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Cardiovascular response to physical exercise and the risk of Internet addiction in 15–16-year-old adolescents


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BRIEF REPORT



ABSTRACT

Background and aim: Subjective symptoms of Internet addiction (IA), such as interpersonal and health-related problems (IH-RP), do not correlate with objective physiological parameters. This study aimed to investigate the cardiovascular reactivity after physical exercise in 15–16-year-old adolescents showing different severities of symptoms of health-related problems due to Internet overuse. *Methods:* This study included 20 healthy adolescents (boys, 15–16 years) with different risks of IA (by the Chen internet addiction scale [CIAS]). The physical exercise test was to perform a standing broad jump three times. The arterial blood pressures and heart rates were recorded before, immediately after, and at 4 minutes of rest after exercise. *Results and discussion:* The total sample of adolescents was divided into two groups, that is, those with IH-RP scores of 12 or less (Group I, $n = 12$) and those scoring more than 12 points (Group II, $n = 8$). The diastolic blood pressure significantly increased after exercise in group II, whereas it remained stable in group I. The heart rate in group I tended to increase, but the changes were not statistically significant. Group II adolescents showed significant increases in heart rate, and at rest, this parameter was significantly higher than the baseline value. *Conclusions:* Adolescents with a risk of IA and severe symptoms of interpersonal and health-related problems had increased sympathetic activity during and after speed-strength physical exercise compared to those without the aforementioned symptoms.

KEYWORDS

internet addiction, cardiovascular system, adolescents

INTRODUCTION

On reaching adolescence, the autonomic nervous regulation of cardiac activity remains imperfect due to an imbalance in the sympathetic-vagal relationship. Nowadays, young people need to spend significant amounts of time on the Internet for educational purposes and to gain recognition of their personal worth or value. Simultaneously, signs of Internet-dependent behaviour may develop, which can also affect health (Cernigula et al., 2016). Internet addiction (IA) is characterised by excessive or poorly controlled preoccupations, urges, or behaviours regarding computer use and Internet access that lead to impairment or distress (Shaw & Black, 2008). As not all specialists recognise the state of IA as an independent disease, it is necessary to express different points of view on this state: ‘internet addiction’, ‘internet overuse’ and ‘excessive internet use’ (Weinstein & Lejoyeux, 2010). Interpersonal and health-related problems can be assessed using the revised Chen Internet Addiction Scale (CIAS) (Chen, Weng, Su, Wu & Yang, 2003; Mak et al., 2014). The symptoms of IA, such as compulsiveness, withdrawal symptoms, and time management disorders, have a fairly specific meaning for interpretation among psychologists and psychiatrists. However, subjective symptoms of intrapersonal and health-related problems still have an

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ambiguous correlation with objective physiological parameters. Prolonged sympathicotonia and a decreased vagal regulation of heart rate may lead to health-related problems in individuals with IA (Lin, Kuo, Lee, Sheen, & Chen, 2014; Kim, Hughes, Park, Quinn, & Kong, 2016; Zhang, Luo, Lan, & Barrow, 2020). The physical exercise test most clearly demonstrates the ability of the human cardiovascular system to adapt to environmental challenges. The role of genetic factors is recognised in the restoration of vagal activity after physical exercise in adolescents, but regular physical activity is important (Nederend, Schutte, Bartels, Harkel, & de Geus, 2016). Therefore, the study of the relationship between the subjective symptoms of health-related problems and cardiovascular reactivity after physical exercise is important for assessing the risk of cardiovascular pathology in adolescents who excessively use Internet resources.

Thus, this study aimed to determine the reactivity of the cardiovascular system to physical exercise in adolescents aged 15–16 years with different severities of symptoms of health-related problems due to Internet overuse.

METHODS

Participants

All the study participants were born in Arkhangelsk, the main city of the Arkhangelsk region (one of the 85 constituent entities of the Russian Federation). Since 2019, on the basis of the chosen school in this city, male students of the senior classes, aged 14–16 years (grades 8 and 9), had been participating in a research program to study the reactivity of the cardiovascular system during and after physical exercise ($n = 50$). According to the school's educational program, all the students attended 45-min lessons of physical training twice a week mandatorily. This group was initially formed as a group of healthy individuals according to medical criteria, based on the opinion of the paediatrician, as reflected in the personal medical documentation in the medical office of the school. Due to sex and age-related differences in the reactivities of the cardiovascular system in adolescents, we decided to form a homogeneous group in terms of sex and age. This study was carried out in January–February, 2020; 30 male adolescents (15–16 years old) were offered questionnaires with a Chen scale, of which 20 accepted this invitation. After the formation of this group, it was found that all the subjects had been brought up in families where both parents were present, and the families lived in apartments in multi-story buildings in Arkhangelsk. Each participant had access to the Internet through both a personal phone and a computer at home. The parents of all the participants were working citizens, and the levels of financial income of the families in which the respondents were brought up corresponded to the average income in the region of residence. There were no students who could not cope with the school curriculum, and none of them studied according to individual programs due to physical or mental health disabilities. None of the participants smoked or

consumed alcoholic drinks. The study participants had not committed any offences and did not need police or psychological supervision in connection with the manifestation of aggression, depression, and suicidal behaviour or the use of psychoactive substances. Anthropometric parameters (height and body mass index [BMI]) were measured for each participant in the school medical office. BMI was defined as the body mass divided by the square of the body height (kg/m^2), with mass in kilograms and height in meters. Height, weight, and BMI were measured using certified medical equipment with electronic scales and a height meter ("REP+VMEN-200-100-D1-A", Russian Federation). The anthropometric parameters of the examined individuals were above the 97th and below the 3rd percentiles according to the height-for-age for 5–19 years and the BMI-for-age for 5–19 years scales for boys of the corresponding age according to the criteria of the World Health Organization (The WHO Child Growth Standards, 2007).

Measures and procedure

All the participants were administered the Chen Internet Addiction Scale (CIAS) (Chen et al., 2003) and the Russian version by Feklisov and Malygin (Malygin, Feklysov, Iskandirova, & Antonenko, 2011). The CIAS comprised a questionnaire with 26 items and a 4-point Likert scale ranging from 1 point (Does not match my experience) to 4 points (Definitely matches my experience). Thus, the minimum CIAS value was 26, and the maximum value was 104. Respondents with CIAS scores above 64 points were considered to have symptoms of Internet-dependent behaviour (Chen et al., 2003; Malygin et al., 2011). Scores of 43–64 were associated with a risk of developing Internet-dependent behaviour, and those less than 43 points indicated a minimal risk of such behaviour. Total CIAS and subscales scores corresponding to 'compulsive use', 'withdrawal symptoms', 'tolerance', 'interpersonal and health-related problems' (IH-RP), and 'time management problems' have been identified. In this study, we used the results only of the IH-RP subscale. Further, in the sitting position, cardiovascular indicators were recorded in three stages: baseline (Stage 1), immediately after exercise (Stage 2), and at 4 min of rest after exercise, the recovery period (Stage 3). An A&D device (Japan) was used to register the systolic and diastolic blood pressures (SBP, DBP, mmHg) and the heart rate (HR, bpm). The test of physical speed-power exercise was to perform a standing broad jump with maximum effort three times. The indices of the percentage increase in cardiovascular parameters (in %) were calculated according to the formula

$$\text{value}_{\text{Stage2}}/\text{value}_{\text{Stage1}} \times 100\%.$$

Thus, indicators were obtained for each group, such as $\text{SBP}_{\text{Stage2}/\text{Stage1}}$, $\text{DBP}_{\text{Stage2}/\text{Stage1}}$, and $\text{HR}_{\text{Stage2}/\text{Stage1}}$ in percentages.

Statistical analysis

Statistical data was processed using Statistica software (StatSoft, USA, v.13.0). The description of quantitative



indicators was carried out with an indication of the median and range of values corresponding to the 25th and 75th percentiles (lower and upper quartiles). Quantitative variables in the independent groups were compared using the Mann-Whitney U test ($P < 0.05$). The dependent variables in each group were compared using the Friedman test and pairwise Wilcoxon comparison (while comparing three dependent groups, $P < 0.017$). The correlation analysis was performed using the Spearman test (r_{Spearman}), $P < 0.05$.

Ethics

The study procedures were carried out in accordance with the Declaration of Helsinki. The Institutional Review Board of the N. Laverov Federal Center for Integrated Arctic Research of the Ural Branch of the Russian Academy of Sciences approved the study. All subjects were informed about the study. Parental consent was sought for those younger than 18 years of age.

RESULTS

The average CIAS score in the general group was 47.5 (41; 51) points. Two subjects had stable patterns of IA (≥ 65 points), 7 subjects had minimal risks of IA (≤ 42 points), and 11 subjects had pronounced risks of IA (43–64 points). The IH-RP subscale score was 11 points (9; 14). According to

studies on the level of Internet-addicted behaviour using the CIAS scale among the residents of Russia, the level on the IH-RP subscale was verified in adolescents with a risk of IA of more than 12 points (Malygin et al., 2011). Thus, the total sample of adolescents was divided into two groups; that is, one with a subscale IH-RP level of 12 or less points (Group I, $n = 12$) and the other with that more than 12 points (Group II, $n = 8$) Table 1.

The SBP increased significantly after exercise and decreased to baseline in both groups I and group II. The DBP significantly increased after exercise only in the adolescents in group II whereas in group I, it remained stable. The HR in group I individuals tended to increase, but without statistically significant changes ($P = 0.470$). Group II adolescents showed significant increases in HR according to the Friedman test ($P = 0.046$), and at Stage 3 (rest), this parameter was significantly higher in comparison with the baseline value ($P = 0.016$).

$SBP_{\text{Stage2/Stage1}}$ and $HR_{\text{Stage2/Stage1}}$ did not differ statistically between the groups ($P > 0.05$) Table 2.

$DBP_{\text{Stage2/Stage1}}$ was significantly higher in group II than that in group I ($P = 0.034$). A significant correlation of $DBP_{\text{Stage2/Stage1}}$ and IH-RP in the general sample of individuals, including adolescents of both groups, was identified ($r = 0.57$, $P = 0.013$). Thus, in adolescents with severe symptoms of IH-RP as determined by the IH-RP CIAS subscale, a pronounced percentage increase in DBP was detected during exercise, and during the recovery period

Table 1. Cardiovascular parameters in 15–16-year-old adolescents with different risks of IA (by subscale IH-RP) during the physical exercise test^a

Variables	Stage 1 (baseline)	Stage 2 (physical exercise test)	Stage 3 (rest)	<i>P</i> Fridman test	<i>P</i> Wilcoxon test
Group I (IH-RP ≤ 12), $n = 12$					
SBP, mm Hg	115 (105; 119)	136.5 (130; 153.5)	116 (114; 122)	<0.001	0.003 ^b 0.002 ^c 0.350 ^d
DBP, mm Hg	71 (66; 74)	75.5 (71; 85)	72.5 (71; 76)	0.075	0.036 ^b 0.116 ^c 0.114 ^d
HR, bpm	77.0 (69; 91)	81.0 (67; 95)	86.0 (75; 94)	0.470	0.646 ^b 0.272 ^c 0.260 ^d
Group II (IH-RP > 12), $n = 8$					
SBP, mm Hg	113 (108; 131)	141 (126; 164)	129 (111; 140)	0.012	0.016 ^b 0.028 ^c 0.128 ^d
DBP, mm Hg	66 (62; 76)	79 (76; 92)	75 (67; 79)	0.019	0.016 ^b 0.046 ^c 0.115 ^d
HR, bpm	75 (60; 75)	72 (62; 93)	78 (75; 93)	0.046	0.554 ^b 0.236 ^c 0.016 ^d

IH-RP: “Interpersonal and Health-Related Problems”; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; HR: Heart Rate.

^a Data are presented as Median (lower and upper quartiles).

^b For Stage 1 and Stage 2 values.

^c For Stage 2 and Stage 3 values.

^d For Stage 1 and Stage 3 values.

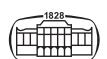


Table 2. The percent increase in cardiovascular parameters in 15–16-year-old adolescents with different risks of IA (by subscale IH-RP) during the physical exercise test^a

Variables	Group I (IH-RP ≤ 12) <i>n</i> = 12	Group II (IH-RP > 12) <i>n</i> = 8	<i>P</i> Mann-Whitney test
SBP _{Stage2/Stage1} ^b , %	122.8 (112.5; 134.5)	114.8 (111.5; 138.9)	0.356
DBP _{Stage2/Stage1} ^b , %	109.6 (103.0; 117.8)	122.6 (110.8; 127.5)	0.034
HR _{Stage2/Stage1} ^b , %	103.3 (86.6; 112.1)	101.2 (90.9; 128.0)	0.567

IH-RP: “Interpersonal and Health-Related Problems”; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; HR: Heart Rate.

^a Data are presented as Median (lower and upper quartiles).

^b The percentage ratio of values at Stage 2 in relation to Stage 1.

after exercise, increased sympathetic activity without a return to baseline values was revealed.

DISCUSSION

The excessive use of Internet resources is associated with impaired inhibition processes in the central nervous system when emotion control is impaired. Simultaneously, the accuracies of responses to emotionally significant stimuli and vagal autonomous heart rate control decrease (Moretta, Sarlo, & Buodo, 2019). A specific study involving male students aged 15–16 years conducted earlier in this school showed that the standing long jump was an informative test to assess the physical activity of adolescents and could track trends in youth health (Pinoniemi, Tomkinson, Walch, Roemmich, & Fitzgerald, 2020; Poskotinova, Krivonogova, & Zaborsky, 2020). Physical speed-power exercises require maximum muscular effort in a minimal period using an explosive force. Sympathetic activity and left ventricular stroke volume significantly increased while performing this exercise. The return of cardiovascular parameters to baseline values in humans occurs after physical exercise along with vagal regulation of cardiac activity. However, adolescents who overuse Internet resources had reduced parasympathetic activity (Kim et al., 2016; Zhang et al., 2020), probably due to a lack of physical activity (Nederend et al., 2016) and insomnia (Lin et al., 2014). Chen and Shur Fen Gau (2016) reported that excessive Internet use brings about changes in sleep patterns and circadian rhythm “Sleep-Wakefulness” (early insomnia, moderate insomnia, etc.). Therefore, in the future, it is necessary to assess the circadian rhythm of sleep and wakefulness to clarify the nature of sympathicotonia in adolescents after exercise. The relationship between the duration of Internet use and the risk of IA remains unclear. Grohol (1999) doubted whether excess time spent online always leads to IA; that is, a person can spend a lot of time on the Internet but not experience withdrawal symptoms or symptoms of deteriorating health when there is no access to the Internet. Consequently, the response of the sympathetic autonomic nervous system to physical activity will be excessive in individuals with an increased risk of IA, which would be reflected in a pronounced increase in diastolic blood pressures and persistent increases in heart rate in the recovery period following this exercise. Furthermore, a similar increase in sympathetic autonomic nervous system

response was also associated with a high risk of IA (Lu, Wang, & Huan, 2010). One of the mechanisms for maintaining an increased heart rate after exercise in individuals at high risk of IA is a decrease in the baroreflex response (Oliveira, Barker, Debras, O’Doherty, & Williams, 2018), which is also common in people with low physical activity. A prolonged increase in diastolic pressure is associated with impaired peripheral vasodilation mechanisms, and it is assumed that the vagal rebound effect decreases in individuals with high risks of IA and severe symptoms of health-related problems, as well as in those with low physical activity (Nederend et al., 2016). In general, the nature of changes in these cardiovascular parameters indicates a risk of arterial hypertension and an increase in the body’s need for oxygen, and the initial signs of hypoxia can be the basis for subjective complaints about deteriorating health in persons with a high risk of IA.

The limitations of the study may be due to the limited number, age, and gender of the study participants.

CONCLUSIONS

Adolescents with a risk of IA and severe symptoms of IH-RP (according to the IH-RP subscale by CIAS) have increased sympathetic activity during speed-strength physical activity in the form of increased diastolic pressure and an increased heart rate during the recovery period after exercise. Therefore, their blood pressures and HR during exercise and in the subsequent recovery period need to be monitored. For adolescents at the risk of developing IA, breathing exercises to activate vagal regulation are preferable in order to reduce the level of sympathicotonia and prevent the risk of arterial hypertension. The results obtained for the ratios of certain symptoms of IA and the reactivity of the cardiovascular system during physical activity were characteristic primarily of male school students aged 15–16 years without daily physical activity and with free access to Internet resources. It is assumed that adolescents of other age groups, girls, and those with high levels of physical activity will have other dependence symptoms of IA and other reactions of the cardiovascular system to physical activity.

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Authors' contribution: PL study concept and design, analysis and interpretation of data, statistical analysis, obtained funding. KO obtaining primary data, analysis and interpretation of data. ZO obtaining primary data, analysis and interpretation of data.

All authors had full access to all data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Conflict of interests: All authors are requested to disclose any actual or potential conflict of interest including any financial, personal or other relationships with other people or organizations within three years of beginning the work submitted that could inappropriately influence, or be perceived to influence, their work. The authors declare no conflict of interest.

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