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Social vulnerability effect over obesity anthropometric indexes: results from population-based epidemiological study

O efeito da vulnerabilidade social sobre indicadores antropométricos de obesidade: resultados de estudo epidemiológico de base populacional

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ABSTRACT: ***Objectives:*** The study aimed at evaluating the contextual effects of social vulnerability over anthropometric indexes related to global and central obesity in adults living in Ribeirão Preto (SP), Brazil, in 2006. ***Methods:*** In a population-based cross-sectional study using multistage sampling, multilevel linear models were applied considering two levels: ecological and individual. The 81 census tracts drafted for sample composition were considered the ecological level and classified according to Paulista Social Vulnerability Index (IPVS). ***Results:*** Individual correlates to body mass index (BMI) were age, familial and personal antecedents of overweight, and total fat consumption (direct relationship), exception to gender and schooling (inverse relationship). Individual correlates to waist circumference were age, familial antecedents of stroke, personal antecedent of overweight, BMI, number of medicines taken, time of smoking, and diet total energy (direct relationship), exception to gender (inverse relationship). Considering both outcomes (BMI and waist circumference), in the final models, the variance of IPVS showed statistical significance ($p < 0.05$), depicting the contextual effect (rho ≈ 8%) over global and central obesity, even after the adjustment for individual correlates. ***Conclusion:*** Results showed that interventions to promote healthy behaviors and to prevent obesity might be focused not only on individual factors but also on socioenvironmental context in which people are inserted.

Keywords: Social vulnerability. Anthropometry. Body mass index. Waist circumference. Contextual effect. Multilevel analysis. Cross-sectional studies.

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RESUMO: ***Objetivo:*** O estudo teve por objetivo avaliar o efeito da vulnerabilidade social sobre os indicadores antropométricos de obesidade global e central em adultos (30 anos ou mais) de Ribeirão Preto (SP), 2006. ***Métodos:*** Estudo transversal de base populacional com amostra complexa, desenvolvida em três estágios. Modelos lineares multinível foram construídos em dois níveis: ecológico e individual. Os 81 setores censitários sorteados para a amostra compuseram o nível ecológico e foram classificados segundo o Índice Paulista de Vulnerabilidade Social (IPVS). ***Resultados:*** Fatores de nível individual que apresentaram relação direta com o índice de massa corporal (IMC): idade, antecedentes familiares e pessoais de excesso de peso e consumo de lipídios, com exceção de sexo e escolaridade (relação inversa). Fatores de nível individual que apresentaram relação direta com a circunferência da cintura (Ccint): idade, antecedentes familiares de acidente vascular cerebral (AVC), história pessoal de excesso de peso, IMC, número de medicamentos, tempo de tabagismo e energia total da dieta, com exceção da variável sexo (relação inversa). Para ambos os desfechos (IMC e Ccint), a variância do IPVS nos modelos finais apresentou significância estatística ($p < 0,05$) revelando o efeito contextual (rho ≈ 8%) da vulnerabilidade social sobre os indicadores de obesidade, mesmo após ajustamento para variáveis de nível individual. ***Conclusão:*** Os achados apontam para a necessidade de ações de promoção de hábitos saudáveis e de prevenção da obesidade, direcionadas não apenas aos fatores de nível individual, mas ao contexto socioambiental onde os indivíduos estão inseridos.

Palavras-chave: Vulnerabilidade social. Antropometria. Índice de massa corporal. Circunferência da cintura. Efeito contextual. Análise multinível. Estudos transversais.

INTRODUCTION

In general, the epidemiological and nutritional profile of modern societies is a result of complex and progressive changes in their patterns of morbidity, mortality and fertility (Epidemiological Transition), with the consequent restructuring over the centuries of their age profile (Demographic Transition), their different dietary habits (Nutritional Transition), alongside their environmental, socioeconomic, and lifestyle determinants[1,2].

Obesity, similar to other chronic diseases, is a multifactorial disease whose origin involves environmental, genetic, biological, and behavioral factors. In developing countries, the emergence of obesity initially affected the highest socioeconomic strata of the population. However, recent trends reveal a different pattern, as its prevalence has shifted to the lower strata of income and education[2,3].

McLaren[4], in a literature review study, compiled results from cross-sectional studies that investigated the association between socioeconomic status (SES) and overweight. In this study, the SES comprised eight indicators: income, educational level, occupation, employment status, consumer goods, social class, and neighborhood context; host countries were classified according to the Human Development Index (HDI) into three levels: high, medium, and low. A total of 1,994 associations were examined and the results showed that 71% of them were reversed among women in high-HDI countries, especially when the SES was evaluated from the occupation, educational level, or neighborhood contexts. Among males, inverse associations were detected in 37% of studies.

In the last decades, some studies aimed at investigating the determinants of positive energy balance beyond the purely individual dimension[5-7]. However, studies investigating the environmental characteristics in determining the overall or central obesity are still scarce, and efforts to understand the contextual effects are incipient.

Characteristics of particular region or neighborhood, such as the availability of green areas, large supermarket chains, or architectural features, have been identified as associated with overweight in studies of mixed effects, both in developed and in developing countries. Many researchers have endeavored to evaluate the context effect on obesity, facing methodological limitations mainly related to the concept and definition of "neighborhood," the selection of its attributes that are worth investigating, and the adoption of the most appropriate strategy to measure them. Identifying how the social-environmental context influences the behavior of individuals or population subgroups, taking them to different levels of exposure to risk and protection factors for chronic outcomes, may be a major contribution to the planning of future interventions, as it allows applying effective measures and greater coverage in the prevention and control of obesity[8].

Within this perspective, this study aimed at evaluating the effect of social vulnerability on anthropometric indicators of global and central obesity, and to identify individual factors associated with the outcome in the adult population of Ribeirão Preto (SP).

METHODS

STUDY DESIGN AND SAMPLING PROCESS

This study is a subproject derived from OBEDIARP Project, which is a cross-sectional population-based study, entitled "Risk factors for overweight, obesity and diabetes mellitus in adults living in Ribeirão Preto, SP-2006." The target population consisted of individuals aged 30 years and over living in Ribeirão Preto (SP), in which a cluster sample developed in three stages was selected. The census tract[9,10] was the primary sampling unit, and domiciles and residents corresponded to randomly selected units in the second and third stages, respectively. Sample consisted of 930 adults, and variability (different stages of selection) was considered by assigning sample weights, thus originating a weighted sample (n_w) of 2,197 participants. Sample weighting details can be found in a previous publication[11].

Data were collected at participant's home by pairs of previously trained and "calibrated"[12] interviewers. Data quality was evaluated by the replication of 12.5% of the interviews, applying the Kappa statistic for all the questions of the replication.

Portable electronic scales (Tanita BF 680 model) were used for weight measurements. For height measurements wall-mounted stadiometers were used (Seca, Hamburg, Germany) with accuracy of one millimeter. The measurement techniques followed the recommendations of Lohman et al.[13].

STUDY VARIABLES

Dependent variables

BMI[14], overall index of obesity, which is obtained by calculating: $BMI = \frac{Weight\ (kg)}{Height\ (m^2)}$ and Ccint, central obesity index, measured at the anatomical site (lesser curvature) located between the costal margin and the iliac crest[13].

Independent variable of ecological level

IPVS[15], designed and calculated by the *Fundação Sistema Estadual de Análise de Dados* (SEADE) for all census tracts of the 645 municipalities in São Paulo State. Factor analysis with the inclusion of nine variables (five for the socioeconomic and four for demographic dimension) enabled the linear combination of these two dimensions, creating the IPVS indicator as *constructo* of social vulnerability, which was classified into seven groups: 1 – extremely low; 2 – very low; 3 – low; 4 – medium; 5 – high; 6 – very high vulnerability and 7 – high vulnerability—the latter only applied for census tracts located in rural areas. In this study, social vulnerability variable was reclassified into three categories: very low (first and second groups), low (third group), and upper-middle vulnerability (fourth, fifth, and sixth groups).

The ecological level of this study was composed of 81 census tracts randomly selected in the first phase of the sampling process.

Independent variables of individual level

The variables were grouped into different blocks, according to the conceptual model developed *a priori*[16]:

1. Block 1 – Demographic and socioeconomic characteristics: gender; age; educational level; working conditions (labor activity, with remuneration in cash, carried out in the seven days preceding the interview); individual income; marital status; and length of residence in the city.
2. Block 2 – Family background: presence of family history of stroke and/or overweight.
3. Block 3A – Morbidity: personal history of overweight (participants were asked whether they had received such diagnosis at some point during their lives).

4. Block 3B – Access to health services: use of outpatient services (public or private, in the last six months) and number of medicines taken in the 15 days preceding the interview).
5. Block 4 – Behavioral aspects: smoking time (in years, calculated for participants who self-reported being smokers or ex-smokers); alcohol dependence measured by the questionnaire AUDIT[17], in which participants were divided into two categories: "nondependent" and "dependent."[18] Metabolic waste (in Metabolic Equivalents [METs]*minute*week[1]), and daily mean of sitting time, both measured by the International Physical Activity Questionnaire (IPAQ) (short version)[19]. Participants were asked whether they were engaged in a specific diet to lose weight. With regard to the dietary pattern, a semiquantitative food frequency questionnaire containing 128 items[20,21] with their respective portions and sizes was applied. Quantification of dietary nutrients was processed in NutWin software. In this study, total lipids (in grams) and total energy (in calories) were considered, in which the amount of lipids were adjusted for total energy of the diet[22].

STATISTICAL ANALYSIS

In the descriptive phase, the municipality and the study population were characterized, and estimates were calculated by points and confidence intervals (95%CI). Linear trend tests were applied, adopting $\alpha = 0.05$. At this phase, the variable BMI was considered as an adjustment variable for the central obesity index (Ccint) and categorized according to the cutoffs recommended by the World Health Organization (WHO)[14].

In the analytical phase, adherence tests to the normal distribution were performed for BMI and Ccint variables. Multicollinearity was evaluated by the correlation matrix between independent variables. Multilevel Linear models[23] with two levels were built, obtaining measures of effect estimated by points and confidence intervals. All independent variables of the individual level that were classified in more than two categories were treated as dummy, and the numerical variables were centralized[24] and treated as continuous. The contribution of the ecological level was estimated by the Intraclass Correlation Coefficient (ICC) and by the variance of the ecological variable (IPVS). Model variance was divided into parts corresponding to the levels considered in the model. Therefore, ICC estimated the contribution of the variance of the ecological level (census tracts) in relation to the total variance of the model. The goodness of fit of the final model was evaluated by the residuals homoscedasticity, separating the residuals of the ecological level (u[sector]), individual levels (e[sector]), and total (u[sector] + e[sector]). Data were analyzed using Stata software, version 13.1. The fraction corresponding to the sample weight was incorporated into the multilevel model, considering the sample design effect[24].

ETHICAL CONSIDERATIONS

The OBEDIARP project was approved in 2005 by the Ethics Committee of the *Escola de Enfermagem de Ribeirão Pr eto* (CEP-EERP/USP nº 0528/2005). All participants signed the informed consent form, according to the recommendations of the Resolution 196/96 from the National Health Council (CNS).

RESULTS

Table 1 shows the characteristics of the municipality of Ribeirão Preto based on the data extracted from the 2010 Census and from the OBEDIARP Project sample, as well as the outcome averages, according to IPVS categories. Noteworthy is the representativeness of the sample in relation to the 2010 Census. Highest BMI and Ccint means were observed among participants who were living in areas of medium or high social vulnerability.

The main characteristics of the study population are presented in Table 2. With regard to age, 19.13% of the participants were elderly; 53% had eight or more years of schooling; 37.58% reported having no labor activity in the week prior to the interview; and the majority (76%) lived in Ribeirão Preto for at least 20 years. It is worth noting that BMI and Ccint means were higher than the respective cutoff points for the classification of global pre-obesity and central obesity.

In Table 3, BMI and Ccint averages are presented with their respective confidence intervals in the categories of individual variables. For both indexes, a positive relation with age, length of residence in the city, family history of stroke, family and personal history of overweight, number of medicines taken, daily means of sitting time, and adopting a diet to lose

Table 1. Characteristics of Ribeirão Preto city, according to data of the 2010 Census and sample of the OBEDIARP Project. Ribeirão Preto, SP, 2006.

IPVS Categories	DPPs[a] %	DPPs[b] %	BMI* (in kg/m^2) Means (SD)	95%CI*	Ccint* (in cm) Means (SD)	95%CI*
Very low	65.5	68.7	27.33 (0.23)	26.87 – 27.79	87.16 (0.50)	86.14 – 88.15
Low	22.5	21.8	27.28 (0.41)	26.45 – 28.10	86.81 (0.83)	85.15 – 88.47
Medium-high	12.0	9.5	28.03 (0.99)	26.04 – 30.01	88.29 (1.57)	85.17 – 91.42
Sources:	1	2	2		2	

[a]2010 Census; [b]Sample of the OBEDIARP Project; *all estimates considered the design effect (deff); DPP: private, permanent domiciles; BMI: Body mass index; 95%CI: 95% confidence intervals; Ccint: waist circumference; SD: standard deviation.

Table 2. Characteristics of the study sample. Ribeirão Preto, SP, 2006. OBEDIARP Project.

Variables	n_w*	%*	Means*	95%CI*
Gender				
Male	660.1	30.04		27.11 – 33.15
Female	1537.0	69.96		66.85 – 72.89
Age ranges (years)			48.52	47.39 – 49.66
30 – 39	655.5	29.83		26.05 – 33.61
40 – 49	667.0	30.36		27.73 –32.98
50 – 59	454.3	20.68		17.65 – 23.69
60 and over	420.3	19.13		15.80 – 22.45
Schooling (years)			8.20	7.61 – 8.79
0 – 3	343.1	15.62		12.89 – 18.34
4 – 7	679.3	30.92		27.09 – 34.75
8 – 11	320.9	14.61		11.99 – 17.21
12 and over	853.7	38.85		33.46 – 44.24
Working				
No	825.5	37.58		33.81 – 41.33
Yes	1371.0	62.42		58.66 – 66.18
Individual Income (in BRL)			826.14	638.69 – 1013.58
None	825.5	37.58		33.89 – 41.41
1st tertile (60.00 – 520.00)	442.2	20.13		16.68 – 24.08
2nd tertile (520.10 – 1,100.00)	463.7	21.10		18.23 – 24.30
3rd tertile (> 1,100.00)	465.6	21.19		17.59 – 25.31
Length of Residence (in years)			31.27	29.79 – 32.76
1st quartile (< 20)	529.1	24.11		20.27 – 27.94
2nd quartile (20 – 31)	571.0	26.01		22.92 – 29.11
3rd quartile (32 – 41)	548.3	24.99		21.81 – 28.15
4th quartile (> 41)	546.1	24.89		21.35 – 28.41
Outcomes				
BMI (in kg/m^2)†			27.38	26.97 – 27.80
Ccint (in cm)‡			87.21	86.36 – 88.05

*All estimates considered the design effect (deff); n_w: weighted sample; †deff: 1.16666; ‡deff: 1.05411.

weight was observed. BMI and Ccint means showed a linear trend for the variables age and number of medicines taken.

Variables that showed direct relationship with BMI (Table 4) were age, family and personal history of overweight, and consumption of lipids, except for gender and schooling, which showed an inverse relation, being the variance of the IPVS statistically significant ($p < 0.05$) and ICC = 8.04%.

The set of variables associated with Ccint (Table 5) was composed of age, family history of stroke, personal history of overweight, BMI, number of medicines taken, smoking time and total energy of diet, all being directly related to the outcome, except for "gender" (inverse relationship). The variance of the IPVS was statistically significant ($p < 0.05$), and CCI was equivalent to 8%. The goodness of fit of the final models was confirmed by the residuals homoscedasticity (data not shown).

DISCUSSION

Multilevel analysis identified contribution equivalent to 8% (CCI) of the ecological level and significant variance of the variable "IPVS," revealing contextual effect of social vulnerability on central and global obesity indexes, even after adjusting for individual variables. At this level, the variables associated with the two outcomes were gender (inverse relation), age, and personal history of overweight (direct relation). With regard to the variables related to the dietary pattern, the independent effect (direct relation) of fat intake and total dietary energy was identified for at least one of the obesity indexes.

The OBEDIARP Project was carried out using complex sample and its population pyramid was similar to those of the city of Ribeirão Preto, which reveals the representativeness in relation to the reference population. The number of ecological units (n = 81), the average of observations per sector (n = 12), the high response rate (≈ 80%), and the selection of a single participant per household, reinforce the internal validity of the study and allow concluding that findings do not seem to have been caused by selection and/or information bias. In contrast, the training and the "calibration"[12] of the team of interviewers, along with the replication of the interviews (kappa > 0.80), contributed to minimize measurement bias.

With regard to physical activity, its relationship with obesity remains controversial. Although the metabolic waste owing to physical activity is closely related to the maintenance of a healthy body weight, neighborhood context, in general, has modulated this relation[8,25]. In Ribeirão Preto, the nine municipal parks are concentrated in the central region, thus residents of suburban areas need to commute long distances to use these spaces. Owing to the context effect, variables related to physical activity pattern, which were measured at the individual level, may have lost associations with the outcome, and

Table 3. Body mass index and waist circumference means, with respective confidence intervals, according to the individual level variables. Ribeirão Preto, SP, 2006. OBEDIARP Project.

Variables	BMI		Ccint	
	Means*	95%CI*	Means*	95%CI*
Block of Demographic and socioeconomic characteristics				
Gender				
Male	26.96	26.37 – 27.55	92.26	91.06 – 93.46
Female	27.57	27.04 – 28.10	85.05	83.95 – 86.15
Age ranges (years)†‡				
30 – 39	26.26	25.55 – 26.98	83.47	82.08 – 84.85
40 – 49	27.64	26.89 – 28.38	86.52	85.04 – 87.99
50 – 59	27.82	27.08 – 28.55	89.19	87.67 – 90.70
60 and over	28.26	27.46 – 29.07	92.00	90.25 – 93.74
Schooling (years)‡				
0 – 3	27.81	26.92 – 28.70	89.57	87.59 – 91.55
4 – 7	27.82	27.01 – 28.61	88.23	86.71 – 89.75
8 – 11	28.17	27.10 – 29.24	87.44	85.33 – 89.56
12 and over	26.58	26.06 – 27.10	85.36	84.14 – 86.57
Individual Income (in BRL)				
None	27.78	27.15 – 28.41	87.96	86.57 – 89.35
1st tertile (60.00 – 520.00)	27.49	26.58 – 28.40	85.54	83.58 – 87.49
2nd tertile (520.10 – 1,100.00)	27.27	26.38 – 28.16	87.37	85.58 – 89.16
3rd tertile (> 1,100.00)	26.69	26.03 – 27.35	87.31	85.61 – 89.02
Marital status				
With partner	26.98	26.35 – 27.61	86.76	85.40 – 88.12
Without partner	27.60	27.04 – 28.16	87.44	86.31 – 88.56
Length of Residence (in years)				
1st quartile (< 20)	26.58	25.84 – 27.32	85.09	83.48 – 86.70
2nd quartile (20 – 31)	27.47	26.78 – 28.16	86.69	85.36 – 88.02
3rd quartile (32 – 41)	27.21	26.39 – 28.03	86.31	84.45 – 88.17
4th quartile (> 41)	28.27	27.58 – 28.95	90.78	89.15 – 92.40

Continue...

Table 3. Continuation.

Variables	BMI		Ccint	
	Means*	95%CI*	Means*	95%CI*
Bock of family background				
Stroke				
No	27.03	26.51 – 27.55	86.50	85.38 – 87.62
Yes	28.04	27.30 – 28.78	88.59	87.01 – 90.18
Overweight				
No	26.14	25.72 – 26.56	85.26	84.33 – 86.18
Yes	28.95	28.29 – 29.60	89.70	88.34 – 91.05
Block of Morbidity				
Personal history of overweight				
No	24.97	24.60 – 25.35	82.69	81.84 – 83.53
Yes	31.60	30.92 – 32.28	95.10	93.70 – 96.50
Block of access to health services				
Used (in the last 6 months)				
No	27.18	26.39 – 27.96	87.66	85.94 – 89.38
Yes	27.45	26.98 – 27.92	87.06	86.06 – 88.05
Number of medicines taken[††]				
None	25.84	25.16 – 26.53	85.50	83.90 – 87.10
1 – 2	27.43	26.85 – 28.01	86.27	85.09 –87.45
3 or more	28.32	27.55 – 29.08	89.70	88.04 – 91.36
Block of behavioral variables				
Smoking time (in years)				
Non-smoker	27.50	26.92 – 28.09	86.28	84.96 – 87.59
1st tertile (1 – 12)	27.37	26.25 – 28.49	88.16	85.85 – 90.47
2nd tertile (12.1 – 25)	27.43	26.39 –28.46	87.37	85.25 – 89.49
3rd tertile (> 25)	26.90	25.95 – 27.85	89.59	87.55 – 91.63
Alcohol dependence				
No (scores 0 – 7)	27.54	27.03 – 28.04	86.64	85.59 – 87.70
Yes (scores 8 – 40)	26.78	26.06 – 27.51	89.42	87.76 – 91.09

Continue...

Table 3. Continuation.

Variables	BMI		Ccint	
	Means*	95%CI*	Means*	95%CI*
Metabolic waste (METs*minute*week[1])				
≤ median (≤ 412.5)	27.17	26.60 – 27.73	86.77	85.55 – 87.98
> median (> 412.5)	27.60	27.07 – 28.13	87.64	86.57 – 88.70
Daily mean of sitting time (in min/day)‡				
1st quartile (≤ 166.0)	26.73	25.81 – 27.66	85.57	83.74 – 87.41
2nd quartile (116.1 – 240.0)	27.57	26.83 – 28.32	87.40	85.90 – 88.89
3rd quartile (240.1 – 360.0)	27.55	26.77 – 28.32	87.15	85.57 – 88.73
4th quartile (> 360.0)	27.67	27.00 – 28.34	88.73	87.16 – 90.29
Diet to lose weight				
No	27.15	26.71 – 27.59	86.61	85.67 – 87.54
Yes	28.72	27.81 – 29.62	91.06	89.21 – 92.90
Total lipids (in grams)				
1st quartile (≤ 60.42)	27.08	26.45 – 27.72	89.10	87.69 – 90.50
2nd quartile (60.43 – 68.44)	27.50	26.75 – 28.35	86.70	85.11 – 88.28
3rd quartile (68.45 – 76.81)	27.48	26.71 – 28.24	86.45	84.71 – 88.20
4th quartile (> 76.81)	27.47	26.58 – 28.36	86.66	84.89 – 88.44
Total dietary energy (in kcal)				
1st quartile (≤ 1,640.20)	27.90	27.16 – 28.64	86.85	85.29 – 88.41
2nd quartile (1,640.21 – 2,157.20)	27.82	26.97 – 28.67	86.79	85.10 – 88.48
3rd quartile (2,157.21 – 2,847.20)	26.88	26.01 – 27.75	86.57	84.64 – 88.50
4th quartile (> 2,847.20)	26.92	26.16 – 27.67	88.60	86.98 – 90.23

*All estimates considered the design effect; †p-value < 0.05 for linear trend test – BMI ; ‡p-value < 0.05 for linear trend test – Ccint.

it is plausible to suppose that the effects may have been mitigated by the influence of social vulnerability.

Among the findings in the literature, few studies[26,27] has considered the effect of "family history of chronic events" on obesity and, when taken into account, its objectives only consisted in the investigation of individual-level determinants. Hajian-Tiaki and Heidari[26]

Table 4. Crude means and adjusted slopes for the body mass index, with respective confidence intervals. Final model. Ribeirão Preto, SP, 2006. OBEDIARP Project.

Individual variables (level 1)	Crude means	95%CI	Adjusted slopes (β)*	95%CI
Gender			**-0.81**	-1.50 – 0.12
Male	26.96	26.37 – 27.55		
Female	27.57	27.04 – 28.10		
Age ranges (years)			**0.04**	0.01 – 0.07
30 – 39	26.26	25.55 – 26.98		
40 – 49	27.64	26.89 – 28.38		
50 – 59	27.82	27.08 – 28.55		
60 and over	28.26	27.46 – 29.07		
Schooling (years)			**-0.12**	-0.20 – 0.04
0 – 3	27.81	26.92 – 28.70		
4 – 7	27.81	27.01 – 28.61		
8 – 11	28.17	27.10 – 29.24		
12 and over	26.58	26.06 – 27.10		
FB of overweight			**1.29**	0.57 – 1.99
No	26.14	25.72 – 26.56		
Yes	28.95	28.29 – 29.60		
PH of overweight			**6.38**	5.68 – 7.07
No	24.97	24.60 – 25.35		
Yes	31.60	30.92 – 32.28		
Total lipids (in grams)			**0.02**	0.01 – 0.04
1st quartile (≤ 60.4)	27.08	26.45 – 27.72		
2nd quartile (60.5 – 68.4)	27.50	26.75 – 28.25		
3rd quartile (68.5 – 76.8)	27.48	26.71 – 28.24		
4th quartile (> 76.8)	27.47	26.58 – 28.36		
Ecological variable (level 2)	**Crude means**	**95%CI**	**Variance**	**Standard error**
IPVS: Very low	27.33	26.87 – 27.79	**1.823802**	0.665931
Low	27.28	26.45 – 28.10		
Medium-high	28.02	26.04 – 30.01		
ICC (%)			8.04	

*Adjusted for “Diet to lose weight”; FB: family background; PH: personal history; in bold: p-value < 0.05; IPVS: *Índice Paulista de Vulnerabilidade Social* (Social vulnerability index of São Paulo).

Table 5. Crude means and and adjusted slopes for the waist circumference, with respective confidence intervals. Final model. Ribeirão Preto, SP, 2006. OBEDIARP Project.

Individual variables (level 1)	Crude means	95%CI	Adjusted slopes (β)*	95%CI
Gender			**-8.48**	-9.24 – 7.72
Male	92.26	91.06 – 93.46		
Female	85.05	83.95 – 86.15		
Age ranges (years)			**0.16**	0.11 – 0.20
30 – 39	83.47	82.08 – 84.85		
40 – 49	86.52	85.04 – 87.99		
50 – 59	89.19	87.67 – 90.70		
60 and over	92.00	90.25 – 93.74		
FB of stroke			**0.66**	0.01 – 1.31
No	86.50	85.38 – 87.62		
Yes	88.60	87.01 – 90.18		
PH of overweight			**2.17**	0.07 – 4.27
No	82.69	81.84 – 83.54		
Yes	95.10	93.70 – 96.51		
Nutritional status			**1.69**	1.42 – 1.96
Normal weight	76.44	75.63 – 77.26		
Pre-obese	88.82	88.09 – 89.55		
Obese	101.18	99.81 – 102.53		
Nº of medicines taken			**0.22**	0.04 – 0.39
None	85.50	83.90 – 87.10		
1 – 2	86.27	85.09 – 87.45		
3 or more	89.70	88.04 – 91.36		
Smoking time			**0.03**	0.01 – 0.06
Non-smoker	86.28	84.96 – 87.59		
1 – 12 years	88.16	85.85 – 90.47		
12 – 25 years	87.37	85.25 – 89.49		
> 25 years	89.59	87.55 – 91.63		

Continue...

Table 5. Continuation.

Individual variables (level 1)	Crude means	95%CI	Adjusted slopes (β)*	95%CI
Total dietary energy (in Kcal)			**0.11**	0.03 – 0.18
1st quartile (≤ 1,640)	86.85	85.29 – 88.41		
2nd quartile (1,640.1 – 2,157)	86.79	85.10 – 88.48		
3rd quartile (2,157.1 – 2,847)	86.57	84.64 – 88.50		
4th quartile (> 2,847)	88.60	86.98 – 90.23		
Ecological variable (level 2)	**Crude means**	**95%CI**	**Variance**	**Standard error**
IPVS: Very low	86.16	85.16 – 88.15	**2.040663**	0.6033421
Low	86.81	85.15 – 88.47		
Medium-high	88.29	85.16 – 91.42		
ICC (%)			7.94	

*Adjusted for "Diet to lose weight"; FB: family background; PH: personal history; in bold: p-value < 0.05; IPVS: *Índice Paulista de Vulnerabilidade Social* (Social vulnerability index of São Paulo).

carried out a study with 3,600 adults participants (aged 20 – 70 years) in four cities of the Mazandran province, Iran. Final models showed gender, marital status, and family history of obesity with statistically significant odds ratios for obesity, whereas educational level was identified as a protective factor.

In Ribeirão Preto, the independent effect of variables "family history of overweight," "family history of stroke," and "personal history of overweight" on obesity indexes was detected. Future studies, preferably with longitudinal design, are necessary to verify the consistency of these associations.

Findings from different studies[8,28] reinforce the association of central obesity with chronic diseases. However, determinants of central obesity, which constitutes an intermediate event in relation to chronic non-communicable diseases and their complications (*end-points*), have been scarcely investigated.

Results of studies conducted on the basis of the European information Prospective Investigation into Cancer and Nutrition (EPIC)[29,30], applying multilevel models, revealed significant associations of lifestyle factors (smoking, alcohol consumption, and total dietary energy) in relation to Ccint. In this study, the independent effect of "smoking time" and "total dietary energy" on at least one of the two considered outcomes was clear.

In the literature of the last decade, environmental factors such as type and availability of food trade, settlement of urban space favorable to physical activities, among others, were identified as determinants of overweight[30,31,33]. In addition to socioeconomic factors and their relationship already well known in relation to obesity[7,31,32], there is a consensus that the neighborhood also has an important effect on obesity, since its characteristics can modulate the effect of individual-level determinants.

Despite several studies have pointed out, in the last two decades, that the urban environment adversely affects the health of its inhabitants, not much is known about the mechanisms related to the combined action of the physical environment and social factors on the onset of ecological exposures that may generate inequalities in health status among different population groups[30].

In Brazil, government policies that were focused on economic growth achieved the national targets to some extent; however, in general, they failed to extend its benefits to the most of the population, resulting in an economic growth model that is exclusionary and concentrator of wealth. In addition to the poverty of these populations, the prevailing social inequalities in urban areas resulted in a complex process of spatial segregation that helps to maintain the condition of poverty and promotes the diffusion of behaviors from the socialization processes in which certain values, objectives, and expectations are transmitted, and thus influence individual trajectories (determining or mediating them)[15].

In general, the suburban areas of urban centers have deteriorated architectural standard, offer few employment opportunities, concentrate the worst safety indicators, and have limited availability of public spaces. Such characteristics may, among others, influence the quality of life of residents and their families. Living in spatially segregated environments promotes the formation of ghettos of families who share certain characteristics, which might make them more susceptible to adverse exposures over time[8].

In Ribeirão Preto, census tracts that are classified as presenting medium or high social vulnerability are located in the suburban areas of the municipality (data not shown), suggesting that the ongoing urban expansion process has "expelled" from the center low-income people and family arrangements most vulnerable. Similar results to those of this study were reported by other authors[31-33].

Townshend and Lake[34], in a review study, evaluated the effect of contextual obesogenic environments on the positive energy balance. The main findings indicate that, with regard to dietary habits, the association of availability of unhealthy foods with overweight showed inconsistent results, whereas "neighborhoods of suburban locations with presence of ethnic minorities" associated consistently and positively with obesity.

Results of studies carried out in the U.S. population identified the neighborhood context effect by means of the associations of the ecological variables such as types of restaurants[35] and density of health food trade[36] with nutritional status. In Ribeirão Preto, the characteristics related to types of food trade were not investigated. Despite this limitation, it is possible to assume that more peripheral areas that are classified as presenting medium or high social vulnerability are served almost exclusively by small businesses with limited availability of healthy and good quality foods, besides being more expensive than those found in large supermarket chains, often located in central areas with higher socioeconomic status.

Most authors that included ecological variables related to dietary[35,36] or physical activity patterns[25,37] opted to evaluate the effect of these variables on the outcomes exclusively (sociological fallacy), without considering individual determinants. In Ribeirão Preto, authors estimated the contribution of the neighborhood context to the outcomes, as well as identified the individual factors independently associated with BMI and Ccint, without establishing hierarchy between the levels and considering the multidimensional aspects of the associations.

Among the limitations of the study, the cross-sectional design prevented a clear understanding of the detected contextual effect, which could not be classified as part of the causal network, since the ecological exposure (area of residence) was not prospectively evaluated. Within this perspective, simultaneous measurements of referred exposures and outcomes may have led to the reverse causality bias, the global association between "number of medicines taken" and the two outcomes being one example.

Given the observed context effect (ICC ≈ 8%) and the magnitude of the variance attributed to social vulnerability, it is possible to conclude that regions of medium or high social vulnerability can be defined as "dynamic components" or "exposure regulators"[3] in interconnected systems, thus modulating individual behavior and public policies related to prevention of obesity. Statistical models that estimate the extent to which individuals living in a particular neighborhood are submitted to similar exposures for certain outcomes, such as overweight, become essential to the development of efficient intervention strategies that can gradually cease to prioritize targeted interventions on changes that operate exclusively on the individual level[38].

CONCLUSION

Considering the existence of the context effect, traditional measures of effects (classic models) can lead to erroneous focus of intervention. Therefore, it is necessary to understand that individual effect measures along with the context effect provide additional information that may assist in the combination of approaches focused on both the individuals and their contexts, when elaborating strategies of health promotion and prevention of obesity.

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