Healthy excessive weight in Portuguese women 4 years after delivery of a liveborn

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ABSTRACT

Objective. To quantify the prevalence of healthy excessive weight and determinants of metabolic profile, considering women's reproductive life.

Methods. We evaluated 1847 mothers of a birth cohort assembled after delivery and reevaluated 4 years later. A healthy profile was defined as the absence of hypertension, diabetes, dyslipidemia, C-reactive protein <3 mg/l and being below the second tertile of HOMA-IR. Adjusted odds ratios (OR) and confidence intervals (95% CI) were computed using multinomial logistic regression, taking women with normal BMI as the reference category of the outcome.

Results. Four years after delivery, 47% of women had normal BMI, 33% were overweight and 20% obese. In each BMI class, 61%, 33% and 12% presented a healthy metabolic profile, respectively. Family history of CVD/cardiometabolic risk factors was associated with a higher probability of obesity with a not healthy metabolic profile (OR = 1.39 95% CI: 0.98–1.98). Women who breastfed the enrolled child for >26 weeks and practiced physical exercise were less likely to be obese and metabolically unhealthy (OR = 0.39 95% CI: 0.23–0.68; OR = 0.48 95% CI: 0.33–0.70, respectively), with no effect on healthy excessive weight.

Conclusions. These results support the existence of a healthy excessive weight phenotype in women after motherhood, influenced by anthropometrics, genetic and lifestyles characteristics.

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Introduction

Overweight and obesity are increasingly prevalent worldwide and expected to be one of the major public health problems of the XXI century (Finucane et al., 2011). In Portugal, 20% of women in their thirties are overweight and 8% obese (Carreira et al., 2012) and this increase in excessive body weight will have an important impact on the global incidence of several diseases, (Visscher and Seidell, 2001). However, a subset of obese subjects seems to be protected from obesity-related cardiovascular and cardiometabolic abnormalities (Pataky et al., 2011; Stefan et al., 2008; Karelis, 2008; Manu et al., 2012). The phenotype called healthy obesity is characterized by a favorable metabolic profile: high levels of insulin sensitivity, no hypertension, as well as a favorable inflammatory (Phillips and Perry, 2013), lipid, hormonal and immune profile (Primeau et al., 2011). The importance of recognizing this phenotype is strengthened by the fact that weight loss may adversely impact the favorable metabolic profile (Karelis et al., 2008; Shin et al., 2006).

Despite the absence of a uniform definition for this subtype of obesity, the literature shows a high prevalence of healthy obese individuals (Wildman, 2009; Bluher, 2010), ranging from 6% to 37% (Kuk and Ardern, 2009; Brochu et al., 2001; Phillips et al., 2013). Even when unique criteria are used, considerable variability in the prevalence of healthy obesity is found across different European countries (Van Vliet-Ostaptchouk et al., 2014) and, to the best of our knowledge, there are no estimates for Portugal.

Abdominal fat seems to be linked to a more adverse cardiometabolic profile (Thomas et al., 2012; Jensen, 2008). The increase of fat deposition in abdominal visceral adipose tissue is favored after pregnancy due to increased abdominal compliance, rendering women more susceptible to abdominal obesity after childbirth (Gunderson et al., 2008) and it remains unclear to which extent this abdominal fat is associated with metabolic complications.

Thus, it is interesting to characterize overweight and obesity phenotypes in women who had a child, thus supporting or not the need for preventive action directed at this segment of the population. Specifically, we intend to (a) quantify the prevalence of healthy excessive weight in a cohort of Portuguese women 4 years after delivering a child, (b) assess the dependence of a healthy metabolic profile on the distribution and BMI evolution from prepregnancy to 4 years later and

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(c) identify if sociodemographic characteristics, family history of cardiovascular diseases (CVD) or cardiometabolic risk factors, reproductive history and lifestyles are associated with this metabolically healthy phenotype.

Materials and methods

Study design and participants

This study is based on the birth cohort Generation XXI described elsewhere (Alves et al., 2012). Briefly, in 2005–2006, 8495 women, who gave birth to 8647 infants, were enrolled into the cohort after the child's birth. They were recruited in the maternity clinics of five public hospitals covering the metropolitan area of Porto, Portugal within 72 h after delivery.

Four years after birth, in 2009–2011, a follow-up took place and 84.2% of the mothers were reevaluated. Of all mothers, 5729 (67.4%) attended a face-to-face evaluation, comprising questionnaires and physical examination (anthropometrics and blood pressure) and 1428 (16.8%) provided self-reported data by telephone interview. Women interviewed by telephone were excluded due to the lack of physical examination data. Among those who attended the face-to-face interview, half were randomly selected to provide a fasting blood sample. From the 2733 mothers who provided a fasting blood sample, we excluded from the current analysis 553 who had subsequent pregnancies after the baseline evaluation, 175 with a C-reactive protein level above 10 mg/l, which suggests a clinically relevant inflammatory condition (Yeh and Willerson, 2003), 28 with body mass index (BMI) <18.5 kg/m^2 at follow-up and 130 with missing data on BMI, waist circumference, diabetes, dyslipidemia, hypertension, C-reactive protein or insulin resistance, leaving 1847 women for the current analysis.

Exposure variables

During reevaluation, socioeconomic characteristics, personal and family history of disease, obstetric history and lifestyles of the women were self-reported. Women's age was collected as a continuous variable. Education was collected as a continuous variable considering the complete years of schooling and later categorized. Working condition was defined as employed, unemployed, housewife and others (student or retired). Marital status at follow-up was categorized as married/living together and others (separated, divorced, widow or single). Family history of CVD or cardiometabolic risk factors was considered when women reported having at least one parent or sibling with diabetes, hypertension, dyslipidemia, stroke or myocardial infarction. The number of pregnancies was recorded including the enrolled infant and the mode of delivery was classified as vaginal or caesarean section. Duration of breastfeeding was recorded as the period of time that the child received maternal milk exclusively or together with complementary foods, in weeks. Information about hormonal contraceptives included ever use of hormonal contraceptives (contraceptive pill, patch or ring and subdermal implant) and duration of use, and women were then classified as never, former and current users.

Current smokers included both daily and occasional smokers, and ex-smokers those that did not smoke for at least 6 months. Physical exercise was considered as the practice of any type of exercise regardless of the intensity or duration.

Waist circumference was measured midway between the lowest rib and the superior border of the iliac crest and a waist circumference >88 cm defined abdominal obesity (Grundy et al., 2005). To study the BMI evolution from prepregnancy to 4 years later a variable was defined as the difference between prepregnancy BMI and BMI 4 years later and comprised three categories: those who had an increase, a decrease and those who maintained the same BMI during this period.

Outcome variables

Weight was measured and recorded to the nearest 0.1 kg in light clothing, and height was measured without shoes to the nearest 0.1 cm and mothers' BMI 4 years after delivery was categorized according to the World Health Organization (1998). The same procedure was used for the prepregnancy BMI but using self-reported weight. Blood pressure was measured by non-physician trained interviewers. Two measurements of blood pressure separated by 5 min were taken with an automatic upper arm blood pressure monitor (OMRON M6 comfort (HEM-7000-E)) after 10-minute rest, on the dominant upper arm resting at the heart level. The mean was calculated and when the

difference was larger than 5 mm Hg for systolic or diastolic blood pressure a third measurement was taken and the mean of the 2 closest values was considered. Hypertension was defined as systolic and/or diastolic blood pressure ≥ 140/90 mm Hg and/or self-reported antihypertensive drug therapy prescribed for Hypertension Guidelines (2007).

Blood was sampled after an overnight fast of at least 10 h and all the parameters were measured using automatic standard enzymatic methods. Dyslipidemia was considered when one of these conditions was verified: total cholesterol ≥ 240 mg/dl, high-density lipoprotein (HDL) ≤ 40 mg/dl, low-density lipoprotein (LDL) ≥ 160 mg/dl, triglycerides ≥ 200 mg/dl or self-reported antidyslipidemic drug therapy (ATP III Report, 2002). Diabetes mellitus was defined as fasting plasma glucose concentration ≥ 126 mg/dl or self-reported antidiabetic drug therapy prescribed specifically for diabetes (IDF, 2014). Regarding C-reactive protein, more than >3 mg/l was defined as the threshold beyond which women were considered to have a higher risk for cardiovascular events (Cox et al., 2012). Homeostasis model assessment of insulin resistance (HOMA-IR) was derived from fasting glucose and insulin concentrations as [(fasting plasma glucose (mmol/l) * fasting serum insulin (μU/ml)) / 22.5] (Matthews et al., 1985). Low HOMA-IR values indicate high insulin sensitivity, whereas high HOMA-IR values indicate low insulin sensitivity (insulin resistance). The entire sample was divided into insulin-resistant (upper third of HOMA) and insulin-sensitive (lower and middle thirds of HOMA). The sample-derived HOMA cut-off value for insulin resistance was 1.803.

A metabolically healthy profile was defined as the absence of hypertension, diabetes, dyslipidemia, a level of C-reactive protein until 3 mg/l and being below the second tertile of HOMA.

To define the main outcome, we considered several obesity profiles considering BMI (normal/overweight/obese) and metabolic profile (healthy/not healthy) resulting in five groups: women with normal BMI, overweight women metabolically healthy, overweight women metabolically not healthy, obese women metabolically healthy and obese women metabolically not healthy.

Statistical analysis

Statistical analysis was performed using the statistical software Stata 11.0 (College Station, TX, 2009). Sample characteristics are presented as counts and proportions for categorical variables and mean and standard deviation (SD) for normally distributed continuous variables. Proportions were compared using the chi-square test and continuous variables with independent sample Student's t test, Kruskal–Wallis test or ANOVA. The association of putative determinants with the outcome was assessed using multinomial logistic regression. Crude and adjusted odds ratios (OR) and 95% confidence intervals (95% CI) were computed, taking women with normal BMI as the reference category of the outcome. From a list of a priori potential determinants, a final model was conducted comprising only variables associated with the outcome.

Ethics

All the phases of the study complied with the Ethical Principles for Medical Research Involving Human Subjects expressed in the Declaration of Helsinki. The study was approved by the University of Porto Medical School/Centro Hospitalar de São João ethics committee and a signed informed consent was obtained from all participants.

Results

Four years after delivery, 46.9% of women had a normal BMI, 33.2% were overweight and 19.9% obese. In this sample, obese women were the oldest, with a mean (SD) age of 35.3 (5.3) years. Compared to women with normal BMI, obese women more often had lower levels of education, were unemployed and had three or more pregnancies. Regarding the index pregnancy, the prevalence of caesarean section was higher among obese women than among normal or overweight women. At the time of the follow-up evaluation, more than half of the women with normal BMI and overweight were using hormonal contraceptives. Obese women less often practiced any type of regular physical exercise. Almost 90% of the obese women had a waist circumference above 88 cm contrasting with only 2% of women with normal BMI. Almost all women with normal BMI 4 years after delivery were already

in this BMI category before pregnancy, while in both categories of excessive weight more than half of the women had recently gained considerable weight enough to move across BMI categories (Table 1).

There was a gradient between all metabolic parameters considered and women's BMI 4 years after delivery, with obese women presenting the least favorable profile. Among obese women 4 years after delivery, 1 out of 10 had a metabolic healthy profile, compared to 3 out of 10 of the overweight and 6 out of 10 of the women with normal BMI (Table 2).

Fig. 1 illustrates the prevalence of the healthy metabolic phenotype according to women's waist circumference and BMI evolution from prepregnancy to 4 years later, by women's BMI. Within each BMI stratum, a waist circumference below 88 cm was associated with a significantly higher prevalence of a healthy metabolic profile (for example, among the obese: 28.2% vs. 10.3%, p = 0.001). However, BMI evolution from prepregnancy to 4 years later did not influence the prevalence of a

metabolically healthy profile, independently of the BMI category (Fig. 1).

In the crude analysis and compared to women with normal BMI, being unemployed or a housewife was associated with a higher likelihood of being obese with a not healthy metabolic profile (unemployed: OR = 1.69; 95% CI: 1.21–2.36; housewife: OR = 2.22; 95% CI: 1.21–4.09). Having a family history of CVD/cardiometabolic risk factors was associated with a higher probability of having excessive weight and a non-healthy metabolic profile, this association being stronger for obese women (OR = 1.41 95% CI: 1.00–1.98). The number of previous pregnancies increased the odds of having a higher BMI independently of the metabolic profile, but with a stronger association with healthy excessive weight. Breastfeeding was gradually and inversely associated with BMI, with a stronger association for not healthy than healthy excessive weight. Compared to women with normal BMI, women who

Table 1
Participants' characteristics 4 years after delivery of a liveborn, according to BMI (Portugal, 2009–2011).

| | Body mass index 4 years after delivery | | | |
| | Normal | Overweight | Obese | |
	n (%)[a]	n (%)[a]	n (%)[a]	p
Overall	867 (46.9)	612 (33.2)	368 (19.9)	
Age				
Mean (SD)	34.4 (5.2)	35.2 (5.2)	35.3 (5.3)	0.002
Education (years)				
≤9	323 (37.3)	318 (52.0)	214 (58.2)	
10–12	256 (29.6)	177 (28.9)	94 (25.5)	
>12	286 (33.1)	117 (19.1)	60 (16.3)	<0.001
Working condition				
Employed	700 (81.2)	461 (75.3)	266 (72.3)	
Unemployed	119 (13.8)	120 (19.6)	70 (19.0)	
Housewife	26 (3.0)	19 (3.1)	22 (6.0)	
Others	19 (2.2)	12 (2.0)	10 (2.7)	0.004
Marital status				
Married/living together	614 (87.5)	453 (89.2)	255 (87.9)	
Others	88 (12.5)	55 (10.8)	35 (12.1)	0.658
Family history of CVD/cardiometabolic risk factors[b]				
No	181 (20.9)	113 (18.5)	60 (16.3)	
Yes	686 (79.1)	499 (81.5)	308 (83.7)	0.151
Number of pregnancies (including index)				
1	423 (48.8)	252 (41.2)	144 (39.2)	
2	328 (37.8)	240 (39.2)	128 (34.9)	
≥3	116 (13.4)	120 (19.6)	96 (25.8)	<0.001
Type of delivery (index pregnancy)				
Vaginal	566 (65.8)	386 (63.9)	207 (56.7)	
Caesarean	294 (34.2)	218 (36.1)	158 (43.3)	0.010
Breastfeeding (index child)				
Never	33 (3.8)	34 (5.6)	33 (9.0)	
≤26 weeks	515 (59.7)	333 (54.8)	216 (58.7)	
>26 weeks	314 (36.4)	241 (39.6)	119 (32.3)	0.002
Use of hormonal contraceptives				
Never	45 (5.2)	24 (3.9)	26 (7.1)	
Former	318 (36.8)	225 (36.9)	181 (49.3)	
Current	502 (58.0)	361 (59.2)	162 (43.6)	<0.001
Smoking status				
Never	475 (54.8)	364 (59.5)	217 (59.0)	
Former	251 (29.0)	145 (23.7)	91 (24.7)	
Current	141 (16.2)	103 (16.8)	60 (16.3)	0.203
Regular physical exercise				
No	681 (78.6)	485 (79.4)	321 (87.2)	
Yes	186 (21.4)	126 (20.6)	47 (12.8)	0.001
Waist circumference (cm)				
≤88	850 (98.0)	380 (62.1)	39 (10.6)	
>88	17 (2.0)	232 (37.9)	329 (89.4)	<0.001
BMI evolution (Prepregnancy − 4 years later)				
Same prepregnancy BMI	775 (89.4)	272 (44.4)	153 (41.6)	
Recent increase in BMI	29 (3.5)	298 (50.6)	195 (56.0)	
Recent decrease in BMI	31 (3.7)	19 (3.2)	NA	<0.001

BMI, body mass index; CVD, cardiovascular diseases; NA, not applicable; SD, standard deviation.

Note: In each variable, the total may not add up to 1847 due to missing data.

[a] Except for age, summarized as mean and standard deviation.

[b] Family history of CVD or cardiometabolic risk factors was considered when women reported having at least one parent or sibling affected by diabetes, hypertension, dyslipidemia, stroke or myocardial infarction.

Table 2
Metabolic Characteristics of women 4 years after delivery of a liveborn, according to BMI (Portugal, 2009–2011).

	Body mass index 4 years after delivery			
	Normal	Overweight	Obese	p
Systolic blood pressure (mm Hg), mean (SD)	103.7 (10.8)	108.7 (12.5)	111.0 (12.7)	<0.001
Diastolic blood pressure (mm Hg), mean (SD)	70.4 (8.6)	74.7 (9.8)	77.8 (10.2)	<0.001
Fasting glucose (mg/dl), mean (SD)	80.2 (12.1)	82.3 (7.9)	85.7 (10.7)	<0.001
C-reactive protein (mg/l), median (IQR)	1.1 (0.5–2.6)	1.9 (0.9–4.0)	3.2 (1.7–5.4)	<0.001
Total cholesterol (mg/dl), mean (SD)	188.6 (33.5)	196.0 (38.8)	200.0 (34.6)	<0.001
LDL cholesterol (mg/dl), mean (SD)	111.8 (27.6)	119.0 (32.3)	124.6 (30.2)	<0.001
HDL cholesterol (mmol/l), mean (SD)	60.4 (13.2)	57.5 (11.8)	53.5 (11.9)	<0.001
Triglycerides (mmol/l), median (IQR)	74 (56–99)	86 (63–117)	95 (75–132)	<0.001
HOMA-IR[a], median (IQR)	1.1 (0.8–1.5)	1.6 (1.2–2.2)	2.2 (1.7–3.1)	<0.001
Metabolically healthy[b], n (%)	525 (60.6)	200 (32.7)	45 (12.2)	<0.001

BMI, body mass index; IQR, interquartile range; LDL, low-density lipoprotein; HDL, high-density lipoprotein; HOMA-IR, homeostasis model assessment of insulin resistance; SD, standard deviation.

[a] Computed as fasting plasma glucose (mmol/l) ∗ fasting serum insulin (μU/ml) / 22.5.
[b] Defined as the absence of hypertension, diabetes, dyslipidemia, a level of C-reactive protein below 3 mg/l and being below the second tertile of HOMA.

were using hormonal contraceptives at the time of the evaluation had more chances of being overweight and having a not healthy metabolic profile (OR = 2.32 95% CI: 1.18–4.56) but a different trend was found considering obese women with the same phenotype (OR = 0.59 95% CI: 0.35–1.01). Doing any kind of regular physical exercise was associated with a lower likelihood of being obese and having a not healthy metabolic phenotype (OR = 0.50 95% CI: 0.35–0.73) (Table 3).

Table 4 presents the results of the multivariate analysis. Having a family history of CVD/cardiometabolic risk factors was associated with a higher probability of having excessive weight and a not healthy metabolic profile, this association being stronger for obese women (OR = 1.39 95% CI: 0.98–1.98), whereas no association was observed with a healthy excessive weight. A graded inverse association was found between breastfeeding the Generation XXI child for more than 26 weeks and BMI at 4 years with a not healthy metabolic profile (obesity, not healthy − OR = 0.39 95% CI: 0.23–0.68), and the effect was null on healthy excessive weight. The pattern described in the crude analysis for hormonal contraceptive use was independent of confounders. Finally, doing any kind of physical exercise remained

associated with a lower likelihood of being obese and having a not healthy metabolic profile (OR = 0.48 95% CI: 0.33–0.70).

Discussion

Our results support the existence of a healthy metabolic profile in women 4 years after delivery, with 3 out of 10 overweight women and 1 out of 10 obese women presenting this phenotype. Abdominal obesity strongly influences the prevalence of a healthy metabolic profile, whereas BMI evolution from prepregnancy to 4 years after birth does not. Genetic, reproductive and lifestyles features are associated with this healthy phenotype and can help to better characterize this metabolic profile.

The prevalence of the healthy obesity phenotype varies according to obesity markers and criteria used to define metabolic abnormalities, impairing the comparability among studies (Velho et al., 2010). When healthy obesity is defined as having none or one of the six more common cardiometabolic abnormalities (elevated blood pressure, elevated triglyceride level, decreased HDL level, elevated glucose level, insulin
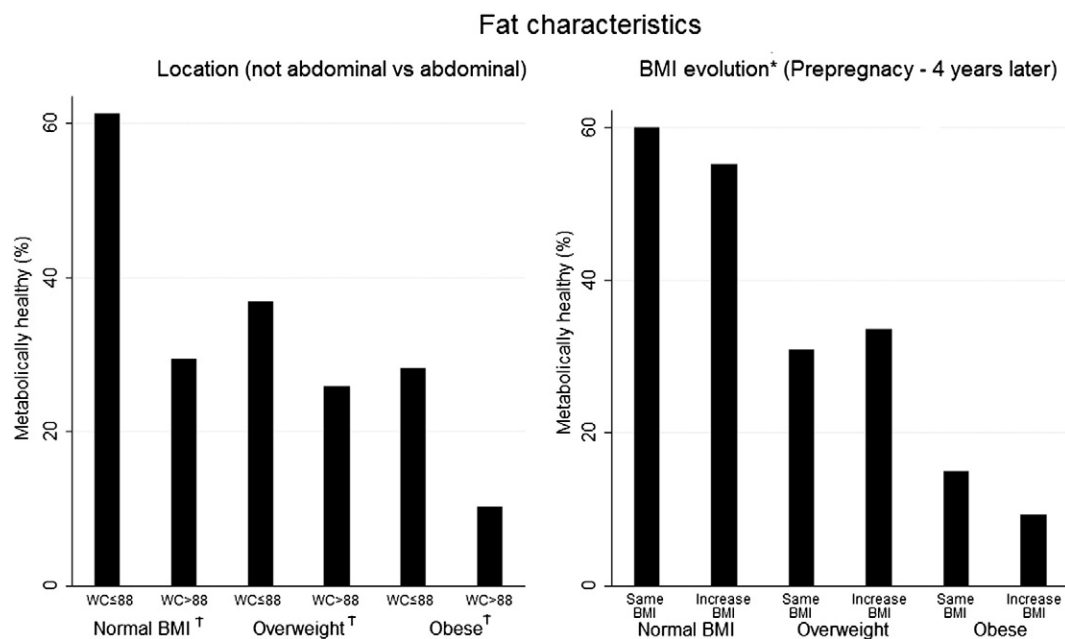
Fat characteristics

Fig. 1. Prevalence of healthy metabolic profile by body mass index and fat characteristics in mothers of a Portuguese birth cohort, 2009–2011 (Left panel: location; Right panel: body mass index evolution). BMI, body mass index; WC, waist circumference. ∗Computed as the difference between BMI 4 years after delivery and BMI before pregnancy. Women with a decrease in BMI were scarce and were not considered. [†]p < 0.05 for the comparison between WC ≤ 88 and WC > 88.

Table 3
Crude odds ratio for the association between demographic, genetic, reproductive and behavioral characteristics and metabolic profile, according to body mass index, in mothers of a Portuguese birth cohort, 2009-2011.

	Normal BMI	Overweight		Obese	
		Healthy	Not healthy	Healthy	Not healthy
Overall, n (%)	867 (46.9)	200 (10.8)	412 (22.3)	45 (2.4)	323 (17.5)
		Crude OR (95% CI)			
Age	1	1.04 (1.01–1.07)	1.03 (1.00–1.05)	1.09 (1.02–1.15)	1.03 (1.00–1.05)
Education (years)					
≤9	1	1	1	1	1
10–12	1	0.90 (0.63–1.30)	0.62 (0.47–0.82)	0.50 (0.24–1.01)	0.56 (0.41–0.76)
>12	1	0.63 (0.43–0.92)	0.33 (0.24–0.46)	0.24 (0.10–0.60)	0.33 (0.23–0.46)
Work condition					
Employed	1	1	1	1	1
Unemployed	1	1.51 (1.01–2.26)	1.54 (1.12–2.11)	0.65 (0.23–1.87)	1.69 (1.21–2.36)
Housewife	1	0.88 (0.33–2.34)	1.22 (0.63–2.37)	2.24 (0.65–7.76)	2.22 (1.21–4.09)
Others	1	0.97 (0.32–2.89)	0.95 (0.41–2.20)	2.05 (0.46–9.13)	1.28 (0.55–2.97)
Marital status					
Married/living together	1	1	1	1	1
Others	1	0.78 (0.45–1.35)	0.88 (0.59–1.32)	1.16 (0.44–3.08)	0.93 (0.60–1.45)
Family history of CVD/cardiometabolic risk factors					
No	1	1	1	1	1
Yes	1	0.99 (0.68–1.45)	1.27 (0.94–1.72)	1.06 (0.50–2.23)	1.41 (1.00–1.98)
Number of pregnancies					
1	1	1	1	1	1
2	1	1.37 (0.97–1.93)	1.16 (0.90–1.51)	1.75 (0.86–3.54)	1.08 (0.81–1.45)
≥3	1	1.94 (1.26–2.99)	1.65 (1.18–2.30)	3.12 (1.41–6.94)	2.33 (1.65–3.28)
Type of delivery					
Vaginal	1	1	1	1	1
Cesarean	1	0.98 (0.70–1.35)	1.14 (0.89–1.46)	1.76 (0.96–3.23)	1.43 (1.10–1.86)
Breastfeeding					
Never	1	1	1	1	1
≤26 weeks	1	0.75 (0.35–1.62)	0.58 (0.34–1.00)	0.51 (0.15–1.79)	0.41 (0.24–0.69)
>26 weeks	1	0.97 (0.45–2.11)	0.66 (0.38–1.16)	0.63 (0.18–2.25)	0.35 (0.20–0.61)
Use of hormonal contraceptives					
Never	1	1	1	1	1
Former	1	1.21 (0.63-2.32)	1.47 (0.73-2.93)	1.60 (0.47-5.44)	0.90 (0.53–1.55)
Current	1	0.52 (0.27–1.02)	2.32 (1.18–4.56)	0.24 (0.06–0.93)	0.59 (0.35–1.01)
Smoking status					
Never	1	1	1	1	1
Current	1	1.06 (0.74–1.51)	0.63 (0.47–0.84)	0.69 (0.34–1.41)	0.81 (0.60–1.10)
Former	1	1.23 (0.81–1.87)	0.84 (0.60–1.17)	0.45 (0.16–1.30)	1.01 (0.71–1.44)
Practice of physical exercise					
Sedentary	1	1	1	1	1
Does any kind of exercise	1	0.97 (0.67–1.42)	0.94 (0.70–1.26)	0.79 (0.36–1.73)	0.50 (0.35–0.73)

95% CI, 95% confidence interval; BMI, body mass index; CVD, cardiovascular diseases; OR, odds ratio; WC, waist circumference.

Table 4
Multivariate-adjusted odds ratio for the association between age, family history of cardiovascular diseases/cardiometabolic risk factors, breastfeeding, use of hormonal contraceptives and physical exercise with metabolic profile, according to body mass index, in mothers of a Portuguese birth cohort, 2009–2011.

	Normal BMI	Overweight		Obese	
		Healthy	Not healthy	Healthy	Not healthy
		Adjusted OR (95% CI)[a]			
Age	1	1.02 (0.98–1.05)	1.04 (1.01–1.06)	1.04 (0.98–1.11)	1.01 (0.99–1.04)
Family history of CVD/cardiometabolic risk factors					
No	1	1	1	1	1
Yes	1	0.93 (0.63–1.38)	1.21 (0.89–1.66)	0.87 (0.40–1.88)	1.39 (0.98–1.98)
Breastfeeding					
Never	1	1	1	1	1
≤26 weeks	1	0.84 (0.39–1.82)	0.58 (0.33–1.00)	0.65 (0.18–2.33)	0.44 (0.26–0.74)
>26 weeks	1	1.10 (0.50–2.40)	0.64 (0.37–1.12)	0.85 (0.23–3.08)	0.39 (0.23–0.68)
Use of hormonal contraceptives					
Never	1	1	1	1	1
Former	1	1.22 (0.63–2.36)	1.35 (0.67–2.73)	1.66 (0.48–5.69)	0.88 (0.50–1.52)
Current	1	0.55 (0.23–1.07)	2.55 (1.29–5.04)	0.27 (0.07–1.09)	0.60 (0.35–1.04)
Practice of physical exercise					
Sedentary	1	1	1	1	1
Does any kind of exercise	1	0.93 (0.63–1.36)	0.92 (0.68–1.23)	0.71 (0.32–1.56)	0.48 (0.33–0.70)

95% CI, 95% confidence interval; BMI, body mass index; OR, odds ratio; WC waist circumference.
Note: performed only with women with information for all the variables considered (n = 1825).
[a] Each factor in the table is adjusted for every other factor in the table.

resistance and systemic inflammation), data suggest that 35.4% of North American obese women possess a healthy phenotype but it decreases drastically when we restrict the criteria to not having any of the cardiometabolic risk factors with only 16.6% maintaining the same phenotype (Wildman et al., 2008). In Europe, a lower prevalence was found in cohort studies, ranging from 7% in Finland to 28% in the United Kingdom, using the same criteria in all countries (Van Vliet-Ostaptchouk et al., 2014). The most common definitions of healthy obesity were compared in a Swiss population-based sample and less than 5% of all obese subjects were considered metabolically healthy by all definitions used and irrespective of the anthropometric markers used (Velho et al., 2010). The prevalence found in our work among obese women was similar to only one study mentioned above (Karelis, 2008). Nevertheless, in our study we considered a particular population: women who recently experienced pregnancy, which brings specific body fat characteristics that needed to be studied in order to determine their impact on women's metabolic profile.

Concerning the definition of our outcome, the majority of published work uses similar parameters (Manu et al., 2012; Stefan et al., 2008; Van Vliet-Ostaptchouk et al., 2014; Velho et al., 2010) and for diabetes, dyslipidemia, C-reactive protein and blood pressure the cut-off values are well defined. For insulin, there is no cut-off clearly separating insulin sensitive and resistant subgroups (Bluher, 2010). It is common to define insulin resistance using the three upper quartiles (Karelis et al., 2008) of HOMA-IR or above the 90th percentile (Wildman et al., 2008); however, mean values of HOMA-IR in our sample were considerably lower. Therefore, we used another threshold that was also previously used in samples that have HOMA-IR values closer to ours (Manu et al., 2012). Additionally, the cut-off of 1.803 that we used is only slightly lower than thresholds for insulin resistance in recent population studies which ranged from 2.1 to 3.8 (Manu et al., 2012).

Since central fat deposition is strongly associated with CVD risk independently of BMI (Demerath et al., 2008), it was hypothesized that waist circumference could play a role in the distinction between healthy and not healthy profile. In this sample of Portuguese women who achieved a successful pregnancy, abdominal obesity was associated with a lower probability of having a healthy metabolic profile in every BMI stratum. Given the important role of visceral adipose tissue in the genesis of both insulin resistance and inflammation (Diamant et al., 2005), it is not surprising that a relatively lower amount of abdominal adiposity could explain a more favorable metabolic profile even in women who recently gained weight.

It remains unclear whether this favorable profile represents a permanent characteristic or is just a step in the natural history of obesity. Longitudinal data concerning this subject are scarce. A recent study showed that among overweight/obese metabolically healthy subjects at baseline, 57% developed one or more cardiometabolic risk factor 3 years later (Bobbioni-Harsch et al., 2012). Moreover, a recent meta-analysis highlights that the incidence of cardiometabolic disturbances is not linear over time among healthy obese people and the duration of follow-up can be a critical element in this evaluation, since differences between healthy and not-healthy subjects in the incidence of events were evident only after 10 years (Kramer et al., 2013). Concerning our study population, longitudinal studies are needed and it is expected that the next follow-ups of the Generation XXI cohort will provide more information to address all the uncertainty regarding the duration of this healthy phenotype.

To date, little is known about the factors that delay the onset of or protect individuals with excessive weight from developing metabolic disturbances. Physical activity influences the prevalence of a healthy cardiometabolic profile (Velho et al., 2010; Wildman, 2009; Yoo et al., 2013). Moderate regular physical activity is associated with higher insulin sensitivity, an improved lipid profile, and a decrease in components of metabolic syndrome (Caro et al., 2013) and this fact can explain the lower probability of being obese and metabolically not healthy among women who practice any kind of physical exercise.

Having a family history of CVD or cardiometabolic risk factors increases the chances of having a non-healthy metabolic profile among obese women which suggests that this phenotype can also be the expression of a genetic trait. Knowing that fat deposition on the visceral area is influenced by genes (Fox et al., 2007), genetic background possibly influences healthy metabolic profile, however up to now no evidence supports this hypothesis.

No study was found that tried to ascertain the impact of the use of hormonal contraceptives and the duration of breastfeeding on healthy metabolic profile. It is already established that duration of breastfeeding is inversely associated with mother's obesity (Turcksin et al., 2014) and this study adds that, even among obese women, the longer one breastfeeds the lower the probability of having an adverse metabolic profile, confirming the beneficial effect of breastfeeding also at a metabolic level. Regarding the use of hormonal contraceptives, discrepant results were observed in overweight and obese women and we believe that this difference can be partly explained by reverse causality: contraception is often feared in women with chronic medical problems like obesity and these women might not be using hormonal contraceptives at the time of the evaluation in consequence of their obesity.

Our study has several strengths including a large sample size of women who recently were mothers and the assessment of this healthy phenotype in this particular population which was unexplored so far. Also, using objective measures of height, weight and waist circumference allowed us to have a more accurate estimation of overweight and obesity. However, some limitations can also be identified. BMI was used to classify overweight and obese women and does not discriminate between lean and fat body mass. Moreover, the cross sectional study design limited our ability to make an inference about causal relationships between exposure and outcome variables.

Conclusions

These results support the existence of a healthy metabolic phenotype in overweight and obese women after motherhood, influenced by anthropometrics, genetic and lifestyles characteristics. Since pregnancy promotes abdominal obesity, young adult women with excessive weight might need a close surveillance of their cardiometabolic parameters as well as prevention for further weight gain.

Disclosure statement

The authors declare that there are no conflicts of interest.

Acknowledgments

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