

Influence of Cardiorespiratory Fitness and Parental Lifestyle on Adolescents' Abdominal Obesity

Susana Vale¹ Luísa Soares-Miranda¹ Rute Santos^{1,2} Carla Moreira¹ Ana Isabel Marques¹ Paula Santos^{1,3} Laetitia Teixeira⁴ Jorge Mota¹

¹Research Centre in Physical Activity Health and Leisure. Faculty of Sport Sciences - University of Porto

²Maia Higher School Education - Porto

³School of Health Technology of Porto – Institute Polytechnic of Porto

⁴Research and Training Centre in Adult and Elderly - Institute of Biomedical Sciences Abel Salazar. University of Porto

Aim: The aims of this study were (1) to analyze the influence of cardiorespiratory fitness (CRF) and parent's overweight status (POS) and socioeconomic status (SES) on abdominal obesity.

Subjects and methods: This study comprised of 779 adolescents (12 to 18 years). Waist-height ratio (WHtR), 20m shuttle-run test to ascertain CRF, POS according to World Health Organisation recommendations and SES of parents using level of education were analysed.

Results: Using WHtR, the prevalence of abdominal obesity was 21.3% (23.5% girls and 17.9% boys; $p=0.062$). Regardless of gender, participants who belonged to the WHtR risk group had significantly ($p\leq 0.05$) lower CRF scores than the WHtR non-risk group. 84.4% of girls who belonged to the WHtR risk group had one or two overweight parents ($p\leq 0.05$). Boys with low CRF (OR: 6.43; CI: 3.33 - 12.39) were more likely to belong to the WHtR risk group compared with their lean peers. Girls with low CRF (OR: 1.78; CI: 1.14 - 2.78) and with at least one overweight parent (OR: 2.50; CI: 1.07 - 5.85) or two overweight parents (OR: 4.90; CI: 2.08-11.54) were associated with the risk of abdominal obesity.

Conclusion: This study highlights the influence of adolescents' family on abdominal obesity, especially in girls. Further, our data suggested that low CRF was a strong predictor of risk values of abdominal obesity in adolescence.

During recent decades prevalence of childhood obesity has been rising in many parts of the world (WHO 2000). A recent national report showed a high prevalence of overweight and obesity in Portuguese youngsters (Sardinha et al. 2010). While childhood obesity is associated with increased risk of chronic disease in adulthood (Ortega et al. 2008), there is also evidence showing that obese children may experience more illness and health related problems in childhood (Wijga et al. 2010). In this context, as 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 can 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 the offspring of obese parents have a risk of obesity due to shared genes and shared environment (Harrap et al. 2000). However, most studies focusing on the relationship of parental obesity (BMI) with the obesity status of their offspring have provided some contradictory findings (Davey Smith et al. 2007, Kivimaki et al. 2007, Li et al. 2009). Within obesity status, abdominal obesity, a status of excessive accumulation of both central subcutaneous and visceral fat, has emerged as a main predictor for metabolic complications and adverse health effects in both adults (Sardinha L. B. et al. 2000) and youth (Rizzo et al. 2007, Teixeira et al. 2001). Additionally, obesity has been linked to low physical fitness, especially low cardiorespiratory fitness (CRF). Indeed, a large number of studies have shown a significant and inverse relationship between CRF and body fatness (Deforche et al. 2003, Kim et al. 2005, Mota et al. 2006). Lower CRF has been especially negatively and consistently associated with total and central body fat in adolescents (Moliner-Urdiales et al. 2009). Indeed, those who are physically fit maintain a more favourable caloric balance and lower body weight, both of which protect against the development of cardiovascular disease risk factors (Carnethon et al. 2003).

Thus, this study set out to (1) to analyze the differences in CRF and parent's overweight status between different waist-height ratio (WHtR) categories and (2) to determine the association between CRF and both maternal and parent's overweight status with WHtR risk group (abdominal obesity) of their offspring.

Methods

Participants and data collection -This is a cross-sectional study carried out in middle and high suburban schools comprising all the students registered in 7th to 12th grade during the 2006/2007 academic year. The sample used in this study comprised 779 students (472 girls and 307 boys), aged 12-18 years old along with their parents. A letter informing families that students would be measured was sent home two weeks before measurements took place and written given consent was required. This study was conducted according to the guidelines of the Helsinki Declaration of Human Studies. The Portuguese Foundation for Science and Technology provided permission to conduct this study.

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 (m²).

The parents' body mass index was calculated from self-report weight and height and used to evaluate overweight status according to World Health Organisation (WHO) recommendations. First, parent's overweight status was divided into two categories: normal weight ($18.5 \text{ kg/m}^2 \geq \text{BMI} < 25 \text{ kg/m}^2$) and overweight ($\text{BMI} \geq 25 \text{ kg/m}^2$) (WHO 1998). Given the analysis of the associations between adolescents and parental characteristics, parents were further divided into three groups: (1) both normal-weight parents; (2) at least one overweight parent, and (3) both overweight parents.

Waist circumference measurement was taken in a standing position, to the nearest 0.1 cm, with a tape measure midway between the lower rib margin and the anterior superior iliac spine at the end of normal expiration (Lohman et al. 1988). We then calculated waist-height ratio (WHtR) as the ratio of waist (cm) and height (cm), which has been used as an effective, surrogate measure of abdominal obesity and may be good predictor of cardiovascular disease risk in children (Adegboye et al. 2010). A WHtR cutoff of 0.5 has been used to define abdominal obesity for 6- to 19-year-old boys and girls (McCarthy and Ashwell 2006). Thus, for purposes of the analyses we defined two categories; the non risk group (WHtR <0.5cm) and at risk group (WHtR ≥ 0.5 cm).

Cardiorespiratory Fitness (CRF)

CRF was predicted by maximal multistage 20m shuttle-run test according to procedures described in FITNESSGRAM (FITNESSGRAM 1999). FITNESSGRAM was selected because it is easy to administer to large numbers of subjects, and in addition it incorporates a choice of reliable and valid health-related physical fitness measures (FITNESSGRAM 1999). The Shuttle Run Test predicts maximal aerobic capacity and showed significant correlation with VO₂max ($r=0.80$) suggesting that it could be used as a measure of aerobic fitness in children (Vincent et al. 1999). Students were familiarized with the procedure for each test before recording data. Furthermore, the participants received verbal encouragements from the investigators in order to achieve maximum performance. The result was recorded as laps taken to complete the 20m shuttle-run test. Children were then classified according to the age and sex-specific cut-off points of FITNESSGRAM 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 socioeconomic status (SES). Single parent families were included, and these children were classified according to school education of the single parent. SES was defined based upon the 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 (LSES); 2= Middle (MSES) and 3= High (HSES) level of education, respectively. Similar procedures have been applied in the Portuguese context (Mota and Silva 1999).

Statistical Analysis

Means and standard deviations were calculated to describe participants' characteristics by sex and WHtR categories. The comparisons between sex categories were done by independent t-test for quantitative variables and chi-square test for qualitative variables (WHtR, CRF, parental overweight status and SES). For both genders, the independent association of predictors with WHtR as dependent variable (non-risk vs. risk) was examined using logistic regression analysis with parental overweight status, SES and CRF as independent variables. Statistical analysis was performed using SPSS 17 software (SPSS Inc., Chicago, IL, USA) and Microsoft Excel 2000. The level of significance was set at $p \leq 0.05$.

Results

Table 1 and 2 show descriptive statistics (mean and SD) of adolescents and parents by sex and WHtR categories, respectively. Boys were taller, heavier and had higher CRF values than girls ($p \leq 0.05$), while girls had higher WHtR. Using WHtR, the prevalence of abdominal obesity was 21.3% (23.5% for girls and 17.9% for boys, respectively). Regardless of gender, participants within WHtR risk group had significantly ($p \leq 0.05$) lower CRF scores than their non-risk peers. In 45 percent (44.6%) of the families, at least one parent was overweight, while 33 percent had two overweight parents. Only 22 percent of families were headed by two normal-weight parents. Girls but not boys, belonging to WHtR risk group had significantly ($p \leq 0.05$) two overweight parents.

Insert Table 1

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Logistic regression analysis (Figure 1) showed that boys with low CRF (OR: 6.43; CI: 3.33 - 12.39; $p \leq 0.05$) were more likely to be at risk of abdominal obesity than their fit peers. Girls with low CRF (OR: 1.78; CI: 1.14-2.78; $p \leq 0.05$), and having at least one overweight parent (OR: 2.50; CI: 1.07-5.85; $p \leq 0.05$) or having both overweight parents (OR: 4.90; CI: 2.08-11.54; $p \leq 0.05$) were more likely to be associated with the risk of abdominal obesity.

Insert Figure 1

Discussion

This paper examined the association between CRF and abdominal obesity status in adolescents taking into account parents' overweight status and education (SES). The main finding of this study was that low CRF was a strong predictor of a higher risk of abdominal obesity in adolescence and that having two overweight parents may substantially raise the girls', but not the boys' risk of abdominal obesity.

Our data gave additional information and support with regard to the association between low CRF and abdominal obesity in both boys and girls. Our data agreed with several findings showing an inverse and significant association between CRF and adiposity in youngsters (Kim et al. 2005, Moliner-Urdiales et al. 2009). Given the fact that central obesity has been linked to metabolic and cardiovascular disease even in childhood (Rizzo et al. 2007, Teixeira et al. 2001), our data highlighted the importance of increasing CRF as a protective effect at an early age since there is some evidence that CRF levels track from childhood and adolescence into adulthood (Hasselstrom et al. 2002).

Furthermore, our data showed an interesting finding regarding the differing association between parental overweight status and their offspring's abdominal obesity expression in terms of gender. Thus, our data are worthy of analysis with regard to gender-related differences in parental-related offspring overweight influence. The present study showed those girls who had at least one overweight parent or both overweight parents were respectively, 2.9 and 4.9 times more likely to be in the at WHtR risk group than those with two normal-weight parents. In this context, our data partially agreed with other studies showing that both maternal and paternal BMI are associated with total and central adiposity in offspring (Davey Smith et al. 2007, Kivimaki et al. 2007, Labayen et al. 2010). However, on the other hand, we found that the parental-offspring overweight status influence was only statistically significant for girls.

Thus, our data raised some additional questions regarding the etiology of intergenerational obesity. Indeed to the best of our knowledge this is one of the few studies showing different

parental influence patterns with regard to their offspring's gender. Findings from longitudinal studies have indicated that although there is evidence that patterns of lifestyle factors related to obesity often co-occur within families, these parents-descendants fatness associations may reflect a combined influence of both genetic and lifestyle factors (Labayen et al. 2010). Our study design did not allow an analysis from a genetic point of view. However, some studies have suggested that maternal BMI may be more strongly associated with offspring BMI than paternal BMI (Kivimaki et al. 2007, Lawlor et al. 2007, Whitaker et al. 2010). Other recent data have shown that both parents influence the fetal environment, and both can contribute to intergenerational increase in obesity (Abu-Amero et al. 2006). Therefore, while genetic variables are outside the scope of this paper we can assume that environmental and lifestyle factors within families may play a stronger role (Perez-Pastor et al. 2009). Previous studies have looked at the sex-specific effects between parents and their offspring, although the results have been contradictory. Some have shown youth obesity to be confined to those whose same-sex parents are obese (Perez-Pastor et al. 2009), while others have shown that maternal BMI was more strongly associated with female than with male offspring BMI but paternal associations were similar for both gender (Leary et al. 2010). Furthermore, it is also possible that influences in the postnatal life interact with the child's prenatally defined susceptibility (Cole et al. 2008). The findings of the present study agree with other data suggesting that overweight parents predicted fat gain among normal weight girls (Treuth et al. 2003). Our results may have some importance from a preventive point of view because they potentially point out some future negative health implications. Indeed, while there is evidence 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); the health impact of small increases in youth with lower fitness levels has also been suggested (Klasson-Heggebo et al. 2006). Despite, the tracking of obesity (Dietz 2004, Guo et al. 2002) and CRF (Janz and Mahoney 1997, Twisk et al. 2000), coupled with the decreasing trend of CRF (Martins et al. 2008) which have already been described, our findings raised concerns with regard to further social strategies at both national and community level that need to account for the family role in children and youth obesity prevention, especially in girls.

Some limitation should be recognized. The present study relied on the use of reported measures of both maternal and paternal body mass index (weight/height*height) when their offspring were recruited. Nevertheless, studies related to measured weight and height suggest that reporting, especially in young adults (Kuczmarski et al. 2001) is generally accurate, with no evidence of substantial sex related differences (Bolton-Smith et al. 2000). Furthermore, we cannot draw any conclusion regarding how much of the relationship between parental overweight and WHtR risk is due to genetic or environmental factors or to an interaction between them. Our study has as an advantage in that we used a relatively large sample and included several potential confounders.

Conclusion

Results from this study highlighted the influence of adolescents' families on abdominal obesity, especially in girls. Further, our data suggested that low CRF was a strong predictor of risk values of abdominal obesity in adolescence.

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Table 1 – Sample Characteristics

Characteristics	Total (n=779)	Girls (n=472)	Boys (n=307)	p	
Age (years)	15.07±1.86	15,22±1.74	14.84±2.01	0.006	
Weight (kg)	59.64±11.76	57.95±9.87	62.23±13.80	0.000	
Height (m ²)	1.65±0,09	1.61±0.07	1.68±0.10	0.000	
Body Mass Index (BMI) (kg/m ²)	21.93±3.47	22.10±3.35	21.68±3.64	0.099	
Waist/height Ratio (WHtR) (cm)	0.46±0.05	0.47±0.05	0.46±0.06	0.017	
Cardiorespiratory Fitness (CRF) (laps)	41.31±20.20	31.37±12.09	56.59±20.63	0.000	
Father BMI (kg/m ²)	26.64±3.34	26.60±3.32	26.71±3.38	0.666	
Mother BMI (kg/m ²)	25.58±3.94	25.78±3.99	25.26±3.84	0.072	
WHtR (%)	<0.5	78.7	76.5	82.1	0.062
	>0.5	21.3	23.5	17.9	
CRF (%)	Under Health Zone	44.3	49.8	35.8	0.000
	Health Zone and Above	55.7	50.2	64.2	
POS (%)	Both normal weight parents	18.2	15.7	22.1	0.051
	At least one overweight parent	48.7	51.3	44.6	
	Both overweight parents	33.1	33.1	33.2	
SES (%)	Low SES	56.9	58.7	54.1	0.374
	Middle SES	23.7	23.3	24.4	
	High SES	19.4	18	21.5	

WHtR - Waist/height Ratio ; CRF – cardiorespiratory fitness; POS – parental overweight status; SES – socioeconomic status; ns - $p>0.05$

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

Characteristics	Girls			Boys			
	WHtR <0.5 (n=361)	WHtR >0.5 (n=111)	<i>p</i>	WHtR <0.5 (n=252)	WHtR >0.5 (n=55)	<i>p</i>	
Age (years)	15.23±1.72	15.21±1.82	0.904	15.00±1.91	14.07±2.31	0.007	
Weight (kg)	55.26±8.16	66.70±9.93	0.000	59.89±10.48	72.95±20.66	0.000	
Height (m ²)	1.62±0.07	1.60±0.07	0.003	1.70±0.10	1.65±0.12	0.014	
BMI (kg/m ²)	20.92±2.37	25.95±3.21	0.000	20.69±2.34	26.19±4.90	0.000	
Waist/height Ratio (WHtR) (cm)	0.44±0.03	0.54±0.04	0.000	0.44±0.03	0.55±0.06	0.000	
Cardiorespiratory Fitness (CRF) (laps)	32.61±12.50	27.34±9.64	0.000	60.83±19.26	37.15±14.81	0.000	
Father BMI (kg/m ²)	26.37±3.16	27.35±3.70	0.006	26.36±3.24	28.30±3.59	0.000	
Mother BMI (kg/m ²)	25.24±3.60	27.59±4.64	0.000	25.06±3.70	26.20±4.37	0.046	
CRF (%)	Under Health Zone	46.3	61.3	0.006	28.2	70.9	0.000
	Health Zone and Above	53.7	38.7		71.8	29.1	
POS (%)	Both normal weight parents	18.6	6.3	0.000	23.8	14.5	0.261
	At least one overweight parent	53.2	45		44.4	45.5	
SES (%)	Both overweight parents	28.3	48.6	0.369	31.7	40	0.753
	Low SES	57.6	62.2		54	54.5	
	Middle SES	23	24.3		23.8	27.3	
	High SES	19.4	13.5	22.2	18.2		

WHtR - waist/height Ratio ; CRF – cardiorespiratory fitness; POS – parental overweight status; ns - *p*>0.05

Figure 1 - Logistic Regression Analysis

