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Original Research

The Relationship of Cardiorespiratory Fitness, Birth Weight, and Parental BMI on Adolescents' Obesity Status.

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Abstract

Background/Objectives: The aims of this study **was** (1) to analyze differences in **cardio respiratory fitness (CRF)**, parents' body mass index (BMI) and **birth weight (BW)** between **non-overweight (NOW)** and overweight/obese (OV/OB) adolescents, and (2) to investigate the association of those variables with **the risk of their biological offspring being OV/OB.**

Subjects/Methods: This study comprised 788 adolescents (477 girls and 311 boys), aged from 12-18 years old. CRF was predicted by maximal multistage 20m shuttle-run test according to procedures described **in** FITNESSGRAM. Children's BMI was classified according to International Obesity Task Force. Adolescent's BW was assessed **by** each child's pediatric record at birth. Parent's OV/OB status **was** defined and classified according to WHO. Socioeconomic status was defined **by** parental education.

Results: The prevalence OV/OB was 21.4% and 5.3 %, respectively and there were no gender differences. The OV/OB adolescents (girls and boys) had significantly ($p \leq 0.05$) lower CRF scores and higher BW ($p \leq 0.05$) than the **NOW peers**. 92.9% of OV/OB girls had one or two parents with OV/OB ($p \leq 0.05$). Boys with low CRF (OR: 3.75; $p \leq 0.05$) and high BW (OR: 1.65; $p \leq 0.05$) were more likely to be classified as OV/OB compared with **NOW**. Girls with low CRF (OR: 2.66; $p \leq 0.05$), high BW (OR: 2.09; $p \leq 0.05$) and at least one parent (OR: 2.28; $p \leq 0.05$) or two parents with OV/OB (OR: 4.39; $p \leq 0.05$, respectively) were associated with being OV/OB.

Conclusions: Results from this study **highlight association between the** family adolescents' obesity, in girls. Further our data suggested that low CRF and high BW were strong predictors of OV/OB **in** adolescence.

Keys words: Adolescents; Obesity Status; Cardiorespiratory Fitness, Birth Weight, Parental BMI

Introduction

The prevalence of childhood obesity has been rising during the past decades in many parts of the world (WHO, 2000). Previous studies have shown a high prevalence of overweight and obesity in Portuguese young children (Padez et al., 2004) and adolescents (Ribeiro et al., 2003). Because the onset of obesity lies in early childhood, it is of great importance to examine the risk trends in order that effective preventive strategies targeting those at risk start as early as possible.

The origin of obesity is complex and is influenced by genetic and environmental factors. For instance, it has been shown that obese parents offspring's **have a higher risk** of obesity due to shared genes and shared environments (Gordon-Larsen et al., 2000). Indeed, fatness tends to aggregate within families (Garn et al., 1989) as a result of relations among genetic and environmental factors (Borecki et al., 1993, Faith et al., 1997) and increases the risk that a child will become an obese adult, (Magarey et al., 2003, Lake et al., 1997) independent of fatness status in childhood (Whitaker et al., 1997).

Birth weight (BW) has also been reported as an important marker of genetic factors and intrauterine environment related with increased obesity prevalence. Some studies have demonstrated associations between fetal experiences and later risk for adult cardiovascular and other chronic diseases (Hales and Barker, 2001, Karter et al., 1999). **Conversely, Wei et al. (2007) in a recent study showed that higher BW was associated with youth obesity and diabetes.** It is also known that obesity during the pre-school years was associated with other clinical factors easily assessed at birth (Baird et al., 2005). For instance, it was found an association between BW and the risk to be obese in children at the age of 4, 8, 10 and 12 years old (Maffei et al., 1994), while a high BW was associated with higher BMI at age of 7 years (Toschke et al., 2004, Hui et al., 2008).

On the other hand, the epidemic of overweight likely involves changes in the balance between energy intake and energy expenditure. Indeed, patterns of physical activity; sedentary living and diet, appear to play an important role in long-term weight regulation (Bouchard, 2000). Besides, low physical fitness, especially low cardiorespiratory fitness (CRF) showed a significant and inverse relationship with body fatness in a large number of studies (Kim et al., 2005, Mota et al., 2006, Deforche et al., 2003). This highlights the importance of increasing

CRF for a protective effect in early ages since there are some evidences that CRF levels tracked from childhood and adolescence into adulthood (Hasselstrom et al., 2002). Persons who are physically fit maintain a more favourable caloric balance and lower body weights, both of which protect against the development of cardiovascular disease risk factors (Carnethon et al., 2003).

Despite that, the relationship of adolescence obesity with BW and CRF were not found consistently (Gibson et al., 2006), especially when parental characteristics were taken into account (McMurray et al., 2000, Francis et al., 2003).

Therefore, the aims of this study were (1) to analyze differences in CRF fitness, parents' BMI and BW between **non-overweight (NOW)** and overweight/obese (OV/OB) adolescents, and (2) to investigate the association of those variables with **the risk of their biological offspring being OV/OB.**

Methods

Participants and data collection

This is a cross-sectional study carried out in **two middle and high suburban schools** comprising **of** all the students registered **in 7th to 12th grade** during 2006/2007 academic year. A letter informing families that students will be measured was sent home two weeks before measurements took place. This study was conducted according to the guidelines of the Helsinki Declaration of Human Studies. Written given consent was required. The Portuguese Foundation for Science and Technology provided permission to conduct this study.

This study **was** comprised **of** 788 students (477 girls and 311 boys), aged 12-18 years old along with their parents. The questionnaires were distributed and filled out during physical education classes. Data collection was also **obtained** by mailing questionnaires to adolescents' parents.

Anthropometric Measures

Body height was measured to the nearest millimetre in bare or stocking feet with the adolescent standing upright against a Holtain stadiometer. Weight was measured to the nearest 0.10 kg, lightly dressed using an electronic weight scale (Seca 708 portable digital beam scale).

Body Mass Index (BMI) was calculated from the ratio of body weight (kg) to body height (m^2). For purposes of this study, participants were classified as either **NOW** or **OV/OB** based on the **International Obesity Task Force** (Cole et al., 2000). Parents' BMI was calculated from self-report weight and height and used to evaluate weight status according to WHO recommendations. BMI was divided **into** three categories: normal weight ($18.5 \text{ kg/m}^2 \geq \text{BMI} < 25 \text{ kg/m}^2$); overweight ($25 \text{ kg/m}^2 \geq \text{BMI} < 30 \text{ kg/m}^2$) and obese ($\text{BMI} \geq 30 \text{ kg/m}^2$) (WHO, 1998). Further, for the analysis of the associations between adolescents obesity with parental characteristics, parents were further divided into three groups: (1) **both parents with normal-weight**; (2) one overweight/obese parent, and (3) **both parents OV/OB**.

Adolescents' BW was assessed from each child's pediatric record at birth.

Cardiorespiratory Fitness (CRF)

CRF was measured using the 20-m shuttle run test (20mSRT) as previously described by Léger et al (1988). This test requires subjects to run back and forth between two lines set 20 m apart. Before testing, the tape was checked for accuracy. Running speed started at 8.5 km/h and increased by 0.5 km/h each minute, reaching 18.0 km/h at minute 20. Each level was announced on the tape. The participants were told to keep up with the pacer until exhausted. The test was finished when the participant failed to reach the end lines concurrent with the audio signals on two consecutive occasions. Otherwise, the test ended when the subject stopped because of fatigue. Participants were encouraged to keep running as long as possible throughout the course of the test. Numbers of shuttles performed were recorded. Participants were then classified according to the age and sex-specific cut-off points of Fitnessgram 8.0 criteria, as belonging to a healthy zone or under health zone.

Socioeconomic status

The highest school education achieved by either mother or father was used to define social class (Parental Education). Single parent families were included, and these children were classified according **to** school education of the single parent. Parental Education was defined based upon Portuguese Educational system [(1) 9 years' education or less- sub secondary

level; **(2)** 10-12 years' education-secondary level and **(3)** higher education)] and then assigned into three groups (1=Low (LE); 2= Middle (ME) and 3= High (HE) level of education, respectively). Similar procedures have been applied in the Portuguese context (Mota and Silva, 1999).

Statistics

Means and standard deviations were calculated to describe participants' characteristics by **gender** and obesity status. The comparisons between **genders** and obesity status **were** done by independent t-test for anthropometric variables and **chi-square test for BMI categories**, CRF, parental BMI and parental education. For both genders, the independent association of predictors with BMI as dependent variable (**Non-Overweight** and Overweight/Obese) was examined using stepwise logistic regression analysis with age, birth weight, parental obesity status and parental education as independent variables. Statistical analysis was performed using SPSS 15 software (SPSS Inc., Chicago, IL, USA) and Microsoft Excel 2000. The level of significance was set at $p \leq 0.05$.

Results

Table 1 shows descriptive statistics (mean and SD) of adolescents and parents by **gender**. Boys were taller, heavier, **had higher BW and CRF than girls** ($p \leq 0.05$), while girls were older. No statistical significant differences were found with **regard to the BMI**. The overall prevalence of overweight and obesity was 21.4% and 5.3 %, respectively. No statistical significant differences between genders were found. A higher ($p \leq 0.05$) proportion of girls (49.9%) were classified as unfit than boys (35.7%) were. **Fifty three percent of fathers were classified as overweight while 15% were classified as obese**. For mothers the numbers were **36.6%** for overweight and **13.4%** for obese, respectively.

Insert Table 1

Table 2 shows differences within genders according to obesity status for the variables under study. Regardless **of** gender the OV/OB group was significantly heavier, **had higher BMI**

and BW and had both parents with high BMI values than their NOW peers. CRF values (**numbers of laps**) were significantly lower in OV/OB than in **NOW group**. A statistically higher ($p \leq 0.05$) proportion of OV/OB girls (61.4%) and boys (54.8%) were assigned to the under health zone (unfit) compared to their lean counterparts. Parental BMI differed between **NOW** and OV/OB only in girls ($p \leq 0.05$). No statistical significant differences were found regarding parental education.

Insert Table 2

Stepwise logistic regression analysis (Figure 1) showed that boys with low CRF (OR: 3.75; CI: 2.14-6.59; $p \leq 0.05$) and high BW (OR: 1.65; CI: 1.02-2.67; $p \leq 0.05$) were more likely to be classified as OV/OB compared with **NOW** peers. Girls with low CRF (OR: 2.66; CI: 1.64-4.32; $p \leq 0.05$), high BW (OR: 2.09; CI: 1.36-3.24; $p \leq 0.05$) **and with at least one parent** with OV/OB (OR: 2.28; CI: 1.05-4.95; $p \leq 0.05$) or two parents with OV/OB (OR: 4.39; CI: 1.99-9.64; $p \leq 0.05$) were more likely to be classified as OV/OB compared with **NOW** peers.

Insert Figure 1

Discussion

This paper examined the association between CRF and obesity status in adolescents taking into account BW, parental BMI and education. Prevalence of overweight and obesity in the present study was 21.4% and 5.3% **for the whole samples**. Although participants were not country representative, the prevalence of overweight and obesity was similar to values reported in other samples of Portuguese youth (Ribeiro et al., 2003, Padez et al., 2004). This prevalence values found in our study must be highlighted because our data also showed that the percentage of OV/OB adolescents at risk of CRF (under health zone) was significantly higher ($p \leq 0.05$) compared to NOW peers. Although the overall percentage of adolescents at risk for CRF **is in line with the one described in Irish adolescents** (Boreham et al., 1993) and **our data agreed with another study** showing that boys **reached the CRF** health zones criterion than girls (Riddoch et al., 2004). **Our** results might have some importance from a preventive

point of view because they potentially pointed out some future health negative implications. Indeed, there are evidences showing that low levels of CRF associated with excess body fat and sedentary daily life are significant predictors of developing heart disease (Janssen et al., 2005) as **well as suggesting the health impact** of small increases in youth with lower fitness levels (Klasson-Heggebo et al., 2006). Thus, since **tracking obesity** (Dietz, 2004, Guo et al., 2002) and CRF (Janz and Mahoney, 1997, Twisk et al., 2000) from childhood to adulthood has been described and a secular decreasing **trend of CRF has also been found** (Martins et al., 2008). Our findings raised concerns with regard **to** those whom are classified as OV/OB and unfit, **which has already been pointed out previously** (Pate et al., 2006).

Furthermore, the major finding of this study was that parent obesity was a strong predictor of adolescents OV/OB girls and not in boys. Although some studies showed an association between parents' obesity level and their offspring obesity status (Whitaker et al., 1997, Maffei et al., 1998, Treuth et al., 2003), our data highlighted the association of parents' BMI and their daughter. **This has already been suggested in another** survey showing that the number of overweight parents predicted fat gain among normal weight girls (Treuth et al., 2003). Furthermore our data clearly showed that association was even stronger when obesity was found in both, rather than in only one parent, which agrees with other studies (Davison and Birch, 2001, Herbert et al., 2006). For instance, having an obese mother was associated with earlier age at obesity onset (Gordon-Larsen et al., 2007). This is particularly worthy because some data suggested that an overweight child living in a family where one or more parents are overweight is likely to remain overweight throughout his or her childhood and into adolescence and adulthood (Magarey et al., 2003). Therefore our data suggested that adolescents' BMI status in girls, but not in boys, is likely to reflect the fact that childhood overweight/obesity occurs within a **family context**, in which environmental factors besides genetic factors played an important role. Thus, our data suggests, the need of taking the **family environment** into consideration when designing intervention programs, especially in girls.

Several studies have addressed the association between BW and late development of cardiovascular diseases (Karter et al., 1999, Wei et al., 2007) and obesity (Stettler et al., 2002). Our data demonstrated that high BW girls had two times higher odds of being OW/OB, while boys had 1.65 times higher odds of being classified as **OW/OB**, which is consistent with other

studies showing a positive association between BW and further prevalence of obesity in both children and adolescents (Curhan et al., 1996, Dubois and Girard, 2006, Wei et al., 2007). Therefore, our data showed **that regardless of gender high BW was a strong predictor of being OV/OB in adolescence and, thus, strategy options should be taken into consideration with regard to the intrauterine factors.**

Strengths of this study included the large sample size and response rate of parents as well as measures of **socioeconomic status**. This study has also some limitations that should be acknowledged. First, our parental BMI are based on self-report data, which could indicate an underestimation of the true prevalence of overweight and obesity (Yun et al., 2006). Nevertheless, BMI from self-report data was found to be sufficiently accurate and widely used in epidemiological studies, **on the other hand objective measurements of weight and height in large samples can be difficult and unattainable**. Second, dietary factors weren't assessed and it is well **known** the influence of diet on energy regulation. Further studies should also consider the nutritional factors that might be related to obesity.

Conclusion

Results from this study **highlight association between the** family adolescents' obesity, in girls. Further our data suggested that low CRF and high BW were strong predictors of OV/OB **in** adolescence.

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Conflict of Interest

The authors declare no conflict of interest.

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Figure 1 - Prevalence of Overweight and Obesity by stepwise multiple logistic regression analysis in each gender.

Table 1 – Sample Characteristics

Characteristics		Total (n=788)	Girls (n=477)	Boys (n=311)	p
Age (years)		15.08±1.87	15.24±1.74	14.82±2.02	0.003
Weight (kg)		59.60±11.79	57.96±9.91	62.10±13.84	0.000
Height (m ²)		1.65±0.09	1.62±0.07	1.69±0.10	0.000
BMI (kg/m ²)		21.93±3.47	22.10±3.36	21.66±3.63	ns
Birthweight (BW) (kg)		3.31±0.55	3.25±0.52	3.39±0.59	0.001
Cardiorespiratory Fitness (CRF) (laps)		41.28±20.22	31.34±12.12	56.52±20.66	0.000
Father BMI (kg/m ²)		26.64±3.33	26.59±3.32	26.71±3.36	ns
Mother BMI (kg/m ²)		25.59±3.95	25.81±4.00	25.26±3.85	ns
BMI (%)	Normal Weight	73.2	73.4	73	ns
	Overweight	21.4	21.2	21.9	
	Obese	5.3	5.5	5.1	
CRF (%)	Under Health Zone	44.3	49.9	35.7	p≤0.05
	Health Zone and Above	55.7	50.1	64.3	
P-BMI (%)	Two parents with Normal Weight	31.5	32.4	30	ns
	At least one parent with OV/OB	53.7	53.6	53.9	
	Two parents with OV/OB	14.8	14	16	
P-Edu (%)	Low Education	57.0	58.9	54.0	ns
	Middle Education	23.7	23.3	24.4	
	High Education	19.3	17.8	21.5	

BMI – Body Mass Index; CRF – Cardiorespiratory Fitness; P-BMI – Parental BMI; P-Edu – Parental Education; OV/OB – Overweight/Obese

ns - $p > 0.05$

Table 2 – Mean and SD of adolescents and parents characteristics by BMI category within each sex

Characteristics	Girls			Boys		
	Normal Weight (n=350)	Overweight/Obese (n=127)	p	Normal Weight (n=227)	Overweight/Obese (n=84)	p
Age (years)	15.32±1.71	15.04±1.81	ns	15.04±1.96	14.25±2.10	0.002
Weight (kg)	54.05±7.05	68.74±8.59	0.000	58.18±10.56	72.71±15.98	0.000
Height (m ²)	1.62±0.07	1.61±0.07	ns	1.69±0.11	1.67±0.09	ns
BMI (kg/m ²)	20.53±1.89	26.43±2.62	0.000	20.15±2.00	25.75±3.89	0.000
Birthweight (BW) (kg)	3.20±0.51	3.40±0.52	0.000	3.35±0.56	3.50±0.63	0.046
Cardiorespiratory Fitness (CRF) (laps)	32.80±12.00	27.31±11.59	0.000	60.88±20.05	44.76±17.54	0.000
Father BMI (kg/m ²)	26.25±3.12	27.54±3.65	0.000	26.25±3.25	28.02±3.36	0.000
Mother BMI (kg/m ²)	25.18±3.64	27.57±4.41	0.000	24.99±3.64	25.96±4.31	0.050
CRF (%)	Under Health Zone	61.4	p≤0.05	28.6	54.8	p≤0.05
	Health Zone and Above	45.7		71.4	45.2	
P-BMI (%)	Two parents with Normal Weight	7.1	p≤0.05	21.4	12.7	ns
	At least one parent with OV/OB	46.5		45.0	49.4	
	Two parents with OV/OB	28.3		33.6	38.0	
P-Edu (%)	Low Education	59.1	ns	54.6	52.4	ns
	Middle Education	22.3		22.5	29.8	
	High Education	18.9		22.9	17.9	

BMI – Body Mass Index; LBW – Low Birth Weight; NBW – Normal Birth Weight; HBW - High Birth Weight; PBMI – Parental BMI

ns - $p>0.05$

