Perinatal and early adulthood factors associated with adiposity

Fatores perinatais e da vida adulta jovem associados à adiposidade

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Abstract

We used body mass index (BMI) and waist circumference (WC) as fat indicators to assess whether perinatal and early adulthood factors are associated with adiposity in early adulthood. We hypothesized that risk factors differ between men and women and are also different when WC is used for measuring adiposity as opposed to BMI. We conducted a longitudinal study based on a sample of 2,063 adults from the 1978/1979 Ribeirão Preto birth cohort. Adjustment was performed using four sequential multiple linear regression models stratified by sex. Both perinatal and early adulthood variables influenced adulthood BMI and WC. The associations differed between men and women and depending on the measure of abdominal adiposity (BMI or WC). Living with a partner, for both men and women, and high fat and alcohol intake in men were factors that were consistently associated with higher adulthood BMI and WC levels. The differences observed between sexes may point to different lifestyles of men and women, suggesting that prevention policies should consider gender specific strategies.

Adiposity; Obesity; Young Adult; Waist Circumference

Introduction

Obesity has become a severe worldwide public health problem. It is considered one of the major risk factors linked to the development of cardiovascular diseases such as hypertension, diabetes and dyslipidemia, and is associated with increased mortality [1]. Over the last decades, Brazil, like several other Latin American countries, has undergone a rapid demographic, epidemiological and nutritional transition [2,3,4], resulting in an increased prevalence of overweight and obesity in the country [5,6].

Studies have shown that individuals with lower levels of schooling and income have a higher prevalence of overweight and obesity [7,8]. However, in Brazil, a higher prevalence of obesity has been observed in women with lower levels of schooling and in men with higher levels of schooling [4]. It has also been found that married men and women have a higher prevalence of obesity [9,10,11].

Prevalence of obesity is higher in children born to primiparous women [12]. Experimental studies on animals have also demonstrated that maternal parity influences size at birth, postnatal growth and body composition [13]. Studies have also revealed a relationship between higher weight at birth and risk of obesity in adolescence and in adult life [4,14].

The body mass index (BMI) has been internationally recommended as an indicator of body adiposity but is limited because it does not distinguish between excess muscle, fat or bone mass [15]. Waist circumference (WC) is used in population studies as an indicator of adiposity for the following reasons: it is associated with the occurrence of cardiovascular diseases [16]; results obtained using this method highly correlate with those of laboratory methods for assessing body composition [17]; it is one of the simplest methods to use and is highly reproducible [18,19,20]. Some studies have suggested that the combined use of the two measures (BMI and WC) improves identification of the risk of cardiovascular diseases [21].

The objective of the present study was to determine the association between specific perinatal factors (BMI at birth, socioeconomic status and number of gestations) and early adulthood factors (socioeconomic status, marital status, smoking, alcohol consumption and daily fat intake) and adiposity in adult life. We hypothesized that risk factors differ between men and women and when WC, as opposed to BMI, is used to measure adiposity. The study was conducted among the young population (aged 23 to 25 years) of a city with high per capita income in a middle-income country.

Material and methods

The present study arose during the fourth stage of a prospective longitudinal birth cohort study, which included infants born in the municipality of Ribeirão Preto, State of São Paulo, Brazil between June 1 1978 and May 31 1979 [22,23,24]. In 2005, Ribeirão Preto, located 320km northeast of the city of São Paulo in the Southeast Region of Brazil, had 543,885 inhabitants [25] and an area of 642km^2.

Population and sample

A total of 9,067 liveborn neonates delivered in hospitals in Ribeirão Preto between June 1 1978 and May 31 1979 (98% of all liveborn babies) participated in the study. For the follow-up of the cohort, babies whose mothers were not originally from Ribeirão Preto and not resident in the city at the time of childbirth were excluded from the study. Of the 6,973 liveborn babies whose mothers were residents of the city, 6,827 were single births and 146 were twins. Of the 6,827 single births, 246 died within the first year of life [26] and 97 died before reaching the age of 20 (a total of 343 deaths) [27].

In 2002, after excluding multiples, 6,484 cohort members residing in the city were eligible for follow-up. Due to a high urbanization rate of 99.6% (Brazilian Institute of Geography and Statistics, 2000), the search was performed only in the urban zone and 5,665 individuals (87.4%) were located. The city was divided into four geoeconomic areas: poor, middle-poor, middle-rich and rich. Using the geo-economic characterization of the city [28] as a basis, one out of every three residents of the same geographic area was randomly selected, contacted and invited to participate in the follow-up study. During this process, 705 individuals had to be randomly replaced due to refusal (209), imprisonment (31), death before the age of 20 (34), and failure to attend the interview (431). Therefore, a total of 2,063 young adults effectively participated in the study, corresponding to 31.8% of the original sample (Figure 1). Details of the methodology used by this study have been published elsewhere [29]. The project was approved by the Research Ethics Committee of the University Hospital, Faculty of Medicine of Ribeirão Preto, University of São Paulo (Hospital Universitário, Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo – HCFMRP-USP).

Instruments and variables

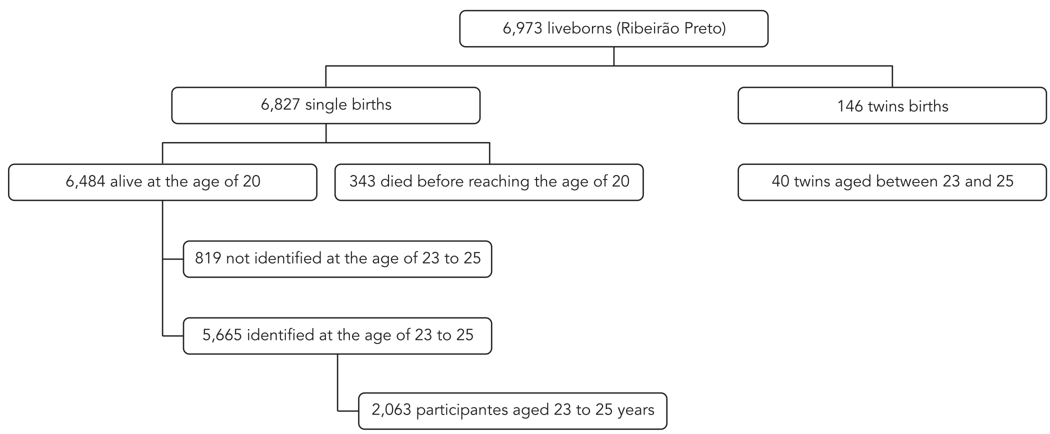
Structured questionnaires were conducted through face-to-face interviews undertaken with the mother after childbirth and with the adults between the ages of 23 and 25 years.

The following variables were studied at birth: birth weight and length, birth BMI (calculated as weight, in kg, divided by height, in m, squared), preterm birth (defined as < 37 weeks gestational age, measured from the first day of the last normal menstrual period as reported by the mother); maternal level of schooling in number of years of study (0-4, 5-8, 9-11 and ≥ 12 years); maternal smoking (categorized as yes, regardless of the number of cigarettes smoked per day, and no); maternal marital status (partner or no partner), and number of gestations (1, 2 to 3, and ≥ 4). Anthropometric measurements were taken using hospital pediatric table scales (with 10g precision) tested and calibrated on a weekly basis. The infant was weighed immediately after birth. Birth length was measured with the infant in the supine position using an anthropometric instrument specially made for the project and available in all hospitals. The BMI was used instead of the ponderal index that is used as an indicator of thinness at birth, because it is a better measure of adiposity [30].

The following variables were studied in the adults: current occupation of the head of the family [23], categorized as non-manual, skilled manual,

Figure 1

Some of the characteristics of liveborn individuals from the 1978/1979 cohort evaluated in the fourth stage of the study at the age of 23 to 25 years.



semi-skilled manual, unskilled manual and other (people undergoing training or students, unemployed, retired and housewives); level of schooling categorized as number of years of study (0-4, 5-8, 9-11 and ≥ 12 years); marital status (partner or no partner), smoking habits during the last month (non-smoker, ex-smoker and smoker: < 5, ≥ 5 cigarettes per day). Alcohol consumption during the last month was assessed in g/day, with > 31.1g/day being considered "high" and ≤ 31.1g/day being considered "low". This cut-off point, to separate low and high alcohol consumption, was defined because above this level consumption is considered excessive [31]. A comparison between low and high consumption was made because low and moderate alcohol consumption has been associated with lower risk of cardiovascular diseases [32]. Daily fat intake was measured and analyzed as a continuous variable. Information on alcohol consumption and daily fat intake was obtained using a food frequency questionnaire (FFQ) on the "habitual" diet regarding food intake over the previous 12 months. The FFQ was based on a questionnaire validated for use with the Japanese-Brazilian community of São Paulo [33]. The BMI was calculated using the formula: BMI = weight (kg)/height (m)^2 (BMI = W/H^2). WC was considered to be high when > 102cm for men and > 88cm for women [34]. Anthropometric measurements (weight, height and WC) were performed by trained personnel using standardized techniques [35], with the subject barefoot and wearing light clothes. The instruments used were a periodically calibrated precision scale, anthropometric instruments for measurements with the subject standing or sitting, and an inextensible measuring tape.

Statistical analysis

A sample of 783 individuals from both sexes was necessary in order to obtain a linear regression model coefficient equal to 0.10, with 80% power at significance level of 0.05. We opted to stratify the sample by gender because in Brazil the variables associated with obesity differ between men and women [6,11].

The response variables used were adulthood BMI and WC. BMI at birth was used as a continuous variable. Sequential adjustment was performed with four models stratified by sex using a hierarchical approach: the first model – adjustment for BMI at birth and preterm birth; the second model – adjustment for birth variables such as maternal smoking, level of schooling, age, marital status and number of gestations, as well as BMI at birth and preterm birth; the third model – adjustment for adulthood variables such as level of schooling, occupation, marital status, smoking, alcohol consumption and daily fat intake, as well as BMI at birth and preterm birth; the fourth model – adjustment for all variables.

The statistical model used for analysis was multiple linear regression. This model requires residuals with normal distribution with zero mean and constant variance. Since this assumption was not satisfied, the bootstrap method was applied to the regression model. The bootstrap confidence interval (*BCa*) of 95% was adopted by the present study, and the percentiles of bootstrap distribution and the percentile interval were also used. The advantage of the *BCa* is that it generates more accurate confidence limits than the intervals obtained by the percentile method. The results were obtained using Stata 8.0 software (Stata Corp., College Station, USA).

Results

With regard to birth weight (p = 0,618), birth length (p = 0,507) and maternal age at delivery (p = 0,065), no differences were found between those that participated and those that did not participate in the follow-up study. In the group that participated in the follow-up study there was a greater proportion of women (p = 0,004), a greater number of preterm births (p = 0,037), a greater proportion of heads of family employed in high-skilled occupations (p < 0,001), a greater proportion of mothers with ≥ 5 years of schooling (p < 0,001) and a greater number were married (p < 0,001) (Table 1).

Of a total of 2,063 individuals that participated in the study, 51.8% were females and 48.2% males. Almost two thirds of the sample (63.3%) self-reported themselves as white, 84.5% had ≥ 9 years of schooling, 34.3% were skilled or semi-skilled manual workers, 23.8% were not economically active, 21% were employed in a non-manual occupation, 32% were married and 27.2% had children. The family income of more than half of the sample (53%) was three to 10 minimum wages and approximately 10% of individuals studied were from low income families (< 3 minimum wages).

The results showed significant differences between the sexes regarding anthropometric characteristics, alcohol consumption and smoking habits (Table 2). A higher proportion of men were overweight (30.3% compared to 17.7% of women). The prevalence of obesity was similar for both genders (12.8% of men and 11.1% of women). Alcohol consumption was lower among women (58.3%). "High" alcohol consumption (> 31.1g/day) in men was greater than in women (32.8% vs. 8.7%). Women also presented lower levels of tobacco use compared to males (13.9% vs. 20.8%). With respect to daily fat intake, approximately 25% of the total sample reported that they consumed 40g or more of fat per day. However, fat intake did not differ significantly between the sexes.

When adulthood BMI was used as a response variable, no association between adult BMI and BMI at birth was found for either of the sexes using the first model, adjusted for preterm birth (Table 3).

In the second model, adjusted for preterm birth plus birth variables, among women, for every 1kg/m² increase in BMI at birth there was a 0.26kg/m² increase in adulthood BMI. The adulthood BMI of women with mothers with lower levels of schooling at the time of birth showed an increase of between 1.6 and 1.8kg/m². For women whose mothers had two or three gestations, adulthood BMI showed a decrease of 1.22kg/m². Among men, there was an association between BMI at birth and adulthood BMI (Table 3).

In the third model, adjusted for preterm birth and for adulthood variables, among women, for every 1kg/m² increase in BMI at birth there was an 0.27kg/m² increase in adulthood BMI. The adulthood BMI of women whose head of family was employed in a semi-skilled occupation showed an increase of 1.4kg/m². The adulthood BMI of women who lived with a partner showed an increase of 1.72kg/m². The adulthood BMI of men who lived with a partner showed an increase of 0.9kg/m². The adulthood BMI of men who consumed large amounts of alcohol showed an increase of 1.15kg/m² (Table 3).

In the fourth model, adjusted for all variables, among women, for every 1kg/m² increase in BMI at birth there was a 0.28kg/m² increase in adulthood BMI. The adulthood BMI of women whose mothers had had two or three gestations, showed a decrease of 0.97kg/m². Among women whose head of family was employed in a semi-skilled occupation, adulthood BMI showed an increase of 1.13kg/m². The adulthood BMI of women who lived with a partner showed an increase of 1.47kg/m². The adulthood BMI of men who lived with a partner also showed an increase of 0.93kg/m². In men whose alcohol consumption was ≥ 31.1g/day, adulthood BMI showed an increase of 1.1kg/m². In men, for every 1% increase in daily fat intake, there was a 0.05kg/m² increase in adulthood BMI (Table 3).

Using WC as the response variable, for the first model, adjusted for preterm birth, there was no association between BMI at birth and adulthood WC in either of the sexes (Table 4). In the second model, adjusted for preterm birth and other birth variables, the WC of adult women whose mothers had lower levels of schooling at the time of delivery was 3.3 to 4.0cm larger. There was no association between any other variable using this model (Table 4).

With respect to the third model, adjusted for preterm birth and adulthood variables, adult-

Table 1

Comparison of the characteristics of the cohort at birth (1978/1979) with those of the participants in the fourth phase of the study (2002/2004).

Variables	Initial population 1978/1979 * n (%)	Individuals not interviewed in 2002/2004 ** n (%)	Individuals interviewed in 2002/2004 *** n (%)	p-value
Sex				0.004
Female	3,185 (49.1)	2,117 (47.9)	1,068 (51.8)	
Male	3,299 (50.9)	2,304 (52.1)	995 (48.2)	
Birth weight (g)				NS
< 2,500	380 (5.9)	252 (5.7)	128 (6.2)	
2,500-2,999	1,349 (20.8)	935 (21.1)	414 (20.1)	
3,000-3,499	2,644 (40.8)	1,796 (40.6)	848 (41.1)	
3,500-3,999	1,673 (25.8)	1,149 (26.0)	524 (25.4)	
≥ 4,000	438 (6.7)	289 (6.6)	149 (7.2)	
Birth length (cm)				NS
< 47	723 (11.1)	498 (11.3)	225 (10.9)	
47-49	1,612 (24.9)	1,109 (25.1)	503 (24.4)	
49-51	2,664 (41.1)	1,830 (41.4)	834 (40.4)	
51-53	1,170 (18.0)	775 (17.5)	395 (19.2)	
≥ 53	281 (4.3)	186 (4.2)	95 (4.6)	
Unknown	34 (0.6)	23 (0.5)	11 (0.5)	
Preterm birth				0.037
Yes	388 (6.0)	246 (5.6)	142 (6.9)	
No	6,096 (94.0)	4,175 (94.4)	1,921 (93.1)	
Occupation of the head of the family				< 0.001
Non-manual	1,079 (16.6)	740 (16.7)	339 (16.4)	
Skilled and semi-skilled manual	3,685 (56.9)	2,420 (54.8)	1,265 (61.3)	
Unskilled manual or unemployed	1,514 (23.3)	1,115 (25.2)	399 (19.3)	
Unknown	206 (3.2)	146 (3.3)	60 (3.0)	
Maternal schooling (years)				< 0.001
≥ 12	655 (10.1)	440 (10.0)	215 (10.4)	
5-11	2,483 (38.3)	1,595 (36.1)	888 (43.0)	
0-4	3,186 (49.1)	2,266 (51.2)	920 (44.6)	
Unknown	160 (2.5)	120 (2.7)	40 (2.0)	
Maternal age (years)				NS
20-35	4,998 (77.1)	3,372 (76.3)	1,626 (78.8)	
≥ 35	537 (8.3)	366 (8.3)	171 (8.3)	
< 20	889 (13.7)	635 (14.4)	254 (12.3)	
Unknown	60 (0.9)	48 (1.0)	12 (0.6)	
Maternal marital status				< 0.001
Married	5,375 (82.9)	3,565 (80.6)	1,810 (87.7)	
Cohabiting	613 (9.5)	481 (10.9)	132 (6.4)	
Non-cohabiting	422 (6.5)	317 (7.2)	105 (5.1)	
Unknown	74 (1.1)	58 (1.3)	16 (0.8)	

NS: not significant.

* N = 6,484 excluding 343 deaths;

** N = 4,421;

*** N = 2,063.

Table 2

Anthropometric characteristics and alcohol, tobacco and fat consumption according to sex. Ribeirão Preto, São Paulo State, Brazil, 2002/2004.

Variables/Categories	Sex		p-value *
	Male n (%)	Female n (%)	
BMI (kg/m²)			< 0.001
Thin (< 18.5)	26 (2.6)	92 (8.6)	
Adequate (18.5-24.9)	537 (54.0)	664 (62.2)	
Overweight (25.0-29.9)	302 (30.3)	189 (17.7)	
Obese (≥ 30.0)	127 (12.8)	119 (11.1)	
Not determined	3 (0.3)	4 (0.4)	
Waist circumference			0.066
Normal	882 (88.7)	918 (86.0)	
High	112 (11.2)	149 (13.9)	
Smoking habit in the last month			< 0.001
Yes	207 (20.8)	148 (13.9)	
No	788 (79.2)	920 (86.1)	
Alcohol consumption in the last month			< 0.001
Yes	756 (76.0)	623 (58.3)	
No	239 (24.0)	445 (41.7)	
Alcohol consumption (g/day) **			< 0.001
No	194 (19.6)	370 (34.9)	
≤ 31.1	470 (47.6)	599 (56.5)	
> 31.1	324 (32.8)	92 (8.7)	
Fat consumption in diet (%)			0.950
< 30.0	122 (12.3)	134 (12.6)	
30.0-39.9	630 (63.3)	669 (62.6)	
≥ 40.0	243 (24.4)	265 (24.8)	

BMI: body mass index.

* Chi-square test;

** Based on a food-frequency questionnaire.

Table 3

Estimates of the coefficients and 95% confidence intervals (95%CI) for body mass index (BMI) in adult life adjusted for birth and adult life variables in four sequential models. Ribeirão Preto, São Paulo State, Brazil, 2002/2004.

Variables	Female		Male	
	Coefficient	95%CI *	Coefficient	95%CI *
Model 1				
BMI at birth (continuous)	0.223	-0.011; 0.443	0.149	-0.042; 0.329
Model 2				
BMI at birth (continuous)	0.259	0.008; 0.491	0.160	0.028; 0.327
Maternal schooling (years of study)				
0-4	1.621	0.516; 2.548	-0.486	-1.410; 0.327
5-8	1.818	0.653; 2.803	0.711	-0.276; 1.702
9-11	0.598	-0.566; 1.622	0.181	-0.882; 1.136
≥ 12	Reference			

(continues)

Table 3 (continued)

Variables	Female		Male	
	Coefficient	95%CI *	Coefficient	95%CI *
Model 2				
Number of maternal pregnancies				
1	-0.765	-1.915; 0.433	-0163	-1.252; 0.782
2-3	-1.220	-2.221; -0.268	-0.065	-1.027; 0.761
≥ 4	Reference			
Model 3				
BMI at birth (continuous)	0.268	0.016; 0.491	0.147	-0.032; 0.343
Current occupation of family head				
Non-manual	Reference			
Skilled manual	0.698	-0.048; 1.391	-0.640	-1.309; 0.063
Semiskilled manual	1.393	0.572; 2.283	-0.258	-1.059; 0.606
Unskilled manual	0.544	-0.384; 1.527	-0.387	-1.259; 0.437
Others **	0.101	-1.234; 2.512	0.352	-1.083; 2.020
Marital status of the interviewee				
Without a companion	Reference			
With a companion	1.719	1.010; 2.338	0.910	0.247; 1.567
Alcohol consumption by the interviewee (g/day)				
Low (< 31.1)	-0.091	-0.807; 0.568	0.540	-0.274; 1.191
High (≥ 31.1)	0.289	-0.801; 1.461	1.148	0.284; 1.880
None	Reference			
Model 4				
BMI at birth (continuous)	0.277	0.035; 0.495	0.162	-0.028; 0.348
Number of maternal pregnancies				
1	-0.545	-1.690; 0.624	-0.104	-1.102; 0.828
2-3	-0.965	-1.989; -0.006	0.0461	-0.838; 0.909
≥ 4	Reference			
Current occupation of family head				
Non-manual	Reference			
Skilled manual	0.495	-0.257; 1.269	-0.655	-1.354; 0.102
Semiskilled manual	1.133	0.210; 1.981	-0.279	-1.149; 0.600
Unskilled manual	0.215	-0.764; 1.226	-0.302	-1.192; 0.656
Others **	0.117	-1.402; 2.471	0.329	-1.067; 2.032
Marital status of the interviewee				
Without a companion	Reference			
With a companion	1.466	0.786; 2.152	0.927	0.258; 1.622
Alcohol consumption by the interviewee (g/day)				
Low (< 31.1)	-0.069	-0.789; 0.609	0.414	0.368; 1.089
High (≥ 31.1)	0.228	-0.964; 1.522	1.110	0.215; 1.899
None	Reference			
% fat ingested per day (continuous)	0.039	-0.018; 0.099	0.050	0.001; 0.100

* Bootstrap BCa confidence interval; Model 1: adjusted for preterm birth; Model 2: adjusted for birth variables (maternal smoking, schooling, age, marital status and number of gestations, as well as BMI at birth and preterm birth); Model 3: adjusted for adult life variables (occupation of the family head, marital status, smoking, alcohol consumption and percent fat in the diet, as well as BMI at birth and preterm birth); Model 4: adjusted for all birth and adult life variables;
** Others = persons under training or students, unemployed, retired, and housewives.

Table 4

Estimates of the coefficients and 95% confidence intervals (95%CI) for waist circumference (WC) in adult life adjusted for birth and adult life variables in four sequential models. Ribeirão Preto, São Paulo State, Brazil, 2002/2004.

Variables	Females		Males	
	Coefficient	95%CI *	Coefficient	95%CI *
Model 1				
BMI at birth (continuous)	0.210	-0.349; 0.735	0.447	-0.034; 0.900
Model 2				
Maternal schooling (years)				
0-4	4.088	1.300; 6.459	-1.382	-3.801; 0.827
5-8	3.371	0.702; 5.801	2.269	-0.378; 4.951
9-11	0.623	-2.160; 3.001	0.483	-2.194; 3.078
≥ 12	Reference			
Model 3				
Occupation of family head				
Non-manual	Reference			
Skilled manual	1.730	-0.053; 3.447	-1.259	-2.981; 0.438
Semiskilled manual	4.002	1.948; 5.990	-0.332	-2.415; 1.767
Unskilled manual	1.531	-0.702; 3.741	-0.552	-2.883; 1.689
Others **	1.589	-1.734; 9.311	0.478	-2.850; 4.870
Marital status of the interviewee				
Without companion	Reference			
With a companion	3.376	1.825; 4.859	2.483	0.847; 4.337
Smoking habit of the interviewee (cigarettes)				
Non-smoker	Reference			
Ex-smoker	2.948	0.061; 7.521	-0.006	-2.112; 2.429
< 5	2.360	-0.342; 6.324	-0.204	-3.263; 3.318
≥ 5	0.907	-1.591; 3.899	0.311	-1.747; 2.715
Alcohol consumption by the interviewee (g/day)				
Low (< 31.1)	-0.475	-2.134; 1.067	1.901	0.032; 3.783
High (≥ 31.1)	0.367	-2.364; 3.150	3.467	1.252; 5.632
None	Reference			
Model 4				
Maternal schooling (years)				
0-4	2.101	-1.041; 4.653	-0.828	-3.298; 1.728
5-8	1.808	-0.866; 4.210	2.790	0.123; 5.600
9-11	-0.388	-3.073; 2.253	1.108	-1.527; 3.696
≥ 12	Reference			
Occupation of family head				
Non-manual	Reference			
Skilled manual	1.223	-0.710; 2.943	-0.933	-3.090; 0.993
Semiskilled manual	3.194	1.136; 5.239	-0.220	-2.545; 1.870
Unskilled manual	0.534	-1.764; 3.033	0.047	-2.392; 2.482
Others **	1.303	-2.131; 8.352	0.352	-3.073; 4.230
Marital status of the interviewee				
Without a companion	Reference			
With a companion	2.799	1.158; 4.350	2.528	0.824; 4.317

(continues)

Table 4 (continued)

Variables	Females		Males	
	Coefficient	95%CI *	Coefficient	95%CI *
Model 4				
Smoking habit of the interviewee (cigarettes)				
Non-smoker	Reference			
Ex-smoker	3.442	0.209; 7.413	0.102	-2.171; 2.706
< 5	2.192	-0.984; 6.236	-0.305	-3.312; 3.416
≥ 5	0.752	-1.715; 3.741	0.534	-1.753; 2.793
Alcohol consumption by the interviewee (g/day)				
Low (< 31.1)	-0.354	-2.016; 1.195	1.530	-0.406; 3.519
High (≥ 31.1)	0.215	-2.709; 3.535	3.413	1.209; 5.460
None	Reference			
% fat ingested per day (continuous)	0.047	-0.086; 0.181	0.139	0.012; 0.269

* Bootstrap BCa confidence interval; Model 1: adjusted for preterm birth; Model 2: adjusted for birth variables (maternal smoking, schooling, age, marital status and number of gestations, as well as BMI at birth and preterm birth); Model 3: adjusted for adult life variables (occupation of the family head, marital status, smoking, alcohol consumption and percent fat in the diet, as well as BMI at birth and preterm birth); Model 4: adjusted for all birth and adult life variables;
** Others: persons under training or students, unemployed, retired, and housewives.

hood WC was 4.0cm larger in women from households where the head of the family was employed in a semi-skilled occupation at the time of birth. Adulthood WC was 2.9 larger in ex-smokers. Adult hood WC was 3.38cm and 2.48cm larger in women and men respectively living with a partner, compared to men and women living without a partner. Adulthood WC of men who consumed alcohol was 1.9 to 3.5cm larger than that of men who did not consume alcohol (Table 4).

Regarding the fourth model, adjusted for all variables, there was no association between BMI at birth and adulthood WC in either of the sexes. Adulthood WC was larger in women from households where the head of the family was employed in a semi-skilled manual occupation (3.19cm), women living with a partner (2.80cm) and women who were ex-smokers (3.44cm). Adulthood WC was larger in men whose mothers had 5 to 8 years of schooling at the time of birth (2.79cm), men living with a partner (2.53cm) and men who consumed ≥ 31.1g alcohol per day (3.41cm). For every 1% increase in fat intake among men, there was a 0.14cm increase in adulthood WC (Table 4).

Discussion

Main findings

An association between BMI at birth and adulthood BMI was found only among women. Adulthood BMI was larger in women living with a partner and from households whose head of the family was employed in a semi-skilled manual occupation and lower in women born to mothers who had had two to three gestations. Adulthood BMI was larger in men living with a partner, who consumed large amounts of alcohol and had a large fat intake.

No association between BMI at birth and adulthood WC was found using the sequential adjustment models. Adulthood WC was generally larger among women living with a partner, belonging to a household whose head of the family was employed in a semiskilled occupation and who were ex-smokers. Adulthood WC was generally larger in men whose mother had 5 to 8 years of schooling at the time of birth, living with a partner and who consumed large amounts of alcohol and fat.

BMI at birth

The association detected between greater BMI at birth and greater adulthood BMI confirms the findings of other studies that have proved the association between greater birth weight and greater adulthood BMI [36,37]. However, in the present study, this association was only observed in women and the effect was small, probably due to the young age of the cohort. Previous systematic reviews have found consistent associations between birth weight and obesity in childhood and adulthood [38,39] and there is no suggestion that such an association is limited to the female sex as found here. The different results for men and women may be explained by health behavior or by differences in *in utero* programming mechanisms.

No association was observed between BMI at birth and adulthood WC in men or women. This may be because the accumulation of abdominal fat occurs at a later age and therefore the effect of BMI at birth on adulthood WC manifests itself in later adult life. In a study conducted in the United Kingdom, greater birth weight was associated with a larger WC at 43 years of age only in men [40].

Number of gestations

While women born to mothers who had had two or three gestations presented lower adulthood BMI compared to those whose mothers had had four or more gestations (a fact that was not observed in men), no association was found between number of gestations and adulthood WC. Recent studies have emphasized the importance of parity in the development of adipose tissue. This suggests that first born offspring have an increased capacity for adipogenesis, which may be an important factor determining later adiposity [13]. Reynolds et al. [12] demonstrated higher body fat percentages among men and women born to primiparous women. The association between primiparity and offspring adiposity and late metabolic disease was also described in models used to study animals [13]. In our study, however, body mass index was higher only among women born from mothers who had had four or more gestations. Any gender affected association between the number of gestations and later offspring adiposity might be explained by differential gender effects of programming due to interactions between biological mechanisms and life-style factors.

Marital status

Velásquez-Meléndez et al. [11] demonstrated a higher prevalence of obesity and overweight among individuals living with a spouse. In the present study, living with a partner was associated with higher BMI and WC values in adulthood among men and women, thus demonstrating a consistent association between having a partner and greater body adiposity.

Socioeconomic status in adulthood

Studies in developed countries have shown that higher socioeconomic status is associated with a lower risk of obesity for both men and women [7,8]. Studies conducted in Brazil have reported that, among women, lower levels of schooling are associated with higher levels of obesity, whereas among men a higher prevalence of obesity is associated with higher socioeconomic status [4,6]. Velásquez-Meléndez et al. [11] demonstrated that there is a higher prevalence of obesity and overweight among women with less than 9 years of schooling. According to Veloso & Silva [9], lower levels of schooling among women were associated with a higher prevalence of abdominal obesity and excess weight, whereas among men higher levels of schooling were associated with a greater prevalence of excess weight. In the present study, having a medium socioeconomic status (defined as coming from a household where the head of the family is employed in a manual semi-skilled occupation) was associated with a higher BMI and larger WC only among women. It is possible that women that have a medium socioeconomic status enjoy greater access to higher energy and lower cost foods than women of a low socioeconomic status, and that women having a higher socioeconomic status can afford more expensive low energy dense foods. Han et al. [41] reported that Dutch women who had not completed high school are almost three times more likely to have abdominal adiposity than women with higher levels of schooling.

Socioeconomic status during childhood

Goldani et al. [42] demonstrated an association between lower levels of maternal schooling at childbirth (< 8 years) and higher BMI among males aged 18 years. These results were not replicated by the present study, since lower levels of maternal schooling during childhood (< 8 years) was associated with greater BMI and WC in adulthood among women but not among men.

Other factors

It is well known that adiposity increases in people who give up smoking [43]. A study conducted in Brazil demonstrated that ex-smokers of both sexes had greater mean WC values compared to smokers and non-smokers [44]. In the present study, however, no association of this nature was found in men and, in women, being an ex-smoker was only associated with a larger adulthood WC and not with a higher adulthood BMI.

The influence of certain behavioral factors on adiposity has also been subject to study. Dallongeville et al. [45] demonstrated an association between alcohol consumption and larger WC, regardless of BMI, in both sexes. Donadussi et al. [46]

demonstrated an association between high total fat intake and greater abdominal circumference in men. In the present study, men who consumed a high quantity of alcohol and had a high fat diet (≥ 40%) presented higher BMI and greater WC values.

Strengths and limitations

One of the strengths of the present study is that it comprises a longitudinal population-based investigation involving a young population in a middle-income country undergoing nutrition transition. It is known that a significant increase in the prevalence of obesity and glucose intolerance has been observed in middle-income countries which have experienced rapid changes in socioeconomic conditions and where food scarcity has given way to greater availability and abundance within a short period of time [47,48,49,50].

The present study is limited due to losses in the cohort during the first year after birth when infant mortality rates were still high, especially among small for gestational age infants. Many of the lighter and smaller newborns did not survive [26], limiting the analysis of the relationship between birth weight and disease during adult life. Furthermore there were some differences between subjects followed-up and those not interviewed in 2002/2004. Follow-up rates were lower in the case of males, particularly those engaged in manual occupations, not born preterm, with low levels of schooling and unmarried.

Conclusions

Both early and current life variables influenced BMI and WC in adulthood. Associations differed inmen and women and were also different between BMI and WC. The most consistent associations were that men and women living with a partner and men that have a high intake of fat and alcohol present higher BMI and WC values in adulthood. The difference detected between genders may indicate some differences in life style between men and women, suggesting that preventive policies should also incorporate specific strategies for each sex.

Resumo

Utilizou-se o índice de massa corporal (IMC) e a circunferência de cintura (CC) para avaliar se alguns fatores perinatais e da vida adulta se associam com adiposidade na vida adulta jovem. Trabalhou-se com a hipótese de que os fatores de risco diferem entre homens e mulheres e também são diferentes quando a CC é utilizada como medida de adiposidade em vez do IMC. Realizou-se estudo longitudinal baseado em 2.063 pessoas da coorte de nascimentos de 1978/1979 de Ribeirão Preto, São Paulo, Brasil. Foi feito ajuste sequencial em quatro modelos de regressão linear múltipla, estratificados por sexo. Tanto variáveis do início da vida como atuais interferiram no IMC e na CC. As associações foram diferentes para homens e mulheres, e também quando se considerou o IMC ou a CC. Homens e mulheres que vivem com companheira(o) e homens que têm consumo elevado de gordura e álcool apresentam maiores valores de IMC e de CC. As diferenças encontradas podem apontar para estilos de vida diferentes de homens e mulheres, sugerindo que as políticas de prevenção também precisam traçar estratégias diferenciadas segundo gênero.

Adiposidade; Obesidade; Adulto Jovem; Circunferência da Cintura

Contributors

V. M. F. Simões participated in the study design, the literature review, data analysis, the discussion of results and was responsible for the drafting and revision of the final version of this paper. M. A. Barbieri, A. A. M. Silva and H. Bettiol participated in study design, data analysis, discussion of results and revised the final version of this paper. R. F. L. Batista, M. T. S. S. B. Alves and V. C. Cardoso participated in data analysis, the discussion of results and revised the final version of this paper. H. J. F. Veloso collaborated in the discussion of results and revised the final version of this paper.

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