



ORIGINAL ARTICLE

The relationship between dietary patterns and aggressive behavior in adolescent girls: A cross-sectional study

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Abstract

Background: There are few studies about the relationship between dietary patterns and aggression. The aim of this study was to assess the relationship between the main dietary patterns and aggression scores among adolescent girls in Iran.

Methods: This cross-sectional study was conducted on 670 adolescent girls. The 168-item self-administered Semi-quantitative Food Frequency Questionnaire was used to evaluate dietary intake and to identify major dietary patterns, while factor analysis was applied. Aggression was evaluated by the validated Persian version of the Buss-Perry questionnaire. Statistical analysis was performed by crude and adjusted models.

Results: Three main dietary patterns including healthy, fast food, and Western were identified. A significant positive association was found between more adherence to Western dietary pattern and the presence of a high aggression score (OR: 2.00; 95% CI: 1.32–3.05, $p_{\text{trend}} = .001$); even after adjustment for potential confounders, these findings were significant.

Conclusion: Although Western dietary patterns were associated with increased aggression risk, there was no significant relationship between healthy and fast food dietary patterns and the prevalence of a high aggression score. Further studies, particularly longitudinal intervention studies, are required to clarify this relationship.

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KEYWORDS

adolescent, aggression, dietary patterns, factor analyses

1 | INTRODUCTION

In the previous years, the prevalence of psychological disorders has increased, and studies have shown that dietary patterns can affect the consequences of these disorders (Hosseinzadeh et al., 2016; Mousavi et al., 2022). Aggression is known as one of these psychological disorders that in psychology is defined as a tendency to violent behavior that can cause physical or psychological noxiousness to human (Anderson & Bushman, 2002). Aggression causes a threat to social safety and potentially leads to severe criminality, risking the safety of potential victims and causing harm, and imposing costs to society as a whole (Dambacher et al., 2015). Physical and verbal aggression is common in adolescent females (Cotter & Smokowski, 2016; Fagan et al., 2017). The prevalence of behavioral disorders in female adolescents suggests that there is a likelihood of comorbidities with aggressive behavior (Merikangas et al., 2010). The prevalence of aggression among the Iranian adolescents of both sexes has been estimated to be 30% to 65.5% (Sadeghi et al., 2014), while the differences between the rate of behavioral disorders between male and female subjects are marginally significant (Lahey et al., 2006; Odgers & Moretti, 2002). However, female aggression has been reported to have increased by 86%, while male aggression has increased by 17% in the past twenty years (Puzzanchera & Hockenberry, 2012). Thus, female aggression has had a significantly greater increase compared to male aggression, and yet most of the adolescent aggression studies have focused on men (Berkout et al., 2011; Kerig, 2014; Valois et al., 2002).

Various lifestyle factors, such as watching television, stress, socioeconomic variables, and dietary factors, are related to adolescent aggression (Laninga-Wijnen et al., 2016; Pahlavani et al., 2014; Taubner et al., 2016). There is evidence to suggest that diet can affect health-related indicators, albeit not significantly (Khayatzadeh et al., 2018; Pahlavani et al., 2020). Austin et al. (2014) found that supplementation of multivitamins and proteins in military personnel could alleviate aggressive behavior. While McNamara and Strawn (2013) found that long-chain omega 3 fatty acid may affect the state of anger when inflammatory cytokines levels are raised, such that supplementation of this nutritious factor could help to minimize nervousness (Rasad et al., 2014). Furthermore, Zahedi et al. (2014) found that the intake of “junk foods” (high energy and low nutritional content foods) in adolescents and children may increase the risk for psychiatric disorders and aggressive behaviors. Another study has indicated that high consumption of dairy products reduced state-trait anger expression in female students (Kalantari et al., 2016).

No studies have investigated the relationship between habitual dietary patterns and occurrence of aggression among female adolescents in Iran, even though such a study could be widely applied in interdisciplinary fields. This study can be extended to different regions of the world, as different cultures and geographical areas coupled with

religious beliefs affect dietary patterns, which could lead to different trends in aggression in the same subject group (Hu, 2002; Kant et al., 2004; Mansouri et al., 2020). As such, the paper aims to explore this area of research and provide food for thought for further studies.

2 | METHODS

2.1 | Study population

The present study was a cross-sectional study that started in January 2015, 854 individuals were invited to participate in the study initially, and finally 670 adolescent girls were selected and recruited using a random cluster sampling method from several schools in different areas of Razavi Khorasan Province to participate in the study. Inclusion criteria were the age of 12–18 years with no history of any chronic diseases (colitis, diabetes, cardiovascular diseases, cancer, and hepatitis). Also, we initially excluded all participants who were suffering from chronic diseases such as hypertension, diabetes, and so forth and were taking related medications, as well as subjects who were taking supplements such as vitamin D, calcium, and so on were not included in the study. This information was obtained using a checklist designed by the research team.

At first, all of the subjects filled written informed consent forms; the study was approved by The Ethics Committee of Mashhad University of Medical Sciences.

2.2 | Assessment of demographic status

Trained interviewers collected the general characteristics of subjects including age, smoking status, menstruation status, and medical history. Physical activity was assessed by the validated Modifiable Activity Questionnaire (MAQ) (Delshad et al., 2015), and the level of physical activity was estimated based on metabolic equivalent task (MET) minutes per week.

2.3 | Dietary assessment

Dietary intakes of participants were collected by a valid and reliable food frequency questionnaire (FFQ) containing 168 food items (Esfahani et al., 2010). Subjects had nine multiple choice frequency response categories for each food, ranging from “never or < 1/month” to “12/day.” Since the Iranian culture and food habits were judged similar to that of Americans, the US Department of Agriculture’s (USDA) national nutrient databank was used to estimate the daily nutrient intake (Esfahani et al., 2010). Finally, 40 food groups were defined to extract major dietary patterns (see Table S1).

2.4 | Anthropometric and biochemical assessment

Anthropometric measurements including weight, height, and waist circumferences (WC) were estimated by using standard protocols. All anthropometric measurements were done twice, and the mean values were reported, respectively. Blood pressure was measured using a standardized protocol, and averages were recorded.

2.5 | Assessment of aggression

Aggression score was assessed using a validated Persian translation of the Buss-Perry questionnaire (Zivari-Rahman et al., 2012). This questionnaire includes 29 questions with multiple choice responses.

Median cut-point for the definition of aggression was used; such that subjects were categorized as aggressive if their score was below 64.

2.6 | Statistical methods

Three major dietary patterns based on 40 food groups were identified by a principal component analysis, and factors were rotated using the varimax rotation technique. Furthermore, three factors were determined in relation to Eigen values > 1.5 and the interpretation of scree plot. Therefore, according to our data interpretation and the previous studies, three major dietary patterns were defined by considering factor loading and total intakes of weighted foods; then, the scores of each pattern were calculated for each subject factor (Khani et al., 2004; Oddy et al., 2009). Individuals were classified according to tertiles of dietary pattern scores. A one-way analysis of variance was performed in order to assess the differences in continuous variables across tertiles in categories of three dietary pattern scores; moreover, chi-squared test was used for assessing the categories across tertiles of dietary pattern in participants. To investigate the relationship between dietary patterns and aggression presence, logistic regression was used in several models. In model I, age and energy intake were controlled. In model II, the same factors were assessed together with physical activity and menstruation. Body mass index (BMI) was added as a factor in model III. Total trends of the odds ratios through ascending tertiles of dietary patterns scores were assessed using the Mantel-Haenszel extension. A P -value < .05 was considered statistically significant. For all statistical analyses, SPSS software version 15.0 (SPSS Inc., Chicago, IL, USA) was used.

3 | RESULTS

3.1 | Identification of major dietary patterns

The following three major dietary patterns were identified: (i) the “first” dietary pattern (healthy), which was high in vegetables, eggs, yoghurt, cruciferous vegetables, tomatoes, green leafy vegetables, gar-

lic, fruits, low and high fat dietary products; (ii) the “second” dietary pattern (fast food) which was greatly laden with potato, hydrogenated fats, sugars, tea, salt, and spices; (iii) the “third” dietary pattern (Western) which was rich in snacks, red meat, poultry, industrial fruit juices and compote, soft drinks, sweets, and desserts. Overall, these dietary patterns accounted for 18.38% of the variance in dietary intakes (see Table S2).

3.2 | General characteristics and dietary intakes of study participants

General characteristics of study participants across tertiles of dietary patterns are presented in Table 1. Among general characteristics, physical activity for first pattern in the third tertile was significantly higher than that of the first tertile. According to the anthropometric measurements, the BMI for participants, who were in tertile 1 of second dietary pattern, was significantly higher than that of participants who were in tertile 3. No significant differences in the distribution of other variables in terms of tertiles of dietary patterns were observed.

Subjects in the third tertile of first pattern had a higher intake of energy, low and high fat dairy, fruits, vegetables, legumes, but lower intake of sugar, soft drink, and snacks compared with those in the first tertile. The participants in the highest tertile of the second pattern had higher intakes of energy, spices, hydrogenated fat, sugar, soft drink, snack, and sweet and dessert but lower intake of high fat dairy and red meat compared with those in the lowest tertile.

Individuals in the third tertile of third pattern had higher intakes of energy, red meat, processed meat, low and high fat dairy, soft drinks, snack and sweet and desserts but lower intake of legumes, spices, hydrogenated fat, and sugar compared with those in the first tertile (Table 2).

3.3 | The relationship between three habitual dietary patterns and aggression

Multivariable-adjusted odds ratios for aggression scores across the tertile categories of dietary pattern are shown in Table 3. No significant associations were found between the first [$p_{trend} = .57$, odds ratio and confidence interval for second and third tertile were, respectively: OR:1.44, 95% CI: 0.95,2.19, OR: 0.89, 95% CI: 0.6,1.32] and second dietary patterns [$p_{trend} = .39$, odds ratio and confidence interval for second and third tertile were respectively: OR: 0.73, 95% CI: 0.49,1.09, OR: 1.2, 95% CI: 0.79,1.82] and aggression score following the application of multivariate models. The participants in the highest tertile of third dietary pattern had a significantly greater odds ratio for aggression (with and without adjusting for variables in Table 3) [p_{trend} for crude model = .001, odds ratio and confidence interval for tertile 2 and 3 were, respectively: OR: 1.18, 95% CI: 0.8,1.74, OR: 2.00, 95% CI: 1.32–3.05 and p_{trend} After adjustment for potential confounding variables was .0006, and odds ratio and confidence interval for tertile 2 and 3 were, respectively: OR: 1.17, 95% CI: 0.78,1.76, OR: 2.04, 95% CI: 1.24,3.35].

TABLE 1 Demographic and anthropometric measurements of study participants by tertiles (Q) categories of dietary pattern score

Tertile	Healthy pattern			Fast food pattern			Western pattern		
	Tertile 1	Tertile 3	P-value ^a	Tertile 1	Tertile 3	P-value	Tertile 1	Tertile 3	P-value
Age (y) ^b	14.5 ± 1.5	14.5 ± 1.5	.9	14.4 ± 1.6	14.6 ± 1.5	.24	14.4 ± 1.4	14.4 ± 1.5	.19
Weight (kg)	51.6 ± 12.4	53.7 ± 11.9	.19	53.9 ± 13.2	52.8 ± 13.4	.1	53.6 ± 14.7	52.9 ± 11.5	.21
BMI (kg/m ²)	20.6 ± 3.7	21.6 ± 5.04	.05	21.7 ± 4.6	21.2 ± 4.8	.04	21.5 ± 5.4	21.2 ± 4.05	.3
Waist circumference (cm)	69.8 ± 8.1	70.9 ± 9.1	.41	70.8 ± 9.5	70 ± 9.3	.45	70.7 ± 9.6	70.5 ± 8.4	.25
Physical activity (MET)	44.8 ± 2.8	45.8 ± 3.9	.006	45.1 ± 3.3	45.3 ± 3.5	.64	44.9 ± 2.7	45.5 ± 3.8	.1
Systolic blood pressure (mmHg)	96.8 ± 13.3	97.4 ± 13.9	.32	96.4 ± 13.9	95.6 ± 13.1	.31	96.9 ± 14.1	95.9 ± 15.3	.67
Diastolic blood pressure (mmHg)	62.8 ± 12.2	62.8 ± 13.3	.99	62.6 ± 13.5	62.5 ± 13.3	.76	61.9 ± 13.3	62.8 ± 13.6	.31
Passive smoker (%) (yes)	35.6	27.8	.18	29.3	30.2	.33	32	31.4	.98
Menstruation (%) (yes)	87	87.8	.91	86.7	85.8	.2	85.5	87.5	.28

^aANOVA for continuous variables and chi-squared test for categorical variables.

^bAll values are mean ± SD.

4 | DISCUSSION

Three main dietary patterns in the population of female adolescents were detected. The individuals in the third tertile of Western dietary pattern had a higher prevalence of a high aggression score. No other significant associations were observed between the healthy or fast food dietary patterns and aggression. To the authors' best knowledge, this study is the first to link the main habitual dietary patterns and aggression.

Aggression is a common behavioral problem among adolescents, which is characterized by offensive verbal and physical behaviors (Cotter & Smokowski, 2016). Diet is among the factors that play an important role in the control of aggression (Han & Dingemans, 2017). This paper demonstrates that habitual dietary patterns may contribute to the alleviation or worsening of aggression. Therefore, the improvement of diet quality and the avoidance unhealthy diets may lead to the reduction of aggressiveness in adolescents, although this will need to be confirmed by longitudinal intervention studies. Adolescence is the most sensitive period in terms of emotions and body perception, where teenagers are under great influence from their peers; this peer influence has been seen to adversely affect food choices by way of, for example, weight loss or other unsound beliefs, which may lead to a lower intake of essential nutrients (Berkout et al., 2011; Cotter & Smokowski, 2016; Kalantari et al., 2016).

The role of diet and nutrients in antisocial behavior has been considered in clinical trials (Benton, 2007). Meta-analysis of five double-blind placebo-controlled trials revealed that children were potentially influenced by a wide range of food items, but the pattern was proprietary to the child (Benton, 2007). However, it is clear that food nutrient poli-

cies in schools, where children and adolescents spend 30 h a week and consume over a third of their meals, has had an overall positive impact on students' food choices (Van Ansem et al., 2013). Therefore, it can be asserted with some degree of certainty that public health policies have been successful in forming the eating habits of students.

Leading from the earlier parts of the current paper on the effect of dietary habits on aggression, it can be asserted by extension, therefore, that increasing food security and availability in schools and the local areas will have beneficial effects on reducing aggression rates among female adolescents (Helton et al., 2019; World Health Organization, 2018). There is no evidence to suggest that the results from the implementation of nutrient food policies in Iran will differ from the policies examined above. Therefore, as a matter of public policy, it is suggested that local and provincial policy makers in Iran also begin to adopt best practices from the vast array of school nutrient food policies in order to tackle public health problems such as aggression in female adolescents.

The current study showed that individuals who were in the third tertile, so-called Western diet pattern, which was rich in red and processed meat (high protein), experienced high aggression scores. Other studies focused on behavioral changes as a consequence of nutrient status. A significant and strong association between soft drinks consumption, and violence was observed in the study of Boston public high schools, where the participants were asked how often they drank nondiet soft drinks and engaged in physical violence with a peer. A direct cause-and-effect relationship between sugary drinks consumption and violence is not untenable in such circumstance; such that the sugar or caffeine content of soft drinks is sometimes found to be an

TABLE 2 Dietary intakes of study participants by tertiles (Q) categories of dietary pattern scores

	Healthy pattern			Fast food pattern			Western pattern		
	Tertile 1	Tertile 3	P-value ^a	Tertile 1	Tertile 3	P-value	Tertile 1	Tertile 3	P-value
Food groups (g/1000 Kcal)									
Energy (Kcal/d)	2414.8 ± 846.1	3101.1 ± 731.1	<.001	2359.9 ± 830.6	3049.5 ± 770.4	<.001	2237.6 ± 776.6	3301.2 ± 662.7	<.001
Red meat ^b	4.77 ± 5	5.44 ± 5.81	.2	5.59 ± 4.69	4.24 ± 3.99	.001	3.66 ± 3.5	6.47 ± 6.39	<.001
Processed meat	1.81 ± 2.38	1.79 ± 2.68	.92	1.97 ± 2.96	1.58 ± 1.94	.15	0.94 ± 1.24	2.84 ± 3.39	<.001
Low fat dairy	54.1 ± 52.07	99.4 ± 73.3	<.001	85.8 ± 69.7	73.2 ± 67.3	.09	92.3 ± 75.5	69.2 ± 55.3	.001
High fat dairy	45.1 ± 44.3	79.1 ± 67.5	<.001	73.5 ± 65.6	51.7 ± 42.1	<.001	56 ± 52.5	61.6 ± 48.7	.01
Fruit	62.02 ± 56.2	97.4 ± 68.2	<.001	82.6 ± 70	73.8 ± 61.8	.28	71.5 ± 51.3	83.1 ± 71.6	.1
Vegetable	50.5 ± 29.5	130.6 ± 73.2	<.001	89.4 ± 61.2	90.4 ± 68.5	.59	101.4 ± 69.6	77.2 ± 53.6	<.001
Legumes	30.8 ± 26.5	34.4 ± 26.6	.05	31.8 ± 25.2	30.1 ± 22.3	.51	34.6 ± 27.1	28.4 ± 20.2	.01
Spices	1.05 ± 1.11	1.03 ± 1.11	.89	0.63 ± 0.66	1.51 ± 1.51	<.001	1.2 ± 1.4	0.92 ± 0.89	.01
Hydrogenated fat	8.03 ± 10.1	7.7 ± 8.9	.46	4.3 ± 5.6	11.3 ± 11.2	<.001	10.4 ± 11.6	5.35 ± 6.08	<.001
Sugar	5.02 ± 5.91	3.44 ± 3.25	.001	1.6 ± 1.95	6.8 ± 6.1	<.001	4.71 ± 5.52	3.51 ± 3.53	.01
Soft drink	27.7 ± 48.01	15.7 ± 29.1	<.001	12.9 ± 30.2	28.5 ± 45.4	>.001	8.51 ± 13.07	35.6 ± 52.03	>.001
Snack	12.8 ± 13.4	8.6 ± 8.4	<.001	8.9 ± 9.8	12.3 ± 11.1	.001	6.25 ± 6.6	15.3 ± 12.5	<.001
Sweet and dessert	14.5 ± 11.5	12.6 ± 10.9	.1	11.9 ± 10	15.3 ± 12.3	.002	9.88 ± 8.63	17.2 ± 12.04	>.001

^aObtained from one-way ANOVA.^bAll values are mean ± SD.

TABLE 3 Multivariate adjusted odds ratios (95% CIs) for aggression (Q) categories of dietary pattern scores

	Crude	Model I ^a	Model II ^b	Model III ^c
Healthy pattern				
Tertile 1	1	1	1	1
Tertile 2	1.44 (0.95–2.19)	1.4 (0.92–2.14)	1.43 (0.93–2.19)	1.47 (0.96–2.27)
Tertile 3	0.89 (0.6–1.32)	0.77 (0.51–1.19)	0.78 (0.51–1.21)	0.8 (0.51–1.23)
P trend ^d	.57	.88	.31	.34
Fast food pattern				
Tertile 1	1	1	1	1
Tertile 2	0.73 (0.49–1.09)	0.66 (0.43–0.99)	0.64 (0.42–0.98)	0.62 (0.41–0.96)
Tertile 3	1.2 (0.79–1.82)	1.01 (0.65–1.58)	0.94 (0.59–1.49)	0.92 (0.58–1.46)
P trend ^d	.39	.95	.8	.73
Western pattern				
Tertile 1	1	1	1	1
Tertile 2	1.18 (0.8–1.74)	1.18 (0.8–1.76)	1.2(0.8–1.81)	1.17 (0.78–1.76)
Tertile 3	2.00 (1.32–3.05)	2.00 (1.23–3.25)	2.02 (1.23–3.32)	2.04 (1.24–3.35)
P trend ^d	.001	.006	.006	.006

^aAdjusted for age and energy intake.

^bAdditionally adjusted for passive smoking, Physical activity, menstruation, drug and supplement use.

^cAdditionally adjusted for BMI.

^dResulted from Mantel-Haenszel extension c2 test.

intervening factor in reducing one's self esteem which may result in aggression (other factors could also have played a role which may have been unaccounted for in this analyses) (Solnick & Hemenway, 2012); their findings were in line with those of the current study. When ecological and individual factors were controlled in Moore's study, children at the age of 10 who ate confectioneries on a daily basis were considerably more likely to depict violent behaviors at age 34 years (Moore et al., 2009). That may be due to high concentration of simple sugar, saturated, and trans fatty acids that alter the mental functions. Conversely, a healthy lifestyle was linked with a relatively lower association of being frequently violent in developing countries (Turagabeci et al., 2008). However, the current study did not find a significant effect of a healthy dietary pattern as a component of healthy lifestyle on violence in female adolescents. Nevertheless, studies have shown results similar to those in the current paper, such that the intake of high energy and low nutritional content foods may increase the risk for psychiatric distress and violent behaviors in children and adolescents, aged 6 to 18 years old in Iran (Zahedi et al., 2014). Another study indicated a higher consumption of dairy products reduced state-trait anger expression in female students (Kalantari et al., 2016), whereas in this paper, in the third tertile of third dietary pattern that intake of dairy products was high, the risk of aggression was also high. This anomaly may be due to the effect of another component of third dietary pattern, for example, the effect of red and processed meat was dominant.

In their study, Feingold assumed that salicylates (chemicals in food with a similar structure to aspirin), which is a chemical component used as an additive to processed foods like processed meat, cause hyperactivity (Benton, 2007). According to this theory, the reason that the

third tertile of Western pattern were related to more aggression will be explained.

Psychological disorders, including aggression, are the result of interactions between genetics, the body's immune status, hormones, and biochemical indices (Hillbrand & Spitz, 1999; Maes, 1999). However, the mechanisms of this is complex and not completely understood. Therefore, diet and food patterns can affect brain and psychological function by playing a role in mechanisms related to inflammation and oxidative stress (Aleksandrova et al., 2021). In addition, legumes and vegetables, which are consumed more in the group of healthy patterns, are rich in antioxidants, as well as folate and B vitamins, which can reduce inflammatory reactions and oxidative stress and related with reducing aggression rates (Kamphuis et al., 2008; Wang et al., 2021). Also, adherence to the Western dietary pattern is related to the reduction of brain-derived neurotrophic factor level, which is the protective factor of brain neurons against oxidative stress (Molteni et al., 2002; Shirayama et al., 2002).

Since examining the relationship between dietary patterns and aggression among female adolescents in Iran has occurred for the first time, there were several limitations which should be considered. Firstly, similar to other cross-sectional studies, the exact causal link is not ascertained. Secondly, similar to other observational studies, this study has some confounders that could not be measured or controlled. The final limitation is inherent in the title of the research, namely that only females have been examined. On the other hand, examining a wide range of potential confounders together with the high quality with which data were collected and controlled, represent the strength of the findings of the current paper.

5 | CONCLUSION

In conclusion, the present study indicates that a high adherence to a Western dietary pattern, characterized by high energy, red meat, processed meat, low and high fat dairy, soft drinks, snack and sweet and desserts but lower intake of legumes, spices, hydrogenated fat, and sugar was associated with increased risk of aggression in female adolescents. On the other hand, there is a need for food and nutrition policymakers to modify dietary patterns in adolescents towards healthy patterns to reduce possible psychological disorders. Further studies, especially longitudinal intervention studies using a larger sample sizes is needed to examine the association between adherence to major dietary patterns and aggression presence among children and adolescents.

AUTHOR CONTRIBUTIONS

All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it. The study was conceived by Majid Ghayour-Mobarhan, Gordon A. Ferns, and Naseh Pahlavani. The instruments were developed by Mahsa Malekahmadi, Sayyed Saeid Khayyat-zadeh, Shadia Hamoud Alshahrani, Javad Heshmati, Nikzad Oraee, Majid Ghayour-Mobarhan, Sayyed Saeid Khayyat-zadeh, and Naseh Pahlavani. Data were collected by Sayyed Saeid Khayyat-zadeh, Safieh Firouzi, and Mahsa Malekahmadi, with data analysis and interpretation by Shadia Hamoud Alshahrani, Mahsa Malekahmadi, and Naseh Pahlavani wrote the first draft of the manuscript. All authors read and approved the final version of the manuscript.

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CONFLICT OF INTEREST

The authors have no conflict of interest to disclose.

DATA AVAILABILITY STATEMENT

The datasets used and/or analyzed during the current study are available from the corresponding authors on reasonable request.

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PEER REVIEW

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REFERENCES

Aleksandrova, K., Koelman, L., & Rodrigues, C. E. (2021). Dietary patterns and biomarkers of oxidative stress and inflammation: A systematic

review of observational and intervention studies. *Redox Biology*, 42, 101869.

Anderson, C. A., & Bushman, B. J. (2002). Human aggression. *Annual Review of Psychology*, 53, 27–51.

Austin, K. G., McGraw, S. M., & Lieberman, H. R. (2014). Multivitamin and protein supplement use is associated with positive mood states and health behaviors in US Military and Coast Guard personnel. *Journal of Clinical Psychopharmacology*, 34, 595–601.

Benton, D. (2007). The impact of diet on anti-social, violent and criminal behaviour. *Neuroscience & Biobehavioral Reviews*, 31, 752–774.

Berkout, O. Y. J., & Gross, A. M. (2011). Mean girls and bad boys: Recent research on gender differences in conduct disorder. *Aggression and Violent Behavior*, 16, 503–511.

Cotter, K. L., & Smokowski, P. R. (2016). An investigation of relational risk and promotive factors associated with adolescent female aggression. *Child Psychiatry & Human Development*, 48, 754–767.

Dambacher, F., Schuhmann, T., Lobbetael, J., Arntz, A., Brugman, S., & Sack, A. T. (2015). Reducing proactive aggression through non-invasive brain stimulation. *Social Cognitive and Affective Neuroscience*, 10, 1303–1309.

Delshad, M., Ghanbarian, A., Ghaleh, N. R., Amirshakari, G., Askari, S., & Azizi, F. (2015). Reliability and validity of the modifiable activity questionnaire for an Iranian urban adolescent population. *International Journal of Preventive Medicine*, 6, 3.

Esfahani, F. H., Asghari, G., Mirmiran, P., & Azizi, F. (2010). Reproducibility and relative validity of food group intake in a food frequency questionnaire developed for the Tehran Lipid and Glucose Study. *Journal of Epidemiology*, 20, 150–158.

Fagan, S. E., Zhang, W., & Gao, Y. (2017). Social adversity and antisocial behavior: Mediating effects of autonomic nervous system activity. *Journal of Abnormal Child Psychology*, 45(8), 1553–1564.

Han, C. S., & Dingemans, N. J. (2017). You are what you eat: Diet shapes body composition, personality and behavioural stability. *BMC Evolutionary Biology*, 17, 8.

Helton, J. J., Jackson, D. B., Boutwell, B. B., & Vaughn, M. G. (2019). Household food insecurity and parent-to-child aggression. *Child Maltreatment*, 24, 213–221.

Hillbrand, M., & Spitz, R. T. (1999). Cholesterol and aggression. *Aggression and Violent Behavior*, 4, 359–370.

Hossein-zadeh, M., Vafa, M., Esmail-zadeh, A., Feizi, A., Majd-zadeh, R., Afshar, H., Keshteli, A. H., & Adibi, P. (2016). Empirically derived dietary patterns in relation to psychological disorders. *Public Health Nutrition*, 19, 204–217.

Hu, F. B. (2002). Dietary pattern analysis: A new direction in nutritional epidemiology. *Current Opinion in Lipidology*, 13, 3–9.

Kalantari, N., Doaei, S., Gordali, M., Rahimzadeh, G., & Gholamal-zadeh, M. (2016). The association between dairy intake, simple sugars and body mass index with expression and extent of anger in female students. *Iranian Journal of Psychiatry*, 11, 43–50.

Kamphuis, M., Geerlings, M., Grobbee, D., & Kromhout, D. (2008). Dietary intake of B6-9-12 vitamins, serum homocysteine levels and their association with depressive symptoms: The Zutphen Elderly Study. *European Journal of Clinical Nutrition*, 62, 939–945.

Kant, A. K., Graubard, B. I., & Schatzkin, A. (2004). Dietary patterns predict mortality in a national cohort: The National Health Interview Surveys, 1987 and 1992. *Journal of Nutrition*, 134, 1793–1799.

Kerig, & P. K. (2014). Introduction: For better or worse: Intimate relationships as sources of risk or resilience for girls' delinquency. *Journal of Research on Adolescence*, 24, 1–11.

Khani, B. R., Ye, W., Terry, P., & Wolk, A. (2004). Reproducibility and validity of major dietary patterns among Swedish women assessed with a food-frequency questionnaire. *The Journal of Nutrition*, 134, 1541–1545.

Khayyat-zadeh, S. S., Mehramiz, M., Mirmousavi, S. J., Mazidi, M., Ziaee, A., Kazemi-Bajestani, S. M. R., Ferns, G. A., Moharreri, F., & Ghayour-Mobarhan, M. (2018). Adherence to a DASH-style diet in relation to

- depression and aggression in adolescent girls. *Psychiatry Research*, 259, 104–109.
- Lahey, B. B., Van, H. C. A., Waldman, I. D., Rodgers, J. L., D'Onofrio, B. M., Pedlow, S., Rathouz, P., & Keenan, K. (2006). Testing descriptive hypotheses regarding sex differences in the development of conduct problems and delinquency. *Journal of Abnormal Child Psychology*, 34, 737–755.
- Laninga-Wijnen, L., Harakeh, Z., Steglich, C., Dijkstra, J. K., Veenstra, R., & Vollebergh, W. (2016). The norms of popular peers moderate friendship dynamics of adolescent aggression. *Child Development*, 88(4), 1265–1283.
- Maes, M. (1999). Major depression and activation of the inflammatory response system. *Cytokines, Stress, and Depression*, 25–46.
- Mansouri, M., Pahlavani, N., Sharifi, F., Varmaghani, M., Shokri, A., Yaghubi, H., Asbaghi, O., Keshtkar, A., Tabrizi, Y. M., & Sadeghi, O. (2020). Dairy consumption in relation to hypertension among a large population of university students: The MEPHASOUS study. *Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy*, 13, 1633.
- McNamara, R. K., & Strawn, J. R. (2013). Role of long-chain omega-3 fatty acids in psychiatric practice. *PharmaNutrition*, 1, 41–49.
- Merikangas, K. R., He, J. - P., Burstein, M., Swanson, S. A., Avenevoli, S., Cui, L., Benjet, C., Georgiades, K., & Swendsen, J. (2010). Lifetime prevalence of mental disorders in U.S. adolescents: Results from the National Comorbidity Survey Replication–Adolescent Supplement (NCS-A). *Journal of the American Academy of Child & Adolescent Psychiatry*, 49, 980–989.
- Molteni, R., Barnard, R., Ying, Z., Roberts, C., & Gomez-Pinilla, F. (2002). A high-fat, refined sugar diet reduces hippocampal brain-derived neurotrophic factor, neuronal plasticity, and learning. *Neuroscience*, 112, 803–814.
- Moore, S. C., Carter, L. M., & Van Goozen, S. (2009). Confectionery consumption in childhood and adult violence. *British Journal of Psychiatry*, 195, 366–367.
- Mousavi, S. M., Ebrahimi-Mousavi, S., Keshteli, A. H., Afshar, H., Esmailzadeh, A., & Adibi, P. (2022). The association of plant-based dietary patterns and psychological disorders among Iranian adults. *Journal of Affective Disorders*, 300, 314–321.
- Oddy, W. H., Robinson, M., Ambrosini, G. L., Therese, A., De Klerk, N. H., Beilin, L. J., Silburn, S. R., Zubrick, S. R., & Stanley, F. J. (2009). The association between dietary patterns and mental health in early adolescence. *Preventive Medicine*, 49, 39–44.
- Odgers, C. L., & Moretti, M. M. (2002). Aggressive and antisocial girls: Research update and challenges. *International Journal of Forensic Mental Health*, 1, 103–119.
- Pahlavani, N., Khayyat-zadeh, S. S., Banazadeh, V., Bagherniya, M., Tayefi, M., Eslami, S., Ferns, G. A., & Ghayour-Mobarhan, M. (2020). Adherence to a Dietary Approach to Stop Hypertension (DASH)-style in relation to daytime sleepiness. *Nature and Science of Sleep*, 12, 325–332.
- Pahlavani, N., Sadeghi, A., Rasad, H., & Azizi Soleiman, F. (2014). Relation of inflammation and oxidative stress with blood glucose, lipids and BMI, fat mass and body weight in people with type 2 diabetes. *Journal of Zabol Diabetic Nursing*, 2, 42–51.
- Puzzanchera, C. A. B., & Hockenberry, S. (2012). *Juvenile court statistics 2009*. National Center for Juvenile Justice.
- Rasad, H., Dashtabi, A., Khansari, M., Chaboksavar, F., Pahlavani, N., Maghsoudi, Z., & Entezari, M. H. (2014). The effect of honey consumption compared with sucrose on blood pressure and fasting blood glucose in healthy young subjects. *Global Journal of Medicine Research and Studies*, 1, 117–121.
- Sadeghi, S., Farajzadegan, Z., Kelishadi, R., & Heidari, K. (2014). Aggression and violence among Iranian adolescents and youth: A 10-year systematic review. *International Journal of Preventive Medicine*, 5, S83–S96.
- Shirayama, Y., Chen, A. C.-H., Nakagawa, S., Russell, D. S., & Duman, R. S. (2002). Brain-derived neurotrophic factor produces antidepressant effects in behavioral models of depression. *Journal of Neuroscience*, 22, 3251–3261.
- Solnick, S. J., & Hemenway, D. (2012). The 'Twinkie Defense': The relationship between carbonated non-diet soft drinks and violence perpetration among Boston high school students. *Injury Prevention*, 18, 259–263.
- Taubner, S., Zimmermann, L., Ramberg, A., & Schroder, P. (2016). Mentalization mediates the relationship between early maltreatment and potential for violence in adolescence. *Psychopathology*, 49, 236–246.
- Turagabeci, A. R., Nakamura, K., & Takano, T. (2008). Healthy lifestyle behaviour decreasing risks of being bullied, violence and injury. *PLoS One*, 3, e1585.
- Valois, R. F., Macdonald, J. M., Bretous, L., Fischer, M. A., & Drane, J. W. (2002). Risk factors and behaviors associated with adolescent violence and aggression. *American Journal of Health Behavior*, 26, 454–464.
- Van Ansem, W. J., Schrijvers, C., Rodenburg, G., Schuit, A. J., & Van De Mheen, D. (2013). School food policy at Dutch primary schools: Room for improvement? Cross-sectional findings from the INPACT study. *BMC Public Health*, 13, 1–10.
- World Health Organization. (2018). *The state of food security and nutrition in the world 2018: Building climate resilience for food security and nutrition*. Food and Agriculture Organization.
- Wang, J., Shen, C., Li, R., Wang, C., Xiao, Y., Kuang, Y., Lao, M., Xu, S., Shi, M., & Cai, X. (2021). Increased long noncoding RNA LINK-A contributes to rheumatoid synovial inflammation and aggression. *JCI Insight*, 6.
- Zahedi, H., Kelishadi, R., Heshmat, R., Motlagh, M. E., Ranjbar, S. H., Ardalan, G., Payab, M., Chinian, M., Asayesh, H., Larjani, B., & Qorbani, M. (2014). Association between junk food consumption and mental health in a national sample of Iranian children and adolescents: The CASPIAN-IV study. *Nutrition*, 30, 1391–1397.
- Zivari-Rahman, M., Lesani, M., & Shokouhi-Moqaddam, S. (2012). Comparison of mental health, aggression and hopefulness between student drug-users and healthy students: A study in Iran. *Addiction and Health*, 4, 36–42.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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