Comparison of executive functions in attention deficit hyperactivity disorder, obsessive compulsive disorder and pathological internet use in children and adolescents

Dikkat eksikliği hiperaktivite bozukluğu, obsesif kompülsif bozukluk ve patolojik internet kullanımı olan çocuk ve gençlerin yürütücü işlevlerinin karşılaştırılması

Sevcan Karakoç[1], Sibelnur Avcil[2], Hatice Aksu[3], Börte Gürbüz Özgür[2], Zafer Güleş[4], Sercan Öztürk[5]
[1]Prof., Doğuş University, Faculty of Arts and Sciences, Department of Psychology, İstanbul, Turkey, https://orcid.org/0000-0002-2778-9174
[2]Assoc. Prof., Aydın Adnan Menderes University Faculty of Medicine, Department of Child Psychiatry, Turkey, https://orcid.org/0000-0002-7855-894X, https://orcid.org/0000-0002-9176-7359
[3]Prof., Aydın Adnan Menderes University Faculty of Medicine, Department of Child Psychiatry, Turkey,https://orcid.org/0000-0001-6882-1129
[4]M.D, Aydın Adnan Menderes University Faculty of Medicine, Department of Child Psychiatry, Turkey,https://orcid.org/0000-0002-7325-7486
[5]Res., Assist, Aydın Adnan Menderes University Faculty of Medicine, Department of Public Health, Turkey,https://orcid.org/0000-0001-7390-0657

SUMMARY

Objective: Prevalance of pathological internet use (PIU) is increasing in children and adolescents. Although it has multifactorial etiologies, some symptoms are considered as impulsive whereas some are compulsive in nature. This study is aimed to compare individuals having PIU with attention deficit hyperactivity disorder (ADHD) and obsessive compulsive disorder (OCD) which have more specific findings in terms of executive functioning. **Method:**Participants (n=104) of this study were 8-18 years-old-aged right-handed, drug-naive children and adolescents with IQ>85, and were grouped into 4 groups: ADHD, OCD, PIU and healthy control (HC). They are assessed with K-SADS, Yale Brown Obsessive Compulsive Disorder Scale, Young Internet Addiction Scale and Turgay Disruptive Behavior Scale-ADHD. STROOP test, Wisconsin Card Sorting Test (WCST), Judgement of Line Orientation (JLO) and Visual-Aural Digit Span Test (VADST) were used as neuropsychological (NP) tests. **Results:**Study sample was composed of 13 (12.5%) girls and 91 (87.5%) boys with a mean age of 11.5±2.7 years old. PIU group had the lowest scores in STROOP time and the highest scores in BLOT and VADST tests(p>0.05). ADHD group has the lowest scores in JLO and VASDT- auditory verbal, visual-verbal and visual-written subtests (p<0.05) Groups were similar in WCST completed category, conceptual response and scores. ADHD group had the highest scores in WCST perseverative responses and errors (p>0.05). **Discussion:**Executive function abnormalities are more specific for ADHD cases rather than PIU and OCD. However, shorter response time in PIU group suggests that online games and other internet use may increase the speed of information processing. Visual content of internet might cause PIU group to score better in short term memory, visual perception, visual memory and orientation tests. NP profile of the PIU resembles OCD group than ADHD group suggesting that PIU cases with no comorbid conditions might have same neurobiology as OCD.

Key Words: Attention deficit hyperactivity disorder, obsessive compulsive disorder, Pathologic internet use

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ÖZET

Amaç: İnternet bağımlılığı(İB) sıklığı çocuk ve ergenlerde giderek artmaktadır. Etiyolojisi multifaktöryel olmakla birlikte bazı belirtileri impulsivite, bazı belirtileri kompülsivite olarak ele alınmaktadır. Bu çalışmanın amacı dikkat eksikliği hiperaktivite bozukluğu (DEHB) ve obsesif kompülsif bozukluk (OKB) ile patolojik internet kullanımı (PİK) olan grupların yürütücü işlevler açısından karşılaştırılmasıdır. **Yöntem:** Çalışmaya 8-18 yaş arası, sağ el dominant ve ilaç kullanmayan, IQ>85 olan çocuk ve ergenler (N=104) DEHB, OKB, PİK ve sağlıklı kontrol olarak 4 grup şeklinde katıldı. Olgular K-SADS yarı-yapılandırılmış tanısal görüşme, Yale Brown Obsesif Kompülsif Bozukluk Ölçeği, İnternet bağımlılığı Ölçeği ve Turgay DSM-IV-DEHB ölçeği ile değerlendirildi. Nöropsikolojik(NP) testler olarak STROOP renk-kelime testi, Wisconsin Kart Eşleme Testi(WKET), Çizgi Yönünü Belirleme Testi(ÇYBT) ve Görsel İşitsel Sayı Dizileri Testi (GİSDT) uygulandı. **Bulgular:** Örneklem yaş ortalaması 11,5±2,7,13(%12,5) kız,91(%87,5) erkek içermekteydi. PİK grubu tüm STROOP alt testlerini en kısa sürede tamamlamıştır(p>0,05). ÇYBT için en çok doğru yanıtı veren PİK grubu (p>0,05), DEHB ise en düşük veren gruptur(p<0,05). GİSDT tüm alttest puanları PİK için en yüksek değere sahipken(p>0,05), GİSDT/ işitsel-sözel, görsel-sözel ve görsel-yazılı alttest puanları DEHB grubunda düşüktür(p<0,05). WKET tamamlanan kategori sayısı, kavramsal tepki puanı ve kurulumu sürdürme puanı açısından gruplar arasında anlamlı fark yokken, WKET Toplam perseveratif tepki ve hata ise DEHB grubunda fazladır (p>0,05). **Sonuç:** Yürütücü işlev bozuklukları OKB veya PİK grubuna göre DEHB tanısı için daha spesifiktir. Ancak tepki süresinin PİK grubunda daha kısa olması; çevrimiçi oyun ve diğer programların çocukların bilgi işlemleme hızına etki ettiğini gösterebilir. İnternetin görsel içeriği, PİK grubunun görsel algılama, hatırlama ve yönlenim ile ilgili testlerde daha başarılı olmalarına neden olmuş olabilir. PİK grubunun NP profili DEHB grubu ile kıyaslandığında OKB grubuna benzemektedir. Komorbiditesi olmayan PİK olguları OKB grubuna benzer nörobiyolojiye sahip olabilir.

Anahtar Sözcükler: Dikkat eksikliği hiperaktivite bozukluğu, Obsesif kompülsif bozukluk, Patolojik internet kullanımı

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INTRODUCTION

Internet addiction (IA) is defined by excessive or poorly controlled preoccupations, impulses or behaviors regarding computer use and internet access for games, shopping or social media issues, which causes impairment or distress in the individual's life (1). Internet addiction or pathological internet use (PIU), is classified as a behavioral addiction and has been increased among whole age groups especially in children and adolescents. The rates are increasing after smart phones which provide internet continuously. Also there has been an enormous increase of internet use due to the lockdowns and isolations because of the outbreak of coronavirus (2).

The number of internet game players reached to 1.8 billions worldwide (3). Similar to this high rates, in Turkey the prevalance of internet-computer addiction in high school level youth was found 4.5-16% (4,5). In another study conducted among middle school aged children in Turkey, the rate of internet addiction in general group and high group was 2.33% and 17.45% consecutively (6). In the 5th edition of Diagnostical and Statistical Manual of Mental Disorders (DSM-5) (APA 2013) (7), excessive internet use is not classified as an addiction therefore researchers have started to use pathological or problematic internet use as a term more commonly. Recent Chinese study reported that the internet addiction among high school children is 13.4 % and male gender, depression, stress and insomina were revealed as risk factors for IA (8).

The etiopathogenesis of pathological internet use (PIU) is multifactorial and the neurobiological mechanisms havenot been clarified. Orbitofrontal cortex, anterior cingulate cortex, posterior cingulate cortex and dorsolateral prefrontal cortex and altered gray matter volume are found to be responsible neuroanatomical areas (9,10).

Attention deficit hyperactivity disorder (ADHD) and obsessive compulsive disorder (OCD) are common childhood psychiatric disorders. Deficits in inhibitory control mechanisms have been reported as shared characteristics between ADHD, OCD and PIU. Controversies about the diagnostic classification of IA are still present. Some authors put the IA into impulse control disorders whereas some classify it in the OCD related disorders (3,11). As a clinical point of view these three disorders are very different from each other. However they share the common pathway which is the corticothalamostriatal tract (12).

Executive functions are higher cognitive functions including; planning, organization, self regulation, flexibility, response inhibition and completing goal oriented behaviors, attention focusing and working memory. In order to understand the neuroanatomic and neurofunctional correlates of psyhciatric disorders, researches on neuropsychological tests have been increased recently (13). Abnormalities in executive functions have been showed in youth with ADHD and OCD so far (9,13-17). However research on neuropsychological assessments of PIU is still lacking. Some studies showed that IA has some common symptoms with OCD such as uncontrolled repetitive behaviors and similar executive functions like diminished cognitive flexibility (8).

Here we aimed to enlighten the etiology of pathological internet use with neuropsychological measures and compare the results with ADHD and OCD and with healthy population. Attention, memory, impulsivity and compulsivity are aimed to be evaulated in terms of pathophysiology.

METHOD

Participants

Study sample consisted of 8-18 years old right-handed children physically healthy with normal cognitive functioning (IQ>85), without any vision or hearing anomalies, any mental retardation or autism spectrum disorders who have been following in the 3rd reference of child psychiatry outpatient with pure diagnoses of ADHD, OCD and PIU and classified into 3 groups. Healthy control group was the same age and sociodemograpic group with no physical or psychiatric disorders. The sample size was calculated according to power analysis and at least 25 patients for each groups were needed (17). Totally 104 individuals (26 for each group)

were gathered into this study.

Measurements

Sociodemographic data form: This form was produced by the authors. It was administered by the clinicians and based on the parent report and direct clinical observation. This form was composed of a detailed developmental history, as well as history of behavioral, emotional and physical problems if present. Detailed medical history internet use was obtained. Daily use of internet, durations on internet were assessed. Computer or smart phone use, purpose of the internet use (shopping, fun etc.) and ways of the use were asked in the form.

The Kiddie Schedule for Affective Disorders and Schizophrenia (K-SADS): K-SADS is a semi-structured DSM-IV interview aimed at early diagnosis of affective disorders such as depression, bipolar disorder, and anxiety disorder. Clinical diagnosis of OCD and ADHD were also done by this interview. Turkish adaptation was completed by Gokler et. al and it is a valid and reliable test used commonly. (18).

Internet Addiction Test (IAT): This test was developed by Young and commonly used worldwide. It is a 5 point Likert scale with 20 questions. The higher score represents the higher compulsivity and addiction. Young suggests that total scores between 31 and 49 show the presence of a mild level addiction, 50 to 79 represent the presence of a moderate level, and scores of 80 to 100 indicate a severe dependence (19). In this study we defined the pathological internet users who had scores higher than 50 which is used as a cut-off in Turkish version of this test (20).

Children's Yale–Brown Obsessive–Compulsive Scale (CY–BOCS; Scahill et al., 1997): The CY–BOCS is a semi-structured clinician-administered interview. The clinician can get obtain severity scores of obsessions, compulsions and total scores. It is valid in Turkish (21).

Turgay DSM-IV-Based Child and Adolescent Disruptive Behavioral Disorders Screening and Rating Scale (T-DSM-IV-Scale)-parent form (T-DSM-IV-S): It was developed by Turgay and translated and adapted into Turkish and it is based on the DSM-IV diagnostic criteria and assesses hyperactivity/ impulsivity (9 items), inattention (9 items), opposition/defiance (8 items), and conduct disorder (15 items) (22,23).

Neuropsychological Tests: In this study, manual form of the NP tests which have the Turkish reliability and validity are used (24).

STROOP test: This test measures the frontal lobe functions including focused attention, selective attention, response inhibition, speed of information processing .

Wisconsin Card Sorting Test (WSCT): This test also measures the frontal lobe functions especially executive attention, working memory, perseveration, conceptualization and abstract thinking.

Judgement of Line Orientation Test (JLOT): This test provides information about the visual perception an orientation which are accepted as parietal lobe and right hemisphere functions (25).

Visual-Aural Digit Span Test (VADST): This test measures the short term memory,working memory and attention. It gives information about the functioning of hippocampus ad prefrontal cortex.

Procedure

All study groups had the psychiatric assessment and NP tests. Psychiatric assessment was conducted by experienced child psychiatrists based on DSM-5 (APA 2013) diagnostic criteria and also with K-SADS. All measures including sociodemographic data form, IAT, CY-BOCS and T-DSM-IV-S were also filled out prior to assessment. After psychiatric assessment; neuropsychological (NP) test appointments were given for the following days in order to decrease the negative effects of tiredness on cognition. The NP tests were done by the NP testing certified author (SK).

Ethics

Ethical approval was obtained from the Local Institutional Review Board of Ethics. It is imperative to note that the study was carried out according to the Declaration of Helsinki Human Rights.

Statistical analysis

Data analysis was conducted by way of computer based statistics software (SPSS 24.0, SPSS Inc., Chicago, IL, USA). All data was evaluated by Kolmogorov-Smirnov for checking the normal distribution. Through this software, descriptive statistics including the means and ratio intervals were calculated. The study groups were primarily divided into 4 subgroups. ANOVA and Pearson Corelation Tests were used for parametric variables whereas Kruskal Wallis H and spearman correlation tests were used for nonparametric variables. For binary comparisons Bonferroni correction, Tukey, Tamhane and Mann Whitney U tests were used. Type I error level was defined as 0.05.

RESULTS

Mean age of the participants was 11.47±2.7 (minimum 8-maximum 17 years old). Most of the participants were male (87.5%) and they were at the primary level of education. Characteristics of the groups are shown in the Table 1.

All groups were similar in terms of the subjects' age (Kruskal Wallis test (KWT): 4,692; p=0.196), maternal age (KWT=0.733, p=0.865), paternal age (KWT:1.516, p=0.679) and number of siblings (KWT: 5.660, p=0.129).

Type of the internet use was checked among the PIU patients and the most common type was online games (53.8%). Other choices for the internet use were; social media websites (26.9%), online chat and texting (15.4%) and web surfing (3.8%).

Table 1. Characteristics of the study groups

Characeristics		ADHD (n=26)		OCD (n=26)		PIU (n=26)		HC (n=26)		Total (n=104)	
		N	%	N	%	N	%	N	%	N	%
Age group	8-12	19	73.1	9	34.6	13	50.0	9	34.6	50	48.1
	12-18	7	26.9	17	65.4	13	50.0	17	65.4	54	51.9
Gender	Female	6	23.1	3	11.5	1	3.8	3	11.5	13	12.5
	Male	20	76.9	23	88.5	25	96.2	23	88.5	91	87.5
Education	Primary school	14	53.8	10	38.5	7	26.9	13	50.0	44	42.3
	Middle school	10	38.5	11	42.3	10	38.5	8	30.8	39	37.5
	High School	2	7.7	5	19.2	9	34.6	5	19.2	21	20.2

ADHD: Attention Deficit Hyperactivity Disorder, OCD: Obsessive Compulsive disorder, PIU: Pathological Internet Use, HC: Healthy Control

Neuropsychological Test Scores

Table 2 shows the overall results and comparison of the NP tests of the study groups.

STROOP tests: Pathological internet users had the shortest time of responses in all STROOP subtests. This group showed significantly shorter time than the ADHD group in the STROOP1 task and the OCD group in the STROOP3 task. Also for the STROOP 5 task, PIU group had significantly lower scores comparing to ADHD groups (Kruskal Wallis test, p>0.05).

Table 2: Comparison of the neuropsychological test results among the study groups

Tests	ADHD (n=26)			OCD (n=26)			PIU (n=26)			HC (n=26)			F/KWT	p
	M	SD	%95 CI	M	SD	%95 CI	M	SD	%95 CI	M	SD	%95 CI		
STROOP 1	12.56	1.72	11.86-13.25	11.50	1.61	10.85-12.15	10.15	2.07	9.32-10.99	11.71	2.05	10.88-12.54	-/17.214	0.001
STROOP 2	12.73	2.20	11.84-13.62	12.65	2.30	11.73-13.58	10.00	1.85	9.25-10.75	12.54	3.06	11.29-13.78	-/21.897	<0.001
STROOP 3	18.00	3.10	16.75-19.25	18.42	2.98	17.22-19.63	14.88	3.72	13.38-16.59	17.77	5.24	15.66-19.89	-/15.767	0.001
STROOP 4	26.85	6.73	24.13-29.57	26.54	4.95	24.54-28.54	21.65	10.20	17.53-25.77	27.15	8.14	23.86-30.44	-/19.713	<0.001
STROOP 5	43.85	8.38	40.46-47.23	40.92	5.24	38.81-43.04	34.69	13.71	29.15-40.23	43.03	9.74	39.09-46.96	-/23.412	<0.001
JLOT	18.54	4.29	16.81-21.27	22.00	3.11	20.74-23.26	22.42	3.85	20.87-23.98	22.12	2.99	20.90-23.33	6.705/-	<0.001
VADST-Auditory Verbal	4.00	0.80	3.68-4.32	5.12	1.07	4.68-5.55	4.81	1.13	4.35-5.26	4.77	0.99	4.37-5.17	-/15.873	0.001
VADST-Auditory-Written	3.88	0.65	3.62-4.15	5.12	1.14	4.65-5.58	4.69	0.88	4.34-5.05	4.54	0.99	4.14-4.94	-/19.716	<0.001
VADST-Visual-Verbal	3.83	0.73	3.55-4.14	5.00	1.20	4.52-5.48	5.08	1.47	4.48-5.67	4.73	1.04	4.31-5.15	-/17.564	0.001
VADST-Visual-Written	3.73	0.78	3.42-4.04	4.88	1.03	4.47-5.30	4.92	1.23	4.43-5.42	4.46	0.95	4.08-4.84	-/20.731	<0.001
WCST: Cpmpleted categories	3.46	1.33	2.92-4.00	3.54	1.27	3.02-4.05	3.69	1.32	3.16-4.23	3.92	1.35	3.38-4.47	-/1.482	0.686
WCST: total perseverative response	41.31	20.27	33.12-49.49	31.77	15.74	25.41-38.13	29.15	17.68	22.01-36.29	26.62	15.54	20.30-32.93	-/8.228	0.042
WCST: Perserverative Errors	30.88	15.21	24.74-37.03	20.35	11.52	15.69-25.00	23.62	15.53	17.34-29.89	18.27	13.35	12.88-23.66	-/9.451	0.024
WCST: Conceptualization	63.38	14.46	57.54-69.22	67.04	12.08	62.16-71.92	68.54	14.85	62.54-74.54	67.77	14.09	62.08-73.46	0.700/-	0.554
WCST-Set-maintenance	1.58	1.10	1.13-2.02	1.27	1.25	0.76-1.77	1.23	1.11	0.78-1.68	1.50	1.10	1.05-1.95	-/2.174	0.537

M: Mean, SD: standard deviation, 95% CI: confidence interval, F: ANOVA; KWT: Kruskal Wallis Test
ADHD: Attention Deficit Hyperactivity Disorder, OCD: Obsessive Compulsive disorder, PIU: Pathological Internet Use, HC: Healthy Control
JLOT: judgement of line orientation test, VADST: Visual Aural Digit Span Test, WCST: Wisconsin Card sorting Test

Judgement of Line Orientation Test:Although the mean of the correct responses was the highest in the PIU group, the difference was not significant, whereas the ADHD group showed the significant lowest score. The mean of the JLOT scores are as follows; 22.4 for PIU, 22.0 for OCD and 22.1 for HC and 18.5 for ADHD group.

*Visual Aural Digit Span Test:*The lowest scores were obtained form the ADHD group and the highest scores were obtained from the PIU group.

VADST/auditory-verbal: The significant differences were noted in OCD and ADHD groups, the scores in a descending order are; OCD>PIU>HC>ADHD.

ADHD groups showed significant differences in VADST/ auditory-written, VADST/visual-verbal and VADST/visual-written scores.

Wisconsin Card Sorting Test: There were not any significant differences among the 4 groups for the completed category, conceptualization and set maintenance subtests in WCST.

Scores in conceptualization subtest of WCST were in this order; PIU> HC> OCD > ADHD. Mean number of completed category was highest in the HC and it was the second highest in the PIU group.

Perseverative responses and perseverative errors were significantly different in the ADHD group. Perseverative responses scores were: ADHD> OCD> PIU> HC and whereaas perseverative errors were ADHD>PIU>OCD>HC. The perseverative profiles of PIU group were similar to OCD groups rather than HC and ADHD.

Correlations of sociodemographic and clinical features with neuropsychological functioning were evaluated and shown in the Table 3. Data of one of the mothers and one of the fathers were absent since they were dead.

Table 3: Correlates of sociodemographic and clinical features on the neuropsychological functioning

TESTS	Age n=104	Sibling number n=104	Maternal age n=103	Paternal age n=103	ADHD/IA n=26	ADHD/HA n=26	ADHD/Combined n=26	CY-BOCS n=26
STROOP 1	-0.629**	0.069	-0.293**	-0.173	0.225	0.279	0.327	-0.046
STROOP 2	-0.504**	0.094	-0.269**	-0.166	0.208	0.162	0.257	-0.018
STROOP 3	-0.532**	0.003	-0.279**	-0.171	0.023	0.011	-0.045	0,129
STROOP 4	-0.496**	0.011	-0.257**	-0.155	0.004	0.016	-0.044	0.089
STROOP 5	-0.578**	0.062	-0.238*	-0.128	0.050	0.092	0.027	-0.235
JLOT	0.646**	-0.034	0.242*	0.111	-0.013	0.023	0.004	0.156
VADST-Auditory-Verbal	0.685**	0.025	0.279**	0.268**	-0.096	-0.164	-0.223	0.024
VADST-Auditory-Written	0.567**	0.007	0.238*	0.221*	-0.122	0.096	-0.013	0.122
VADST-Visual-Verbal	0.698**	0.007	0.230*	0.182	-0.083	0.168	0,006	0.009
VADST- Visual-Written	0.699**	-0.027	0.171	0.201*	0.040	-0.364	-0.255	0.066
WCST: Completed categories	0.701**	-0.047	0.333**	0.213*	-0.271	0.087	-0.082	-0.191
WCST: total perseverative response	0.559**	0.164	-0.218*	-0.090	0.331	0.270	0.337	0.144
WCST: Perserverative Errors	0.542**	0.152	-0.205*	-0.083	0.385	0.351	0.470	0.100
WCST: Conceptualization	0.486**	-0.056	0.262**	0.093	-0.148	-0.267	-0.318	-0.101
WCST: set maintenance	0.541**	-0.048	-0.102	-0.064	-0.101	-0.222	-0.190	0.149

*p<0.05 **p<0.01 (Pearson correlation test was used if both of the variables were normally distributed, if not Spe correlation was used)

ADHD: Attention Deficit Hyperactivity Disorder, OCD: Obsessive Compulsive disorder, PIU: Pathological Internet Use, HC: Healthy Control, JLOT: judgement of line orientation test, VADST: Visual Aural Digit Span Test, WCST: Wisconsin Card Sorting Test, ADHD/IA: Scores from inattention section from the Turgay Child and Adolescent Disruptive Behavioral Disorders Screening and Rating Scale, ADHD/HA: Scores from hyperactivity-impulsivity from the Turgay Child and Adolescent Disruptive Behavioral Disorders Screening and Rating Scale, ADHD/T: Total Scores from the Turgay Child and Adolescent Disruptive Behavioral Disorders Screening and Rating Scale, CY-BOCS: Scores from the Children's *Yale Brown Obsessive Compulsive Scale*_IAT: Scores from internet addiction test, Age of the participants is significantly correlated with the all NP tests. It is poorly correlated with Stroop 4 and WCST conceptualization tests (r<0.5) whereas moderately (0.5<r<0.69) (p<0.05). Scale scores and NP tests are very poorly and insignificantly correlated.

DISCUSSION

Internet use is an inevitable behavior of our current lifestyle. Internet use can be classifed as general or special use, also pathological and nonpathological use. Through the pandemic of COVID-19, internet use has been seriously increased (2,26) and unfortunately children and youth have the highest risk for addiction and their developing brains are susceptible to the damage of internet over use. From the developmental view; pediatric population is especially vulnerable due to their lower capacity of behavioral control, overt seeking for pleasure and their immature brain structure. There is no approved treatment modality for the pathological internet use (PIU). Treatment options are developed depending on the nature of the disease (8). Current data about the etiology of the PIU is still lacking. In this study, we compared children with the ADHD and OCD in terms of PIU in order to identify the neuropsychological etiology. In our study we found that the youth spent their time with online games in the first place and the social media in the second place. Gaming disorder is a type of PIU which researcher must investigate seperately. This may be resulted form the gender of the population or the referral pattern of the parents Boys play more internet games than girls (27). Parents of our study group had identified internet addiction

tendency more easily with observing gaming pattern of children rather than their use of social media, this would be an explanation. Boys spend more time on games and girls spend more time on social network (28). Sex and corresponding risk factors for internet addiction and gaming disorder is underresearched. But male gender is reported as a risk factor in Chinese study (8).

In our study the ADHD group showed bad scores in STROOP and WCST tests, which is relevant with the literature (29,30). Stroop scores of our PIU group were better than ADHD and OCD group. This might result from the proper timing of PIU group because of their responses in video games. We know that addiction is a pathology of nucleus accumbens, where as ADHD is a prefrontal lobe dysfunction. So, our data is consistent with the previosu neurological findings. Homack and Riccio and Parsons et. al reported that Stroop Color-Word test is an indicator of prefrontal functioning and Stroop 5 is a function of nondominant hemisphere frontal lobe activation (29,31).

Our PIU group has showed better results in Stroop tests comparing to ADHD and OCD group. Stroop Color-Word test shows prefrontal pathologies whereas Stroop 5 scores Show nondominant hemisphere frontal activation (29,31).

Our PIU group has showed significant differences in WCST perseverative errors. WCST perseverative response rates were the highest in ADHD group. This also shows that WCST test measures executive functions which is dysfunctional in ADHD group. (2,29,30).

In our study PIU group didnt show significant differences in WCST perseverative responses but showed more perseverative errors. Second highest perseverative responsenses were seen in OCD group. Neuropsyhological tests specific for executive functions are mostly disturbed in ADHD group. (32). Therefore endophenotypes for ADHD are executive functions. In literature the data on executive functions in OCD are inconsistent.

In our study our OCD group showed similar results with the healthy control group like previous data given by Ornstein et al. (16). We found no difference in short term memory tests such as digit span test as previously reported results of Sawamura et al. (33). In our study NP test profile of PIU group was similar to the OCD group. Gao et al. (8) reported that there are some overlaps between the symptomatology of OCD and IA in adolescents. Compulsive mail/website checking, uncontrolled social media use, excessive online buying and cyberhoarding are also classified as pathological internet use and obsessive compulsive related disorders (33).

Dong et al (34). reported that male individuals with internet addiction problems had more prolonged reaction time and more errors in color-word test. In contrast, reaction time of our sample was lower than that of the controls. This finding may be partly related with a relatively shorter time reaching the reward and a possible deficit in waiting for the longer outcomes (36).

Our findings on judgement of line orientation test revealed that PIU group had the highest scores. This may be interpretteted as PIU is associated with visual-spatial and orientation problems which reflects more intact parietal and right hemisphere functions (36). Although healthy controls were not different from OCD group, both of them had higher scores than ADHD group. In the OCD group, visual processing scores were within normal range, as reported in previous studies (37,38).

In our study, ADHD group had lower scores on JLOT, which is in parallel with Parson et al (31). On the contrary, Schafer ve Semrud-Clikeman (39), reported that children with ADHD had visual perception problems leading to social skill deficit but they didnot find any significant diffe-rences in social problems with the JLOT scoring. Therefore further studies related with visual perception and PIU are needed.

Working memory deficits are among the core endophentypes of ADHD (40). VADST is one of the tools to examine working memory. In the present study, VADST scores found to be impaired in ADHD group but not in PIU. Children with PIU were not found to have a significant difficulty in

remembering numbers paired with visual stimulus. Therefore we suggest that there is a difference in PIU and ADHD group in terms of visual information processing system. Further neuroanatomical and neurofunctional researches to find out the diffrences are needed.

In our study, we investigated the possible impact of the sociodemographic variables on executive functioning scores. According to our findings, age is strongly associated with overall test scores. In line with Hong et al (2010), older ages was found to be related with better performances (41). Cognitive flexibility, target selection and information processing have been shown to start developing between the ages of 7-9 and maturation takes place during adolescence (42). When the age increases memory capacity is shifted from the visual field to the verbal phonological field (43).

Limitations: Our study population was composed of children aged 8-18 years old. ADHD group was mostly children and the OCD and HC group were adolescents. Our sample groups were drug naive groups. Therefore severity of the diseases might be milder form and it is hard to generalize the NP test scores to all types of diseases. Moreover our study groups were from clinically referred population, therefore we cannot generalize the results for the general population. Another limitation is the gender ratio, our sample is mostly composed of boys therefore we can not generalize our data to females. Also, the scales for pathologic internet use are self report questionnaires therefore there might be rater biases which is a common problem in assessment of PIU in the field.

CONCLUSION

Our study is amongst the few studies; which consists of a wide range of neuropsychological tests in the comparison of PIU, OCD, ADHD and healthy control groups. Neuropsychological profile of the PIU group is found to be similar to OCD group rather than the ADHD group. So, we suggest that, as a definitive explanation, compulsive internet use is a more valid theory than the impulsive use. To clarify the etiological background of PIU, future neuroimaging and clinical studies in larger sample sizes are needed. A better understanding of PIU will lead to more effective prevention strategies for this vulnerable population.

Conflicts of interest: The authors declare that they have no conflict of interest.

Correspondence address: Prof. Sevcan Karakoç , Bağdat Cad. No: 149/7 Kadıköy İstanbul - Türkiye drsevcankarakoc@yahoo.com

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