Eat Weight Disord (2018) 23:117–123
https://doi.org/10.1007/s40519-016-0320-6

ORIGINAL ARTICLE

Central or overall obesity: which one is a better predictor of depressive symptoms in children, adolescents, and youths?

Samad Esmaeilzadeh[1] · Reza Farzizadeh[1] · Hassan-Ali Kalantari[1] · Asghar Mahmoudi[1] · Omid Yousefi Bilehsavar[1] · Ali Mehranpour[2]

Received: 21 February 2016 / Accepted: 8 September 2016 / Published online: 21 September 2016

Abstract

Background and purpose Despite the strong effect of central obesity on individuals' physical health outcomes, there is little evidence underlying the relationship between central obesity and mental disorders such as depression, especially in children, adolescents, and youths of the developing countries. This study explores the relationship between depressive symptoms (DS) with central and overall obesity in a sample of Iranian children, adolescents, and youths.

Methods One thousand and fifty-two male participants ranging from 7 to 24 years old underwent standard anthropometry, and filled the DS questionnaire.

Results Having controlled the potential confounders (e.g., age, socioeconomic status, pubertal maturation status, and physical activity), we found waist circumference (WC) significantly related to DS in the children (standardized $\beta = 0.14; P < 0.05$) and adolescents (standardized $\beta = 0.13$; $P < 0.05$). No significant relationship was observed between WC and DS in the youths (standardized $\beta = 0.09$; $P = 0.22$). In addition, no significant relationship was observed between DS and the percentage of fat in the sampled children (standardized $\beta = 0.085$; $P = 0.13$), adolescents (standardized $\beta = 0.10$; $P = 0.10$), and youths (standardized $\beta = -0.02$; $P = 0.75$).

Conclusion Central obesity (but not overall obesity) was a significant predictor of DS in the children and adolescents (7–18 years). However, DS in the youths (19–24 years) were not significantly associated with both the central and overall body obesity indices.

Keywords Adolescents · Children · Depressive symptoms · Fat percentage · Physical activity · Waist circumference

Abbreviations

BDI-II	Beck Depression Inventory-II
BMI	Body mass index
CDI	Children's Depression Inventory
DS	Depressive symptoms
PA	Physical activity
PAQ-C	PA Questionnaire-Children
PAQ-A	PA Questionnaire-Adolescents
PMS	Pubertal maturation status
SES	Socioeconomic status
WC	Waist circumference

Introduction

Although obesity is believed to be a public health problem worldwide because of its negative effects on individuals' health, its rate is seemingly increasing [1–3]. Not only has

✉ Samad Esmaeilzadeh
samad_esmaeilzadeh@uma.ac.ir;
samad.esmaeilzade@yahoo.com

Reza Farzizadeh
Reza_Farzizadeh@yahoo.com

Hassan-Ali Kalantari
hassankalantari88@yahoo.com

Asghar Mahmoudi
asgharmahmoodi64@yahoo.com

Omid Yousefi Bilehsavar
o_yousefi@ymail.com

Ali Mehranpour
Alimehranpur@gmail.com

1 Department of Physical Education and Exercise Science, University of Mohaghegh Ardabili, Ardabil, Iran

2 Department of Psychology, Azad University of Ardabil, Ardabil, Iran

adverse impact of obesity on physical health been shown, but it is also associated with mental disorders such as increased depressive symptoms (DS) [4–11], a situation having substantial effects on public health [12].

Despite the strong effect of abdominal obesity on individuals' physical health outcomes, there is little evidence underlying the relationship between central obesity and mental disorders such as depression [11]. It has been reported that body mass index (BMI) as an overall body obesity index was not [9, 13–16] or was even negatively associated with some forms of mental illnesses [9, 17]. Some other studies have shown that fat distribution (e.g., central and overall obesity) is differentially associated with DS [9, 18, 19]. On the other hand, it has been indicated that subcutaneous fat percentage, as an overall body obesity index, can predict obesity better than BMI and concluded that BMI as a measure of overall obesity does not account for varying proportions of muscle mass, bone, and fat, or the distribution of body fat [20, 21]. However, little evidence exists underlying the relationship between subcutaneous fat percentage and depression.

According to the literature, it seems that abdominal obesity is a stronger predictor of DS when compared to overall obesity [11]. However, since the relationship between central obesity and DS may vary according to country of origin, and there is scare evidence for developing countries [11], there is little evidence for children, adolescents, and youths; the majority of the studies did not adjust their analyses for some potential confounders, such as age, socioeconomic status, and physical activity (PA) [17, 18]; therefore, there is a need for further studies [11].

This study explores the relationship between DS with central and overall obesity in a sample of Iranian children, adolescents, and youths.

Methods

Participants and procedure

During 2015–2016, a round of cross-sectional data was collected from a sample of one thousand and fifty-two males ranging from 7 to 24 years old in the center of Ardabil Province, North West of Iran. To select children and adolescents (7–18 years), eight urban public schools were randomly selected. Then, classes were selected randomly in each school, and the children or adolescents in the classes were invited to participate in the study. 780 children and adolescents informed their consent verbally and underwent the measurements. However, since 45 participants did not deliver the signed written consent of their parents, they were excluded from the study. In addition, since 59 participants did not complete all the measurements, their data were excluded from the statistical analyses. To select youths (19-to-24-year-old male students), university students who were studying at the University of Mohaghegh Ardabili were recruited to participate in the study. To this end, from 26 physical education classes, 17 were randomly selected. The procedure of the study was explained to the students, and they were invited to participate in the study. 427 students informed their consent verbally and signed the written consent and underwent the measurements. However, since 51 students did not complete all the measurements, their data were excluded from the statistical analyses. The age of the children and adolescents was determined based on their date of birth in their school registering forms, but the university students wrote their age in the researcher made questionnaire. All measurements were carried out during regularly scheduled physical education lessons. The present study was approved by the Human Ethics Committee of the Ardabil department of Education and University of Mohaghegh Ardabili and the experiment was performed in accordance with the ethical standards of the committee and with the Helsinki Declaration. All the participants volunteered for this study and their informed consents were acquired according to the rules of the department in written signed form for the university students, adolescent (parents' signed form), and children (parents' signed form).

Anthropometric variables

Weight was measured in underwear and without shoes with an electronic scale (Type SECA 861) to the nearest 0.1 kg, and height was measured barefoot in the Frankfurt horizontal plane with a telescopic height measuring instrument (Type SECA 225) to the nearest 1 mm [22, 23]. BMI was calculated as body weight in kilograms divided by the square of height in meters.

Subcutaneous fat skinfold was measured as a general obesity index. Subcutaneous fat skinfold has been suggested as a more reliable overall obesity index than BMI [20, 21]. Lange skinfold caliper was used to assess triceps and calf skinfold thickness on the children and adolescents' right side of the body and the average of three measures was calculated for each site [24, 25]. Then, body fat percentage was calculated according to Slaughter et al. [26]. For the university students, body fat percentage was determined from the average of three measures of the thickness of three sites on the right side of the body (chest, abdomen, and thigh) and calculated according to Jackson–Pollock method [27].

Waist circumference (WC), as a central body obesity index, was measured at a point immediately above the iliac crest on the midaxillary line at minimal respiration to the nearest 0.1 cm [28].

Depressive symptoms (DS)

Children's Depression Inventory (CDI) [29], the most widely used measure of DS in children [4, 5], with good support for its reliability and validity [30, 31], was used to obtain the DS of the children (7–12 years old). Children were recommended to fill out the CDI questionnaire by their parents' supervision. For the participants equal to or younger than 13 years old, the Beck Depression Inventory-II (BDI-II) [32] was employed as a valid measure of DS [33].

Possible covariates/confounders

The participants whose age was between 13 and 18 years were requested to classify themselves in one of the five stages of pubertal maturation status (PMS) defined by Tanner and Whitehouse [34]. Socioeconomic status (SES) was determined on the basis of parents' education and occupation status by collecting data of monthly household income and the highest level of education [4, 5, 22, 24]. Physical activity (PA) for the children and adolescents was obtained using the PA Questionnaire-children (PAQ-C) [35] and PA Questionnaire-adolescents (PAQ-A) [36], respectively, with some alternations to suit to our society [4, 22, 24]. Both questionnaires have been shown valid for PA inventory [37, 38]. For the university students, the 12-month recall Baecke PA questionnaire was used [39] as a valid and reliable PA [PA at work, PA during leisure excluding sport (PAL) and sport during leisure time (PAS)] inventory [40, 41]. Since almost all the students had not jobs, the questions regarding PA at work were excluded.

Statistical analysis

The subjects were categorized into three groups as follows: children (7–12 years), adolescents (13–18 years), and youths (19–24 years). General characteristics (descriptive statistics) of the categorized groups are shown in Table 1. Before further analysis, all data were screened for problems of skewness, kurtosis, and outliers. Hierarchical linear regression analyses were conducted as follows: covariates (including age, SES, PMS, and PA) were included in the first step and obesity indices (WC and fat percentage) were included in the second step, separately. All calculations were performed using SPSS, version 21.0. The significance level was set at $P < 0.05$.

Results

Multiple linear regression analysis revealed significant relationship of DS with age ($P < 0.01$) and PA ($P < 0.05$) in the children (Table 2; step 1 and step 2). Positive but not significant relationship was observed between fat percentage and DS in the children (Table 2, step 2, standardized $\beta = 0.085$; $P = 0.13$). Introducing WC to the model had significant effect (F change $= 5.4$; $P < 0.05$) and showed significant relationship with DS in the children (Table 2, step 2, standardized $\beta = 0.13$; $P < 0.05$).

Significant negative relationship was observed between DS and PA in the adolescents (Table 3, step 1 and 2, $P < 0.05$). Positive but not significant relationship was observed between fat percentage and DS in the adolescents (Table 3, step 2, standardized $\beta = 0.010$; $P = 0.10$). Introducing WC had significant effect on the model (F change $= 4.9$; $P < 0.05$) and showed significant relationship with DS in the adolescents (Table 3, step 2, standardized $\beta = 0.14$; $P < 0.05$).

Significant negative relationship was observed between PAS and DS in the youths (Table 4, step 1 and 2, $P < 0.05$). No significant relationship was observed between fat percentage and DS in youths (Table 4, step 2, $P > 0.05$). Positive but not significant relationship was

Table 1 General characteristics of the participants

	Mean (SD)
Children (7–12 years; $n = 320$)	
Age (year)	10.3 (2.4)
%Fat	23.8 (9.7)
BMI (kg/m^2)	16.5 (2.9)
WC (cm)	58.9 (9.2)
CDI (score)[a]	10.3 (5.2)
PA (score)	2.6 (0.8)
Adolescents (13–18 years; $n = 356$)	
Age (year)	16.4 (1.8)
%Fat	22.5 (9.1)
BMI (kg/m^2)	20.2 (4.2)
WC (cm)	72.1 (11.8)
BDI-II (score)[b]	10.8 (7.5)
PA (score)	2.8 (1.5)
Youths (19–24 years; $n = 376$)	
Age (year)	20.3 (1.4)
%Fat	21.8 (10.3)
BMI (kg/m^2)	22.4 (3.5)
WC (cm)	81.3 (10.6)
BDI-II (score)	12.6 (9.0)
PAS	2.8 (0.8)
PAL	2.7 (0.6)

BDI-II Beck Depression Inventory, *BMI* body mass index, *CDI* Children's Depression Inventory, *PA* physical activity, *PAL* PA during leisure excluding sport, *PAS* sport during leisure time, *SES* socioeconomic status, *WC* waist circumference

[a] CDI scores for 7-to-12-year-old participants

[b] BDI-II score for the subjects ≥13 years

Table 2 Hierarchical regression analysis between DS with central and overall obesity indices after adjustment for the covariates in the children (7–12 years; $n = 356$)

	Depressive symptoms				
	Tolerance	Standardized β (P)	R^2	F change	Adj. R^2
Step 1			0.068	8.0 ($P < 0.01$)	0.060
Age	0.99	0.21 ($P < 0.01$)			
SES	0.99	−0.09 ($P = 0.11$)			
PA	0.99	−0.13 ($P < 0.05$)			
Step 2			0.072	1.7 ($P = 0.20$)	0.061
Age	0.86	0.180 ($P < 0.01$)			
SES	0.99	−0.09 ($P = 0.09$)			
PA	0.96	−0.12 ($P < 0.05$)			
%Fat	0.84	0.085 ($P = 0.13$)			
Step 2			0.083	5.4 ($P < 0.05$)	0.072
Age	0.88	0.16 ($P < 0.01$)			
SES	0.99	−0.09 ($P = 0.08$)			
PA	0.98	−0.12 ($P < 0.05$)			
WC	0.87	0.13 ($P < 0.05$)			

PA physical activity, *SES* socioeconomic status, *WC* waist circumference

Table 3 Hierarchical regression analysis between DS with central and overall obesity indices after adjustment for the covariates in the adolescents (13–18 years; $n = 320$)

	Depressive symptoms				
	Tolerance	Standardized β (P)	R^2	F change	Adj. R^2
Step 1			0.061	7.2 ($P < 0.01$)	0.054
Age	0.99	0.10 ($P = 0.10$)			
PMS	0.99	0.09 ($P = 0.12$)			
SES	0.98	−0.11 ($P = 0.08$)			
PA	0.99	−0.15 ($P < 0.05$)			
Step 2			0.069	1.6 ($P = 0.25$)	0.061
Age	0.89	0.09 ($P = 0.13$)			
PMS	0.98	0.08 ($P = 0.13$)			
SES	0.97	−0.11 ($P = 0.09$)			
PA	0.98	−0.14 ($P < 0.05$)			
%Fat	0.89	0.10 ($P = 0.10$)			
Step 2			0.078	4.9 ($P < 0.05$)	0.070
Age	0.91	0.08 ($P = 0.14$)			
PMS	0.94	0.08 ($P = 0.13$)			
SES	0.98	−0.10 ($P = 0.10$)			
PA	0.98	−0.13 ($P < 0.05$)			
WC	0.90	0.14 ($P < 0.05$)			

PA physical activity, *PMS* pubertal maturation status, *SES* socioeconomic status, *WC* waist circumference

observed between WC and DS in the youths (Table 4, step 2, standardized $\beta = 0.09$; $P = 0.22$).

Discussion

Using a large sample of 7-to-24-year old male participants, it was observed that greater central obesity (but not overall obesity) was significantly associated with DS in the children and adolescents. Although positive relationship was observed between central obesity and DS in the youths, the relationship was not significant in this group. The possible reasons for this relationship in the youths are not clear but may be related to the students' changed situation from school to university and/or their mood while answering the DS questionnaire.

The findings of this study are in line with the previous studies and suggest abdominal obesity as a stronger factor

Table 4 Hierarchical regression analysis between DS with central and overall obesity indices after adjustment for the covariates in the youths (19–24 years; $n = 376$)

	Depressive symptoms				
	Tolerance	Standardized β (P)	R^2	F change	Adj. R^2
Step 1			0.028	1.33 ($P = 0.26$)	0.007
Age	0.99	0.01 ($P = 0.89$)			
SES	0.99	−0.01 ($P = 0.93$)			
PAS	0.98	−0.16 ($P < 0.05$)			
PAL	0.95	−0.02 ($P = 0.79$)			
Step 2			0.029	0.10 ($P = 0.75$)	0.002
Age	0.99	0.01 ($P = 0.89$)			
SES	0.99	−0.01 ($P = 0.97$)			
PAS	0.98	−0.17 ($P < 0.05$)			
PAL	0.94	−0.02 ($P = 0.79$)			
%Fat	0.96	−0.02 ($P = 0.75$)			
Step 2			0.037	1.45 ($P = 0.22$)	0.009
Age	0.98	−0.01 ($P = 0.91$)			
SES	0.99	−0.02 ($P = 0.79$)			
PAS	0.97	−0.15 ($P < 0.05$)			
PAL	0.94	−0.03 ($P = 0.71$)			
WC	0.97	0.09 ($P = 0.22$)			

PAL PA during leisure excluding sport, *PAS* sport during leisure time, *SES* socioeconomic status, *WC* waist circumference

impacting mental health than overall obesity [11] and may be a preferred predictor of depression in human [42]. Furthermore, the findings are in line with other studies indicating that abdominal obesity, more than overall obesity, is related to poor health outcomes, such as cardiovascular diseases, diabetes, and mortality [6–8]. However, one large epidemiological study could not demonstrate an association between WC and depression [43]. Recently, a longitudinal study by including a large sample of older individuals observed that depressed individuals showed a significantly higher increase in abdominal obesity over five years compared with their non-depressed peers, and interestingly, such a relationship was not observed for an increase in general obesity and appeared to be independent of changes in general obesity. The authors concluded that DS was rather specifically related to fat gain in the abdominal region [44].

Some mechanisms have been suggested underlying the positive relationship between abdominal obesity and depression. For instance, it has been shown that chronic stress and depression are associated with a dysregulation of the hypothalamic–pituitary–adrenal axis and elevated concentrations of cortisol [45, 46], while visceral fat is highly sensitive to cortisol concentration [47] by activating lipoprotein lipase and inhibiting lipid mobilization [48]. Moreover, depression has been reported to be associated with high levels of inflammatory markers [49] that can activate the hypothalamic–pituitary–adrenal axis [50] and, in turn, resulting in abdominal obesity. On the other hand, it seems that depressed individuals have an unhealthier lifestyle [44] that may increase their abdominal obesity. For instance, even in individuals with non-hypercortisolemic atypical depression, because of overeating, a cycling of weight loss and gain occurring throughout recurrent episodes of depression can preferentially distribute weight to visceral fat areas [51].

Significant negative relationship was observed between PA and DS for all the participants, and interestingly, in the youths, significant relationship was observed between PAS (but not PAL) and DS. The result is consistent with the results of both cross-sectional and longitudinal studies [4, 5, 52]. In a recent review study, small but significant overall effect for PA on depression in children and adolescents has been demonstrated, and it was concluded that PA may play a role in the prevention and treatment of depression in young people [53].

PA has been suggested as a protective factor against depressed mood and several biological and psychological mechanisms by distracting negative thoughts and influencing self-esteem, and therefore, improving the retrieval of positive thoughts [54]. Neurobiological mechanisms have been reported as other possibilities. For instance, it has been suggested that neurotransmitters released during PA may mediate changes in mood and DS by positively impacting psychological well-being such as self-esteem [53, 55].

Conclusion

In summary, the results indicated that abdominal obesity (but not general obesity) could significantly predict DS in the children and adolescents (but not youths). Furthermore, it was observed that higher PA was significantly associated with lower DS in all the participants. Thus, in line with other studies, mental health status may be monitored and evaluated in these age groups using abdominal obesity [11, 42, 44] and may be protected by efficient PA prescription [53, 56].

However, this study is subject to several limitations. First, the causal relationship between WC and having higher DS may not be established based on the cross-sectional nature of the study. For instance, bidirectional relationship has been reported between obesity and DS, by the existence of some evidence of the association between low SES, the poor social relationship and chronic diseases with obesity which may have predisposed people with obesity to impaired mental health [14, 42]. Second, this study could not include subjects of both sexes. As a result, further research can possibly be done by the simultaneous inclusion of male and female participants.

Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

Informed consent Informed consent was obtained from all individual participants included in the study.

Funding No funding was received for performing the present study.

Ethical approval All procedures performed in studies involving human participants were in accordance with the Human Ethics Committee of Ardabil Department of Education and University of Mohaghegh Ardabili and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

References

1. Flegal KM, Carroll MD, Ogden CL, Curtin LR (2010) Prevalence and trends in obesity among US adults, 1999–2008. JAMA 303:235–241. doi:10.1001/jama.2009.2014
2. Freedman DS, Goodman A, Contreras OA et al (2012) Secular trends in BMI and blood pressure among children and adolescents: the Bogalusa heart study. Pediatrics 130:e159–e166. doi:10.1542/peds.2011-3302
3. Sanders RH, Han A, Baker JS, Cobley S (2015) Childhood obesity and its physical and psychological co-morbidities: a systematic review of Australian children and adolescents. Eur J Pediatr 174:715–746. doi:10.1007/s00431-015-2551-3
4. Esmaeilzadeh S (2014) Relationship between depressive symptoms with physical activity and physical fitness among children. Ment Health Prev 2:11–17. doi:10.1016/j.mhp.2014.05.002
5. Esmaeilzadeh S (2015) The association between depressive symptoms and physical status including physical activity, aerobic and muscular fitness tests in children. Environ Health Prev Med 20:434–440. doi:10.1007/s12199-015-0484-0
6. Nicklas BJ, Penninx BWJH, Cesari M et al (2004) Association of visceral adipose tissue with incident myocardial infarction in older men and women: the health, aging and body composition study. Am J Epidemiol 160:741–749. doi:10.1093/aje/kwh281
7. Ohlson LO, Larsson B, Svardsudd K et al (1985) The influence of body fat distribution on the incidence of diabetes mellitus. 13.5 years of follow-up of the participants in the study of men born in 1913. Diabetes 34:1055–1058. doi:10.2337/diab.34.10.1055
8. Rexrode KM, Carey VJ, Hennekens CH et al (1998) Abdominal adiposity and coronary heart disease in women. JAMA 280:1843–1848. doi:10.1001/jama.280.21.1843
9. Rivenes AC, Harvey SB, Mykletun A (2009) The relationship between abdominal fat, obesity, and common mental disorders: results from the HUNT study. J Psychosom Res 66:269–275. doi:10.1016/j.jpsychores.2008.07.012
10. Ting WH, Huang CY, Tu YK, Chien KL (2012) Association between weight status and depressive symptoms in adolescents: role of weight perception, weight concern, and dietary restraint. Eur J Pediatr 171:1247–1255. doi:10.1007/s00431-012-1753-1
11. Xu Q, Anderson D, Lurie-Beck J (2011) The relationship between abdominal obesity and depression in the general population: a systematic review and meta-analysis. Obes Res Clin Pract 5:e267–e278. doi:10.1016/j.orcp.2011.04.007
12. Moussavi S, Chatterji S, Verdes E et al (2007) Depression, chronic diseases, and decrements in health: results from the world health surveys. Lancet 370:851–858. doi:10.1016/S0140-6736(07)61415-9
13. Hach I, Ruhl UE, Klose M et al (2007) Obesity and the risk for mental disorders in a representative German adult sample. Eur J Public Health 17:297–305
14. Herva A, Laitinen J, Miettunen J (2006) Obesity and depression: results from the longitudinal Northern Finland 1966 birth cohort study. Int J Obes (Lond) 30:520–527. doi:10.1038/sj.ijo.0803174
15. Pagoto SL, Ma Y, Bodenlos JS et al (2009) Association of depressive symptoms and lifestyle behaviors among Latinos at risk of type 2 diabetes. J Am Diet Assoc 109:1246–1250. doi:10.1016/j.jada.2009.04.010
16. Turley M, Tobias M, Paul S (2006) Non-fatal disease burden associated with excess body mass index and waist circumference in New Zealand adults. Aust N Z J Public Health 30:231–237. doi:10.1111/j.1467-842X.2006.tb00863.x
17. Ho RC, Niti M, Kua EH, Ng TP (2008) Body mass index, waist circumference, waist-hip ratio and depressive symptoms in Chinese elderly: a population-based study. Int J Geriatr Psychiatry 23:401–408
18. Ahlberg AC, Ljung T, Rosmond R et al (2002) Depression and anxiety symptoms in relation to anthropometry and metabolism in men. Psychiatry Res 112:101–110. doi:10.1016/S0165-1781(02)00192-0
19. Everson-Rose SA, Lewis TT, Karavolos K et al (2009) Depressive symptoms and increased visceral fat in middle-aged women. Psychosom Med 71:410–416. doi:10.1097/PSY.0b013e3181a20c9c
20. Nooyens AC, Koppes LL, Visscher TL et al (2007) Adolescent skinfold thickness is a better predictor of high body fatness in adults than is body mass index: the Amsterdam growth and health longitudinal study. Am J Clin Nutr 85:1533–1539
21. Sarrıa A, Garcı a-Llop LA, Moreno LA et al (1998) Skinfold thickness measurements are better predictors of body fat percentage than body mass index in male Spanish children and adolescents. Eur J Clin Nutr 52:573–576

22. Kalantari HA, Esmaeilzadeh S (2016) Association between academic achievement and physical status including physical activity, aerobic and muscular fitness tests in adolescent boys. Environ Health Prev Med 21:27–33. doi:10.1007/s12199-015-0495-x
23. Esmaeilzadeh S (2014) Reaction time: does it relate to weight status in children? HOMO-J Compar Hum Biol 65:171–178. doi:10.1016/j.jchb.2013.09.007
24. Moradi A, Esmaeilzadeh S (2015) Association between reaction time, speed and agility in schoolboys. Sport Sci Health 11:251–256. doi:10.1007/s11332-015-0230-4
25. Esmaeilzadeh S, Kalantari HA (2013) Physical fitness, physical activity, sedentary behavior and academic performance among adolescent boys in different weight statuses. Mediterr J Nutr Metab 6:207–216. doi:10.1007/s12349-013-0133-3
26. Slaughter MH, Lohman TG, Boileau RA et al (1988) Skinfold equations for estimation of body fatness in children and youth. Hum Biol 60:709–723
27. Jackson AS, Pollock ML (1978) Generalized equations for prediction body density of men. Br J Nutr 40:497–504
28. Chumlea NC, Kuczmarski RJ (1995) Using a bony landmark to measure waist circumference. J Am Diet Assoc 95:12
29. Kovacs M (1992) Manual for the children's depression inventory (CDI). Multihealth System, Norton
30. Al-Balhan EM (2006) The children's depression inventory as a reliable measure for post—Iraqi invasion Kuwaiti Youth. Soc Behav Pers 34:351–355
31. Dehshiri GH, Najafi M, Sheykh M, Habibi A (2009) Investigating primary psychometric properties of children's depression inventory (CDI). J Family Res 5:159–177 **(Persian)**
32. Beck AT, Steer RA, Brown GK, Lindfors J (2006) BDI-II: beck depression inventory: manual, svensk version. Stockholm, Psykologiförlaget
33. Ghassemzadeh H, Mojtabai R, Karamghadiri N, Ebrahimkhani N (2005) Psychometric properties of a Persian-language version of the Beck depression inventory-second edition: BDI-II-PERSIAN. Depression Anxiety 21:185–192
34. Tanner JM, Whitehouse RH (1976) Clinical longitudinal standards for height, weight, height velocity and stages of puberty. Arch Dis Child 51:170–179
35. Kowalski KC, Crocker PRE, Faulkner RA (1997) Validation of the physical activity questionnaire for older children. Pediatr Exerc Sci 9:174–186
36. Kowalski KC, Crocker PRE, Kowalski NP (1997) Convergent validity of the physical activity questionnaire for adolescents. Pediatr Exerc Sci 9:342–352
37. Crocker PRE, Bailey DA, Faukner RA (1997) Measuring general levels of physical activity: preliminary evidence for the physical activity questionnaire for older children. Med Sci Sports Exerc 29:1344–1349
38. Janz KF, Lutuchy EM, Wenthe P, Levy SM (2008) Measuring activity in children and adolescents using self-report: PAQ-C and PAQ-A. Med Sci Sports Exerc 40:767–772. doi:10.1249/MSS.0b013e3181620ed1
39. Baecke J, Burema J, Frijters J (1982) A short questionnaire for the measurement of habitual physical activity in epidemiological studies. Am J Clin Nutr 36:936–942
40. Pereira MA, Fitzgergerald SJ, Gregg EW et al (1997) A collection of physical activity questionnaires for health-related research. Med Sci Sports Exerc 29:S1–S205
41. Westerterp KR (1999) Assessment of physical activity level in relation to obesity: current evidence and research issues. Med Sci Sports Exerc 31:S522–S525
42. Zhao G, Ford ES, Li C et al (2011) Waist circumference, abdominal obesity, and depression among overweight and obese U.S. adults: national health and nutrition examination survey 2005–2006. BMC Psychiatry 11:130. doi:10.1186/1471-244X-11-130
43. Hach I, Ruhl UE, Klotsche J et al (2006) Associations between waist circumference and depressive disorders. J Affect Disord 92:305–308. doi:10.1016/j.jad.2006.01.023
44. Vogelzangs N, Kritchevsky SB, Beekman AT et al (2008) Depressive symptoms and change in abdominal obesity among older persons. Arch Gen Psychiatry 65:1386–1393. doi:10.1001/archpsyc.65.12.1386
45. Chrousos GP, Gold PW (1992) The concepts of stress and stress system disorders. Overview of physical and behavioral homeostasis. JAMA 267:1244–1252. doi:10.1001/jama.1992.03480090092034
46. Deuschle M, Weber B, Colla M et al (1998) Effects of major depression, aging and gender upon calculated diurnal free plasma cortisol concentrations: a re-evaluation study. Stress 2:281–287. doi:10.3109/10253899809167292
47. Bronnegard M, Arner P, Hellstrom L et al (1990) Glucocorticoid receptor messenger ribonucleic acid in different regions of human adipose tissue. Endocrinology 127:1689–1696
48. Bjorntorp P, Rosmond R (2000) Neuroendocrine abnormalities in visceral obesity. Int J Obes Relat Metab Disord 24(Suppl 2):S80–S85
49. Penninx BW, Kritchevsky SB, Yaffe K et al (2003) Inflammatory markers and depressed mood in older persons: results from the health, aging and body composition study. Biol Psychiatry 54:566–572. doi:10.1016/S0006-3223(02)01811-5
50. Kyrou I, Chrousos GP, Tsigos C (2006) Stress, visceral obesity, and metabolic complications. Ann N Y Acad Sci 1083:77–110. doi:10.1196/annals.1367.008
51. Gold PW, Chrousos GP (2002) Organization of the stress system and its dysregulation in melancholic and atypical depression: high vs low CRH/NE states. Mol Psychiatry 7:254–275. doi:10.1038/mp.2014.163
52. Jonsdottir IH, Rodjer L, Hadzibajramovic E et al (2010) A prospective study of leisure-time physical activity and mental health in Swedish health care workers and social insurance officers. Prev Med 51:373–377. doi:10.1016/j.ypmed.2010.07.019
53. Brown HE, Pearson N, Braithwaite RE (2013) physical activity interventions and depression in children and adolescents. Sports Med 43:195–206. doi:10.1007/s40279-012-0015-8
54. Birkeland MS, Torsheim T, Wold B (2009) A longitudinal study of the relationship between leisure-time physical activity and depressed mood among adolescents. Psychol Sport Exer 10:25–34. doi:10.1016/j.psychsport.2008.01.005
55. Biddle SJH, Asare M (2011) Physical activity and mental health in children and adolescents: a review of reviews. Br J Sport Med 45:886–895. doi:10.1136/bjsports-2011-090185
56. Janssen I, LeBlanc AG (2010) Review Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. Int J Behav Nutr Phys Act 7:40. doi:10.1186/1479-5868-7-40