



Original Article

## Metabolic syndrome and associated factors in Iranian children and adolescents: the CASPIAN-V study

Ramin Heshmat<sup>1</sup>, Zeinab Hemati<sup>2</sup>, Mostafa Qorbani<sup>3,4\*</sup>, Laleh Nabizadeh Asl<sup>1,5</sup>, Mohammad Esmaeil Motlagh<sup>6</sup>, Hasan Ziaodini<sup>7</sup>, Majzoubeh Taheri<sup>8</sup>, Zeinab Ahadi<sup>1</sup>, Gita Shafiee<sup>1</sup>, Tahereh Aminaei<sup>8</sup>, Hooman Hatami<sup>9</sup>, Roya Kelishadi<sup>2\*</sup>

<sup>1</sup>Chronic Diseases Research Center, Endocrinology and Metabolism Population Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

<sup>2</sup>Pediatrics Department, Child Growth and Development Research Center, Research Institute for Primordial Prevention of Non-communicable Disease, Isfahan University of Medical Sciences, Isfahan, Iran

<sup>3</sup>Non-Communicable Diseases Research Center, Alborz University of Medical Sciences, Karaj, Iran

<sup>4</sup>Endocrinology and Metabolism Research Center, Endocrinology and Metabolism Clinical Sciences Institute, Tehran University of Medical Sciences, Tehran, Iran

<sup>5</sup>Department of Nutrition and Dietetics, Faculty of Health Sciences, Hacettepe University, Ankara, Turkey

<sup>6</sup>Pediatrics Department, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran

<sup>7</sup>Bureau of Health and Fitness, Ministry of Education and Training, Tehran, Iran

<sup>8</sup>Office of Adolescents and School Health, Ministry of Health and Medical Education, Tehran, Iran

<sup>9</sup>Student Research Committee, Alborz University of Medical Sciences, Karaj, Iran

### Article info

#### Article History:

Received: 20 August 2017  
Accepted: 16 November 2018  
published: 5 December 2018

#### Keywords:

Metabolic Syndrome  
Obesity  
Pediatric

### Abstract

**Introduction:** Metabolic syndrome (MetS) is one of the common metabolic disorders seen in children and adolescents. This study aims to assess the rate of the MetS and its associated factors in a nationally-representative sample of Iranian pediatric age groups.

**Methods:** This nationwide cross-sectional study was designed in 2015 in 30 provinces of Iran. Participants consisted of 4,200 school students, aged 7-18 years, studied in a national school-based surveillance program (CASPIAN-V). Physical examination and laboratory tests were performed using standard protocols. Blood samples were drawn from 3834 students for biochemical tests.

**Results:** The participation rate for blood sampling was 91.5%. MetS was significantly more prevalent among students in urban than in rural areas (5.7% vs. 4.8%,  $P$  value < 0.01). MetS was more prevalent in students with obese parents than in those with non-obese parents (6.4% vs. 4.5%,  $P$  value < 0.05). Significant association existed between moderate level of healthy nutritional behaviors and MetS after controlling for potential confounders (odds ratio [OR]: 0.62, 95% CI: 0.40-0.98). Students with high unhealthy nutritional behaviors showed an increased risk of MetS in crude (OR: 1.6, 95% CI: 1.05-2.44) and adjusted model (OR: 1.65, 95% CI: 1.05-2.63).

**Conclusion:** High rate of MetS and associated risk factors was observed in Iranian pediatric age groups, with higher rates among boys. These findings provide useful information for effective preventive strategies based on diet, exercise, and lifestyle modification rather than therapeutic modalities.

**Please cite this article as:** Heshmat R, Hemati Z, Qorbani M, Nabizadeh Asl L, Motlagh ME, Ziaodini H, Taheri M, Ahadi Z, Shafiee G, Aminaei T, Hatami H, Kelishadi R. Metabolic syndrome and associated factors in Iranian children and adolescents: the CASPIAN-V study. *J Cardiovasc Thorac Res* 2018;10(4):214-220. doi: 10.15171/jcvtr.2018.37.

### Introduction

The prevalence of non-communicable diseases (NCDs) is rapidly increasing worldwide, with special concern in developing communities. It estimated that NCDs will account 75% of global mortality rate especially in low- and middle- income countries.<sup>1</sup> According to the Global Burden of Disease Study metabolic risk factors are the

most important determinants of emerging problem of NCDs at global level.<sup>2,3</sup>

Metabolic syndrome (MetS) is one of the most common metabolic disorders, which leads to many NCDs as cardiovascular diseases, diabetes mellitus, some cancers, kidney disease, and mental disorders. The concept of MetS in pediatric group gained great concern during

\*Corresponding Authors: Mostafa Qorbani, Email: Mqorbani1379@yahoo.com; Roya Kelishadi, Email: roya.kelishadi@gmail.com

© 2018 The Author (s). This is an open access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

last decades because of various factors including gene-environment interactions, epidemiologic transition, nutritional disorders, sedentary lifestyle, and escalating trend of childhood obesity.<sup>4,5</sup>

Previous studies suggested that generalizes and abdominal obesity, weight disorder,<sup>6</sup> dietary factors,<sup>7</sup> sedentary lifestyle<sup>8,9</sup> are the most of risk factors for MetS. According to various definitions of MetS, the rate of MetS in the pediatric age group, ranges between 0% to 19.2%.<sup>10</sup>

Although MetS has been extensively studied in adults, but limited evidence exists in pediatric group. Furthermore, considering that MetS tracks from childhood to adulthood, early detection of MetS prevent from subsequent clinical complications.<sup>11</sup> In recent decades, Iran due to rapid epidemiological transition state is facing double burden of weight disorder, and MetS is documented even in young Iranian children.<sup>12</sup>

Present study aims to determine the prevalence of the MetS and its associated factors in a nationally representative sample of Iranian pediatric age groups.

### Materials and Methods

This national wide cross-sectional study was designed in 2015 as the fifth survey of a national surveillance program entitled "Childhood and Adolescence Surveillance and Prevention of Adult Non-communicable Disease (CASPIAN-V) study. This study was accomplished among aged 7–18 year-old students in urban and rural regions of 30 provinces of Iran, by via stratified cluster sampling method.<sup>13</sup> There were 48 clusters in each province and 10 statistical units in each cluster, so a total of 14400 students were participated in this study. In each province, randomly 14 clusters out of 48 clusters were selected for blood sample test and overall 4200 students were selected for biochemical test. Data for some variables were missing. Sample size was estimated according to previous published study in Iranian children and adolescent,<sup>14</sup> and using one proportion estimate formula for sample size and considering this formula the prevalence of MetS was considered as 4% ,  $\alpha$ - error 5%, and precision was considered 0.6%, that sample size was 14400 students.

Study objectives and protocol were clarified prior to obtaining the informed written and verbal consents from the parents and students. A comprehensive description of the protocol has been described previously.<sup>13</sup>

### Procedure and measurements

Data were collected by the translated and validated questionnaire of the World Health Organization-Global School Students Health Survey (WHO-GSHS).<sup>15</sup>

Physical examination including weight and height was done under standard anthropometric. Weight was measured to the nearest 0.1 kg using a calibrated scale placed on a flat ground and height was measured to the nearest 0.1 cm using a portable audiometer.<sup>16</sup> Body mass index (BMI) was calculated as weight (kg) divided by

height squared ( $m^2$ ). Waist circumference was measured to the nearest 0.1 cm three times and the average of three values was used for the analyses. A non-elastic tape was used to measure waist circumference at a point midway between the lower border of the rib cage and the iliac crest at the end of normal expiration.<sup>17</sup> A mercury sphygmomanometer was used to measure BP on the right arm while participants were in the sitting position. Blood pressure (BP) was measured 2 times at 5 min intervals, and the average of the two values was used for the analyses.<sup>18</sup> After 12 hours overnight fasting, venous blood sample was collected from students. Fasting blood glucose, triglycerides (TGs), total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C) and high-density lipoprotein cholesterol (HDL-C) were measured enzymatically by Hitachi Auto Analyzer (Tokyo, Japan).<sup>19,20</sup>

### Definition of terms

The screen time (ST) behaviors was asked the numbers of hours that students spent watching television (TV) and/or videos, personal computer, or electronic games per day. Low ST was defined as less than 2 hours per day, and high ST was defined as a spending more than 2 hours per day for watching TV, and/or videos, personal computer, or electronic games.<sup>21</sup>

SES was calculated according previous study.<sup>22</sup> SES was constructed using principle component analysis (PCA) method and considering some variables including father's job and education, mother's job and education, having private car and computer, and type of student's school (private, public). SES was categorized as a tertile and the lowest tertile considered as a low SES and the third tertile as a high SES.

To define healthy and unhealthy nutritional behaviors, students were asked to determine frequency of consumption of breakfast, fruit, vegetables, milk, sugar sweetened beverages, fast foods, sweets and salty snacks. According to PCA method,<sup>23</sup> two factors were loaded in PCA method; in the first factor which defined as healthy eating behavior consumption and in the second factor which defined as unhealthy eating behavior. Healthy and unhealthy eating behaviors factor was categorized into tertiles. The first tertile was defined as a low, second tertile as a moderate and third tertile as a high.

Validated questionnaire was used to measure physical activity (PA).<sup>24</sup> Physical activity was categorized into two groups. The first group was defined as a low, second group as a high.

MetS was defined according to modified definition ATP III for children. Students were categorized as having MetS if they had more than three following criteria: fasting TG  $\geq 150$  mg/dL; HDL cholesterol  $\leq 40$  mg/dL; waist circumference (WC)  $\geq 90$ th percentile for age and sex, according to national reference curves; SBP and/or DBP  $> 90$ th percentile for sex, age and height, from national reference cut-off points; and FBG  $\geq 100$  mg/dL. LDL-C

$\geq 110$  mg/dL, TC  $\geq 200$  mg/dL, overweight and obesity also were determined as risk factors of MetS.<sup>25</sup> Obesity was defined according WHO chart and students were categorized overweight and obese if MBI > 85th–95th, and BMI >95th, respectively.<sup>26</sup>

### Statistical analysis

Categorical variables were reported as frequency (percent). Chi-square test was used to assess association between categorical variables. Association between independent variables with MetS was assessed using two different logistic regression models: In model I crud association and in model II was adjusted for age, sex, region, SES, ST, PA, and BMI. All statistical analysis was performed using STATA version 11.0 and significant level was considered as  $P$  value < 0.05.

### Results

The participation rate of students for blood sample was 91.5% (3844 out of 4200 students selected for blood sampling). Totally 49.4% of students were girls and 71.4% lived in urban areas. The mean (SD) age of students was  $12.3 \pm 3.2$  years. The frequency of demographic and nutritional characteristics of participants was shown in Table 1.

Table 2 showed prevalence of MetS according to demographic and nutritional characteristics. The prevalence of MetS was significant higher in urban areas than rural areas (5.7% vs. 4.8%,  $P < 0.01$ ). Students with obese parents had higher frequency of MetS than those with non-obese parents (6.4% vs. 4.5%,  $P < 0.05$ ). The greater number of MetS components was significantly associated with gender, age, region and healthy nutritional behaviors in students ( $P < 0.05$ ). Boys compared to girls and students in urban areas compared to rural areas had higher number of MetS components ( $P < 0.05$ ). ST, SES, Unhealthy nutritional behaviors, parental obesity and PA were not associated with the number of MetS components ( $P > 0.05$ ).

The adjusted and crude odds ratios (95% confidence intervals) for association between MetS and independent variables are presented in Table 3. Negative association was documented in the crude analysis between living in rural region and MetS (odds ratio [OR]: 0.57, 95% CI: 0.39–0.83), but this became non-significant after controlling for confounders (OR: 0.71, 95% CI: 0.46–1.12). According to crude OR, students with excess weight were 6.1 times more likely to have MetS (OR: 6.19, 95% CI: 3.55–10.79) and this association, although reduced, remained significant after adjustment for potential confounding factors (OR: ratio 4.24, 95% CI: 2.93–6.15). The association between healthy nutritional behavior and MetS was significant after adjusted potential confounders (OR: 0.62, 95% CI: 0.40–0.98). Students with high unhealthy nutritional behaviors showed increased risk of MetS in both crude (OR: 1.6, 95% CI: 1.05–2.44) and adjusted models (OR: 1.65, 95%

**Table 1.** Frequency of demographic and nutritional characteristics: the CASPIAN -V study

Variable	No.	%	
Sex	Male	2013	52.4
	Female	1831	47.6
	Missing	0	0
Age (y)	7-10	1147	29.8
	11-14	1655	43.1
	15-18	1042	27.1
	Missing	0	0
	Region	Urban	2776
Rural		1068	27.8
Missing		0	0
PA	Low	2229	58.0
	High	1584	41.2
	Missing	32	0.8
SES	Low	1244	32.4
	Moderate	1220	31.7
	High	1205	31.3
	Missing	175	4.6
ST	Low	3226	83.9
	High	518	13.5
	Missing	100	2.6
Healthy nutritional behaviors	Low	1046	27.2
	Moderate	1016	26.4
	High	1057	27.5
	Missing	725	18.9
Unhealthy nutritional behaviors	Low	988	25.7
	Moderate	1106	28.8
	High	1025	26.7
Parental obesity	Missing	725	18.9
	Yes	1365	35.5
	No	2419	62.9
MetS	Missing	60	1.6
	Yes	188	4.9
	No	3544	92.2
	Missing	112	2.9

PA: physical activity; ST: screen time; SES: socioeconomic status; MetS, Metabolic syndrome.

CI: 1.05–2.63).

### Discussion

This nationwide study serves as confirmatory evidence on the importance of considering MetS in health issue of children and adolescents. The prevalence of MetS was high in urban, boys, and in those with obese parents.

Most of the previous studies in representative samples have demonstrated that MetS was more prevented in urban than rural areas.<sup>11,12,27,28</sup> The lower prevalence of MetS in rural children might be because of their healthier lifestyle, in terms of higher physical activity and healthier dietary habits than their urban counterparts.

This study showed that parental obesity was associated with MetS of students. This finding was consistent with previous evidence that showed parental obesity is one

**Table 2.** Prevalence of metabolic syndrome according to demographic and nutritional characteristics: the CASPIAN -V study

Variable		MetS		Number of MetS components			
		Yes	No	0	1	2	3<
Sex	Male	108 (5.5)	1856 (94.5)	706 (35.9)	747 (38.0)	403 (20.5)	108 (5.5)
	Female	80 (4.5)	1688 (95.5)	737 (41.7)	610 (34.5)	341 (19.3)	80 (4.5)
	<i>P</i> value*	0.174		0.004			
Age (y)	7-10	55 (4.9)	1061 (95.1)	487 (43.6)	391 (35.0)	183 (16.4)	55 (4.9)
	11-14	85 (5.3)	1524 (94.7)	628 (39.0)	580 (36.0)	316 (19.6)	85 (5.3)
	15-18	48 (4.8)	959 (95.2)	328 (32.6)	386 (38.3)	245 (24.3)	48 (4.8)
	<i>P</i> value*	0.825		<0.001			
Region	Urban	154 (5.7)	2560 (94.3)	1008 (37.1)	992 (36.6)	560 (20.6)	154 (5.7)
	Rural	34 (3.3)	984 (96.7)	435 (42.7)	365 (35.9)	184 (18.1)	34 (3.3)
	<i>P</i> value*	0.004		0.001			
PA	Low	122 (5.6)	2046 (94.4)	822 (37.9)	788 (36.3)	436 (20.1)	122 (5.6)
	High	66 (4.3)	1474 (95.7)	612 (39.7)	558 (36.2)	304 (19.7)	66 (4.3)
	<i>P</i> value*	0.067		0.257			
SES	Low	66 (5.5)	1143 (94.5)	480 (39.7)	415 (34.3)	248 (20.5)	66 (5.5)
	Moderate	59 (5.0)	1122 (95.0)	451 (38.2)	453 (38.4)	218 (18.5)	59 (5.0)
	High	55 (4.7)	1121 (95.3)	450 (38.3)	427 (36.3)	244 (20.7)	55 (4.7)
	<i>P</i> value*	0.680		0.453			
ST	Low	159 (5.1)	2980 (94.9)	1220 (38.9)	1136 (36.2)	624 (19.9)	159 (5.1)
	High	26 (5.2)	475 (94.8)	191 (38.1)	182 (36.3)	102 (20.4)	26 (5.2)
	<i>P</i> value*	0.906		0.988			
Healthy nutritional behaviors	Low	61 (5.9)	974 (94.1)	391 (37.8)	349 (33.7)	234 (22.6)	61 (5.9)
	Moderate	42 (4.2)	961 (95.8)	421 (42.0)	352 (35.1)	188 (18.7)	42 (4.2)
	High	51 (4.9)	987 (95.1)	395 (38.1)	395 (38.1)	197 (19.0)	51 (4.9)
	<i>P</i> value*	0.207		0.036			
Unhealthy nutritional behaviors	Low	36 (3.7)	932 (96.3)	365 (37.7)	360 (37.2)	207 (21.4)	36 (3.7)
	Moderate	59 (5.4)	1036 (94.6)	432 (39.5)	399 (36.4)	205 (18.7)	59 (5.4)
	High	59 (5.8)	954 (94.2)	410 (40.5)	337 (33.3)	207 (20.4)	59 (5.8)
	<i>P</i> value*	0.077		0.117			
Parental obesity	Yes	51 (6.4)	751 (93.6)	291 (36.3)	294 (36.7)	166 (20.7)	51 (6.4)
	No	130 (4.5)	2743 (95.5)	1133 (39.4)	1042 (36.3)	568 (19.8)	130 (4.5)
	<i>P</i> value*	0.034		0.103			

PA: physical activity; ST: screen time; SES: socioeconomic status; MetS, Metabolic syndrome.

\* According to chi-squared test

of the risk factors.<sup>29,30</sup> Children of obese parents are five times more likely to be obese.<sup>31</sup> A study in Serbia reported higher maternal body weight in children and adolescents diagnosed with MetS.<sup>32</sup> Family studies show that genetic factors account for about 50% of the variance in intra-abdominal fat even after controlling potential confounders for age, sex and total body fat.<sup>33</sup> Other studies show that children of hypertensive parents also have more insulin resistance and higher blood pressure, serum cholesterol and triglyceride levels than controls.<sup>34,35</sup> In Mexican Americans, parental type 2 diabetes is the most predictive factor for the development of MetS.<sup>30</sup> We found that number of MetS components was correlated with male gender, higher age, urban residence

and unhealthy dietary habits. Prevalence of MetS in adolescents was 13% including 21% of boys and 4% of girls in the United Arab Emirates.<sup>36</sup>

In the present study, children and adolescents with excess weight, i.e. obese and overweight, were 6.1 times more likely to have MetS which was consistent with previous studies.<sup>37-41</sup>

Our results found that consuming unhealthy nutritional behaviors was associated with increased risk of MetS.

A study of 14-year-old Australian adolescents found that Western dietary pattern was positively correlated with OR of MetS.<sup>42</sup> A systematic review on 3168 Korean adolescents (13-18 years) between 1998-2009 showed that MetS was associated with western dietary pattern

**Table 3.** Association of independent variables with metabolic syndrome in logistic regression model: the CASPIAN-V study

		Crude		Adjusted	
		OR	95% CI	OR	95% CI
Gender	Male	Reference	-	Reference	-
	Female	0.81	0.6-1.09	0.76	0.53-1.09
Age (year)	7-10	Reference	-	Reference	-
	11-14	1.07	0.76-1.52	1.04	0.68-1.58
	15-18	0.96	0.64-1.43	0.92	0.57-1.49
Region	Urban	Reference	-	Reference	-
	Rural	0.57	0.39-0.83*	0.71	0.46-1.12
PA	Low	Reference	-	Reference	-
	High	0.67	0.98-1.81	1.13	0.77-1.65
SES	Low	Reference	-	Reference	-
	Moderate	0.91	0.63-1.30	0.72	0.48-1.10
	High	0.85	0.58-1.2	0.68	0.44-1.04
ST	Low	Reference	-	Reference	-
	High	1.02	0.67-1.57	1.04	0.61-1.80
BMI	Normal weight	Reference	-	Reference	-
	Underweight	1.43	0.81-2.50	0.90	0.49-1.64
	Excess weight	6.19	3.55-10.79*	4.24	2.93-6.15*
Healthy nutritional behaviors	Low	Reference	-	Reference	-
	Moderate	0.69	0.46-1.04	0.62	0.40-0.98*
	High	0.82	0.56-1.20	0.83	0.55-1.26
Unhealthy nutritional behaviors	Low	Reference	-	Reference	-
	Moderate	1.47	0.96-2.25	1.49	0.94-2.36
	High	1.60	1.05-2.44*	1.65	1.05-2.63*
Parental obesity	No	Reference	-	Reference	-
	Yes	1.33	1.02-2.01	1.21	0.82-1.80

PA: physical activity; ST: screen time; SES: socioeconomic status; MetS, Metabolic syndrome; BMI, body mass index.

\* Statistically significant.

and traditional dietary pattern protectively associated with cardio metabolic risk factors.<sup>43</sup> Positive association between energy-dense, high fat, low-fiber dietary patterns and fat mass index is documented, as well.<sup>44</sup>

In our study, sedentary life style was associated with MetS. This finding is line with previous evidence that screen time is associated with cardio-metabolic risk factors.<sup>36,45</sup> The inverse association between PA and risk of MetS which was observed in current study was consistent with previous study which was performed in Danish pediatric population.<sup>46</sup> In another study, lower PA was associated with MetS in both gender.<sup>47</sup>

One of the main limitation of this study is cross-sectional nature of study which preclude causal inference. Large and representative sample size are the main strengths of present study.

### Conclusion

The high prevalence of MetS and related risk factors in Iranian children and adolescents provides useful information for implementing effective preventive strategies based on diet, exercise, and life style modification rather than therapeutic modalities in later life.

### Ethical approval

This study was approved by ethical committee of Isfahan University of Medical Sciences.

### Competing interests

All authors declare no competing financial interests exist.

### Funding

Data of a national surveillance program, funded by the Ministry of Health, were used for the current study.

### Acknowledgments

The authors are thankful of all participants and large team working on this project in different provinces.

### References

1. MBoutayeb A, Boutayeb S. The burden of non-communicable diseases in developing countries. *Int J Equity Health* 2005;4(1):2. doi:10.1186/1475-9276-4-2
2. Lim SS, Vos T, Flaxman AD, Danaei G, Shibuya K, Adair-Rohani H, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: A systematic analysis for the global burden of disease study 2010. *Lancet* 2012;380(9859):2224-60. doi:10.1016/S0140-6736(12)61766-8
3. Stevens GA, Singh GM, Lu Y, Danaei G, Lin JK, Finucane MM, et al. National, regional, and global trends in adult overweight

- and obesity prevalences. **Popul Health Metr** 2012;10(1):22. doi: 10.1186/1478-7954-10-22.
4. Kelishadi R, Hovsepian S, Djalalinia S, Jamshidi F, Qorbani M. A systematic review on the prevalence of metabolic syndrome in Iranian children and adolescents. **J Res Med Sci** 2016; 21:90. doi: 10.4103/1735-1995.192506
  5. Kelishadi R, Poursafa P. A review on the genetic, environmental, and lifestyle aspects of the early-life origins of cardiovascular disease. **Curr Probl Pediatr Adolesc Health Care** 2014 44(3):54-72. doi: 10.1016/j.cppeds.2013.12.005.
  6. Elks CM, Francis JCH. Central Adiposity, Systemic Inflammation, and the Metabolic Syndrome. **Curr Hypertens Rep** 2010;12(2):99-104. doi: 10.1007/s11906-010-0096-4.
  7. Kapourchali FR, Surendiran G, Goulet A, Moghadasian MH. The Role of Dietary Cholesterol in Lipoprotein Metabolism and Related Metabolic Abnormalities: A Mini-review. 2016, 56, 2408-2415. **Crit Rev Food Sci Nutr** 2016;56(14):2408-15. doi: 10.1080/10408398.2013.842887.
  8. Shenghui Wu, Susan P. Fisher-Hoch, Belinda Reininger, McCormick JB. Recommended Levels of Physical Activity Are Associated with Reduced Risk of the Metabolic Syndrome in Mexican-Americans. **PLoS One** 2016;11(4):e0152896. doi: 10.1371/journal.pone.0152896.
  9. Hwang H-J, Kim S-H. The association among three aspects of physical fitness and metabolic syndrome in a Korean elderly population. **Diabetol Metab Syndr** 2015;7:112. doi: 10.1186/s13098-015-0106-4.
  10. Friend A, Craig L, Turner S. The prevalence of metabolic syndrome in children: a systematic review of the literature. **Metab Syndr Relat Disord** 2013;11(2):71-80. doi: 10.1089/met.2012.0122.
  11. Khashayar P, Heshmat R, Qorbani M, Motlagh ME, Aminae T, Ardalan G, et al. Metabolic Syndrome and Cardiovascular Risk Factors in a National Sample of Adolescent Population in the Middle East and North Africa: The CASPIAN III Study. **Int J Endocrinol** 2013;2013(12):702095. doi: 10.1155/2013/702095.
  12. Kelishadi R, Ardalan G, Gheiratmand R, Adeli K, Delavari A, Majdzadeh R. Paediatric metabolic syndrome and associated anthropometric indices: The CASPIAN Study. **Acta Paediatr** 2006;95(12):1625-34. doi:10.1080/08035250600750072
  13. Motlagh ME, Ziaodini H, Qorbani M, Taheri M, Aminae T, Goodarzi A, et al. Methodology and early findings of the fifth survey of childhood and adolescence surveillance and prevention of adult non-communicable disease: The CASPIAN-V study. **Int J Prev Med** 2017;8:4. doi: 10.4103/2008-7802.198915.
  14. Kelishadi R, Heshmat R, Farzadfar F, Esmail Motlag M, Bahreynian M, Safiri S, et al. Prevalence of cardio-metabolic risk factors in a nationally representative sample of Iranian adolescents: The CASPIAN-III Study. **J Cardiovasc Thorac Res** 2017;9(1):12-20. doi: 10.15171/jcvtr.2017.02.
  15. Kelishadi R, Motlagh ME, Roomizadeh P, Abtahi S-H, Qorbani M, Taslimi M, et al. First report on path analysis for cardiometabolic components in a nationally representative sample of pediatric population in the Middle East and North Africa (MENA): the CASPIAN-III Study. **Ann Nutr Metab** 2013;62(3):257-65. doi: 10.1159/000346489.
  16. Health WO. **Expert committee on physical status. Physical Status: The use and interpretation of anthropometry.** Geneva: WHO: 1995.
  17. Knowles K, Paiva L, Sanchez S, Revilla L, Lopez T, Yasuda M, et al. Waist circumference, body mass index, and other measures of adiposity in predicting cardiovascular disease risk factors among Peruvian adults. **Int J Hypertens** 2011;2011. doi: 10.4061/2011/931402.
  18. Pediatrics AAo. National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents. 2004 0031-4005 Contract No.: Supplement 2.
  19. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. **Clin Chem** 1972;18(6):499-502.
  20. McNamara JR, Schaefer EJ. Automated enzymatic standardized lipid analyses for plasma and lipoprotein fractions. **Clin Chim Acta** 1987;166(1):1-8.
  21. Salmon J, Campbell KJ, Crawford DA. Television viewing habits associated with obesity risk factors: a survey of Melbourne schoolchildren. **Med J Aust** 2006;184(2):64.
  22. Caro DH, Cortés D. Measuring family socioeconomic status: an illustration using data from PIRLS 2006. IERI monograph series. Issues and methodologies in large-scale assessments, vol. 5; 2012. p. 9:33.
  23. Varraso R, Garcia-Aymerich J, Monier F, Le Moual N, De Batlle J, Miranda G, et al. Assessment of dietary patterns in nutritional epidemiology: principal component analysis compared with confirmatory factor analysis. **Am J Clin Nutr** 2012;96(5):1079-92. doi: 10.3945/ajcn.112.038109.
  24. Kelishadi R, Majdzadeh R, Motlagh M-E, Heshmat R, Aminae T, Ardalan G, et al. Development and evaluation of a questionnaire for assessment of determinants of weight disorders among children and adolescents: The CASPIAN-IV study. **Int J Prev Med** 2012;3(10).
  25. Kelishadi R, Cook SR, Motlagh ME, Gouya MM, Ardalan G, Motaghian M, et al. Metabolically obese normal weight and phenotypically obese metabolically normal youths: the CASPIAN Study. **J Am Diet Assoc** 2008;108(1):82-90. doi: 10.1016/j.jada.2007.10.013.
  26. Li C, Ford ES, Mokdad AH, Cook S. Recent trends in waist circumference and waist-height ratio among US children and adolescents. **Pediatrics** 2006;118(5):e1390-e8. doi: 10.1542/peds.2006-1062
  27. Singh N, Parihar RK, Saini G, Mohan SK, Sharma N, Razaq M. Prevalence of metabolic syndrome in adolescents aged 10-18 years in Jammu, J and K. **Indian J Endocrinol Metab** 2013;17(1):133-7. doi: 10.4103/2230-8210.107849.
  28. Tandon N, Garg MK, Singh Y, Marwaha RK. Prevalence of metabolic syndrome in urban Indian adolescents and its relation with insulin resistance (HOMA-IR). **J Pediatr Endocrinol Metab** 2013;26(11-12):1-8. doi: 10.1515/jpem-2013-0020.
  29. Grube M, Bergmann S, Keitel A, Herfurth-Majstorovic K, Wendt V, Klitzing Kv, et al. Obese parents - obese children? Psychological - psychiatric risk factors of parental behavior and experience for the development of obesity in children aged 0-3: study protocol. **BMC Public Health** 2013;13:1193. doi: 10.1186/1471-2458-13-1193.
  30. Young JH, Chang Y-PC, Kim JD-O, Chretien J-P, Klag MJ, Levine MA, et al. Differential Susceptibility to Hypertension Is Due to Selection during the Out-of-Africa Expansion. **PLoS Genet** 2005;1(6):e82. doi: 10.1371/journal.pgen.0010082
  31. Hadjiyannakis S. The metabolic syndrome in children and adolescents. **Paediatr Child Health** 2005;10(1):41-7.
  32. Folic N, Folic M, Markovic S, Jankovic S. Risk Factors for the Development of Metabolic Syndrome in Obese Children and Adolescents. **Srp Arh Celok Lek** 2015;143(3- 4):146-52.
  33. Bouchard C, Despres JP, Mauriege P. Genetic and non-genetic determinants of regional fat distribution. **Endocr Rev** 1993; 34:72-93. doi: 10.1210/edrv-14-1-72
  34. Grunfeld B, Balzaret M, Romo M, Gimenez M, Gutman R. Hyperinsulinemia in normotensive offspring of hypertensive parents. **Hypertension** 1994; 23:12-5.
  35. Vlasakova Z, Pelikanova T, Karasova L, Skibova J. Insulin secretion, sensitivity and metabolic profile of young, healthy offspring of hypertensive parents. **Metabolism** 2004; 53:469-75.
  36. Mehairi AE, Khouri AA, Naqbi MM, Muhairi SJ, Maskari FA, Nagelkerke N, et al. Metabolic syndrome among Emirati adolescents: A school based study. **PLoS One** 2013;8(2):e56159. doi: 10.1371/journal.pone.0056159.
  37. Giordano P, Vecchio GCD, Cecinati V, Delvecchio M, Altomare M, Palma FD, et al. Metabolic, inflammatory, endothelial and haemostatic markers in a group of Italian obese children and adolescents. **Eur J Pediatr** 2011;170(7):845-50. doi: 10.1007/

- s00431-010-1356-7.
38. Park J, Hilmers DC, Mendoza JA, Stuff JE, Liu Y, Nicklas TA. Prevalence of Metabolic Syndrome and Obesity in Adolescents Aged 12 to 19 Years: Comparison between the United States and Korea. **J Korean Med Sci** 2010;25(1):75-82. doi: 10.3346/jkms.2010.25.1.75.
  39. Ramírez-Vélez R, Anzola A, Martínez-Torres J, Vivas A, Tordecilla-Sanders A, Prieto-Benavides D, et al. Metabolic Syndrome and Associated Factors in a Population-Based Sample of Schoolchildren in Colombia: The FUPRECOL Study. **Metab Syndr Relat Disord** 2016;14(9):455-62. doi: 10.1089/met.2016.0058.
  40. Rashidi H, Payami SP, Latifi SM, Ghasemi M. Prevalence of metabolic syndrome and its correlated factors among children and adolescents of Ahvaz aged 10 – 19. **J Diabetes Metab Disord** 2014;13(1):53. doi: 10.1186/2251-6581-13-53.
  41. Wan N-j, Mi J, Wang T-y, Duan J-l, Li M, Gong C-x, et al. Metabolic syndrome in overweight and obese schoolchildren in Beijing. **Zhonghua Er Ke Za Zhi** 2007;45(6):417-21.
  42. Ambrosini GL, Huang R-C, Mori TA, Hands BP, O'Sullivan TA, Klerk NHd, et al. Dietary patterns and markers for the metabolic syndrome in Australian adolescents. **Nutr Metab Cardiovasc Dis** 2010;20(4):274-83. doi: 10.1016/j.numecd.2009.03.024.
  43. Kelishadi R, Heshmat R, Mansourian M, Motlagh ME, Ziaodini H, Taheri M, et al. Association of dietary patterns with continuous metabolic syndrome in children and adolescents; a nationwide propensity score-matched analysis: the CASPIAN-V study. **Diabetol Metab Syndr** 2018;10:52. doi: 10.1186/s13098-018-0352-3.
  44. Nourian M, Yassin Z, Taib MNM, Haghighatdoost F, Kelishadi R. Systematic Review on Dietary Intake and Metabolic Syndrome in Children and Adolescents. **Indian J Res** 2014;3(6):162-9.
  45. Kang H-T, Lee H-R, Shim J-Y, Shin Y-H, Park B-J, Lee Y-J. Association between screen time and metabolic syndrome in children and adolescents in Korea: the 2005 Korean National Health and Nutrition Examination Survey. **Diabetes Res Clin Pract** 2010;89(1):72-8. doi: 10.1016/j.diabres.2010.02.016.
  46. Brage S, Wedderkopp N, Ekelund U, Franks PW, Wareham NJ, Andersen LB, et al. Features of the metabolic syndrome are associated with objectively measured physical activity and fitness in Danish children: the European Youth Heart Study (EYHS). **Diabetes Care** 2004; 27(9):2141-8.
  47. Neto AS, Sasaki JE, Mascarenhas LP, Boguszewski MC, Bozza R, Ulbrich AZ, et al. Physical activity, cardiorespiratory fitness, and metabolic syndrome in adolescents: A cross-sectional study. **BMC Public Health** 2011;11:674. doi: 10.1186/1471-2458-11-674.