Review Article

Behavioral Addictions and Cardiovascular Health: A Scoping Review of the Peer-Reviewed Primary Research Literature

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Abstract

Background: Most studies that have examined the association of addiction with cardiovascular diseases (CVDs) have been completed regarding substances. However, behavioral addictions may indirectly or directly negatively impact one's health. We engaged in a scoping review on the associations of behavioral addictions (i.e., sex, exercise, love, Internet, shopping, gambling, and work) with cardiovascular health. We aimed to explore (1) the addictive behaviors addressed in the literature, (2) the study samples and country contexts, (3) the methods used, and (4) the associations found with CVD or its precursors. **Methods:** Using the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews checklist and following Arksey and O'Malley's (2005) methodological framework, a search across the Web of Science, PubMed, 13 ProQuest databases, and Google Scholar yielded 59 primary research articles. **Results:** The majority of these studies inferred cardiovascular consequences emerging from engaging in these addictions, based on stresses induced, sedentary behavior involved, or proximal physiological data such as heart rate variability or electrocardiogram reactivity. However, the literature is quite weak in indicating that behavioral addictions lead to later cardiovascular events. Studies are also confounded by other variables (e.g., substance use disorders). No love addiction or shopping addiction-cardiovascular event studies were located, nor were the potential confounding effects of substitute addictions. **Conclusions:** Future longitudinal research and qualitative studies among older adults are needed to better discern the impact of behavioral addictions on cardiovascular health. For example, in studies that find cardiovascular effects such as high blood pressure, there is a need to try to discern whether the effects followed from addiction or preceded the addiction. In addition, studies are needed to discern whether behavioral addictions primarily impact cardiovascular health through social and reactivity consequences of engaging in the behaviors or merely indirectly through engagement in sedentary lifestyles.

Keywords: Addictive behaviors, behavioral addictions, cardiovascular diseases, cardiovascular health, process addictions, scoping review

Introduction

Cardiovascular diseases (CVDs), disorders of the heart and blood vessels, are the primary contributor to mortality and morbidity worldwide (claiming 17.8 million lives in 2017).[1] CVDs encompass heart failure, cerebrovascular disease, coronary heart disease, various other cardiac conditions and hypertension.[2] Of these, the majority of deaths are attributable to coronary heart disease and cerebrovascular disease for which key behavioral risk factors are poor nutrition, sedentariness, and tobacco and alcohol use.[3,4] Substance addictions, such as tobacco, alcohol, methamphetamine, and cocaine have been linked to CVD.[5]

Addictive disorders may involve a myriad of substances (e.g., drugs and food) and behaviors (e.g., gambling, gaming, shopping, and work). Addiction may be defined as imbibing substances or engaging in behaviors repetitively serving to obtain an appetitive effect (subjectively experienced as improvement in mood and cognition or level of arousal), leading to a preoccupation with the substance or behavior, loss of control regarding when the substance or behavior may be engaged in or stopped, and undesired/negative consequences.[6] Substance addictions involve introducing exogenous ligands which impact one's neurobiology. Behavioral addictions involve repetitively engaging in behaviors on which one relies to manipulate one's

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Key question

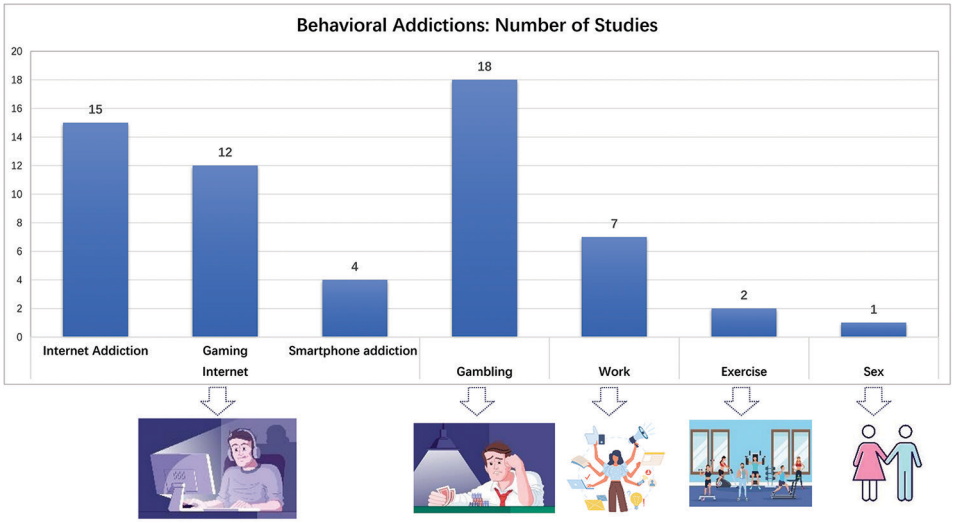
What is the scope of the available peer-reviewed primary research literature on behavioral addictions and cardiovascular health? Do these studies indicate consistent associations between behavioral addictions and CVDs?

Key finding

The included studies suggest that internet-related addictions; gambling; work; exercise and sex can impact cardiovascular health via inactivity and stress though robust evidence is lacking for direct associations.

Message for readers

Future longitudinal and qualitative research focusing on age, chronic stress, gender, and the confounding effects of substance use is necessary for clarity.



Central Illustration: Number of studies by type of behavioral addiction. CVDs = Cardiovascular diseases

endogenous ligands. One of the dire consequences of addiction is cardiovascular complications. Most but not all behavioral addictions likely provide an indirect impact on cardiovascular health, through lowering the quality of lifestyle (e.g., sedentary activity, sleep problems, and increasing daily stressors). CVDs are a public health priority area encapsulated by the United Nations' Sustainable Development Goal (SDG) 3: Good Health and Well-Being.[7] Target 3.4.1 specifically pertains to reducing the mortality rate attributed to CVD. While the subgoals of the SDG address the need to strengthen the prevention and treatment of substance use, they fail to directly address behavioral addictions, which frequently co-occur with substance use disorders (SUDs).[8]

Therefore, through this scoping review, we sought to map the existing literature regarding the peer-reviewed primary research on behavioral addictions and cardiovascular health. We aimed to explore (1) the addictive behaviors addressed in the literature, (2) the study samples and country contexts, (3) the methods used, and (4) the associations found with CVD or its precursors. To the best of our knowledge, this is the first such scoping review. We focused on the seven behavioral addictions listed in Sussman *et al.*'s,[9] focal addictions, namely gambling, Internet (electronic media), love, sex, exercise, work, and shopping.

Methods

This review was performed using Arksey and O'Malley's[10] methodological framework and entailed identifying a research question, searching for relevant studies, study selection, charting the data, and synthesizing the results. The Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews checklist guides the reporting on the review.[11] We did not register or publish a review protocol.

Research questions

The research questions guiding this review were: What is the scope of the available peer-reviewed primary research literature on behavioral addictions and cardiovascular health? We also asked: Do these studies indicate consistent associations between behavioral addictions and CVDs?

Searching for relevant studies

Web of Science, PubMed, ProQuest (APA PsycArticles®, Health and Medical Collection, Healthcare Administration Database, MEDLINE®, Nursing and Allied Health Database, Psychology Database, Public Health Database, Science Database, Social Science Database, Social Science Database, Sociology Collection, Sociology Database, Telecommunications Database), and Google Scholar were searched from database inception to

June 30, 2024 to identify the English-language studies. No constraints were placed on the study designs to be included. Preliminary searches were conducted to identify and refine the search terms. The final searches [Supplementary Table 1] were for **cardiac health** (e.g., "heart," "cardi*," "coronary," "arrhythmia," and "myocardial"), paired with terms for **behavioral addictions** (e.g., "addictive disorders," "behavioral addictions," "nonchemical addictions," "nonsubstance addictions," "process addictions"), and *problem and disordered engagement* with **internet** (e.g., "social media addiction," "internet addiction," "electronic media addiction," "smartphone addiction"), **love** (e.g., "love addiction," "pathological love," "romance addict," "pathological limerence," "obsessive love"), **work** (e.g., workahol*, work addict*, addict* to work, work dependen*, dependen* to work, excess* work, compuls* work, obsess* work), **exercise** (e.g., "addiction to exercise," "exercise addiction," "exercise dependence," "obsessive exercise," "excessive exercis*," "pathological exercis*," "primary exercise addiction," "secondary exercise addiction," compulsive exercis*, sport dependenc*, "sport addiction"), **gambling** (e.g., gambl*, problem gambl*, disorder*, gambl*, gambl*, disorder*, gambl*, addiction*, "pathological gambling," "excessive gambling," "gambling dependence," "online bet"), **sex** (e.g., "addictive sex," "compulsive sexual behavior," compulsive sexual behavio*r disorder, "Don Juanism," erotomania, "excessive sexual desire disorder," hyperactive sexual behavio*r, hyperlibido, hypersexuality, "hypersexual disorder," "hypersexuality disorder," hypersexual behavio*r, "nonparaphilic sexual disorders," nymphomania, "paraphilia-related disorders," "problematic pornography use," satyriasis, "sex addiction," sexaholism, "sexual compulsivity," "sexual dependence," "sexual desire disorders," "sexual disinhibition," "sexual impulsivity," "sexual obsession," "sexual preoccupation," "sexual sensation seeking," "sexual torridity," "uninhibited sexual desire") and **shopping** (e.g., addictive buyi*, addictive purchas*, addictive shop*, addictive spend*, buying addict*, buying disord*, buying problem*, buying-shopping*, compulsive buyi*, compulsive shop*, compulsive spend*, excessive buyi*, excessive spend*, hyperspend*, "internet shopping," obsessive buyi*, obsessive spend*, onioman*, online buy*, "online purchase," "online shopping," overshop*, overspend*, pathological buyi*, pathological purchas*, pathological shop*, pathological spend*, problematic buyi*, problematic purchas*, problematic shop*, problematic spend*, shopahol*, shopping addict*, spending addict*, spending disord*). Further records were identified by searching reference lists.

Study selection

Only peer-reviewed primary research literature (original empirical or qualitative data-based studies) was eligible for inclusion; books, chapters, commentaries, correspondence, replies, viewpoints, debate papers, literature reviews, reviews,

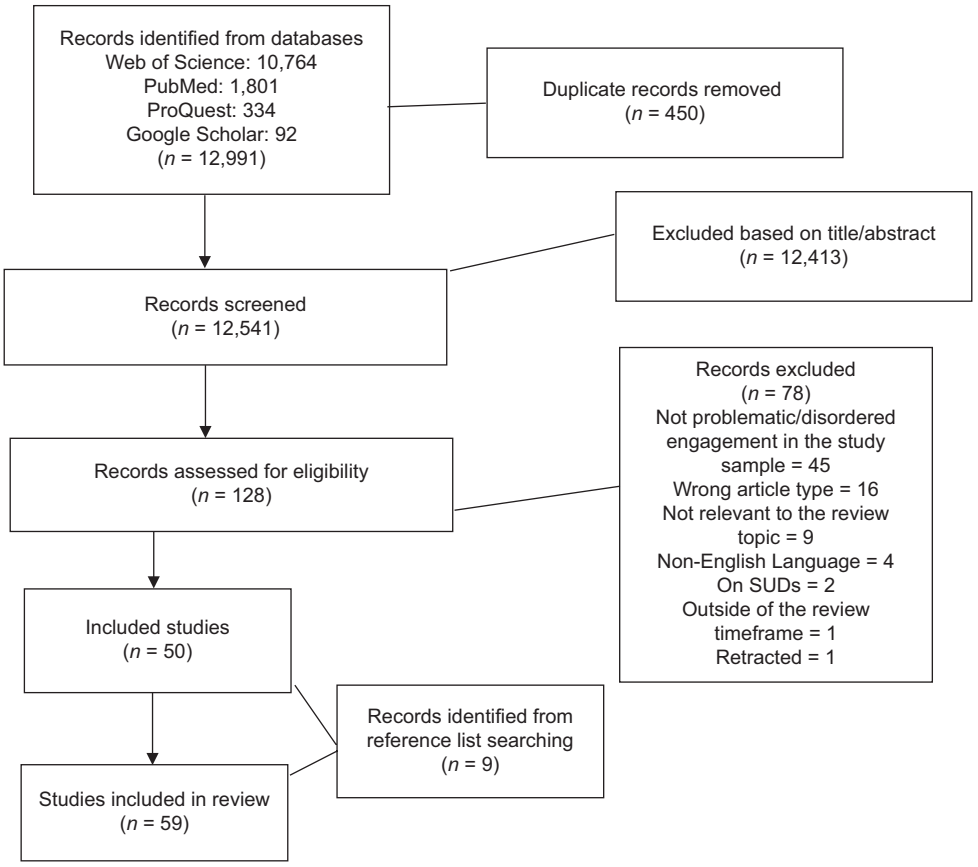


Figure 1: Flowchart of the study selection process

Table 1: Summary of the included studies

Type of addiction and reference	Cardiovascular method (as specified in the article)	Number of participants	Relevant findings
Sex addiction: Scanavino *et al*.[12]	BP ≥ 130/ ≥ 85 mmHg Smoking dependence (Fagerström Test for Nicotine Dependence), sedentariness (IPAQ-short version), family history of heart disease, BMI ≥ 25 kg/m^2, C-reactive protein > 3 mg/dL, triglyceride ≥ 150 mg/dL Cholesterol non-HDL > 130 mg/dL, HD L < 40/50 mg/dL (men/women), glucose levels ≥ 100 mg/dL, FRS for heart disease	*n* = 117 individuals with CSB (*n* = 94 nonsexually compulsive, *n* = 57 sexually compulsive, and *n* = 60 hypersexual individuals); 94 controls	There is a negative association between sexual compulsivity and FRS
Exercise addiction: Aidman and Woollard[13]	Self-assessed RHR, using a stopwatch	60 runners (30 women, 30 men)	Exercise-deprived group: Significant withdrawal-like symptoms + elevated RHR, within 24 h, moderated by self-reported exercise addiction
Exercise addiction: Heaney *et al*.[14]	Cardio-respiratory fitness was estimated using the formula, ([age] × 0.10 − [BMI] × 0.17) − ([RHR] × 0.03) + (physical activity score) + 18.07 BP and HR Saliva samples	Probable exercise dependence (*n* = 10 women; 10 controls)	Exercise-dependent: Blunted cortisol and cardiac responses, independent of stress task performance and differences in cardiorespiratory fitness
Smartphone addiction: Aftab and Khyzer[15]	BMI BP	200 medical students	Prevalence of hypertension: 35.5%; significant positive relationship with smartphone addiction, poor sleep quality and obesity
Smartphone addiction: Jasrotia *et al*.[16]	RHR: ECG data Resting BP HRV	500 young adults	Posttreatment: Significant decreases in Internet addiction score Perceived stress scores Average daily mobile use LF/HF ratio Significant increase in HRV
Smartphone addiction: Liu *et al*.[17]	BP	2,573 students	High BP and PSU are potential correlates
Smartphone addiction: Zou *et al*.[18]	BMI BP	2,639 junior school students	Hypertension was highly prevalent, linked to poor sleep quality, obesity, and SPA
Workaholism: Aziz *et al*.[19]	Self-reported type 2 diabetes, heart disease, high cholesterol, high BP	266 medical school employees	Workaholism a significant risk factor for high BP, high cholesterol, heart disease, type 2 diabetes
Workaholism: Aziz *et al*.[20]	Self-reported family history of metabolic diseases (type 2 diabetes, heart disease and/or high cholesterol)	194 employees from various organizations and professions	Familial metabolic disease history significantly related to type 2 diabetes, heart disease+hypercholesterolemia
Workaholism: Balducci *et al*.[21]	Day BP (exclusively) systolic BP	61 workers	Daily fluctuations in workaholism impacts short-term SBP
Workaholism: Balducci *et al*.[22]	BP (exclusively) systolic BP	Study 1 (*n* = 311), workers Study 2 (*n* = 235), health-sector employees	Workaholism results in significant cardiovascular health implications
Workaholism: Salanova *et al*.[23]	Cardiovascular age composite of gender, height, waist circumference, family antecedents (cardiovascular pathology, hypertension, hypercholesterolemia, diabetes or cardiopathy), smoking, diabetes, total cholesterol levels, HDL cholesterol and systolic BP values FRS Measure of the metabolic syndrome: modified ATPIII criteria Isolated CVR (9 indicators) Hypercholesterolemia Hypertension Overweight-obesity (BMI; > 25 and 30, yes = 1, no = 0) Body fat	537 hospital employees	Workaholism potentially a factor in sleep problems and CVD

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Table 1: Contd...

Type of addiction and reference	Cardiovascular method (as specified in the article)	Number of participants	Relevant findings
	Tobacco (yes = 1, no = 0) Caffeine (yes = 1, no = 0) Alcohol (sporadic = 1, at weekends = 2, daily = 3, no = 0) Coca-Cola (yes = 1, sporadic = 2, frequently = 3, no = 0) Medication for cardiovascular problems (yes = 1, no = 0)		
Workaholism: Snir *et al*.[24]	A medical interview Physical examination Blood sampling (postovernight fast) Urinalysis FRS	244 workers	Workaholics = 3.70 times more likely to develop a CVD than common full-time workers
Workaholism: Vodanovich *et al*.[25]	Not specified Myocardial infarction High BP	773 working adults	No significant relationships between scores on the WART and two indicators of cardiovascular health; a significant, small correlation between myocardial infarction and the WART subscale of Delegation ($r = 0.095$, $P < 0.05$)
Gaming: Chang *et al*.[26]	ECG data HRV Sample entropy (SampEn) (assesses autonomic regularity) Cross-SampEn (quantifies autonomic coordination)	22 males with "PIU excessive gaming type" and 22 controls	People with PIU exhibited reduced CRC when gaming.
Gaming: Coyne *et al*.[27]	RSA SC	374 adolescents and their parents	More pathologic video game symptoms associated with less RSA withdrawal following a cognitively stimulating task
Gaming: Hong *et al*.[28]	ECG data HRV	$n = 21$ young males with IGD $n = 27$ controls	IGD: Significantly reduced HF HRV
Gaming: Hsieh and Hsiao[29]	ECG data HRV	IGD: $n = 19$ Non-IGD: $n = 21$	During gaming the IGD cohort displayed heightened positive affect and sympathetic activity and lower physiological activity
Gaming: Hsieh and Hsiao[30]	ECG signals HRV RSA	Thirty-four college recruits were classified into high- and low-risk IA groups	RSA value changes biologically significantly different between HIA and LIA, especially with induced emotions
Gaming: Kannan *et al*.[31]	ECG data HRV	$n = 201$ medical students	Internet addiction: Significantly longer auditory reaction time. Did not extend to differing visual reaction time and short-term HRV parameters
Gaming: Kim *et al*.[32]	HRV	68 adolescent males ($n = 38$ with IGA and $n = 30$ controls)	IGA associated with alterations in autonomic functions and distressed personality traits
Gaming: Kim *et al*.[33]	ECG data HRV	Game-addicted: n = 11 Nonaddicted: $n = 12$	HRV parameters were moderately accurate in distinguishing game addiction
Gaming: Lee *et al*.[34]	ECG data HRV	IGD: $n = 23$ Controls: $n = 18$	During gaming, the IGD group displayed significant decreases in HF HRV
Gaming: Park *et al*.[35]	ECG data HR HRV	163 adults ($n = 53$ IGD, 49 = Diagnosed with AUD, and 61 = HCs)	IGD and AUD patients present lower HRV
Gaming: Park *et al*. (2020)[36]	ECG data HR HRV	111 young adults ($n = 53$ IGD patients and $n = 58$ controls)	IGD: Raised HR and diminished HRV
Gaming: Shiue[37]	Participant-reported longstanding health problems or chronic condition (yes/no), e.g., diabetes, hypertension, heart disease (myocardial infarction, angina pectoris, etc.)	5,003 Japanese adults, 5.5% "addicted to" gaming	Poor self-rated health and heart disease

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Table 1: Contd...

Type of addiction and reference	Cardiovascular method (as specified in the article)	Number of participants	Relevant findings
Internet: Balconi *et al*.[38]	ECG data (converted to HR, number of beats per minute) SCR	25 undergraduate students	IA was accounted for by impairments in inhibitory control, and reward bias
Internet: Bibbey *et al*.[39]	Estimated cardio-respiratory fitness calculated by formula BP HR (semi-automatic sphygmomanometer) Saliva samples	88 university students	Alcohol use + problematic internet behaviour, alone or combined are un-related to blunted cardiovascular or cortisol stress reactions
Internet: Gür *et al*.[40]	Physical and Psychosocial Behavior Problems Questionnaire	549 secondary school students	Significant differences between IA scores and psychosocial behaviour problems (restlessness, anger, heart palpitations, or tremors when offline)
Internet: Krivonogova *et al*.[41]	BMI HR HRV	*n* = 49 adolescents	"In 16–17-year-old adolescents with different levels of risk of developing IA, including signs of IA, we revealed a high severity of symptoms of withdrawal from IU, difficulty in time estimation against the background of sympathicotonia and a decrease in vagal regulation of HR" (p. 497)
Internet: Krivonogova *et al*.[42]	BMI HR HRV	*n* = 49 adolescents	"The significance of the performed study lies in the need to identify early signs of Internet addiction in adolescents, not only according to the criteria for impaired autonomic regulation of the heart rhythm, but primarily in determining the time estimation. Underestimation of subjective time may be an early marker of Internet addiction, including against the background of vagotonia" (p. 5–6)
Internet: Lin *et al*.[43]	HRV	240 school-aged children	IA linked to higher and lower sympathetic and parasympathetic activity respectively
Internet: Liu *et al*.[44]	ECG data RSA (HF-HRV)	146 undergraduates	"The indirect effect of autonomy-supportive parenting on internet addiction via need satisfaction was much stronger in adults with low levels of RSA" (p. 4255)
Internet: Moretta and Buodo[45]	ECG data SCL HRV	PU (*n* = 24) and non-PU (*n* = 21)	Problematic IU is potentially due to reduced autonomic balance at rest
Internet: Moretta *et al*.[46]	ECG data HRV	Problematic users (PU, *n* = 20) and nonproblematic users (non-PU, *n* = 20)	Lowered HRV potentially indicative of defective inhibitory control in PIU
Internet: Nayak *et al*.[47]	RHR BP ECG data	148 medical students	Those with IA demonstrated increased RHR
Internet: Zhang *et al*.[48]	ECG data RSA	105 (65 men) young adults	Marital conflict and lower RSA suppression interactively predict IA
Internet: Zhang *et al*.[49]	ECG data RSA	99 young adult undergraduates	The relation between IA and basal RSA was moderated by RSA reactivity
Internet: Zhang *et al*.[50]	ECG data RSA	One-hundred and nine participants, 17–21 years old	The relation between IA symptoms and family functioning was moderated by resting RSA

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Table 1: Contd...

Type of addiction and reference	Cardiovascular method (as specified in the article)	Number of participants	Relevant findings
Internet: Zhao *et al*.[51]	Resting RSA	108 undergraduate students	"Loneliness mediated the negative association between resilience and IA, with resting RSA and resilience interactively predicted loneliness" (p. 828)
Internet: Zeng *et al*.[52]	HRV	82 healthy participants Leipzig magnetic resonance imaging database	"Resting vagally-mediated HRV moderates the relationship between internet addiction scores and grey matter volume in the precuneus and cerebellum" (p. 1)
Gambling: Abdul Rahim *et al*.[53]	Physician-recorded ICD codes in patients' medical records CVD Hypertension diseases (ICD-10 codes I10–I15) Ischemic heart diseases (I20–I25) Diseases within lung circulation (I26–I28) Other forms of heart diseases (I30–I52) Cerebrovascular diseases (I60–I69) Arterial diseases (I70–I79) Venous diseases (I80–I89) Respiratory-related diseases ICD-codes J40–J47 Diabetes: E10–E14 Obesity: E66	10,766 patients 3,592 had GD Control group: 5,581	GD patients: Higher prevalence of CVD (18% vs. 12%)
Gambling: Black *et al*.[54]	(modified) medical history and services utilization interview Medical outcome SF-36 health survey (medical health and quality of life) BMI (using self-reported weight and height)	95 people with DSM-IV PG and 91 controls	People with PG: More medical and mental health conditions, more likely to avoid regular exercise, smoke ≥ 1 pack/day, drink ≥ 5 servings of caffeine daily, and watch television ≥ 20 hours/week; more emergency department visits for physical and mental health, heart disease/coronary heart disease 11% (persons with PG) 10% (controls)
Gambling: Blanchard *et al*.[55]	BP HR in beats per minute ECG data and HR beat by beat SRL	7 male "compulsive gamblers" and 7 controls	HR responses of gamblers significantly greater than controls
Gambling: Diskin and Hodgins[56]	HR SCL	Video lottery gamblers (pathological *n* = 30, and nonpathological *n* = 34)	Significant physiological increases during gambling tasks and thoughts of wins and losses. Preference for stimulation negatively correlated with baseline HR and EMG
Gambling: Germain *et al*.[57]	Cardiology in-patients presenting or not presenting CHD	*n* = 73 CHD patients n = 61 Patients controls	PG = 6 cases (8.2%) + 1 case of problem gambling; no cases in controls
Gambling: Goudriaan *et al*.[58]	ECG data SCL (Vrije Universiteit Ambulatory Monitoring System-36) HR	PG group (*n* = 46) addiction treatment centre outpatients Controls (*n* = 47)	PG: Lower anticipatory HR decreases over disadvantageous choices, decreased HR after wins and losses, after wins controls show HR increase
Gambling: Kennedy *et al*.[59]	Participant- counted heartbeats for six timed periods (different time intervals) Actual heartbeats recorded via ECG trace RSA	GD: *n* = 50 Controls: *n* = 35	People with GD do not display changes in interoceptive processing under resting conditions
Gambling: Krueger *et al*.[60]	HR: Portable HR monitor ECG data	29 males	Once gambling, HR and cortisol levels increased significantly and remained elevated
Gambling: Moccia *et al*.[61]	BMI Heartbeat detection task: Participant-counted heartbeats (different time intervals)	*n* = 22 patients with GD and *n* = 22 controls	GD group exhibited significantly diminished RSA reactivity and interoceptive accuracy

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Table 1: Contd...

Type of addiction and reference	Cardiovascular method (as specified in the article)	Number of participants	Relevant findings
	ECG recording RSA		
Gambling: Morasco *et al*.[62]	SF-12v2 Respondents report that a physician had diagnosed: Angina; arteriosclerosis; arthritis; cirrhosis; gastritis; hypertension; myocardial infarction; other heart disease; other liver disease; stomach ulcer; tachycardia Respondent reported frequency of past-year: overnight hospital stays, days in hospital, times treated in ER, and injuries that reduced usual activities or needed medical care BMI	*n* = 43,093 adults	Diagnoses of angina, tachycardia, cirrhosis+other diseases more prevalent in pathologic gamblers
Gambling: Paris *et al*. (2010)[63]	Salivary cortisol	*n* = 21 active pathological gamblers *n* = 21 nonpathological, recreational gamblers	"PG is accompanied by a hypo-arousal of the HPA axis in response to gambling cues and that gender differences may contribute to this response" (p. 233)
Gambling: Pietrzak *et al*.[64]	BMI Respondent-reported (past-year) physician-diagnosed presence of angina; arteriosclerosis; arthritis; cirrhosis; gastritis; hypertension; myocardial infarction; other heart disease; other liver disease; stomach ulcer; tachycardia	*n* = 10,563 older adults (28.74% = Lifetime recreational gamblers; 0.85% = Lifetime disordered gamblers)	Disordered gamblers were significantly more likely to have angina (22.7% vs. 8.8%) or arthritis (60.2% vs. 44.3%) diagnosed in the prior year
Gambling: Pilver and Potenza[65]	BMI (past-year) presence or absence of doctor-diagnosed arteriosclerosis, arthritis, hypertension, and liver conditions (cirrhosis and/or any others), heart conditions (angina, myocardial infarction, tachycardia, and/or any others), and any stomach condition (gastritis and/or stomach ulcer)	*n* = 10,231 adults aged 55 years and older	Higher incidences of arteriosclerosis and any cardiovascular condition prospectively linked to meeting any inclusions for PG
Gambling: Sharpe *et al*.[66]	HR (beats per minute) SCL	Problem gamblers (PG: *n* = 13); HF gamblers (HFG: *n* = 12) and low-frequency gamblers (LFG: *n* = 13)	HR did not differ significantly across various tasks for any sub-group
Gambling: Van Patten *et al*.[67]	Lifetime presence of coronary heart disease, heart attack, stroke and other general physical conditions	7,045 low-risk gamblers and 244 problem/ pathological gamblers	No indicators of physical health (e.g., coronary heart disease, exercise behaviour,) differentiated groups
Gambling: Vestergaard *et al*.[68]	Hospital records (reported comorbidities included cerebrovascular disease, congestive heart failure, diabetes (type 1 or type 2), myocardial infarction, peripheral vascular disease)	1,381 individuals with GD	People with GD had more frequent comorbidity, such as myocardial infarction (0.8% vs. 0.5%)
Gambling: Yucha *et al*.[69]	BP HR, respiratory rate, skin conductance, and skin temperature	23 females (11 at-risk, problem, or pathological gamblers)	Females found slot play physiologically arousing, whether or not there were financial stakes
Gambling: Zack *et al*.[70]	HR BP	Male PGs (*n* = 12) and Controls (*n* = 11)	PGs had persistently elevated DBP and accompanying reduced HR past 90 minutes postdose

We do not support the use of stigmatizing or pejorative language; descriptions are provided as they were by the authors. BP = Blood pressure; CVD = Cardiovascular disease; CHD = Coronary heart disease; CRC = Cardiorespiratory coupling; DBP = Diastolic blood pressure; ECG = Electrocardiogram; ER = Emergency room; GD = Gambling disorder; HR = Heart rate; HRV = HR variability; HF = High frequency; IA = Internet addiction; IAT = Internet addiction test; IU = Internet use; FRS = Framingham risk score; PG = Pathological gambling; PVGU = Pathologic video game use; PIU = Problematic IU; RSA = Respiratory sinus arrhythmia, RHR = Resting HR; SC = Salivary cotinine; SCL = Skin conductance level; SRL = Skin resistance level; SCR = Skin conductance response; SBP = Systolic blood pressure; SPA = Smartphone addiction; WART = Work addition risk test; IPAQ = International Physical Activity Questionnaire; SF-36 = Short form-36; SF-12v2 = Short-form Health Survey, version 2; AUD = Alcohol use disorder

and gray literature were excluded. Across databases, the initial search yielded 12,991 potential publications (Web of Science: 10,764, PubMed: 1,801, ProQuest: 334 and Google Scholar: 92). After de-duplication (*n* = 450), screening titles and abstracts for relevance, 128 full-texts were appraised; 78 articles were excluded, and 50 were retained. There were no author disagreements on article retention. A large proportion of studies were excluded because the study sample's behaviors did not reach the threshold for problematic/disordered engagement in (*n* = 45); several publications were also outside the scope

of the article types that are the focus (n = 16; e.g., reviews or commentaries) or irrelevant to the review topic (n = 9; e.g., mentioning health but not cardiovascular health). Four non-English language studies were excluded as were two studies on SUDs. Single articles that were outside of the review timeframe (n = 1) and retracted by the journal were also excluded (n = 1) [Appendix 1]. A further 9 were identified through reference mining. Figure 1 is a flowchart outlining the study selection process.

Charting the data

The following data were extracted from each publication: authors, year of publication, country data source, cardiovascular measure/variable, sample, and key findings [Table 1]. Extracted data were then synthesized using textual narrative synthesis, which provides a useful way to contrast study characteristics, highlight their differences and establish strengths and gaps in evidence.[71]

Results

Years studies were conducted

We identified 59 quantitative studies published between 1995 and 2023. Years of publications that emerged included: 2023 (n = 7), 2015 (n = 7), 2021 (n = 6), 2019 (n = 5), 2018 (n = 5), 2022 (n = 4), 2016 (n = 4), 2017 (n = 3), 2007 (n = 3), 2020 (n = 2), 2013 (n = 2), 2011 (n = 2), 2006 (n = 2), 2003 (n = 2), 2014 (n = 1), 2009 (n = 1), 2005 (n = 1), 2000 (n = 1), and 1995 (n = 1). Table 1 summarizes the key characteristics of the included studies.

Sample

Most studies emanated from the United States (n = 12;[19,20,25,27,55,62-65,69,72]), China (n = 7;[17,18,44,49-52]), South Korea (n = 7;[26,28,32-36]), and Italy (n = 6;[21,22,38,45,46,61]). Equal numbers of studies emerged from Canada (n = 3;[56,59,70]), India (n = 3;[16,31,47]), Taiwan (n = 3;[29,30,43]), Australia (n = 2;[13,66]), Germany (n = 2;[60,73]), the United Kingdom (n = 2;[14,39]) and Russia (n = 2;[41,42]). Single studies from Brazil,[12] Denmark,[68] France,[57] Israel,[24] Japan,[37] Saudi Arabia,[15] Spain,[23] Sweden,[53] the Netherlands,[58] and Turkey[40] were also included.

No studies on love and shopping met the inclusion criteria for the review.

Summary of measures of cardiovascular disease indicators

The measurement of cardiovascular factors varied with some studies collecting only self-report and no objective measures. While studies also differed in focus, precluding direct comparison, the vast majority demonstrated a negative association between the addiction of interest and cardiovascular health, particularly when compared to control subjects. In general, the measures of CVD risk appeared reasonable. The indicators of heart function employed were from most prevalently used measure to least prevalently used measure: electrocardiogram (ECG, n = 23), heart rate variability (HRV, n = 18), hypertension/blood pressure (BP, n = 21), heart rate (HR, n = 16), chart or self-report history of cardiovascular risk or Framingham risk score (FRS, n = 12), body mass index (BMI, n = 11), Respiratory Sinus Arrhythmia (RSA, n = 8), Skin Conductance Response (SCR) or Skin Conductance Level (SCL) (n = 6), blood glucose level or diabetes indication (n = 4), family history (n = 3), indication of high low-density lipoprotein or total cholesterol (n = 3), resting heart rate (RHR) (n = 3), and skin conductance (SC, n = 2).

Sex (n = 1)

In a recent study, the only one to be included on sex-related cardiovascular aspects, Scanavino *et al*.,[12] assert that they sought to address the lack of studies on compulsive sexual behavior and cardiovascular risk factors. Their study, emanating from Brazil, categorized participants as *nonsexually compulsive* (n = 94), *sexually compulsive* (n = 57), and *sexually compulsive and hypersexual* (n = 60). The control group comprised 94 individuals (n = 86 men) and individuals with compulsive sexual behavior numbered 117 (n = 107 men). Cardiovascular risk factors that were assessed included: blood pressure, tobacco dependence, sedentariness, familial history of CVD, BMI, C-reactive protein, triglycerides, non-high-density lipoprotein (HDL) cholesterol, HDL cholesterol, glucose level, and FRS for heart disease. Individuals with sexually compulsive and hypersexual behaviors were more likely to be linked to an HIV-positive status and had higher FRS. Individuals aged 44 years and older categorized as sexually compulsive displayed lower FRS than younger participants. Substance-related disorders were associated with higher cardiovascular risk.[12] The approach to ascertaining cardiovascular factors was comprehensive, comprising both self-report and objective measures.

Exercise (n = 2)

Heaney *et al*.,[14] sought to explore whether the finding that acute psychological stress elicits lower or reduced cardiovascular and cortisol reactions in people with alcohol and tobacco use disorders is also displayed in individuals reporting "exercise dependency." From a larger sample (n = 219), 10 women with self-reported exercise dependence and matched controls were subject to stress testing in a laboratory where salivary cortisol and cardiovascular activity were measured twice – at baseline and following a stress task of 10-min duration. In response to the stress task, women allocated to the exercise dependence condition displayed blunted cardiac reactions and cortisol after 10, 20, and 30 min. The authors conclude that low stress-reactivity is a hallmark of addictive behaviors beyond substance use.

An earlier study by Aidman and Woollard[13] conducted a controlled experiment on 60 club-level runners. Following baseline assessments of RHR measurements, the Running Addiction Scale and the Profile of Mood States (POMS) participants were randomized into two groups (n = 15 men; 15

women) who were asked to abstain from their daily training regime for 24 h or continue uninterrupted. Participants completed the same assessment postexperiment. A key finding was that the exercise-deprived competitive runners recorded significantly elevated RHR and POMS scores that correspond to anger, depressed mood, confusion, fatigue, heightened tension, and reduced vigor a day after missing their training. In contrast, the control group displayed no changes in RHR. Furthermore, these physiological and mood changes were moderated by self-reported exercise addiction (EA). Taken together, these two studies on EA demonstrate that cardiovascular reactions (elevated RHR and reduced cardiovascular and cortisol levels) may place these individuals at (heightened) risk for cardiovascular events.

Internet (n = 31)

The largest number of studies was retrieved on problematic behaviors enabled by the internet. While we initially sought studies on "social media addiction," "internet addiction," "electronic media addiction," and "smartphone addiction" our search yielded literature grouped on internet addiction (n = 15), gaming (n = 12), and smartphone addiction (n = 4).

Internet addiction (n = 15)

Studies on the internet addiction category employed terms such as Internet Addiction[38,40-42,44,47-51,74] and problematic Internet use (PIU).[39,45,46] The terms internet-dependent behavior[41] and internet addiction tendency[52] were also used. Samples primarily comprised university students[38,39,44-51] and adolescents.[40-42] Samples were also drawn from schools[74] and a Magnetic Resonance Imaging database.[52] All but one study[44] included mixed-sex samples. All 15 studies employed cross-sectional designs. Operational definitions of internet addiction varied widely. Whereas Zhang *et al*.[50] operationalized internet addiction as "general internet addiction symptoms rather than specific PIU (such as internet gaming addiction)" (p. 20), Nayak *et al*.'s[47] study with undergraduate students (n = 148, 73 females) categorized participants' purposes for using the Internet (in order of prevalence) as including media, chatting, education, and gaming. In Moretta *et al*.,'s[46] study on PIU with university students (n = 40), 20 participants (n = 17 females) were classified as using the internet nonproblematically and 20 (n = 12 females) as having mild-to-moderate problematic use. Reported motives for internet use included: checking/responding to text messages (20%); for nonspecific purposes (16%), social network use (14%), mood regulation (12%), searching for information (10%), checking/sending E-mails (8%), video watching, and education-related online activities (both 4%), online gaming and job searching (2%, respectively).

Gaming (n = 12)

Twelve studies were on the topic of gaming,[26-37] which was termed internet gaming disorder,[28-31,34-36] internet gaming addiction,[32] excessive online gaming and PIU excessive gaming type,[26] and pathologic video game use.[27] Participants were recruited from colleges/universities,[26,29-31,33] the community,[28,34] hospital,[35,36] high school,[32] and a larger study on families.[27] Some studies included male-only samples.[26,28,32-34] All studies except for one[27] were cross-sectional. Various experimental[26,28-30,75] and observational[27,31-33,35,36] study designs were employed.

Smartphone addiction (n = 4)

Four studies focused on smartphone addiction,[15-18] which in two studies were termed problematic smartphone use[17] and internet addiction.[16] Studies recruited university students,[15] school-going children,[17,18] and patients from a tertiary care teaching hospital.[16] All studies enlisted male and female participants. The three cross-sectional studies[15,17,18] were complemented by a longitudinal and intervention study.[16] Study sample sizes varied considerably, with two large-scale surveys by Zou *et al*.[18] and Liu *et al*.[17] recruiting 2,639 and 2,573 school children, respectively. Studies discussed the various uses of smartphones including social networking, entertainment, and information collection,[17] sending E-mails, taking photos, playing games, playing media, and browsing the internet.[18]

Associations of internet, gaming, and smartphone addiction with cardiovascular disease-related variables

Of the 31 internet addiction studies, 30 found a negative association between internet addiction and cardiovascular health. Stresses, lack of engagement in other life demands, and sedentary behavior suggested that later cardiovascular consequences would emerge. However, since most studies were conducted with young people, such claims relied on risk factors rather than distal events [Table 1]. For example, drawing from a sample of 2,313 university students, Bibbey *et al*.[39] sought to explore whether blunted cardiovascular or cortisol stress reactions would be linked to PIU and alcohol use (as single or co-existing conditions). Salivary cortisol and cardiovascular activity were measured at rest and following tasks (public speaking and performing mental calculations) in four sub-groups [alcohol dependence (n = 28), internet dependence (n = 17), concurrent alcohol and internet dependence (n = 17) and controls (n = 26)]. None of the "behavioural dependencies" were associated with blunted stress reactivity. A few studies did find that hypertensive youth suffered from internet addiction,[15,17,18] but there was no way to discern whether the high BP followed from the addiction, came before the addiction, or was associated with other variables such as substance addictions or a sedentary lifestyle.

Gambling (n = 18)

Most studies (n = 8) adopted the term pathological gambling.[54-58,63,64,70] The term gambling disorder (n = 4[53,59,61,68]) appeared in more recent studies. Studies also referred to problem gambling[60,66] or a combination of problem and pathological gambling.[62,65,67,69] One study was longitudinal.[65] Mixed-sex studies were commonplace;[53] however, there were four men-only studies.[55,60,61,70] Only one women-only

study sample was included in the review.[69] Several studies recruited current or former treatment-seekers[53,55,57-59,61,63,66,76] or support group attendees.[54,63] Ten studies directly compared people with problematic and disordered gambling and controls,[53-59,61,70] three studies drew upon data from the National Epidemiologic Survey on Alcohol and Related Conditions,[62,64,65] and one used a national patient registry.[76] A majority of the gambling addiction studies, 14 out of 18, found a negative association between gambling addiction and cardiovascular health.[53-59,61-65,68,70] However, when people with differing levels of gambling severity were compared[66,67] no physical health variables or HR levels distinguished the groups. Conversely, Yucha *et al*.[69] demonstrated that at-risk and not-at-risk gamblers had heightened HR, BP and SC when gambling. In a study of 29 male blackjack players (n = 14 problem gamblers,[60]) subjected to two conditions (casino and control), there were significant increases in HR and cortisol once gambling was initiated and throughout.

Work (n = 7)

In the seven studies included in this category on workaholism, a few used the term interchangeably with work addiction.[20,22,23] Six out of 7 studies reported a negative association between work addiction and cardiovascular health,[19-24] with one specifically focused on family history of metabolic diseases.[20] Sample sizes varied considerably, from a small longitudinal study (n = 61[21]) to a larger, broader cross-sectional study (n = 773) on work-life factors.[25] This latter study explored workaholism and the health of 773 working adults in the United States. Participants' (60.2% males, M_age = 33.3 years; standard deviation = 10.4) responses to the 25-item Workaholism Risk Test[77] failed to correlate with myocardial infarction and hypertension.

Discussion

This review aimed to explore the peer-reviewed primary research literature on the focal behavioral addictions and cardiovascular health. A scoping review was preferred as it enabled all potential studies to be included.[78] We identified and analyzed 59 studies published between 1995 and 2023. Of the seven focal behavioral addictions (gambling, Internet, love, sex, exercise, work, and shopping), no studies were included on shopping and love. Specifically, 31 studies pertained to internet (15 on the internet addiction, 12 on gaming, and 4 on smartphones), 18 studies were included on gambling, 7 on work, 2 on exercise, and 1 on compulsive sexual behavior. Most studies emanated from the United States, China, South Korea, and Italy and were published in 2023.

Despite a comprehensive strategy, love addiction and compulsive buying-shopping disorder were unrepresented in the sample. While love addiction as a term first appeared in the 1970s, and the phenomenon predates this name, few empirical studies have been conducted to date. A more fundamental issue also concerns the clarity of extant definitions and psychometrically sound assessment.[79] While the tendency to buy or shop in excess has also long been recognized, compulsive buying-shopping disorder lacks consensus as a distinct diagnostic category.[80]

Our initial search for internet-related addictions, specifically, "social media addiction," "internet addiction," "electronic media addiction," and "smartphone addiction" also yielded literature on gaming. While these 11 studies contributed significantly to this review, our search on the topic cannot be considered exhaustive given our search terms. In agreement with authors such as Griffiths *et al*.,[81] we distinguished between "Internet Gaming Disorder" and "Internet addiction," recognizing that the Internet may serve as a medium to drive other addictive behaviors; rather than being the object of the addiction.[81,82]

Few studies centered on sex, exercise, and smartphone addiction. While exercise is universally acknowledged to lower CVD risks and related mortality, a proportion of individuals will develop EA.[83,84] A disputed condition, EA has been linked to adverse health outcomes including pernicious cardiovascular consequences.[83-85] EA is not to be conflated with high-volume exercise; the former is characterized by loss of control, emotional, job-related, and social disturbances.[85] Moreover, indicators of EA are often missed by providers given the focus on health benefits and limited awareness.[86]

No studies emerged on the topic of substitute addictions which further complicates the clinical picture. Substitute addictions, "the experience of quitting or cutting down on a particular addictive behavior but replacing it with another addictive behavior, that had begun, resumed, or increased in frequency and/or intensity after addressing the targeted addiction,"[87] (p. 2) are likely to differ in their consequences for cardiovascular health. The interactions between behavioral addictions warrant further attention. Furthermore, integrated, coordinated care ensures that medical and addiction services are addressed contemporaneously and improves screening, provider communication, referrals, access to mental health services and medical treatment, and addiction-related outcomes.[88-93]

Limitations of this review

This review was limited in scope to primary studies published in English peer-reviewed journals, potentially biasing the results. Indicators of CVD risk were not consistent across studies and types of addictions. Measurement error regarding CVD risk factors or any of these addictions was not clear. Longitudinal study designs were rare; thus, the order of precedence between the addictions and CVD was not at all clear. There was a notable absence of qualitative and mixed methods studies across the addictions examined. Addiction recovery stages (i.e., early recovery: < 1 year; sustained recovery: 1–5 years; and stable recovery: > 5 years,[94]) and the duration of 'active addiction' were not critically considered. However, as far as we are aware, this is the first scoping review on the focal behavioral addictions and cardiovascular health and, in general, these

studies do indicate or at least suggest an association between behavioral addictions and CVD indicators. That is, it would appear, no matter what the causal mechanisms are, that persons suffering from substance or behavioral addictions are at relatively higher risk for CVD events. As this interdisciplinary focus area continues to evolve, a narrower focus on specific facets of cardiovascular functioning is recommended for future work.

Conclusions

In sum, these studies suggest that certain behavioral addictions and their cardiovascular characteristics and consequences have received scant attention in the scholarly literature. Dedicated methodologically robust studies will move the field forward on this specific research focus. Given that the demographic characteristics and clinical profiles of people with addictive disorders vary,[32] there is a compelling need for more systematic consideration of age, chronic stress, gender and corresponding cardiovascular factors in such studies. Accordingly, we recommend an intentional approach to sampling varied groups of participants for studies on cardiovascular health and behavioral addictions; transparent reporting of the study methodology (including how participants were recruited and selected and using valid and reliable measures where possible); using diverse research designs (including longitudinal and lived experience research) and systematic consideration of substance use (disorders), i.e., co-occurring or substitute addictions with known impacts on cardiovascular health.

Author contributions

Steve Sussman conceptualized the study. Deborah L. Sinclair conducted the literature searches and charted the data. Both authors analyzed the data and prepared, edited, and reviewed the manuscript. The current version has been approved for the publication by both authors.

Ethical statement

The ethical statement is not applicable to this article.

Data availability statement

All data generated or analyzed during this study are included in this published article and its supplementary materials.

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Conflicts of interest

Prof. Steve Sussman is an Editorial Board Member of *Heart and Mind*. Dr. Deborah Louise Sinclair is a Youth Editorial Board Member of *Heart and Mind*. The article was subject to the journal's standard procedures, with peer review handled independently of the authors. There are no conflicts of interest.

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Supplementary Table 1 and Appendix 1. Supplementary data

Supplementary data to this article can be found online at [http://doi.org/10.4103/hm.HM-D-24-00080].

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Appendix and Supplementary Materials

Supplementary Table 1: Search string – PubMed

Behavioural addictions and cardiac health: (((((((“addictive disorders”[Title/Abstract]) OR (“behavioural addictions”[Title/Abstract])) OR (“behavioral addictions”[Title/Abstract])) OR (“non-chemical addictions”[Title/Abstract])) OR (“nonsubstance addictions”[Title/Abstract])) OR (“non-substance addictions”[Title/Abstract])) OR (“process addictions”[Title/Abstract])) AND (((((heart[Title/Abstract]) OR (cardi*[Title/Abstract])) OR (coronary[Title/Abstract])) OR (arrhythmia[Title/Abstract])) OR (myocardial[Title/Abstract]))

Internet addiction: ((((“social media addiction”[Title/Abstract]) OR (“internet addiction”[Title/Abstract])) OR (“electronic media addiction”[Title/Abstract])) OR (“smartphone addiction”[Title/Abstract])) AND (((((heart[Title/Abstract]) OR (cardi*[Title/Abstract])) OR (coronary[Title/Abstract])) OR (arrhythmia[Title/Abstract])) OR (myocardial[Title/Abstract]))

Love addiction: (((((((“love addiction”[Title/Abstract]) OR (“pathological love”[Title/Abstract])) OR (“romance addict”[Title/Abstract])) OR (“pathological limerence”[Title/Abstract])) OR (“obsessive love”[Title/Abstract])) OR (lovesickness[Title/Abstract])) OR (infatuation[Title/Abstract])) AND (((((heart[Title/Abstract]) OR (cardi*[Title/Abstract])) OR (coronary[Title/Abstract])) OR (arrhythmia[Title/Abstract])) OR (myocardial[Title/Abstract]))

Work addiction: (((((((workahol*[Title/Abstract]) OR (work addict*[Title/Abstract])) OR (addict* to work[Title/Abstract])) OR (work dependen*[Title/Abstract])) OR (dependen* to work[Title/Abstract])) OR (excess* work[Title/Abstract])) OR (compuls* work[Title/Abstract])) OR (obsess* work[Title/Abstract])) AND (((((heart[Title/Abstract]) OR (cardi*[Title/Abstract])) OR (coronary[Title/Abstract])) OR (arrhythmia[Title/Abstract])) OR (myocardial[Title/Abstract]))

Exercise addiction: ((((((((((((“addiction to exercise”[Title/Abstract]) OR (“exercise addiction”[Title/Abstract])) OR (“exercise abuse”[Title/Abstract])) OR (“exercise dependence”[Title/Abstract])) OR (“obsessive exercise”[Title/Abstract])) OR (excessive exercis*[Title/Abstract])) OR (obligatory exercis*[Title/Abstract])) OR (compulsory exercis*[Title/Abstract])) OR (pathological exercis*[Title/Abstract])) OR (“primary exercise addiction”[Title/Abstract])) OR (“secondary exercise addiction”[Title/Abstract])) OR (compulsive exercis*[Title/Abstract])) OR (sport dependenc*[Title/Abstract])) OR (“sport addiction”[Title/Abstract])) AND (((((heart[Title/Abstract]) OR (cardi*[Title/Abstract])) OR (coronary[Title/Abstract])) OR (arrhythmia[Title/Abstract])) OR (myocardial[Title/Abstract]))

Gambling disorder: ((((((((((((((((((((((((((gambl*[Title/Abstract]) OR (problem gambl*[Title/Abstract])) OR (gambling problem*[Title/Abstract])) OR (disorder* gambl*[Title/Abstract])) OR (gambl* disorder*[Title/Abstract])) OR (gambl* addiction*[Title/Abstract])) OR (lotto[Title/Abstract])) OR (lotter*[Title/Abstract])) OR (casino[Title/Abstract])) OR (betti*[Title/Abstract])) OR (wage*[Title/Abstract])) OR (“pathological gambling”[Title/Abstract])) OR (“excessive gambling”[Title/Abstract])) OR (“gambling dependence”[Title/Abstract])) OR (sport* bet[Title/Abstract])) OR (horse* bet[Title/Abstract])) OR (“online bet”[Title/Abstract])) OR (electronic gaming machine*[Title/Abstract])) OR (electronic gambling machine*[Title/Abstract])) OR (poker[Title/Abstract])) OR (blackjack[Title/Abstract])) OR (bingo[Title/Abstract])) OR (roulette[Title/Abstract])) OR (card player*[Title/Abstract])) OR (card game*[Title/Abstract])) OR (slot machine*[Title/Abstract])) OR (fantasy sport*[Title/Abstract])) AND (((((heart[Title/Abstract]) OR (cardi*[Title/Abstract])) OR (coronary[Title/Abstract])) OR (arrhythmia[Title/Abstract])) OR (myocardial[Title/Abstract]))

Contd...

Supplementary Table 1: Contd...

Sex addiction: ((((((((((((((((((((((((((((((“addictive sex”[Title/Abstract]) OR (“compulsive sexual behavior”[Title/Abstract])) OR (compulsive sexual behavio*r disorder[Title/Abstract])) OR (“Don Juanism”[Title/Abstract])) OR (erotomania[Title/Abstract])) OR (“excessive sexual desire disorder”[Title/Abstract])) OR (hyperactive sexual behavio*r[Title/Abstract])) OR (hyperlibido[Title/Abstract])) OR (hypersexuality[Title/Abstract])) OR (“hypersexual disorder”[Title/Abstract])) OR (“hypersexuality disorder”[Title/Abstract])) OR (hypersexual behavio*r[Title/Abstract])) OR (“non-paraphilic sexual disorders”[Title/Abstract])) OR (nymphomania[Title/Abstract])) OR (“paraphilia-related disorders”[Title/Abstract])) OR (“problematic pornography use”[Title/Abstract])) OR (satyriasis[Title/Abstract])) OR (“sexual addiction”[Title/Abstract])) OR (“sex addiction”[Title/Abstract])) OR (sexaholism[Title/Abstract])) OR (“sexual compulsivity”[Title/Abstract])) OR (“sexual compulsiveness”[Title/Abstract])) OR (“sexual dependence”[Title/Abstract])) OR (“sexual desire disorders”[Title/Abstract])) OR (“sexual disinhibition”[Title/Abstract])) OR (“sexual impulsivity”[Title/Abstract])) OR (“sexual obsession”[Title/Abstract])) OR (“sexual preoccupation”[Title/Abstract])) OR (“sexual sensation seeking”[Title/Abstract])) OR (“sexual torridity”[Title/Abstract])) OR (“uninhibited sexual desire”[Title/Abstract])) OR (“unrestrained sexual desire”[Title/Abstract])) AND (((((heart[Title/Abstract]) OR (cardi*[Title/Abstract])) OR (coronary[Title/Abstract])) OR (arrhythmia[Title/Abstract])) OR (myocardial[Title/Abstract]))

Shopping disorder: ((((((heart[Title/Abstract]) OR (cardi*[Title/Abstract])) OR (coronary[Title/Abstract])) OR (arrhythmia[Title/Abstract])) OR (myocardial[Title/Abstract]))) AND ((addictive buyi*[Title/Abstract]) OR (addictive purchas*[Title/Abstract])) OR (addictive shop*[Title/Abstract])) OR (addictive spend*[Title/Abstract])) OR (buying addict*[Title/Abstract])) OR (buying disord*[Title/Abstract])) OR (buying problem*[Title/Abstract])) OR (buying-shopping*[Title/Abstract])) OR (compensatory buyi*[Title/Abstract])) OR (compensatory purchas*[Title/Abstract])) OR (compensatory shop*[Title/Abstract])) OR (compensatory spend*[Title/Abstract])) OR (compulsive buyi*[Title/Abstract])) OR (compulsive purchas*[Title/Abstract])) OR (compulsive shop*[Title/Abstract])) OR (compulsive spend*[Title/Abstract])) OR (“e-commerce”[Title/Abstract])) OR (“electronic commerce”[Title/Abstract])) OR (“e-shopping”[Title/Abstract])) OR (“e-tail”[Title/Abstract])) OR (excessive buyi*[Title/Abstract])) OR (excessive purchas*[Title/Abstract])) OR (excessive shop*[Title/Abstract])) OR (excessive spend*[Title/Abstract])) OR (hyperspend*[Title/Abstract])) OR (impulsive buyi*[Title/Abstract])) OR (impulsive purchas*[Title/Abstract])) OR (impulsive shop*[Title/Abstract])) OR (impulsive spend*[Title/Abstract])) OR (“internet commerce”[Title/Abstract])) OR (“internet shopping”[Title/Abstract])) OR (obsessive buyi*[Title/Abstract])) OR (obsessive purchas*[Title/Abstract])) OR (obsessive shop*[Title/Abstract])) OR (obsessive spend*[Title/Abstract])) OR (onioman*[Title/Abstract])) OR (online buy*[Title/Abstract])) OR (“online purchase”[Title/Abstract])) OR (“online shopping”[Title/Abstract])) OR (overshop*[Title/Abstract])) OR (overspend*[Title/Abstract])) OR (pathological buyi*[Title/Abstract])) OR (pathological purchas*[Title/Abstract])) OR (pathological shop*[Title/Abstract])) OR (pathological spend*[Title/Abstract])) OR (problematic buyi*[Title/Abstract])) OR (problematic purchas*[Title/Abstract])) OR (problematic shop*[Title/Abstract])) OR (problematic spend*[Title/Abstract])) OR (purchasing addict*[Title/Abstract])) OR (purchasing disord*[Title/Abstract])) OR (purchasing problem*[Title/Abstract])) OR (shopahol*[Title/Abstract])) OR (shopping addict*[Title/Abstract])) OR (shopping disord*[Title/Abstract])) OR (shopping problem*[Title/Abstract])) OR (spending addict*[Title/Abstract])) OR (spending disord*[Title/Abstract])) OR (spending problem*[Title/Abstract]))

Appendix 1: Reasons for Article Exclusion

Outside of the review timeframe

1. Chin SC, Chang YH, Huang CC, Chou TH, Huang CL, Lin HM, *et al.* Altered heart rate variability during mobile game playing and watching self-mobile gaming in individuals with problematic mobile game use: Implications for cardiac health. Psychol Res Behav Manag 2024;17:2545-55.

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On substance use disorders

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Non-English Language

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Behaviours do not rise to the level of problematic/disordered engagement in the study sample

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Not relevant to the review topic

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