Mediterranean diet habits and their effects on symptomatology among children and adolescents with attention deficit hyperactivity disorder

Dikkat eksikliği ve hiperaktivite bozukluğu tanılı çocuk ve ergenlerde Akdeniz diyeti alışkanlıkları ve semptomlar üzerine etkileri

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SUMMARY

Objective: Attention deficit hyperactivity disorder (ADHD); is a common neurodevelopmental disorder with multifactorial etiology. Despite the dominant role of the genetic factors; environmental factors such as diet related features may have effect on ADHD diagnosis and symptomatology. In our study we aimed to compare Mediterranean diet (MD) habits of ADHD group with healthy controls and explore the effect of MD on ADHD symptom severity. **Method:** All participants were evaluated with semi-structured psychiatric interviews and total of 113 individuals with ADHD and 120 healthy controls were included. Socioeconomic and clinical features of both groups were examined. Adherence to MD was evaluated with Mediterranean Diet Quality Index (KIDMED) and ADHD symptomatology was evaluated with Turgay scale. **Results:** ADHD group had lower KIDMED scores and worse adherence to MD compared to healthy controls. "Medium adherence" to MD increased the risk of ADHD diagnosis two-folds and "low adherence" to MD increased the risk of ADHD diagnosis five-folds compared to "good adherence". Total KIDMED scores and MD adherence levels were negatively correlated with inattention symptoms. **Discussion:** Adherence to a healthy diet (MD) seems to be related to lesser inattention problems in addition to lower rates of ADHD diagnosis and this indicates the importance of a "healthy diet" not only in the occurrence of ADHD, but also in the clinical symptomatology. certain dietary habits may play a role in both ADHD development and clinical appearance; but further evaluation is needed to shed light on causality and to determine if dietary manipulation could ameliorate ADHD symptoms.

Key Words: Mediterranean diet, attention deficit hyperactivity disorder, symptomatology

ÖZET

Amaç: Dikkat eksikliği hiperaktivite bozukluğu (DEHB), multifaktöriyel etiyolojiye sahip sık görülen nörogelişimsel bir hastalıktır. Genetik etmenlerin baskın rolüne rağmen; diyetle ilişkili özellikler gibi bazı çevresel etmenler de DEHB tanısında ve semptomatolojisinde etkili olabilmektedir. Çalışmamızda Akdeniz diyeti (AD) alışkanlıklarının DEHB grubu ve sağlıklı kontroller arasında karşılaştırılması ve DEHB semptom şiddetine etkisinin incelenmesi amaçlanmıştır. **Yöntem:** Tüm katılımcılar yarı-yapılandırılmış psikiyatrik görüşmelerle incelenmiş ve toplam 113 DEHB olgusu ile 120 sağlıklı kontrol çalışmaya alınmıştır. İki grubun da sosyoekonomik ve klinik özellikleri araştırılmıştır. AD'ne uyumları Akdeniz Diyeti Kalite İndeksi (KIDMED) ve DEHB semptomatolojisi Turgay Ölçeği ile değerlendirilmiştir. **Bulgular:** DEHB gurubunun daha düşük KIDMED puanlarına ve daha kötü AD uyum düzeylerine sahip oldukları saptanmıştır. AD'ne "iyi düzeyde uyuma" göre "orta düzeyde uyum" DEHB tanı riskini iki kat, "düşük düzeyde uyum" ise beş kat arttırmaktadır. Ayrıca toplam KIDMED puanları ve AD'ne uyum düzeyleri ile dikkatsizlik semptomları arasında negatif korelasyon gözlenmiştir. **Sonuç:** Sağlıklı bir diyete (AD) uyumun daha düşük DEHB tanı oranları ve daha düşük şiddette dikkatsizlik problemleriyle ilişkili olduğu gözlenmiştir ve bu "sağlıklı bir diyetin" yalnızca DEHB'nin ortaya çıkmasında değil, kliniğinde de etkili olduğunu göstermektedir. Ancak nedensellik ilişkisini açığa çıkarmak ve diyetsel girişimlerin DEHB bulgularını düzeltip düzeltemeyeceklerini saptamak için ileri araştırmalara ihtiyaç vardır.

Anahtar Sözcükler: Akdeniz diyeti, dikkat eksikliği ve hiperaktivite bozukluğu, semptomatoloji

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INTRODUCTION

Attention deficit hyperactivity disorder (ADHD); is a relatively common neurodevelopmental disorder of child and adolescent age group which can persist through adulthood and it is characterized by symptoms such as; inattention during academic and/or daily life tasks, distractibility, hyperactivity and inadequate impulse control (1). In DSM-IV classification system, ADHD is divided into three diagnostic categories based upon the severity of the symptom clusters such as; "predominantly inattentive type", "predominantly hyperactive type" and "combined type" (2). Worldwide prevalence of ADHD is reported to be between 5.9% - 7.1% among children and adolescents and these rates tend to change according to age and gender (3). ADHD is more common among males compared to females and younger age groups compared to older age groups (4).

Much like other neurodevelopmental disorders, etiology of ADHD is multifactorial. Despite the dominant role of the genetic factors in ADHD etiology; numerous studies report that environmental factors such as gestational, perinatal and diet related features are also important (5). Lead/mercury exposure, organophosphates, nutrition qualities, lifestyle features and psychosocial factors are some of the environmental factors which are thought to be effective in the pathophysiology of ADHD (6). Even though the exact effect of nutritional factors on ADHD is still unclear; several studies have shown that they play an important role on the emergence of certain behavioral disorders of childhood and adolescence (7). Low blood zinc/iron/copper levels, inadequate omega-3 fatty acid intake, artificial food colorants, chemical food preservatives and unhealthy diet (high refined sugar/saturated fatty acid intake, low fruit and/or vegetable consumption) are some of the nutritional factors which are reported to be related to ADHD (8–11).

In the light of these literature findings, a healthy diet can have positive effects in the context of diagnosis and clinical features of ADHD and Mediterranean diet (MD) is the best-known and well-acknowledged type of healthy diet which includes almost all of the nutritional elements in the best balanced proportions (12). In this aspect, primary aim of our study is to determine if there are any differences between ADHD and control groups regarding their adherence to MD. Secondary aim of our study is to explore the effects of MD on the symptom severity of patients with ADHD diagnosis.

METHOD

Study Design

Our case group consisted of children and adolescents between the ages of 6 – 18 who were referred to Child and Adolescent Psychiatry unit of the institution, did not use any psychiatric treatment previously and received ADHD diagnosis according to semi-structured psychiatric interviews (Schedule for Affective Disorders and Schizophrenia for School Aged Children Kiddie-SADS-lifetime Version [K-SADS-PL]) done by trained professionals. Children and adolescents between the ages of 6 – 18 who were referred to our unit, did not use any psychiatric treatment previously and did not receive any psychiatric diagnosis according to semi-structured psychiatric interviews (K-SADS-PL) were included in the control group. Power analysis was conducted using G*Power analysis program and for effect size (d) 0.5, Type I Error (α) 0.05, Type II Error (β) 0.05 and power (1-β) 95%; the sample size was calculated as 105 for each group (total sample size of 210) (13). Informed consent was obtained from both the children/adolescent and his/her parent/legal guardian prior to the study. Individuals with mental retardation or autism spectrum disorder diagnosis, psychotic symptoms, previous ADHD diagnosis and/or treatment and history of using nutritional supplements (vitamins/minerals) were excluded from the study. Total of 233 participants (113 for case and 120 for control group) were included in our study and their heights and weights were measured and recorded. Their corresponding body-mass index (BMI) percentiles were calculated according to the study of Neyzi et al. (2008) done in Turkish population (14).

Measurement Tools

Sociodemographic and Clinical Data Form: This form was designed by researchers in order to examine the age, gender, height, weight, BMI value/percentile, are of living, physical illnesses, age of mother/father, education level of mother/father, employment status of mother/father, marital status of mother/father and level of family income of the participants.

Schedule for Affective Disorders and Schizophrenia for School Aged Children Kiddie-SADS-Lifetime Version (K-SADS-PL): This semi-structured psychiatric interview was adapted from original K-SAD-P by Kaufman et al. (1997) in order to use for evaluating the psychiatric disorders seen in childhood and adolescence (15). This interview is administered to both the children/adolescents and their parents and it includes five diagnostic appendices (mood disorders, psychotic disorders, anxiety disorders, conduct disorders and substance use/other disorders) and their their sub-diagnostic appendices. K-SADS-PL was found to be a reliable and valid tool in Turkish language (16).

Turgay DSM-IV Based Child and Adolescent Behavior Disorders Screening and Rating Scale – Parent form (Turgay): This scale, which was originally developed by Turgay, is used to screen for disruptive behavior disorders based on the diagnostic criteria of DSM-IV (17). Validity and reliability study of Turgay Form in Turkish population was done by Ercan and colleagues (18). It consists of total of 41 items which include; 9 items screening for "inattention" (Turgay–IA), 9 items screening for "hyperactivity and impulsivity" (Turgay–HAI), 8 items screening for "oppositional defiant behavior" (Turgay–OD) and 15 items screening for "conduct disorder" (Turgay–CD). All items are scored between 0 – 3 points. It indicates clinically important situations which need further evaluation if the individual receives 2 or 3 points from at least 6 items of Turgay-IA, at least 6 items of Turgay-HAI, at least 4 items of Turgay-OD or at least 3 items of Turgay-CD.

Mediterranean Diet Quality Index (KIDMED): This scale was developed by Serra-Majem et al. (2004) in order to examine the adherence of children and adolescents to MD and it includes total of 16 items (19). In consists of 12 favorable and 4 unfavorable items; answering "yes" to a favorable item is scored as +1 whereas answering "yes" to an unfavorable question is scored as -1. Answering "no" to any item is scored as 0 and total KIDMED scores range between 0 – 12. Total KIDMED scores of ≥8 represent "high adherence", 4 – 7 represent "medium adherence" and ≤3 represent "low adherence" to MD. Kabaran et al. (2013) successfully translated and used KIDMED in Turkish children and adolescents (20).

The study was conducted in accordance with the ethical guidelines, including the World Medical Association (1975) Declaration of Helsinki 2008, and the legal requirements of the Ethics Committee of the institution it was conducted in (approval no: 2021/123).

Statistical Analysis

Statistical analysis of our study was done with Social Sciences software version 21.0 (21). Mean and standard deviation (±SD) values were given for continuous data; whereas number and percentages were given for categorical data. Kolmogorov-Smirnov test was used to check whether the continuous data were normally distributed. In order to compare continuous data between groups; Independent T-test was used for parametric and Mann Whitney-U (MWU) test was used for non-parametric data. Categorical data were analyzed using Chi-Square or Fisher's Exact test. Evaluation of the correlations between variables was done by Pearson Correlation test for continuous data and Spearman Correlation test for ordinal data. Correlation coefficient values between ±0.50 and ±1 are considered as a "high degree (strong)", between ±0.30 and ±0.49 are considered as a "moderate degree (medium)" and between ±0.01 and ±0.29 are considered as a "low degree (small)" correlation. Effect of adherence to MD on ADHD diagnosis was evaluated by logistic regression analysis and odds ratio (OR) and 95% confidence intervals (95% CI) were given. The value of $p<0.05$ was accepted as statistically significant.

Table 1: Comparison of sociodemographic features and Mediterranean diet habits between attention deficit - hyperactivity disorder patients and healthy controls.

	Case	Control	Z	p
	Mean (–SD)	Mean (–SD)		
Age (Years)	9.16 (–2.82)	9.35 (–3.25)	-0.058	0.954
Weight (kg)	36.88 (–15.36)	37.93 (–16.21)	-0.450	0.653
Height (cm)	136.63 (–15.94)	138.69 (–19.18)	-0.570	0.569
Mother s Age (Years)	37.99 (–6.08)	38.66 (–5.70)	-1.147	0.251
Father s Age (Years)	42.82 (–6.69)	42.19 (–6.72)	-0.763	0.446
BMI	18.97 (–4.31)	19.06 (–4.48)	-0.128	0.898
KIDMED (Total Score)	4.48 (–2.49)	6.05 (–2.32)	-4.697	**<0.001**
Fruit or fruit juice daily	0.57 (–0.50)	0.73 (–0.44)	-2.675	**0.007**
Second serving of fruit daily	0.47 (–0.50)	0.46 (–0.50)	-0.099	0.921
Fresh or cooked vegetables daily	0.33 (–0.47)	0.69 (–0.46)	-5.561	**<0.001**
Fresh or cooked vegetables >1/day	0.20 (–0.40)	0.45 (–0.50)	-4.095	**<0.001**
Regular fish consumption (?2-3/week)	0.40 (–0.49)	0.37 (–0.49)	-0.443	0.658
Fast-food more than once a week	-0.38 (–0.49)	-0.29 (–0.46)	-1.338	0.181
Legumes/Pulses more than once a week	0.57 (–0.50)	0.71 (–0.46)	-2.234	**0.025**
Pasta or rice consumption ?5/week	0.73 (–0.45)	0.37 (–0.49)	-5.410	**<0.001**
Cereals or cereal product (bread) for breakfast	0.58 (–0.50)	0.56 (–0.50)	-0.397	0.691
Regular nut consumption (?2-3/week)	0.61 (–0.49)	0.65 (–0.48)	-0.734	0.463
Use of olive oil at home	0.73 (–0.45)	0.89 (–0.31)	-3.255	**0.001**
Skipping breakfast	-0.27 (–0.44)	-0.08 (–0.27)	-3.739	**<0.001**
Dairy products for breakfast	0.63 (–0.48)	0.73 (–0.45)	-1.504	0.132
Commercially baked goods or pastries for breakfast	-0.62 (–0.49)	-0.29 (–0.46)	-4.959	**<0.001**
Two cups of yogurt and/or >40 g cheese	0.63 (–0.49)	0.72 (–0.45)	-1.486	0.137
Sweets and candy several times everyday	-0.73 (–0.45)	-0.62 (–0.49)	-1.714	0.087

SD, standard deviation; kg, kilogram; cm, centimeter; BMI, body-mass index; KIDMED, Mediterranean Diet Quality Index
Mann-Whitney U test, statistically significant p values are written in bold.

RESULTS

There were no statistically significant differences between groups regarding their age, gender, area of living, physical illnesses, weight, height, BMI score/percentile, ages/education level/employment status/marital status of their mothers/fathers and level of family income (Table 1 and 2). ADHD group scored significantly worse on KIDMED-Total compared to control group ($p<0.001$, MWU test, Table 1). There was also a statistically significant difference between groups regarding their levels of adherence to MD [$\chi2(1, N=233) =17.891$, $p<0.001$, Table 2]. ADHD group consumed vegetables less ($p<0.001$, MWU test), legumes/pulses less ($p=0.025$, MWU test), olive oil less ($p=0.001$, MWU test), pasta/rice more ($p<0.001$, MWU test), commercially baked goods/pastries more ($p<0.001$, MWU test) and skipped breakfast more often ($p<0.001$, MWU test). All item differences of KIDMED between groups are summarized on Table 1.

Table 2: Comparison of categorical data between ADHD patients and healthy controls.

	Number (Percentage)		?²	p
	Case (*n=120*)	Control (*n=113*)		
Gender				
Female	41 (34.2%)	45 (39.8%)	0.800	0.371
Male	79 (65.8%)	68 (60.2%)		
Area of Living				
High Population	60 (50%)	57 (50.4%)		
Medium Population	48 (40%)	48 (42.5%)	0.667	0.716
Low Population	12 (10%)	8 (7.1%)		
Physical Illness				
Not Present	108 (90%)	94 (83.2%)	2.343	0.126
Present	12 (10%)	19 (16.8%)		
Marital Status of Parents				
Married/Together	113 (94.2%)	110 (97.3%)		0.335
Divorced/Separated	7 (5.8%)	3 (2.7%)		
Education Level of Mother				
Primary/Middle School	64 (53.3%)	67 (59.3%)		
High School	31 (25.8%)	21 (18.6%)	1.783	0.410
University/Degree	25 (20.8%)	25 (22.1%)		
Employment of Mother				
Working in a Job	21 (17.5%)	17 (15.0%)	0.257	0.612
Unemployed	99 (82.5%)	96 (85.0 %)		
Education Level of Father				
Primary/Middle School	53 (44.2%)	53 (46.9%)		
High School	47 (39.2%)	38 (33.6%)	0.839	0.657
University/Degree	20 (16.7%)	22 (19.5%)		
Employment of Father				
Working in a Job	96 (80.0%)	88 (77.9%)		
Unemployed	13 (10.8%)	16 (14.2%)	0.648	0.723
Retired	11 (9.2%)	9 (8.0%)		
Level of Family Income				
Low	16 (13.3%)	11 (9.7%)	0.736	0.391
Middle/High	104 (86.7%)	102 (90.3%)		
Adherence to MD				
Low Adherence	45 (37.5%)	18 (15.9%)		
Medium Adherence	59 (49.2%)	61 (54.0%)	17.891	**<0.001**
High Adherence	16 (13.3%)	34 (30.1%)		
BMI Percentile				
<5	8 (6.7%)	13 (11.5%)		
5 15	5 (4.2%)	9 (8.0%)		
15 25	6 (5.0%)	4 (3.5%)		
25 50	20 (16.7%)	16 (14.2%)	7.603	0.369
50 75	27 (22.5%)	14 (12.4%)		
75 85	13 (10.8%)	16 (14.2%)		
85 95	18 (15.0%)	20 (17.7%)		
>95	23 (19.2%)	21 (18.6%)		

MD, Mediterranean diet; BMI, body-mass index
Chi-Square test, statistically significant p values are written in bold.
Fisher s Exact Chi-Square test, statistically significant p values are written in bold.

In the correlation analyses conducted in ADHD group; there were negative correlations between KIDMED-Total and Turgay-IA scores ($r=-0.202$, $p=0.027$, Pearson correlation); legumes/pulses consumption and Turgay-HAI scores ($r=-0.222$, $p=0.010$, Pearson correlation), Turgay-OD scores ($r=-0.205$, $p=0.024$, Pearson correlation), Turgay-CD scores ($r=-0.187$, $p=0.041$, Pearson correlation); and adherence level to MD and Turgay-IA scores ($\rho=-0.251$, $p=0.006$, Spearman correlation). Results of the correlation analyses are summarized on Table 3. Furthermore we examined the effect of adherence to MD on ADHD diagnosis and found that compared to "high adherence" to MD; "medium adherence" to MD increased the likelihood of ADHD diagnosis 2.06 fold (95% CI = 1.03 – 4.11, $p=0.042$) whereas "low adherence" to MD increased the likelihood of ADHD diagnosis 5.31 fold (95% CI = 2.73 – 11.91, $p<0.001$, Table 4).

DISCUSSION

In this study, we found that ADHD patients had lower overall KIDMED scores and worse adherence to MD compared to healthy controls. In fact, according to our analyses, individuals with "medium adherence" to MD were twice likely and individuals with "low adherence" to MD were five times likely to be diagnosed with ADHD. In addi-

Table 3: Correlations between Mediterranean diet habits and attention deficit - hyperactivity disorder symptoms.

Correlations		Turgay DSM-IV Based Child and Adolescent Behavior Disorders Screening and Rating Scale Parent form				
		Inattention	Hyperactivity/ Impulsivity	OD Behavior	Conduct Disorder	Total Score
KIDMED Total Score	r	**-0.202**	0.015	0.042	-0.002	-0.043
	p	**0.027**	0.870	0.646	0.980	0.643
Fruit or fruit juice daily	r	-0.152	0.023	0.008	0.045	-0.028
	p	0.097	0.803	0.935	0.626	0.761
Second serving of fruit daily	r	-0.054	-0.008	0.100	0.025	0.018
	p	0.555	0.931	0.277	0.788	0.846
Fresh or cooked vegetables daily	r	0.280	0.046	0.099	0.148	0.016
	p	0.060	0.620	0.280	0.106	0.858
Fresh or cooked vegetables >1/day	r	-0.151	-0.040	0.060	-0.003	-0.044
	p	0.100	0.668	0.514	0.977	0.637
Regular fish consumption (?2-3/week)	r	-0.051	0.083	0.071	0.022	0.053
	p	0.582	0.369	0.443	0.808	0.567
Fast-food more than once a week	r	-0.056	0.082	-0.025	-0.135	-0.015
	p	0.540	0.374	0.788	0.142	0.872
Legumes/Pulses more than once a week	r	-0.092	**-0.233**	**-0.205**	**-0.187**	**-0.241**
	p	0.318	**0.010**	**0.024**	**0.041**	**0.008**
Pasta or rice consumption ?5/week	r	-0.018	-0.013	-0.121	-0.054	-0.067
	p	0.846	0.892	0.188	0.559	0.465
Cereals or cereal product (bread) for breakfast	r	0.025	0.080	0.092	0.067	0.086
	p	0.784	0.383	0.317	0.466	0.352
Regular nut consumption (?2-3/week)	r	-0.030	0.000	0.006	-0.017	-0.012
	p	0.746	0.996	0.945	0.856	0.899
Use of olive oil at home	r	-0.162	0.055	0.091	0.140	0.045
	p	0.076	0.549	0.323	0.053	0.625
Skipping breakfast	r	0.088	-0.024	0.134	0.170	0.100
	p	0.336	0.793	0.143	0.051	0.277
Dairy products for breakfast	r	-0.067	0.088	0.051	-0.043	0.028
	p	0.469	0.337	0.583	0.641	0.763
Commercially baked goods or pastries for breakfast	r	0.140	0.028	-0.120	-0.107	-0.114
	p	0.053	0.763	0.191	0.244	0.217
Two cups of yogurt and/or >40g cheese daily	r	0.015	0.084	0.023	0.000	0.048
	p	0.871	0.360	0.806	1.000	0.604
Sweets and candy several times every day	r	-0.042	-0.141	0.003	-0.104	-0.091
	p	0.649	0.123	0.974	0.258	0.324
Adherence to Mediterranean diet	?	**-0.251**	0.010	0.061	-0.020	-0.029
	p	**0.006**	0.917	0.508	0.826	0.755
BMI Percentiles	?	0.102	0.022	0.113	0.107	0.096
	p	0.267	0.810	0.219	0.243	0.295

OD, oppositional-defiant; KIDMED, Mediterranean Diet Quality Index; BMI, body-mass index

Pearson correlation coefficients (r) were given for continuous data, Spearman correlation coefficients (?) were given for categorical data, statistically significant p values are written in bold.

tion, total KIDMED scores and adherence level to MD were negatively correlated with inattention scores on Turgay scale. Research done by Martin et al. (2018) is one of the few studies which investigate the relationship between MD and ADHD and they found that ADHD patients scored significantly lower on KIDMED overall (7). Also number of individuals who scored 8 and higher on KIDMED (indicative of a healthy diet) was significantly lower in ADHD group compared to healthy controls (7). Rios-Hernandez et al. (2017) have also reported lower KIDMED scores in ADHD patients and children and adolescents with a "low adherence" to the MD were more likely to be associated with an ADHD diagnosis (RR: 2.80; 95% CI: 1.54–5.25)

Table 4: Logistic regression for attention deficit - hyperactivity disorder diagnosis by categories of adherence to Mediterranean diet.

	p	Odds Ratio	95% Confidence Interval
Adherence to Mediterranean Diet			
High (n=50)	-	1 (reference)	-
Medium (n=120)	**0.042**	2.06	1.03 4.11
Low (n=63)	**<0.001**	5.31	2.37 11.91
Constant	0.013	0.47	

(22). A cohort study examining the effects of an unhealthy dietary pattern ("Western Type" which includes high intakes of fat, refined sugars and sodium and low intakes of fibre, folate and omega-3 fatty acids) has found significant associations with ADHD diagnosis (9). Another case-control study showed that traditional-healthy Korean dietary pattern was associated with a lower probability of ADHD diagnosis compared to an unhealthy dietary pattern (11). In addition to all of these previous data, we found a direct effect of MD on both ADHD diagnosis and also inattention symptoms. Adherence to a healthy diet (MD in this case) seems to be related to lesser inattention problems and this indicates the importance of a "healthy diet" not only in the occurrence of the disorder, but also in the clinical symptomatology.

When we investigated the items included in KIDMED; we found that ADHD patients had lower vegetables, legumes and olive oil and higher pasta/rice and commercially baked good/pastry consumption rates. Regarding these features, studies in this field report varying results: Martin et al. (2018) reported higher commercially baked good/pastry and lower fish and cereal consumption; whereas Rios-Hernandez et al. (2017) reported lower fruit, vegetable, pasta/rice and higher fast-food consumption in ADHD group compared to control group (7,22). Lower vegetable intake in our ADHD group is parallel with the study done by Park et al. (2012) in which a negative correlation between vegetable consumption rates and inattention scores was observed (10). In addition, one clinical trial have also reported an association between high intake of vegetables and fewer attentional/behavioral problems in children and adolescents with ADHD (23). There are numerous evidence on positive effects of vegetables on cognitive function and psychological well-being which are attributed to their high content of antioxidant and anti-inflammatory properties (24–26).

Another important difference between our study groups was regarding their pulse/legume intake. In addition to significantly lower pulse/legume consumption rates seen in our ADHD group, we also found negative correlations between pulse/legume consumption rates and hyperactivity/impulsivity, oppositional-defiant and conduct problems. To our

knowledge this study is the first one report a direct relationship between pulse/legume intake and ADHD symptomatology; but these findings should be approached with caution because data regarding effects of legumes/pulses on psychological well-being are paradoxical. On one hand pulses/legumes are low in fat and rich in protein/fibre/minerals/vitamins, have low glycaemic index and certain amounts of non-nutritional factors (such as isoflavones); all of which link them with various health-promoting properties (27). On the other hand pulses/legumes contain a large number of unhealthy components, including phytates which could block the body's uptake of essential minerals like magnesium, calcium, iron and especially zinc (28). Also isoflavone content of pulses/legumes can potentially be problematic as the chemical structure of isoflavones is similar to that of oestrogen, so they can mimic oestrogen's effect on the human body (29). Testosterone is suggested as a particularly relevant risk factor for disruptive behavior disorders (oppositional-defiant and conduct disorder) and linked to hyperactive-impulsive ADHD symptoms in preschool-age children (30). In the light of these literature findings, reverse relationship between pulse/legume intake and hyperactivity/impulsivity, oppositional-defiant and conduct symptoms that we observed might reflect the possible protective effect of a high-oestrogenic state caused by pulse/legume consumption. Along with potential hormonal effects of pulses/legumes; hormonal factors underlying pathophysiology and symptomatology of ADHD and disruptive behavior disorders are candidates for further investigation.

Furthermore, our ADHD patients reported significantly lower olive oil intake rates compared to healthy volunteers. Several studies have found that olive oil has mild anti-anxiety and memory enhancing effects together with their antioxidant properties (31). In laboratory experiments, it was shown that olive oil improves learning and memory in mice (32). Researchers have explained the memory-enhancing effects of olive oil in terms of antioxidant properties of active components, including hydroxytyrosol, tyrosol, oleuropein, deacetoxyligstroside aglycon, and acetoxypinoresinol (33). In addition, olive oil consumption was associated with decreased brain serotonin and dopamine metabolisms which play major role in pathophysiology of ADHD and this potentially shed light on relationship between low olive oil intake and ADHD (4,34).

Several researchers have reported an association between increased risk of ADHD and sugar, artificial food colorants and preservatives (8,35). Junk foods (which are generally high in fat, sugar, additives, artificial food colorings and preservatives) might negatively affect ADHD symptoms (36). Wiles et al. (2009) have demonstrated a possible longitudinal relationship between a 'junk food' diet at age 4 and hyperactivity at age 7 (37). Furthermore, Lien et al. (2006) found a general relationship between sugar consumption and hyperactive behavior in a large sample of adolescents (38). We showed that children and adolescents with ADHD consumed more pasta/rice (which include high carbohydrate) and commercially baked goods/pastries (which also include high carbohydrate and possibly artificial food colorants and/or preservatives). Even though our findings are conflicting with the previous research on MD/ADHD interaction; it can be speculated that high pasta/rice and commercially baked good/pastry intake of ADHD patients might fall into same scope as a diet with high sugar, artificial food colorants and preservatives (7,22).

Another major difference between ADHD group and healthy controls which has been repeatedly observed in both our study and previous studies on ADHD/MD interaction is "skipping breakfast". All of the evidence on this subject suggests that children and adolescents with ADHD skipped breakfast more often compared to their counterparts (7,22). Wesnes et al. (2003) have found that skipping breakfast or substituting it for a sugary drink impairs attention and episodic memory in children (39). Several researchers suggested that in addition to analyzing the impact that a single food component may have on ADHD, the role of dietary patterns as a whole (e.g. three regular meals a day) can be more informative (40). Public health authorities promote provision-of-breakfast initiatives since three regular meals, especially breakfast, improve cognitive function and academic performance (41). Park et al. (2012) found that children who usually have three regular meals a day showed

lower odds of probable ADHD compared to the children who seldom have them (10). Another study reported that ADHD patients displayed more disruptive patterns of eating behaviors and exhibited markedly diminished adherence to a traditional breakfast, lunch, and dinner schedule, which was linked to a significantly higher frequency of irregular eating times (42). Even though direct interaction between "skipping breakfast" and ADHD is widely unclear; unbalanced diet can lead to deficiencies in essential nutrients or substituting it with a snack might result in higher intakes of certain food components (e.g. food additives, sugar) (43). However, possible reverse causation between ADHD and disrupted dietary patterns should not be overlooked in this matter (9). Impulsivity and oppositional-defiant/conduct problems which are frequently seen among ADHD patients, may result in a more chaotic lifestyle, noncompliance with parents' instructions about eating behaviors and less structured meal times (10). Skipping regular meals and/or substituting them with unhealthy food can potentially lower the diet quality and eventually lead to a low intake of certain nutrients which may induce certain nutritional subclinical deficiencies and, hence, worsen ADHD symptoms. In return, individuals with ADHD might experience more severe behavioral problems and end up in a vicious cycle of symptom exacerbation – unhealthy dietary patterns (7,44,45).

To our knowledge, this is one of the few studies done on MD habits of ADHD patients and first one to evaluate the effects of MD on ADHD symptomatology. By including drug naïve ADHD patients and matching them with healthy controls regarding their age/sex/height/weight/BMI, we minimized the effects of possible confounding factors and we believe this is the major strength of our study. Apart from these, some limitations of our research should also be acknowledged. Major limitation of our study is the case – control design which may hinder our ability to establish a causal relationship between the parameters that were analyzed. It should also be emphasized that, even though ADHD diagnoses were done according to semi-structured psychiatric interviews; other data which we explored were gathered according to self-reports and for this reason they are prone to some disruptions. Furthermore, our study was conducted in a single center so it might reflect only a portion of the population rather than a more comprehensive observation.

CONCLUSION

In conclusion, we found a positive relationship between a lower adherence to the MD and ADHD diagnoses. Also MD habits seem to be related to the inattention symptoms seen among ADHD patients. Another curious finding is the possible relationship between pulse/legume consumption and hyperactivity-impulsivity, oppositional-defiant behavior and conduct problems which warrants further research due to the potential hormonal effects of pulses/legumes. Our results suggest that certain dietary habits may play a role in both ADHD development and clinical appearance; but further evaluation is needed to shed light on causality and to determine if dietary manipulation could ameliorate ADHD symptoms.

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REFERENCES

1. Scahill L, Schwab-Stone M. Epidemiology of ADHD in school-age children. Child Adolesc Psychiatr Clin N Am. 2000;9(3):541–55.

2. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 4th Editio. Washington, DC: American Psychiatric Association; 2000.

3. Huss M, Duhan P, Gandhi P, Chen CW, Spannhuth C, Kumar V. Methylphenidate dose optimization for ADHD treatment: Review of safety, efficacy, and clinical necessity. Neuropsychiatric Disease and Treatment. 2017;13:1741–51.

4. Schmidt S, Petermann F. Developmental psychopathology: Attention Deficit Hyperactivity Disorder (ADHD). BMC Psychiatry. 2009;9(1):58.

5. Núñez-Jaramillo L, Herrera-Solís A, Herrera-Morales WV. Adhd: Reviewing the causes and evaluating solutions. Journal of Personalized Medicine. 2021;11(3):166.

6. Polanczyk G V., Salum GA, Sugaya LS, Caye A, Rohde LA. Annual research review: A meta-analysis of the worldwide prevalence of mental disorders in children and adolescents. J Child Psychol Psychiatry Allied Discip. 2015;56(3):345–65.

7. San Mauro Martín I, Blumenfeld Olivares JA, Garicano Vilar E, Echeverry López M, García Bernat M, Quevedo Santos Y, Blanco López M, Elortegui Pascual P, Borregon Rivilla E, Rincón Barrado M. Nutritional and environmental factors in attention-deficit hyperactivity disorder (ADHD): A cross-sectional study. Nutr Neurosci. 2018;21(9):641–7.

8. Millichap JG, Yee MM. The diet factor in attention-deficit/hyperactivity disorder. Pediatrics. 2012;129(2):330–7.

9. Howard AL, Robinson M, Smith GJ, Ambrosini GL, Piek JP, Oddy WH. ADHD is associated with a "Western" dietary pattern in adolescents. J Atten Disord. 2011;15(5):403–11.

10. Park S, Cho SC, Hong YC, Oh SY, Kim JW, Shin MS, Kim BN, Yoo HJ, Cho IH, Bhang SY. Association between dietary behaviors and attention-deficit/hyperactivity disorder and learning disabilities in school-aged children. Psychiatry Res. 2012;198(3):468–76.

11. Woo HD, Kim DW, Hong YS, Kim YM, Seo JH, Choe BM, Park JH, Kang JW, Yoo JH, Chueh HW, Lee JH, Kwak MJ, Kim J. Dietary patterns in children with attention deficit/hyperactivity disorder (ADHD). Nutrients. 2014;6(4):1539–53.

12. Donini LM, Serra-Majem L, Bulló M, Gil Á, Salas-Salvadó J. The Mediterranean diet: Culture, health and science. British Journal of Nutrition. 2015;113(Suupl 2):S1–3.

13. Faul F, Erdfelder E, Lang A, Buchner A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods. 2007;39(2):175–91.

14. Neyzi O, Günöz H, Furman A, Bundak R, Gökçay G, Darendeliler F, Baş F. Weight, height, head circumference and body mass index references for Turkish children. Çocuk Sağlığı ve Hast Derg. 2008;51:1–14.

15. Kaufman J, Birmaher B, Brent D, Rao U, Flynn C, Moreci P, Williamson D, Ryan N. Schedule for affective disorders and schizophrenia for school-age children-present and lifetime version (K-SADS-PL): Initial reliability and validity data. J Am Acad Child Adolesc Psychiatry. 1997;36(7):980–8.

16. Gökler B, Ünal F, Pehlivantürk B, Kültür E, Akdemir D, Taner Y. Reliability and Validity of Schedule for Affective Disorders and Schizophrenia for School Age Children-Present and Lifetime Version-Turkish Version (K-SADS-PL-T). Turkish J Child Adolesc Ment Heal. 2004;11(3):109–16.

17. Turgay A. DSM-IV Based Child and Adolescent Behavior Disorders Screening and Rating Scale. Integrative Therapy Institude, Toronto, Canada; 1995.

18. Ercan E, Amado S, Somer O, Çıkoğlu S. Dikkat eksikliği ve hiperaktivite bozukluğu ve yıkıcı davranım bozuklukları için bir test bataryası geliştirme çabası. Çocuk ve Ergen Ruh Sağlığı Derg. 2001;8(3):132–44.

19. Serra-Majem L, Ribas L, Ngo J, Ortega RM, García A, Pérez-Rodrigo C, Aranceta J. Food, youth and the Mediterranean diet in Spain. Development of KIDMED, Mediterranean Diet Quality Index in children and adolescents. Public Health Nutr. 2004;7(7):931–5.

20. Kabaran S, Gezer C. Determination of the Mediterranean Diet and obesity status of children and adolescents in Turkish Republic of Northern Cyprus. Turkish J Pediatr Dis. 2013;1:11–20.

21. IBM SPSS statistics for Windows. IBM Corporation; 2018.

22. Rios-Hernandez A, Alda JA, Farran-Codina A, Ferreira-Garcia E, Izquierdo-Pulido M. The mediterranean diet and ADHD in children and adolescents. Pediatrics. 2017;139(2).

23. Ghanizadeh A, Haddad B. The effect of dietary education on ADHD, a randomized controlled clinical trial. Ann Gen Psychiatry. 2015;14(1):12.

24. Hughes TF, Andel R, Small BJ, Borenstein AR, Mortimer JA, Wolk A, Johansson B, Fratiglioni L, Pedersen NL, Gatz M. Midlife fruit and vegetable consumption and risk of dementia in later life in swedish twins. Am J Geriatr Psychiatry. 2010;18(5):413–20.

25. Akbaraly TN, Brunner EJ, Ferrie JE, Marmot MG, Kivimaki M, Singh-Manoux A. Dietary pattern and depressive symptoms in middle age. Br J Psychiatry. 2009;195(5):408–13.

26. Dai Q, Borenstein AR, Wu Y, Jackson JC, Larson EB. Fruit and Vegetable Juices and Alzheimer's Disease: The Kame Project. Am J Med. 2006;119(9):751–9.

27. Azadbakht L, Kimiagar M, Mehrabi Y, Esmaillzadeh A, Padyab M, Hu FB, Willett WC. Soy inclusion in the diet improves features of the metabolic syndrome: A randomized crossover study in postmenopausal women. Am J Clin Nutr. 2007;85(3):735–41.

28. Hunt JR. Moving toward a plant-based diet: Are iron and zinc at risk? Nutr Rev. 2002;60(5 pt 1):127–34.

29. Li Y, Dai Q, Tedders SH, Arroyo C, Zhang J. Legume consumption and severe depressed mood, the modifying roles of gender and menopausal status. Public Health Nutr. 2010;13(8):1198–206.

30. Roberts BA, Martel MM. Prenatal testosterone and

preschool disruptive behavior disorders. Pers Individ Dif. 2013;55(8):962–6.

31. Cheema M, Mahmood K, Haleem D. Nootropic and Anti-anxiety Effects of Olive Oil: Relationship with Dopamine and Serotonin Metabolism. J Nutraceuticals Food Sci. 2018;3(1):4.

32. Pitozzi V, Jacomelli M, Catelan D, Servili M, Taticchi A, Biggeri A, Dolara P, Giovannelli L. Long-term dietary extra-virgin olive oil rich in polyphenols reverses age-related dysfunctions in motor coordination and contextual memory in mice: Role of oxidative stress. Rejuvenation Res. 2012;15(6):601–12.

33. Farr SA, Price TO, Dominguez LJ, Motisi A, Saiano F, Niehoff ML, Morley JE, Banks WA, Ercal N, Barbagallo M. Extra virgin olive oil improves learning and memory in SAMP8 mice. J Alzheimer's Dis. 2012;28(1):81–92.

34. Perveen T, Hashmi BM, Haider S, Tabassum S, Saleem S, Siddiqui MA. Role of Monoaminergic System in the Etiology of Olive Oil Induced Antidepressant and Anxiolytic Effects in Rats. ISRN Pharmacol. 2013;2013:615685.

35. Cormier E, Harrison Elder J. Diet and child behavior problems: fact or fiction? Pediatr Nurs. 2007;33(2):138–43.

36. Azadbakht L, Esmaillzadeh A. Dietary patterns and attention deficit hyperactivity disorder among Iranian children. Nutrition. 2012;28(3):242–9.

37. Wiles NJ, Northstone K, Emmett P, Lewis G. "Junk food" diet and childhood behavioural problems: Results from the ALSPAC cohort. Eur J Clin Nutr. 2009;63(4):491–8.

38. Lien L, Lien N, Heyerdahl S, Thoresen M, Bjertness E. Consumption of soft drinks and hyperactivity, mental distress, and conduct problems among adolescents in Oslo, Norway. Am J Public Health. 2006;96(10):1815–20.

39. Wesnes KA, Pincock C, Richardson D, Helm G, Hails S. Breakfast reduces declines in attention and memory over the morning in schoolchildren. Appetite. 2003;41(3):329–31.

40. Tucker KL. Dietary patterns, approaches, and multicultural perspective. Appl Physiol Nutr Metab. 2010;35(2):211–8.

41. Wyon DP, Abrahamsson L, Järtelius M, Fletcher RJ. An experimental study of the effects of energy intake at breakfast on the test performance of 10-year-old children in school. Int J Food Sci Nutr. 1997;48(1):5–12.

42. Ptacek R, Stefano GB, Weissenberger S, Akotia D, Raboch J, Papezova H, Domkarova L, Stepankova T, Goetz M. Attention deficit hyperactivity disorder and disordered eating behaviors: Links, risks, and challenges faced. Neuropsychiatric Disease and Treatment. 2016;12:571–9.

43. Izquierdo-Pulido M, Rios-Hernandez A, Farran A, Alda J. The role of diet and physical activity in children and adolescents with ADHD, in Recent Advances in Pharmaceutical Sciences V. Editör Munoz-Torrero D, Vinardell M, Palazon J. Kerala, India: Research Signpost; 2015. p. 51–64.

44. O'Neil A, Quirk SE, Housden S, Brennan SL, Williams LJ, Pasco JA, Berk M, Jacka FN. Relationship between diet and mental health in children and adolescents: A systematic review. American Journal of Public Health. 2014;104(10):e31–42.

45. Barkley RA. ADHD, obesity, and eating pathology. ADHD Rep. 2014;22(5):1–6.