



## Original Research

# Attention-deficit Hyperactivity Disorder Symptoms and Conduct Problems in Children and Adolescents with Obesity

Arzu Önal Sönmez, Burcu Göksan Yavuz, Sibel Aka, Serap Semiz

Department of Child and Adolescent Psychiatry, Acibadem Mehmet Ali Aydınlar Faculty of Medicine, Istanbul, Turkey

### Abstract

**Objectives:** Recent studies focus on the potential factors that increase the potential risks of obesity in children and adolescents. According to research for the past years, one of the factors that increases the risk of obesity may be attention-deficit hyperactivity disorder (ADHD). We hypothesized that overweight/obese children and adolescents that apply to pediatric endocrinology for treatment would be at higher risk for ADHD symptoms.

**Methods:** In this cross-sectional study, the sample consisted of 55 children and adolescents aged between 6-14 years with body mass index greater than 95th percentile and 37 nonobese control group. Sociodemographic form, Strengths and Difficulties Questionnaire and The Turgay Diagnostic and Statistical Manual of Mental Disorders Based Child and Adolescent Behavior Disorders Screening and Rating Scale has been used.

**Results:** The rates of inattentive subtype, hyperactivity/impulsivity subtype, and the combined type in the subject group were 10.9%, 3.6% and 7.3%, respectively. The rates of inattentive subtype, hyperactivity/impulsivity subtype were 5.4%, 2.7%, respectively, in the nonobese group. In terms of SDQ scores, peer problems subscale scores were significantly higher in the subject group than the control group ( $5.13 \pm 1.24$  vs  $4.32 \pm 1.18$ ,  $p=0.003$ ). According to the binary regression analysis, having peer problems was found to be significantly related to being obese (Exp B (OR): 3.3,  $p=0.04$ ).

**Conclusion:** Our findings show that obese children and adolescents have higher rates of ADHD symptoms and problems in peer relations. Underestimation of ADHD might be a risk factor for treatment failure in obesity since ADHD symptoms cause a lack of motivation and compliance.

**Keywords:** Attention deficit hyperactivity disorder; obesity; overweight.

Please cite this article as "Önal Sönmez A, Yavuz BG, Aka S, Semiz S. Attention-deficit Hyperactivity Disorder Symptoms and Conduct Problems in Children and Adolescents with Obesity. Med Bull Sisli Etfal Hosp 2019;53(3):300–305".

Obesity is now considered as an important health problem in children and adolescents as well as adults. Therefore, many studies are conducted on the risk factors that increase the risk of obesity in children and adolescents. In recent studies, one of the risk factors may be Attention-Deficit Hyperactivity Disorder (ADHD), which is a neurodevelopmental disorder encompassing attention, hyperactivity, and both are seen incompatible with patient's age.<sup>[1–4]</sup>

Obesity is defined as a health problem increasing in frequency among children and adolescents in developed and developing countries.<sup>[5]</sup> According to the data of the National Health and Examination Survey, 18.8% of children and adolescents between the ages of 6-11 and 17.4% of those between the ages of 12-19 were found to be overweight in the United States.<sup>[6]</sup> In a study conducted in Europe, the findings showed that 15% of children between

**Address for correspondence:** Arzu Önal Sönmez, MD, Acibadem Mehmet Ali Aydınlar Tıp Fakültesi, Çocuk ve Ergen Psikiyatrisi Anabilim Dalı, İstanbul, Turkey

**Phone:** +90 532 516 51 53 **E-mail:** arzudr@yahoo.com

**Submitted Date:** April 11, 2019 **Accepted Date:** May 20, 2019 **Available Online Date:** August 21, 2019

©Copyright 2019 by The Medical Bulletin of Sisli Etfal Hospital - Available online at [www.sislietfaltip.org](http://www.sislietfaltip.org)

**OPEN ACCESS** This is an open access article under the CC BY-NC license (<http://creativecommons.org/licenses/by-nc/4.0/>).



the ages of 3-17 are overweight.<sup>[7]</sup> In Turkey, in children and adolescents, the prevalence of overweightedness and obesity vary from region to region, but it still seems to be lower compared with European countries and the United States.<sup>[8, 9]</sup> When psychiatric and psychological aspects of pediatric obesity are examined, overweight and obese children have a higher rate of psychiatric disorder than their normal weight peers.<sup>[10]</sup> In relation to this, studies on ADHD and obesity have started to gain importance in recent years.

Recent studies have shown that the risks of being overweight, and obese are 50%, and 40% higher in the ADHD group when compared with healthy people.<sup>[11]</sup> In addition, children with ADHD were found to be overweight twice as much as their peers without ADHD.<sup>[12]</sup> In contrast, overweight children also showed higher rates of ADHD than their normal-weight peers. However, some studies do not support this relationship. In a general population study conducted in the United States, the prevalence of overweight was equal in children with and without ADHD. Moreover, in another study, the weight of children with ADHD was lower than their peers.<sup>[13, 14]</sup> Obtaining different results may be due to different definitions of obesity/overweight or to diagnose ADHD with self-report scales.

In the literature that investigated ADHD and obesity, many hypotheses have been proposed. Attention deficit and impulsivity, which are the two main signs of ADHD, are thought to increase the risk of obesity.<sup>[15]</sup> It is thought that impulsivity may be associated with disinhibited eating behavior pattern. Again, it is conceived that peer relations can be affected by impulsivity. In addition, children with ADHD are very sensitive to immediate rewards.<sup>[12]</sup> Dysregulation of ADHD in the dopaminergic reward system can lead to unhealthy and chaotic food consumption. In addition to impulsivity and avoidance behaviors, inability to observe the behaviors of the planning, organization among executive functions and other people are impaired in attention deficit disorder that may lead to chaotic eating habits.<sup>[15]</sup> In addition, attention deficit may limit awareness about hunger and satiety.<sup>[16, 17]</sup>

Another factor that causes an increase in body mass index (BMI) in children and adolescents is physical inactivity. Although one of the main findings of ADHD is hyperactivity, this finding does not indicate a high level of mobility.<sup>[12]</sup> Physical activities require concentration and cognition that are difficult for patients with ADHD. Instead of exercising, they prefer to spend time with activities that cause weight gain, such as playing video games and watching television more frequently.<sup>[18]</sup>

In the last decade, Western culture has given importance to the relationship between ADHD and obesity. It is impor-

tant to understand the relationship between people from different cultural backgrounds. Both controlling ADHD and preventing childhood obesity are important for pediatric public health. In the light of the literature, our hypothesis is that overweight/obese children and adolescents admitted to the pediatric endocrinology outpatient clinic may be at risk for ADHD symptoms.

## Methods

This is a cross-sectional study conducted with outpatients who were referred to the pediatric endocrinology outpatient clinic of Maslak Acibadem hospital. Cases were selected from children and adolescents aged 6-14 years with a BMI greater than 95<sup>th</sup> percentile. In our study, mental retardation, psychosis, autism, bipolar disorder, substance abuse, and endocrinologic disorders other than obesity (such as hypothyroidism) were identified as an exclusion criteria. Antipsychotic drugs, steroid and stimulant users, patients with epilepsy, brain diseases, neurological and genetic diseases such as Turner, Down, Fragile X Syndromes were excluded from this study. Fifty-five children and adolescents who did not have exclusion criteria were included in the present study.

Nonobese children and adolescents who were referred to the pediatric outpatient clinic of Maslak Acibadem hospital were included in this study. The control group consisted of 37 sex and age-matched children and adolescents without hormonal problems. All information was obtained from children and adolescents and their families. Written informed consent was obtained first from the parents and then from the children. Our study was obtained from the Acibadem Mehmet Ali Aydinlar Faculty of Medicine Ethics Committee on 03.31.2016 with protocol number 2016-5/29.

## Scales

### Sociodemographic Data Form

Information, such as age, sex, number of siblings and history of medical, and psychiatric disorders, drug use, frequency of physical exercise, were collected through a survey at the beginning of the interview in the light of the information obtained from parents and children. Socio-economic data were evaluated according to parental education and income level.

### Body Mass Index

All subjects underwent physical examination, including pubertal development according to height, weight and Tanner classification.<sup>[19]</sup> BMI was measured by dividing the weight (kilogram) by the square of the height (meter) ( $\text{kg}/\text{m}^2$ ). National BMI chart was taken as a reference.<sup>[20]</sup>

## Strengths and Difficulties Questionnaire (SDQ)

Strengths and Difficulties Questionnaire (SDQ) was developed by Goodman (1999) to inquire about some positive aspects and emotional and conduct problems of children and adolescents aged 4-16 years. The 25-item Likert-type questionnaire consists of five subscales. As the scores of emotional problems, conduct problems, peer relationship problems and hyperactivity subscales increased, susceptibility to clinical problems increased, and as social score subscale scores increased, susceptibility to clinical problems decreased. The sum of the subscales of emotional problems, conduct problems, peer relationship problems and hyperactivity subscales give the total score of the scale and the higher the total score, the higher the frequency of conduct problems in children or adolescents. The 7<sup>th</sup>, 14<sup>th</sup>, 11<sup>th</sup>, 21<sup>st</sup> and 25<sup>th</sup> questions of the scale should be reversed and scored. In the scale, the questions are answered by the parents as "incorrect", "partially correct" and "absolutely correct" and scored as "0", "1" and "2, respectively. The validity and reliability study of the Turkish version of the SDQ and the parent form was realized by Güvenir et al.<sup>[24]</sup> Table 1.

## Screening and Evaluation Scale for Attention Deficit and Disruptive Behavior Disorders based on DSM-IV (ADHDODD DSM-IV Evaluation Scale)

This 36-item scale developed according to DSM-IV criteria consists of items questioning attention deficit (n=9), hyperactivity (n=6), impulsivity oppositional defiant disorder (OPD: and conduct disorder (n=15) (see Turgay 1994). The scale was developed by converting DSM-IV criteria into questions without changing their meaning. The scale is completed by parents, teachers and teachers of the children who were considered to have ADHD. The options of 0=not at all, 1=slightly, 2=severe, 3=very are available for each item. As the score increases, the problematic behaviors increase. The questionnaire was completed by parents and teachers in 0-1-3-6-9-12-15-18 months. Validity and reliability study for the Turkish population was realized by Ercan et al.<sup>[26]</sup>

SDQ	Normal	Borderline	Abnormal
Emotional problems	0-5	6	7-10
Conduct problems	0-3	4	5-10
Hyperactivity/impulsivity	0-5	6	7-10
Peer relationship problems	0-3	4-5	6-10
Social relationship	6-10	5	0-4
Total	0-15	16-19	20-40

SDQ: Strengths and Difficulties Questionnaire.

## Statistical Analysis

SPSS for statistical analysis v. 13. compatible with software windows was used (SPSS, Inc., Chicago, IL, USA). Demographic and clinical data (age, height, BMI, BMI-z scores, parental height and weight, pubertal development stage and scores) were shown as mean and standard deviation (SD) or percentages.

The mean scores were compared between the groups using the Mann-Whitney U test. Categorical data were analyzed using chi-square analysis or Fisher's Exact Test. Bilateral logistic regression analysis was used to determine independent predictors of obesity and Hosmer-Lemeshow goodness of fit statistics was used to evaluate the fitness of model data. Statistical significance was set at  $p < 0.05$ .

## Results

Fifty-five obese and 37 nonobese children and adolescents were included in this study. The control group consisting of nonobese children matched with each other in terms of age, gender and sociodemographic data. The mean age of the patient population was  $9.56 \pm 2.39$  years (range 6-14 years) consisting of 25 (45.5%) male, and 30 (54.5%) female individuals. The mean BMI of the control group was  $26.25 \pm 3.74$  kg/m<sup>2</sup>. According to DSM-IV criteria of ADHD, attention deficit, hyperactivity/impulsivity subtypes and compound type of ADHD were more frequently seen in the obese group than in the nonobese group. Attention deficit and hyperactivity/impulsivity subtype and compound type were seen in 10.9, 3.6 and 7.3%, of the patients, respectively. In the control group, attention deficit, and hyperactivity/impulsivity subtypes were seen in 5.4% and 2.7% of the control group, respectively. Compound type of ADHD was not detected in the control group. Though not statistically significant, the prevalence of ADHD was higher in the obese group ( $p=0.26$ ). Physical exercise was practiced by 33% (n=4) of the patients in the obese group with ADHD and 58.1% (n=25) in the group without ADHD ( $p=0.19$ ). The sociodemographic and anthropometric characteristics of both groups and the distribution of ADHD in these two groups are shown in Table 2.

According to the SDQ peer problems subtest, the obese group had more problems in peer relationships than the nonobese group ( $5.13 \pm 1.24$  vs  $4.32 \pm 1.18$ ,  $p=0.003$ ). Although the hyperactivity/impulsivity subtype scores were higher in the obese group, it did not reach statistical significance ( $4.26 \pm 1.43$  vs  $3.97 \pm 1.44$ ,  $p=0.35$ ). SDQ scores between the groups are shown in Table 3. When the cut-off hyperactivity/impulsivity subtype score was selected as

≥7 points, the clinical abnormality rate was 9.4% in the patient group and 8.3% in the control group. When the cut-off point of the peer problems subtest was determined as ≥6 points, the peer problems were found in 37%, and 13.5% of the obese, and nonobese individuals, respectively. Problems in peer relationships were significantly, and more frequently seen in the obese group (p=0.014). Its distribution in both groups is shown in Table 4. Obesity-related factors, such as gender, emotional and behavioral problems, hyperactivity/impulsivity, social association and the presence of ADHD, were not correlated with obesity.

In addition, findings showed that having peer problems was significantly related to being obese (Exp B (OR): 3.3, p=0.04) according to dual regression analysis (Table 5). The Hosmer-Lemeshow goodness of fit test showed that the fitness of model data were good (p=0.59).

**Table 2.** Sociodemographic data and clinical characteristics

Characteristics	Case group (n=55) Mean±SD %, (n)	Control group (n=37) Mean±SD %, (n)	p
Age (years)	9.56±2.39	8.86±2.44	0.18
Gender			
Female	54.5 (30)	45.9 (17)	0.41
Male	45.5 (25)	54.1 (20)	
BMI (kg/m <sup>2</sup> )	26.25±3.74	18.16±4.28	<0.001
Diagnosis of ADHD			
Subtype of			
attention deficit	10.9 (6)	5.4 (2)	0.26
Diagnosis of ADHD			
Hyperactivity/impulsivity	3.6 (2)	2.7 (1)	
Diagnosis of ADHD			
Compound subtype	7.3 (4)	–	

BMI: Body mass index; ADHD: Attention Deficit Hyperactivity Disorder.

**Table 3.** Intergroup comparison of SDQ scores

SDQ	Case group (n=55) Mean±SD	Control group (n=37) Mean±SD	t	p
Emotional problems	2.08±2.04	2.22±2.19	0.32	0.75
Conduct problems	1.98±1.14	1.89±0.84	-0.41	0.69
Hyperactivity	4.26±1.43	3.97±1.44	-0.94	0.35
Peer relationship problems	5.13±1.24	4.32±1.18	-3.1	0.03
Social relationship	8.87±3.43	8.22±1.99	-1.05	0.3
Total	22.47±4.43	20.83±4.10	-1.8	0.08

GGA: Strengths and Difficulties Questionnaire.

## Discussion

In recent years, the relationship between ADHD and obesity has gained importance in Western countries. Although inconsistent results were detected because of differences in the definition of obesity/overweightness due to the self-report scales used to diagnose ADHD, recent clinical and epidemiological studies have shown that children diagnosed with ADHD are overweight twice more frequently compared to their peers without ADHD.<sup>[12]</sup> According to Lam and Yang, Warning and Lapane, the risk of obesity increases 1.4 and 1.5 times in children and adolescents with ADHD, respectively.<sup>[14, 27]</sup> As the eating behavior changes, obesity rate increases in both children and adults.<sup>[15]</sup> Therefore, it is important to identify the risk factors associated with this increasing health problem.

In this study, it was assumed that overweight/obese children and adolescents might carry a high risk for ADHD symptoms. According to the data of our study, obese children and adolescents had a higher rate of ADHD symptoms. According to DSM-IV, the rates of attention deficit, hyperactivity/impulsivity and compound subtypes were found in 10.9%, 3.6% and 7.3%, of the patients, respectively. In the control group, at-

**Table 4.** Distribution of abnormal findings between obese, and nonobese groups

SDQ	Obese group (n=55) % (n)	Control group (n=37) % (n)	p
Emotional problems	1.9 (1)	5.6 (2)	0.57
Conduct problems	5.6 (3)	–	0.27
Hyperactivity	9.4 (5)	8.3 (3)	1.0
Peer problems	37 (20)	13.5 (5)	0.014
Social relationship	3.7 (2)	8.1 (3)	0.39
Total	76.5 (39)	66.7 (24)	0.31

GGA: Strengths and Difficulties Questionnaire.

**Table 5.** Factors associated with obesity

Independent factors	Exp (B) (OR)	p
Gender	0.52	0.18
Presence of emotional problems	0.32	0.4
Presence of conduct problems	0.62	1
Presence of hyperactivity/impulsivity problems	0.76	0.77
Peer problems	3.3	0.04
Problems in a social relationship	0.0	1
Presence of ADHD according to ADHD + ODD	0.197	2.68

ADHD: Attention deficit hyperactivity disorder; ADHD DSM-IV Scanning, and Assesment Scale for Attention Deficit Hyperactivity Disorder and Disruptive Behaviour based on DSM-IV criteria.

tention deficit and hyperactivity/impulsivity subtypes were detected in 5.4% and 2.7%, of the cases, respectively. In addition, although not statistically significant, SDQ hyperactivity/impulsivity subtest scores were found to be higher in the patient group compared to the control group.

According to the literature, shared genetic factors, such as emotional dysregulation, impulsivity, and the 7-repeat allele of the dopamine 4 receptor gene (7R), are among the reasons that children with ADHD are prone to obesity.<sup>[15, 28]</sup> Inadequate regulation of emotion associated with ADHD and impulsivity may explain the relationship between obesity and ADHD.<sup>[4]</sup> Consistent with this assumption, there are also studies showing that there is a relationship between impulsivity symptoms and high BMI values.<sup>[13]</sup> In addition to impulsivity, attention deficit, which is one of the main symptoms of ADHD, may restrict awareness about hunger and satiety.<sup>[16, 17]</sup> Another hypothesis explaining the relationship between ADHD and obesity is an imbalance in the dopaminergic reward system.<sup>[29]</sup> The inadequate dopaminergic reward system turns into unnatural instantaneous rewards, such as inappropriate eating behavior.<sup>[27]</sup> In recent years, some studies showed that it is more difficult for children and adolescents with ADHD to wait for the preparation of healthy food, so they preferred fast food when compared with those without ADHD (16, 30).

In this study, the findings showed that the frequency of physical activity of obese children with ADHD was lower than those without ADHD. In a study by Khalife et al.,<sup>[18]</sup> a relationship was found between ADHD symptoms and low-level physical mobility. In the same study, both attention deficit and hyperactivity were predictors of being overweight or obese, and even attention deficit was important in terms of being an indicator of later physical inactivity. Peer problems associated with ADHD are likely to prevent them from participating in physical activities such as team sports.<sup>[18]</sup> Physical activities may require high concentration, which is challenging for children with ADHD. Therefore, they may prefer to spend most of their time in a way that may result in obesity, such as watching video games and TV.<sup>[18]</sup>

Another finding obtained from this study is that peer problems increase the risk of obesity. Obese children had more problems than their nonobese peers. A study has shown that overweight children are more prone to psychiatric diseases and problems in peer relationships than their normal weight peers.<sup>[31]</sup> In another similar study, 5-year-old obese boys had more problems in peer relationships, hyperactivity and attention problems than their normal-weight peers.<sup>[32]</sup> Another study suggests that peer problems are independent of overweightness.<sup>[33]</sup>

Limitations of this study should also be considered. Being a cross-sectional study prevents detection of individual differences between obesity, ADHD and peer relationships. The detection of ADHD symptoms through self-report or parent-filled scales should also be mentioned as a limitation. In general, important clinical results were reached in this study. Taking into account the increasing obesity rate in children and adolescents, it is important to raise awareness of the risk factors that cause obesity, ie a public health problem. Furthermore, identifying these risk factors sheds light on the prevention and treatment of obesity.

In our study, the findings showed that obese children had high ADHD scores and an increased number of problems in peer relationships. The presence of ADHD symptoms in children may cause them to become physically inactive and increase the risk of becoming obese. When treating obesity, the clinician should consider undiagnosed ADHD and associated peer problems. Failure to recognize ADHD symptoms may lead to lack of motivation and adherence to treatment in obesity.<sup>[13]</sup> Diagnosis and treatment of ADHD may also help in the treatment of eating disorders. Further studies are needed to clarify the relationship between ADHD, peer relationships and obesity in children and adolescents.

#### Disclosures

**Ethics Committee Approval:** Our study was obtained from the Acibadem Mehmet Ali Aydinlar Faculty of Medicine Ethics Committee on 03.31.2016 with protocol number 2016-5/29.

**Peer-review:** Externally peer-reviewed.

**Conflict of Interest:** None declared.

**Authorship Contributions:** Concept – A.Ö.S., S.S.; Design – A.Ö.S., S.S.; Supervision – B.G.Y.; Materials – S.S., S.A., A.Ö.S.; Data collection &/or processing – S.S., S.A.; Analysis and/or interpretation – B.G.Y., A.Ö.S.; Literature search – A.Ö.S.; Writing – A.Ö.S., B.G.Y., S.S.; Critical review – S.S., A.Ö.S.

#### References

1. Cortese S, Vincenzi B. Obesity and ADHD: clinical and neurobiological implications. *Curr Top Behav Neurosci* 2012;9:199–218.
2. Altfas JR. Prevalence of attention deficit/hyperactivity disorder among adults in obesity treatment. *BMC Psychiatry* 2002;2:9.
3. Agranat-Meged AN, Deitcher C, Goldzweig G, Leibenson L, Stein M, Galili-Weisstub E. Childhood obesity and attention deficit/hyperactivity disorder: a newly described comorbidity in obese hospitalized children. *Int J Eat Disord* 2005;37:357–9.
4. Davis C. Attention-deficit/hyperactivity disorder: associations with overeating and obesity. *Curr Psychiatry Rep* 2010;12:389–95.
5. O'Connor TM, Hilmers A, Watson K, Baranowski T, Giardino AP. Feasibility of an obesity intervention for paediatric primary care targeting parenting and children: Helping HAND. *Child Care*

- Health Dev 2013;39:141–9.
6. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999–2004. *JAMA* 2006;295:1549–55.
  7. Kurth BM, Schaffrath Rosario A. The prevalence of overweight and obese children and adolescents living in Germany. Results of the German Health Interview and Examination Survey for Children and Adolescents (KiGGS). [Article in German]. *Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz* 2007;50:736–43.
  8. Yuca SA, Yılmaz C, Cesur Y, Doğan M, Kaya A, Başaranoğlu M. Prevalence of overweight and obesity in children and adolescents in eastern Turkey. *J Clin Res Pediatr Endocrinol* 2010;2:159–63.
  9. Oner N, Vatansever U, Sari A, Ekuklu E, Güzel A, Karasalihoğlu S, et al. Prevalence of underweight, overweight and obesity in Turkish adolescents. *Swiss Med Wkly* 2004;134:529–33.
  10. Hebebrand J, Herpertz-Dahlmann B. Psychological and psychiatric aspects of pediatric obesity. *Child Adolesc Psychiatr Clin N Am* 2009;18:49–65.
  11. Hanç T. ADHD as a risk factor for obesity. Current state of research. *Psychiatr Pol* 2018;52:309–22.
  12. Fliers EA, Buitelaar JK, Maras A, Bul K, Höhle E, Faraone SV, et al. ADHD is a risk factor for overweight and obesity in children. *J Dev Behav Pediatr* 2013;34:566–74.
  13. Erhart M, Herpertz-Dahlmann B, Wille N, Sawitzky-Rose B, Hölling H, Ravens-Sieberer U. Examining the relationship between attention-deficit/hyperactivity disorder and overweight in children and adolescents. *Eur Child Adolesc Psychiatry* 2012;21:39–49.
  14. Waring ME, Lapane KL. Overweight in children and adolescents in relation to attention-deficit/hyperactivity disorder: results from a national sample. *Pediatrics* 2008;122:e1–6.
  15. Nigg JT, Johnstone JM, Musser ED, Long HG, Willoughby MT, Shannon J. Attention-deficit/hyperactivity disorder (ADHD) and being overweight/obesity: Newdata and meta-analysis. *Clin Psychol Rev* 2016;43:67–79.
  16. Davis C, Levitan RD, Smith M, Tweed S, Curtis C. Associations among overeating, overweight, and attention deficit/hyperactivity disorder: a structural equation modelling approach. *Eat Behav* 2006;7:266–74.
  17. Nederkoorn C, Jansen E, Mulkens S, Jansen A. Impulsivity predicts treatment outcome in obese children. *Behav Res Ther* 2007;45:1071–5.
  18. Khalife N, Kantomaa M, Glover V, Tammelin T, Laitinen J, Ebeling H, et al. Childhood attention-deficit/hyperactivity disorder symptoms are risk factors for obesity and physical inactivity in adolescence. *J Am Acad Child Adolesc Psychiatry* 2014;53:425–36.
  19. Tanner JM, Whitehouse RH. Standards for subcutaneous fat in British children. Percentiles for thickness of skinfolds over triceps and below scapula. *Br Med J* 1962;1:446–50.
  20. Zoppi G, Bressan F, Luciano A. Height and weight reference charts for children aged 2–18 years from Verona, Italy. *Eur J Clin Nutr* 1996;50:462–8.
  21. Goodman R. Psychometric Properties of the Strengths and Difficulties Questionnaire (SDQ). *J Am Acad Child Adolesc Psychiatry* 2001;40:1337–5.
  22. Goodman R, Meltzer H, Bailey V. The Strengths and Difficulties Questionnaire: a pilot study on the validity of the self-report version. *Int Rev Psychiatry* 2003;15:173–7.
  23. Goodman R, Ford T, Simmons H, Gatward R, Meltzer H. Using the Strengths and Difficulties Questionnaire (SDQ) to screen for childpsychiatric disorders in a community sample. *Br J Psychiatry* 2000;177:534–9.
  24. Guvenir T, Ozbek A, Baykara B, Arkar H, Şentürk B, İncekaş S. Psychometric properties of the Turkish version of the Strengths and Difficulties Questionnaire (SDQ). *Turk J Child Adolesc Ment Health*. 2008;15:32–40.
  25. Turgay A. Disruptive behavior disorders child and adolescent screening and rating scales for children, adolescents, parents and teachers. West Bloomfield (Michigan): Integrative Therapy Institute Publication, 1994.
  26. Ercan ES, Amado S, Somer O, et al. Development of a test battery for the assessment of attention deficit hyperactivity disorder. *Turk J Child Adolesc Ment Health* 2001;8:132–44.
  27. Lam LT, Yang L. Overweight/obesity and attention deficit and hyperactivity disorder tendency among adolescents in China. *Int J Obes (Lond)* 2007;31:584–90.
  28. Caleo M, Cenni MC. Anterograde transport of neurotrophic factors: possible therapeutic implications. *Mol Neurobiol* 2004;29:179–96.
  29. Liu LL, Li BM, Yang J, Wang YW. Does dopaminergic reward system contribute to explaining comorbidity obesity and ADHD? *Med Hypotheses* 2008;70:1118–20.
  30. Bitsakou P, Psychogiou L, Thompson M, Sonuga-Barke EJ. Delay Aversion in Attention Deficit/Hyperactivity Disorder: an empirical investigation of the broader phenotype. *Neuropsychologia* 2009;47:446–56.
  31. Hestetun I, Svendsen MV, Oellingrath IM. Associations between overweight, peer problems, and mental health in 12–13-year-old Norwegian children. *Eur Child Adolesc Psychiatry* 2015;24:319–26.
  32. Griffiths LJ, Dezateux C, Hill A. Is obesity associated with emotional and behavioural problems in children? Findings from the Millennium Cohort Study. *Int J Pediatr Obes* 2011;6:e423–32.
  33. Pitrou I, Shojaei T, Wazana A, Gilbert F, Kovess-Masféty V. Child overweight, associated psychopathology, and social functioning: a French school-based survey in 6- to 11-year-old children. *Obesity (Silver Spring)* 2010;18:809–17.