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Original Article

Postpartum weight retention and cardiovascular risk

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ABSTRACT

Introduction: Pregnancy has been considered a risk period of excessive weight gain leading to postpartum weight retention in the short, medium and long terms and therefore to woman's obesity with significant health risks.
Objective: To determine relationships of the pre-pregnancy nutritional state and gestational weight gain with postpartum weight retention as a cardiovascular risk factor.
Method: Cross-sectional study in 29 women, apparently healthy, with postpartum weight retention by the year.
Results: There were found average values of pre-pregnancy body mass index increased in 1.9 kg/m^2 by the postpartum year, an average weight gain of gestational retention of 18.8 kg and weight retention of 11.3 kg; 34.5% of pregnant women found to be pre-hypertensive and 20.7%, hyperreactive. The waist/height index showed statistically significant differences.
Conclusions: Weight gain above the recommended has a positive relationship with postpartum weight retention, but states of pre-hypertension and vascular hyperreactivity appear to be associated with this retention. The waist/height index was the most effective indicator of cardiovascular risk.
Key words: Body Mass Index, Pregnancy weight gain, Postpartum weight retention, Cardiovascular risk, Pregnancy, Cardiovascular complications of pregnancy

Retención de peso postparto y riesgo cardiovascular

RESUMEN

Introducción: El embarazo ha sido considerado como un período de riesgo de ganancia excesiva de peso que conduce a una retención de peso postparto a corto, mediano y largo plazos y, por tanto, a la obesidad de la mujer con riesgos importantes para su salud.
Objetivo: Determinar relaciones del estado nutricional pregestacional y la ganancia de peso gestacional con la retención de peso postparto como factor de riesgo cardiovascular.
Método: Estudio observacional transversal en 29 mujeres, supuestamente sanas, con retención de peso al año postparto.
Resultados: Se encontraron valores promedios del índice de masa corporal pregestacional incrementados en 1,9 kg/m^2 al año postparto, un promedio de ganancia de peso gestacional de 18,8 kg y de retención de peso de 11,3 kg; el 34,5% de las gestantes resultó ser prehipertensa y el 20,7%, hiperreactiva. El índice cintura/talla mostró diferencias estadísticas significativas.

Conclusiones: La ganancia de peso por encima de lo recomendado tiene relación positiva con la retención de peso postparto, pero los estados de prehipertensión e hiperreactividad vascular parecen no estar asociados a esta retención. El índice cintura/talla resultó el indicador de riesgo cardiovascular más efectivo.
Palabras clave: Índice de masa corporal, Ganancia de peso gestacional, Retención de peso postparto, Riesgo cardiovascular, Embarazo, Complicaciones cardiovasculares del embarazo

INTRODUCTION

Pregnancy weight gain is crucial not only for the fetal development, but also for the maternal health, given its importance in the deposition of fat in the mother's body and retention after delivery as a possible cardiovascular risk[1] with the consequent rise in the morbidity and mortality worldwide[2].

Obese people more likely to develop high blood pressure −strong risk factor for cardiovascular mortality−, are those that have a fat regional distribution of central pattern, no matter the degree of obesity[3].

Women who have given birth once or twice are three or four times more likely to develop obesity over the next five years, than those who have not in the same period of time[4], that is why, the strongest predictor of maternal overweight or obese consecutive childbirth is excessive weight gain during pregnancy[5].

Pregnant women who gain weight above the recommended, tend to retain more weight after giving birth than those who fulfill those recommendations[6, 7]. While in pregnant women with normal weight, physiological changes are adaptive in the evolutionary-functional sense, in the ones overweight or obese, molecular signals emanating from the adipose tissue and placenta affect multiple organs and systems by inflammatory conditions of low degree and fetal and maternal insulin resistance, with inappropriate activation of adaptive control circuits[8].

The dysfunction of the adipose tissue produces metabolic changes[9] in the secretion of free fatty acids that contribute to chronic vascular inflammation, oxidative stress, activation of the renin-angiotensin-aldosterone system and overstimulation of the sympathetic system[10], with increased cardiovascular risk[11,12].

Postpartum weight retention is a major risk factor of obesity even in women with initial normal weight; modifications in their behavior can reduce this risk[13].

The aim of this study was to determine the relationship of the pre-pregnancy nutritional state and pregnancy weight gain with postpartum weight retention as a cardiovascular risk factor.

METHOD

Out of a population of 207 pregnant women who received prenatal care in the health area Chiqui Gómez Lubián in Santa Clara, Cuba, between September 2012 and September 2013, there were identified 59 who had gained weight above recommended during pregnancy[14,15], therefore a cross-sectional study was performed on 29 women, reportedly healthy, with postpartum weight retention after a year. The study included anthropometric and hemodynamic aspects.

Variables

Related to body weight

- Preconception nutritional state. Determined at the time of detection of pregnancy from the values of body mass index (BMI) declared in the anthropometric tables of pregnant in Cuba..
- Pregnancy weight gain. Defined as the difference in weight between the end and the beginning of the pregnancy (at the time of pregnancy's detection).
- Nutritional state after a year of childbirth. Determined at the time of the research, from the BMI values declared in the anthropometric tables of pregnant in Cuba.
- Postpartum weight retention. Defined as the difference between the weight in kilograms at the time of the research and the time of the pregnancy's detection.

Other anthropometric variables

- Waist circumference. Defined as the measure taken in centimeters at the umbilical scar.
- Hip circumference. Defined as the measure taken in centimeters at the greater trochanters.
- Waist/hip index after the postpartum year. Arithmetic ratio between the values of the circumferen-

ces of the waist and hip, calculated at the time the research was carried out.

- Waist/height index pre-pregnancy and after the postpartum year. Arithmetic relationship between values of waist circumference and height, calculated at the time and detection of pregnancy and subsequently during the course of the research.

Related to blood pressure

- Basal blood pressure. Defined as systolic and diastolic pressure, measured from the sitting position in the upper right limb, the classic auscultation method (Korotkoff) defined by the World Health Organization and the criteria of the National Hypertension Program.

From the blood pressure records in sitting position, pregnant women are classified in:

- Normotensive: Values of systolic blood pressure less than 120 mmHg and diastolic 80 mmHg.
- Prehypertensive: Values of systolic blood pressure of 120-139 mmHg and diastolic 80-89 mmHg.
- Hypertensive: Systolic/diastolic blood pressure greater than or equal to 140/90 mmHg.

- Vascular reactivity. Defined as the vascular response of the patient evaluated by measuring blood pressure taken in the right arm in the sitting position, induced by the sustained weight test. The mean blood pressure (MBP) is calculated with the following mathematical formula: MBP = DBP + ⅓(DBP-SBP), where DBP means diastolic blood pressure and SBP systolic blood pressure.

According to MBP values for females in the second minute of the sustained weight test, patients were classified in normoreactive (MBP<105 mmHg), hyperreactive (MBP 105≤MBP<115 mmHg) or with hypertensive response (MBP≥115 mm Hg).

Processing and analysis of information

The definitions of adequate weight, overweight, obese, normal BP, prehypertension and risk indicators were established according to the recommendations of previous researches[5-7,10-12].

The data were stored and processed in the software SPSS version 15 for Windows.

Descriptive measures of central tendency and dispersion were determined, the Pearson's correlation coefficient was used to relate the quantitative variables in the analysis; only the value and significance was shown when it was significant (p<0.05).

Distributions of absolute and relative frequencies for qualitative variables were used. To determine whether differences exist in the postpartum weight retention, according to the pre-pregnancy maternal nutritional state, the parametric method of comparison of means was used for more than two independent groups ANOVA with its F statistician and its significance associated.

There was performed a comparison of the average weight retention variables useful for identifying cardiovascular risk (basal blood pressure, response to sustained weight test, waist circumference and waist/height index). The *t* Student test was used with its statistician and p significance associated. In both cases the statistical decision was taken to prefix a significance level α=0.05.

Ethical aspects

The Research Ethics Committees of the participating institutions gave their full authorization. All women studied gave their informed consent.

RESULTS

When distributing the women studied according to their pre-pregnancy nutritional state and a year after delivery (**Table 1**), it showed that 90.9% of those with an adequate pre-partum weight retained this condition a year postpartum, while the remaining 9.1% went to the overweight category, but neither became obese. Instead, 1 (25.0%) with overweight became obese and the 3 that had this condition before childbirth maintained that state a year of childbirth.

The average values of BMI after a year of childbirth showed an average increase of 1.9 kg/m^2 with respect to the BMI before pregnancy, with very similar standard deviation values (**Table 2**). The pregnancy weight gain value averaged 18.8 kg, with an average weight retention of 11.3 kg, representing a statistically significant positive correlation (p= 0,019).

The greater weight gain corresponds to pregnant with overweight (**Table 3**), followed by those with healthy weight at the time of the pregnancy detection, with high variability and no statistically significant differences between groups.

The third part of the studied women was found to be prehypertensive, while the sustained weight

Table 1. Pre-pregnancy nutritional state after a year of childbirth.

Pre-pregnancy nutritional state	Nutritional state after a year of childbirth						Total (n=29)	
	Adequate weight		Overweight		Obesity			
	Nº	%	Nº	%	Nº	%	Nº	%
Adequate weight (n=22)	20	90,9	2	9,1	0	0,0	22	75,9
Overweight (n=4)	1	25,0	2	50,0	1	25,0	4	13,8
Obesity (n=3)	0	0,0	0	0,0	3	100,0	3	10,3
Total	21	72,4	4	13,8	4	13,8	29	100,0

Percentage calculated by rows, except in the total at the right.

test yielded that a fifth part of them were hyperreactive (Table 4). There was no correlation between the average value of retained weight and conditions of hyperreactivity or prehypertension.

Table 5 shows the average values of postpartum weight retention as known indicators of cardiovascular risk. Although there were no statistically significant differences, women with higher weight retention are in the categories indicating cardiovascular risk (waist/hip index 11.5 vs. 10.7 and waist/height 12.5 vs. 10.2), except for the waist circumference. It is worth noticing the increased waist/height index from the detection of pregnancy up to a year after delivery (delta CA/height); the greater weight retention was associated, statistically significant ($p < 0.05$), with those in which there was a greater increase in this index.

Table 2. Mean values of BMI, pregnancy weight gain and postpartum weight retention.

Variables	Mean	Standard deviation
Pre-pregnancy BMI	24,0	3,5
Pregnancy weight gain	18,8	3,1
Postpartum weight retention	11,3	6,7
Postpartum BMI	25,9	3,8

r=0,431; p=0,019 (ratio between pregnancy weight gain and postpartum weight retention).
p>0,05 (ratio between pre-pregnancy BMI and postpartum weight retention).
BMI: body mass index.

Table 3. Postpartum weight retention according to pre-pregnancy nutritional state.

Pre-pregnancy nutritional state	Mean	Standard deviaton
Adequate weight (n=22)	11,3	6,3
Overweight (n=4)	12,0	8,6
Obesity (n=3)	10,6	10,5
Total (n=29)	11,3	6,7

F=0,003; p=0,960

DISCUSSION

Amorim *et al.*[14], and Lowell and Miller[15] have informed that pregnant women with poor weight gain, when in excess, retain more weight than overweight and obese ones; however, in this study it is not possible to make comparisons, because in the sample studied no woman with poor nutritional state before pregnancy was found. There was found that women with pre-gestational nutritional status of healthy weight and overweight showed superior mean values of postpartum retention, regarding those obese under similar conditions, suggesting that obese pregnant women who earn too much are not the ones that retain more weight after giving birth, nor are the ones with the largest absolute gains.

Other studies on postpartum weight retention adjusted for age and pre-pregnancy BMI among women who gained excess weight, expose average values of 5.0 kg[16]; lower figures than those found in this study do agree with the ones observed by Linnaeus *et al.*[17], who have found that women with overweight before pregnancy showed no increased risk of weight retention after

Table 4. Suggestive tests of cardiovascular risk by weight retention (n=26).

Variable	Categories	Nº	%	Average of weight retention
Blood pressure*	Normotensive	19	65,51	12,3
	Prehypertensive	10	34,5	9,4
Sustained weight test*	Normoreactive	23	69,31	12,1
	Hyperreactive	6	20,7	8,0

* No statistically significant differences.

Table 5. Distribution of weight retained as abdominal obesity suggestive indices of cardiovascular risk.

Indicators of CV risk	Categories	Indicator's value	Weight retention average	Comparison
WC (cm)	Risk indicator	93,1 cm	11,1	t = - 0,204
	No risk	80,5 cm	11,6	p = 0,840
WC/HC index	Risk indicator	0,92	11,5	t = 0,273
	Normal	0,84	10,7	p = 0,787
WC/height Index	Risk indicator	0,57	12,5	t=0,901
	Normal	0,48	10,2	p=0,375
Delta WC/HC	WC/HC larger pre-pregnancy	- 0,03	7,9	t = - 1,920
	WC/HC larger after the postpartum year	0,04	12,8	p = 0,065
Delta WC/height	WC/height larger pre-pregnancy	- 0,02	7,3	t = - 2,524
	WC/height larger after the postpartum year	0,04	13,4	p = 0,018

CV: cardiovascular; HC: hip circumference; WC: Waist circumference

childbirth compared to those with normal weight.

Ashley-Martin and Woolcott have informed changes in weight retention after childbirth on pre-pregnancy BMI in all categories, most notably in those with poor weight (7.5 kg)[6], and other authors[18] consider that the average weight retention, from pre-pregnancy weight, is 0.5 to 4 kg, although about 25% of women hold more than 4.5 kg. A study with Brazilian women showed that for every unit that pre-pregnancy BMI increases, the postpartum weight retention is reduced 0.5[19], which coincides with the results of this work, where obese women showed the lowest average value of weight retention.

The increasing BMI of 24 to 25.9 kg/m^2 a year from childbirth, found in the present study, is similar to that described by other authors in the journal Obstetrics and Gynecology[13], over a period of postpartum time alike. With respect to the amount of weight retention, in this same study it is suggested that 47.4% retained more than 10 pounds (≈4.5 kg), but it does not specify how much more, while in the present work this variable reached an average value of 11.3 kg, marking an interesting difference between the two researches, perhaps because, among other reasons, this sample was formed only by women who had gained too much weight during pregnancy. It is not possible to compare other related results, as the percentage of women who weighed more a year after birth, with this study.

There were confirmed minimal raises of BMI values, although it has been published that one third of women who began their pregnancy as normal weight, were overweight or obese a year after childbirth[19].

Similar studies inform that weight gain during pregnancy is critical for postpartum weight retention, while others have found difficulties in such a relationship[20,21].

A study of 540 healthy women, followed from early pregnancy until a year after birth, established a positive relationship between pregnancy weight gain and postpartum retention (average of 5.95 kg more after a year)[22].

The found average values of retained weight match other researches of the region[13], while at the same time they result superior to the ones published in other latitudes[16].

The findings of prehypertensive and hyperreactive women in the study sample appear to be a consequence of the identified weight retention process, because during pregnancy, physiological hemodynamic responses appear before the new organizational demands, including the declining of the peripheral resistance and blood pressure[23]; these require adaptations of major proportions when weight gains are higher than those required by the body fitting the BMI. If the body was already responding to high demands caused by being overweight or obese, then the propensity to vascular hyperreactivity or prehypertension is even greater.

The absence of relationship of weight retention with this hyperreactivity and prehypertension, and the fact that it has proved the largest relationship between the two phenomena with the waist/height index, suggests that it is not exactly the weight retention what makes the woman more vulnerable to cardiovascular risks, but what that represents in fat tissue and the places where this is located. Current criteria defend the counterposed role of two proteins: leptin and adiponectin in the metabolic transit towards overweight and obesity. Normal adiponectin levels could be useful in the future to identify the phenotype described recently as healthy obese[24]. It is interesting to note that the increased cardiovascular risk has lower titers of adiponectin, a phenomenon whose presence is not ruled out in the present study[25].

A recent publication has found a positive and significant association of weight retention with the three phenotypes of obesity[6].

The most widely used rate in epidemiological studies, to estimate overall adiposity, is the BMI, but in recent years, there have been other more strongly associated with metabolic risk factors[27]. The waist circumference and waist/hip index have been used as indicators of abdominal fat distribution, but now they are being overwhelmed by the waist/height index that has proven the ability to detect cardiovascular risk factors in non-obese, healthy people, according to other anthropometric indicators like BMI[28].

The results of this study are consistent with previous approaches, as women with more retained weight, although they are in the categories indicating cardiovascular risk (11.5 vs. 10.7 for the waist/hip index 12.5 vs. 10.2 for waist/height index), had normal values of the abdominal circumference. Authors like Lee *et al.*[29] and Huxley *et al.*[30] have conducted studies to determine which of the four indices is the best discriminator for cardiovascular risk: hypertension, type II diabetes, and dyslipidemia. Another study in Taiwanese adults found that patients of either sex with normal BMI and waist circumference, but waist/height index high, have a high risk of cardiometabolic illnesses[31]. Also, in Costa Rica has been registered an increase of cardiovascular risk prevalence from the values of the abdominal circumference, with highly significant statistical differences between the group of women under 24 and the group of 25 to 29 years[32].

CONCLUSIONS

The postpartum weight retention after a year does not seem to be associated with pre-pregnancy nutritional state, or prehypertension states and hyperreactivity identified, unlike weight gain above recommended. The waist/height index is the most effective indicator of cardiovascular risk in women who retain weight postpartum.

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REFERENCES

1. Moulana M, Lima R, Reckelhoff JF. Metabolic syndrome, androgens, and hypertension. Curr Hypertens Rep. 2011;13:158-62.
2. Barquera S, Campos-Nonato I, Hernández-Barrera L, Flores M, Durazo-Arvizu R, Kanter R, *et al.* Obesity and central adiposity in Mexican adults:

Results from the Mexican National Health and Nutrition Survey 2006. Salud Publica Mex. 2009;51(Supl. 4):S595-603.
3. Genique Martínez R, Marin Ibáñez A, Cía Gómez P, Gálvez Villanueva AC, Andrés Bergareche I, Gelado Jaime C. Utilidad del perímetro abdominal como método de cribaje del síndrome metabólico en las personas con hipertensión arterial. Rev Esp Salud Publica. 2010;84:215-22.
4. Davis EM, Zyzanski SJ, Olson CM, Stange KC, Horwitz RI. Racial, ethnic, and socioeconomic differences in the incidence of obesity related to childbirth. Am J Public Health. 2009;99:294-9.
5. Herring SJ, Rose MZ, Skouteris H, Oken E. Optimizing weight gain in pregnancy to prevent obesity in women and children. Diabetes Obes Metab. 2012;14:195-203.
6. Nehring I, Schmoll S, Beyerlein A, Hauner H, von Kries R. Gestational weight gain and long-term postpartum weight retention: A meta-analysis. Am J Clin Nutr. 2011;94:1225-31.
7. Siega-Riz AM, Viswanathan M, Moos MK, Deierlein A, Mumford S, Knaack J, *et al*. A systematic review of outcomes of maternal weight gain according to the Institute of Medicine recommendations: Birthweight, fetal growth, and postpartum weight retention. Am J Obstet Gynecol. 2009;201: 339:e1-14.
8. Power ML, Schulkin J. Maternal regulation of offspring development in mammals is an ancient adaptation tied to lactation. Appl Transl Genom. 2013;2:55-63.
9. Bartha JL, Marín-Segura P, González-González NL, Wagner F, Aguilar-Diosdado M, Hervias-Vivancos B. Ultrasound evaluation of visceral fat and metabolic risk factors during early pregnancy. Obesity (Silver Spring). 2007;15:2233-9.
10. Dorresteijn JA, Visseren FL, Spiering W. Mechanisms linking obesity to hypertension. Obes Rev. 2012;13:17-26.
11. Vazquez G, Duval S, Jacobs DR, Silventoinen K. Comparison of body mass index, waist circumference, and waist/hip ratio in predicting incident diabetes: A meta-analysis. Epidemiol Rev. 2007; 29:115-28.
12. de Koning L, Merchant AT, Pogue J, Anand SS. Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: meta-regression analysis of prospective studies. Eur Heart J. 2007;28(7):850-6.
13. Endres LK1, Straub H, McKinney C, Plunkett B, Minkovitz CS, Schetter CD, *et al*. Postpartum weight retention risk factors and relationship to obesity at 1 year. Obstet Gynecol. 2015;125:144-52.
14. Amorim AR, Rössner S, Neovius M, Lourenço PM, Linné Y. Does excess pregnancy weight gain constitute a major risk for increasing long-term BMI? Obesity (Silver Spring). 2007;15:1278-86.
15. Lowell H, Miller DC. Weight gain during pregnancy: Adherence to Health Canada's guidelines. Health Rep. 2010;21:31-6.
16. Ashley-Martin J, Woolcott C. Gestational weight gain and postpartum weight retention in a cohort of Nova Scotian women. Matern Child Health J. 2014;18:1927-35.
17. Linné Y, Dye L, Barkeling B, Rössner S. Long-term weight development in women: a 15-year follow-up of the effects of pregnancy. Obes Res. 2004;12: 1166-78.
18. Althuizen E, van Poppel MN, de Vries JH, Seidell JC, van Mechelen W. Postpartum behaviour as predictor of weight change from before pregnancy to one year postpartum. BMC Public Health [Internet]. 2011 [citado 31 Ene 2016];11:165. Disponible en: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3068095/pdf/1471-2458-11-165.pdf
19. Kac G, Benício MH, Velásquez-Meléndez G, Valente JG, Struchiner CJ. Gestational weight gain and prepregnancy weight influence postpartum weight retention in a cohort of brazilian women. J Nutr. 2004;134:661-6.
20. Harris HE, Ellison GT. Do the changes in energy balance that occur during pregnancy predispose parous women to obesity? Nutr Res Rev. 1997;10: 57-81.
21. Lederman SA. The effect of pregnancy weight gain on later obesity. Obstet Gynecol. 1993;82:148-55.
22. Olson CM, Strawderman MS, Hinton PS, Pearson TA. Gestational weight gain and postpartum behaviors associated with weight change from early pregnancy to 1 y postpartum. Int J Obes Relat Metab Disord. 2003;27:117-27.
23. Purizaca M. Modificaciones fisiológicas en el embarazo. Rev Per Ginecol Obstet [Internet]. 2010 [citado 11 Dic 2016];56:57-9. Disponible en: http://108.163.168.202/web/revista/index.php/RPGO/article/download/255/228
24. Karelis AD. Metabolically healthy but obese individuals. Lancet. 2008;372:1281-3.
25. Han SH, Quon MJ, Kim JA, Koh KK. Adiponectin and cardiovascular disease: Response to therapeutic interventions. J Am Coll Cardiol. 2007;49:

531-8.
26. Fernández-Bergés D, Consuegra-Sánchez L, Peñafiel J, Cabrera de León A, Vila J, Félix-Redondo FJ, *et al*. Perfil metabólico-inflamatorio en la transición obesidad, síndrome metabólico y diabetes mellitus en población mediterránea. Estudio DARIOS Inflamatorio. Rev Esp Cardiol. 2014;67: 624:31.
27. Després JP, Lemieux I. Abdominal obesity and metabolic syndrome. Nature. 2006;444:881-7.
28. Park YS, Kim JS. Association between waist-to-height ratio and metabolic risk factors in Korean adults with normal body mass index and waist circumference. Tohoku J Exp Med. 2012;228:1-8.
29. Lee CM, Huxley RR, Wildman RP, Woodward M. Indices of abdominal obesity are better discriminators of cardiovascular risk factors than BMI: A meta-analysis. J Clin Epidemiol. 2008;61:646-53.
30. Huxley R, Mendis S, Zheleznyakov E, Reddy S, Chan J. Body mass index, waist circumference and waist:hip ratio as predictors of cardiovascular risk - A review of the literature. Eur J Clin Nutr. 2010;64:16-22.
31. Li WC, Chen IC, Chang YC, Loke SS, Wang SH, Hsiao KY. Waist-to-height ratio, waist circumference, and body mass index as indices of cardiometabolic risk among 36,642 Taiwanese adults. Eur J Nutr. 2013;52:57-65.
32. Aráuz-Hernández AG, Guzmán-Padilla S, Roselló-Araya M. La circunferencia abdominal como indicador de riesgo de enfermedad cardiovascular. Acta Méd Costarric. 2013;55:122-7.