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Differentiation of Internet Addiction Risk Level Based on Autonomic Nervous Responses: The Internet-Addiction Hypothesis of Autonomic Activity

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Abstract

How high-risk Internet addiction (IA) abusers respond to different autonomic nervous activities compared with low-risk subjects may be a critical research goal with prevention and treatment implications. The aim of the present study was to address this issue by observing differences between high- and low-risk IA abusers in four physiological assessments when surfing the Internet: blood volume pulse (BVP), skin conductance (SC), peripheral temperature (PTEMP), and respiratory response (RESPR). Forty-two male and ten female participants aged 18–24 years were screened with the Chen Internet Addiction Scale (CIAS, 2003), and then separated into high- and low-risk IA groups. Using psychophysiology equipment, participants encountered a 3-minute adaptation period followed by a 6-minute testing period for surfing the Internet on baseline and testing phases. The present results indicate that: (a) the CIAS scores were positively and negatively correlated with the RESPR and the PTEMP; (b) the PTEMP and RESPR of high-risk IA abusers were respectively weaker and stronger than those of low-risk IA abusers; the BVP and SC of high-risk IA abusers were respectively augmented and decreased relative to low-risk IA abusers. Thus we suggest that four autonomic responses may be differentially sensitive to abusers' potency in terms of the IA hypothesis of autonomic activity. The stronger BVP and RESPR responses and the weaker PTEMP reactions of the high-risk IA abusers indicate the sympathetic nervous system was heavily activated in these individuals. However, SC activates parasympathetic responses at the same time in the high-risk IA abusers. The paradoxical responses between the sympathetic and parasympathetic actions are addressed in the discussion.

Introduction

THE INTERNET HAS BEEN PROGRESSIVELY developed and has been gaining worldwide popularity in recent years. People can enjoy its convenient services, such as playing games, making friends, job searching, shopping, and so on. Yet despite its many advantages, numerous problematic Internet uses emerge.[1–4] For instance, excessive time spent in front of the computer for non-productive purposes is gradually becoming a problem in many countries.[1–4] High-risk Internet addiction (IA) abusers can trigger uncontrollable abuse, significantly distressing feelings, and time-consuming social and occupational difficulties.[2] Some IA abusers report that their addiction can cause mood depression and feelings of guilt, or induce aggressive behavior after prolonged use of the Internet.[3] Almost all IA abusers claim to encounter relational, academic, familial, and occupational impairments.[4] IA is therefore seemingly a severe problem.

Although the term IA is currently not recognized as a psychological disorder by the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition—Revised* (DSM-IV-R),[5] compulsive behavior is seen as an important feature of IA disorder where abnormally long periods of time are spent on the Internet. Until Ivan Goldberg formalized the term, IA was loosely used to describe the compulsive behavior of overusing the Internet.[6,7] Considering Goldberg's IA definition, the compulsive symptoms of IA are critical, and are similar to those of other addictions, such as chemical addiction,[8] compulsive sexual behaviors,[9] pathological gambling,[10] eating disorders,[11] and video-game addiction.[12] Moreover, addictive-behavior researchers have generally accepted that addictions may include an array of common features, such as mood alterations, tolerance, abstinence, and withdrawal symptoms in addition to compulsive behavior.[13]

Nevertheless, definitions of IA remain diverse in practice.[13–16] In describing IA, Young referred to several symptoms that are associated with substance addiction, and outlined seven criteria, three of which are necessary for an IA diagnosis:[17] withdrawal; tolerance; preoccupation with the Internet; heavier or more frequent use of the Internet than

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intended; centralized activities to procure more interaction with the Internet; loss of interest in other social, occupational, and recreational activities; and disregard for the physical or psychological consequences caused by Internet use. Importantly, Young's IA criteria are based on the current DSM-IV-R substance-abuse criteria.

Psychophysiology equipment can be used to assess human autonomic nervous activities, such as blood volume pulse (BVP), skin conductance (SC), peripheral temperature (PTEMP), and respiratory response (RESPR). Such equipment has many clinical applications. For example, some evidence has shown that subjects can use their biofeedback data to learn how to control their breathing patterns[18] or heart rates voluntarily,[19] and then use that information to learn to relieve stress.[20]

Clinical psychologists or psychiatrists can also use patients' neurofeedback signals to treat anxiety and affective disorders.[21] However, little research has directly examined the role of autonomic activity in IA.[22] There are some indirect data concerning the autonomic nervous activities underlying the abuse of some specific drugs. For example, multiple drug abusers, as well as subjects with vigilance, impulsivity, and emotional problems, have greater SC values than non-drug abusers.[23] Similarly, the action of betel chewing in betel-addicted persons has been shown to produce an increased heart rate, blood pressure, and body temperature.[24] Moreover, drug abusers have higher psychophysiological responses when solving math problems, and possess augmented SC when viewing films related to drug administration.[22] Such evidence suggests that addictive drugs strongly trigger abusers' sympathetic reactions. Nevertheless, until now, there have been no hypotheses to account for the relationship between high-risk IA abusers and autonomic nervous activities.

Given the dearth of research on IA and the rising use of the Internet worldwide, how the high-risk IA abuser reflects the different autonomic nervous activities in the sympathetic–parasympathetic system may be a crucial research goal with prevention and treatment implications. The purpose of the current study was therefore to address this issue by way of assessments using biofeedback equipment, and we thereby proposed an IA hypothesis for the autonomic nervous activities.

Methods

Participants

A total of 52 participants (42 male and 10 female) aged between 18 and 24 years were chosen from Fo Guang University students using random sampling. All subjects were screened on the CIAS.[25] A cutoff score of 58 on the CIAS yielded 27 high-risk and 25 low-risk participants. A CIAS cutoff score of 64 yielded 11 high-risk and 41 low-risk IA abusers. All participants gave informed written consent before participating in the study. This study was carried out in compliance with the Ethical Principles of Psychologists and Code of Conduct 2002.

Apparatus

The psychophysiology equipment consisted of four physiological recordings: BVP, SC, PTEMP, and RESPR. All physiological signals were delivered to a personal computer, and analyzed with Biofeedback Multimedia Software,[26] which was designed to set up procedural programs, and examined these four physiological indices. Moreover, these four physiological indices were analyzed used the percentage-change scores from the baseline of these variables, a method similar to Miller and Ditto (1989). All tested physiological indices are described in detail below.[27]

For BVP assessment,[28] infrared ray equipment on the surface of the skin was used to determine the magnitude of changes in blood volume. Each heartbeat triggers an increase in skin blood volume, and this is then reflected by an increase in the amount of red light emitted by the equipment. On the other hand, skin blood volume may decrease during the inter-beat interval, and the red light would then be absorbed. Accordingly, the absorption and reflection of red light produces a sinusoidal wave, and the frequency between waves can be measured. Thus when an individual is nervous and triggers sympathetic-nervous-system activity, their heart rate increases and their BVP is augmented.

The second measure, SC, was obtained from two electrodes connected to two fingers. One electrode was attached on the forefinger, and the other was connected to the distal finger.[29] When a subject is stressed, their SC typically increases.[30] Thus this measurement is conventionally thought to reflect the activity of the sympathetic nervous system.

The third measure, PTEMP, was assessed with a sensor, designed to detect PTEMP alternation, attached to the fingertips. Typically, when a subject is stressed, the blood constricts, causing the finger temperature to decrease and thus reducing the PTEMP value. Alternatively, when a subject is relaxed, PTEMP typically increases.

In the final measure, RESPR was assessed with respiratory equipment fitted onto the chest. When stressed, a subject's sympathetic nervous system becomes activated, and RESPR is increased. On the other hand, when the parasympathetic nervous system is activated, the RESPR decreases.

Assessments

The Chen Internet Addiction Scale (CIAS) is a clinician-administered assessment used for discriminating the magnitudes of IA for abusers in our study. Chen et al. took several concepts of Young's definition of IA, and offered their contributions to develop a reliable test, the CIAS, used for screening Internet abusers from populations.[25] However, Chen's CIAS is not viewed as a diagnosis, and IA is not currently recognized as a psychiatric disorder by the DSM-IV-R. Instead, Chen seemly emphasized the concept of susceptibility to IA. Thus her screening test uses two specific cutoff scores—58 and 64—to divide subjects into high- and low-risk abusers.[31] According to her recommendations, a CIAS score greater than 58 indicates that the subject is probably susceptible to IA and may benefit from professional counseling. Meanwhile, a CIAS score greater than 64 indicates that the subject may have IA problems and should consult with a psychiatrist to confirm their mental status or receive psychological therapy.[31] Therefore, these two CIAS cutoff levels were used in the present study, and were related to the BVP, SC, PTEMP, and RESPR measures. Subjects with a CIAS score above the first cutoff of 58 were first classified as belonging to the high-risk IA group, while those that scored below this level were grouped into the low-risk IA group. Moreover, these data were subsequently reanalyzed with the distinction between high- and low-risk IA groups set at 64.

The CIAS (2003) was, in total, 26 items without subscales. The participants' CIAS scores were tabulated using a 4-point Likert scale for each item on the questionnaire. Point values designated for each item reflected the degree of agreement that the participant felt between his/her own situation and each prompt. The designated points for all of the items were summed to produce the CIAS score. The items were based on concepts derived from pathological gambling and substance addiction.

IA is characterized by two kinds of behavioral responses: core symptoms and related problems of IA that were revealed by the subject's clinical interview or the diagnostic criteria of other well-defined addictions. Chen's test results (2003) suggested that the CIAS is a reliable test due to its test–retest reliability and internal consistency between 0.79 and 0.93 ($p < 0.05$). Moreover, the validity of the CIAS assessment is also shown by Chen's finding that high-risk students possess significantly different attitudes than normal subjects toward Internet use.

Experimental procedure

All participants were initially given the CIAS assessment, and divided into high- and low-risk IA groups. To avoid the experimenter's expectation bias, the experimenter was blinded to the IA scores. The time interval between the procedure to screen the IA scores and the psychophysiology test while subjects were surfing the Internet was almost 7 days, and the experimenter did not know the subject's IA scores when subjects were surfing the Internet. Participants were hooked up to the psychophysiology equipment, and then given 3 minutes served as baseline to acclimatize to new computer and settings for recording on rest phase and during the period of time, subjects encountered to go surfing the Internet. Later, all participants were allowed free access to the Internet for 6 minutes, which served as a testing phase. Because some confounding factors (such as the fatigue effect) should be considered in our study, the 3- and 6-minute time periods for the baseline and testing phases were determined by way of a pilot study. The raw data for the BVP, SC, PTEMP, and RESPR were recorded at the baseline and testing phases for statistical analyses.

Because each IA abuser's habits in surfing the Internet were probably variable, our study procedures were designed to not restrict surfing identical websites or Internet stimuli. Instead, subjects were able to access to surf any website that they wanted freely. In effect, this experimental procedure likely mimics their habit for surfing the Internet in their daily lives.

Statistical analyses

A percentage value was obtained for each subject's physiological data by employing the following calculation:

$$\text{percentage value} = [\text{each physiological value being testing} - \text{each physiological value at the baseline}] / \text{each physiological value on the baseline}^{28}$$

The relationships between CIAS scores, the BVP, SC, PTEMP, and RESPR were initially analyzed using Spearman's rank correlation test, following which the CIAS cutoff score was defined as 58 or 64. For each definition, the data were analyzed using a Mann-Whitney U test. Because of the ordinal nature of the data, Spearman's rank correlation test and nonparametric statistics were considered to be appropriate analyses for our study. Levels of significance were set at $p < 0.01$ and $p < 0.05$, and respectively labeled as (**) and (*).

Results

Spearman's rank correlation test

Spearman's rank correlation revealed that CIAS scores were negatively correlated with PTEMP ($r = -0.312$, $p < 0.05$) and positively correlated with RESPR ($r = 0.336$, $p < 0.01$) respectively. However, CIAS scores did not have significant correlations with BVP ($r = 0.188$, $p > 0.05$) or SC ($r = -0.065$, $p > 0.05$). Further, SC correlated negatively with both PTEMP and RESPR. Hence, the high-risk IA abuser showed a stronger magnitude of RESPR and fewer PTEMP responses; however, the BVP and SC were not influenced by the degree of IA risks (see Table 1).

Blood volume pulse test for high- and low-risk IA abusers

Figure 1 summarizes the mean ± SEM BVP percentage for high- and low-risk IA abusers with the two different cutoff scores of 58 and 64. A Mann-Whitney U test revealed that the difference between high- and low-risk IA abusers was not significant for BVP ($U = 268$, $p > 0.05$) when the CIAS cutoff score was defined as 58. However, when the cutoff score of 64 was used, the BVP for high-risk IA abusers was significantly higher than that of low-risk IA abusers ($U = 105$, $p < 0.01$; see Figure 1).

Skin conductance test for high- and low-risk abusers

Figure 2 shows the mean ± SEM SC percentage for high- and low-risk IA abusers with the two different cutoff scores of 58 and 64. A Mann-Whitney U test revealed no significant difference in SC between high- and low-risk IA abusers when the cutoff score of 58 was used ($U = 322$, $p > 0.05$). However, when the cutoff score of 64 was employed, the SC values of the high-risk IA abusers were significantly lower than those of the low-risk abusers ($U = 314$, $p < 0.05$; Figure 2).

Peripheral temperature test for high- and low-risk abusers

Figure 3 depicts the mean ± SEM PTEMP percentage for high- and low-risk IA abusers with the two different cutoff scores of 58 and 64. A Mann-Whitney U test revealed that the PTEMP of the high-risk IA group was significantly lower than that of the low-risk group when the cutoff score was 58 ($U = 446$, $p < 0.05$). However, no significant difference was found between the groups for PTEMP when the cutoff score was 64 ($U = 217$, $p > 0.05$; Figure 3).

Respiratory response test for high- and low-risk IA abusers

Figure 4 depicts the mean ± SEM RESPR percentage for high- and low-risk IA abusers with the two different cutoff scores of 58 and 64. A Mann-Whitney U test revealed that the

TABLE 1. SPEARMAN RANK CORRELATION FOR BVP (%), SC (%), PTEMP (%), RESP R(%), AND CIAS SCORES

	BVP	*SC*	*PTEMP*	*RESPR*	*CIAS scores*
BVP (%)	1.000				
(Mean = 0.024, SE = 0.011)					
SC (%)	−0.101	1.000			
(Mean = 0.649, SE = 0.223)	0.239				
PTEMP (%)	−0.056	−0.461**	1.000		
(Mean = 0.002, SE = 0.009)	0.346	0.000			
RESPR (%)	−0.044	−0.238*	0.001	1.000	
(Mean = 0.202, SE = 0.039)	0.379	0.045	0.497		
CIAS scores	0.188	−0.065	−0.312*	0.336**	1.000
(Mean = 56.221, SE = 1.605)	0.091	0.323	0.012	0.007	

**$p < 0.01$; *$p < 0.05$.

RESPR of the high-risk IA abusers was significantly higher than that of the low-risk IA abusers when the cutoff score of 58 was used ($U = 197$, $p < 0.01$), and a non-significant trend toward a difference in the same direction when the cutoff score of 64 was used ($U = 149$, $p = 0.08$; Figure 4).

Discussion

Taken together, the present results indicate several interesting relationships between the CIAS and physiological measures. First, a higher CIAS score was positively correlated with RESPR and negatively related to PTEMP, but was not relative to BVP and SC when using Spearman's rank correlation test. Second, using a Mann-Whitney *U* test and setting the cutoff score at 58 to separate low- and high-risk IA abusers, PTEMP values of high-risk IA abusers were lower than those of low-risk IA subjects. RESPR values of high-risk IA abusers were stronger than those of low-risk IA abusers. However, the other physiological responses, BVP and SC, were not significantly different between high- and low-risk IA abusers. The present results were consistent with Spearman's rank correlation data. Finally, setting the cutoff score at 64 and using a Mann-Whitney *U* test, the BVP values of high-risk IA abusers were stronger than those of low-risk IA abusers, and weaker than those of low-risk IA abusers. However, there were no significant differences between high- and low-risk IA abusers for PTEMP and RESPR.

According to our present data, we know that the BVP and RESPR values for high-risk IA abusers were higher than for the low-risk group. Meanwhile, the SC and PTEMP magnitudes were smaller for the high-risk than for the low-risk IA abusers. The stronger BVP and RESPR responses and the weaker PTEMP reactions of the high-risk IA abusers indicate that the sympathetic nervous system was heavily activated in

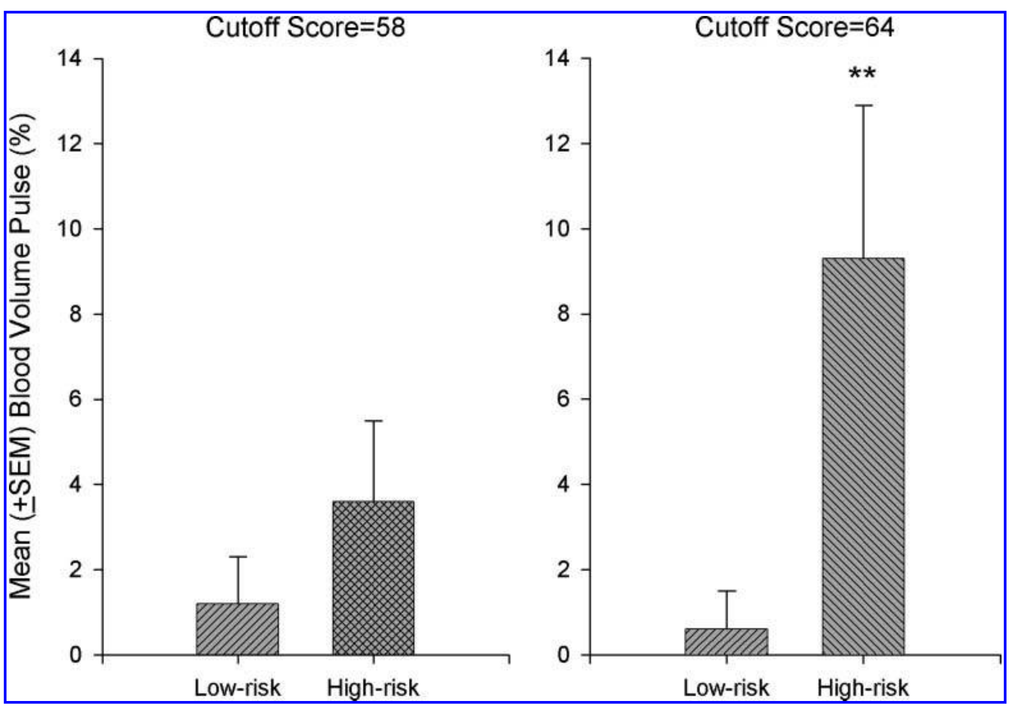

FIG. 1. Mean ± SEM BVP percentage for high- and low-risk Internet abusers using cutoff scores of either 58 or 64 on the CIAS screening of IA. **$p < 0.01$ compared with the low-risk group with the same cutoff score.

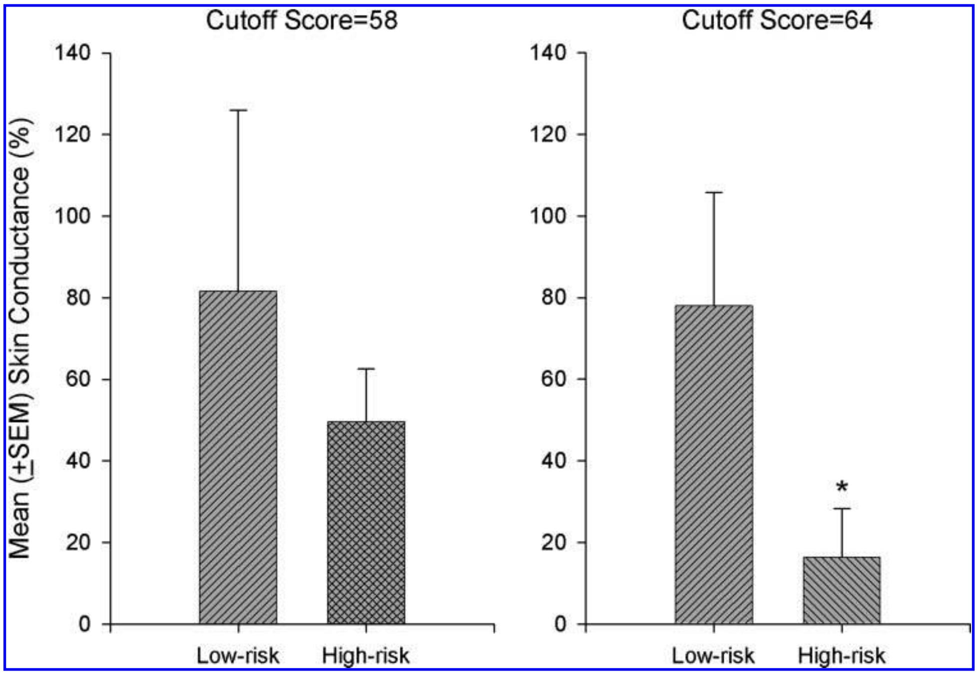

FIG. 2. Mean ± SEM SC percentage for high- and low-risk Internet abusers using cutoff scores of either 58 or 64 on the CIAS screening of IA. *$p < 0.05$ compared with the low-risk group with the same cutoff score.

these individuals. Surprisingly, only the SC index revealed an activated parasympathetic nervous system at the same time in the high-risk IA abusers.

In general, addiction-related cues can elicit the alternation of the affective states, such as euphoric and aversive effects, and thereby affect the sympathetic–parasympathetic divisions of the autonomic nervous activities. We found two lines of research in the literature assessing autonomic nervous-system activity in humans and animals: those that tested rewarding stimuli and those that tested aversive stimuli.[32–35] To illustrate, rewarding events have been shown to increase subjects' heart rates significantly.[32] Firestone and Douglas (1975) manipulated reward, punishment, and reward plus punishment separately in three conditions, and tested the subjects' SC and heart rate. Although there was no significant difference in SC amongst the groups, they found that

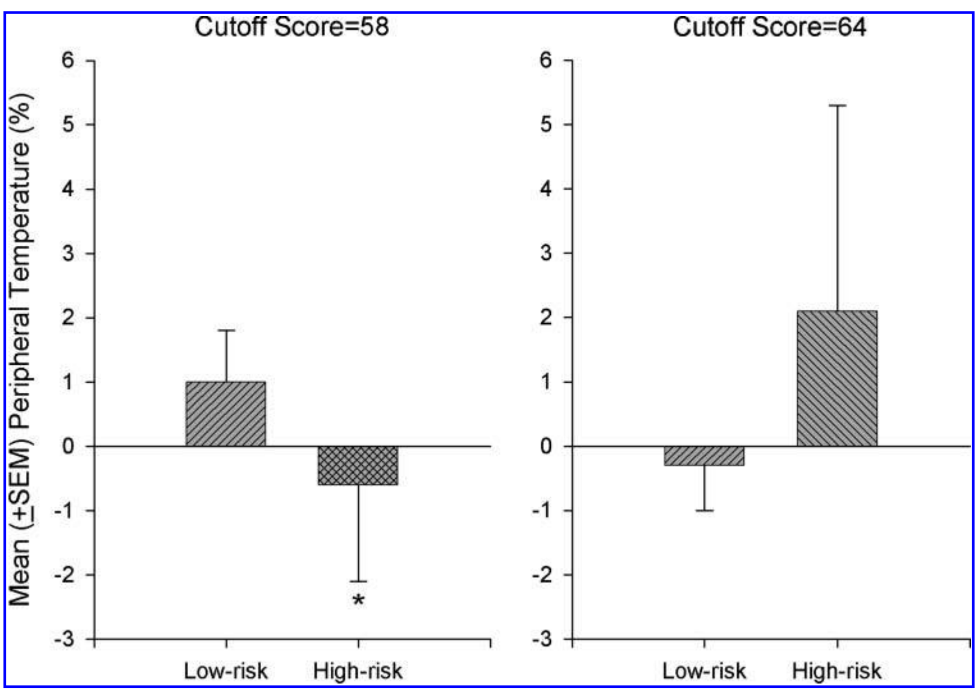

FIG. 3. Mean ± SEM PTEMP percentage for high- and low-risk Internet abusers using cutoff scores of either 58 or 64 on the CIAS screening of IA. *$p < 0.05$ compared with the low-risk group with the same cutoff score.

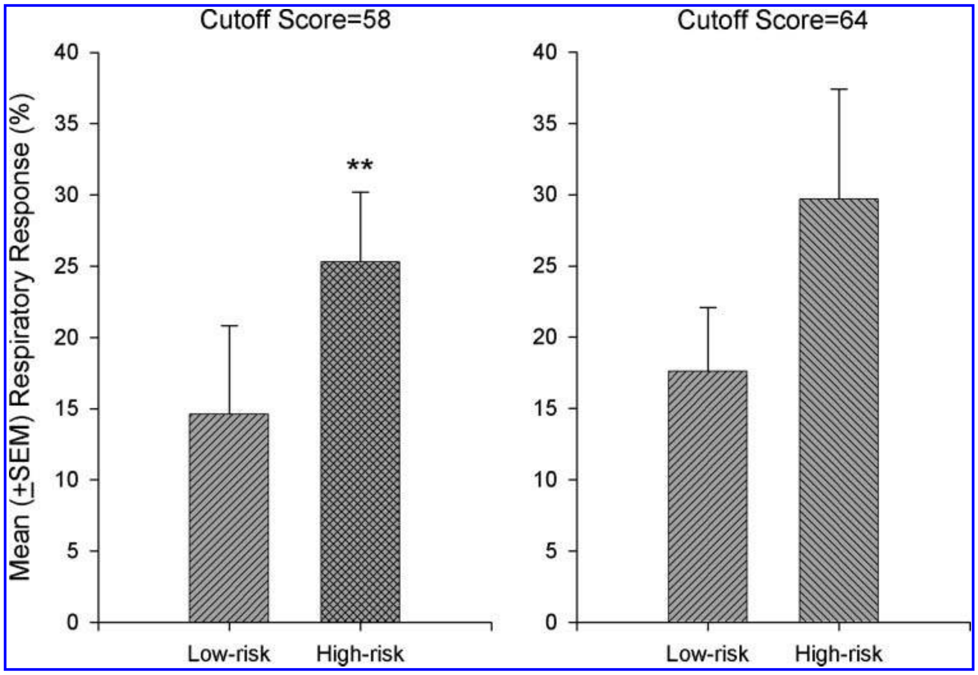

FIG. 4. Mean ± SEM RESPR percentage for high- and low-risk Internet abusers using cutoff scores of either 58 or 64 on the CIAS screening of IA. $^{**}p < 0.01$ compared with the low-risk group with the same cutoff score.

heart-rate response was greater in the reward condition than in the other two groups.[36] Several groups have also tested how aversive events may influence the autonomic activities of the autonomic nervous system.[37–39] Palomba et al. (2000) demonstrated that the heart rate decelerated in subjects who were exposed to unpleasant film stimuli. Marsh et al. (2008) found that sad facial expressions could trigger parasympathetic activity and decrease sympathetic function (higher RESPR and lower SC). Olafsdottir et al. (2001) discovered that recurrent abdominal pain in children was associated with depression, anxiety, and withdrawal responses; these children also had different patterns of sympathetic and parasympathetic activities compared with normal subjects.[40] Bradley et al. (2008) suggested that a decrease in heart rate was associated with the occurrence of unpleasant stimuli, except for increases in the subjects' pupil diameter and SC, when the subjects viewed emotionally arousing pictures of pleasant and unpleasant stimuli.[41] These indirect data reflect the probable relationship between autonomic nervous activities and rewarding events and aversive stimuli. However, high-risk IA abusers can suffer from these two opposing rewarding and aversive processes. When surfing the Internet, they may expose a rewarding stimulus; sometimes they may encounter aversive feelings, especially when experiencing withdrawal symptoms.[6,17]

Nevertheless, a limitation of the current direct literature is that we cannot make causal inferences regarding the etiological role of the nervous system in the prevention and treatment implications of IA. Thus how high-risk IA subjects reflect reward- or aversion-like autonomic nervous activity was a concern of the present study.

Accordingly, the mechanisms behind the physiological differences between high- and low-risk IA abusers that we claim here can be distilled into two viewpoints. One is that rewarding events are probably able to activate sympathetic functions, such as an accelerated heart rate and decreased SC. The other is that aversive events can decrease sympathetic functions while increasing parasympathetic activities; thus the heart rate may decelerate, while SC is augmented in response to aversive conditions.

The present results are partially congruent with the suggestion that subjects with high-risk IA have stronger sympathetic activity (i.e., higher BVP, lower PTEMP, and stronger RESPR). These physiological patterns are very similar to previous data related to a rewarding event's induction. This viewpoint can be termed "the IA hypothesis of autonomic activity," and suggests that sympathetic activity reflects the rewarding properties of IA. Only the subjects' SC response did not support this viewpoint in this study, since high-risk Internet abusers showed a lower SC response than the low-risk Internet abusers. Instead, the SC response appeared to be linked to parasympathetic activity.

According to the notion of sympathetic–parasympathetic antagonism, the sympathetic nervous system should be antagonized when the parasympathetic system is activated within the same organs or glands, and the two systems should counterbalance each other.[42] The IA hypothesis of autonomic activity is not well aligned with the antagonism of the sympathetic–parasympathetic systems. Similar paradoxical data have previously been shown in other investigations. For instance, Gatchel (1976) has shown that deceleration of the heart rate was associated with increased SC after voluntary control training, suggesting that there may be a "fractionation" phenomenon at work. Additionally, Weng and Teng (2005) found that anxiogenic events not only suppressed parasympathetic activity but also simultaneously depressed the sympathetic response of subjects.

Meyers (1959) demonstrated in a review paper that although many organs or glands are controlled by the sympathetic and parasympathetic nerves, most do not show dual innervations. For example, the nictitating membrane, most blood vessels, and the sweat glands are supplied specifically by sympathetic nerves. Meanwhile, the ciliary body is fully conducted by the parasympathetic fibers but not the sympathetic system. The salivary glands are governed by the sympathetic and parasympathetic fibers; however, one type of cell receives sympathetic innervations while another type of cell receives parasympathetic innervations. Thus, some glands and organs are probably synergized rather than antagonized by these two divisions of the autonomic nervous system.[43] Following this evidence, our data showing paradoxical sympathetic and parasympathetic reactions appear to follow this prior evidence of a dissociation of the two divisions rather than a strict antagonism.

Although the present data were seemingly so powerful to connect Internet Addiction Disorder (IAD) and the physiological indices of the peripheral nervous reactions, some limitations (including possible factors confounding and mediating the relationship of the IA to autonomic nervous activities) should be noted. First, because only 42 male and 10 female college students participated in this study, the external validity of the results may be limited. We therefore used the nonparametric Mann-Whitney *U* test to test physiological indices between high- and low-risk IAD abusers to increase the probability of correctly rejecting a null hypothesis when the null hypothesis is true. Second, the baseline of the physiological measurement should be controlled by a standard procedure to avoid any unpredicted error for the trial of each measurement. For example, we found that the measurement of SC is very easily influenced by the room temperature. Third, autonomic nervous activities can be affected by the participant's emotional responses or the status of their mood. Therefore, the mood/emotional response of the participants should be calmed before taking any physiological measurements. In general, we would recommend asking participants to spend 5 to 10 minutes relaxing their emotions before beginning the study. Finally, individual differences can strongly influence the physiological indices. We would therefore suggest testing participants' baselines and deleting the difference at the beginning. Thus the above factors confounding and mediating the relationship of the IA to autonomic nervous activities might have affected the present results, and should therefore be controlled to decrease any bias.

In summary, we could see that the high-risk IA abuser showed a specific pattern of autonomic activities for the four physiological responses. This pattern was higher for BVP and RESPR, and lower for PTEMP and SC. Accordingly, this pattern of autonomic reactions could be used in an assessment to predict and screen the probability of high- or low-risk IA in clinic. and it thereby offers a different approach to current screening methods, such as psychological testing or psychiatric diagnosis. The present study is the first step in combining the study of IAD with autonomic nervous activities, particularly in the division of the sympathetic–parasympathetic nervous system. Further analyses of the present data or further studies with respect to the diagnostic validity of the four physiological assessments on autonomic nervous activities for detecting IA risks need to be carried out.

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Disclosure Statement

No competing financial interests exist.

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