

*Original article (short paper)*

## **Cumulative incidence of youth obesity is associated with low cardiorespiratory fitness levels and with maternal overweight**

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**Abstract**—This longitudinal study evaluated the association between the incidence of youth overweight/obesity (Ow/Ob) and low levels of cardiorespiratory fitness (CRF) over 4 years and youths' and their parents' demographic and nutritional characteristics. The randomized sample comprised 398 youth, aged 7-17 years at baseline, from a city in southern Brazil. Subjects were classified as being Ow/Ob according to international body mass index (BMI) parameters. Parental weight and height were determined by direct questioning. Youth CRF was measured by a 9-minute walk-and-run test. The cumulative incidences of Ow/Ob and of low CRF levels were 25.1% and 20.5%, respectively. Relative to other youth, youth who were classified as "unhealthy" at baseline (with respect to CRF) and by the fourth year were more likely to be classified as Ow/Ob (relative risks: 1.12 and 1.10, respectively). Youth whose mothers were categorized as Ow/Ob were at higher risk of being classified as Ow/Ob than youth whose mothers had normal BMIs (relative risks: 1.19 at baseline and 1.20 in the fourth year). The incidence of Ow/Ob among the former youth was associated with low CRF levels and with maternal Ob.

**Keywords:** obesity, youth, cardiorespiratory fitness, parents

**Resumo**—“Incidência cumulativa de obesidade juvenil está associada com níveis baixos de aptidão cardiorrespiratória e com excesso de peso materno.” O presente estudo longitudinal avaliou a associação entre a incidência de sobrepeso/obesidade e de baixos níveis de aptidão cardiorrespiratória (APCR) em escolares, ao longo de 4 anos, com características demográficas e nutricionais de seus pais. A amostra aleatória foi composta por 398 escolares, com idades entre 7 e 17 anos, de uma cidade do sul do Brasil. Os escolares foram classificados em sobrepeso/obesidade de acordo com os pontos de corte internacionais para o índice de massa corporal (IMC). O peso e a estatura dos pais foram avaliados através de uma pergunta direta. A APCR dos escolares foi avaliada através do teste de corrida/caminhada de 9 minutos. A incidência cumulativa de sobrepeso/obesidade encontrada nos escolares foi de 25,1% e baixos níveis de APCR foi de 20,5%. Escolares classificados com baixos níveis de aptidão cardiorrespiratória (risco relativo: 1,12 no início do estudo e 1,10 após 4 anos) e cujas mães são obesas (risco relativo: 1,19 no início do estudo e 1,20 no quarto ano) apresentaram risco maior de apresentarem sobrepeso/obesidade. Assim, a incidência de sobrepeso/obesidade em escolares está associada com baixos níveis de aptidão cardiorrespiratória e obesidade da mãe.

**Palavras-chave:** obesidade, escolares, aptidão cardiorrespiratória, pais

**Resumen**—“Incidencia acumulativa de la obesidad juvenil es asociada con niveles de baja aptitud cardiorespiratoria y con sobrepeso materno.” Este estudio longitudinal examinó la asociación entre la incidencia de sobrepeso/obesidad y de bajos niveles de aptitud cardiorespiratoria (APCR) en escolares, en un período de cuatro años, con características demográficas y nutricionales de sus padres. La muestra aleatoria estuvo conformada por 398 escolares entre 7 y 17 años, en el sur de Brasil. Los estudiantes fueron clasificados como con sobrepeso/obesidad según los puntos de corte internacionales para el índice de masa corporal (IMC). El peso y la talla de los padres fueron evaluados por una pregunta directa. La APCR en niños se evaluó mediante la prueba de carrera/caminata en nueve minutos. La incidencia acumulada de sobrepeso/obesidad en los niños fue de 25,1% y los bajos niveles de APCR fueron de 20,5%. Los niños clasificados con bajos niveles de aptitud cardiorespiratoria (riesgo relativo: 1,12 al inicio y 1,10 después de 4 años) y que tienen madre obesa (riesgo relativo: 1,19 al inicio y 1,20 en el cuarto año) tienen un riesgo mayor para el desarrollo de sobrepeso/obesidad. La incidencia de sobrepeso/obesidad en escolares se muestra asociada a los bajos niveles de capacidad cardiorespiratoria y la obesidad de la madre.

Palabras claves: obesidad, escolares, aptitud cardiorespiratoria, padres

## Introduction

Cross-sectional studies have shown that overweight (Ow) and obesity (Ob) are the most prevalent diseases among youth (Freedman *et al.*, 2012; Ogden, Carroll, Kit, & Flegal, 2012). Globally, approximately 30% of youth have become Ow/Ob. Recent data confirm that Brazilian children are among the most affected by Ow/Ob (Flores, Gaya, Petersen, & Gaya, 2013; IBGE, 2010), as are children in the USA (Ogden *et al.*, 2012). Moreover, children with excess weight exhibit an elevated risk of becoming obese as adults (Guo, Wu, Chumlea, & Roche, 2002), and Ob tends to persist from childhood to adulthood (Simmonds *et al.*, 2015). In addition, there is strong evidence that parental Ob is associated with Ow or Ob among children (Abu-Rmeileh *et al.*, 2008; Lake, Power, & Cole, 1997; Li, Law, Lo Conte, & Power, 2009; Whitaker, Wright, Pepe, Seidel, & Dietz, 1997).

However, to the best of our knowledge, there are only a few longitudinal studies that address the problem of cumulative obesity among Brazilian youth and obesity's relation to several determinants and predictors. Recently, in a trend study, Flores *et al.* (2013) suggested that the prevalence of Ow/Ob among a representative population of Brazilian children and adolescents has stabilized. However, this stable group represents approximately 30% of the youth population with Ow/Ob.

It is important to identify lifestyles and socio-demographic characteristics during a period of time that can be associated with the early development of Ow/Ob in youth. A recent longitudinal study that included a sample of Portuguese youth, conducted over a period of three years, showed a significant effect of low cardiorespiratory fitness (CRF) on changes in body mass index (BMI) in youth (Aires *et al.*, 2010). In fact, studies have demonstrated that children have become more sedentary, have low degrees of CRF, and spend little time engaged in moderate to vigorous physical activity (Metcalf, Voss, Hosking, Jeffery, & Wilkin, 2008; Reilly, 2008; Wells *et al.*, 2008). Low CRF levels are associated with Ob; in addition, CRF is negatively related to cardiometabolic risk (Boddy *et al.*, 2014; Buchan *et al.*, 2015). Moreover, Andersen *et al.* (2015) have suggested incorporating CRF into the definition of metabolic syndrome to improve the diagnostic criteria for this syndrome among children.

The identification of the incidence of Ow/Ob and CRF levels during childhood and adolescence provide important data for

early intervention. Therefore, this longitudinal study sought to verify the four-year incidence of Ow/Ob and CRF levels in a sample of Brazilian children and adolescents and to identify the associated socio-demographic and nutritional characteristics of these subjects' parents.

Our hypothesis is that an increased incidence of Ow/Ob and low CRF levels among children and adolescents followed for four years would be related to the nutritional characteristics of these subjects' parents.

## Methods

### Population and sample

This longitudinal study is part of a larger project aimed at studying the incidence and prevalence of Ow and Ob among youth, their risk factors for this condition, and the consequences of Ow and Ob in a representative, randomized sample of schoolchildren and adolescents from Santa Cruz do Sul-Brazil. The examined municipality included 54 elementary and middle schools. The subjects were selected from a stratified cluster sample (center and north, south, east and west, in the periphery of the urban area; and north, south, east and west in the rural area) from 18 schools (14 in the urban area and 4 in the rural area). For this study, the sample size was calculated based on a significance level of 5%, a statistical power of test of 0.80, and an Ow/Ob prevalence of 30% (Flores *et al.*, 2013). Thus, a representative sample of 398 schoolchildren and adolescents aged 7 to 17 years was recruited. Representativeness criteria were used to select subjects in accordance with the population density of the examined municipality. We included students of both sexes agreeing to participate. These students were enrolled in schools in the study region. In addition, parents (father or mother) who completed the questionnaire that we sent were included. Students who were not assessed four years after the first evaluation were excluded from this study.

The project was submitted and approved by the Ethics in Research Committee of the University of Santa Cruz do Sul (CEP-Unisc) under Protocol 4913-2007, Letter No. 261/07, in accordance with the Declaration of Helsinki. Parents or guardians signed the informed consent at study entry, allowing the participation of their children in assessments and tests.

*Anthropometric characteristics of the youth*

Height was measured to the nearest mm in bare or stockinged feet with the children and adolescents standing upright against a DSM370 stadiometer. Weight was measured to the nearest 0.10 kg using an electronic weight scale (Filizola) with the subjects lightly dressed and after having eaten breakfast. BMI was calculated from the ratio of body weight/body height (m<sup>2</sup>). The youth were categorized as normal weight or Ow/Ob in accordance with international cutoff points (Cole, Bellizzi, Flegal, & Dietz, 2000).

*Parental BMI, residence zone and birth weight*

Information on parental BMI, children’s birth weight and zone residences were accessed by querying records after obtaining the authorization for conducting this research. Parental BMI was categorized as normal weight or Ow/Ob in accordance with international cutoff points (World Health Organization, 1995).

*Cardiorespiratory fitness*

Cardiorespiratory fitness was evaluated by a 9-minute run/walk test aimed at measuring the distance traveled in that time. Trained professionals administered the test on a university running track. The enrolled youth were encouraged to run or walk as great a distance as possible. After 9 minutes, the traveled distance was recorded in meters. Data were categorized as being in the “healthy” or “unhealthy” zone in accordance with cutoff points (adjusted for age and gender) validated for Brazilian children and adolescents by Sport Brazil Project (*Projeto Esporte Brasil* (PROESP-BR), 2009).

*Statistical analyses*

Prior to analysis, data were evaluated for normality using the Shapiro-Wilk test. If data exhibited normality

( $p > .05$ ), parametric tests were used. The means and frequencies of predictors and determinant variables were compared between normal and overweight/obese youth at baseline and four years later by an independent *t*-test for continuous variables and a chi-squared ( $X^2$ ) test for categorical variables. Mean differences in Ow/Ob and normal weight between baseline and the fourth year were calculated by repeated measured *t*-tests. Generalized linear model Poisson regression (with robust variance selected) was used to verify the association between outcomes at baseline and in the fourth year, with the incidence risk of Ow/Ob as a dependent variable. Birth weight and zone of residence were not included in the model because their associations with incidence of Ow/Ob were statistically insignificant ( $p > .20$ ) in initial association analyses. A generalized linear Poisson regression model was also used to correlate youth Ow/Ob condition with parental nutritional status. The SPSS software, version 20.0, was used for all analyses, and the significance level was established at 5%.

**Results**

*Sample characteristics*

Table 1 summarizes sample characteristics stratified by baseline compared with fourth year and normal compared with Ow/Ob. The sample comprised similar numbers of males and females. The majority of subjects lived in urban areas (61.2%). The mean age increased from baseline to the fourth year, suggesting that most of the youth became adolescents during the follow-up period in both the Ow/Ob and normal weight groups.

The mean values for the BMI of the youth and parental BMI increased from baseline to the fourth year for the Ow/Ob group only. There was no significant difference between the groups for CRF and birth weight.

Table 1. Data of normal weight and overweight/obese youth at baseline and at 4-year follow-up.

	Nw		Ow/Ob	
	Baseline n= 310	4 years n= 208	Baseline n= 95	4 years n= 197
Age (years)	9.84 ± 1.87	14.10 ± 1.84*	9.78 ± 1.61	13.80 ± 1.71*
Weight (kg)	34.17 ± 8.81 <sup>+</sup>	46.65 ± 10.29*	47.64 ± 10.20	60.74 ± 12.57*
Height (cm)	142.03 ± 12.38	160.33 ± 12.17*	144.84 ± 11.47	161.53 ± 13.02*
BMI (kg/m <sup>2</sup> )	16.64 ± 1.88 <sup>+</sup>	17.88 ± 1.88	22.47 ± 2.36	22.98 ± 3.52
CRF (m)	1249.98 ± 244.46	1368.82 ± 237.61	1156.88 ± 204.49	1262.92 ± 287.21
Birth weight (g)	3239.24 ± 636.80	-	3400.47 ± 588.82	-
Mother’s BMI (kg/m <sup>2</sup> )	24.23 ± 4.09 <sup>+</sup>	-	27.79 ± 6.00	-
Father’s BMI (kg/m <sup>2</sup> )	25.54 ± 3.41 <sup>+</sup>	-	27.97 ± 5.70	-
Male/Female (%)	51.6/48.4	-	-	-
City area % (rural/urban)	38.8/61.2 <sup>”</sup>	-	-	-

Nw: normal weight; Ow: overweight; Ob: obese; BMI: body mass index; CRF: cardiorespiratory fitness. \*Independent *t*-test: differences in Nw between baseline and four-year follow-up; differences in Ow between baseline and four-year follow-up (for  $p < .05$ ). <sup>+</sup>Independent *t*-test: differences between Nw and Ow/Ob at baseline and four-year follow-up (for  $p < .05$ ). <sup>”</sup>Differences among city areas and between males and females were obtained by  $X^2$  test (for  $p < .05$ ).

*Incidence of Ow/Ob and low degrees of cardiorespiratory fitness*

Table 2 shows the changes in BMI categories over the four years of follow-up. Approximately 50.9% of subjects remained in the “normal” BMI category, and only a few subjects changed from the Ow/Ob to the “normal” BMI category. However, 23.2% of the youth became overweight (changing from the “normal” to the Ow/Ob BMI categories). Furthermore, approximately 10% of youngsters became obese in the short follow-up period of four years. With respect to CRF, 31.8% of the examined youth changed from normal to low CRF levels during the course of follow-up, and 31.4% of the examined youth remained at low CRF levels throughout the study period.

Table 2. Nutritional status and CRF at 4-year follow-up.

	n (%)
<b>BMI</b>	
Normal (maintaining)	206 (50.9)
Normal to overweight	94 (23.2)
Normal to obesity	10 (2.5)
Overweight (maintaining)	36 (8.9)
Overweight to normal	2 (0.5)
Overweight to obesity	28 (6.9)
Obesity (maintaining)	24 (5.9)
Obesity to overweight	5 (1.2)
<b>CRF</b>	
Normal (maintained)	103 (25.4)
Normal to low levels	129 (31.8)
Low levels to normal	46 (11.4)
Low levels (maintained)	127 (31.4)

Figure 1 demonstrates 4 years of follow-up of youngsters with Ow/Ob, including youth who became Ow/Ob over time and youth who remained in these categories over the four-year follow-up period. Cumulative incidence from baseline until the fourth year was approximately 25.1% ( $\chi^2=120.52; p < .05$ ; Cramer’s *V*: .56). Figure 2 shows that 20.5% of youth remained within or switched to the “unhealthy” CRF categories ( $\chi^2= 13.51; p < .05$ ; Cramer’s *V*: .18).

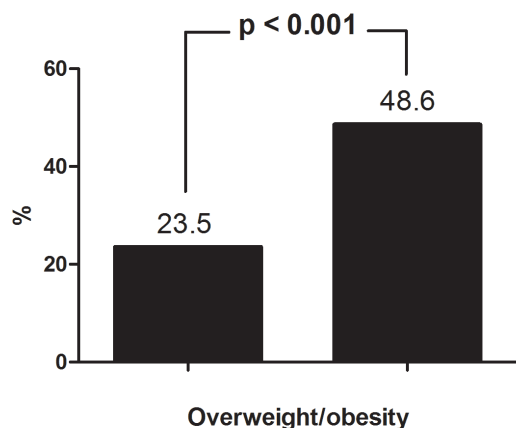


Figure 1. Incidence of overweight/obesity at 4-year follow-up.

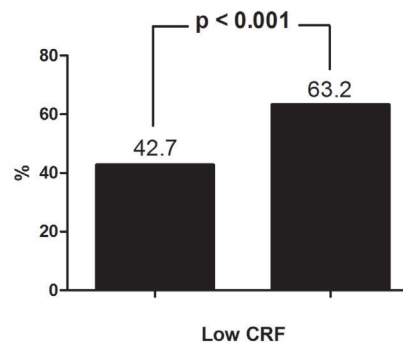


Figure 2. Incidence of low cardiorespiratory fitness at 4-year follow-up.

*Association of outcomes with incidence of Ow/Ob at baseline and at four-year follow-up*

Tables 3 and 4 show the adjusted Poisson regression model using the incidence of Ow/Ob as a dependent variable. Residence zone and birth weight were both excluded from the model because these metrics did not exhibit statistically significant associations with the incidence of Ow/Ob ( $p > .20$ ). Outcomes that did show a significant association (or  $p < .20$  on the previous robust model) were included in a multivariate model (data not shown). Table 3 shows the baseline association, and Table 4 shows the association of outcomes with Ow and Ob incidence after four years of follow-up. Residence zone, birth weight, gender, age and paternal BMI outcomes did not show a significant association ( $p < .05$ ) with the risk of becoming or remaining Ow/Ob over the four years of follow-up. However, both at baseline and four years afterwards, “unhealthy” CRF showed a significant association with the risk of youth becoming or remaining in the Ow/Ob category (Table 3 and Table 4). Additionally, youth with a mother categorized as Ow/Ob at baseline showed a significant association with the risk of becoming or remaining in the Ow/Ob category.

Table 3. Incidence of overweight/obesity and baseline determinant variables.

Model 1: Baseline	RR (CI 95%)	p
Gender		
Male	1	
Female	1.02 (0.94-1.11)	.636
Age group		
Children	1	
Adolescents	1.06 (0.97-1.17)	.210
Zone		
Urban	1	
Rural	0.99 (0.92-1.09)	.959
Mother’s BMI		
Normal	1	
Overweight/obesity	1.19 (1.09-1.30)	$\leq .001^*$
CRF		
Fit	1	
Unfit	1.12 (1.02-1.22)	.018*

Poisson regression analysis; RR: relative risk; CRF: cardiorespiratory fitness; BMI: body mass index. The reference group is youth who remained or became overweight or obese. Statistically significant association with the reference categories for  $p < .05$

Table 4. Incidence of overweight/obesity and 4-year follow-up determinant variables.

Model 2: 4-year follow-up	RR (CI 95%)	p
Gender		
Male	1	.813
Female	0.99 (0.91-1.08)	
Age group		
Children	1	.450
Adolescents	1.06 (0.91-1.25)	
Zone		
Urban	1	.771
Rural	1.01 (0.93-1.10)	
Mother's BMI		
Normal	1	≤ 0.001*
Overweight/obesity	1.20 (1.11-1.31)	
Incidence of CRF		
Fit	1	.032*
Unfit	1.10 (1.01-1.20)	

Poisson regression analysis; RR: relative risk; CRF: cardiorespiratory fitness; BMI: body mass index. The reference group is youth who remained or became overweight or obese. Statistically significant association with the reference categories for  $p < .05$ .

In addition, our study demonstrated that among male youth, Ow/Ob was associated with maternal Ow (PR: 1.25;  $p \leq .001$ ). No associations between Ow/Ob in male youth and paternal BMI were identified. Among female youth, Ow and Ob were associated with both maternal (PR: 1.36;  $p \leq .001$ ) and paternal (PR: 1.22; 0.015) Ob (Table 5).

Table 5. Relationship between youth and parental overweight/obesity in 2008.

	Youth overweight/obesity (based on BMI)			
	Male		Female	
	PR (95% CI)	p	PR (95% CI)	p
Maternal BMI				
Normal	1		1	
Overweight	1.25 (1.10-1.43)	.001	1.08 (0.95-1.23)	.249
Obesity	1.17 (0.99-1.40)	.071	1.36 (1.20-1.54)	≤ .001
Paternal BMI				
Normal	1			
Overweight	0.99 (0.87-1.13)	.898	1.10 (0.97-1.25)	.140
Obesity	1.00 (0.80-1.24)	.978	1.22 (1.04-1.43)	.015

Poisson regression analysis; PR: prevalence ratio; CI: confidence interval; BMI: body mass index.  $p < .05$  indicates a statistically significant association between the referenced categories.

### Discussion

We analyzed the incidence of Ow/Ob over a four-year period and its relation to several parents' and youths' lifestyles and socio-demographic variables in a representative sample of schoolchildren and adolescents. Our results showed an

extremely high incidence of Ow/Ob, with approximately 25% of youth becoming Ow/Ob over the four-year period.

Several studies have shown an elevated prevalence of Ow/Ob among Brazilian schoolchildren and adolescents (Abrantes, Lamounier, & Colosimo, 2003; Pelegrini, Petroski, Coqueiro, & Gaya, 2008; Sune, Dias-da-Costa, Olinto, & Pattussi, 2007). Despite the variability in Ow/Ob prevalence observed in these studies, recent data from IBGE (2010) showed that approximately 30% of youth had become Ow/Ob. These data included Brazil among the countries with the highest incidence of Ow/Ob. In our study, after four years of follow-up, the prevalence of both Ow and Ob was twice that observed at baseline. Thus, studies have shown stable trends of Ow/Ob prevalence over time (Flores *et al.*, 2013; IBGE, 2010). In the United States, the prevalence of Ob among children and adolescents in 2009-2010 was 9.7%, which did not differ from the corresponding prevalence in 2007-2008 (Ogden *et al.*, 2012). We analyzed the cumulative incidence within the same population sample; these results appeared to be slightly different.

Furthermore, our results showed that the "unhealthy" CRF zone is one of the main modification variables associated with the incidence of Ow/Ob. Most of the subjects in our sample had become adolescents, were at school, and should have been active and spending much of their time engaged in moderate activity. However, recent studies have shown that in Brazil, even when physical education class was included, youth did not spend even one hour per day engaged in moderate to vigorous physical activity (Hallal, Bertoldi, Gonçalves, & Victora, 2006). In our study, youth with "unhealthy" CRF were at a higher risk of becoming Ow/Ob. This result most likely occurred because of the small amount of time spent by the youth in moderate to vigorous physical activity. In this context, the health zone of CRF was already identified as one of the main physiological responses associated with prevention and control of Ow/Ob and its consequences (Andersen *et al.*, 2008; Eisenmann, Wickel, Welk, & Blair, 2005; Katzmarzyk, Malina, & Bouchard, 1999). Several studies have demonstrated the protective effect of high degrees of CRF on early development of obesity and cardiometabolic risk (Bergmann, Bergmann, & Hallal, 2014; Martins *et al.*, 2013). Our results are consistent with this finding, as the four-year follow-up showed: youth with low degrees of CRF were at higher risk of becoming Ow/Ob.

Additionally, several characteristics of children and adolescents appear to be associated with their parents' lifestyles (Bammann *et al.*, 2013; Davison, Jurkowski, Li, Kranz, & Lawson, 2013). In addition to low degrees of CRF, our data suggest that high maternal BMI is the main predictor associated with the risk of youth becoming Ow/Ob. Recent systematic reviews and meta-analyses (including several prospective studies regarding risk factors for youth Ow during infancy) suggest that many maternal characteristics are associated with the risk of youth becoming Ow/Ob (Weng, Redsell, Swift, Yang, & Glazebrook, 2012). Included among these risk factors are the mother being Ow during pregnancy and the mother smoking during pregnancy. Thus, a combination of genetic factors and lifestyle may be associated with the early development of Ow/Ob. Furthermore, in addition to the contribution of genetics,

parents and physical education instructors should be involved in the management of this health problem. Our children became inactive as their parents, developing Ow/Ob and low degrees of CRF. Several studies have demonstrated the contribution to the health children when their parents are included in intervention programs (Davison *et al.*, 2013). Our data show that high maternal BMI increases the risk of both boys and girls becoming Ow/Ob. However, our study is limited by a lack of data regarding parental CRF and physical activity levels.

Despite the importance of controlling low degrees of CRF and high maternal BMI because of their effect on the incidence of Ow/Ob among youth, biological characteristics such as gender, age, residence zone and birth weight did not show an association with the incidence of Ow/Ob. The prevalence of males and females as well as children and adolescents who became Ow/Ob over the four-year follow-up period was similar. In addition, the prevalence of Ow/Ob was similar among youth from rural and urban areas and with low compared with extremely high birth weight and normal birth weight.

Our study also demonstrated that among male youth, Ow/Ob was associated with maternal Ob, although no association with paternal BMI was observed. In contrast, among female youth, Ow/Ob was correlated with maternal and paternal Ob. In a study in Scotland, Abu-Rmeileh *et al.* (2008) demonstrated that sons and daughters of Ob parents were five and four times, respectively, more likely to be obese than sons and daughters of parents of normal weight. Gómez-López *et al.* (2013) found that maternal BMI was associated with infant growth velocity and with subsequent adiposity, whereas paternal BMI was not associated with these phenomena. A study in North China indicated that maternal and paternal obesity were associated with child and adolescent obesity (Jiang, Yang, Guo, & Sun, 2013). In contrast, a study conducted in Mashhad, Iran, demonstrated that paternal BMI was significantly associated with BMI for male (OR: 2.02) and female (OR: 1.59) subjects but that maternal BMI was associated only with BMI for female subjects (Shafaghi *et al.*, 2014).

This study was restricted by limitations associated with the indirect measurement of both Ow/Ob and CRF, lack of evaluation of youth maturational stages, self-reported nature of parental BMI data (due to the low participation of parents in in-person meetings), and lack of data regarding parental CRF and physical activity levels. However, this investigation suggests a high incidence of Ow/Ob among youth during a four-year follow-up period. Furthermore, our data demonstrates that the stage between childhood and adolescence is an important time to initiate concentrated health intervention programs. These programs may include regular physical activity for youth and their parents, as evidenced by our data suggesting that mothers with Ow/Ob could represent a relevant risk factor for the early development of obesity among their children.

## Conclusion

Our data should sound the alarm regarding the high incidence of Ow/Ob and low levels of CRF among youth. Furthermore,

relative to other subjects, children and adolescents who exhibited low CRF levels at baseline and maintained these low CRF levels throughout the four-year follow-up period were more likely to be classified as Ow/Ob. Youth whose mothers were categorized as Ow/Ob were at a higher risk of being classified as Ow/Ob than youth whose mothers had normal BMIs. Thus, the incidence of Ow/Ob in the examined youth was associated with low CRF levels and with maternal obesity. In addition, among male youth, Ow/Ob was associated with maternal Ob; among female youth, Ow/Ob was associated with maternal and paternal Ob.

The results of our study emphasize the importance of parental characteristics in the development of Ow/Ob. These data should also encourage the engagement of youth in regular physical activity programs aimed at improving CRF, with the aim of reducing the high prevalence of Ow/Ob. Furthermore, because obesity is a multifactorial condition, we suggest that future studies should address associations among genetic and lifestyle-related characteristics of parents and their children.

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