days, if at all; 4) she was the biological mother of the child; 5) the child was younger than 12 months; 6) the mother read or spoke English; 7) the mother planned to continue well-baby care for her infant at the BPC beyond two months postpartum; 8) she had at least one clinic visit after her 10-16 day visit; 9) she had weight and height measurements; and 10) she gave consent to participate in the study. The rest of the women did not meet these eligibility requirements or declined to participate.

The sample under analysis was derived from the 2,433 women eligible for the study (figure 1). Restrictions were made resembling those used by Scholl et al.[32] Of the eligible women, we excluded those who did not have a normal pre-pregnancy BMI according to IOM guidelines[10] because the relationships between pregnancy outcomes and various risk factors have been shown to vary by pre-pregnancy BMI.[23,25,33-36] We then excluded women who: 1) were of races other than White, Black, Hispanic, or Asian, as there were very few of these women; 2) were missing data on gestational weight gain, race, and age; and 3) had a history of hypertension/preeclampsia, pre-pregnancy diabetes mellitus, gestational diabetes, eating disorders, and/or anemia. Data on these medical conditions were obtained from the participants' medical records when available and from the surveys otherwise. The size of the final sample of analysis was 1,086 women.

Compared to women in the analysis sample ($p < 0.05$), women excluded for being underweight, overweight and obese were less likely to be primiparous, be White, be Asian, have completed graduate school, and have mid-range or high-range income. They also smoked more cigarettes per day during the postpartum period. Women excluded for having missing data on gestational weight gain, race, and age were no different than women in the analysis sample. Women excluded for having medical conditions were, in comparison to sample women, more likely to be primiparous and smoke more cigarettes per day during pregnancy and the postpartum period.

Measures

Questionnaires

Each participant was weighed and filled out a Clinic Questionnaire when she brought her child into the clinic for a well-baby appointment. In addition to the Clinic Questionnaires, Baseline and Follow-Up Questionnaires were mailed to participants at the 2 and 12-month well-baby visits, respectively. Mothers who enrolled at the 12-month visit completed one take-home questionnaire, a Combination Questionnaire that included questions from both the Baseline and Follow-Up Questionnaires. Shorter versions of the Follow-Up and Combination Questionnaires, called Mini Questionnaires, were given to mothers who did not return the original take-home questionnaires. The Baseline, Follow-Up, Combination, and Mini Questionnaires asked women to report various demographic, behavioral, social, and medical characteristics. Women enrolled in the study also gave consent to have data abstracted from their medical records.

Dependent variables

At each well-baby appointment, trained individuals weighed mothers twice on professionally calibrated weighing scales. They also measured the mother's heights (without shoes) twice per visit. If the pairs of measures differed by more than 0.1 kg for the weight measures or more than 0.5 cm for height measures, they took third measurements that were then used as the final measures. If the pairs of measures did not differ, they were used as the final measures.

Postpartum weight retention (kg) was calculated as pre-pregnancy weight (self-reported in medical records) subtracted from the last measured postpartum weight. Though self-reported measures of pre-pregnancy weight are potentially biased, these measures have been shown to be as accurate as measured weights and appropriate for use in epidemiological studies.[37,38] In accordance with IOM guidelines, a woman was categorized as being overweight postpartum if the BMI corresponding to her last measured postpartum weight exceeded 25.0.[10]

Medical records provided us with data on infant birthweight (g) and method of delivery (vaginal, cesarean section, other). Birthweight was treated as a continuous variable and also as two different dichotomous variables: 1) low birthweight (less than 2500 g) vs. normal birthweight (2500-4000 g), and 2) high birthweight (greater than 4000 g) vs. normal birthweight.

Independent variable

We calculated gestational weight gain (kg) by subtracting pre-pregnancy weight from delivery weight (both abstracted from medical records). Gestational weight gain for each mother was then categorized as low, recommended, or high. According to IOM guidelines, those who gained within the IOM's recommended range for gestational weight gain for women who have a normal BMI prior to pregnancy (11.5-16 kg or 25-35 lbs) were categorized as "recommended."[10] Those gaining below the IOM recommendation were categorized as "low," and those gaining above the recommendation were categorized as "high."

Confounding variables

We chose possible confounding variables based on those chosen by Scholl et al.[32] and based on risk factors established in the literature. We also chose active duty status as a possible confounding variable because active duty women may have had different health outcomes than military dependents due to the physical requirements of military service. The time of the last measured postpartum weight varied across participants (from 14 to 551 days postpartum; mean = 330 days) and was controlled for in all analyses of maternal postpartum outcomes.

Medical records provided us with data on sex of the infant, gestation duration, alcohol use during pregnancy, and methods of past deliveries (including cesarean sections). The take-home and mailed questionnaires collected self-reported data on education level, income level, marital status, active duty status, parity, number of cigarettes smoked per day postpartum, and breastfeeding initiation. Data on race and the number of cigarettes smoked per day during pregnancy were both abstracted from the mothers' medical records and collected in the Baseline questionnaires.

Statistical analysis

The main independent variable in the analysis was gestational weight gain category—low, recommended, or high. Four outcomes—birthweight, cesarean section, postpartum weight retention, and postpartum overweight—were examined in this analysis. Univariate statistics (chi-square tests and analysis of variance) were used to assess associations between gestational weight gain category and maternal background characteristics, as well as differences in outcomes across gestational weight gain categories. Statistical significance was assessed using the F-ratio or overall chi–square test ($p < 0.05$).

Multiple linear regression was used to investigate relationships between gestational weight gain categories and continuous outcomes (birthweight and postpartum weight retention), controlling for possible confounding variables. Multiple logistic regression was used to calculate odds ratios (ORs), adjusted for confounding variables, and 95 percent confidence intervals for the relationships between gestational weight gain categories and dichotomous outcomes (cesarean section and postpartum overweight). In addition, multiple logistic regression was used to examine the associations between gestational weight gain categories and each of the two dichotomous birthweight variables, low birthweight and high birthweight.

The models for birthweight (continuous), low birthweight, and high birthweight controlled for gestation duration (weeks), parity, pre-pregnancy weight (kg), mother's height (cm), race, education level, income level, number of cigarettes smoked per day during pregnancy, alcohol use during pregnancy, mother's age, marital status, and active duty status.

The multiple logistic regression model examining cesarean section was restricted to those women who had delivered vaginally or who had had a primary cesarean section, as the majority of women who have a cesarean section in their first pregnancy have a cesarean section in their second pregnancy.[39] The model for cesarean section controlled for birthweight in addition to the same confounding variables as the model for birthweight, except for gestation duration.

The model for postpartum weight retention and the multiple logistic regression model for postpartum overweight controlled for gestation duration, parity, mother's height, race, education level, income level, number of cigarettes smoked per day postpartum, mother's age, breastfeeding initiation, time of last measured postpartum weight, marital status, and active duty status.

Interactions between gestational weight gain category and race, and gestational weight gain category and mother's age were tested for statistical significance ($p < 0.10$) by adding interaction terms to the model for each outcome. However, for the models for cesarean section, the interaction between weight gain and race could not be investigated because of the small number of Black and Hispanic women that had cesarean sections. All statistical analyses were conducted using Intercooled Stata 7.

RESULTS

Most of the mothers in our sample were married, well-educated women. Over half of the mothers were White and more than three-quarters were not on active military duty. Forty-four percent of the women had incomes of $1501-$3000 per month and 24% had incomes of more than $3000 per month. The average age of the mothers was 26 years and 44% of them were first-time mothers. One-half of our sample gained weight above the IOM guideline, one-third gained within the guideline, and the rest gained below the guideline (table 1). The mean birthweight of infants in the sample was 3393 g and 12.7% of the infants were delivered by cesarean section. One-quarter of the sample became overweight postpartum, and the mean postpartum weight retention was 3.8 kg.

Certain maternal and infant characteristics were different between women in the various gestational weight categories (table 1). Gestation duration and primiparity both increased as women's weight gain categories increased. Mothers with high gestational weight gain were slightly younger and had a higher percentage of White women than mothers with low and recommended gain. Birthweight, weight retention, and the proportion of women overweight postpartum increased across increasing weight gain categories (table 2). All four dependent variables also differed by maternal race (table 3). Black babies were the smallest of all babies, and Black and Hispanic women had the highest postpartum weight retention and rates of postpartum overweight. Asian women had the highest rate of cesarean section.

After controlling for confounding variables, infant birthweights did not differ significantly between women whose gestational gain fell below the IOM recommendation and those who gained within the recommended range (table 4). However, women who gained above the recommendation had babies who weighed over 97 g more than babies born to women with recommended weight gain. Black and Asian infants were significantly smaller than White babies, independent of income and education levels. Active duty status was not associated with infant birthweight.

A mother's high weight gain did not protect her infant from being born with a low birthweight (OR = 1.0, 95% confidence interval: 0.3, 3.8) and a mother's low weight gain did not increase her infant's risk of being born with a low birthweight (OR = 1.7, 95% confidence interval: 0.4, 7.5). Women who gained high had twice the risk of having a high birthweight baby, but the association was only marginally significant (95% confidence interval: 1.0, 3.7). There was no evidence that low weight gain protected an infant from being born high birthweight (OR = 0.6, 95% confidence interval: 0.2, 2.3).

Women with weight gain above the IOM guideline were almost three times more likely than women with recommended weight gain to have delivered their infants by cesarean section, but women with low weight gain had the same risk of cesarean section as women with recommended weight gain (table 5). Compared with white women, Asian women had a fourfold risk and Hispanic women an almost threefold risk of cesarean section. Black women were no more likely to have a cesarean section than White women.

The multiple linear regression model for postpartum weight retention examining the interaction between gestational weight gain and race found that race modified the effect of gestational weight gain on postpartum weight retention and postpartum overweight (tables 6 & 8; figure 2). Black women with high weight gain retained less weight and were less likely to become overweight postpartum than Black women with recommended weight gain. However, Black women with high weight gain were almost four times more likely to become overweight postpartum than White women with recommended weight gain. White high-gainers were three times more likely, Asian high-gainers more than six times more likely, and Hispanic high-gainers almost seven times more likely to become overweight postpartum than White women with recommended weight gain. In addition, this model showed that recommended weight gain produced markedly different postpartum results for women of different races. Black women with recommended weight gain were likely to have the highest weight retention postpartum, White women were likely have the lowest weight retention, and Hispanic and Asian women were likely to have weight retentions between those of Blacks and Whites.

The effects of weight gain on postpartum weight retention also varied by maternal age (table 7; figure 3). Among those women with high weight gain, weight retention decreased with age. Weight retention did not vary by age among women with low or recommended weight gains.

DISCUSSION

Almost 20% of women in the United States, representing 20 million women, are obese. The prevalence of obesity among women has been rising rapidly—only 12% of women were obese in 1991.[40,41] Obese women are at increased risk for coronary heart disease, stroke, type II diabetes, hypertension, high blood cholesterol, and other chronic illnesses.[42,43] The retention of weight gained during pregnancy into the postpartum period may be contributing to this epidemic of obesity among American women.

In this study, we found unexpected interactive effects between gestational weight gain and race on postpartum weight retention and postpartum overweight that do not correlate with the findings of the IOM[10] or with recent studies that test the impact of the

IOM guidelines on weight retention.[31,32] We found that though all women who gained above the IOM guidelines retained more weight postpartum and thus were at greater risk of becoming overweight postpartum than women who gained below the guidelines, the magnitudes of these increases varied by race. Our results suggest that Black women who gained above the guidelines fared better than those who gained within.

We have little understanding of the mechanisms at work in these complex interactions, but these counterintuitive results may possibly be explained in a few different ways. First, the pattern we see may be due to random variation. We have quite a small number of Black women in each of the three weight gain categories and many more White and Hispanic women in our sample—this disparity may be driving the interaction that we see. Second, there are factors that were not considered in our examination of postpartum weight retention and overweight, such as women's physical activity, social support, mental health, dieting history, and occupational status. It is possible that one or more of these factors may account for the interaction we see between weight gain and race. Third, Black women with recommended weight gain may, for some reason, gain more weight after delivery than other women, and this weight is being accounted for in their postpartum weight retention along with their pregnancy-related weight retention. Finally, it may be that Black women with recommended weight gain are truly at higher risk for reasons that we simply do not yet understand.

Our analyses of postpartum weight retention also showed an interaction between weight gain categories and mother's age, with younger women with high gain retaining more weight than older women with high gain. This pattern was not seen for women with low or recommended weight gains. Research has shown that younger pregnant women gain and retain more weight because they are still growing. The bodies of these young women mobilize fat reserves late in pregnancy to enhance their own development rather than that of their fetuses.[44] However, it is not clear why this pattern was seen in only high-gainers.

When women in our study gained more than 16 kg during pregnancy, they almost tripled their risk of delivering their infants by cesarean section. This elevated risk corresponds to that found in studies by Johnson et al.,[18] Shepard et al.,[22] Turcot et al.,[24] and Brost et al.[25] However, low weight gain during pregnancy did not protect women from having a cesarean section.

Asian women and Hispanic women had much higher risks of cesarean sections than White women. Possible effects of the usually shorter height of Asians and larger infants of Hispanics were adjusted for in our model. The increased risk of cesarean section for these specific groups of women remains largely unexplained in the literature.

Obesity in women is not only a risk factor for the chronic illnesses described earlier, but also for complications of pregnancy and childbirth,[42,43] including cesarean section. Pre-pregnancy obesity has been linked to increase risk of cesarean section.[23,25,33-36] In 2000, the cesarean delivery rate in the United States rose 4 percent to 22.9, the fourth consecutive increase. The primary cesarean section rate was also higher than the year before.[39] Though the women in our sample started pregnancy with normal BMIs, 25% of them ended their pregnancies overweight or obese, and therefore may be at risk for cesarean section in subsequent pregnancies.

Cogswell et al.[12] showed that for average-weight women, increasing weight gain during pregnancy reduced the risk of having a low birthweight infant. In our sample, by gaining above IOM guideline, not only did women increase their likelihood of having a cesarean section or becoming overweight postpartum, they did not confer protection to their infants against low birthweight. However, these infants were slightly bigger than those born to women with recommended weight gain by 97g, discounting our hypothesis, based on that of Scholl et al., that women with recommended and high gains would have babies of the same size. However, Luke et al.[31] found that high-gainers had babies 299 g bigger than recommended-gainers, and Brown[9] reported that regardless of a mother's weight gain category, birthweight increased with maternal weight gain.

How clinically significant and beneficial to the infant is a 97 g increase in birthweight? The mean birthweight in this population was 3393 g and only 3.3% of the infants were low birthweight—this was a group of fairly healthy weight infants. As others have also concluded,[13,31,32] the small increase in birthweight for an infant attributed to high gestational weight gain may not be worth the consequences of cesarean section and postpartum weight retention for the mother.

Researchers[12,31,32] have reported associations between low gestational weight gain and adverse birth outcomes. In contrast, our results indicate that low maternal weight gain posed no harm to infants. Low weight gain also provided no protection against cesarean delivery or postpartum weight retention. These women and the women who gained within the IOM guidelines were no different in terms of risk of cesarean section or kilograms of weight retained postpartum.[16,17]

This study had several limitations. First, our study sample did not have a great variation in birthweights, so this may account for the lack of protective effect of high gestational weight gain on low birthweight and lack of association between low weight gain and reduced birthweight. Our sample also had a much smaller rate of low weight gain than recommended or high weight gain. This small number of low-gainers may reflect the fact the "normal variability" in weight gain during pregnancy that is not related to environmental factors and is not a risk for poor health outcomes.[45]

Sample sizes were greatly reduced in regression analyses due to missing data for various covariates. We may need more power to uncover statistically significant relationships with a larger sample size in these analyses. Also, the generalizability of our results is restricted due to the fact that we studied a group of women who all received military-based health care and had much lower rates of cesarean section and low birthweight than the general population.

Lastly, the measure of postpartum weight retention that we utilized possesses a "part-part" correlation with gestational weight gain[46]. In other words, part of weight gain is contained within weight retention. These two variables are thus correlated, and this biases the assessment of the association between gestational weight gain and postpartum weight retention. Though a significant association most likely exists between these variables, its magnitude may change if the bias is removed. No studies have yet been published detailing techniques for testing this association in an unbiased manner.

However, this analysis possesses many strengths. Our fairly large sample size exceeded those of Scholl et al.[32], whose methods we replicated, affording us more power to test the hypotheses of interest. The present analysis accounted for more confounding variables than their study, as well. Though our sample was mostly composed of White women, we still had the ability to examine our hypotheses for other groups of women and make conclusions about racial disparities based on our results. Finally, we had the opportunity to consider the relationship of pregnancy weight gain to birthweight, cesarean section, and postpartum weight retention and overweight all in one study, affording us the optimal information to assess the IOM recommendation.

Further research on gestational weight gain and maternal and infant outcomes should utilize an improved measure of postpartum weight retention to eliminate bias associated with part-part correlation, utilize samples with larger numbers of minority women to ensure more accurate comparisons, and include other covariates that may affect the associations being tested. The timing of weight gain during pregnancy should also be explored. Whether weight is gained during early, middle, or late pregnancy may change the gain's influence on weight retention and birthweight.[47]

In this study, we aimed to assess the appropriateness of the IOM guideline for gestational weight gain in normal BMI women. We did not find that gaining below the IOM guideline protected women against low birthweight or cesarean section. Though gaining above the guideline was associated with a marginal increase in infant birthweight, it was linked to a significantly elevated risk of cesarean section. These results suggest that the IOM's recommended range of gestational weight gain for normal BMI women is valid and beneficial in terms of these two outcomes.

However, our results demonstrate that the controversy surrounding the impact of the IOM guideline for postpartum weight retention is far from over. Racial and ethnic differences in weight gain and retention need to be explored further in order to understand the interactive effects seen here. Given the rising epidemic of obesity in women in the United States, a full understanding of the consequences of the IOM's recommendation for gestational weight gain is vital to developing interventions and policies to ensure that normal weight women will not become overweight after pregnancy and be faced with increased risks of serious chronic illness and disability.

FIGURE 1. Sample Size and Exclusions

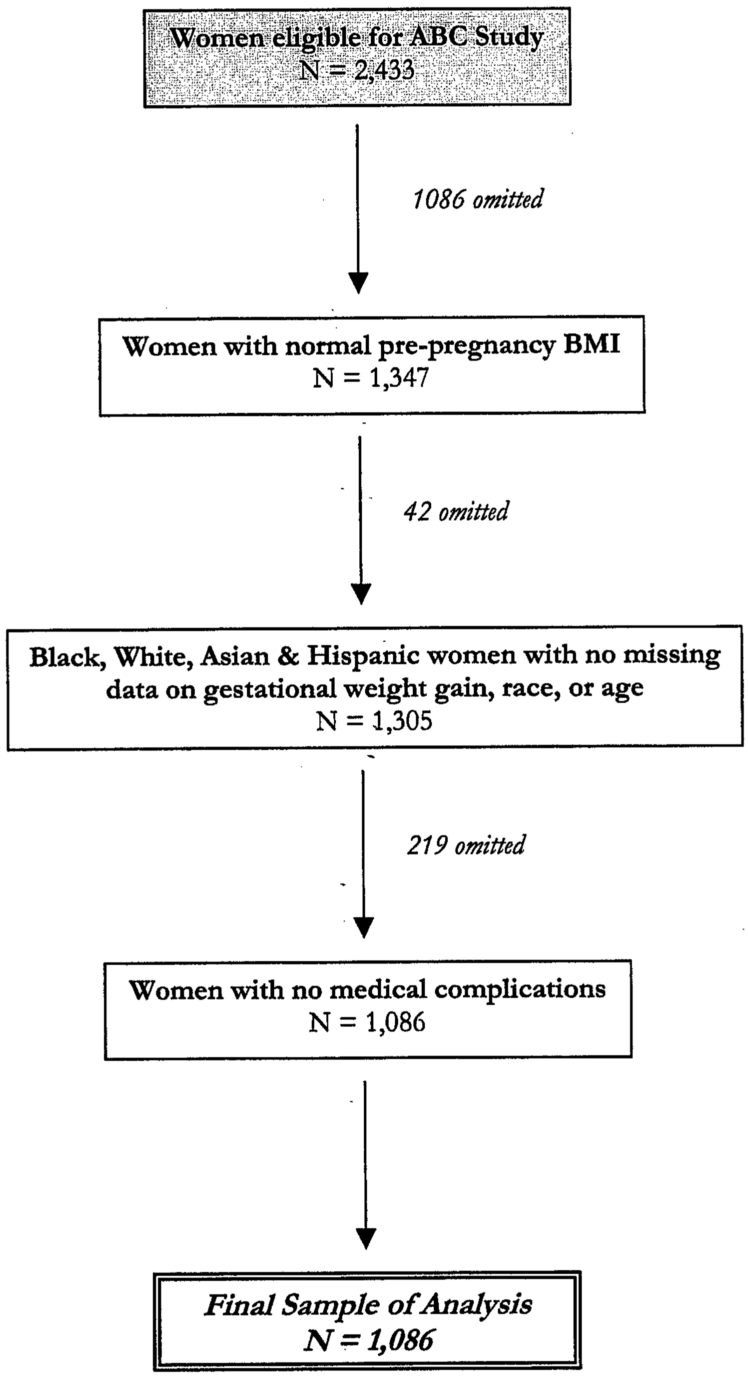


TABLE 1. Maternal and infant characteristics by gestational weight gain category (low, recommended, high), After the Baby Comes (ABC) Study, San Diego, California, 1997-1999.

Characteristic	Low n = 181 (16.7%)	Recomm. n = 360 (33.1%)	High n = 545 (50.2%)	Test statistic	P-value
Male infant, n (%)	60 (49.6)	152 (53.5)	228 (52.7)	$\chi^2 = 0.5$	0.765
Gestation duration, wks. (mean ± sd)	38.5 ± 1.7	38.9 ± 1.4	39.1 ± 1.4	F = 8.94	0.001§
Primiparous, n (%)	64 (35.4)	149 (40.8)	271 (49.7)	$\chi^2 = 14.1$	0.001§
Race, n (%)					
White	95 (52.5)	184 (51.1)	330 (60.6)	$\chi^2 = 20.2$	0.003‡
Black	30 (16.6)	35 (9.7)	68 (12.5)		
Asian	27 (14.9)	71 (19.7)	64 (11.7)		
Hispanic	29 (16.0)	70 (19.5)	83 (15.2)		
Education, n (%)					
Did not complete high school	8 (5.0)	14 (4.5)	27 (5.7)	$\chi^2 = 9.5$	0.303
Completed high school/GED	48 (30.2)	91 (28.9)	152 (32.0)		
Vocational or trade school	11 (6.9)	19 (6.1)	30 (6.3)		
College	82 (51.6)	152 (48.4)	235 (49.5)		
Graduate school	10 (6.3)	38 (12.1)	31 (6.5)		
Income, n (%)					
$1500/month or less	35 (22.4)	67 (21.7)	90 (19.3)	$\chi^2 = 2.2$	0.698
$1501-$3000/month	84 (53.9)	155 (50.2)	243 (52.0)		
More than $3001/month	37 (23.7)	87 (28.1)	134 (28.7)		
Cigs./day during preg. (mean ± sd)	0.3 ± 1.5	0.5 ± 2.3	0.8 ± 2.7	F = 2.8	0.064*
Cigs./day postpartum (mean ± sd)	0.6 ± 1.5	0.8 ± 2.1	1.0 ± 2.3	F = 1.9	0.145
Drank alcohol during preg., n(%)	116 (99.2)	269 (97.8)	419 (98.8)	$\chi^2 = 1.5$	0.469
Age, years (mean ± sd)	26.0 ± 5.3	26.6 ± 5.7	25.6 ± 5.4	F = 2.8	0.030†
Initiated breastfeeding, n (%)	115 (81.6)	210 (80.8)	318 (81.1)	$\chi^2 = 0.04$	0.981
Married/living with partner, n (%)	168 (92.8)	325 (90.3)	495 (90.8)	$\chi^2 = 1.0$	0.614
Active duty, n (%)	34 (18.8)	72 (20.0)	136 (25.0)	$\chi^2 = 4.6$	0.100

$p < 0.07$
† $p < 0.05$
‡ $p < 0.01$
§ $p \leq 0.001$

TABLE 2. Maternal and infant outcomes for women by gestational weight gain category (low, recommended, high), After the Baby Comes (ABC) Study, San Diego, California, 1997-1999.

Characteristic	Low n = 188 (16.7%)	Recommended n = 360 (33.1%)	High n = 545 (50.2%)	Test statistic	P-value
Infant birthweight, g (mean ± sd)	3189 ± 465	3333 ± 442	3497 ± 512	F = 27.9	<0.001*
Cesarean section, n (%)	21 (11.6)	39 (10.8)	78 (14.3)	$\chi^2 = 2.6$	0.272
Postpartum weight retention, kg (mean ± sd)	0.8 ± 4.9	2.6 ± 4.7	5.6 ± 6.1	F = 64.0	<0.001*
Became overweight postpartum, n (%)	25 (14.5)	57 (17.8)	191 (39.0)	$\chi^2 = 61.5$	<0.001*

* $p \leq 0.001$

TABLE 3. Maternal and infant outcomes for women by race (White, Black, Asian, Hispanic), After the Baby Comes (ABC) Study, San Diego, California, 1997-1999.

Characteristic	White n = 609 (56.1%)	Black n = 133 (12.2%)	Asian n = 162 (14.9%)	Hispanic n = 182 (16.8%)	Test statistic	P-value
Infant birthweight, g (mean ± sd)	3471 ± 491	3196 ± 496	3311 ± 455	3362 ± 492	F = 13.1	<0.001‡
Cesarean section, n (%)	62 (10.2)	19 (14.3)	34 (21.0)	23 (12.6)	$\chi^2 = 13.8$	0.003†
Postpartum weight retention, kg (mean ± sd)	3.4 ± 5.9	4.6 ± 5.7	3.6 ± 5.5	4.6 ± 5.8	F = 5.84	0.037*
Became overweight postpartum, n (%)	133 (24.0)	44 (37.6)	35 (23.8)	61 (37.0)	$\chi^2 = 17.6$	0.001‡

* $p < 0.05$
† $p < 0.01$
‡ $p < 0.001$

TABLE 4. Multiple linear regression coefficients for birthweight in grams (n = 667), After the Baby Comes (ABC) Study, San Diego, California, 1997-1999.

Characteristic	β (grams)	95% Confidence Interval
Weight Gain (vs. recommended weight gain)		
Low	-56.3	-149.9, 37.3
High	97.4	31.1, 163.8‡
Sex of infant: Female (vs. Male)	-156.1	-215.4, -96.8§
Gestation duration (weeks)	177.1	155.9, 198.2§
Parity: Not primiparous (vs. Primiparous)	60.4	-5.7, 126.6
Pre-pregnancy weight (kg)	4.6	-2.3, 11.5
Mother's height (cm)	4.2	-2.8, 11.2
Race (vs. White)		
Black	-185.9	-291.1, -80.8§
Asian	-101.1	-193.7, -8.5†
Hispanic	-39.8	-127.9, 48.3
Education (vs. graduate school)		
Did not complete high school	-194.4	-403.8, 15.1*
Completed high school/GED	-73.8	-204.3, 56.7
Vocational or trade school	-79.0	-243.0, 84.9
College	-82.2	-199.4, 34.9
Income (vs. more than $3001/month)		
$1500/month or less	-39.8	-141.7, 62.2
$1501-$3000/month	9.2	-68.8, 87.3
Number of cigarettes smoked per day during pregnancy	-18.3	-32.3, -4.2†
Alcohol use during pregnancy: Yes (vs. No)	31.8	-194.6, 258.2
Mother's age (years)	-1.2	-8.5, 6.2
Marital status: Married (vs. not married)	-83.1	-197.2, 31.0
Active duty status: Active duty (vs. not active duty)	-30.3	-106.7, 46.1
$R^2 = 0.39$		

* $p < 0.07$
† $p < 0.05$
‡ $p < 0.01$
§ $p \leq 0.001$

TABLE 5. Odds Ratios and 95% confidence intervals for primary cesarean section from multiple logistic regression model (n = 615), After the Baby Comes (ABC) Study, San Diego, California, 1997-1999.

Characteristic	Odds Ratio	95% Confidence Interval
Weight Gain (vs. recommended weight gain)		
Low	1.3	0.4, 3.7
High	2.7	1.3, 5.4†
Birthweight	1.0	1.0, 1.0
Parity: Not primiparous (vs. Primiparous)	0.2	0.1, 0.5‡
Pre-pregnancy weight (kg)	1.1	1.0, 1.1
Mother's height (cm)	0.9	0.9, 1.0
Race (vs. White)		
Black	1.6	0.5, 4.6
Asian	3.8	1.7, 8.7‡
Hispanic	2.6	1.1, 6.1*
Education (vs. graduate school)		
Did not complete high school	--	--
Completed high school/GED	1.4	0.4, 5.2
Vocational or trade school	1.1	0.2, 6.1
College	1.7	0.5, 5.7
Income (vs. more than $3001/month)		
$1500/month or less	1.5	0.5, 4.0
$1501-$3000/month	1.8	0.8, 3.9
Number of cigarettes smoked per day during pregnancy	1.0	0.9, 1.2
Alcohol use during pregnancy: Yes (vs. No)	1.3	0.1, 12.1
Mother's age (years)	1.1	1.0, 1.2†
Marital status: Married (vs. not married)	0.7	0.3, 1.9
Active duty status: Active duty (vs. not active duty)	0.8	0.4, 1.7

* $p < 0.05$
† $p < 0.01$
‡ $p \leq 0.001$

TABLE 6. Multiple linear regression coefficients for postpartum weight retention in kilograms (n = 561), with interaction between gestational weight gain category and race, After the Baby Comes (ABC) Study, San Diego, California, 1997-1999.

Characteristic	β (kilograms)	95% Confidence Interval
Weight Gain x Race Interaction		
Black woman with low weight gain	-0.2	-3.2, 2.8
Black woman with recommended weight gain	4.2	1.4, 7.1‡
Black woman with high weight gain	3.5	1.5, 5.5§
Asian woman with low weight gain	0.9	-2.2, 4.1
Asian woman with recommended weight gain	1.3	-0.8, 3.4
Asian woman with high weight gain	4.4	2.4, 6.4§
Hispanic woman with low weight gain	-0.1	-3.3, 3.1
Hispanic woman with recommended weight gain	2.0	-0.1, 4.1*
Hispanic woman with high weight gain	3.5	1.5, 5.5§
White woman with low weight gain	-1.5	-3.2, 0.2
White woman with high weight gain	2.7	1.5, 3.9§
(vs. White woman with recommended weight gain)		
Parity: Not primiparous (vs. Primiparous)	0.4	-0.5, 1.4
Mother's height (cm)	0.1	0, 0.1*
Education (vs. graduate school)		
Did not complete high school	1.3	-1.5, 4.1
Completed high school/GED	1.0	-0.8, 2.9
Vocational or trade school	-0.5	-2.8, 1.8
College	0.8	-0.8, 2.4
Income (vs. more than $3001/month)		
$1500/month or less	1.1	-0.4, 2.5
$1501-$3000/month	1.4	0.3, 2.5
Number of cigarettes smoked per day during postpartum period	-0.1	-0.3, 0.04
Mother's age (years)	-0.1	-0.2, 0.02
Time of last measure postpartum weight (days)	-0.01	-0.01, 0†
Marital status: Married (vs. not married)	2.1	0.2, 3.9†
Active duty status: Active duty (vs. not active duty)	-0.7	-1.8, 0.4
$R^2 = 0.2$		

* $p < 0.07$
† $p < 0.05$
‡ $p < 0.01$
§ $p \leq 0.001$

TABLE 7. Odds Ratios and 95% confidence intervals for postpartum overweight from multiple logistic regression model, with interaction between gestational weight gain category and race, After the Baby Comes (ABC) Study, San Diego, California, 1997-1999.

Characteristic	Odds Ratio	95% Confidence Interval
Weight Gain x Race Interaction		
Black woman with low weight gain	1.6	0.3, 8.9
Black woman with recommended weight gain	11.3	2.8, 45.4‡
Black woman with high weight gain	3.6	1.3, 10.4*
Asian woman with low weight gain	2.2	0.4, 13.2
Asian woman with recommended weight gain	0.8	0.1, 3.9
Asian woman with high weight gain	6.2	2.2, 17.2‡
Hispanic woman with low weight gain	1.0	0.1, 8.9
Hispanic woman with recommended weight gain	1.1	0.3, 4.4
Hispanic woman with high weight gain	6.8	2.5, 18.8‡
White woman with low weight gain	0.8	0.2, 2.6
White woman with high weight gain	3.1	1.5, 6.5†
(vs. White woman with recommended weight gain)		
Parity: Not primiparous (vs. Primiparous)	1.1	0.6, 1.8
Mother's height (cm)	1.0	1.0, 1.1
Education (vs. graduate school)		
Did not complete high school	4.8	0.9, 26.4
Completed high school/GED	2.4	0.6, 1.8
Vocational or trade school	1.6	0.3, 8.4
College	2.7	0.7, 10.0
Income (vs. more than $3001/month)		
$1500/month or less	1.1	0.5, 2.5
$1501-$3000/month	2.0	1.0, 3.7*
Number of cigarettes smoked per day during postpartum period	1.0	0.9, 1.1
Mother's age (years)	1.0	0.9, 1.0
Time of last measure postpartum weight (days)	1.0	1.0, 1.0
Marital status: Married (vs. not married)	1.0	0.4, 2.4
Active duty status: Active duty (vs. not active duty)	1.1	0.6, 2.1

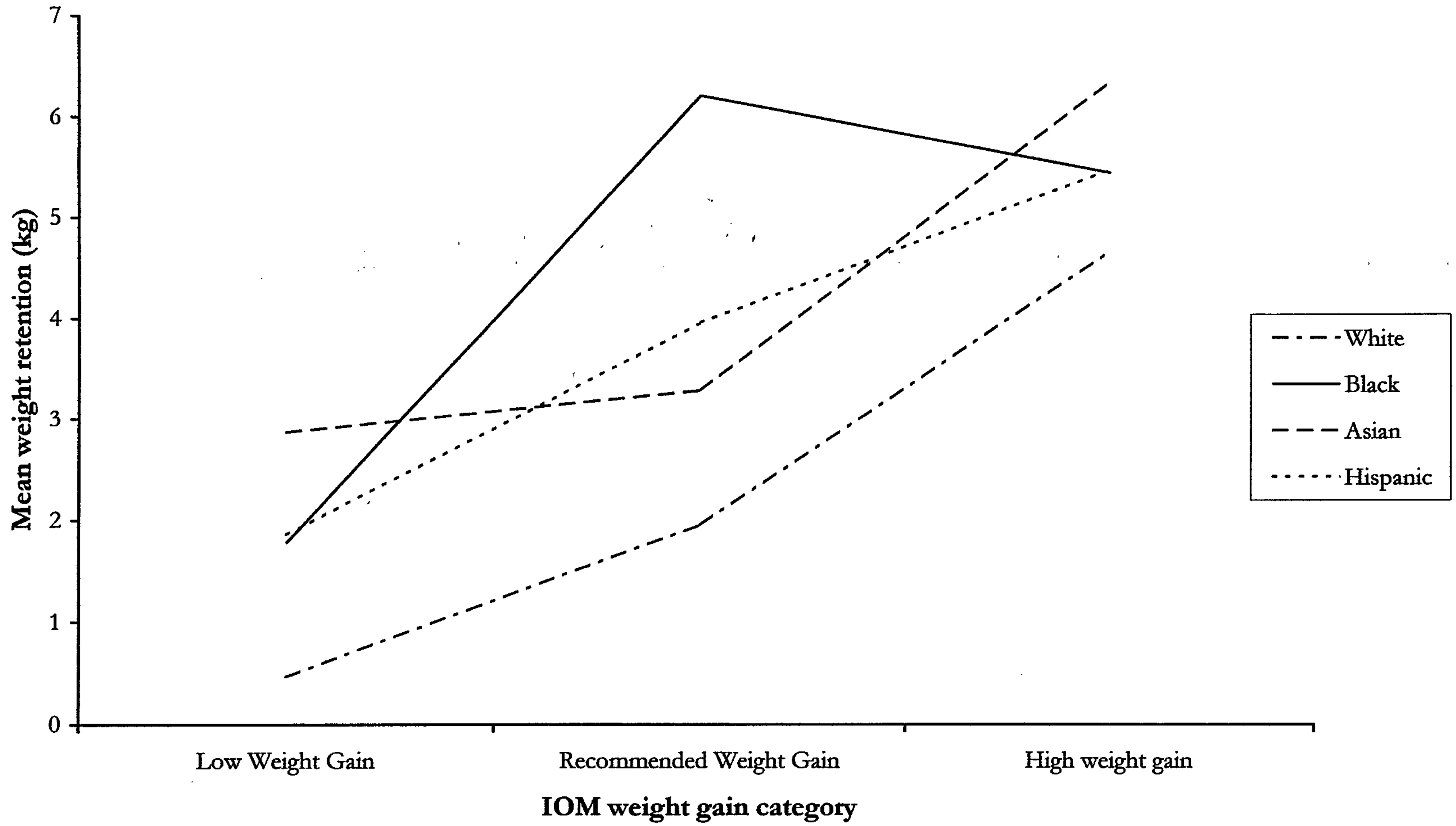
* $p < 0.05$
† $p < 0.01$
‡ $p \leq 0.001$

TABLE 8. Multiple linear regression coefficients for postpartum weight retention in kilograms (n = 561), with interaction between gestational weight gain category and mother's age After the Baby Comes (ABC) Study, San Diego, California, 1997-1999.

Characteristic	β (kilograms)	95% Confidence Interval
Selected Effect Estimates		
Low weight gain (vs. Recommended) at age 15	-1.4	-4.4, 1.7
Low weight gain (vs. Recommended) at age 25	-1.7	-3.0, -0.3
Low weight gain (vs. Recommended) at age 35	-2.0	-4.3, 0.4
Low weight gain (vs. Recommended) at age 45	-2.3	-6.7, 2.2
High weight gain (vs. Recommended) at age 15	4.2	2.0, 6.3
High weight gain (vs. Recommended) at age 25	2.5	1.6, 3.5
High weight gain (vs. Recommended) at age 35	0.9	-0.8, 2.6
High weight gain (vs. Recommended) at age 45	-0.7	-4.0, 2.5
Model Parameter Estimates		
Weight Gain (vs. recommended weight gain)		
Low	-0.9	-7.3, 5.5
High	6.6	2.1, 11.1
Mother's age (years: effect for recommended weight gain)	0.01	-0.1, 0.2
Low weight gain x Mother's age Interaction	-0.02	-0.2, 0.2
High weight gain x Mother's age Interaction	-0.2	-0.3, -0.03
Parity: Not primiparous (vs. Primiparous)	0.4	-0.5, 1.4
Mother's height (cm)	0.1	0, 0.1
Race (vs. White)		
Black	1.7	0.2, 3.1†
Asian	1.5	0.1, 2.9†
Hispanic	1.2	-0.1, 2.6*
Education (vs. graduate school)		
Did not complete high school	1.6	-1.2, 4.4
Completed high school/GED	1.2	-0.6, 3.0
Vocational or trade school	-0.6	-2.9, 1.7
College	0.9	-0.7, 2.6
Income (vs. more than $3001/month)		
$1500/month or less	1.2	-0.2, 2.7
$1501-$3000/month	1.5	0.4, 2.6‡
Number of cigarettes smoked per day during postpartum period	-0.1	-0.3, 0.04
Time of last measure postpartum weight (days)	-0.01	-0.01, 0†
Marital status: Married (vs. not married)	2.2	0.4, 4.0†
Active duty status: Active duty (vs. not active duty)	-0.7	-1.8, 0.4
$R^2 = 0.2$		

* $p < 0.07$ † $p < 0.05$ ‡ $p < 0.01$

FIGURE 2. Predicted mean weight retention by weight gain category and race



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Physical Activity and Postpartum Weight Retention

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Introduction

The prevalence of obesity in the United States steadily increased over the past two decades. Data from the Third National Health and Nutrition Examination Survey in 1994 showed that over 1/5th of adults in the United States were obese, up from about 14% in the early 1970s (1). The same study estimated that 55% of the adult population in the United States was overweight. This increase continued despite studies showing evidence of an association between obesity and morbidity and mortality due to cardiovascular disease, diabetes, cancer and other adverse health outcomes (2-8). High health costs due to the already substantial and rising number of overweight adults has led researchers to question not only why individuals gain weight but also what can be done to prevent obesity.

In the United States women are more likely than men to become obese; the greatest increase in prevalence of obesity has been in women of reproductive age (1,9). A number of studies have examined pregnancy as one possible pathway to obesity. Öhlin and Rössner studied 1423 women at one year postpartum and found their mean weight 0.5kg above their age-adjusted prepregnancy weight, while an analysis of pregnant women from the First National Health and Nutrition Examination Survey (NHANES I) by Williamson et al. found an average excess weight gain of 1.7 kg (compared to women who did not give birth) at 10 years follow-up (10-11). However, for some subgroups of women the effects of pregnancy on weight gain appear to be even more extreme. For example, women from the NHANES I data that had three or more births in the study period gained 2.2 kg more on average than women not giving birth (9).

Other studies have shown age, African-American race, lower socioeconomic status, higher gestational weight gain, and higher parity to be associated with increased postpartum weight retention. An association has been shown between smoking and the amount of weight retained after pregnancy . Investigations into breastfeeding and dieting postpartum have had mixed results (12-21).

While pregnancy may (for some women more than others) be a part of the "why do women become obese?" equation, physical activity has been perceived as a major factor in the "what can be done to prevent obesity?" solution. Both the Centers for Disease Control and the Institutes of Medicine have made physical activity recommendations for fitness; the CDC has also advised increased physical activity and decreased caloric consumption as the preferred method of weight loss (22-23). The Surgeon General's Report and Physical Activity and Health, released in 1996, advised "moderate" levels of activity everyday (for example, 30 minutes of brisk walking daily) for optimal health. The report also emphasized the trade-off between duration and intensity; with lower intensity activities required a longer duration to achieve the desired effect (24). Recent studies on weight loss found exercise and diet changes (particularly calorie and fat restriction) to be key not only in promoting the initial loss but in weight loss maintenance (25-26).

The intersection of one probable cause of excess weight gain, pregnancy, and one often-prescribed prevention, exercise, would seem to be a fruitful area of research. Previous studies into methods of preventing weight retention and gain after pregnancy have not conclusively shown an association with physical activity. Two small intervention trials examining exercise, diet restriction, and lactating women had mixed results and the larger, prospective studies have not provided more definitive answers (27-28). Öhlin and Rössner found an association between smoking cessation and weight retention and a suggestion that women who had increased their energy intake and performed little or no leisure time physical activity retained more weight at one year postpartum, but this association was not statistically significant (7, 29). Schauberger, et al. on the other hand found no association between reported physical activity and postpartum weight retention (30). A study by Boardley, et al. found a statistically significant difference between white and African-American women in amount of physical activity reported postpartum and in dieting behavior but these variables were not significant predictors of weight retention postpartum (31).

The goal of this study is to answer the following questions: 1) Does participation in leisure-time physical activity lower postpartum weight retention? 2) Do women that spend more time and intensity in leisure-time physical activity retain less weight postpartum? We hypothesize that women spending more time at higher intensity activities will retain less weight at the conclusion of postpartum follow-up.

Methods

The data for this research were collected from the After the Baby Comes (ABC) study. This study of postpartum maternal weight change patterns and the factors that contribute to them was conducted between 1997 and 1999 at the Balboa Hospital pediatrics clinic in the Naval Medical Center, San Diego (NMCSD). The ABC study attempted to enroll all eligible mothers of infants receiving well-baby care at NMCSD;

these women were either dependents of active duty military personnel or active duty themselves. Eligibility was restricted to women who were not pregnant, were fluent in English, had a child younger than 12 months old that had not been in neonatal intensive care, and women that were planning to continue their child's care at the pediatrics clinic. Also, an invitation to participate was not extended if the woman was not the child's biological mother.

While every attempt was made to enroll and follow all eligible women and children, the unique nature of the population made this task very difficult. The high traffic and round the clock schedule of the pediatric clinic meant that often there were too many women for the recruiters to handle or women keeping appointments after hours. The military population is also highly mobile, making extended follow-up a problem. The target population consisted of the 7,723 women who took their babies to Balboa for well-child care in the study period. Of these, 4,321 were approached to be in the study, 652 refused and 847 were ineligible leaving 2,812 in the final study population. To deal with the mobility of the population and maximize the amount of data collected, the ABC study is cross sectional in design –though a cohort can be constructed from the smaller subset of women that were followed throughout the study period.

The ABC study provided our research with three main types of data. First, it had maternal height and weight measurements taken during the postpartum well-baby visits. Trained personnel measured maternal height without shoes twice using a stadiometer at the first clinic visit. If these values differed by more than 0.5cm a third measurement was taken. Maternal postpartum weight was measured at the enrollment visit and at all subsequent visits. Women were weighed twice on a calibrated digital scale, and if the two measurements differed by more than 0.1kg a third measurement was taken.

Next, we gathered information from questionnaires that were administered during each clinic visit or completed by the women at home. Clinic visits were scheduled to take place at 3-7 days and 10-14 days (administered brief questionnaire) and at 2, 4, 6, 9, and 12 months postpartum (administered a more detailed questionnaire). Take-home questionnaires were given at baseline (which was 2 months postpartum or at enrollment if it occurred after 2 months) and at follow-up (12 months) or in a combination form if enrollment occurred at the 12 month point. These self-administered questionnaires collected information on a number of maternal characteristics including age, race, parity, education level, prior history of weight loss and gain (and from this weight cycling information), smoking, depression, household income, prepregnancy weight and infant feeding method.

Finally, information was available that was abstracted from the mother's medical records of the pregnancy. These data included the mother's weight gain during pregnancy along with age and rank, the infant's weight at birth, and any complications developed during the pregnancy (e.g., gestational diabetes, pre-eclampsia, hypertension).

The information collected allowed for the creation of several variables that were used in this research. Maternal race was recoded to take into account the number of women who reported belonging to two or more racial or ethnic groups. Women who identified themselves as White and no other ethnic or racial group were considered White and women who reported they were White and another racial or ethnic group (Black, Asian, or Hispanic) were classified as that racial/ethnic group. Women who considered themselves Black were coded as Black whether or not they indicated belonging to another racial or ethnic group. This is because studies have shown that being Black is a key predictor of postpartum weight retention, above belonging to any other racial/ethnic group (14). A dichotomous weight cycling variable was created from information on prior weight loss and regain. Women were considered weight cyclers if they had lost and then regained 10 pounds at least three times.

Creation of a maternal dieting practice variable has been previously described in Katherine Hoggatt's master's paper (32). We appreciate her guidance in the design of this variable. A dichotomous healthy dieting variable was created using a checklist of behaviors from the questionnaires. Women were asked to indicate things they had done to control their weight over the past seven days. Women who indicated they "ate less food/followed a low calorie diet", "avoided junk foods", "bought low fat foods", or "tried to be more physically active" and had not participated in an unhealthy behavior were considered "healthy dieters". Unhealthy behaviors consisted of "skipped meals", "fasted for at least one day", "smoked cigarettes", "took laxatives to lose weight", "took diuretics or water pills", "intentionally vomited after eating", "I worried but did nothing" and "did nothing". In creating the healthy dieting variable, preference was given to the earliest questionnaire for each woman that contained the dieting practice questions.

Physical Activity

Questions about physical activity were posed on nearly every questionnaire. However, the depth of the questions varied by questionnaire. In order to best address our hypothesis that increased time and intensity of activity leads to lower postpartum weight retention, we chose to focus on a series of questions posed on the baseline, follow-up and combination questionnaires. These questionnaires feature a list of activities (and a space to indicate activities not listed) and ask whether the woman has performed any of them during the past seven days (baseline) or over the year (other forms) and if so how many times and, on average, how many hours and minutes each time. We could then use this list to create a "metabolic" (met) variable. A met variable is created through multiplication of time spent at an activity and a met rate assigned to each activity, which is an indication of an activity's intensity. The met rate ranges from 1-10, with 1 being the least intense and 10 being the most (e.g. walking normal pace is a 2 met activity, kung fu is 10 met). The met scale has been validated, though not in a postpartum population (33-35).

The combination of the women's met scores for all activities allowed us to create a "total met" variable for each woman for the seven days prior to questioning. If a woman answered the series of met construction questions at more than one time point (for example, at baseline and at follow-up), her earlier "total met" variable was given preference in the analysis to ensure the exercise was prior to the weight retention outcome.

Study Sample

The study sample was limited to women who had data to create the met variable (had a baseline, follow-up, or combo questionnaire). To examine the desired outcome, weight retention, we further restricted the sample to women with a final weight measurement (3 months or later postpartum) and a prepregnancy weight. The time frame for the final weight was chosen based on Cromwell's review of literature on weight change in the postpartum period that required studies allow at least 3 months postpartum to facilitate return to prepregnancy weight, though 6 months was considered optimal (13). An analysis using only women with weight measurements 6 months postpartum or later had the same results (but fewer numbers –results not shown). Women also weren't included if they became pregnant again during the study follow-up (n=125). Using these eligibility criteria 1690 of the 2812 women enrolled in the study were included in the sample.

From this initial sample further exclusions were made based upon missing data. Those with no data on dieting practices (n=24), parity (n=128), weight cycling(n=115), income (n=15), or age (n=3) were not included in the analysis. Women with ambiguous race data were also excluded (n=46). Finally, women with impossible measurements for prepregnancy or postpartum weight and hours of physical activity were excluded (n=10). It is important to note that these exclusions were only made for data outside the realm of biological possibility (e.g., reporting more hours of physical activity in 7 days than there are hours in a week) to avoid these extreme measurements driving the analyses. The final analytical sample included 1349 women (**Figure 1**).

Analysis

The focus of this study was to examine the impact of the amount and intensity of exercise on postpartum weight retention. The outcome measure, postpartum weight, measured as final postpartum weight minus the self-reported prepregnancy weight was continuous and the main predictor variable, physical activity, was assessed using the met variable described above. Univariate and multivariate techniques were used to examine this relationship. All multivariate models were controlled for the effects of diet, weight cycling, race, age, parity, education, income, rank, and active duty status in order to examine the independent of effect of physical activity on weight. Stratified analyses were conducted to examine difference between women who exercised and those who did not, those with early vs. late exercise measures, and those who ate healthy diets while exercising vs. those who did not.

The initial analysis focused on whether there were any differences in mean weight retention and selected demographic characteristics for women within early measure of physical activity as compared with a late measure. "Early" for this analysis was defined as a measure made at 6 months or earlier postpartum.

The difficulty of how best to answer both of our research questions became apparent when we began analysis by our exposure variable. To begin, we used a dichotomous variable (any vs. no exercise) in statistical analyses with mean weight retention as the outcome variable. The dichotomous variable had limitations for interpretation: it only examined "any" exercise –even small amounts—versus none and this may not be where differences are seen. This led to our next analyses with continuous variables.

We next performed analyses with total mets as a continuous variable and as a categorical variable (none, low, medium, high – categorized by quartiles). This, too, had problems for interpretation. Since the met variable itself is a combination of intensity and time of activity we could not draw conclusions about what part these components of exercise play in postpartum weight retention. To aid in interpretation we decided to analyze the components of the total met variable, time of physical activity and total met score, as separate continuous variables.

We used multivariate linear regression to assess the association between time and intensity of physical activity and postpartum weight retention. Before we began model construction several choices were made. The outcome variable chosen for the models was final postpartum weight, controlling for prepregnancy weight and height. Weight retention, the discussion outcome of interest, could then be calculated from the model. The decision to use these variables rather than the compound variables of postpartum weight retention and prepregnancy BMI (weight in kg/height in m squared) was made for much the same reason the compound total mets variable was abandoned. The breakdown allowed us to examine the association of the variables of interest to the component parts and improved model fit.

Models were constructed in a manual stepwise fashion. First examined were the effects of time spent at physical activity and intensity of activity on postpartum weight retention, controlling for prepregnancy weight and mother's height. The possible interaction of time and intensity was next assessed through fitting a time/intensity multiplicative term, which was not significant ($p<0.10$ considered significant). From knowledge of previous studies we theorized that diet has a significant impact on the effects of exercise and the healthy dieting variable was next added to the model. We also examined a possible healthy dieting and exercise interaction through dieting/time and dieting/intensity interaction terms. The healthy dieting and time of physical activity interaction term was significant at an alpha of 0.10. We decided to handle this interaction by stratifying the analysis on healthy dieting.

We continued to build models for the healthy dieters by adding biological factors parity, weight cycling history, maternal age, race, and pregnancy gain that proved significant predictors of postpartum weight retention in other studies. Because we hypothesized that these factors would be important predictors of postpartum weight retention in our study too the variables were retained in the model regardless of significance (though only parity was not significant at 0.10). We then added the socioeconomic factors education, income and income squared (an interaction term of income with itself), and rank to the model. Only income and its squared term were found to be significant and were retained. We also examined variables that we hypothesized may be important though verifying studies were lacking. These included mother's active duty status and breastfeeding status. Active duty status was significant and was kept in the model.

Results

Table 1provides a comparison of selected demographic characteristics of the study sample and the final analytical sample. Few differences existed between the 1690 women in the study population and the 1394 women selected for analysis. Both had an average age of 26 years, were predominantly White (55.6% in the study, 57.3% in the analytical sample) and non-active duty (approximately 82% for both). Prepregnancy weight, postpartum weight and weight retention differed little between the two populations (the study sample averaged 4.8 kg weight retention, while the analytical sample averaged 4.6 kg). The measures of physical activity and diet were similar with one exception: the total met variable was much higher in the study group (1994.4 mets/min vs. 1891.5 mets/min). This may be explained by the exclusion from the analytical sample of individuals exercising more hours than there are in a week, such extreme measures could be driving the mean. . Overall the two groups were very similar with the largest differences occurring between finishing high school (5.7% vs. 4.8) being a weight cycler (42.6% vs. 41.6%), though these differences were small.

The analysis in **Table 2** was run in an attempt to examine what, if any, differences existed between the women whose physical activity data was collected early (before or at 6-months, the halfway point of follow-up) and late in the postpartum period. Limiting the study to only women with data from one of these time points would have severely limited sample size. But combining groups with very different trends of physical activity or differences among other variables could be a problem for interpretation. The analysis suggested that there were some borderline significant differences (at an alpha of 0.05) between the groups. The total met score was higher in those measured later (2070 vs. 1747, p=0.053) and the total time of exercise approached a significant difference with a p-value of 0.07. Also off-balance between the two groups was parity, with those measured earlier more likely to be nulliparous (and now having their first child). This finding was significant with a p-value of 0.02 (48.9% vs. 40.6%); no other variables proved significant, including intensity of physical activity. With the tide of the analysis shifting towards the continuous time and intensity variables, the decision was made to examine all time period physical activity data.

Table 3 presents the univariate analysis of weight retention, physical activity in terms of total met score, and other demographic variables. The total met variable was examined by quartiles and as a dichotomous variable (no exercise vs. any exercise) in this analysis. In neither form was physical activity in terms of total met score a predictor of postpartum weight retention ($p=0.83$ and 0.16 respectively). A categorical version of mother's age, parity, previous history of weight cycling, healthy diet, income and education were all significantly associated with postpartum weight retention ($p \leq 0.05$).

We began a multivariate linear analysis even though the univariate data was not encouraging. We decided to use continuous total met score as the exposure variable and final postpartum weight as the outcome (adjusting for prepregnancy weight and height). These results are summarized in **Table 4a**. Total met score was not significant in the final model, which included age, race, diet, parity, weight cycling, and income variables. An interaction with diet was considered during the modeling process but found to be non-significant. Because of our desire to better understand the role of intensity and time on postpartum weight and to understand the factors that, in turn, influence the time and intensity of activity we decided to construct a model with these factors as separate exposures. An interaction between the time spent at physical activity and healthy dieting was found to be significant ($p<0.10$), interactions between intensity and time and intensity and dieting were not significant. We decided to stratify on dieting because of the evidence of interaction and built models for the healthy dieters. These results are presented in **Table 4b**. These models do represent a subset of the analytical sample. They are the more important subset in terms of making recommendations to women for dieting and weight loss in concert. If time had permitted, a separate set of models could have been constructed for the non-healthy dieting women.

Table 4b shows evidence of an association between intensity of activity and lower postpartum weight (p=0.05) after adjusting for parity, income and its interaction, weight cycling, mother's race, age, and active duty status. Time spent at leisure time activity did not show a significant association with postpartum weight loss. Other studies have shown an interaction between race and physical activity (21, 28). Unfortunately we lacked power to adequately examine this question after stratification on healthy dieting and race exists in the model as a purely additive term.

Discussion

The findings of this study suggest that, among women who practice healthy forms of dieting, the intensity of leisure time activities performed is associated with reduced postpartum weight retention. A significant effect was not seen between the total amount of time spent at leisure time activity and weight retention. These results were only seen when using continuous time and intensity score as separate exposure variables in the model. Models using the continuous combined time and intensity score, or "total mets", and the categorical version of this variable found no association between leisure time physical activity and postpartum weight retention.

Attempting to compare the results of this study to those of past prospective studies of physical activity and postpartum weight retention is difficult. This is not only because this analysis differs from all others in its breakdown of the usual met variable into its components but also because of the differences between these other studies in conceptualization and calculation of physical activity and dieting variables. The difficulty lies in finding valid and reliable instruments to measure physical activity and food intake. Researchers recognize the need to measure not only amount of time spent at exercise but also the intensity ,however, vary in opinion on how best to accomplish this goal (36- 37). Researchers also have noted the importance of adjusting for diet (or energy intake) when studying exercise (energy expenditure) and have as many instruments for measuring this as for activity itself (38-40). A comparison between such varied studies may seem impossible but is not without its rewards; it can provide insights into problems and positives in this study and into future directions for physical activity research in the postpartum period.

The three prospective studies that examined physical activity as a main effect among causes of postpartum weight retention form the basis for comparison. The first of these was a study of 795 women by Schauberger *et al.* in 1992 (30). The researchers in this study compared weight loss and retained weight at 6 months postpartum and amount of self-reported exercise and found no significant association between physical activity and either outcome. The women were followed from their first prenatal visit until the final 6-month interview and exercise was discussed at each interview after delivery, allowing for adjustment based on when the exercise was resumed. However, the instrument used queried only about 5 different exercise "subgroups" and no information was given about validation. Further, no adjustment was made for food intake or the intensity of each exercise "subgroup".

The next study by Ohlin and Rossner in 1994 followed 1423 Swedish women from their first prenatal visit until 1 year postpartum (29). A physical activity score was constructed for the women based upon two questions asked about each time point of the study: before pregnancy, during pregnancy, at 1-6 months, and at 7-12 months postpartum. These two questions were multiple choice and concerned the intensity of activity performed at work and during leisure hours. Adjustments for diet were made using a 7-question scale that examined the types of foods regularly consumed and number of meals/snacks per day. Ohlin and Rossner found a significant association between increased snack eating and increased energy intake overall and greater postpartum weight retention. A non-significant association was seen between a larger amount of weight retention and less leisure time activity. As in the Schauberger study, validation of the questionnaire was not mentioned. However, this study put the primary focus on the intensity of the exercise (none, light, moderate, heavy) over the time spent at physical activity and was unique in its inclusion of work activity data.

The final study by Boardley *et al.* in 1995 followed 121 white women and 224 black women for 7-12 months postpartum (31). Information on physical activity (activity performed, length and duration over the past week and estimation of week prior to pregnancy) was collected at the final visit in this 7-12 month window (expanded from 1 year follow-up only to include as many women as possible in the study). The physical activity questionnaire was used to construct a met score (as in this study) for prepregnancy and postpartum periods. The met questionnaire has been validated in women, but not in a postpartum population. Diet was measured using the food frequency questionnaire, which has been validated in a range of populations including postpartum women. Boardley *et al.* found significant differences between postpartum met score in black and white women, but postpartum activity was not significantly associated with weight retention. A significant association was found between prepregnancy activity score and lower postpartum weight retention, but this finding may be subject to recall bias based upon the distant collection of data about exercise in this period.

Our study attempted to improve upon the sample size of past research while utilizing the best study techniques. But we had to deal with the same problems other studies have grappled with: temporality of data collection, validity of the questionnaire for collecting physical activity and diet data and for constructing scores, selection bias and power.

Unlike the studies by Schauberger and Ohlin and Rossner we only had physical activity data to calculate a met score at one time point, not at each study visit. Unfortunately, this was also not the same time point for all women. The univariate analyses showed borderline statistically significant differences between those with earlier vs. later measurements of physical activity in terms of the total met variable, the total time of activity, and parity. The decision to include as many women as possible was a crucial one, but these differences may be problematic. Women with earlier measures may not have scores that accurately reflect their activity levels throughout the postpartum period and, conversely, those with later measures may not have implemented the activity regimen prior to weight loss.

A valid and reliable collection instrument can lessen temporality concerns. The met construction questionnaire attempts to reduce recall bias by limiting its focus to the prior week only but it also attempts provide an accurate picture of a person's usual amount and intensity of exercise. The fact that this scale has not yet been validated in a postpartum population, however, is a cause for some concern. The postpartum period can be a time of not only biological changes but also social and interpersonal shifts (13, 41). A measure of physical activity at one time point may not be readily applicable to the rest of the postpartum period. Further, we chose to use the met questionnaire for construction of scores that the initiators of the scale didn't intend. The time of physical activity is fairly straightforward, but the use of the intensity score alone has not been validated and may not be reliable. However, we felt this breakdown was the best way to answer our question.

Selection bias became a bigger issue in this study after the interaction with healthy dieting was discovered. Stratification on this variable led to much smaller sample sizes than this investigator intended upon the study's inception. The analytical sample (and the smaller healthy dieting subsample) and the study sample appear to be very close in make-up, but the match between the study sample and the entire study population is unknown. Of course, also unknown is the match between the population obtained for the entire study and those that declined, were ineligible, or were missed and on a grander scale, the match between this military population and the rest of California or whole of the United

States. We must consider the possibility that selection bias could be a force behind our findings. The small sample sizes also led to power problems, specifically to the inability to test for interactions on race (a major finding from the study of Boardley, *et al.*).

Even with the problems this study faced, it did produce some positive findings. It reinforced the importance of considering all components of exercise when performing physical activity research. Just totaling hours spent in activity or what activities are performed may not give the complete picture of an individual's exercise. It also reemphasized the need to control for diet when examining physical activity.

This study does have limitations, however. The sample size, power, and bias issues have been addressed, but there are also self-reporting issues to consider. The fact that the analysis showed a positive association with intensity and weight loss but not time could be reflecting an overreporting of activity. There exists the possibility of bias in this direction from wanting to please the researchers or conform to society's standards of exercise and diet. These facts must be kept in mind while examining the study results.

Finally, this study continued down a path that has been relatively lightly traveled to this point but could hold the key to a lower prevalence of overweight and obesity among women in the United States. It makes sense that diet and activity would lead to less weight retention. So why continue this avenue of study? Because the next step needs to be concrete recommendations for postpartum women. Is the Surgeon General's recommendation of "moderate" activity daily (1000 kcals/week) enough to induce weight loss in the postpartum period? The answer may only come through randomized controlled trials. Two small intervention trials have examined exercise and weight loss postpartum. Dewey *et al.* assigned 18 previously sedentary women to a regimen of aerobic activities for 12 weeks (27). All the women were breastfeeding and were 6-8 weeks postpartum. They found increased cardiovascular fitness in the study group compared to controls but no significantly increased weight loss. A study by McCrory *et al.* focused on dieting and exercise in a group of lactating postpartum women. Placed on a strict 8-day diet and exercise plan, the study group of women achieved a statistically significant weight loss compared to a control group. In contrast to current recommendations for health however, these women were restricting energy intake and increasing output for a difference of 1000 kcals/day. A third intervention looked at only dieting in obese women but had similar results (42). The energy balance needed to achieve weight loss in the postpartum period may exceed recommended daily amounts for lasting health or even for weight loss during other time periods. Randomized controlled trials may be the best hope we have for circumventing the problems with physical activity measurement and developing a solid recommendation for fitness and weight loss for all women.

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Figure 1

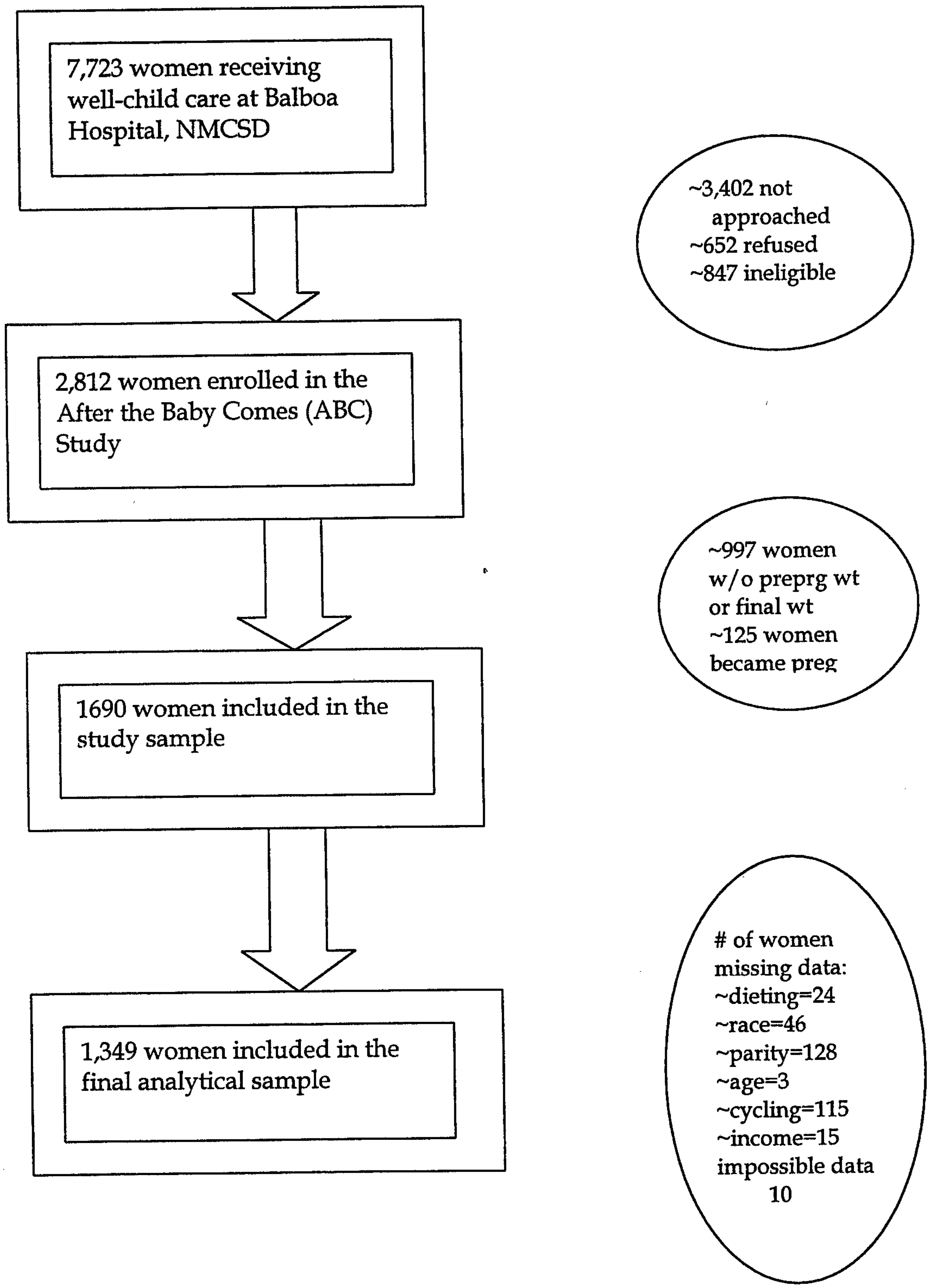
7,723 women receiving well-child care at Balboa Hospital, NMCSD
~3,402 not approached
~652 refused
~847 ineligible
2,812 women enrolled in the After the Baby Comes (ABC) Study
~997 women w/o preprg wt or final wt
~125 women became preg
1690 women included in the study sample
# of women missing data:
~dieting=24
~race=46
~parity=128
~age=3
~cycling=115
~income=15
impossible data 10
1,349 women included in the final analytical sample

Table 1: Selected demographic characteristics of the study and analytical samples

Characteristic	Study Sample N (Total=1690)		Analytic sample N (Total=1349)	
P.A. time (hrs), mean, (sd)	1690	8.3 (12.1)	1349	7.9 (11.2)
P.A. intensity score, mean, (sd)	1690	9.2 (7.9)	1349	9.1 (7.8)
METTOT (met/min), mean, (sd)	1690	1994.4 (2984.4)	1349	1891.5 (2597.1)
Prepregnancy Wt (kg), mean, (sd)	1690	64.1 (13.9)	1349	64.2 (13.6)
Postpartum Wt (kg), mean, (sd)	1690	68.9 (16.1)	1349	68.9 (15.3)
Wt Retention (kg), mean, (sd)	1690	4.8 (9.3)	1349	4.6 (7.4)
Gestational Wt Gain, mean, (sd)	1682	16.5 (8.2)	1349	16.5 (7.8)
Mother's Age (yrs), mean, (sd)	1684	25.8 (5.6)	1349	25.9 (5.4)
>30 n(%)		411 (24.3)		331 (24.5)
<=30 n(%)		1279 (75.7)		1018 (75.5)
Parity n(%)	1561		1349	
0		701 (44.9)		610 (45.2)
1		560 (35.9)		487 (36.1)
2		218 (14.0)		183 (13.6)
3		62 (4.0)		51 (3.8)
>=4		20 (1.2)		18 (1.3)
Weight Cycler? n(%)	1557		1349	
Yes		648 (41.6)		575 (42.6)
No		909 (58.4)		774 (57.4)
Active Duty? n(%)	1690		1349	
Yes		312 (18.5)		247 (18.3)
No		1378 (81.5)		1102 (81.7)
Race n(%)	1640		1349	
White		934 (55.6)		773 (57.3)
Black		235 (14.0)		192 (14.2)
Asian		209 (12.4)		166 (12.3)
Hispanic		262 (15.6)		218 (16.2)
Income n(%)	1624		1349	
$500/mo or less		16 (1.0)		12 (0.9)
$501-1000/mo		101 (6.2)		75 (5.6)
$1001-1500/mo		271 (16.7)		214 (15.9)
$1501-2000/mo		354 (21.8)		301 (22.3)
$2001-2500/mo		291 (17.9)		252 (18.7)
$2501-$3000/mo		212 (13.1)		175 (13.0)

$3001-6250/mo		331 (20.4)		277 (20.5)
More than $6250/mo		48 (3.0)		43 (3.2)
Education n(%)	1650		1349	
Didn't complete high school		94 (5.7)		64 (4.8)
High school or GED		516 (31.3)		419 (31.2)
Vocational or trade school		124 (7.5)		103 (7.7)
College		793 (48.1)		652 (48.5)
Graduate School		123 (7.5)		106 (7.9)
Healthy Diet? n(%)	1666		1349	
Yes		815 (48.9)		655 (48.6)
No		851 (51.1)		694 (51.4)

Table 2: A Comparison of Characteristics for those with Early (>=6 mos.) and Late Physical Activity Data

Characteristic	Women with Early P.A. data N=748	Women with Late P.A. data N=601	Test Stat	p-value
P.A. time (hrs), mean, (sd)	7.4 (9.5)	8.7 (12.9)	t=-1.9	0.07
P.A. intensity score, mean, (sd)	8.8 (7.7)	9.4 (7.9)	t=-1.3	0.19
METTOT (met/min), mean, (sd)	1747.5 (2311.9)	2070.3 (2904.5)	t=-2.0	0.05
Prepregnancy Wt (kg), mean, (sd)	64.4 (13.8)	64.0 (13.8)	t=0.5	0.63
Postpartum Wt (kg), mean, (sd)	69.1 (15.8)	68.6 (14.8)	t=0.5	0.6
Wt Retention (kg), mean, (sd)	4.6 (7.8)	4.6 (6.8)	t=0.2	0.86
Gestational Wt Gain, mean, (sd)	16.5 (7.3)	16.4 (8.3)	t=0.2	0.82
Mother's Age (yrs), mean, (sd)	25.9 (5.5)	25.7 (5.4)	t=0.7	0.51
Parity n(%)				
0	366 (48.9)	244 (40.6)	X^2=16.5	0.02
1	250 (33.4)	237 (39.4)		
2	105 (14.0)	78 (13.0)		
3	21 (2.8)	30 (5.0)		
>=4	6 (0.8)	12 (2.0)		
Weight Cycler? n(%)				
Yes	313 (41.8)	262 (43.6)	X^2=0.4	0.52
No	435 (58.2)	339 (56.4)		
Active Duty? n(%)				
Yes	142 (18.0)	105 (17.5)	X^2=0.5	0.47
No	606 (81.0)	496 (82.5)		
Race n(%)				
White	429 (57.4)	344 (57.2)		
Black	105 (14.0)	87 (14.5)	X^2=0.1	0.99
Asian	93 (12.4)	73 (12.2)		
Hispanic	121 (16.2)	97 (16.1)		
Income n(%)				
$500/mo or less	9 (1.2)	3 (0.5)		
$501-1000/mo	45 (6.0)	30 (5.0)		
$1001-1500/mo	115 (15.4)	99 (16.5)		
$1501-2000/mo	160 (21.4)	141 (23.5)	X^2=5.6	0.58
$2001-2500/mo	137 (18.3)	115 (19.1)		
$2501-$3000/mo	101 (13.5)	74 (12.3)		
$3001-6250/mo	153 (20.5)	124 (20.6)		
More than $6250/mo	28 (3.7)	15 (2.5)		

Education n(%)				
Didn't complete high school	38 (5.1)	26 (4.3)		
High school or GED	229 (30.7)	190 (31.7)		
Vocational or trade school	46 (6.2)	57 (9.5)	X^2=6.9	0.14
College	376 (50.5)	276 (46.1)		
Graduate School	56 (7.5)	50 (8.4)		
Healthy Diet? n(%)				
Yes	357 (47.7)	298 (49.6)	X^2=0.5	0.49
No	391 (52.3)	303 (50.4)		

Table 3: Univariate Analysis of Postpartum Weight Retention, Physical Activity and Other Possible Predictors

Characteristic	Weight Retention N	Weight Retention Mean (kg)	Weight Retention Standard Deviation	Test Statistic	p-value
Physical Activity					
Any	1190	4.7	7.3	t=-1.41	0.16
None	159	3.7	8.2		
None	409	4.5	7.6		
Low	333	4.5	6.5	F=0.28	0.83
Medium	261	4.9	7.4		
High	346	4.8	8.1		
Mother's Age (yrs)					
>30	331	3.8	6.1	t=2.28	0.02
<=30	1018	4.9	7.7		
Parity					
0	610	4.7	7.7		
1	487	4.3	7.2	F=2.55	0.04
2	183	4.6	6.3		
3	51	4.2	7.6		
>=4	18	9.8	9.8		
Weight Cycler?					
Yes	575	5.3	7.7	t=-2.73	<0.005
No	774	4.1	7.1		
Active Duty?	1102	4.6	7.8	t=0.24	0.98
Yes	247	4.6	7.3		
No					
Race					
White	773	4.8	7.7		
Black	192	4.7	7.9	F=0.82	0.48
Asian	166	3.8	6.9		
Hispanic	218	4.7	6.2		
Income					
$500/mo or less	12	-2.3	17.2		
$501-1000/mo	75	5.9	7.6		
$1001-1500/mo	214	4.8	7.6	F=3.19	<0.05
$1501-2000/mo	301	5.2	8.1		
$2001-2500/mo	252	5.1	7.1		
$2501-$3000/mo	175	3.9	7.1		
$3001-6250/mo	277	4.3	6.6		
More than $6250/mo	43	2.2	3.3		

Education					
Didn't complete high school	64	3.8	11.7		
High school or GED	419	5.3	7.3		
Vocational or trade school	103	2.9	8.5	F=2.69	0.03
College	652	4.6	6.4		
Graduate School	106	4.2	8.6		
Healthy Diet?					
Yes	655	4.3	7.7	t=1.77	0.07
No	694	4.9	7.1		

Table 4a: Multivariate Linear Regression Results[a]

	Met total/Continuous Coefficient (N=1394)	Met total/Categorical Coefficient (N=1394)
Intercept	-0.8491	-0.8450
Met total	-0.000034	
Met levels (vs. none)		
Low		0.0094
Medium		0.3969
High		-0.1834
Prepregnancy Wt	0.9948 [e]	0.9960 [e]
Pregnancy Gain	0.3530 [e]	0.3535 [d]
Maternal Height	-0.0057	-0.0070
Maternal Age	-0.0993 [d]	-0.0913 [d]
Income	1.4944 [d]	1.4612 [d]
Income Squared	-0.1553 [d]	-0.1539 [d]
Parity	0.6169 [e]	0.6198 [e]
Weight Cycling	0.7232 [c]	0.7555 [c]
Healthy Diet	-0.6482 [c]	-0.6385 [c]
Diet/Exercise Interaction[b]	0.0002	0.0936
Black	0.1283	0.0959
Asian	-0.9848	-1.0110
Hispanic	0.2239	0.1967

[a] Outcome variable is final measured postpartum weight (must be at least 3 months or after -average, 9 months)

[b] Interaction term coefficient calculated in separate model and found to not be significant. Listed to contrast with Tabl

[c] $p<0.10$

[d] $p<0.05$

[e] $p<0.01$

Table 4b: Multivariate Linear Regression Results[a]

	Continuous time and intensity Coefficient Healthy Dieters(N=655) [b]
Intercept	-4.6727
Total Time of Exer	0.0583
Intensity of Exer	-0.0780 [d]
Prepregnancy Wt	0.9799 [e]
Pregnancy Gain	0.4335 [e]
Maternal Height	0.0008
Maternal Age	-0.0865
Income	2.3045 [d]
Income Squared	-0.2381 [d]
Parity	0.4803
Weight Cycling	0.8511 [c]
Black	-0.3662
Asian	-1.9665 [d]
Hispanic	-0.1386

[a] Outcome variable is final measured postpartum weight (must be at least 3 months or after -average, 9 months)

[b] Interaction term coefficient calculated in separate model and found to be significant with p<0.1.
Stratification based on healthy dieting.

[c] p<0.10

[d] p<0.05

[e] p<0.01

Prepregnancy Body Size, Physical Activity and Postpartum Weight Retention

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INTRODUCTION

The prevalence of obesity and overweight among American women that have been observed within the past decade continued in 1999-2000 (1). Since pregnancy is a time of required weight gain and thus may be a risk factor for overweight and obesity (2-5), exploring characteristics suspected of influencing postpartum weight retention is of public health importance. Such characteristics may include weight gain during pregnancy, pre-pregnancy weight, race/ethnicity, parity, lactation, and physical activity (2, 6, 7).

Because physical activity is an important determinant of body weight, it is surprising that few studies have examined the relationship between exercise and postpartum weight retention. The few studies that have examined this relationship have produced promising results. Ohlin and Rossner found that postpartum weight retention correlated negatively with the amount of physical activity during the second half of the first year postpartum (8). Boardley et al. reported prenatal physical activity to be a significant factor for predicting weight change, but postpartum physical activity was not important (7). In a Swedish study, women who retained excess weight postpartum reported low levels of recreational physical activity during the year after birth and increased physical activity was correlated significantly with postpartum weight loss (9).

An incentive to be physically active may positively influence postpartum weight retention. Active duty military women are required to maintain a level of physical fitness that allows them to meet the demands of their occupation. Thus, these women are expected to achieve weight and fitness standards soon after delivery. In the Navy, for example, these standards must be achieved within 6 months after delivery. Military standards may serve as an incentive for women to be more physically active postpartum.

We conducted multivariable linear regression to answer the following questions: (1) Does postpartum physical activity (measured, on average, at six months postpartum) predict lower weight retention at one year postpartum? (2) Does active duty military status predict lower weight retention at one year postpartum? Our study sample consisted of military women or dependents of active military partners. We hypothesized that the military fitness standards of our active duty women might influence their behaviors and potentially impact their postpartum weight retention.

METHODS

Study design and data collection

The data analyzed in this article are from the project, "Postpartum Weight Changes: Implications for Military Women," which will be referred to in the rest of this report as the "ABC Study." This study enrolled a total of 2,433 postpartum women between 1997 and 1999 whose infants were receiving well-baby care at the Pediatrics Clinic of Balboa Hospital, the United States Naval Medical Center, San Diego. The major objectives of the original study were to 1) describe the pattern of weight loss during the first year after delivery in a large study group of active duty and military dependent women; 2) compare differences in weight loss by maternal characteristic; and 3) identify characteristics of women who are most likely to become permanently overweight or obese as a result of childbearing. Using this study sample of active duty and military dependent women, we will attempt, if appropriate, to apply our results to a target population of American women or women in general.

For this report, we analyzed data on a subset of women for which we had complete information on both outcome and other covariables at six months and one year postpartum, on average (n=578). Prior to any clinic visits, mothers completed an at-home baseline questionnaire at approximately two months postpartum. At each clinic visit, mothers also filled out questionnaires on their current behaviors and conditions. Mother's height was measured at the first clinic visit (on average three months postpartum). An attempt was made to measure mother's weight at each clinic visit, however due to difficulties during data collection, some weight measurements were self-reported.

Definition of variables

Our outcome variable, weight retention, was calculated as mother's postpartum weight minus pre-pregnancy weight in kilograms. Postpartum weight was measured or self-reported, on average, at one year postpartum and pre-pregnancy weight was self-reported on the baseline questionnaire. Pre-pregnancy body mass index (BMI) was calculated as pre-pregnancy weight (kg) divided by mother's height (m^2). For our regression model, we used pre-pregnancy BMI as a dichotomous variable (<25 kg/m^2 vs. ≥ 25 kg/m^2) according to World Health Organization endpoints for overweight and obesity (10). For the purposes of our logistic regression model we defined weight retention as >9kg vs. ≤9kg. Since 9kg is approximately 15 pounds, we chose this cutpoint because 15 pounds may be more likely to have significant health effects compared to postpartum weight retention of only 5 to 10 pounds (11).

Data on physical activity behaviors used in these analyses were collected at well-baby clinic visits at approximately six months postpartum. Physical activity in this study was reported as the number of times in the past seven days a woman had participated in each of the following activities: participation in sports or exercise, walking or bicycling at least 15 minutes at a time (to do errands, i.e., for transportation), vigorous household chores at least 15 minutes at a time, and hours per day of work-related physical activity. Because work-related physical activity was unknown for more than half of the women, we did not include this variable in our analyses. We created inactive, moderate, and high levels of physical activity for the remaining three categories. The moderate levels included 1 to 6 times and the high levels included 7 or more times in the past seven days.

To clarify, parity, as defined in our models, is the number of other children not including the new baby (index child). In the questionnaire breastfeeding was defined as the kind of milk the baby was fed in the past seven days, assessed, on average, at six months postpartum. For the purpose of these analyses we collapsed education into less than high school, high school/vocational or trade school, and some college/some graduate school. Similarly, we combined income into three levels, which include <$1501, $1501 to <$3001, and ≥$3001 per month. Racial groups were defined as White, Black, Asian, Hispanic, and Other. The variable for mother's marital status assessed whether mothers were married or living with a partner.

Outliers and missing information for postpartum and covariable data

We excluded four extreme outliers because we believed measurement and/or self-reported errors of postpartum and pre-pregnancy weight variables may their values. One outlier was removed due to a large negative value for weight retention at one year postpartum. We also examined the incidence of outliers that fell outside of 3 standard deviations from the Y=0 line. We removed these observations to examine the change in the R^2 and Root MSE for each of the models. Our R^2 changed from .2451 to .2620 and the Root MSE, while still quite large, changed by approximately 10 percent (5.48 kg to 4.98 kg). A large discrepancy between pre-pregnancy and post-pregnancy BMI variables additionally supported the decision to remove these three outliers. After the removal of these four outliers our total sample size contained 574 observations.

We also investigated outliers that fell above or below 1.5 times the interquartile range. This consisted of weight retention >15.95 kg or weight retention <-10.05 kg. For the higher end outliers (n=20), we found no statistically significant differences for important covariables other than for pregnancy weight gain (p<.0005). For the lower end outliers (n=3), we found no statistically significant differences for any important covariables. The important covariables that we investigated included: pre-pregnancy BMI, all physical activity variables, education, income, race, active duty status, breastfeeding, parity, and weight gain during pregnancy. These higher and lower end outliers do not appear to differ substantially from the rest of our sample on the variables of interest. Thus, we conclude that weight retention predicted by our model for these outliers is not much worse than that predicted for the majority of the women in our sample.

We examined differences in outcome (weight retention) based on comparisons between complete and missing data for individual variables (Table 1). For the purpose of these comparisons, we used weight retention as a dichotomous variable (≤9 kg vs. >9 kg). We found statistically significant differences in weight retention between individuals with complete versus missing data for the following variables: sports participation, walking/bicycling, household chores, and breastfeeding. We also investigated differences between other covariables based on comparisons between complete and missing data for individual variables. When we compared complete vs. missing data for parity, we found statistically significant differences for pre-pregnancy BMI, education, and income (data not shown). Additionally, for birthweight, we observed statistically significant differences for education, parity, income, active duty status, and total pregnancy weight gain. With regard to the differences in weight retention, the individuals with missing information for the covariables listed in Table 1 tended to have a weight retention >9 kg. This may have introduced a systematic bias in our analyses, however, due to the relatively small number of missing values, it is unlikely that our coefficient estimates were significantly affected.

Statistical analysis

Our main analysis was a linear regression of maternal factors on the amount of weight retention at approximately one year postpartum. In addition to active duty status, we examined factors that have been shown in the literature to impact postpartum weight retention. Pregnancy weight gain, maternal age and height, infant birthweight, and time at clinic visits (days since birth) were entered into regression models as continuous variables. We believed it was necessary to adjust for differences in the time of clinic visits because the time frame (at approximately six months and one year postpartum) varied considerably. We created indicator variables for three levels of physical activity (inactive, moderate, high) for each of the physical activity categories (sports or exercise, walking or bicycling, and household chores). We also included interaction terms for each of our physical activity variables with pre-pregnancy BMI and with active duty status. Active duty status, pre-pregnancy BMI, and marital status were entered as binary variables. We created indicator variables for racial groups, parity, education, income, and breastfeeding. Interaction terms were also included for racial groups and pre-pregnancy BMI.

Variables were retained in the main linear regression model if they were significantly associated with weight retention ($p \leq .10$ for main effect terms and $p \leq .20$ for interaction terms). Significance of interaction terms was initially assessed (using a full vs. restricted F-test) by comparing a restricted model with the removal of groups of interaction terms to the full model with all two-way interaction terms. After examining all cross-product terms we continued to assess the significance of the main effect variables using a backward elimination strategy.

To assess whether our statistical model was adequate to describe our sample of mothers, we investigated important assumptions of multiple linear regression. After generating a residual vs. fitted plot based on our final model (n=574), we saw that the residuals are scattered randomly about the Y=0 line along the fitted values. The residuals did not appear to be systematically positive or negative in any given region and no specific patterns seem to arise. The prescribed functional form (linearity) appears to be an appropriate structure. The residual versus fitted plot also shows both the small and large fitted values have similar variances, indicating that the constant variance assumption is also correct. With our large sample size of 574 we can rely on the central limit theorem, which tells us that the distribution of a linear combination of random variables is approximately normal, regardless of the distribution of the random variables.

Finally, because the results of our multiple linear regression models were limited (R^2=.2620), we chose to explore the usefulness of a logistic regression model. Main effect and interaction terms were identical to those entered into the linear regression model and significance was similarly assessed using likelihood ratio tests. For the logistic model, we dropped the "other" race category (n=12) because when we included interaction terms for pre-pregnancy BMI and race, there were too few numbers to accurately generate a maximum likelihood estimate. After dropping the "other" race category, the remainder of our logistic analyses included 566 observations.

RESULTS

Our main linear regression analysis included 574 women, 114 of active duty status and 460 of non-active duty status. Compared to one another, the active duty women were slightly younger, experienced slightly more weight gain during pregnancy, had a lower pre-pregnancy BMI, and had fewer children. Among active duty mothers there were more Black and fewer Asian women compared to the non-active duty mothers. A description of our study sample by active duty status can be found in Table 2.

The main linear regression showed strong effects for both sports participation and walking or bicycling depending on pre-pregnancy BMI. Physical activity associated with household chores was not significant in our analyses and therefore was excluded from the final model. Table 3 displays the results of this analysis. After adjustment for all other covariables in our model, a high level of sports participation (7 or more times in the past 7 days, assessed, on average, at 6 months postpartum) among women with a pre-pregnancy BMI $\geq$25kg/m^2 was associated with a mean weight retention of 4.3 kg at one year postpartum compared to inactive women with a pre-pregnancy BMI <25kg/m^2 (p=.015). A high level of sports participation among women with a pre-pregnancy BMI <25kg/m^2 was associated with a mean weight retention of -2.2 kg at one year postpartum compared to inactive women with a pre-pregnancy BMI <25kg/m^2 (p=.099), after adjusting for other covariables. At one year postpartum, these women weighed, on average, 2.2 kg less than their pre-pregnancy weight. In contrast, a high level of walking or bicycling (7 or more times in the past 7 days for at least 15 minutes at a time, assessed, on average, at 6 months postpartum) among women with a pre-pregnancy BMI $\geq$25kg/m^2 was associated with a mean weight retention of 2.0 kg at one year postpartum compared to inactive women with a pre-pregnancy BMI <25kg/m^2 (p=.029). In general, inactive women with a pre-pregnancy BMI $\geq$25kg/m^2 had a mean weight retention of 2.0 kg at one year postpartum compared to inactive women with a pre-pregnancy BMI <25kg/m^2, after adjusting for the other covariables in our model (p<.0005).

Other factors that were significant at an α=0.05 level include breastfeeding, weight gain during pregnancy, mother's height, marital status, and income. Women who breastfed within the past 7 days (assessed, on average, at 6 months postpartum) had a mean weight retention of -1.1 kg at one year postpartum compared to women who only formula fed within the past 7 days (assessed, on average, at 6 months postpartum) (p=.043). A mean weight retention of .42 kg at one year postpartum was associated with a 1 kg change in weight gain during pregnancy, after adjusting for all other covariables (p<.0005). A mean weight retention of -.23 kg at one year postpartum was associated with a 1 inch (2.54 cm) change in mother's height, after adjusting for all other covariables (p=.004). Married women or women living with a partner had a mean weight retention of 3.4 kg at one year postpartum compared to women who were single or living alone, after adjusting for all other covariables (p<.0005). Mothers with a monthly income of $1501 to <$3001 had a mean weight retention of 1.2 kg at one year postpartum compared to mothers with a monthly income of $\geq$$3001, after adjusting for all other covariables (p=.015). Mothers in the lowest income bracket (<$1501 per month) had a mean weight retention of 1.1 kg at one year postpartum compared to mothers in the highest income bracket (p=.069). This non-significant result may be due to the small number of women in the lowest income bracket.

Despite the above findings, the variables included in our linear regression model explained only 26% of the variability in weight retention at one year postpartum. Unfortunately, investigation of the usefulness of a logistic regression model provided even less information. In fact, none of the physical activity interaction terms or physical activity main effect variables was found to be statistically significant in our logistic regression model. The only variables found to be significant in our final logistic model included: pre-pregnancy BMI, weight gain during pregnancy, marital status, income, and time at middle clinic. Due to the limited usefulness of these results for public health purposes, the remainder of this report refers only to the results of our multiple linear regression analyses.

DISCUSSION

The prevalence of overweight and obesity continues to increase among American women (1). Since pregnancy is a time of required weight gain and thus may be a risk factor for overweight and obesity (2-5), exploring factors such as physical activity that might influence postpartum weight retention is of public health importance. While regular postpartum physical activity may have a positive effect on maternal physical health, research on this topic is limited (6). The few studies that have been conducted have shown promising results (6-9). The results of our study add support to this growing body of research.

Although we hypothesized that active duty women may have lower postpartum weight retention, the results of our analysis indicated that active duty status was not a significant variable in our final regression model. For the women in our sample, the mean weight retention at one year postpartum was almost identical for both active and non-active duty women (approximately 3 kg). These women were also similar on several other characteristics of interest. It may be that active duty status is not a meaningful incentive for women to return to their pre-pregnancy weight or, more likely, it may be that we were unable to detect a true difference in active duty status in our sample of women. Similarly, race was not a significant factor for postpartum weight retention in our analysis. However, previous studies have shown differences in postpartum weight retention between black and white mothers (7, 11).

Given that we know physical activity to be an important determinant of body weight, we might expect postpartum physical activity to have a beneficial impact on postpartum weight retention. We found that mothers with a pre-pregnancy BMI $\geq 25kg/m^2$ who were in the highest level of sports participation at six months postpartum had a positive mean weight retention (4 kg) at one year postpartum compared to inactive women with a pre-pregnancy BMI $<25kg/m^2$. However, had these same women participated at a lower level of sports participation their mean weight retention may have been greater at one year postpartum. In contrast, mothers with a pre-pregnancy BMI $<25kg/m^2$ who were in the highest level of sports participation had a negative mean weight retention (-2.2 kg) compared to inactive women with the same pre-pregnancy BMI. This result is reasonable given that we would expect women with a "normal" pre-pregnancy BMI who are highly active to experience less weight retention compared to women with similar pre-pregnancy BMIs who are less active.

We also found that mothers with a pre-pregnancy BMI $<25kg/m^2$ who were in the highest level of walking or bicycling at six months postpartum had a positive mean weight retention (2 kg) at one year postpartum compared to inactive women with similar pre-pregnancy BMIs. While at first this result may seem counterintuitive, walking or bicycling in our study was assessed as a form of transportation, not necessarily as a vigorous physical activity. Thus, the highest of level of walking or bicycling may not have captured a level of physical activity sufficiently vigorous to substantially impact postpartum weight retention.

Several significant characteristics in our final regression model have also been found to be important predictors of postpartum weight retention in other studies. For example, weight gain during pregnancy has consistently been associated with postpartum weight retention (12-17). This is important in light of the fact that recommendations for weight gain during pregnancy are motivated by concerns for the health of the infant (18). Less emphasis is placed on long-term maternal health with respect to the potential for overweight or obesity. Recent studies have shown inconsistent results regarding the association between pre-pregnancy weight or BMI and postpartum weight retention (7, 11, 19). Similar to the findings of Parker and Abrams (11) and Boardley et al. (7), we also found pre-pregnancy BMI to be highly significant in our analysis. Breastfeeding, another factor often investigated in studies of postpartum weight retention, was significant in our regression model. However, we should be cautious in our interpretation of this result due to the narrow definition of breastfeeding used for our analyses ("type of milk baby was fed within the past 7 days," assessed, on average, at 6 months postpartum). Other researchers have suggested the importance of improved measures of breastfeeding duration and intensity to better understand the true relationship between this factor and postpartum weight retention (2).

In our analysis education was not a significant variable. However, our model indicates that lower income mothers retain slightly more postpartum weight than higher income mothers. If we view income as a proxy for socioeconomic status (SES), our findings suggest that lower SES women may retain more weight postpartum than higher SES women. This finding is reasonable given that overweight and obesity are known to be associated with SES (20, 21). Similar to Kahn et al. (22), we also found a highly significant association between marital status and weight retention postpartum. In our sample, women who were married or living with a partner had greater mean weight retention at one year postpartum than those who were single or living alone. This finding may be a reflection of lifestyle differences, including dietary and exercise habits.

There are potential limitations of our study that deserve consideration. While our study was originally designed to obtain measured weight at one year postpartum, due to difficulties with our external contractor, data collection was not optimal. Thus, a large number of women in our study self-reported their weight at one year postpartum, rather than having their weight expertly measured at a clinic visit. Pre-pregnancy weight was also self-reported by women at baseline. Studies have shown that measured weight correlates well with self-reported weight in women (23, 24). However, we cannot eliminate the possibility that recall bias affected our coefficient estimates. Differential recall of physical activity by heavier women may have been another potential source of information bias. Previous research has found that women who are overweight or obese may overestimate their level of physical activity (25). Unfortunately, we have incomplete physical activity data from clinic visits both prior and subsequent to the clinic visit at six months postpartum. Given that the physical activity questions assess exercise within the past seven days, the usefulness of only using the physical activity data at the six month clinic visit is limited.

A strength of our study includes the large sample size of mothers (n=574) used to assess differences in weight retention at one year postpartum. Additionally, our questionnaires were designed to collect data on a variety of characteristics that could prove useful in predicting postpartum weight retention. Medical record abstraction allowed us to accurately calculate the total weight gain during pregnancy for the mother and to report the birthweight of the infant, both variables considered in our linear regression models. Another important strength of this study is the long-term follow-up that enabled the calculation of postpartum weight retention at approximately one year postpartum. Considering that the amount of time needed to return to pre-pregnancy weight is unknown, a longer follow-up period may allow us to better assess postpartum weight retention and the factors that influence this outcome.

Given that the variables included in our final linear regression did not explain more than 26% of the variability in weight retention at one year postpartum, we do not recommend that this model be used to predict weight retention among this sample or among similar populations of women. Inclusion of factors not considered in these analyses might improve the usefulness of similar models to predict postpartum weight retention. For example, consideration of both prenatal and postpartum physical activity in the same model could be advantageous. Although studies have investigated prenatal and postpartum physical activity individually, fewer have considered these factors simultaneously. Inclusion of dietary factors in future analyses may also increase the predictive value of similar models. Furthermore, in a study of this kind, oversampling of non-white groups may enhance the ability of our statistical tests to detect true differences among racial groups. Thus, a non-military population may be better suited to such a study design.

Further investigation into the effects of postpartum exercise is warranted given our findings and the fact that postpartum physical activity may positively influence overall well-being of both mother and child (6). Although assessment of physical activity is undoubtedly challenging , it is important to continue to explore this factor because without a clear understanding of the cause of postpartum weight retention, it is difficult to design effective strategies for intervention.

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TABLE 1. Differences in outcome (weight retention) based on comparisons between complete and missing data for individual variables.

	Complete data		Missing data		X^2
Variable with missing information	**Count**	**%**	**Count**	**%**	**(P-value)**
Sports Participation*	721	93.0	54	7.0	9.2 (0.003)
Walking/Bicycling*	720	93.0	55	7.0	15.7 (0.0005)
Household Chores*	724	93.4	51	6.6	13.6 (0.0005)
Breastfeeding	731	94.3	44	5.7	17.0 (0.0005)
Income	761	98.2	14	1.8	0.002 (0.961)
Education	773	99.7	2	0.3	0.53 (0.467)
Parity	726	93.7	49	6.3	0.076 (0.783)
Birthweight	687	88.6	88	11.4	2.4 (0.119)
Mother's Age	772	99.6	3	0.4	0.80 (0.372)

*Number of times during the past seven days (assessed, on average, at six months postpartum)

TABLE 2. Distribution of study characteristics by active duty status

Characteristic	Active duty (n=114)		Non-active duty (n=460)	
Maternal age: mean (se)	25.72	(5.78)	26.82	(5.34)
Pre-Pregnancy weight (kg): mean (se)	62.54	(10.41)	64.16	(13.74)
Pregnancy weight gain (kg): mean (se)	17.04	(5.16)	15.57	(5.92)
Mother's height (cm): mean (se)	162.46	(7.00)	161.85	(6.85)
Weight retained (kg): mean (se)	3.36	(6.02)	3.45	(5.66)
Pre-Pregnancy BMI (kg/m^2): n (%)				
<25	83	(72.81)	296	(64.35)
≥25	31	(27.19)	164	(35.65)
Parity*: n (%)				
0	85	(74.56)	201	(43.70)
1	25	21.93)	178	(38.70)
2	4	(3.51)	59	(12.83)
3	0	(0.00)	17	(3.70)
4	0	(0.00)	5	(1.09)
Education: n (%)				
Less than high school	1	(0.88)	13	(2.83)
High school/vocational or trade school	56	(49.12)	161	(35.00)
Some college/some graduate school	57	(50.00)	286	(62.17)
Income: n (%)				
<$1501 per month	23	(20.17)	95	(20.65)
$1501 to <$3001 per month	45	(39.48)	251	(54.56)
≥$3001 per month	46	(40.35)	114	(24.78)
Race: n (%)				
White	63	(55.26)	275	(59.78)
Black	28	(24.56)	48	(10.43)
Asian	5	(4.39)	56	(12.17)
Hispanic	17	(14.91)	71	(15.43)
Other	1	(0.88)	10	(2.17)
Married or living with partner: n (%)				
Yes	99	(86.84)	443	(96.30)
No	15	(13.16)	17	(3.70)

*Number of other children, not including new baby (index child)

TABLE 3. Significant results from final multiple linear regression model (n=574)

Characteristic	coefficient*	(se)	p-value	95% Confidence Intervals
Sports participation*				
High level with pre-pregnancy BMI ≥25 kg/m²	4.283	1.760	.015	(.826, 7.74)
High level with pre-pregnancy BMI <25 kg/m²	-2.193	1.326	.099	(-4.797, .411)
Walking or bicycling†				
High level with pre-pregnancy BMI ≥25 kg/m²	-.596	1.342	.657	(-3.232, 2.040)
High level with pre-pregnancy BMI <25 kg/m²	1.996	.912	.029	(.204, 3.787)
Pre-pregnancy BMI (kg/m²)‡	1.963	.478	<.0005	(1.025, 2.901)
Breastfeeding¶				
Breast milk only	-1.062	.524	.043	(-2.092, -.032)
Both breast milk and formula	.616	.565	.277	(-.494, 1.726)
Pregnancy weight gain (kg)	.422	.037	<.0005	(.349, .495)
Mother's Height (cm)	-.089	.031	.004	(-.151, -.028)
Married or living with partner§	3.353	.923	<.0005	(1.540, 5.165)
Income¥				
<$1501 per month	1.139	.624	.069	(-.088, 2.365)
$1501 to <$3001 per month	1.222	.503	.015	(.234, 2.211)
Time at middle clinic visit£	.023	.008	.004	(.008, .039)
Time at late clinic visit^	-.013	.004	.002	(-.021, -.005)

* High level of sports participation = 7 or more times in the past seven days (assessed, on average, at six months postpartum); Sports participation coefficients are computed with respect to no sports participation within the past seven days and a pre-pregnancy BMI of <25 kg/m²

†High level of walking/bicycling = 7 or more times in the past seven days for at least 15 minutes at a time (assessed, on average, at six months postpartum); Walking/bicycling coefficients are computed with respect to no walking or bicycling within the past seven days and a pre-pregnancy BMI of <25 kg/m²

‡Coefficient computed with respect to a pre-pregnancy BMI of <25 kg/m²

¶Breastfeeding = the kind of milk the baby was fed in the past seven days (assessed, on average, at six months postpartum); Coefficient is computed with respect to the baby being fed formula only

§Coefficient is computed with respect to being single or not living with a partner

¥Coefficient is computed with respect to ≥$3001 per month

£Middle clinic visit = postpartum clinic visit (on average, six months postpartum); Relevant variables collected at this visit include postpartum exercise and breastfeeding

^Late clinic visit = postpartum clinic visit (on average, one year postpartum); weight measured at this visit was used to compute weight retention at one year postpartum

Is Postpartum Depression Associated with Maternal Weight Retention?

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Precis

Postpartum depression is associated with maternal weight retention, though this relationship does not appear to be mediated by body image or a history of weight cycling.

Abstract

Objective: To explore the relationship between postpartum depressive symptomatology during the first postpartum year, as measured by the Center for Epidemiologic Studies Depression (CES-D) Scale, and maternal postpartum weight retention, history of weight cycling, and concerns about body image.
Methods: Cross sectional data from the "After the Baby Comes Study" were analyzed using 516 participants with normal prepregnancy body mass indexes. Twenty percent of the respondents were active duty while the remainder of the sample made up of wives of servicemen. Postpartum weight and questionnaire data on depression, maternal stressors, psychosocial and demographic data were collected an average of 4.5 months after birth. Data on depression were analyzed using several different multivariable models which yielded similar results.
Results: The prevalence of CES-D score $\geq$ 16 was 39.0%. After adjusting for marital satisfaction, maternal stress, race, income and other maternal characteristics, maternal postpartum weight retention was significantly associated with a CES-D score $\geq$ 16 (OR=1.06; 95% CI 1.01,1.10). Neither history of weight cycling or concerns about body image were associated with an elevated CES-D score. Other significant predictors included marital dissatisfaction, self-perceived stress, stress about childcare and Asian race.
Conclusion: Our study suggests that maternal weight retention may play a role in postpartum depression. The mechanism for this association does not appear to act though history of weight cycling or concerns about body image.

Introduction

Postpartum depression (PPD) is an important public health concern. Clinically diagnosed PPD effects approximately 10 - 13% of all mothers during the first postpartum year [1, 2] while 20-30 % of new mothers experience high levels of depressive symptomatology during this same time period [3]. Both clinically diagnosed PPD and elevated depressive symptomatology have been associated with negative outcomes for mother and infant. Examples include adverse effects on the mother's relationship with the infant and significant others, as well as problems with the infant's emotional and psychological development [2, 4, 5]. Unfortunately, postpartum depression is considerably under-diagnosed, thus it is important to further our knowledge of risk factors to develop effective screening tools to promote better assessment, treatment and prevention [1, 2, 4].

Previous studies have identified several risk factors for postpartum depression, including, in order of the strength of the relationship, prenatal depression, low self-esteem, childcare stress, prenatal anxiety, life stress, low social support, marital dissatisfaction, history of previous depression, infant temperament, maternity blues, marital status, low socioeconomic class, and unplanned/unwanted pregnancy [1, 6, 7].

Pregnancy and the postpartum period are times of rapid weight change. Although thinness is highly valued in most Western societies [8], the incidence of obesity is dramatically increasing [9]. Though depression in women is also common [2], little is known about the relationship between PPD and issues surrounding weight, body image and dieting history. Cameron et al. showed that increased body weight predicted increased dysphoria during the 3rd trimester in 96 white, inner-city women [10]. Carter et al. found increased BMI to be associated with higher CES-D scores in 64 women at both at 4 and 14 months postpartum[11].

Though absolute maternal weight appears associated with depressive symptoms, it is unknown if this relationship is mediated by other factors such as body image. Current hypotheses on the role of body image suggest that it is an indirect mediator of psychological wellbeing through its effects on self-esteem. Prior studies have shown that weight dissatisfaction and poor body image are associated with lowered self-esteem in women [12].

Weight cycling, defined as repeated periods of weight loss and regain during non-reproductive periods, may also contribute to poorer psychological outcomes due to decreased self esteem or self-efficacy. To date, studies have not shown an association between weight cycling and depression in non-pregnant normal or overweight women [13, 14] or in pregnant overweight women [15].

Our study explores the relationship between postpartum depression symptomatology (as measured by the Center for Epidemiologic Studies Depression (CES-D) Scale) during the first postpartum year and various maternal characteristics variables including postpartum weight retention, history of weight cycling, maternal stressors and body image. Specifically, we asked, in women who begin pregnancy at a normal BMI, is postpartum depression (as assessed by the CES-D) associated with (1) post partum weight retention, (2) a history of weight cycling as defined as losing 10 pounds intentionally on more than 3 occasions in the mother's life, (3) poor perceived body image and (4) high levels of self-perceived stress, childcare concerns, and financial security.

Methods

Data

The "After the Baby Comes" Study (ABC study) was conducted at the Balboa Pediatrics Clinic at the Naval Medical Center San Diego in order to investigate the relationship between biological, lifestyle and psychosocial factors and patterns of maternal weight changes during the first postpartum year. All mothers enrolled in this study were either active duty military personnel or dependents of active duty servicemen. In addition to military affiliation, eligible women had an infant that did not spend more than 72 hours in intensive care, and completed a clinic visit questionnaire after 2 months postpartum. Of the 7,723 women who received well-baby care at the Balboa Pediatric Clinics between April 1997 and December 1999, 4,321 women were screened, with 2,812 meeting these requirements.

Information for the study was collected through multiple questionnaires during the course of the first postpartum year. For this analysis, cross-sectional data in the form of two questionnaires were used: (1) a baseline questionnaire, filled out by the participants once, usually within the first month of their enrollment in the study, which contained the CES-D scale and (2) a clinic questionnaire, which was completed within 30 days of the baseline questionnaire and contained additional psychosocial information. After excluding women with CES-D questionnaires with greater than 2 missing responses (n=13), data were available from 1477 women. The study sample was further limited to women with a prepregnancy BMI within the normal range (BMI 20-25), (n=882) and to those who had complete data on the variables used in the analysis. The final sample included 516 mothers.

The study protocol was approved by the UC Berkeley IRB for the use of human subjects.

Questionnaires and Measures

The Center for Epidemiologic Study Depression (CES-D) Scale is a widely used self-report instrument with 20 items, each rated according to the duration and/or frequency experienced during the previous week. The possible range of scores is from 0 to 60, with a score of 16 or greater corresponding to the threshold value used by most researchers and clinicians to indicate "elevated" depressive symptoms [16]. A dichotomized CES-D, (0-15 vs. $\geq$ 16) has been validated in numerous populations and reflects the 80^{th} percentile in one large community sample [17]. Alternatively, in a recent study of depressive symptoms in mothers of toddlers, McLennan et al advocated using a trichotomized CES-D, with 0-15 reflecting "no" depression, 16-22 "possible" depression and $\geq$ 23 or greater, "probable" depression, which may be more closely correlated with clinically diagnosed depression [18].

Coding discrete data as categorical introduces arbitrary cutoffs that may obscure true statistical relationships [19]. For these reasons, this study analyzed the CES-D scale in three different ways, (1) as a dichotomous outcome with one group <16 and the other $\geq$ 16 (2) as a categorical outcome with groups of 0-15, 16-22, and 23 and above and (3) as a discrete variable with reported values from 0-60.

Any missing values on the CES-D were coded as zero, which reduces the CES-D value and biases any possible associations towards the null.

Predictor variables

Time was reported in days since birth of the infant. Maternal age was reported in years. Parity was a discrete variable from 0-5 in our study population. Active duty status and postpartum smoking were self-reported (Y/N). The definitions of additional predictor variables used in the analysis are summarized in the Table 1.

A four point scale was used to assess body image in terms of worries about weight, shape and appearance. Body perception, as measured by assessed the discrepancy between the woman's current BMI status and her self-reported perception about her weight (underweight, normal, overweight, obese), was also evaluated but no difference was found between these different ways of approaching body image, therefore only the "worry" questions were used.

Postpartum weight retention was also calculated in two ways. The variable "retention" was created subtracting the maternal postpartum weight at the time of the baseline questionnaire completion from the reported prepregnancy weight. Due to concerns about "part-whole" correlation between pregnancy weight gain and weight retention [19], retention was also calculated by post statistical analysis where prepregnancy weight and post partum weight were placed in the model separately. The results were similar, so only the latter analysis is presented here.

Analysis

All statistical analyses were conducted using STATA 7.0 statistical software [20]. Univariate distributions and correlations were examined for independent variables and the dichotomized CES-D. Linear regression analysis was conducted using the discrete values of the CES-D as the outcome of interest. Multiple logistic regression was then performed using a CES-D score of 16 or greater as the outcome of interest. Finally, multinomial logistic (m-logit) models were used for the trichotomized CES-D outcome of 0-15, 16-22, and >23. M-logit models allow direct analysis of three groups, using odds ratios to compare variables from a given group to the one designated as the reference group.

Due to concerns that risk factors for depression may vary in women of different postpartum body size, interaction due to weight retention was assessed by stratifying the population into 2 groups, postpartum BMI>26 vs. BMI≥26, and reanalyzing the linear and logistic models. No interactions were found. Due to the limited size of the racial groups and the complexity of the model, we were unable to stratify the data by the four racial groups. However, the linear model was rerun just in the white study population (n=310) and showed no differences in the associations when compared to the model with all four races included.

Finally, post hoc mean CES-D scores were estimated for various levels of an independent variable, while holding all other independent variables in the model constant at the population mean values.

Results

Tables 2 and 3 show that the analyzed study population (n=516) did not differ substantially from the total study population (n=883). Study data were collected on average at 143 days (4.7 months) postpartum. The study population was racially diverse and virtually all were married. A high proportion of women attended at least some college.

Mean CES-D score was 14.3. Two out of 5 women had a CES-D of 16 or greater, and approximately 1 in 5 women had a CES-D of $\geq$23, corresponding to the higher cutoff of "probable depression" (Table 3).

Results of the full multiple linear regression model with CES-D score as a discrete outcome are shown in Table 4. After adjustment for all variables in the model, women who reported higher levels of self-perceived stress, marital dissatisfaction, child care stress, and financial insecurity were significantly more likely to have elevated CES-D scores. There was a 0.17 increase in CES-D score per kilogram retained over the woman's prepregnancy weight.

Table 5 shows the results of the full logistic regression model, with dichotomized CES-D score (<16 vs. $\geq$ 16) as the outcome. Similar to the linear regression model, self-perceived stress, marital dissatisfaction, childcare stress, and maternal postpartum weight were significant predictors. Asian race was also significant in this model.

Results of the m-logit analysis with the trichotomized CES-D score as outcome are shown in Table 6. Self perceived stress was significantly associated with both possible and probable depression when compared to women with low depressive symptoms (CES-D <16). Furthermore, women with probable depression were more likely to report stress than those with possible depression, suggesting a dose response. Marital dissatisfaction and child care stress were significantly associated with both levels of depression compared to the reference group. Compared to whites, Asian women were more likely to fall in the possible depression category but were significantly less likely to fall into the probable category. No other racial differences were apparent. Maternal postpartum weight was significantly associated with probable, but not possible, depression.

Post statistical analysis were used to estimate the unique impact of self-perceived stress, child care stress, martial satisfaction, maternal postpartum weight and race on mean CES-D score (Figure 1). The average predicted CES-D score for women who had no self-perceived stress was 9.3 $\pm$ 0.89, while women who reported feeling of stressed most of the time had a predicted CES-D score of 22.3 $\pm$ 1.17, almost above the cutoff for "probable depression". The predicted mean CES-D scores for childcare stress and marital satisfaction were of similar magnitude. Maternal post partum weight had a smaller absolute effect on mean CES-D scores, with women who retained 10 kg after pregnancy having a predicted CES-D score only 1.5 points higher than women who retained no weight at all.

Though race did not reach levels of statistical significant in the model, predicted mean CES-D scores were produced for the 4 racial groups, as shown in Figure 2. While the predicted CES-D scores for whites and blacks do not appear different, the mean CES-D scores for both Asians and Hispanics are elevated in comparison to whites.

Discussion

This study was conducted in a military affiliated population, but our findings suggest that our population may be comparable to other studied populations of postpartum women. For example, our 39% prevalence rate of elevated depressive symptoms falls well within the 25-42% prevalence range reported by other studies in the literature that have used self-reported depression questionnaires like the CES-D [21-23]. In addition, our study agrees with previous studies; we found strong associations between self-perceived stress, child care stress, marital dissatisfaction and postpartum depression, but no association between postpartum depression and other psychosocial variables like income, age, and education [1, 7]. We could not examine an association between postpartum depression and marital status, due to the almost complete lack of unmarried women in our sample.

Although of smaller magnitude than other psychosocial factors such as stress or marital satisfaction, the association between postpartum weight retention and post partum depression found in this study may be clinically significant given the high prevalence of obesity in the US population. Our results, coupled with the prospective findings of Carter et al of a positive association between BMI and depression at both 4 and 14 months after birth [11], suggest the need to further explore the relationship between childbearing, weight and mood.

This study does not support an association between body image and elevated depressive symptoms. Though Freedman and colleagues reported an association between poor body image and depression in obese non-postpartum women [24], and Abraham et al. found women with body weight and shape concerns during pregnancy more likely to suffer from postnatal distress during the first few weeks after birth [25], our larger study of normal weight postpartum women did not confirm these findings. Furthermore, no association between a history of weight cycling and elevated depressive symptoms in new mothers was apparent (Table 4, 5). Our results in postpartum women coupled with knowledge from studies in non-pregnant [13, 14] and pregnant [15] women suggesting that weight cycling is probably not an independent risk factor for post partum depression.

This study was cross-sectional, thus we cannot determine causality especially given that stress, problems with relationships, and weight fluctuations are symptoms as well as predictors of depression. Because the ABC study was designed to assess postpartum weight retention as its primary outcome of interest, no data were collected on the women's past psychiatric history. Postpartum depression is strongly predicted by depression during pregnancy and a history of prior mood disorder [1, 7, 26]. Therefore, we do not know if the depression seen in our sample started after delivery or after conception or was simply a continuation of a long-standing mood disorder. Unfortunately, we have no information on the treatment status of these women, making it impossible to assess any differences in women being treated for mood disorders.

Our study was also limited by the small sample size of our non-white ethnic groups. Though this study is one of the few studies of postpartum depression to include Asian and Hispanic women, our small numbers limited the power of the study to detect actual differences between racial groups, although our findings suggest a possible difference in the rates of postpartum depression for Asians and Hispanics as compared to whites. Most studies of postpartum depression have not found race to be a significant predictor of PPD but only described black – white differences, which in our study never approached significance. Hopefully, future studies on the prevalence and risk factors associated with post partum depression will enroll greater numbers of non-white groups.

In summary, our study reaffirms that postpartum depression is a common condition that is associated with various psychosocial factors such as stress, marital dissatisfaction and financial insecurity. Furthermore, increased maternal body weight is also associated with depressive symptoms, but this relationship does not seem to be mediated through body image or a history of weight cycling.

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Table 1 Summary of Variables Used in all Statistical Models

Variable Name	Definition
Race:	
White	Self-reported white only
Black	Self-reported black or any mixture of black and other/white
Asian	Self-reported Asian or any mixture of Asian and other/white
Hispanic	Self-reported Hispanic or any mixture of Hispanic and other/white
Income	1= $500/mo. Or less. 2= $501-1000/mo. 3= $1001-1500/mo. 4= $1501-2000/mo. 5= $2001-2500/mo. 6= $2501-3000/mo. 7= $3001-6250/mo. 8= More than $6250/mo.
Education	1= Less than high school 2= High school or equivalent 3= Trade or Vocational School 4= College 5= Graduate School
History of weight cycling	Y/N; = losing 10 or more pounds intentionally 3 or more times during the subject's lifetime
Marital Satisfaction	1= Very Satisfied 2= Satisfied 3= Dissatisfied 4=Very Dissatisfied
Self-perceived Stress	"Having a baby adds a lot of responsibilities to the lives of new mothers. During the past 7 days, how often have you felt stressed?" 1= Rarely or none of the time 2= Some of the time 3= More than half of the time but not most of the time 4= Most or all of the time
Childcare Stress	"During the past 7 days, how often have you felt stress or concern about the child care of your baby?" 1= Rarely or none of the time 2= Some of the time 3= More than half of the time but not most of the time 4= Most or all of the time
Financial insecurity	"Do you have enough money to pay the bills this month?" 1= Yes 2= No or Not Sure
Body Image Concerns: Worry about Weight, Shape and Appearance	"During the past 7 days, how often did you worry about your (appearance/shape/weight)?" 1= Rarely or none of the time 2= Some of the time 3= More than half of the time but not most of the time 4= Most or all of the time

Table 2 Comparing Maternal Characteristics between the Total Eligible Sample (N=803) and the Sample with Complete Data Used in Models (N=516)

Maternal Characteristics	Total eligible N=803	Model N=516
Time, days (mean±sd)	143.3 ± 79.6	137.6 ± 75.2
Age, yrs. (mean±sd)	25.8 ± 5.6	25.9 ± 10.4
Parity, n (%)		
Primiparous	372 (50.3)	256 (49.6)
Multiparious	367 (49.7)	260 (50.4)
Race, n (%)		
White	473 (59.0)	310 (60.0)
Black	102 (12.7)	58 (11.2)
Asian	101 (12.6)	65 (12.6)
Hispanic	127 (15.8)	83 (16.1)
Education, n (%)		
Did not complete H.S.	39 (4.9)	25 (4.8)
Completed H.S./ GED	255 (31.8)	157 (30.4)
Vocational or trade school	49 (6.1)	34 (6.6)
College	399 (49.8)	258 (50.0)
Graduate School	59 (7.4)	42 (8.1)
Income, n (%)		
$0-500/mo.	6 (0.8)	3 (0.6)
$501-1000/mo.	49 (6.2)	32 (6.2)
$1001-1500/mo.	122 (15.5)	75 (14.5)
$1501-2000/mo.	157 (20.0)	100 (19.4)
$2001-2500/mo.	144 (18.3)	89 (17.3)
$2501-3000/mo.	104 (13.2)	73 (14.2)
$3001-6250/mo.	179 (22.8)	126 (24.4)
>$6250/mo	25 (3.2)	18 (3.5)
Married/living with partner n (%)		
Yes	754 (93.9)	500 (96.9)
No	49 (6.1)	16 (3.1)
Active duty, n (%)		
Yes	178 (22.1)	104 (20.2)
No	625 (77.8)	412 (79.8)
Maternal Height, cm. (mean±sd)	162.3 ± 6.9	162.5 ± 6.8
Maternal Prepregnancy Weight kg. (mean±sd)	60.2 ± 6.8	60.4 ± 6.7
Maternal Postpartum Weight kg. (mean±sd)	65.5 ± 9.7	65.6 ± 9.0
Ever smoked n (%)		
Yes	283 (35.3)	188 (36.4)
No	519 (64.7)	328 (63.6)

Table 3 Comparing Outcome Variables between the Total Eligible Sample (N=803) and the Sample with Complete Data, Used for Models (N=516)

Outcome Variables	Total eligible N=803	Model N=516
CES-D (mean$\pm$sd)	14.5 $\pm$ 10.6	14.3 $\pm$ 10.4
10-15 n (%)	480 (59.8)	315 (61.1)
16-22	162 (20.2)	101 (19.6)
$\geq$ 23	161 (20.1)	100 (19.4)
History of Weight Cycling n (%)		
Yes	187 (23.3)	128 (24.8)
No	616 (76.7)	388 (75.2)
Satisfied with relationship, n (%)		
Very satisfied	372 (60.2)	322 (62.4)
Satisfied	207 (33.5)	165 (32.0)
Dissatisfied	25 (4.0)	21 (4.1)
Very dissatisfied	11 (1.8)	8 (1.6)
Self-perceived Stress during last week, n (%)		
None/rarely	159 (24.8)	127 (24.6)
Sometimes	319 (49.8)	257 (49.8)
More than half, but not most	122 (19.0)	97 (18.8)
Most or all of the time	48 (7.5)	35 (6.8)
Childcare stress during last week, n (%)		
None/rarely	368 (57.6)	309 (59.9)
Sometimes	181 (28.3)	147 (28.5)
More than half, but not most	66 (10.3)	43 (8.3)
Most or all of the time	24 (3.8)	17 (3.3)
Financial insecurity: "Enough money to pay the bills" n (%)		
Yes	153 (20.0)	100 (19.4)
No/Not sure	612 (80.0)	416 (80.6)
Worried about shape during last week, n (%)		
None/rarely	136 (21.3)	108 (20.9)
Sometimes	283 (44.2)	231 (44.8)
More than half, but not most	130 (20.3)	104 (20.2)
Most or all of the time	91 (14.2)	73 (14.2)
Worried about weight during last week, n (%)		
None/rarely	170 (26.6)	134 (26.0)
Sometimes	262 (41.0)	217 (42.1)
More than half, but not most	121 (18.9)	95 (18.4)
Most or all of the time	86 (13.5)	70 (13.6)
Worried about appearance during last week, n (%)		
None/rarely	129 (20.1)	103 (20.0)
Sometimes	296 (46.2)	234 (45.4)
More than half, but not most	130 (20.3)	111 (21.5)
Most or all of the time	86 (13.4)	68 (13.2)

Table 4 Linear Regression model (n=516) with CES-D 0-60 as the outcome. R-squared 0.40.

	Coefficent	(95% CI)
Time	0.01	(-0.00, 0.02)
Maternal age	-0.08	(-0.25, 0.08)
Black	0.30	(-2.28, 2.88)
Asian	1.61	(-0.94, 4.16)
Hispanic	1.74	(-0.47, 3.96)
Income	-0.45	(-0.99, 0.09)
Education	-0.65	(-0.98, 0.83)
Parity	-0.08	(-1.39, 0.10)
Marital status	1.64	(-2.64, 5.92)
Marital satisfaction	**2.92**	**(1.71, 4.12)***
History of weight cycling	0.59	(-1.18, 2.35)
Maternal Height	-0.06	(-0.23, 0.11)
Maternal Postpartum weight	**0.17**	**(0.03, 0.31)***
Maternal Prepregnancy weight	-0.13	(-0.35, 0.10)
Self-perceived Stress	**4.34**	**(3.35, 5.33)***
Child care stress	**2.58**	**(1.57, 3.60)***
Financial insecurity	**2.56**	**(0.57, 4.56)***
Worry about shape	0.32	(-1.34, 1.99)
Worry about weight	0.50	(-1.09, 2.09)
Worry about appearance	-0.39	(-1.60, 0.81)
Active duty	-1.11	(-3.07, 0.86)
Smoking (yes is baseline)	-0.84	(-2.47, 0.80)

* *p*<.05; ***p*<.01; ****p*<.001.

Table 5 Multiple logistic regression (n=516) with CES-D ≥ 16 as the outcome. Pseudo R squared 0.29

	OR	(95% CI)
Time	1.00	(0.99, 1.00)
Maternal age	0.97	(0.92, 1.03)
Black	0.79	(0.33, 1.85)
Asian	**3.10**	**(1.43, 6.72)****
Hispanic	1.45	(0.73, 2.87)
Income	0.92	(0.78, 1.09)
Education	0.82	(0.65, 1.04)
Parity	1.06	(0.81, 1.40)
Marital status	1.90	(0.46, 7.89)
Marital satisfaction	**2.14**	**(1.46, 3.16)*****
History of weight cycling	1.27	(0.74, 2.17)
Maternal Height	0.98	(0.93, 1.04)
Maternal Postpartum weight	**1.06**	**(1.01, 1.10)****
Maternal Prepregnancy weight	0.96	(0.89, 1.03)
Self-perceived Stress	**2.55**	**(1.86, 3.49)*****
Child care stress	**1.99**	**(1.45, 2.73)*****
Financial insecurity	1.43	(0.79, 2.56)
Worry about shape	1.17	(0.70, 1.96)
Worry about weight	1.07	(0.65, 1.75)
Worry about appearance	1.01	(0.69, 1.46)
Active duty	0.84	(0.45, 1.58)
Smoking	0.67	(0.41, 1.10)

p<.05; ***p*<.01; ****p*<.001.

Table 6 Significant associations using m-Logit model, with trichotomized CES-D as outcome.

In comparison to women with CES-D scores less than 16:

Women with CES-D scores between 16 and 22 were more likely to be:

	OR	(95% CI)
Asian	**4.26**	**(1.86, 9.77)*** **
Self-perceived stress	**2.11**	**(1.48, 3.01)*** **
Marital satisfaction	**1.86**	**(1.20, 2.88)** **
Child care stress	**1.78**	**(1.25, 2.54)*** **

Women with CES-D scores $\geq$ 23 were more likely to be:

	OR	(95% CI)
Self-perceived stress	**3.26**	**(2.21, 4.82)*** **
Marital Satisfaction	**2.61**	**(1.64, 4.16)*** **
Child care stress	**2.36**	**(1.61, 3.45)*** **
Maternal Post Partum Weight	**1.09**	**(1.03, 1.15)** **

In comparison to women with CES-D scores between 16 and 22:

Women with CESD scores $\geq$ 23 were more likely to be:

	OR	(95% CI)
Self-perceived stress	**1.55**	**(1.05, 2.27)* **
Asian	**0.38**	**(0.14, 1.00)* **

p<.05; ***p*<.01; ****p*<.001

Figures 1: Predicted CES-D Scores for Changes in a Single Independent Variable while Holding All Other Variables in the Model Constant at the Population Means

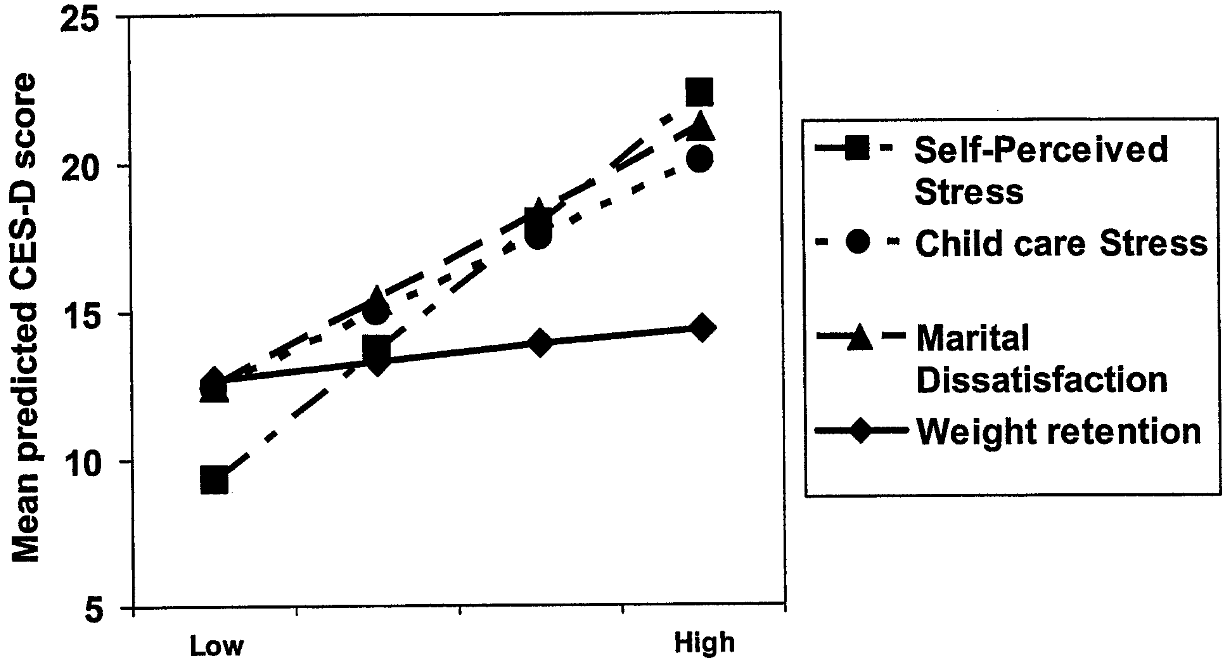
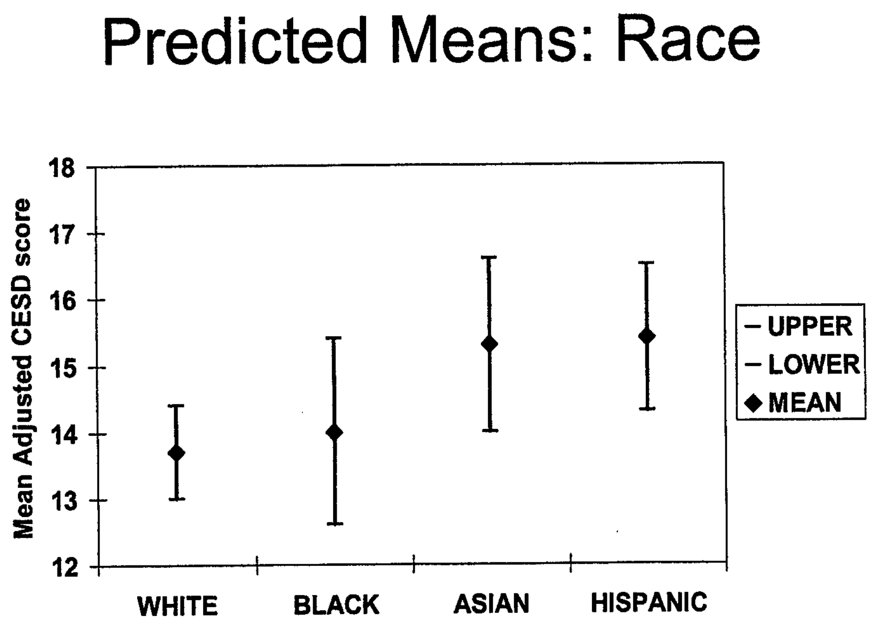


Figure 2 Predicted Mean Adjusted CES-D Scores for the Four Race/Ethnicity Groups Studied.



Predictors of Breastfeeding Initiation and Duration Among Races in a Military Population

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ABSTRACT

Background: Breastfeeding initiation and duration rates in the United States have yet to achieve Healthy People 2010 objectives, and racial disparities have been reported. We examined whether breastfeeding initiation and duration to six months postpartum differed by four maternal race-ethnicity groups, identified predictors of breastfeeding initiation and duration, and assessed reasons reported by women for discontinuing breastfeeding before and after six months postpartum in a military population.

Study Design: A cross-sectional study based on maternal retrospective assessment of infant feeding practices was used to evaluate breastfeeding initiation and duration among white, African-American, Asian, and Hispanic women who received well-baby care for their infants at the Balboa Pediatrics Clinic at the Naval Medical Center San Diego (NMCSD) between April 1997 and December 1999. Medical record abstraction provided additional data not included on self-report questionnaires.

Results: Racial differences in rates of breastfeeding initiation and duration were not found. Overall, four out of five women initiated breastfeeding, and two out of five women continued to breastfeed to at least six months after delivery. Factors significantly associated with breastfeeding initiation were college attendance, income, and infant birthweight. Maternal age, height, gestational weight gain, smoking postpartum, and WIC participation postpartum significantly influenced breastfeeding duration to at least six months following delivery. Reasons for stopping breastfeeding varied by race and by time postpartum.

Conclusions: Although no racial-ethnic differences were found for breastfeeding initiation and duration rates, overall rates were remarkably higher than national averages, which may reflect the unique nature of a military population. The effects of breastfeeding promotion practices, the military environment, and WIC participation are considered.

BACKGROUND

Breastfeeding provides the optimal form of nutrition for infants, and is associated with a broad range of developmental, psychological, immunological, economic, and environmental benefits for both infant and mother(1-4). Current recommendations by global health agencies and professional organizations stipulate that infants should be exclusively breastfed for approximately the first six months of life, and continue to be breastfed with appropriate introduction of supplementary solid foods for at least 12 months(5-9). Given the health benefits of breastfeeding, it is important to evaluate which women choose to initiate breastfeeding, which women continue to breastfeed to at least six months, and why women discontinue breastfeeding before or after the recommended six-month timeframe.

Breastfeeding Rates

Despite nationwide efforts to promote breastfeeding, initiation and duration rates in the United States remain below national objectives. While breastfeeding rates have increased over the last thirty years(10, 11), further increases are necessary to achieve Healthy People 2010 objectives of 75 percent of mothers initiating breastfeeding in the early postpartum period and 50 percent continuing six months postpartum(12). In 1998, 64 percent of mothers breastfed their babies in the early postpartum period, and only 29 percent of mothers continued to breastfeed their babies to six months(12). Noteworthy discrepancies among national breastfeeding rates of black or African Americans, whites, and Hispanic or Latinos exist; less than half of black or African American mothers breastfed in the early postpartum period, while almost three-fourths of white mothers and more than half of Hispanic or Latina mothers initiated breastfeeding(13). A similar trend is shown for breastfeeding duration up to six months, with reported duration rates for black or African American mothers well below that of white and Hispanic or Latina mothers(12). In 2000, the United States Surgeon General, David Satcher, released a national report which outlined research goals for examining racial disparities in breastfeeding rates, specifically to "conduct research that identifies the social, cultural, economic, and psychological factors that influence infant feeding behaviors, especially among African American and other minority and ethnic groups"(13). Assembling a detailed understanding of the complex web of predictors is essential for targeting the populations who are in greatest need of breastfeeding support.

Predictors of Breastfeeding Initiation and Duration

Previous studies have found positive and negative associations between various sociodemographic, biological, and behavioral characteristics and breastfeeding initiation and duration. Increased maternal age(10, 14-17), multiparity(18, 19), higher maternal educational level(14, 20-26), higher income(10, 25), being married(17) or living with a partner(27), and having an infant of normal to higher birthweight(10, 14, 17, 24, 25) have been found to be positively associated with breastfeeding intention and initiation. Factors associated with decreased likelihood of breastfeeding initiation include smoking during pregnancy(14, 15, 23), being on the Special Supplemental Nutrition Program for Women, Infants and Children (WIC)(10, 14, 25, 28), higher pre-pregnancy weight(23), and Cesarean delivery(23, 29, 30). For identifying predictors of breastfeeding duration, studies to date have showed positive associations with higher maternal age(23, 25, 29, 31), higher parity(23, 25, 32), and higher maternal education level(14, 31, 33), while negative associations have been found between increased duration and return to full-time work(17, 25, 32, 34, 35), being married(29), smoking(14, 32, 36), being on WIC(25), higher body mass index (BMI)(36), Cesarean delivery(21), and low birthweight(23). Maternal employment is also a predictor of shortened breastfeeding duration; the earlier a mother returns to work postpartum, the earlier she discontinues breastfeeding her infant(32, 37-39).

The influence of race-ethnic differences on breastfeeding incidence was suggested in 1984 by a study based on mail survey(40), but the authors used simple chi-square tests for equality of proportions from which to draw conclusions and did not control for other variables. In 1988, Kurinij et al(22) showed that initiation of breastfeeding was more dependent on maternal education and less dependent on ethnicity. For example, blacks were not only more likely to breastfeed for a shorter duration than white women, they were also more likely to use formula supplements in the hospital. Therefore, it was unclear whether it was race or formula that was associated with shortened duration(22). Disparities in breastfeeding rates among races continue to be reported; among low-income mothers in Northern California in 1992, initiation rates were highest for Asian-Americans (86 percent) and lowest for Latinas (48 percent), with African-Americans and Anglo-Americans comprising the remainder of the multiethnic study population(41). Brodwick et al have suggested alternative explanations for the observed racial differences: "nondemographic characteristics, such as beliefs, expectancies, and support mechanisms, which also vary by ethnicity, influence breast feeding"(42). Others concur: "Differences in the incidence and duration of breast-feeding among different racial groups...in part reflect varying cultural practices among ethnic communities. The effect of race is also obscured by class differences"(29). While a number of researchers have focused on identifying predictors of breastfeeding initiation and duration, many did not control for important socioeconomic variables or had small numbers of different ethnic groups contributing data(29, 40, 43). Thus, the combined influence of demographic, reproductive, and psychosocial characteristics on breastfeeding initiation and duration remain unclear, inconsistent, and require further attention.

Breastfeeding in a Military Population

Given the demands for physical readiness for active duty military personnel, the application of those requirements on postpartum women who are permitted only six weeks of maternity leave, and the stress resulting from active duty fathers being deployed away from home, breastfeeding may become even more complicated and challenging for mothers in a military setting. Exploring predictive factors beyond race appears to be a promising direction for further clarification of breastfeeding practice among this unique multiethnic population(22).

The purpose of this study was to evaluate whether breastfeeding initiation and duration differed by four maternal race-ethnicity (forthwith referred to as race) groups, and to examine how other sociodemographic and reproductive factors were associated with breastfeeding initiation and duration beyond six months in a military population. Reported reasons for breastfeeding cessation were also described, dichotomized into before and after six months postpartum, and grouped by race, to explore possible targets for future intervention.

METHODS

Study Design

The After the Baby Comes (ABC) Study investigated the relationship between sociodemographic, biological, and psychosocial factors and postpartum weight changes in a population of active duty military women and dependents of active duty servicemen. Out of a possible 7,723 women receiving well-baby care for their infants at the Balboa Pediatrics Clinic in the Naval Medical Center San Diego (NMCSD) between April 1997 and December 1999, 4,321 women were approached to enter the study. To accommodate the transient nature of a military population, whereby one-third of active duty families were transferred each year, the study collected a series of cross-sectional questionnaires that were completed simultaneously with recommended well-baby visits at 1-week, 2-weeks, 2, 4, 6, 9, and 12-months postpartum. From this, a smaller longitudinal cohort comprised of numerous sequential cross-sectional samples was also envisioned. Participants were permitted to contribute as little as one observation and remain enrolled in order to maximize the observations collected. As part of an attempt of the NMCSD to achieve World Health Organization (WHO) "Baby-Friendly" certification(44), Balboa Pediatrics Clinic employed full-time lactation consultants who encouraged all patients to breastfeed. This analysis uses the final cross-section collected for each woman as close as possible to the end of the first postpartum year.

Questionnaires and Measures

Data were collected from two sources; women were given Follow-Up Questionnaires and asked to recall infant feeding practices in the first postpartum year (48%). However, compliance was difficult to assure. After two attempts to collect information, women were sent shorter versions (Mini Follow-Up Questionnaires)(52%) to decrease the time burden of completing the full questionnaire. Data from the self-reported questionnaires included information on maternal age, highest educational level attained (college vs. no college), monthly household income (in eight categories ranging from below $500 to above $6250), active duty status (self, wife, or dependent of active duty serviceman vs. reserve), maternal race, marital status (married or living with partner vs. not married or living with partner), participation in WIC (yes vs. no), return to work postpartum (in days), and infant feeding method. Medical records were requested on all study participants, and 80% were obtained for abstraction despite repeated attempts to collect the remaining 20%. Abstraction of the prenatal medical record provided data on parity (0-6), type of delivery (vaginal vs. Cesarean), infant birthweight (in grams), weight gain during pregnancy (last maternal weight minus self-reported pre-pregnancy weight)(in kilograms), and cigarette smoking during pregnancy (yes vs. no).

Initiation of breastfeeding was assessed by any indication of breastfeeding in responses to the question: "Did you breast feed at any time during your baby's first year?" Initiation was examined as a dichotomous dependent variable, defined as 'ever' for those women who ever breastfed and 'never' for those who never breastfed. Among those women who initiated breastfeeding, duration of breastfeeding was assessed using responses to the question: "How old was your baby when you completely stopped feeding him/her breast milk?" Depending on the type of questionnaire administered, options for responses were recorded in days, weeks, and/or months to accommodate participants' responses, as well as the option of "my baby still gets breast milk" (Follow-Up Questionnaire); these responses were subsequently translated into a discrete number of days of breastfeeding postpartum with the assumption that breastfeeding began at delivery. In the Mini Follow-Up Questionnaire, women chose from five categorical responses ("Less than 2 months"; "2-4 months"; "4-6 months"; "More than 6 months"; "I'm still breastfeeding my baby"), which were recoded into a discrete variable representing the median number of days postpartum for each two-month time frame: "30 days"; "90 days"; "150 days"; "180 days" for those indicating "More than 6 months"; and the time (in days) since delivery when the questionnaire was completed for the option: "I'm still breastfeeding my baby". Taking the median value for duration categories should have accounted for variation within the time categories.

Responses to the question: "Why did you stop breastfeeding your baby?" were used to assess reasons for breastfeeding cessation. Women were offered a checklist of 24 reasons and also an additional opportunity to write in their own responses. Reasons given were grouped into nine broader categories (Table 7) based on a variation of methods used by DaVanzo(18). Reported reasons were examined in categories of women who breastfed for less than six months postpartum and women who continued to breastfeed past six months postpartum, stratified by race, by calculating the proportion of each particular reason reported out of the total number of women who gave information on breastfeeding duration.

Maternal race was obtained from responses completed for the question: "What race or ethnicity would you describe yourself as?" Only women who self-identified as white and no other ethnic group were coded 'white', and women who indicated any Black or African-American ethnicity were coded 'African-American'. Women who reported any mixed race including Asian were coded 'Asian', as well as those who reported Guamanian, Filipina, or Pacific Islander race.

Any women who reported mixed white and Hispanic ethnicity was coded 'Hispanic'. All race variables were coded as nominal dichotomous variables.

Active duty status at the first postpartum visit was based on maternal self-reported data that indicated maternal active duty status or dependency on an active duty serviceman. Maternal height and pre-pregnancy weight were included in models to assess for maternal body size.

Study Group

Participants included in breastfeeding initiation analysis were limited to non-pregnant women of white, African-American, Asian, and Hispanic race who completed a retrospective questionnaire. Of the 2,433 women enrolled in the ABC Study, 1,655 women contributed retrospective data. To assess systematic differences between women with and without final breastfeeding data, the means and distributions of all variables examined in subsequent analyses were compared, and the groups were remarkably similar. Women who had no final breastfeeding data available (n=778) were not significantly different than those included in this study for every variable examined (data not shown). Figure 1 presents the derivation of the study group for both breastfeeding initiation and duration, and rates of breastfeeding in larger and smaller subsets by racial groups. Women who had missing data on variables other than race (n=1,611) breastfed in different proportions than women who had complete data on all variables included in this study (n=1,200). Breastfeeding rates remained similar among Asians, whites, and Hispanics, but the smaller subset included a greater proportion of African-Americans who initiated breastfeeding (Figure 1). Although exclusion of women for missing data on variables other than race (n=411) resulted in the loss of a disproportionate number of African-Americans, identical logistic models for both the larger sample (n=1,611) and smaller subset (n=1,200) did not reveal substantial changes in results (data not shown). Thus, women included in this investigation were representative of the overall population. The final sample of participants with complete data on all variables for breastfeeding initiation analysis totaled 1,200 women.

The breastfeeding duration analysis was limited to women who initiated breastfeeding (n=1,295). Of these, women excluded from duration analysis were lost to follow-up before six months postpartum (n=125), contributed data before their infants were six months old (n=29), or had missing data for other variables specific to the duration analysis (n=543). Exclusion of women for missing data on variables other than race (n=543) resulted in the loss of a disproportionate number of Hispanics, Asians, and whites, but identical final models for both the larger sample (n=1,141) and smaller subset (n=598) did not reveal substantial changes in results (data not shown). The compositions of the original sample (N = 1,141) and the smaller subset (n = 598) were similar for all other available variables (data not shown). The final analytic sample for examining breastfeeding duration prior to and beyond six months postpartum totaled 598 women.

Statistical Analyses

For analyses examining the predictors of breastfeeding initiation, the dependent variable was ever breastfeeding versus never breastfeeding. Several explanatory variables for which there is evidence of association with breastfeeding initiation were included: maternal age, parity, highest maternal education level, marital status, smoking during pregnancy, being on WIC during pregnancy, pre-pregnancy weight, maternal height, gestational weight gain, Cesarean delivery, and infant birthweight. Univariate distributions of breastfeeding initiation among participants grouped by maternal race were examined based on sociodemographic and reproductive characteristics using Pearson χ^2 tests for equality of proportions for categorical variables and Student's *t*tes ts for the equality of means for numeric variables. Multivariable logistic regression including only African-American, Asian, and Hispanic races as independent variables was originally modeled. All other variables were subsequently entered into an additive model for initiation, using the likelihood-ratio test to assess model components. Comparing the logistic model with all variables including race to a restricted logistic model not including race showed no important contributions to model fit by race variables (p=0.63). Interactions between race and the other variables were also investigated in a series of stepwise logistic regressions to assess modification of the effect of variables on breastfeeding initiation. Each set of three two-way interaction terms was entered in series and tested for significant contribution to model fit using the likelihood-ratio test. A logistic model with all interactions was also compared to a restricted model with only main effect variables (not including race), and revealed no substantial improvement in model fit from any interactions. Thus, the additive logistic model with variables not including race was determined to provide the most parsimonious description of breastfeeding initiation.

Breastfeeding duration was defined as a dichotomous dependent variable representing breastfeeding for less than six months and breastfeeding for six months or more. In addition to race, independent variables examined for association with breastfeeding duration included: maternal age, parity, highest maternal education level, income, marital status, active duty status, smoking postpartum, WIC status postpartum, timing of return to work postpartum, maternal height, pre-pregnancy weight, gestational weight gain, method of delivery, and infant birthweight. Univariate comparisons and logistic regression modeling were performed in identical fashion to breastfeeding initiation analyses. Stratified analyses of breastfeeding duration by maternal race were also attempted to determine if there was any effect modification by race, but small numbers of subjects in the models did not lend sufficient power to conduct this further examination. Thus, the additive logistic model with variables not including race was determined to provide the best fit to describe breastfeeding duration.

Study Approval

This investigation (Project number 2002-2-70) was approved by the Committee for Protection of Human Subjects at the University of California, Berkeley.

RESULTS

Figure 1 presents how final analytic samples for breastfeeding initiation and duration were assembled. The study group for the breastfeeding initiation analysis was 59% white, 13% African-American, 13% Asian, and 15% Hispanic. Overall, 81.2% of women initiated breastfeeding in this sample, and rates did not differ significantly by race (p=0.4). The breastfeeding duration analysis group was 64% white, 11% African-American, 11% Asian, and 14% Hispanic, of whom 38.6 percent continued to breastfeed for at least six months postpartum, with no significant difference between races (p=0.1).

Initiation of Breastfeeding

Table 1 compares demographic, psychosocial, and reproductive variables on breastfeeding initiation by race. Among whites, maternal age, college education, income, WIC during pregnancy, and smoking during pregnancy were associated with breastfeeding initiation. White women who initiated breastfeeding had higher monthly incomes than other racial groups who initiated, and attended college in higher proportions. While none of the variables was associated with initiation among African-Americans, smoking during pregnancy was associated with initiation among Hispanics, and both income and birthweight were associated with breastfeeding initiation among Asians. Parity, marital status, maternal height, pre-pregnancy weight, gestational weight gain, and Cesarean delivery were unrelated to breastfeeding initiation in any of the race-ethnicity groups.

Multivariable logistic regression including only races as independent variables demonstrated no significant associations between any race and breastfeeding initiation, compared to whites (Table 2). Shifting baselines for this simple model did not change these relationships nor uncover associations between other races. Furthermore, a multivariable, additive logistic model suggested that race was not significant when adjusted for other demographic, psychosocial, and reproductive variables (data not shown), and the likelihood-ratio test of significance demonstrated that race variables did not improve the fit of the model, nor markedly alter point estimates. Therefore, we dropped race variables from the final model. Table 3 presents the adjusted odds ratios and 95 percent confidence intervals for the final breastfeeding initiation model, and shows significant positive associations with education, income, and infant birthweight, after controlling for other variables in the model. College attendance was associated with a greater than 50 percent increased chance of initiating breastfeeding. For every one-thousand dollar increase in monthly income, women were 22 percent more likely to initiate breastfeeding (Figure 2). In addition, as birthweight increased, so did breastfeeding initiation. Maternal age was associated with breastfeeding initiation, but this finding did not achieve statistical significance ($p = 0.06$). Parity, active duty status, marital status, smoking during pregnancy, WIC during pregnancy, maternal height, pre-pregnancy weight, gestational weight gain, and Cesarean delivery were not predictive of breastfeeding initiation in this study group.

Duration of Breastfeeding

Table 4 presents compares individual demographic, psychosocial, and reproductive variables on breastfeeding duration by race. Among whites, maternal age, WIC postpartum, smoking postpartum, and gestational weight gain were associated with breastfeeding duration. None of the variables were associated with duration among African-Americans, maternal age was associated among Hispanics, and only postpartum WIC participation was associated with duration among Asians. Income, parity, college education, marital status, active duty status, timing of return to work postpartum, maternal height, pre-pregnancy weight, Cesarean delivery, and infant birthweight were not significant predictors of breastfeeding duration in any of the race/ethnicity groups.

Including only the four race categories as independent variables, multivariable logistic regression showed no significant associations between race and breastfeeding duration for at least six months (Table 5). Shifting the baseline between races revealed that African-American women were twice as likely to breastfeed for at least six months than Hispanic women (data not shown). As for initiation, the multivariable, additive logistic model suggested that race was not an important predictor of breastfeeding duration when adjusted for other demographic, psychosocial, and reproductive variables. The likelihood ratio test of significance demonstrated that race variables did not improve the fit of the model, nor did they noticeably alter the point estimates (data not shown). Thus, we dropped race variables from the final multivariable model of breastfeeding duration. Table 6 presents the adjusted odds ratios and 95 percent confidence intervals for the final breastfeeding duration model, and shows significant positive associations with maternal age and height, and significant negative associations with smoking postpartum, postpartum WIC participation, and gestational weight gain. Mothers who smoked since delivery or were on WIC following delivery were roughly 50 percent less likely to continue to breastfeed for at least six months. Both maternal height and age were positively and significantly associated with breastfeeding for at least six months, while higher gestational weight gain was associated with a shorter duration. We found borderline associations with two variables; higher income was associated with a decreased likelihood of breastfeeding for at least six months ($p=0.053$), and mothers who delayed their return to work postpartum were more likely to breastfeed for a longer duration ($p=0.069$). Parity, college education, active duty status, marital status, pre-pregnancy weight, Cesarean delivery, and infant birthweight were not predictive of breastfeeding duration in this study group, after adjusting for other variables.

Reasons for Discontinuing Breastfeeding

Table 7 describes the variety of reasons women reported for stopping breastfeeding during the period under investigation. The proportions of reasons given varied by duration of breastfeeding. Table 8 and Figure 3 present the proportions and distribution of reasons reported by mothers who discontinued breastfeeding before six months after delivery, grouped by race. Reasons were not mutually exclusive; there was no limitation on the number of reasons mothers could identify for stopping. Overall, reasons reported do not appear to vary dramatically across races, although some small numbers contribute to more visible differences in Figure 3. Inconvenience of breastfeeding was the most common reason reported by whites, followed by technical problems with breastfeeding, perceived problems with the quantity and quality of breast milk, and work-related difficulties. Nevertheless, it is notable that whites reported medical contraindications to breastfeeding in higher proportions than any other racial group. Additionally, African-Americans more commonly reported the relationship with their partner as a reason for discontinuing breastfeeding than their white, Asian, and Hispanic counterparts.

Figure 4 presents the distribution of reasons cited for cessation of breastfeeding among women who breastfed for six months or more, and demonstrates the most common reason given by all races was that the "child no longer needed to breastfeed". Table 9 presents the proportions of reasons reported for cessation after six months postpartum, showing that other oft-reported reasons differed by race. A slightly higher percentage of African-Americans reported inconvenience than whites, Asians, and Hispanics. More Asians claimed technical problems with breastfeeding later in the postpartum period than any other racial group. African-American and Asian mothers had higher proportions reporting work-related difficulties with breastfeeding than white and Hispanic mothers. Similar to white women who breastfed for less than six months, whites who breastfed for six months or more were more likely to report medical contraindications than any other racial group.

Asians most frequently cited their relationship with partner for stopping breastfeeding after six months of all the racial groups. Overall, family relationships and body image issues were rarely reported as reasons for discontinuing breastfeeding.

DISCUSSION

Four out of every five women in this study initiated breastfeeding; thus, this study group achieved breastfeeding initiation rates beyond the Healthy People 2010 goal(12). The high rates of breastfeeding initiation found in this group of ethnically diverse women may be the result of the "Baby-Friendly"(44) breastfeeding promotion program, although we have no data to directly link high rates of initiation with this intervention. Less than two out of every five women who initiated breastfeeding were still nursing six months following delivery. Thus, women in this study overall have yet to attain Healthy People 2010 goals for breastfeeding duration to six months(12). Still, it is provocative that our study showed no substantial racial differences in breastfeeding duration rates and that proportions of women breastfeeding to six months are remarkably high (Figure 1) compared to national duration rates reported in 1998 (19% African-American, 28% Hispanic, 31% white)(13). During the study period, all mothers received encouragement and support from lactation consultants, while Balboa Pediatrics Clinic, as part of Balboa Hospital, was actively working towards becoming "Baby-Friendly". While it is quite interesting that the institution provided a "Baby-Friendly" environment, there is no data in this study to evaluate the influence of clinic practices on breastfeeding initiation and duration.

The role of maternal race on breastfeeding initiation has been controversial in previous studies(20, 22, 23). While researchers uniformly found racial differences in crude univariate analyses(29, 42), some studies report that race is an independent risk factor for breastfeeding(20, 23, 45), and others have reported that the effect of race on breastfeeding initiation diminishes when controlling for education(42, 46). It is possible that race is uninformative as a variable in its own right, but serves as a marker for more significant socioeconomic factors.

Consistent with previous studies, we found that women with higher income, higher education, and larger babies were more likely to initiate breastfeeding among this military population(10, 14, 20, 25). It has been proposed that women with more disposable income may have better resources to overcome problems encountered with breastfeeding(32). Our study also contributes to the body of literature linking maternal educational level to breastfeeding rates(14, 15, 18, 21, 23, 26); college attendance was strongly associated with breastfeeding initiation in this military population. Thus, the importance of both income and maternal education as predictors appear suggestive of a more streamlined approach in identifying target populations for breastfeeding promotion by demographic characteristics. As previous studies have shown(14, 24), higher infant birthweight was positively associated with breastfeeding initiation in this study. Possible explanations for this relationship include that larger infants may have better suckling ability and lower birthweight infants have extended hospital stays incompatible with early initiation of breastfeeding(24). Low birthweight infants may also be separated from their mothers for an extended amount of time following delivery, perhaps preventing early establishment of lactation(47).

While breastfeeding duration did not vary significantly by race in this study group, we did find several factors significantly associated with duration; being older, being taller, not smoking after delivery, not participating in WIC after delivery, and gaining lower amounts of weight during pregnancy were positively associated with continuing to breastfeed six months after delivery. A national survey(32) also reported that women who did not smoke following delivery were about twice as likely to breastfeed for at least six months as women who smoked postpartum(14, 32, 36). Two different explanations, biological and behavioral, have been proposed. Experimental and clinical studies have found that smoking was associated with lower breast-milk volume(48), one of the most commonly reported reasons for breastfeeding cessation in this study (Figures 3 and 4). It has been proposed that nicotine in the bloodstream reduces the level of prolactin, the hormone responsible for breast milk production(49), and may also reduce oxygen delivery and blood flow to the mammary gland(50). Additionally, smoking has been proposed to alter the taste of breast milk(51), perhaps leading to refusal of the infant to breastfeed, which is another reason for cessation reported in this study (Table 7). A behavioral explanation suggests that women who smoke may perceive that their breast milk is contaminated or insufficient(49)(Table 7).

In our study, two measures of maternal body size were significantly associated with breastfeeding duration. Women with higher gestational weight gain were less likely to breastfeed their babies for at least six months in our study. High gestational weight gain may result in excess weight retained postpartum, which has been associated with earlier termination of breastfeeding in several studies(14, 36, 52). Maternal obesity may be related to high plasma insulin levels, low plasma glucose levels, and low prolactin concentrations(53), suggesting that inappropriate regulation of hormones and glucose may delay lactogenesis, thereby disrupting breastfeeding duration. From a behavioral view, women who gain high amounts of weight during pregnancy may want to diet postpartum, perceive incompatibility between their dieting practices and providing optimal nutrition with breast milk, and discontinue breastfeeding prior to the recommended six-month duration. Restrictive dieting practices may also compromise the ability to produce sufficient breast milk, also leading to decreased duration(54). The positive effect of maternal height on breastfeeding duration is a peculiar finding in this study, and no plausible explanation can be offered. To our knowledge, an association between height and breastfeeding duration has not been reported to date.

Although the WIC program has explicit recent policies to promote breastfeeding, our study joins others in finding that WIC participation is associated with shorter duration even after adjusting for income, education, age, and timing of return to work, factors that may discriminate WIC mothers from the general population(39). Although WIC has offered breastfeeding support and promotion for participants since 1989(55), both breastfeeding initiation and duration rates among WIC participants have remained stubbornly lower than those not in WIC(10, 28). Due to the fact that a large proportion of the study population participated in the WIC program, it is of great importance to re-evaluate breastfeeding promotion policies and practices of WIC facilities on military populations. Participation in WIC should be examined more closely along with provider support(56), social support(57), formula and food supplementation(58), and other modifiable influences on the continuation of breastfeeding beyond six months. For further evaluation, it would valuable to include information on the workplace environment(59), prenatal intentions(32), and maternal confidence in breastfeeding(58).

In addition, both lower income and delayed return to work postpartum were associated with longer breastfeeding duration in our study. To our knowledge, no other studies have reported an inverse association between income and breastfeeding duration. Although our findings were non-significant, other studies have found significant associations between breastfeeding duration and work or intention to work(15, 26, 30). It may have been informative to assess the impact of the number of hours worked postpartum to expound on this non-significant finding(59).

Previous investigations have uncovered significant associations between Cesarean delivery(21, 23, 29), marital status(17, 29), and parity(18, 19, 29, 32), but our study did not find any influence on breastfeeding initiation or duration due to these factors. Due to the high prevalence of women being married, it is possible that the homogeneity of the study population may have prevented meaningful comparisons of breastfeeding behavior in married and non-married women. Women in our study may also have been likely to receive increased breastfeeding support in tandem with having a Cesarean delivery, possibly due to "Baby-Friendly"(44) practices and the shared social support of being in a military population. The lack of an association between parity and breastfeeding initiation and duration may reflect the homogeneity of the study population as well; most mothers included were primiparous.

Prior studies have reported women's negative perceptions of breastfeeding, but these reports were limited to populations of low-income women and adolescents(60-63). A unique strength of this study was the method of assessing why women stop breastfeeding and the strikingly informative results gathered from women's responses. To our knowledge, our study is the first to examine why women stop breastfeeding by racial group. Although the numbers of reasons reported were small, we did find heterogeneity among races, which may point to future interventions for women by racial group. Further investigation should include identifying reasons why women initiate breastfeeding and continue to breastfeed for a longer duration, which, in addition to the reasons for discontinuing breastfeeding, may be useful knowledge for health practitioners who encourage and support mothers to breastfeed.

Race-ethnicity was not found to be a significant predictor of breastfeeding initiation or duration in these analyses that describe a population inherently different from the general population in the United States. Military populations have equal access to medical care and may live similar lifestyles on naval bases; thus, the distinctions between racial-ethnic groups may be blurred in lieu of a marked, socioeconomic stratification by rank. With relatively unobstructed access to health care at military facilities, mothers in military populations may be able to effectively utilize their resources to affect change for increasing breastfeeding rates. It could be true that living on a military base dampened the effect of variation between races in exchange for a broader military culture, and also that social comraderie within the military population provided an encouraging atmosphere for mothers to breastfeed. Predictors found for breastfeeding initiation and duration in this study may be applicable to United States military populations, but are not necessarily generalizable to civilian populations.

Limitations that may have introduced bias include the cross-sectional study design, retrospective assessment of infant feeding practices, and the difficulty with ensuring collection of complete data in postpartum women. Cross-sectional samples do not allow for establishment of causality. Potential participation bias may have arisen from the possibility that women who were more motivated to initiate breastfeeding and to continue for a longer duration may also be more motivated to complete and return study questionnaires. Thus, women who did not initiate breastfeeding may have been inadvertently selected out of the analytic sample. Selection bias may also have occurred in the initial exclusion of women for whom we did not have breastfeeding information from the final cross-section of data (n=778), who may represent a dissimilar population in terms of maternal age, infant birthweight, and parity (Figure 1). Large amounts of missing data would pose a threat to the validity of our sample if women who did not contribute complete data were systematically different from women who did. Given the available data on the proportions of women breastfeeding in the larger groups and smaller subsets in both initiation and duration analyses (Figure 1), there is no evidence of substantial bias. Additionally, recall bias may have arisen from asking mothers to report on their past behaviors, in addition to bias due to self-reported data that we cannot validate in this study.

In conclusion, racial heterogeneity was reduced in the military study population, and women initiated breastfeeding and continued to breastfeed to six months postpartum at higher rates than national averages. Although we cannot rule out bias in our study, we believe that further examination of "Baby-Friendly" hospital practices is warranted to elucidate our findings, as well as investigation into the effect of military culture. While breastfeeding rates remain below national objectives, it is encouraging to find that factors associated with initiation and increased duration of breastfeeding are not simply demographic in nature, but have modifiable components. Additional study is needed to clarify the influence of modifiable influences such as social support from friends and family(64-66), stress(28), self-confidence(67), formula and food supplementation(22), and hospital and provider practices(56) on breastfeeding initiation and duration, preferably through a prospective cohort design including ethnically- and socioeconomically-diverse women. Expanding awareness of the predictors of breastfeeding initiation and duration, as well as reasons given by mothers who stop breastfeeding, may give public health practitioners ample knowledge to effectively promote and support breastfeeding.

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Figure 1. Derivation of study group for breastfeeding initiation and duration analyses, The After the Baby Comes (ABC) Study, San Diego, California, 1997-1999

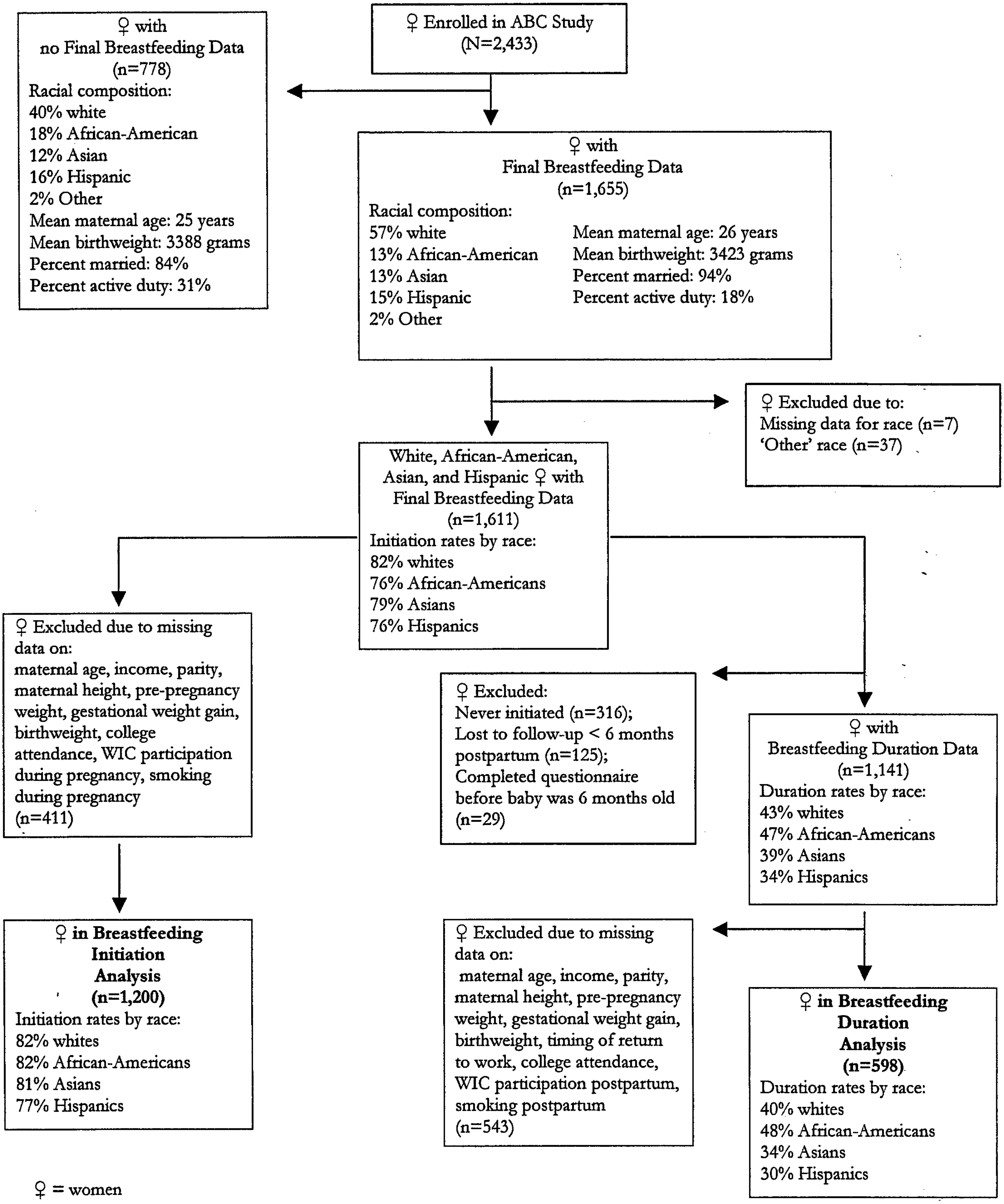

Table 1. Selected characteristics of breastfeeding initiation stratified by maternal race, The After the Baby Comes (ABC) Study, San Diego, California, 1997-1999

Characteristic	White (n=708)		African-American (n=160)		Asian (n=156)		Hispanic (n=176)	
	Never breastfed 126 (17.8%)	Ever breastfed 582 (82.2%)	Never breastfed 29 (18.1%)	Ever breastfed 131 (81.9%)	Never breastfed 30 (19.2%)	Ever breastfed 126 (80.8%)	Never breastfed 41 (23.3%)	Ever breastfed 135 (76.7%)
	Mean ± SD†	Mean ± SD†	Mean ± SD†	Mean ± SD†	Mean ± SD†	Mean ± SD†	Mean ± SD†	Mean ± SD†
Maternal age (years)	24.5 ± 4.8	26.8 ± 5.5*	25.9 ± 5.1	25.7 ± 5.4	26.3 ± 5.4	27.8 ± 5.4	24.8 ± 4.2	24.8 ± 4.9
Parity	0.8 ± 0.8	0.7 ± 0.9	0.9 ± 0.9	0.8 ± 0.9	0.8 ± 1.0	0.7 ± 0.8	0.8 ± 1.0	0.9 ± 1.0
Average income ($/month)	2234 ± 1143	3019 ± 1560*	2090 ± 1098	2126 ± 1183	2167 ± 1104	2818 ± 1398*	2265 ± 1225	2215 ± 1284
Maternal height (cm)	163.6 ± 5.7	164.6 ± 6.4	162.5 ± 7.3	162.5 ± 6.1	157.3 ± 6.7	155.8 ± 6.7	158.1 ± 4.4	158.9 ± 6.1
Pre-pregnancy weight (kg)	68.1 ± 15.3	66.1 ± 13.3	65.4 ± 11.2	66.7 ± 13.8	59.2 ± 16.3	55.4 ± 10.9	63.4 ± 10.4	64.9 ± 15.7
Final gestational gain (kg)	16.3 ± 6.7	16.5 ± 6.5	16.5 ± 8.0	15.8 ± 6.7	17.8 ± 6.8	15.9 ± 5.8	15.2 ± 6.1	15.1 ± 6.0
Birthweight (g)	3484 ± 491	3488 ± 527	3111 ± 471	3265 ± 485	3098 ± 486	3380 ± 499*	3373 ± 408	3477 ± 519
Attended college	47 (11.7)	355 (88.3)*	16 (17.6)	75 (82.4)	17 (15.9)	90 (84.1)	18 (21.4)	66 (78.6)
Active duty	19 (15.0)	108 (85.0)	14 (23.3)	46 (76.7)	3 (27.3)	8 (72.7)	3 (10.7)	25 (89.3)
Married/Living with partner	120 (17.8)	555 (82.2)	25 (18.0)	114 (82.0)	26 (18.3)	116 (81.7)	40 (23.4)	131 (76.6)
Cesarean delivery	16 (16.3)	82 (83.7)	16 (15.5)	87 (84.5)	7 (24.1)	22 (75.9)	5 (13.2)	33 (86.8)
WIC during pregnancy	52 (13.7)	328 (86.3)*	8 (14.3)	48 (85.7)	14 (19.4)	58 (80.6)	18 (25.7)	52 (74.3)
Smoking during pregnancy	32 (23.7)	103 (76.3)*	2 (14.3)	12 (85.7)	2 (16.7)	10 (83.3)	6 (46.2)	7 (53.9)*

* $p < 0.05$
† SD = standard deviation

Table 2. Odds ratios and 95% confidence intervals for breastfeeding initiation from multivariable logistic regression model, The After the Baby Comes (ABC) Study, San Diego, California, 1997-1999

Characteristic†	Odds Ratio	95% Confidence Interval
African-American race	0.98	(0.63, 1.53)
Asian race	0.91	(0.58, 1.42)
Hispanic race	0.71	(0.48, 1.06)

† white race = baseline

Table 3. Adjusted odds ratios and 95% confidence intervals for breastfeeding initiation from final multivariable logistic regression model, The After the Baby Comes (ABC) Study, San Diego, California, 1997-1999

Characteristic	Adjusted Odds Ratio	95% Confidence Interval
Maternal age	1.04	(1.00, 1.07)
Parity	0.86	(0.72, 1.03)
Attended college	1.53	(1.10, 2.11)*
Income (per $1000/month)	1.22	(1.06, 1.40)**
Active duty	1.13	(0.75, 1.71)
Married/Living with partner	1.00	(0.54, 1.87)
Smoking during pregnancy	0.82	(0.55, 1.23)
On WIC during pregnancy	0.90	(0.65, 1.26)
Maternal height (cm)	1.01	(0.99, 1.04)
Pre-pregnancy weight (kg)	0.99	(0.98, 1.00)
Gestational gain (kg)	0.98	(0.96, 1.01)
Cesarean delivery	0.86	(0.58, 1.29)
Birthweight (per 500 g)	1.20	(1.03, 1.40)*

* $p < 0.05$
** $p < 0.01$

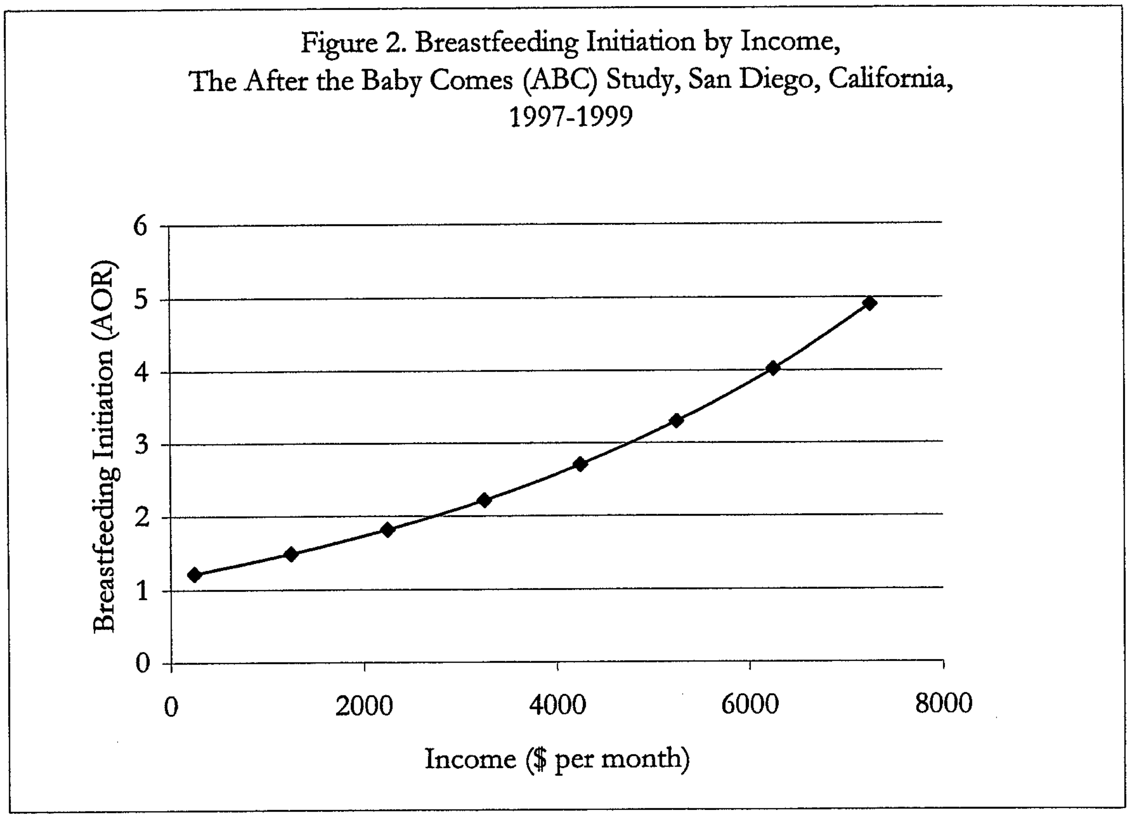
Figure 2. Breastfeeding Initiation by Income,
The After the Baby Comes (ABC) Study, San Diego, California,
1997-1999
Breastfeeding Initiation (AOR)
0
1
2
3
4
5
6
0
2000
4000
6000
8000
Income ($ per month)

Table 4. Selected characteristics of breastfeeding duration stratified by maternal race, The After the Baby Comes (ABC) Study, San Diego, California, 1997-1999

Characteristic	White (n=385)		African-American (n=65)		Asian (n=65)		Hispanic (n=83)	
	< 6 months 232 (60.3%)	≥ 6 months 153 (39.7%)	< 6 months 34 (52.3%)	≥ 6 months 31 (47.7%)	< 6 months 43 (66.2%)	≥ 6 months 22 (33.8%)	< 6 months 58 (69.9%)	≥ 6 months 25 (30.1%)
	Mean ± SD†	Mean ± SD†	Mean ± SD†	Mean ± SD†	Mean ± SD†	Mean ± SD†	Mean ± SD†	Mean ± SD†
Maternal age (years)	25.4 ± 5.4	27.3 ± 5.7*	24.9 ± 5.7	25.4 ± 5.3	26.2 ± 5.9	28.2 ± 4.2	23.7 ± 4.4	26.0 ± 5.1*
Parity	0.7 ± 0.8	0.8 ± 1.0	0.6 ± 0.8	0.8 ± 0.9	0.7 ± 0.8	0.8 ± 1.0	0.8 ± 1.0	1.2 ± 1.3
Average income ($/month)	2724 ± 1510	2929 ± 1585	2140 ± 1325	1790 ± 1045	2629 ± 1194	2977 ± 1354	2080 ± 1242	2225 ± 1414
Return to work (days)	88.9 ± 71.9	100.9 ± 88.7	67.4 ± 54.2	85.0 ± 74.9	125.5 ± 116.0	110.5 ± 96.6	105.4 ± 81.3	113.6 ± 82.1
Maternal height (cm)	164.3 ± 6.4	164.6 ± 6.2	162.6 ± 6.4	164.3 ± 7.6	155.6 ± 6.9	157.4 ± 8.2	159.8 ± 5.5	159.3 ± 8.0
Pre-pregnancy weight (kg)	66.6 ± 13.5	65.3 ± 11.8	37.7 ± 14.5	73.1 ± 16.0	55.3 ± 10.7	59.3 ± 15.8	64.1 ± 15.2	67.1 ± 20.7
Final gestational gain (kg)	18.2 ± 7.8	15.9 ± 5.3*	16.8 ± 5.3	15.3 ± 7.8	16.1 ± 6.1	17.1 ± 7.5	15.7 ± 6.0	13.7 ± 6.3
Birthweight (g)	3472 ± 513	3522 ± 511	3275 ± 544	3379 ± 433	3293 ± 389	3485 ± 631	3416 ± 517	3542 ± 496
Attended college	126 (57.3)	94 (42.7)	16 (48.5)	17 (51.5)	32 (68.1)	15 (31.9)	30 (73.2)	11 (26.8)
Active duty	42 (62.7)	25 (37.3)	15 (57.7)	11 (42.3)	4 (80.0)	1 (20.0)	10 (66.7)	5 (33.3)
Married/Living with partner	218 (59.7)	147 (40.3)	31 (56.4)	24 (43.6)	38 (63.3)	22 (36.7)	56 (69.1)	25 (30.9)
Cesarean delivery	40 (66.7)	20 (33.3)	8 (66.7)	4 (33.3)	11 (68.7)	5 (31.3)	12 (63.2)	7 (36.8)
WIC postpartum	137 (65.9)	71 (34.1)*	23 (48.9)	24 (51.1)	32 (74.4)	11 (25.6)*	41 (74.6)	14 (25.4)
Smoking postpartum	86 (74.1)	30 (25.9)*	9 (52.9)	8 (47.1)	7 (87.5)	1 (12.5)	14 (87.5)	2 (12.5)

* $p < 0.05$
† SD = standard deviation

Table 5. Odds ratios and 95% confidence intervals for breastfeeding duration past six months from multivariable logistic regression model, The After the Baby Comes (ABC) Study, San Diego, California, 1997-1999

Characteristic†	Odds Ratio	95% Confidence Interval
African-American race	1.38	(0.82, 2.34)
Asian race	0.78	(0.45, 1.35)
Hispanic race	0.65	(0.39, 1.09)

† white race = baseline

Table 6. Adjusted odds ratios and 95% confidence intervals for breastfeeding duration past six months from final multivariable logistic regression model, The After the Baby Comes (ABC) Study, San Diego, California, 1997-1999

Characteristic	Adjusted Odds Ratio	95% Confidence Interval
Maternal age	1.05	(1.01, 1.09)†
Parity	1.13	(0.90, 1.41)
Attended college	0.79	(0.52, 1.18)
Income (per $1000/month)	0.85	(0.72, 1.00)‡
Active duty	0.98	(0.60, 1.61)
Married/Living with partner	0.98	(0.46, 2.08)
Smoking postpartum	0.45	(0.29, 0.71)*
On WIC postpartum	0.58	(0.36, 0.93)†
Return to work postpartum(per 30 days)	1.07	(1.00, 1.16)‡
Maternal height (cm)	1.03	(1.00, 1.07)†
Pre-pregnancy weight (kg)	0.99	(0.98, 1.01)
Gestational gain (kg)	0.96	(0.93, 0.99)**
Cesarean delivery	0.98	(0.59, 1.61)
Birthweight (per 500 g)	1.16	(0.96, 1.41)

* $p < 0.0001$
** $p < 0.01$
† $p < 0.05$
‡ $p < 0.07$

Table 7. Description of categorical groupings of reported reasons for breastfeeding cessation, The After the Baby Comes (ABC) Study, San Diego, California, 1997-1999

Reason Category	Description
Child no longer needed to breastfeed	Baby weaned itself
	Baby was old enough to wean
	Mother felt ready to stop breastfeeding
Perceived problems with quantity and quality of breast milk	Baby was not getting enough milk
	Baby was unsettled after breastfeeding
	Had insufficient breast milk or never lactacted
	Mother had poor health habits
Inconvenient to breastfeed	Baby was not sleeping through the night
	Too many feedings were required
	Breastfeeding was too tiring
	Mother did not enjoy breastfeeding
	Preferred bottle-feeding
	Mother and baby were traveling
	Mother did not have enough privacy
	Mother was embarrassed to breastfeed
	Allow for others to feed baby
	Mother was away from baby
	Mother felt she did not get out enough
	Mother was stressed
	Mother was depressed
Technical problems with breastfeeding	Mother had breast infection
	Mother had painful nipples or breast tenderness
	Baby refused to breastfeed
	Baby bit or baby was teething
	Baby had problems latching on
Work-related difficulties	Mother had to return to work
	Mother could not pump breast milk at work
	Mother or Father was deployed
Medical contraindications	Mother had surgery or medical treatment
	Mother took birth control pills
	Mother was diabetic
	Baby allergic to breast milk
	Baby was lactose-intolerant
	Mother or baby was sick
	Mother advised by physician to stop
Relationship with partner	Partner told mother to stop
	Breastfeeding interfered with mother's relationship to partner
	Breastfeeding interfered with sex life
	Domestic violence
Family issues	Other children resided in household
	Other child had tantrum
	Family did not approve of breastfeeding
Body image issues	Mother wanted to lose weight
	Mother wanted control of her body
	Mother wanted normal breast size

Figure 3.
Reported reasons for breastfeeding cessation before six months postpartum stratified by maternal race, The After the Baby Comes (ABC) Study, San Diego, California, 1997-1999

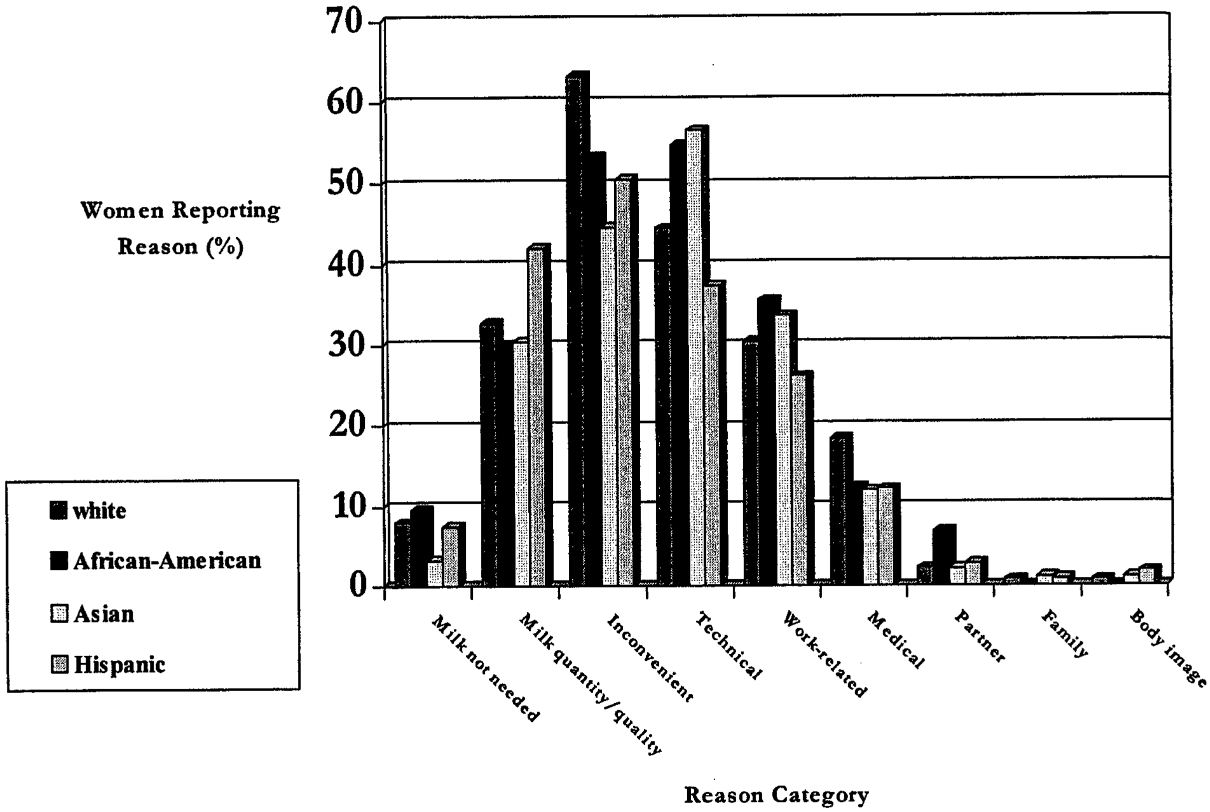

Table 8. Reported reasons for breastfeeding cessation before six months postpartum stratified by maternal race, The After the Baby Comes (ABC) Study, San Diego, California, 1997-1999

Reason	White (N=391)		African-American (N=73)		Asian (N=92)		Hispanic (N=107)		Total (N=663)	
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
Child no longer needed to breastfeed	31	(7.93)	7	(9.59)	3	(3.26)	8	(7.48)	49	(7.39)
Problems with quantity & quality of breast milk	128	(32.74)	22	(30.14)	28	(30.43)	45	(42.06)	223	(33.63)
Inconvenience	247	(63.17)	39	(53.42)	41	(44.57)	54	(50.47)	381	(57.47)
Technical problems	174	(44.50)	40	(54.79)	52	(56.52)	40	(37.38)	306	(46.15)
Work-related difficulties	119	(30.43)	26	(35.62)	31	(33.70)	28	(26.17)	204	(30.77)
Medical contraindications	72	(18.41)	9	(12.33)	11	(11.96)	13	(12.15)	105	(15.84)
Relationship with partner	9	(2.30)	5	(6.85)	2	(2.17)	3	(2.80)	19	(2.87)
Family issues	3	(0.77)	0	(0.00)	1	(1.09)	1	(0.93)	5	(0.75)
Body image issues	3	(0.77)	0	(0.00)	1	(1.09)	2	(1.87)	6	(0.90)

Figure 4.
Reported reasons for breastfeeding cessation after six months postpartum stratified by maternal race, The After the Baby Comes (ABC) Study, San Diego, California, 1997-1999

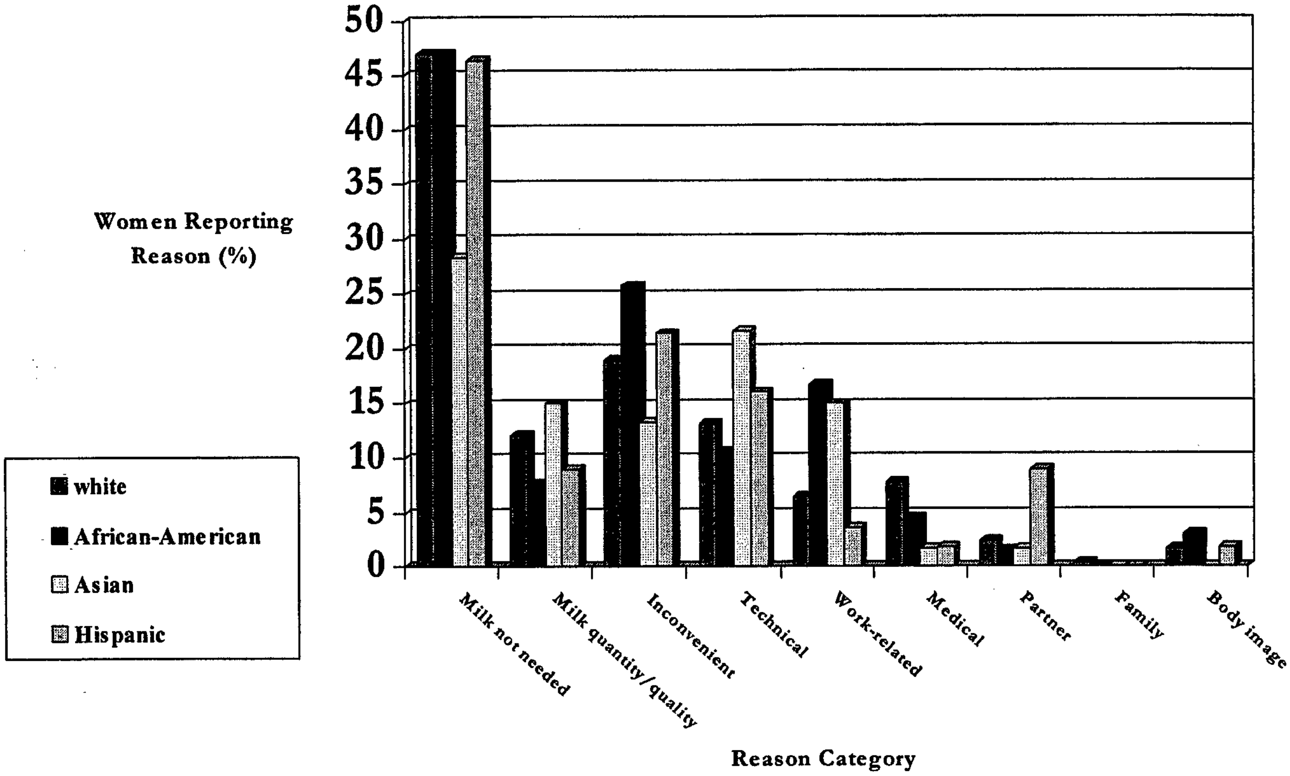

Table 9. Reported reasons for breastfeeding cessation after six months postpartum stratified by maternal race, The After the Baby Comes (ABC) Study, San Diego, California, 1997-1999

Reason	White (N=296)		African-American (N=66)		Asian (N=60)		Hispanic (N=56)		Total (N=478)	
	N	(%)	N	(%)	N	(%)	N	(%)	N	(%)
Child no longer needed to breastfeed	139	(46.96)	31	(46.97)	17	(28.33)	26	(46.43)	213	(44.56)
Problems with quantity & quality of breast milk	36	(12.16)	5	(7.58)	9	(15.00)	5	(8.93)	55	(11.51)
Inconvenience	56	(18.92)	17	(25.76)	8	(13.33)	12	(21.43)	93	(19.46)
Technical problems	39	(13.18)	7	(10.61)	13	(21.67)	9	(16.07)	68	(14.23)
Work-related difficulties	19	(6.42)	11	(16.67)	9	(15.00)	2	(3.57)	41	(8.58)
Medical contraindications	23	(7.77)	3	(4.55)	1	(1.67)	1	(1.79)	28	(5.86)
Relationship with partner	7	(2.36)	1	(1.52)	1	(1.67)	5	(8.93)	14	(2.93)
Family issues	1	(0.34)	0	(0.00)	0	(0.00)	0	(0.00)	1	(0.21)
Body image issues	5	(1.69)	2	(3.03)	0	(0.00)	1	(1.79)	8	(1.67)

PREDICTORS OF POSTPARTUM OVERWEIGHT IN A MILITARY POPULATION

THE ABC STUDY

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December 2002

INTRODUCTION

This study compares active duty and non active duty mothers in a military population with regard to the development of postpartum obesity.

METHODS

To construct a dataset of women enrolled in the ABC Study that would ultimately be used in our multiple regression models, we selected women with clinic data between 16 days and 551 days postpartum and who were not missing data on a list of key variables used in our models. These variables included mother's height, mother's age, pre-pregnancy weight, birthweight of the baby, pregnancy weight gain, parity, active duty status and race. Other characteristics were investigated, either through univariate or multivariate techniques, but this group of variables was determined to be the core set of variables. Of the 2,430 women in the study population, 1,989 women (82%) had complete data on these key variables and comprise our study population. Out of this group of 1,989 women, 449 (23%) were active duty and 1540 (77%) were non-active duty, or military dependents.

Other activities and attitudes that may influence postpartum weight loss were investigated and included: dieting, weight cycling, amount of sports or exercise per week, depression, and financial security. As previously discussed, there are multiple clinic visits and thus multiple points of data in the postpartum period for some women in our study group. For others, there is only one clinic visit and one data point. Across multiple data points reports of amount of weekly exercise, dieting behaviors, feelings of depression or financial security. We looked first at three cross-sectional postpartum time periods for each variable of interest corresponding to an early, middle or late postpartum period. We defined "Early" as less than 105 days, "Middle" as between 106 and 258 days, and "Late" as greater than 256 days postpartum. Clinic responses collected before 16 days and after 551 days postpartum were not included. We next created a summary variable for categorical responses that summed up an individual's multiple responses over the postpartum period and classified them as "Always Yes", "Some Yes/Some No", or "Always No" to reflect an individual's response pattern to a Yes/No question. For continuous variables, we created an average of each individual's responses, not including "missing" data points in the calculation.

The categories of Junior and Senior Officers were combined due to the very small number of active duty women in the latter category. This gave us three tiers of military rank in our analysis, Junior Enlisted, Senior Enlisted, and Junior or Senior Officer. Data on military rank was taken from medical records abstraction.

Analysis included univariate comparisons between active duty and military dependent women, evaluated by t-tests for means of continuous variables and chi-square analysis of categorical variables. Multivariate analysis involved multiple linear and logistic regression models using the subset of active duty women only.

Postpartum BMI was calculated as: Mother's last reported or measured weight^2 / (Mother's height/100)^2. Last reported or measured BMI was cut into two categories at BMI greater than or equal to 25.0 to reflect the current upper limit of acceptable BMI by the U.S. Navy so that the outcome variable classifies women as either underweight/normal weight or as overweight/obese. Optimal ranges for BMI were adopted by the military from the 1995 Dietary Guidelines for Americans to reflect the suggested range of between 19kg/m2 to 25kg/m2 as a body composition associated with a reduced risk to health and increased physical fitness. We restricted our model to women with a pre-pregnancy BMI of less than 25.0. That is, we excluded women with a pre-pregnancy BMI of more than 25.0 (the lower limit for the classification of "overweight") to examine what happens to women who become overweight postpartum if they were not overweight to begin pregnancy.

DESCRIPTIVE CHARACTERISTICS

Pre-pregnancy

Active duty women differed from non-active duty women in several characteristics. First, there was a difference in mean pre-pregnancy weight and pre-pregnancy Body Mass Index (BMI) between the two groups ($p<0.10$ and $p<0.05$, respectively), as well as differences in parity, income, height, age, race, and the number of times that a women reported having lost 10 pounds or more in her lifetime. Table One describes the means for the group of active duty women and for the group of military dependents separately. In summary, active duty women weighed less pre-pregnancy than non-active duty women, had fewer children, reported a higher household income, were taller, younger, and reported a history of weight cycling less often. Two-thirds of the active duty women in our study were previously nulliparous, whereas less than half of the military dependent group had just given birth to their first child. In addition, there were more African American women and fewer Asian or Caucasian women in the active duty group than in the non-active duty group. The group composition of military ranks of the women in the active duty group was comparable to the composition of ranks of the spouses of women in the military dependent group. The majority of women, or their spouses, were Junior or Senior Enlisted personnel, 89% of military dependents and 87% of active duty women. Less than one percent of women or spouses were Senior Officers. Smoking, defined as smoking more than 100 cigarettes ever, was more often reported in the active duty group (64.4% compared to 61.9%) but this difference was not statistically significant.

Pregnancy and Postpartum

Table Two describes the group means for certain pregnancy and postpartum characteristics. The amount of weight that a mother gained during pregnancy differed by military status, with active duty women gaining significantly more than non-active duty women, 17.5 kg versus 15.9 kg, respectively. The mean baby birthweight, however, was nearly the same for each group, about 3,411kg or 7.5 lbs.

Mothers' last postpartum weights were also compared between groups. When we included any given last recorded weight for a woman in the study, either measured or self-reported, the BMI for active duty women is slightly lower than the BMI for non-active duty women and the difference approaches statistical significant. However, there is a statistically significant difference between the two groups in the timing of the last given weight. This difference in time could account for the difference in weight. If we look only at measured weights, the difference in timing of the last recorded postpartum weight disappears and the mean last measured weights between the two groups are nearly equal, 70 kg for active duty women and 69.8 kg for military dependents. A difference in BMI remains, nearly equal to the difference in BMI between the two groups pre-pregnancy, $0.61kg/m^2$ and $0.68kg/m^2$ postpartum and pre-pregnancy respectively. When time of last postpartum weight is included in a regression model, the influence of time on weight loss is controlled and it is possible to include all observations with a reported or a measured last postpartum weight.

Responses to the summary variables are presented in Table Three. Active duty women reported similar responses to their non-active duty counterparts to all of these questions. The amount of weekly sports or exercise reported over the last year was the exception. For this question, active duty women reported exercising more often than the group of women who were military dependents and this difference approached statistical significance.

Some kind of dieting behavior was reported by 61% of respondents. When dieting methods were analyzed and categorized as "healthy" or not, only 30% to 34% of respondents were using healthy dieting methods to lose postpartum weight. Nearly four percent more women in the active duty group were using "healthy" dieting methods, but this difference was not statistically significant.

The two variables that we used in this analysis to capture stress or anxiety were depression and financial insecurity. Though there were no statistically significant differences between groups in either of these variables when analyzed as a summary of multiple responses over the postpartum period, it is interesting to note that over 16.4% of active duty women reported some financial insecurity over this period.

Likewise, 12.7% of military dependent women reported a similar experience. Feeling depressed over the last seven days was reported by 8.7% of military dependent women and 5.5% of active duty women as more than half or all the time.

Table Four details the summary responses to the dieting, exercise, depression and financial security for each group over the postpartum period. The two groups were comparable in their responses to most of the questions across these three periods with the exception of "healthy" dieting and ability to pay bills in the late postpartum period. Healthy dieting increased slightly from the early to the middle postpartum period from 43% to 45% and then decreased to 36% at the late period for active duty women but remained relatively stable from early to middle to late for non-military women. At the late period, 36% of active duty women and 42% of military dependent women were using at least one "healthy" dieting behavior to help them lose weight. This difference approached statistical significance (p=0.08). When any dieting behavior is examined, a larger percentage of both groups of women report dieting to lose weight and dieting appears to decrease in the later part of the postpartum period.

In general, the amount of weekly sports or exercise increased slightly as postpartum time increased but hovered around two times per week for both military dependents and active duty women.

To examine the role of stress in losing pregnancy weight gain, we consider two variables, financial security and feeling depressed. Financial security decreased over the postpartum period for active duty women. Ten percent of active duty women with an early postpartum clinic visit were financially insecure. This increased to 12% at the middle period and 16% at the late period. Inability to pay bills remained at 11% for the non-active duty group for the first two periods and then decreased to 9%. Reports of feeling depressed over the past seven days fluctuated slightly over the postpartum period. In the first period, five percent of active duty women and 7.7% of military dependents responding to this question reported feeling depressed more than half the time. This increased to 6.3% by the middle period for active duty women but remained relatively stable for military dependents. With the exception of the financial security question in the late postpartum period, there were no statistically significant differences between the two groups for these two questions.

Active Duty Women and Physical Readiness Training
Of the 449 active duty women in our study group, we have single or multiple clinic visits for 411 women with information about Physical Readiness Training (PRT). Of these 411 women, 10% consistently reported not having a PRT requirement in their current duty, 11% reported having a PRT requirement some of the time but not all of the time, and 79% consistently reported having required PRT in their current duty assignment. On average, active duty women reported 2.8 days of PRT was required per week with 47 minutes required for each PRT session. Table Five details summary information about PRT.

Table Six describes PRT information given at the early, middle and late postpartum periods. At the Early postpartum period, 82% of active duty women reported that their current duty assignment had a PRT requirement. For those women with a required PRT, 43% reported that their PRT was mandatory, 56% reported that it was voluntary and 1% reported that PRT was both. Nineteen percent reported that their PRT requirement was to be performed within a group, 46% reported that PRT was to be performed individually and 35% reported that it could be both. Finally, 13% responded that time for PRT was not included in their workday.

At the Middle postpartum period, 83% reported that their current duty assignment had a PRT requirement. Within this group of women, 43% reported mandatory PRT and 16% reported that their PRT was to be performed in a group. Fifty-one percent reported that their PRT requirement could be performed independently. Nearly 14% reported not having time for PRT included in their workday.

At the Late period, 89.5% of active duty women reported a current PRT requirement and 50% of these women reported that this requirement was mandatory, not voluntary. At this time, 20% of the women with a current PRT requirement reported that they were required to have PRT as part of a group and 14.5% reported that they were not allowed time within the workday for training.

Finally, we have included a table of univariate comparisons to describe the percentage of women who became overweight postpartum with each variable that we investigated. Table Seven shows the results of this analysis for active duty women and for military dependents separately. For this analysis, only women who had a BMI below 25.0 were included. This population of women comprise the dataset of women used in our multivariate models. In summary, for active duty women the factors pre-pregnancy BMI, each trimester weight gain, income, and dieting were all associated with becoming overweight postpartum. For military dependent women, the same factors were also associated with becoming overweight as were the additional factors of financial security and weight cycling.

MULTIVARIATE REGRESSION MODELS

In the 2001 ABC Study report, we reported on active duty women using a model that attempted to describe the relative odds of becoming overweight postpartum if a woman was considered to have a normal BMI before pregnancy. The prior year's model used a BMI cutoff of 26.0 to indicate the cutoff between normal and overweight. In the analysis described below, we use a BMI of 25.0 to indicate the overweight cutoff. It is our belief that the new cutoff is more relevant to military use. Optimal ranges for BMI were adopted by the military from the 1995 Dietary Guidelines for Americans to reflect the suggested range of between 19kg/m2 to 25kg/m2 as a body composition associated with a reduced risk to health and increased physical fitness[i]. In addition, we added several variables describing the postpartum experience to investigate their association with the risk of becoming overweight postpartum. Any differences between the prior year's model of active duty women who became overweight and the current year's model can be attributed to these two changes.

Measurements and characteristics included in the multivariate analysis initially included: pregnancy weight gain, pre-pregnancy body mass index, birthweight of baby, mother's height, mother's age, parity, time of mother's last reported or measured postpartum weight, mother's military rank, income, race, physical readiness training required in current duty or not, average amount of weekly sports or exercise during the last year, dieting behavior, financial security, and the weight cycling. Factors related to physical readiness training, exercise, dieting, financial security and weight cycling were collected over the postpartum period. All remaining variables were gleaned from the baseline or combo questionnaires or medical records abstraction.

In the final model, presented at Table Eight, we included only those variables whose odds ratio showed a significant association with the outcome, became overweight. Variables that did not improve the fit of the data to the model were also left out of the final model.

The PRT requirement variable was also investigated in preliminary analysis but left out of the final model when it was concluded that the variable did not contribute to a better fit of the data to the model and limited the number of useable observations. In preliminary analysis, there was an increased but not statistically significant odds of becoming overweight with required PRT compared to active duty women who did not have a PRT requirement in their current duty assignment.

In the final model, third trimester weight gain had statistically significant, increased odds ratios associated with postpartum BMI for active duty women. Income and time were associated with a very small decreased odds of becoming overweight. Higher income and increased participation in sports or exercise decreased the probability of becoming overweight, though the effect of income was very small.

Dieting, and financial insecurity increased a woman's risk of becoming overweight or obese postpartum. Women who responded that they used any dieting strategy on some but not all clinic questionnaires were nine times more likely to be overweight postpartum but women who responded to every clinic questionnaire that they employed a dieting strategy some of the time were 3.2 times more likely than non-dieters to be overweight or obese postpartum. Financial insecurity was also associated with an increased odds of becoming overweight. Women who were financially insecure were more than four times more likely to become overweight postpartum.

Discussion

Results from this study confirm that weight gain during pregnancy plays an important role in a woman's ability to lose weight postpartum. In addition, a number of other socio-economic and lifestyle characteristics and behaviors can improve or diminish one's ability to lose weight after the birth of a baby.

Twenty-nine percent of active duty women with a normal pre-pregnancy BMI became overweight postpartum. Upon further analysis, the majority of these women, 74 out of 80, had a pre-pregnancy BMI between 22.1 and 25.0. This may suggest that women with a BMI approaching the upper acceptable military limit for body mass index may have more difficulty losing weight after childbirth than women with a lower number on the index.

The women who returned to a normal BMI postpartum lost more weight during the postpartum period and gained less weight during pregnancy. Active duty women who maintained a normal weight-for-height postpartum lost, on average 15kg, nearly five-and-a-half kg more than women who could not maintain their pre-pregnancy weight-for-height. Women who maintained a normal BMI also had a different pattern of weight gain by trimester gaining almost 1.8 kg in the first trimester, 1.1 kg in the second, and 1.7 kg in the third less than women who did not became overweight. When compared as a percentage of total pregnancy gain, women who did not become overweight gained less during their first semester and more during the third trimester.

Beyond weight gain, other factors appeared to influence the risk of becoming overweight. Among these were income, weight cycling, and dieting. Women who became overweight reported more bouts of weight cycling, had a lower income, were younger, and had a higher pre-pregnancy BMI than women who returned to their normal weight. Furthermore, nine percent fewer women in the became overweight group were financially secure and 19% more women reported feeling depressed. There were inconsequential differences in the racial composition or military rank of women who became overweight versus those that did not.

Regression analysis strengthened these findings. After adjusting for several factors, dieting was also associated with a large and increased odds of becoming overweight. Unlike the sports/exercise variable which had a negative association with being overweight postpartum, dieting appeared to increase the odds of being overweight. This data cannot inform us whether the types of dieting or dieting patterns employed by the women in this study were causing them to retain some portion of their pregnancy weight gain or whether women who were dieting were having trouble losing the weight and then tried to diet. It is possible that some women lose their pregnancy weight easily and don't need to diet while others have a more difficult time and must diet. If this is true, then only women who have weight left to lose would report dieting and therefore, the odds of being overweight be increased for dieters compared to non-dieters. It is possible that required physical readiness training might be similarly related to being overweight postpartum. The results of preliminary analysis using PRT in the model show that having PRT required by a mother's current duty status is associated with 2.5 times increased odds of being overweight postpartum compared to women without a PRT requirement. It is not possible to distinguish from this data whether the physical readiness training itself is contributing to weight retention or whether PRT is ordered for women who were apparently not back to their original level of fitness.

Some issues regarding study participation limit the interpretation of the results of this study. First, the rate of participation in the study by active duty women was lower than anticipated. Furthermore, a sizeable number of active duty women were lost to follow-up, limiting the number of women with postpartum data that could be included in the study analysis. Despite best efforts to recruit military women into the study and careful description of the survey and the value of the information to the application of health and physical readiness standards for women in the military, a large number of active duty women did not choose to participate in the study. Further compounding the problem of less than optimal participation was the less than full completion of questionnaires. Data was collected on 2,430 women, 541 of which were active duty women, or only 22% of the study population. Only 449 (83%) of active duty women provided enough data to be included in preliminary analysis and this number was further reduced to less than 300 when certain characteristics were included in the investigation. These missing data points come from incomplete or non-returned questionnaires. Some of the variables with limited number of observations include income, smoking history, depression, history of weight cycling, and to a lesser extent, physical readiness training and their restriction on the dataset may limit our ability to detect important relationships between and among these factors, postpartum weight loss and the risk of becoming overweight or obese.

Another limitation of this study was the inability to track women who were lost to follow-up. No information was collected on women who left the military or the study or their reasons for doing so. This lack of information prevents us from understanding the needs of military women regarding their job, their physical readiness postpartum and the demands of parenting and how these factors relate to one another.

Assumptions were made about the active duty status of women at the end of the study period, which were projections of their responses to earlier questionnaires. Therefore the number of women who were categorized as active duty could have been overestimated if some of the women left the military during the course of the study or were taken off current active duty status.

It would be important in future studies of return to readiness in military women to utilize a study design that may encourage greater participation. Understandably, new mothers experience many demands on their time. An improved survey design should offer sizable financial or other incentives to adequately compensate new mothers for the increased demand on their time after meeting the demands for work, childcare, physical readiness training and the pressure to return to physical readiness as quickly as possible. A survey of this scope required multiple points of data collection from each respondent and a significant amount of time to complete the baseline and follow-up questionnaires. Surveys of military women regarding the perinatal experience should also be interview-administered to reduce confusion and guarantee completion of all survey questions. Integrating data collection into work time could increase participation rates and follow-up.

TABLE ONE

PRE-PREGNANCY AND BASELINE CHARACTERISTICS OF ACTIVE DUTY AND MILITARY DEPENDENT WOMEN

		Military Dependent			Active Duty	
		N	Mean		N	Mean
Pre-Pregnancy Weights						
Pre-pregnancy Weight		1540	65.1	~	449	64.04
Pre-pregnancy BMI		1539	24.8	*	449	24.12
Mother's Static Characteristics						
Income		1343	2527.6	*	354	2810.5
Mother's Height		1539	161.8	*	449	162.9
Mother's Age		1539	26.4	*	449	24.7
Number of Times Lost 10 lbs.		1202	1.84	~	308	1.66
		N	%		N	%
Smoked at least 100 Cigs. Ever	No	750	*61.9%*		199	*64.4%*
	Yes	461	*38.1%*		110	*35.6%*
		1211			309	
Race	White	833	*54.1%*		218	*48.6%*
	Black	168	*10.9%*		127	*28.3%*
	Asian	255	*16.6%*		21	*4.7%*
	Hispanic	254	*16.5%*		68	*15.1%*
	Other	29	*1.9%*		15	*3.3%*
		1539		*	449	
Rank	Jr Enlisted	704	*45.8%*		211	*47.3%*
	Sr Enlisted	666	*43.4%*		179	*40.1%*
	Jr Officer	159	*10.4%*		52	*11.7%*
	Sr Officer	7	*0.5%*		4	*0.9%*
		1536			446	
Parity	0	680	*44%*		300	*67%*
	1	531	*35%*		118	*26%*
	2	232	*15%*		28	*6%*
	3	68	*4%*		3	*1%*
	4+	28	*2%*		0	*0%*
		1539		*	449	

**** P-Value of Chi-Square or T-Test <0.05***
~ P-Value of Chi-Square or T-Test <0.10

TABLE TWO

PREGNANCY AND POSTPARTUM MEASUREMENTS OF MILITARY DEPENDENT AND ACTIVE DUTY WOMEN

	Military Dependent			Active Duty	
Pregnancy & Birth Weights	N	Mean		N	Mean
Baby's Birthweight	1539	3417.6		449	3410.7
Pregnancy Weight Gain	1540	15.91	*	449	17.48
Mother's Postpartum Last Weights	N	Mean		N	Mean
Time of last weight	1539	325.5	*	449	301.9
Last Weight (kg)	1539	68.8		449	68.2
BMI from Last Weight	1539	26.23	~	449	25.68
Time of Last Measured Weight	1539	231.1		449	230.9
Last Measured Weight (kg)	1539	69.8		449	70.0
BMI from Last Measured Weight	1539	26.60		449	25.99

** P-Value of Chi-Square or T-Test <0.05*
~ P-Value of Chi-Square or T-Test <0.10

TABLE THREE

POSTPARTUM SUMMARY CHARACTERISTICS OF MILITARY DEPENDENT AND ACTIVE DUTY WOMEN

		Military Dependent			Active Duty	
		N	%		N	%
Healthy Dieting reported:	None	656	*44.0%*		209	47.9%
	Some	326	*21.9%*		96	22.0%
	All	508	*34.1%*		131	30.0%
		1490			436	
Any Dieting Reported	None	318	*21.2%*		92	*20.9%*
	Some	254	*16.9%*		79	*17.9%*
	All	927	*61.8%*		270	*61.2%*
		1499			441	
Financial Security	Secure	1095	*73.4%*		311	*71.8%*
	Not Sure	207	*13.9%*		51	*11.8%*
	Some	79	*5.3%*		30	*6.9%*
	Insecure	111	*7.4%*		41	*9.5%*
		1492			433	
Felt Depressed, last 7 days	Rarely or None	691	*60.8%*		187	*65.2%*
	Some	348	*30.6%*		84	*29.3%*
	More than half	70	*6.2%*		11	*3.8%*
	Most or all	28	*2.5%*		5	*1.7%*
		1137			287	
		N	Mean		N	Mean
Weekly Sports/Exercise		1526	1.99	~	437	2.13

**** P-Value of Chi-Square or T-Test <0.05***
~ P-Value of Chi-Square or T-Test <0.10

TABLE FOUR

POSTPARTUM SUMMARY CHARACTERISTICS OF MILITARY DEPENDENT AND ACTIVE DUTY WOMEN BY EARLY, MIDDLE, LATE PERIODS

		Military Dependents Early			Active Duty		Active Duty	
		N	Mean		N	Mean	N	Mean
Amount Sports/Exercise per Week - Early		965	1.83		300	1.91	300	1.91
Amount Sports/Exercise per Week - Middle		1082	2.12		298	2.24	298	2.24
Amount Sports/Exercise per Week - Late		648	1.99		189	2.25	189	2.25
		N	%		N	%	N	%
Healthy Dieting - Early	No	473	*53.0%*		158	*56.6%*	158	*56.6%*
	Yes	419	*47.0%*		121	*43.4%*	121	*43.4%*
		892			279		279	
Healthy Dieting - Middle	No	586	*53.3%*		172	*55.0%*	172	*55.0%*
	Yes	513	*46.7%*		141	*45.0%*	141	*45.0%*
		1099			313		313	
Healthy Dieting - Late	No	384	*57.6%*		127	*64.5%*	127	*64.5%*
	Yes	283	*42.4%*		70	*35.5%*	70	*35.5%*
		667		*	197		197	
Any Dieting - Early	No	249	*35.5%*		85	*29.7%*	85	*29.7%*
	Yes	452	*64.5%*		201	*70.3%*	201	*70.3%*
		701			286		286	
Any Dieting - Middle	No	334	*30.1%*		88	*27.8%*	88	*27.8%*
	Yes	777	*69.9%*		229	*72.2%*	229	*72.2%*
		1111			317		317	
Any Dieting - Late	No	218	*43.5%*		71	*35.5%*	71	*35.5%*
	Yes	283	*56.5%*		129	*64.5%*	129	*64.5%*
		501			200		200	

Financial Security - Early	Secure	760	*77.9%*	245	*81.7%*	245	*81.7%*
	Not Sure	106	*10.9%*	25	*8.3%*	25	*8.3%*
	Insecure	110	*11.3%*	30	*10.0%*	30	*10.0%*
		976		300		300	
Financial Security - Middle	Secure	858	*80.1%*	244	*80.8%*	244	*80.8%*
	Not Sure	92	*8.6%*	22	*7.3%*	22	*7.3%*
	Insecure	121	*11.3%*	36	*11.9%*	36	*11.9%*
		1071		302		302	
Financial Security - Late	Secure	536	*83.5%*	144	*77.8%*	144	*77.8%*
	Not Sure	49	*7.6%*	11	*5.9%*	11	*5.9%*
	Insecure	57	*8.9%*	30	*16.2%*	30	*16.2%*
		642		~ 185		185	
Felt Depressed - Early	Rarely or None	539	*60.9%*	183	*66.5%*	183	*66.5%*
	Some of the time	277	*31.3%*	78	*28.4%*	78	*28.4%*
	More than half	50	*5.6%*	9	*3.3%*	9	*3.3%*
	Most or all the time	19	*2.1%*	5	*1.8%*	5	*1.8%*
		885		275		275	
Felt Depressed - Middle	Rarely or None	657	*60.2%*	197	*65.0%*	197	*65.0%*
	Some of the time	352	*32.3%*	87	*28.7%*	87	*28.7%*
	More than half	59	*5.4%*	13	*4.3%*	13	*4.3%*
	Most or all the time	23	*2.1%*	6	*2.0%*	6	*2.0%*
		1091		303		303	
Felt Depressed - Late	Rarely or None	401	*61.4%*	124	*66.0%*	124	*66.0%*
	Some of the time	204	*31.2%*	53	*28.2%*	53	*28.2%*
	More than half	40	*6.1%*	9	*4.8%*	9	*4.8%*

	Most or all the time	8	*1.2%*	2	*1.1%*	2	*1.1%*
		653		188		188	

P-Value of Chi-Square or T-Test <0.05
~ P-Value of Chi-Square or T-Test <0.10

TABLE FIVE

DESCRIPTION OF ACTIVE DUTY WOMEN AND PHYSICAL READINESS TRAINING POSTPARTUM SUMMARY VARIABLES

Current duty has PRT requirement	N	%
All clinic responses negative	42	*10.2*
Some clinic responses negative/some positive	43	*10.5*
All clinic responses positive	326	*79.3*
	411	
If PRT is required, PRT is:		
PRT is Mandatory	135	*35.6*
PRT is Both (includes multiple responses)	68	*17.9*
PRT is Voluntary	176	*46.4*
	379	
PRT is Group	47	*14.6*
PRT is Both (includes multiple responses)	156	*48.3*
PRT is Individual	120	*37.2*
	323	
PRT Time is allowed in workday	263	*82.2*
PRT Time is allowed- Some responses	24	*7.5*
PRT Time is not allowed in workday	33	*10.3*
	320	
Concern about PRT		
- Not at all	22	*33.8*
- Somewhat	18	*27.7*
- Very	19	*29.2*
- Extremely	6	*9.2*
	65	
	N	Mean

Avg. number of days/week required	292	2.8
Avg. number of minutes/session required	294	47.4

TABLE SIX

DESCRIPTION OF ACTIVE DUTY WOMEN AND PHYSICAL READINESS TRAINING OVER THE EARLY, MIDDLE, AND LATE POSTPARTUM PERIODS

	EARLY		MIDDLE		LATE	
	N	%	N	%	N	%
Current duty has PRT requirement						
No PRT required	47	17.7%	48	17.4%	18	10.5%
Yes PRT required	219	82.3%	228	82.6%	153	89.5%
If PRT is required, PRT is:						
PRT is Mandatory	93	43.3%	95	42.6%	77	50.3%
PRT is Both (includes multiple responses)	2	0.9%	2	0.9%	3	2.0%
PRT is Voluntary	120	55.8%	126	56.5%	73	47.7%
	215		223		153	
PRT is Group	41	18.8%	35	15.8%	31	20.4%
PRT is Both (includes multiple responses)	78	35.8%	74	33.5%	52	34.2%
PRT is Individual	99	45.4%	112	50.7%	69	45.4%
	218		221		152	
PRT Time is allowed in workday	29	13.3%	30	13.6%	22	14.5%
PRT Time is not allowed in workday	189	86.7%	190	86.4%	130	85.5%
	218		220		152	
Concern about PRT						
- Not at all	101	35.3%	114	40.3%	68	39.8%
- Somewhat	105	36.7%	82	29.0%	66	38.6%
- Very	43	15.0%	46	16.3%	18	10.5%

- Extremely	37	12.9%	41	14.5%	19	11.1%
	286		283		171	
PRT Results	Baseline		Follow-up			
Fail	8	2.9%	19	2.9%		
Good	100	36.4%	66	36.4%		
Excellent	111	40.4%	50	40.4%		
Outstanding	56	20.4%	28	20.4%		
	275		163			

Table Seven: Association Between Covariates And Postpartum Overweight/Obesity by Active Duty Status

	N	%	N	%	p value	N	%	N	%	p value
	Active Duty					Military Dependants				
	BMI <25		BMI ≥25			BMI <25		BMI ≥25		
Overall										
Race					0.38					0.33
White	108	52	35	44		408	56	114	53	
Black	55	27	23	29		58	8	22	10	
Asian	14	7	4	5		155	21	39	18	
Hispanic	29	14	17	22		109	15	40	19	
Rank					0.48					0.47
Jr. Enlisted	89	44	39	49		329	45	97	45	
Sr. Enlisted	88	43	28	35		325	45	89	32	
Jr. or Sr. Officer	26	13	12	15		75	10	28	13	
Required PRT					0.97					
No requirement	20	11	8	11		N/A		N/A		
Required– Some of study	22	12	8	11		N/A		N/A		
Required- All of study	145	78	59	79		N/A		N/A		
Financial Security					0.20					0.03
Secure	152	76	50	67		552	77	148	73	
Unsure	24	12	10	13		82	11	37	18	
Insecure	24	12	15	20		80	11	18	9	
Depression					0.08					0.003
Rarely or Never	97	69	22	50		345	64	77	52	
Sometimes	38	27	20	45		155	29	49	33	
Half of the time	3	2	2	5		25	5	16	11	
All the time	2	1	0	0		11	2	7	5	
Any Dieting					<0.001					<0.0001
Never	68	34	10	13		205	29	34	16	
Sometimes	49	24	13	16		137	19	22	11	
All the time	86	42	56	71		374	52	151	73	
Weight Cycling					0.32					0.002
Not a Weight Cycler	121	80	36	73		473	82	111	71	
Weight Cycler	30	20	13	27		103	18	46	29	

Table 7. Association Between Covariates And Postpartum Overweight/Obesity by Active Duty Status, continued

	Mean	SD	Mean	SD	T	p value	Mean	SD	Mean	SD	T	p value
Pre-pregnancy BMI	21.6	0.12	23.5	0.13	-8.9	<0.0001	21.2	0.07	23.3	0.10	-14.8	<0.0001
First Trimester Gain	2.3	0.19	4.0	0.45	-4.1	0.0001	1.9	0.11	3.4	0.30	-5.6	<0.0001
Second Trimester Gain	6.4	0.21	7.4	0.30	-2.6	0.01	6.2	0.13	7.2	0.28	-3.7	0.0002
Third Trimester Gain	7.5	0.21	9.1	0.42	-3.8	0.0002	7.7	0.13	8.5	0.29	-2.7	0.008
Weekly sports/exercise	2.1	0.13	2.1	0.21	-0.16	0.87	1.9	0.08	1.9	0.14	-0.49	0.62
Income	3152	131	2339	163	3.3	0.001	2749	58.8	2440	91.7	2.5	0.01
Parity	0.38	0.04	0.37	0.06	0.14	0.88	0.77	0.03	0.83	0.07	-0.74	0.46
Maternal Age	24.9	0.37	23.8	0.5	1.6	0.10	26.4	0.21	26.1	0.38	0.60	0.55

TABLE EIGHT

Multivariate Logistic Regression Model of the Odds of Becoming Overweight Among Normal Weight Women At Month Six and After: Stratified on Active Duty Status

	Active Duty Women N=159			**Military Dependant Women N=476**			**All Women N=635**		
	OR	Lower CI	Upper CI	OR	Lower CI	Upper CI	OR	Lower CI	Upper CI
First trimester gain	1.12	0.93	1.35	1.14	1.05	1.25	1.15	1.07	1.24
Second trimester gain	1.09	0.93	1.35	1.11	1.02	1.20	1.11	1.03	1.19
Third trimester gain	1.27	1.08	1.49	1.09	1.02	1.17	1.12	1.06	1.20
Parity	1.08	0.42	2.75	1.22	0.90	1.67	1.18	0.89	1.58
Race (vs. white)									
Black	0.37	0.11	1.38	1.24	0.45	3.39	0.83	0.40	1.75
Asian	0.11	0.01	1.5	0.79	0.38	1.65	0.65	0.32	1.32
Hispanic	2.12	0.55	8.17	*1.03*	*0.51*	*2.13*	*1.23*	*0.68*	*2.24*
Maternal age	1.16	1.03	1.30	*1.03*	*0.97*	*1.08*	*1.03*	*0.98*	*1.08*
Weight cycler (vs. not)	1.06	0.34	3.33	*1.03*	*0.82*	*2.69*	*1.37*	*0.82*	*2.29*
Income (vs. medium)	1.00	1.0	1.0	*1.00*	*1.0*	*1.0*	*1.00*	*1.0*	*1.0*
Time	1.00	.99	1.0	*1.00*	*.99*	*1.0*	*1.00*	*1.0*	*1.0*
Amt. Sports/exercise	0.69	0.47	1.02	*1.02*	*0.91*	*1.15*	*0.9*	*0.87*	*1.09*
Any dieting (vs. None)									

Some responses	3.29	0.71	16.45	*0.97*	*0.41*	*2.28*	*1.20*	*0.58*	*2.48*
All response	9.19	2.30	36.65	*1.84*	*0.95*	*3.57*	*2.40*	*1.34*	*4.30*
Financial security (vs. secure)									
Not sure	3.28	0.69	15.57	*1.61*	*0.83*	*3.13*	*1.76*	*0.98*	*3.18*
Insecure	4.19	1.12	15.53	*0.88*	*0.37*	*2.09*	*1.27*	*0.65*	*2.46*

[i] Institute of Medicine. Committee on Body Composition, Nutrition and Health of Military Women. Committee on Military Nutrition Research. Food and Nutrition Board. Assessing readiness in military women: The relationship of body composition, nutrition and health. 1998; Washington, D.C.. National Academy Press.