Abstract

Based on data from a three-year longitudinal study, we assess the effect, according to gender, of emotional psychopathology in preadolescence on anthropometric and body composition parameters in adolescence (N=229). Psychopathology was assessed using the *Screen for Childhood Anxiety and Related Emotional Disorders*, the *Children's Depression Inventory* and the *MINI-International Neuropsychiatric Interview for Kids*. Body fat percentage (%BF), waist circumference (WC) and body mass index (BMI) were also determined. Following analysis with adjusted multiple regression models, the results indicated that symptoms of depression and separation anxiety were significantly associated with increased WC and BMI in boys, and that somatic symptoms were associated with increased WC and %BF in girls. Diagnosis of social phobia, panic disorder or dysthymia led to significantly increased WC and/or BMI in boys and dysthymia increased WC in girls. These findings suggest that emotional psychopathology in preadolescence is associated with increased weight gain and abdominal fat in adolescence.

Keywords: *depression, anxiety, weight gain, waist circumference, longitudinal study.*

Abbreviations: %BF, body fat percentage; WC, waist circumference; BMI, body mass index.

Emotional Psychopathology and Increased Adiposity:

Follow-up study in adolescents

Overweight and obesity now affect 9-36 % of the child and adolescent population in several developed and developing countries (Grupta, Goel, Shah & Misra, 2012; Lobstein & Frelut, 2003; Ogden, Carroll, Kit & Flegal, 2012; Valdes & Royo-Bordonada, 2012). This pathology is associated with serious complications in childhood and adolescence and increased morbidity and mortality in adulthood. Overweight and obese children are also at risk of obesity in adulthood (Deckelbaum & Williams, 2001). Moreover, obesity is a chronic disease with a complex multifactorial nature. Numerous genetic and environmental factors have been found to contribute to the recent epidemic of obesity. Among these risk factors, psychological factors warrant particular attention.

Emotional psychopathology includes some of the most common psychiatric disorders among children and adolescents, such as depression or anxiety disorders (Costello, Mustillo, Erkanli, Keeler & Angold, 2003; Esbjorn, Hoeyer, Dyrborg, Leth & Kendall, 2010). In adolescence, anxiety disorders are the most prevalent condition (31.4%), followed in third place by mood disorders (14.3%) (Merikangas et al., 2010). In Spain, symptoms of depression and anxiety affect 9% and 47%, respectively, of the school population (Canals, Marti-Henneberg, Fernández-Ballart & Domenech, 1995; Romero, Canals, Hernández-Martínez, Jané & Domenech-Llaberia, 2010). Emotional psychopathology often shows comorbidity with other psychological disorders and is related to other childhood complications such as physical dysfunction, substance abuse, suicide attempts and hospitalization. Furthermore, anxiety and depression in childhood may predict adult depression and anxiety disorders (Bittner et al., 2007; Canals, Domenech-Llaberia, Fernandez-Ballart & Martí-Henneberg, 2002; Kendall, Flannery-Schroeder & Webb, 2004).

Therefore, obesity and emotional psychopathology have become critical public health problems.

Abbreviations: %BF, body fat percentage; WC, waist circumference; BMI, body mass index; BIA, bioelectrical impedance; CDI, Children's Depression Inventory; SCARED, Screen for Childhood Anxiety and Related Emotional Disorders; MINI-KID, .Mini-International Neuropsychiatric Interview for Kids.

The relationship between emotional psychopathology and obesity is the subject of considerable debate, both in adults (Ahlberg et al., 2002; Carpenter, Hasin, Allison & Faith, 2000; Garepy, Nitka & Schmitz, 2010; Hach, Ruhl, Klotsche, Klose, & Jacobi, 2006; Needham, Epel, Adler & Kiefer, 2010; Williams et al., 2009; Zhao et al., 2011) and in children and adolescents (Anderson et al., 2010; Duarte et al., 2010; Hillman, Dorn & Bin, 2010; Goodman & Whitaker, 2002; Midei & Matthews, 2009; Rhew et al., 2008; Rofey et al., 2009; Tanofsky-Kraff et al., 2006). It has been suggested that early depression and/or anxiety may be predictive of obesity in adolescence (Anderson et al., 2010; Goodman & Whitaker, 2002; Hillman et al., 2010; Rofey et al., 2009) and in adulthood (Anderson, Cohne, Naumova, & Must, 2006; Vamosi, Heitman, & Kyvik, 2010). However, other authors have not observed this relationship (Duarte et al., 2010; Midei & Matthews, 2009; Rhew et al., 2008; Tanofsky-Kraff et al., 2006). Anderson et al. (2006) studied a community-based US cohort from childhood to adulthood and reported that anxiety and depression disorders were associated with higher weight status in females, whereas in males, depression was associated with lower BMI and childhood anxiety was not substantively associated with weight status. Similarly, among white adolescent girls studied over a two-year follow-up period, depression was related to a higher likelihood of obesity (Anderson et al., 2010). Goodman & Whitaker (2002) found that North American adolescents with symptoms of depression showed risk of obesity at 1-year follow-up in both genders. By contrast, among adolescents studied over a one-year follow-up period using height and weight measurements, depression was not associated with BMI in either gender (Rhew et al., 2008). According to a recent review, the relationship between psychological factors and obesity in children and adolescents has not been confirmed (Incledon, Wake & Hay, 2011).

Although body mass index (BMI) is the most common measurement of overweight, methods measuring excess fat and its abdominal distribution allow us to study more important cardiovascular risk factors. However, few pediatric studies examining the relationship between psychopathology and obesity have applied these methods (Hillman et al., 2010; Midei & Matthews, 2009; Tanofsky et al., 2006).

The transition from childhood to adolescence is a critical period involving both psychological and physical maturation, and as such various symptoms and changes in body composition may be presented. Gender and age are key modulators of emotional psychopathology and obesity. On the one hand, girls are found to experience more emotional problems in adolescence than boys (Canals et al., 1995; Canals et al., 2002; Conley, Rudolph & Bryant, 2012; Moksnes, Espnes & Lillefjell, 2011); however, there is also evidence that overweight and obesity have become more prevalent in males during puberty (Serra et al., 2003).

To date, there have been few longitudinal studies in adolescents that examine the influence of depression and anxiety on adiposity according to gender. Furthermore, none of the studies carried out has used an accurate methodology to assess adiposity in a non-clinical adolescent population.

Given the limitations of current knowledge, we decided to assess the effect, according to gender, of emotional psychopathology in preadolescence on anthropometric and body composition parameters in adolescence. We hypothesized that emotional psychopathology at baseline would contribute significantly to adiposity gain at three-year follow-up in adolescents, and that this relationship would be different between males and females.

Methods

Sample and study design

A three-year longitudinal study was conducted of 229 schoolchildren of preadolescent to adolescent age. The participants were recruited from a three-phase epidemiological study of anxiety and depression disorders that was begun in 2007 in the town of Reus (Catalonia, Spain).

The baseline sample in the study was a group of 1514 schoolchildren (720 boys and 794 girls) with a mean age of 10.2 years old (SD=.9) from 13 schools randomly chosen from the town's state schools and state-subsidized private schools. Screening questionnaires for anxiety and depression were used to select a sample at risk of emotional problems and a risk-free control sample. A child was considered to be at risk of emotional psychopathology if he/she had a score equal to or greater than 25 on the Screen for Children's Anxiety Related Emotional Disorders (SCARED; Birmaher et al., 1997)

and/or a score equal to or greater than 17 on Kovacs' (1985) Children's Depression Inventory (CDI). For the control group, one child without risk of emotional psychopathology (SCARED score below 25 and CDI score below 17) was selected for every three children at risk of emotional psychopathology, matching for age, gender and type of school. Therefore, in the second phase, the participants were 562 children (254 boys and 308 girls), of which 405 were at risk of an emotional disorder (235 at risk of anxiety disorder and 170 at risk of depressive disorder) and 157 were controls. The mean age was 11.2 years old (SD=1.0) (Romero et al., 2010; Vigil et al., 2009). At the follow-up three years after the baseline, all second-phase subjects were contacted. 245 adolescents (147 girls and 98 boys) agreed to participate, with a mean age of 13.5 years (SD=.9). Sixteen subjects were excluded due to a lack of data. Therefore, in this paper we examine the subjects who participated in all three phases of the study. There were no psychopathological, baseline anthropometric and body composition differences three-phase participants and those who withdrew.

Procedure

At baseline, in the first phase, we assessed the presence of anxiety and depressive symptoms and recorded anthropometric, body composition, socio-demographic and body satisfaction data. One year later, in the second phase, we individually evaluated the presence or absence of a diagnosis of anxiety or depression disorder. In the third stage, we recorded anthropometric and body composition parameters and administered questionnaires on dietary quality and physical activity.

The project was approved by the Rovira i Virgili University ethics committee for research on individuals and received permission from the Ministry of Education of the Government of Catalonia. The board of governors of each school was subsequently asked to participate in the first and second phases, and informed consent was requested from the parents of the preadolescent and adolescent subjects participating in the third phase.

Measures

Demographic and sociocultural data. Sociocultural level was calculated according to parents' professions, using the Hollingshead index (Hollingshead, 2011).

Emotional psychopathology.

Screen for Childhood Anxiety and Related Emotional Disorders (SCARED). (Birmaher et al., 1997). This is a 41-item questionnaire used in the pediatric population to screen for anxiety symptoms. The questionnaire was designed from clinical studies of the anxiety disorders in the DSM-IV-TR. We used the validated Spanish version (Vigil et al., 2009), which considers four factors in the factorial analysis: somatic/panic, social phobia, generalized anxiety and separation anxiety. It has good levels of reliability (overall Cronbach's alpha of .86, and by factors: panic/somatic, alpha .78; social phobia, alpha .69; generalized anxiety, alpha .69; and separation anxiety, alpha .70). A score of 25 has been considered the cut-off point for risk of anxiety (Birmaher et al., 1997; Canals, Hernández-Martínez, Cosí & Domènech, 2012).

Children's Depression Inventory (CDI). (Kovacs, 1985). This is a 27-item questionnaire for people aged 7-17 years old. It assesses depressive symptoms in the cognitive, affective and behavioral spheres. The Spanish version has good internal consistency and good test-retest reliability (Cronbach's alpha between .70 and .94). We used a score of 17 as the cut-off point for depressive symptoms (Kovacs, Barrio & Carrasco, 2004).

Personal interview. MINI International Neuropsychiatric Interview for Kids (MINI-Kid). (Sheehan et al., 1998). This is a structured diagnostic interview for children aged 6-17 years old, based on DSM-IV and ICD-10 criteria. The MINI-Kid is organized into diagnosis sections. All questions have a binary response format (yes/no). The administration time is approximately 30 minutes. The reliability and validity of this interview have been demonstrated in a recent study (Sheehan et al., 2010). Mood disorders and anxiety disorders present good psychometric properties (AUC=.81, k=.56, sensitivity=.85, specificity=.76; and AUC=.84, k=.59, sensitivity= .90, specificity=.77, respectively). This study assessed the diagnosis of major depressive episode and dysthymia, as well as anxiety disorders: panic disorder with or without agoraphobia, separation anxiety disorder, generalized anxiety disorder and social phobia.

Anthropometric and body composition measurements.

Anthropometry. The anthropometric parameters evaluated in the initial and final phase were weight, height and waist circumference (WC). Body mass index (BMI) (Kg/m^2) was then calculated.

Weight was measured using the Tanita® TBF-300 scale, which has an accuracy of 100 g and a maximum weight of 200 Kg. WC was measured using a flexible tape and height was measured using an inextensible tape measure, with a variation of 1 mm considered acceptable. WC was measured at the midpoint between the iliac crests and the lower costal margin, without clothes. Weight and height were measured with light clothing, barefoot and without heavy objects in pockets.

Bioelectrical impedance (BIA). The TANITA® TBF-300 body composition analyzer was used to assess body composition. The results were expressed as follows: fat mass in kilograms (Kg), percentage of fat mass, lean mass in Kg, water content in Kg and baseline metabolic rate in kilocalories.

Lifestyle: Dietary and physical activity.

Krece plus food questionnaire. (Serra-Majem, Aranceta-Bartrina, Ribas-Barba, Sangil-Monroy & Rérez-Rodrigo, 2003) This test determines dietary quality. It consists of 16 items, with a score of 1 or -1 for each item). The maximum possible score is 11, and the minimum is -5.

Krece Plus Physical Activity Questionnaire: The Krece Plus Short Physical Activity Test. (Román-Viñas, Serra-Majem, Ribas-Barba, Pérez & Aranceta-Bartrina, 2003). This test consists of two questions. Each question has six possible responses, with a score of 0 to 5. The maximum score for the test is 10 and the minimum is 0.

Body Satisfaction.

Body Areas Satisfaction Scale (BASS) (Cash & Szymanki, 1995). This scale assesses an individual's degree of satisfaction or dissatisfaction with 10 body areas. The scale rates satisfaction with each different body part with a score of 1 to 5.

Statistical analysis

We confirmed the normality of the variables and the criteria for application of the statistical tests. The degree of non-independence of observations from children nested within the same school can be estimated using intraclass correlation coefficients (ICC) (Kenny, Manneti, Pierro, Livi & Kashi, 2002; Pardo, Ruiz & San Martin, 2007). We found no evidence to suggest that observations were non-independent for the outcome variable: “change WC” (ICC=.0827), “change BMI”

(ICC=.0001), and "change %BF" (ICC=.0192, ps>.05). Therefore, we applied traditional statistical analysis. The chi-square test, Student-Fisher t, analysis of variance adjusted for the Bonferroni multiple comparisons and Pearson correlations were used according to the types of variables compared. The values are expressed as the mean and standard deviation for the quantitative variables, and as percentages for the qualitative variables.

The change in anthropometric and body composition measurements from preadolescence to adolescence was calculated as the difference between the final values in adolescence and the initial values in preadolescence.

Various multiple linear regression models were applied to assess the effect of psychopathology on changes in anthropometry and body composition. The multiple linear regression models used the ENTER method for psychopathological variables and the STEPWISE method for the other adjustment variables. The psychopathological variables were as follows: depressive symptoms in model 1; anxiety symptoms in model 2; symptoms of depression, separation anxiety, generalized anxiety, somatic/panic and social phobia in model 3; and diagnosis of panic disorder, separation anxiety disorder, generalized anxiety disorder, social phobia, diagnosis of major depressive episode and dysthymia in model 4. The other adjustment variables were age (years), initial WC (cm), initial BMI (kg/m^2) and initial %BF (%), according to the dependent variable in the multiple linear regression model, the Krece Plus diet test and Krece Plus physical activity test scores, and the body areas satisfaction score.

The lower threshold for statistical significance was $p \leq .05$. Data were analyzed using SPSS 17.0 for Windows.

Results

Descriptive data

Table 1 shows the general, psychopathological, anthropometric and body composition characteristics in preadolescence (phase one) and adolescence (phase three).

Relation between emotional psychopathology and adiposity

Table 2 shows the correlation between the scores for anxiety and depression symptoms and the change in adiposity over the period of the study. A slight or moderate correlation was observed between separation anxiety and increased BMI (r=.220) and %BF (r=.175) in girls and between separation anxiety and increased WC in both gender (Boys, r=.274; Girls r=.196). Somatic symptoms were also found to be slightly or moderately associated with changes in WC (r=.269), BMI (r=.187) and %BF(r=.210) in girls. Scores for depressive symptoms were correlated with change in %BF in girls (r=2.14). In addition, the presence of depressive symptoms in preadolescence was associated with significant increases in BMI in boys (p=.040) but not in girls (p=.150) and with increases in %BF in both genders ($p<.05$), compared to adolescents without these symptoms (measured by the t-test). Although the relationship between depressive symptoms and change in WC was not significant in either boys or girls, those adolescents who presented depressive symptoms showed a greater increase in WC than adolescents without depressive symptoms.

Psychopathological predictors of adiposity

Tables 3 and 4 show the multiple linear regression models adjusted for the various lifestyle variables, initial anthropometry and body composition, body satisfaction and age for boys and girls, respectively.

For boys (Table 3), model 1 shows that the presence of depressive symptoms significantly accounts for the increase in WC, BMI and %BF. Model 3, which adjusts for the anxiety symptoms, confirms the results for the increase in WC (B=3.50, p=.029), BMI (B=1.25, p=.022) and %BF (B=3.32, p=.024). Model 4, which adjusts for the diagnostic category variables, shows that diagnosis of dysthymia was a highly significant predictor of increased WC (B=9.25, p=.001) and BMI (B=3.50, $p<.001$). However, diagnosis of major depressive episode was found to be inversely related to BMI (B=-2.98, p=.020). With regard to anxiety in boys, we can also observe, in model 3, that the symptoms of separation anxiety were associated with increased WC (B=.43, p=.006) and BMI (B=.10, p=.041). Of the anxiety disorders (model 4), social phobia was associated with increased WC (B=9.59, p=.0006) and BMI (B=2.90, p=.019), and panic disorder was related to increased BMI

(B=2.83, p=.043). In addition, lifestyle variables were found to be significant predictors of WC or BMI in all models (p<.05).

For girls (Table 4), no significant relationship was observed between depressive symptoms and WC, BMI or %BF (models 1 and 3). However, model 4 shows that a clinical diagnosis of dysthymia significantly influenced the increase in WC (B=7.86, p=.017). With regard to anxiety in girls, model 2 shows that anxiety symptoms led to the increase in WC, BMI and %BF. More specifically, model 3 shows that somatic/panic symptoms contributed to the increase in WC (B=.34, p=.035) and %BF (B=.30, p=.045). However, we found no relationship between diagnosis of anxiety disorders and changes in anthropometric and body composition parameters. Anthropometric and body composition variables in preadolescence have a highly significant effect on the same parameters in adolescence (p<.001).

Discussion

We observed a relationship between anxiety and depression in preadolescence and increased weight, adiposity and distribution of abdominal fat during adolescence. This relationship was observed in both sexes, although some differences were found according to the type and severity of psychopathology and relations were found predominantly in males.

We found that depressive symptoms led to increased in BMI, WC and %BF in males only. Indeed, although some univariate associations were not observed, multiple regression adjusted for specific risk factors of overweight or obesity enabled us to identify the independent effects of factors such as depression, age, diet and physical activity among others. The relationship between depression and increased adiposity is corroborated in individuals diagnosed with dysthymia but not in those diagnosed with major depression episode. This could be explained by the fact that dysthymia is a chronic disorder whose manifestations affect lifestyle and have long-term health effects. By contrast, a major depressive episode is a much more severe condition and is usually detected much earlier; furthermore, some authors suggest that this disorder may affect eating habits in different ways, leading to different effects on weight status (McElory et al., 2004; Reeves, Postolache, & Snitker, 2008). As such, the effect of a major depressive episode on weight loss in males observed in our study

is supported by previous research (Carpenter et al., 2000). By contrast, we found that dysthymia leads to increased abdominal fat in both the male and female population. These findings are consistent with some research studies of adults with depressive disorder or depressive symptoms (Ahlberg et al., 2002; Needham et al., 2010; Zhao et al., 2011). In this regard, a review in adults showed that depression may be associated with abdominal obesity in both men and women (McElory, et al., 2004). In children and adolescents, a relationship has only been observed between depression and BMI (Anderson et al., 2006; Anderson et al., 2010; Goodman & Whitaker, 2002; Rofey et al., 2009) and between depression and %BF in the specific case of adolescent girls (Hillman et al., 2010). However, the results of Tanosfky-Kraff et al. (2006) for a sample of 146 American infants did not show greater increases in %BF, measured by dual energy X-ray absorptiometry, in subjects with depression. Despite the evidence described above, and in contrast to studies that indicate a relationship between depression and obesity primarily among the female population, our study shows that the relationship is stronger in boys than in girls. The differences between boys and girls could be explained by the findings of recent studies that applied a novel statistical approach based on spline function, in which it was found that the association between depression and BMIz score was non-linear and that the shape of the curve obtained varied according to gender (Cortese et al., 2009; Revah-Levy et al., 2011). Another study using the same analytical methodology showed that the relationship between BMI and body dissatisfaction was also different for boys and girls (Cortese et al., 2010). This fact may modulate the relationship between depression and BMI according to gender.

We found that anxiety leads to increased anthropometric and body composition parameters, with differences observed according to sex and the type and severity of anxiety. Thus, although we found that the total anxiety score was related to an increase in WC, BMI, and %BF in girls, detailed analysis showed that only somatic/panic manifestations were related. In this respect, our results agree with those of Hillman et al. (2010), who associated anxiety symptoms with %BF measured using dual energy X-ray absorptiometry in a population of 198 female adolescents in the United States. However, Hillman et al. (2010) and Midei & Matthew (2009), who used the waist-hip-ratio in both genders, did not observe a significant relationship between anxiety and abdominal fat.

Unlike girls, the boys with higher scores for separation anxiety showed a greater increase in WC and BMI. This increase in adiposity was also found in boys diagnosed with social phobia and the increase in BMI in boys diagnosed with panic disorder. It is difficult to find the reasons for these differences according to type and severity of anxiety. To our knowledge there are no studies of children or adolescents that analyze the different subtypes of anxiety. One possible explanation is the method used to assess anxiety. The symptoms identified by SCARED are quantitative measures; however, the diagnosis obtained by MINI-Kid is a dichotomous variable and the level of the disorder that it establishes takes into account a minimum number of criteria from the DSM-IV-TR and clinical interference. Social phobia disorder causes limitations, major subjective discomfort and social isolation. Therefore, adolescents with this disorder usually stay at home more, eat more, are more inactive, and do not participate social activities and sports. Similarly, panic disorder can lead to avoidance behaviors such as not leaving home in order to avoid a stressful situation. Therefore, adolescents with this disorder may be more inactive or eat more to reduce anxiety manifestations.

However, it is difficult to explain why some of these relationships were observed in boys but not in girls in our study, in contrast with several studies conducted with adolescents in which the relationship between anxiety and obesity appeared to be more evident in the female subjects (Anderson et al., 2006). Our results show a consistent relationship between anxiety and WC for both genders, similar to the results of other authors who observed the same relationship with abdominal fat in adults (Albergh et al., 2002; Needham et al., 2010; Zhao et al., 2011). Likewise, Rofey et al. (2009) observed weight gain in both boys and girls with anxiety.

In general, the differences in the observed effects of anxiety and depression on adiposity may be due in part to differences in the study design, such as the age range considered and the methodology used to assess psychological disorders and to determine weight, fat and fat distribution (Incledon et al., 2011).

Additionally, our results show that greater baseline anthropometric and body composition measurements influence the change in anthropometric and body composition measurements in

adolescent girls but not in adolescent boys. We are unsure of the reasons for these results, although one possible explanation would be the difference in age at onset of puberty between the genders. Girls in the age range considered in the study are likely to be in mid-puberty, whereas boys in the same age range are more likely to be at the onset of puberty. In prepubertal boys, changes in body composition due to puberty are minimal, and the prepubertal weight and fat distribution may not be critical to the future development of these parameters. By contrast, in girls of the same age, changes in body composition due to puberty have just begun and their bodies are being modified and defined. Therefore, the development of body composition in mid-puberty may influence the subsequent progression of body fat and fat distribution. In addition, mid-pubertal girls are at the stage of becoming concerned about their weight, and many of them want to be thinner. Consequently, girls with higher anthropometric and body composition parameter values make a conscious effort not to gain weight or fat.

However, our results reveal inconsistencies in %BF measured by BIA. Although some studies support the use of this method among children, others argue that it has limitations at critical stages of development, does not detect small changes with sufficient accuracy, and shows varying validity according to adiposity (Eisenmann, Heelan, & Welk., 2004; Goldfield et al., 2006; Treuth, Butte, Wong, & Ellis, 2001). In this case, BMI and, in particular, WC may reflect changes in adiposity more accurately. Our findings on psychopathology and increased WC could support the results of Albergh et al. (2002), which indicate that psychopathology is more closely related to abdominal fat reserves than obesity per se. Furthermore, assessment of WC is important because it is a diagnostic criterion for metabolic syndrome (Varda & Gregoric, 2009). In isolation, some research studies in adults suggest that depression and/or anxiety predict an increased risk of metabolic syndrome and cardiovascular diseases (Goldbacher & Matthews, 2007; Lupino et al., 2011). In the same vein, a recent review in children studied the relationship between chronic stress and metabolic syndrome (Pervanidou & Chrousos, 2011).

There are various interpretations of these findings. On the one hand, the psychopathology may lead to changes in eating behaviour and lifestyle (Reeves et al., 2008). It has been shown that a

substantial proportion of people with depressive and anxiety symptoms have increased appetites and tend to overeat and reduce their levels of physical activity, leading to weight gain (McElory et al., 2004). On the other hand, there is evidence of a shared neurobiological mechanism between emotional psychopathology and weight gain. The emotional psychopathology affects the hypothalamic-pituitary-adrenal axis, leading to increased cortisol secretion. High cortisol levels are associated with obesity, especially abdominal obesity (Pervanidou & Chrousos, 2011; Reeves et al., 2008). This mechanism could account for the consistent observation of a relationship between emotional psychopathology and increased WC in both sexes in our study. The existence of a common genetic foundation has also been suggested (Wermter et al., 2010).

This study has a number of strengths. First, the prospective design in a non-clinical population enabled us to use a sample of schoolchildren at risk of emotional psychopathology and a group of control subjects. Second, by using a three-year follow-up period we were able to assess the effect of the psychopathology on the increase in adiposity from preadolescence to adolescence. Third, we not only evaluated emotional symptoms but also diagnosed the underlying emotional disorder on an individual basis according to standardized clinical criteria (DSM-IV-TR). We thus obtained diagnoses of the different anxiety and depression disorders present in the study population and were able to specifically assess the predictive ability of each one. However, due to the high level of comorbidity between depression and anxiety and between the different types of disorders (Essau, 2008; Polaino-Lorente, Canals & Domènech-Llaberia, 2002) we adjusted our statistical analyses for all of these variables. Fourth, the anthropometric variables were measured by qualified personnel using a standardized methodology. The direct determination of weight and height gives our results greater precision and validity (Incledon et al., 2011; Rhew et al., 2008). Furthermore, most of the studies in the literature only consider BMI, yet this index does not provide scope for analysis of %BF or its distribution. The use of other measures that assess %BF, such as BIA, and abdominal fat distribution, such as WC, is therefore necessary. Both methods are simple, economical, fast and feasible at the population level. By contrast, other more sophisticated methods such as computed tomography or dual energy X-ray absorptiometry are more costly, more time-consuming and more difficult to implement.

Our study has certain limitations that should be considered when interpreting the results, including the limited sample size and follow-up rate, and the non-inclusion of other confounding variables such as ethnicity, pubertal stage, obesity and maternal depression, among others.

Future research should therefore aim to elucidate the interrelationship between depression-anxiety and obesity and/or metabolic syndrome in terms of behaviour, neurobiology and genetics, especially among children and young people, and using various measures of adiposity.

In light of the evidence presented above, to our knowledge this is one of the first data sets for a preadolescent population that describes the influence of depression (and specifically dysthymia) and the various types of anxiety according to DSM-IV on increased WC in adolescents. Depression and anxiety during childhood are common, treatable conditions, and as such, these findings may have significant implications for the prevention and treatment of obesity and metabolic syndrome. In addition, WC is a simple and economical measure that can be used at community and school level, in prevention programs and in clinical settings, enabling rapid monitoring of children with psychopathology to identify weight problems before they become pathological.

In conclusion, emotional psychopathology in preadolescence is associated with increased weight gain and abdominal fat in adolescence, albeit with some differences in the precise relationship with each anxiety and depression disorder according to gender. These factors could lead to disorders such as obesity or metabolic syndrome. Future research should seek to confirm these results and examine the possible mechanisms involved.

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