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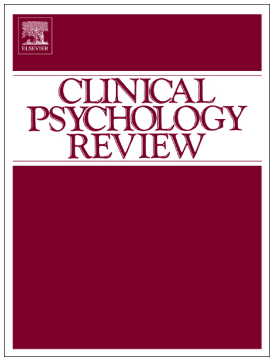

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Short-term abstinence effects across potential behavioral addictions: A systematic review

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Abstract

Observing short-term abstinence effects across potential behavioral addictions is vital for informing understanding about how addiction-related symptoms (withdrawal, craving and relapse) might manifest across these behaviors. Short-term abstinence may also have potential as a clinical intervention for behavioral addictions. This review aimed to synthesize existing research evidence on short-term abstinence effects across potential behavioral addictions in light of (1) manifestations of withdrawal, craving and relapse, and (2) benefits or counterproductive consequences of abstinence. We reviewed 47 prospective studies examining effects of short-term abstinence across six potential behavioral addictions (exercise, gambling, gaming, mobile phone use, pornography use, social media use). Findings of the review showed that there is a paucity of prospective studies investigating abstinence effects in relation to potential behavioral addictions except for exercise. Across all behaviors, exercise demonstrated the clearest pattern of withdrawal-related symptoms mainly related to mood disturbances. While withdrawal and craving were investigated to a fair extent across the studies, the study of relapse using abstinence protocols is underutilized within behavioral addiction research. Short-term abstinence shows promise as an intervention for some problematic behaviors, especially gaming, pornography use, mobile phone use, and social media use. However, potential counterproductive consequences of abstinence (e.g., rebound effects and compensatory behaviors) were not adequately assessed by the studies, which limits current evaluation of the utility of abstinence as an intervention.

Keywords: abstinence; deprivation; behavioral addiction; withdrawal; craving; relapse

Introduction

Although defined in various ways within the addiction literature (see Hughes, 2007c), abstinence broadly refers to a state of voluntary or involuntary non-engagement in a behavior[1]. The psychological effects of abstinence from potential behavioral addictions have important implications for the assessment and treatment of behavioral addictions.

Abstinence as a methodological tool in the assessment of addiction symptomatology

In the assessment of addiction, it is not simply an individual's psychological state while actively engaged in a behavior that is taken into account, but also how they react to situations where they are prevented, whether voluntarily or involuntarily, from engaging in a behavior. Three out of the six components in the 'components model of addiction' (Griffiths, 2005) refer in some way to symptomatology that presuppose (attempted) abstinence situations. First, *withdrawal symptoms* refer to unpleasant emotional states that are experienced when a behavior is abruptly ceased. If an individual is regularly or habitually engaging in a behavior without restriction, it is possible that any latent withdrawal symptoms which might otherwise arise under abstinence conditions might be masked. For withdrawal symptoms to manifest, a period of abstinence is required. Second, *relapse* refers to an individual losing control over a behavior and reverting to earlier patterns of behavior after a period of abstinence. If an individual does not try to abstain from the behavior in the first place, relapse, by definition, cannot be observed. Third, *salience* refers to a behavior dominating an individual's thinking and feelings. Although in most cases salience can be observed in the absence of abstinence, Griffiths (2005) has argued that for behaviors such as smoking, where an individual has practically unrestricted access to the behavior under usual circumstances, salience (and the experience of craving that accompanies salience), may not

[1] There are generally two ways by which abstinence may occur. First, through attempted self-restraint while still having immediate access to the behavior (e.g., a gamer internally committing to not play games while still having access to their electronic devices). Second, through physical separation from the behavior, where immediate access to the behavior is removed. Separation can be voluntary (e.g., the gamer surrendering their electronic devices to a friend) or involuntary, due to circumstances out of one's control (e.g., disrupted internet access forcing a state of abstinence from gaming).

manifest until the person is prevented from engaging in the behavior (e.g., on a 24-hour plane flight).

Accordingly, because some addiction-related symptoms (i.e., withdrawal, relapse, and salience/craving) only manifest (or manifest more strongly) under abstinence conditions, it is possible that they might be masked under non-abstinence conditions. In behavioral addiction research, retrospective and cross-sectional self-report questionnaires asking individuals whether they experience withdrawal symptoms, craving, or relapse are inherently limited if individuals generally do not engage in significant periods of abstinence in the first place. Instead, prospective studies of abstinence situations are particularly useful in allowing observation of these psychological phenomena as they may arise over an abstinence period. Naturally occurring periods of abstinence (e.g., intrinsically motivated cessation attempts) are useful for researchers to systematically observe where they do occur but may be rare depending on the behavior of interest. In their absence, abstinence can be experimentally manipulated in order to examine its effects. Prospective studies examining cognitive, affective, physical, and behavioral reactions to abstinence can be a useful methodological tool in systematically investigating addiction-related symptomatology, especially withdrawal, craving, and relapse (i.e., do these symptoms manifest, and if so, for whom, how, and why?).

Abstinence as a potential intervention for problematic behaviors

Beyond its use as a methodological tool, the possibility of abstinence also being a potentially useful intervention for problematic behaviors needs to be given due consideration within behavioral addiction treatment research. If a behavior is causing problems, abstaining from the behavior appears (at face value) to be a logical solution. For instance, 12-step groups based on the original Alcoholics Anonymous (AA) model advocate an abstinence approach to compulsive behaviors, although abstinence goals across these groups may not always be absolute and may be more nuanced, depending on the behavior involved (Browne,

1991; Efrati & Gola, 2018). Some clinicians treating problematic sexual behavior have even suggested temporary (e.g., 90 days) 'celibacy contracts' of complete abstinence from any sexual behavior in early phases of treatment (Carnes, 1989). Historically, abstinence has also been the dominant long-term treatment goal within treatment settings for gambling disorder (Ladouceur, Lachance & Fournier, 2009).

However, there appears to be some consensus within the behavioral addiction field that controlled use, rather than complete abstinence should be the recommended long-term treatment goal for many behavioral addictions[2], including gaming (King & Delfabbro, 2014), internet use (Young, 2007), SNS use (Andreassen, 2015), exercise (Berczik et al., 2014), shopping (Kellett & Bolton, 2009), work (Holland, 2007), and eating (Yau, Gottlieb, Krasna & Potenza, 2014). For gambling disorder, controlled gambling is increasingly being advocated as a viable goal alongside traditional abstinence treatment goals (e.g., Stea, Hodgins & Fung, 2015). Commonly cited reasons for advocating controlled use over abstinence as a long-term goal include behaviors being (or becoming) an integral part of life and therefore not possible or unrealistic to go without (e.g., buying – Kellet & Bolton, 2009; technology use – Kuss & Griffiths, 2017; Young, 2007; work – Holland, 2007), or having health benefits that would be lost through abstinence (e.g., exercise – Berczik et al., 2014) .

Abstinence as a temporary intervention, on the other hand, has not received as much attention within the empirical literature. Concerns about the viability of abstinence as a long-term goal does not preclude the possibility that short-term periods of abstinence could be beneficial, depending on the behavior in question. The crucial difference is that with short-term abstinence the goal in many cases would be to return to controlled use following the abstinence period. Temporarily disentangling from continued, unrestrained engagement in a

[2] It is worth noting that 'relapse' has different meanings depending on the intended goal (i.e., abstinence or controlled use). In the case of abstinence, any re-engagement in the behavior is typically regarded as relapse. For controlled use, relapse is usually defined as a violation of predetermined moderation goals – for example, gaming more frequently or for longer durations than previously agreed upon (see Rosenberg & Feder, 2014 for further discussion).

behavior could, theoretically, undo to a specific extent negative effects caused by excessive engagement in the behavior (e.g., Wilson, 2016) or enhance self-awareness or insight into the behavior. Abstinence tasks also require practicing self-control, which might increase capacity for self-control strength (Muraven & Baumeister, 2000), and successful abstinence attempts might increase abstinence/avoidance self-efficacy (e.g., Hodgins, Peden & Makarchuk, 2004; Kraus, Rosenborg, Martino, Nich & Potenza, 2017). These potential benefits remain speculative, but are certainly worth empirical scrutiny. All in all, short-term abstinence as a temporary intervention need not be conflated with long-term abstinence as an indefinite treatment goal and can be regarded as separate interventions.

Nonetheless, attempted periods of short-term abstinence, while plausibly having benefits, may also have adverse or counterproductive consequences. For example, individuals who attempt quitting a behavior 'cold turkey' may lack effective coping skills in dealing with withdrawal symptoms and engage in harmful behavior as a result. A recent report indicated that gamers might engage in compensatory behaviors (e.g., searching for gaming-related pornography) during periods of 'forced abstinence' from gaming (Castro-Calvo, Ballester-Arnal, Potenza, King & Billieux, 2018). It is entirely possible that across different behaviors, individuals respond to the unpleasant experience of withdrawal by engaging in compensatory behaviors that might sometimes cause equal or more harm (e.g., binge drinking to cope with gambling cravings). Not knowing how to deal adaptively with lapses or slips during periods of abstinence might also lead to counterproductive consequences – for example, the phenomenon of the abstinence violation effect (Marlatt & Gordon, 1985) might cause a lapse to progress to a full-blown relapse (e.g., Sharma & Anand, 2019). Consequently, it may be possible that abstinence on its own, when it is not part of an intervention that teaches effective coping skills for dealing with withdrawal, cravings, or lapses, might cause more harm than good. It is also worth noting that there have been concerns raised by food addiction

and sex addiction researchers that the goal of abstinence in and of itself (in relation to these specific behaviors) may have harmful effects – abstinence from specific foods potentially leading to patterns of disordered eating (Schulte, Grilo & Gearheardt, 2016), or even temporary sexual celibacy contracts potentially leading to negative attitudes towards sexuality (Coleman, 1990; Kingston & Firestone, 2008). Therefore, understanding potential adverse effects of these abstinence periods, and even abstinence as an approach in and of itself, irrespective of time frame, is vital before its viability as a potential intervention can be properly weighed.

The present study

Taken together, because psychological reactions to abstinence might be indicative of addiction symptomatology (i.e., withdrawal, relapse, and salience/craving), and abstinence in the short-term may be a potentially useful intervention for problematic behaviors, there is a need to systematically review the psychological effects of abstinence and evaluate the extent to which these effects might inform behavioral addiction assessment and treatment.

There have been numerous reviews on the effects of abstinence from exercise over the years (e.g., Antunes, Terrão & Mello, 2011; Hausenblas & Down, 2002; Morgan, Olagunju, Corrigan & Baune, 2018; Szabo, 1995; Weinstein, Koehmstedt & Kop, 2017). However, to date, there has been no systematic review of the effects of abstinence across multiple potential behavioral addictions. We sought to address this gap by reviewing the current state of knowledge on the effects of abstinence from behaviors most commonly investigated within behavioral addiction research. While having significant implications for behavioral addiction treatment research, the effects of long-term abstinence falls outside the scope of the present review. The present review instead focuses on short-term abstinence (hereafter termed 'abstinence' unless otherwise specified). Short-term abstinence, for the purposes of the present review, refers to two kinds of abstinence periods. The first refers to the first four

weeks of a non-temporary, indefinite abstinence period (i.e., a genuine cessation attempt). This may be regarded as 'short-term' because while participants are intending to quit the behavior completely, the focus here is on the experience of early abstinence. A four-week period was chosen on the basis that the time course of acute withdrawal symptoms for substance addictions generally does not last beyond this period (Hughes, Higgins & Bickel, 1994). Consequently, it can be reasonably extrapolated that acute withdrawal symptoms for behavioral addictions (if any do manifest) would also not persist beyond a four-week period. The second refers to any temporary abstinence period, irrespective of time frame, which may also be regarded as 'short-term' because participants are only trying to quit a behavior temporarily. This includes studies that experimentally manipulate abstinence, since participants are only instructed to abstain from the behavior for a predetermined amount of time. Studies that have examined abstinence as a temporary goal, even if the time frame exceeds the initial four-week acute withdrawal stage (e.g., a 90-day celibacy contract), are also of interest because they would be especially useful for evaluating temporary abstinence as a potential clinical intervention.

Abstinence effects across different addictive substances, while useful for comparison with behavioral addictions, are beyond the scope of the present review. The extant literature reviewing abstinence effects in relation to withdrawal and relapse for substances is substantial, particularly in relation to tobacco (e.g., Hughes, 2007a, b). Withdrawal syndromes for most addictive substances are also well-established (for comparisons across substances, see Hughes et al., 1994; Shmulewitz, Greene & Hasin, 2015; West & Gossop, 1994). The relationships between withdrawal, craving and relapse in substance use are complex and have been reviewed and discussed extensively elsewhere (e.g., Patten & Martin, 1996; Piasecki, 2006; Serre, Fatseas, Swendsen & Auriacombe, 2015; Wray, Gass & Tiffany, 2013). However, it is important to bear in mind for this review that the term 'withdrawal'

may have a somewhat different meaning for behavioral addictions when compared with substance addictions. Unlike substance addictions, behavioral addictions do not involve direct contact with brain synapses through the introduction of an exogenous ligand, but instead alter endogenous ligand functions. Neurotransmitter release may become dependent on repeated engagement in the behavior, which may lead to 'withdrawal-like' symptoms when the behavior is ceased (see Sussman, 2017 for further discussion of this issue).

The aims of the present review can therefore be summarized as follows: (i) review the existing literature examining effects of abstinence from potential behavioral addictions (namely gambling, gaming, technology use, sex, pornography use, exercise, work, eating, and buying); (ii) evaluate these effects in relation to addiction symptomatology (i.e., withdrawal, relapse, and salience/craving), along with potential benefits or counterproductive consequences; and (iii) discuss implications of these findings for behavioral addiction assessment and treatment.

Method

Papers were identified via electronic database searches of *Scopus, Web of Science, PubMed, PsycArticles* and *PsycInfo*. In order to identify papers examining abstinence from behaviors commonly investigated within behavioral addiction research (i.e., gambling, gaming, technology use, sex, pornography use, exercise, work, buying, and eating) while excluding substance addiction literature, we used the following search terms: (patholog* OR problem* OR addict* OR compulsiv* OR dependen* OR disorder) AND (gambling OR gaming OR internet OR technolog* OR sex* OR pornography OR exercise OR work OR shopping OR buying OR food) AND (abstinen* OR abstain) NOT (drug* OR substance OR alcohol* OR nicotine OR smok* OR opioid OR opiate OR heroin OR cocaine OR cannabis OR marijuana OR amphetamine). The search terms yielded 1,991 results in total.

Studies were first screened for relevance by reviewing titles and abstracts. Full-text papers were then assessed for eligibility based on the following inclusion criteria: (i) published in English; (ii) published in a peer-reviewed journal; (iii) examined psychological effects of short-term abstinence (whether through self-restraint or separation) from gambling, gaming, internet use, sex, pornography use, exercise, work, shopping (buying), or eating – either through employing abstinence as an independent variable in order to isolate its effects, or by examining abstinence-induced effects, i.e., psychological phenomena that occur under abstinence conditions; and (iv) utilized a prospective design in examining either experimentally manipulated or naturally occurring abstinence.

Papers were excluded if (i) abstinence was examined in the context of a specific non-addiction psychopathology (e.g., masturbation prohibition examined in the context of pedophilia – Brown, Traverso & Fedoroff, 1996), (ii) abstinence effects resulting from an attempt to quit the behavior completely were not assessed within the first four weeks (e.g., Kushnir, Godinho, Hodgins, Hendershot & Cunningham, 2018) because they do not fall within the operational definition of 'short-term abstinence' used for this review; (iii) abstinence was examined as an outcome variable or dependent variable, where the focus was not on abstinence effects, but on a different independent variable (e.g., number of days abstinent as an outcome variable, as an indicator of CBT vs. 12-step treatment effectiveness – Toneatto & Dragonetti, 2008); (iv) abstinence was employed as part of a larger treatment intervention consisting of multiple therapeutic components (e.g., Kim, Han, Lee, Kim & Renshaw, 2012; Sakuma et al., 2017; Uhls et al., 2014) on the basis that any effects observed cannot be directly attributed to abstinence; (v) abstinence effects were examined through retrospective or cross-sectional designs. For example, in terms of gambling, studies using retrospective surveys typically report a range of negative abstinence effects generally characterized by restlessness, irritability and mood disturbances (e.g., Blaszczynski, Walker,

Sharpe & Nower, 2008; Cunningham-Williams, Gattis, Dore, Shi, Spitznagel, 2009; Rosenthal & Lesieur, 1992; Wray & Dickerson, 1981). Studies using cross-sectional designs might attempt to infer possible abstinence effects by comparing differences in various outcomes between abstinent individuals and non-abstinent individuals. However, retrospective designs are subject to several types of bias, and cross-sectional designs limit conclusive inferences about abstinence effects (for a discussion of the limitations of non-prospective designs, see Hughes, 2007c). Therefore, studies employing these designs were excluded from the present review.

Reference lists of included papers and exercise deprivation systematic reviews (Antunes et al., 2011; Hausenblas & Down, 2002; Morgan et al., 2018; Szabo, 1995; Weinstein et al., 2017) were also searched to identify further relevant studies. Figure 1 depicts the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram summarizing the systematic search process.

Results

A total of 46 papers comprising 47 studies met the inclusion criteria and were included in the present review. A large majority of studies examined abstinence effects in relation to exercise (n = 22), followed by electronic media (i.e., mobile phone or social media) use (n = 13), gaming or gambling (n = 9), and pornography use (n = 3). The systematic search strategy used did not identify any papers examining abstinence from sex, work, shopping (buying), or food. The terms 'abstinence', 'deprivation' and 'restriction' appeared to be used interchangeably across studies to describe similar protocols where the goal was ensuring participants did not engage in the behavior. A total of 39 studies employed a self-restraint protocol (where there was still immediate access to the behavior), six employed a separation protocol (where immediate access to the behavior was removed), and two employed a combination of self-restraint and separation protocols across different

experimental conditions. Most of the studies (n = 41) experimentally manipulated abstinence in some way, while six studies prospectively examined naturally occurring abstinence. Forty-five studies examined temporary abstinence, while two studies examined abstinence effects within the first three weeks of an indefinite cessation attempt. Duration of abstinence ranged from four minutes to 99 days. All studies used participant samples who were presumed to be at least regularly engaged in the behavior.

Table 1 summarizes abstinence effects across all six behaviors (see Appendix A for detailed methodological characteristics and findings of each study). Most of the studies (n = 43) examined abstinence effects potentially indicative of withdrawal (i.e., negative cognitive-affective/physical reactions to abstinence). However, less than half of these (n = 21) conceptualized these effects in their studies explicitly as 'withdrawal symptoms'. Four studies examined abstinence-induced craving but did not explicitly conceptualize craving as a withdrawal symptom, while five studies explicitly conceptualized craving as a withdrawal symptom. Only two studies directly assessed relapse. Nonetheless, even if studies did not set out to directly assess relapse, abstinence non-compliance rates (where reported) are noted among the relevant findings as an indicator of potential relapses. We define 'relapse' as any engagement in the behavior during the abstinence period. Most of the studies (n = 33) considered an addiction framework in their interpretation of abstinence effects, while the remaining studies (n = 14) utilized a non-addiction perspective, never explicitly mentioning addiction-related concepts.

Table 1

Summary of abstinence effects across behaviors

	Abstinence protocols (duration, type)	Negative cognitive-affective/physical effects	Negative behavioral effects	Positive effects	Theoretical interpretations of effects
Exercise (n = 22)	24 hrs[2,41] 26-30hrs[10] 2-5 days[9] 3 days[20,29,32] 5 days[10] 7 days[18, 19,26, 38,39,46] 7-14 days[3] 10 days[1] 2 wks[6,25,30,33,45] 1 month[4] *SR*(all)	↑Depression[2,6,9,25,29,30,39,41,45] ↑Total mood disturbance (POMS)[6,9,25,29,33,39,45] ↑Fatigue[1,2,6,9,19,25,45] ↑Tension[2,9,29, 39] ↑Anxiety[4,29,30] ↑Anger[2,9,39] ↑Confusion[2,9,29] ↑Somatic symptoms[18,30] ↑Psychological distress[33] ↑Need to be with others[4] ↑Tense arousal[32] ↑Sexual tension[4] ↑Galvanic skin response[41] ↑Body dissatisfaction[32] ↑Heart rate[39] ↑Insomnia[30] ↑Pain[19] ↑Non-articular tenderness[6] ↑Strained feelings[30] ↓Vigor[2,9, 29, 39] ↓Appetite[4] ↓ Sleep quality[4] ↓ Hedonic tone, energetic arousal[32] ↓Quality of life[46] ↓ Positive affect[39] <u>Moderating/interaction effects</u> • Males, higher competition levels ↑negative moods[10] • Low commitment-high dependence runners ↑mood disturbances[9]	<u>Abstinence non-compliance rates</u>: 0%[30,32,39], 7.5%[20]	<u>Moderating/interaction effects</u> • Females, lower competition levels ↑positive moods[10] • High-dependence/high-commitment runners ↓mood disturbances[9] • 'True' deprivation days ↑positive engagement and revitalization (compared to 'non-exercise' days)[20] • Low dependence ↑positive engagement, revitalization, tranquility[20]	<u>Negative effects</u> Addiction-related withdrawal[2,3,9,10,26,30, 39,41] Non-addiction-related 'withdrawal'[20,29] Negative health outcomes[1,6,32] Biological determinants[3,19,25,33,45,46] Beneficial effects of exercise lost[30] <u>Positive effects</u> Relief from fatigue[10] Relief from obligation[20]

		• Hypoactive biological stress response system↑fatigue, ↑pain, ↑mood disturbances[19] • Exercise addiction ↑anxiety[26], ↑tension[2], ↑anger[2,3], ↑depression[2,3,26], ↑heart rate[2], ↑sympathetic activity[26], ↑confusion[2,3], ↑fatigue[3], ↓bioelectrical activity[26], ↓vigor[3] Trajectory of effects • By Day 3, anxiety, tension, depression and total mood disturbance decreased[29] • Somatic symptoms (wk 1) preceded onset of cognitive-affective symptoms (wk 2)[6,30]			
Gambling (n = 2)	5 – 21 days[12,40] *SR*[12,40]	Gambling craving more severe than alcohol craving[12,40], dependent on external factors[12], related to unpleasant arousing state[12] and depression[40]	NR	NR	Negative effects Addiction-related craving[12,40]
Gaming (n = 7)	4 mins[14] 84 hrs[16, 21,22,23] *IVSP*[13,14] *SR*[16,21,22,23]	↑Boredom[16, 22] ↑Drive for mental stimulation[22] ↑Craving[22] Moderating/interaction effects • IGD group ↑lentiform activation[13], ↑withdrawal symptoms[21] • Females ↑IGU-IGD differences in craving-related functional connectivity[14] Trajectory of effects • Withdrawal symptoms declined over time in both abstinence and control groups[16] • Withdrawal symptoms declined over time in both IGD and non-IGD groups[21]	Abstinence non-compliance rates: 0%[21, 22, 23], 83%[24] Use of action shooting games, endorsement of IGD withdrawal criterion at baseline ↑abstinence non-adherence[24]	↑Insight/attitude shifts towards gaming[16, 22] ↑Positive changes to gaming post-abstinence[16, 22, 23] ↑Free time for other activities[16, 22] ↓IGD symptoms[23] ↓Maladaptive gaming cognitions[23]	Negative effects Addiction-related withdrawal[16, 21, 22, 24] Addiction-related craving[13,14] Structural characteristics of games[24] Positive effects Abstinence useful intervention[16, 22, 23] Potential role of self-monitoring[16, 23]

Mobile phone use (n = 6) 3-5 mins[34] 5 mins[8] 60 mins[7,11] 72 hrs[15] 3/5 days[36] *SR*[36] *VSP*[11,15] *IVSP*[8] *SR/VSP*[7,34]	↑Anxiety[7, 8, 36] ↑Unpleasantness[8] ↑Withdrawal symptoms[15] ↑FoMO[15] ↓Cognitive performance[8] ↓Extended self[8] <u>Moderating/interaction effects</u> • High text users ↑thoughts of texting[36] • When phone in sight ↑anxiety[34] • Heavy daily users ↑anxiety; moderate daily users ↑anxiety only for *VSP* condition[7] <u>Trajectory of effects</u> • Withdrawal symptoms and FoMO reduced over time for abstinence and control groups[15]	NR	↑Attainment of study goals[11]	<u>Negative effects</u> Addiction-related withdrawal[15] Separation anxiety[7] FoMO[7] Phone as extension of self[8, 15] 'Attachment' to phone[34] Non-pathological reliance on technology for communication[36] <u>Positive effects</u> Alleviation of negative effects attributed to mobile phone use[11]
Pornography use (n = 3) 14 days[17] 3 weeks[27,31] *SR*[17,27,31]	↑Perceived compulsivity[17]	<u>Frequency of use during abstinence:</u> *M* = 2.50, *SD* = 2.92[17] *M* = 1.42, *SD* = .67[27] *M* = 1.53, *SD* = .83[31] Self-reported compulsivity predicted by number of relapses when abstinence effort high[17]	↑Relationship commitment[27] ↑Perceived compulsivity – may reflect insight into actual compulsivity in one's own behavior[17] ↓Delay discounting[31]	<u>Negative effects</u> Addiction-related craving, relapse[17] <u>Positive effects</u> Alleviation of negative effects attributed to pornography use[27,31] Abstinence useful behavioral experiment[17]
Social media use (n = 7) 48 hrs[35] 7 days[37, 42, 43, 44] 14 days[28] 99 days[5]	↑Subjective feelings of 'withdrawal'[5] ↑Boredom[37] ↑Craving[37] ↑Social pressure to use social media[37] ↑Time distortion[43]	<u>Abstinence non-compliance rates</u>: 13%[42], 23%[35], 31%[5], 36.4%[43], 38.2%[44], 59%[37]	↑Life satisfaction[42] ↑Affective well-being[42] ↓Perceived stress[44] <u>Moderating/interaction effects</u>	<u>Negative effects</u> Addiction-related withdrawal[5, 37], homeostasis violation[43] FoMO[37] Use motivated by negative

SR[5, 35, 37, 42, 43, 44] *VSP*[28]	↓Sense of connection[35] Moderating/interaction effects • Users at-risk for social media addiction ↑post-abstinence time distortion[43]	Greater disconnection during abstinence ↑usage post-abstinence[35] Baseline frequency of use, negative moods during abstinence, addiction-related feelings ↑likelihood of reversion[5] Facebook switching-stress during abstinence ↓intentions to discontinue use[28] Excessive use[44], higher stress during abstinence[44], increase in time distortion during abstinence[43] ↓abstinence length	• Heavy users, passive users, users who envy others ↑life satisfaction, ↑affective well-being[42] • Excessive users ↓perceived stress[44]	affect[5,28,35,44] Positive effects Alleviation of negative effects attributed to social media use[42, 44]

Note:

↑ indicates significant increase compared to baseline/significantly greater compared to comparison group/significant positive association/perceived abstinence-induced increase; ↓ indicates significant decrease compared to baseline/significantly lower compared to comparison group/significant negative association/perceived abstinence-induced reduction; FoMO: fear of missing out; IGD: Internet Gaming Disorder; *IVSP*: involuntary separation; NR: not/none reported; POMS: Profile of Mood States; RGU: recreational game use; *SR*: self-restraint; *VSP*: voluntary separation.

Studies: 1: Ablin et al. (2013); 2: Aidman & Woollard (2003); 3: Antunes et al. (2016); 4: Baekeland (1970); 5: Baumer et al. (2015); 6: Berlin et al. (2006); 7: Cheever et al. (2014); 8: Clayton et al. (2015); 9: Conboy (1994); 10: Crossman et al. (1989); 11: Cutino & Nees (2017); 12: de Castro et al. (2007); 13: Dong et al. (2019a); 14: Dong et al. (2019b); 15: Eide et al. (2018); 16: Evans et al. (2018); 17: Fernandez et al. (2017); 18: Gauvin & Szabo (1992); 19: Glass et al. (2004); 20: Hausenblas et al. (2008); 21: Kaptsis et al. (2016); 22: King et al. (2016); 23: King et al. (2017); 24: King et al. (2018); 25: Kop et al. (2008); 26: Krivoschekov & Lushnikov (2017); 27: Lambert et al. (2012); 28: Maier et al. (2015); 29: Mondin et al. (1996); 30: Morris et al. (1990); 31: Negash et al. (2015); 32: Niven et al. (2008); 33: Poole et al. (2011); 34: Sapacz et al. (2016); 35: Sheldon et al. (2011); 36: Skierkowski & Wood (2012); 37: Stieger & Lewetz (2018); 38: Szabo & Gauvin (1992); 39: Szabo and Parkin (2001); 40: Tavares et al. (2005); 41: Thaxton (1982); 42: Tromholt (2016); 43: Turel & Cavagnaro (2018); 44: Turel et al. (2018); 45: Weinstein et al. (2007); 46: Zeller et al. (2011)

Exercise

Apart from being the most extensively studied across the different behaviors in terms of total number of studies (n = 22), exercise abstinence was also studied the earliest, with the first study conducted almost 50 years ago (Baekeland, 1970). Overall, findings across the exercise studies showed a consistent pattern of negative cognitive-affective or physical effects due to abstinence. A total of 20 out of 22 studies reported withdrawal-like effects, with depression and/or mood disturbances (n = 10) followed by fatigue (n = 7) being the most commonly reported effects. Duration of abstinence did not appear to make a difference – negative effects were observed even after as few as 24 hours in two samples (Aidman & Woolard, 2003; Thaxton, 1982) and did not abate even over a two-week period across another two samples (Berlin et al., 2006; Morris et al., 1990). While a significant number of studies (n = 11) investigated these negative effects as potential withdrawal symptoms within an addiction framework, the remainder did not. Notable theoretical perspectives included interpreting these effects in light of potential biological determinants (e.g., Antunes et al., 2016; Glass et al., 2004; Kop et al., 2003; Poole et al., 2011; Weinstein et al., 2007; Zeller et al., 2011), or as negative non-addiction-related health outcomes resulting from not exercising (Ablin et al., 2013; Berlin et al., 2006; Niven et al., 2008). Across all behaviors examined in the present review, only negative abstinence effects from exercise have been interpreted from a biological perspective. Notably, benefits of abstinence related to positive affective shifts were reported across only two studies (Crossman et al., 1987; Hausenblas et al., 2008).

Craving and relapse were never directly examined by any of the studies, even in studies investigating exercise addiction. However, in one study (Hausenblas et al., 2008), although only non-exercise-dependent participants were included in the sample, 7.5% of participants did not fully comply with the abstinence protocol, suggesting that some may have relapsed.

Gambling

Given that gambling is the most extensively researched behavioral addiction, it is arguably surprising that only two studies (i.e., de Castro et al., 2007; Tavares et al., 2005) were identified that met the present review's inclusion criteria. Both studies found that the gamblers had higher craving scores compared to the alcohol-dependent participants during early abstinence (5–21-day period). An important implication found across both studies was that the nature of gambling craving differs from alcohol craving during early abstinence.

Gaming

Four of the seven gaming studies used a similar 84-hour self-restraint protocol (Evans, King & Delfabbro, 2018; Kaptsis, King, Delfabbro & Gradisar, 2016; King, Kaptsis, Delfabbro & Gradisar, 2016; King, Kaptsis, Delfabbro & Gradisar, 2017), the findings of which have important implications for understanding the nature and trajectory of gaming withdrawal, and short-term abstinence as a potential clinical intervention. It should be noted that three of these studies (i.e., King et al., 2016; Kaptsis et al., 2016; King et al., 2017) used the same sample. In one sample (King et al., 2016), the nature of qualitatively reported withdrawal symptoms (i.e., craving, boredom, and drive for mental stimulation) were inconsistent with DSM-5 conceptualizations of withdrawal (i.e., sadness, irritability, anxiety). Across two samples (Kaptsis et al., 2016; Evans et al., 2018), withdrawal-related symptomatology declined over time, regardless of IGD status (Kaptsis et al., 2016), or whether assigned to the abstinence or control group (Evans et al., 2018). This suggests that withdrawal-related symptomatology (i.e., craving) may paradoxically manifest more strongly during periods of intensive gaming compared to abstinence, potentially due to reinforcers during game-playing which maintain craving to keep playing (Kaptsis et al., 2016). The finding that withdrawal symptoms declined in the control group as well is somewhat counterintuitive, and was attributed to either self-monitoring playing a role, or defensive

responding (Evans et al., 2018). Importantly, positive abstinence effects were reported across both samples, including an increase in attitudinal shifts towards gaming, positive behavioral changes to gaming post-abstinence and free time for other activities (King et al., 2016; Evans et al., 2018), along with a decrease in maladaptive gaming cognitions and IGD symptoms (King et al., 2017). Notably, two of these gaming studies (Evans et al., 2018; King et al., 2017) were the only studies in the present review to directly investigate the possibility of using short-term abstinence as an intervention for a problematic behavior (i.e., gaming). Complete compliance with the abstinence protocol was reported in both samples, which means that even IGD participants did not relapse. This was in contrast with another study that reported that up to 83% of an IGD sample did not adhere to their intention to abstain for a seven-day period (King, Adair, Saunders & Delfabbro, 2018). Non-abstainers in this sample were more likely than successful abstainers to endorse the IGD withdrawal criterion at baseline, suggesting that abstinence non-adherence was possibly influenced by the experience of withdrawal.

Another two studies (Dong et al., 2019a, 2019b) using similar protocols both examined abstinence-induced craving-related processes in gamers using fMRI scans, immediately following involuntary separation from gaming. Findings across both studies suggest that examining craving-related processes in gaming, especially under deprivation conditions, is important for understanding the development and maintenance of IGD.

Mobile phone use

In general, abstinence durations for the mobile phone use studies were shortest compared to the other behaviors. Findings across most of the mobile phone use studies (5/6) were characterized by negative cognitive-affective reactions to abstinence. Withdrawal symptoms (assessed by an adapted cigarette withdrawal scale comprising dimensions relating to depression-anxiety, craving, irritability-impatience and difficulty concentrating) and

FoMO were found in a 72-hour voluntary separation period (Eide et al., 2018). Withdrawal symptoms and FoMO reduced over the 72-hour period, but the finding that these symptoms reduced over time for the control group as well suggest that a third variable (e.g., self-monitoring due to daily measures administered) may have played a role in influencing trajectories of symptoms. Importantly, the most common effect found across the studies was anxiety-related reactions. Apart from a single study that found a 60-minute voluntary self-restraint period increased attainment of study goals during a study period (a positive effect of abstinence) but had no effect on anxiety (Cutino & Nees, 2017), four studies found anxiety-related reactions to abstinence. Duration and type of abstinence did not appear to make a difference, with anxiety-related reactions reported over a 3- to 5-day self-restraint period (Skierkowski & Wood, 2012), but also within as little as a 3- to 5-minute self-restraint period (Sapacz et al., 2016), a 5-minute involuntary separation period (Clayton et al., 2015), and 60-minute voluntary separation and self-restraint periods (Cheever et al., 2014). The hypothesis that these anxiety reactions indicate addiction-related withdrawal symptoms was not endorsed by any of the authors due to various plausible theoretical explanations for these reactions. The authors proposed that abstinence-induced anxiety may be explained by a non-pathological reliance on text messaging for communication (Skierkowski & Wood et al., 2012), separation anxiety (Cheever et al., 2014), one's phone being an extension of self (Clayton et al., 2015) based on extended self-theory (Belk, 2013), or fear of missing out (FoMO; Przybylski, Murayama, DeHaan & Gladwell, 2013).

Abstinence compliance rates were not reported across most studies. This is likely because separation protocols (e.g., Eide et al., 2018) render lapses highly unlikely, although still theoretically possible (e.g., using someone else's mobile phone), or where self-restraint conditions were employed, the duration of abstinence was short (e.g., 60 minutes [Cheever et al., 2014]; 3-5 minutes [Sapacz et al., 2016]). In one sample, there was no difference between

high-texting and low-texting users on abstinence non-compliance rates (Skierkowski & Wood, 2012), but the authors speculate that this could be due to participants being dishonest about possible lapses due to fear of losing full credit for study participation.

Pornography use

Studies investigating pornography abstinence were limited in number (n = 3) but provide evidence that there may be some benefits of short-term abstinence from pornography. Two studies using similar three-week self-restraint protocols found positive effects of abstaining from pornography namely greater relationship commitment (Lambert et al., 2012) and less delay discounting (Negash et al., 2015). These effects were interpreted as alleviation of negative effects attributed to pornography use. Not all participants in both studies complied fully with the abstinence protocol, suggesting that some may have relapsed. Notably, findings from the third study (Fernandez et al., 2017) suggest that a short-term self-restraint period could lead to insight about compulsivity in an individual's own patterns of behavior, through observing one's own reactions to abstinence (e.g., cravings/difficulty abstaining or relapses).

Social media use

Abstinence effects across the social media studies were mixed and inconsistent. Negative cognitive-affective reactions resembling withdrawal-like symptoms were found across four studies, including a decreased sense of connection (48-hour period – Sheldon et al., 2011), subjective feelings of withdrawal (99-day period – Baumer et al., 2015), accentuated time distortion, especially in participants 'at-risk' for social media addiction (7-day period – Turel & Cavagnaro, 2018), and boredom, craving and pressure to be on social media (7-day period – Stieger & Lewetz, 2018). Two studies found positive effects resulting from a seven-day abstinence period, resembling alleviation of negative effects attributed to social media use, including greater life satisfaction and affective wellbeing (Tromholt, 2016)

and reductions in perceived stress (Turel, Cavagnaro & Meshi, 2018). Notably, these effects were more pronounced for heavy/problematic users suggesting that that instead of producing withdrawal symptoms among this subset of users, abstaining from *Facebook* may have a positive impact on affective states. Duration of abstinence did not appear to account for any differences in outcomes.

The high rates of non-compliance with the abstinence protocols across five studies, ranging from 13% to 59%, suggest a likely possibility that many regular social media users relapse when attempting to abstain from social media. There was some evidence that the likelihood of experiencing relapse was higher for individuals with frequent baseline use (Baumer et al., 2015) or problematic use (Turel et al., 2018). A significant pattern found across three studies was that relapse/reversion to social media appears to be motivated by the experience of negative affect during abstinence (Baumer et al., 2015; Maier et al., 2015; Sheldon et al., 2011). Notably, one study reported a finding resembling a 'rebound effect', whereby participants who experienced larger increases in disconnection during abstinence engaged in more usage post-abstinence, even when compared to their baseline usage (Sheldon et al., 2011).

Discussion

The aim of the present study was to systematically review the current state of knowledge regarding abstinence effects from potential behavioral addictions, and to interpret these findings in relation to addiction-related symptomatology, along with potential benefits and/or counterproductive consequences of abstinence. We reviewed a total of 47 prospective studies examining short-term abstinence effects from six different potential behavioral addictions (i.e., exercise, gaming, gambling, mobile phone use, pornography use and social media use). In general, there is a paucity of studies prospectively examining abstinence effects across these behaviors, with the exception of exercise, which has gradually built up a

relatively substantial body of research over the past 50 years. Therefore, any conclusions drawn from the findings of the present review are necessarily tentative. Overall, both negative and positive consequences to abstinence were found across the studies, depending on the specific behavior being examined. Evaluation of the findings in relation to addiction symptomatology, along with potential benefits and counterproductive consequences are discussed below.

Withdrawal and craving

Negative cognitive-affective or physical reactions to abstinence possibly indicative of withdrawal symptoms were found to varying extents across five of the behaviors (i.e., exercise, gambling, social media use, mobile phone use and gaming) in participant samples who were generally considered to be at least regularly engaged in these behaviors. These negative effects were typically observed irrespective of total duration and type of abstinence (naturally occurring vs. experimentally manipulated, and voluntary/involuntary separation vs. self-restraint). Across all behaviors, exercise demonstrated the clearest and most consistent pattern of withdrawal-like symptoms, mainly related to depression and mood disturbances. While there have been alternative theoretical explanations for these effects within mental health frameworks (Morgan et al., 2018; Weinstein et al., 2017), findings that these effects were more pronounced for exercise addicted participants suggest that if a withdrawal syndrome were to exist for exercise addiction, depression and mood disturbances would likely be a key symptom.

Firm conclusions cannot be drawn about withdrawal symptomatology for the remaining behaviors because there was a limited number of studies. Even across these few studies, evidence of clear and reliable patterns of withdrawal-related symptoms during abstinence was generally lacking. For instance, in terms of social media, withdrawal-like effects were found in some studies (Baumer et al., 2015; Sheldon et al., 2011; Stieger &

Lewetz, 2018; Turel & Cavagnaro, 2018) but not in others (Tromholt., 2016; Turel et al., 2018). For mobile phone use negative abstinence effects were mainly characterized by anxiety-related reactions which might resemble withdrawal symptoms (Cheever et al., 2014; Clayton et al., 2015; Sapacz et al., 2016; Skierkowski & Wood, 2012), but which had different plausible non-addiction theoretical explanations. For gaming, qualitative responses to abstinence were inconsistent with DSM-5 conceptualizations of withdrawal (King et al., 2016), emphasizing the importance of bottom-up approaches in the study of withdrawal symptomatology. In terms of trajectories, while exercise withdrawal symptoms did not abate and even increased over a 2-week period (Morris et al., 1990; Berlin et al., 2006), gaming and mobile phone withdrawal symptoms, rather than increasing, declined over the first few days (Kaptsis et al., 2016; Eide et al., 2018; Evans et al., 2018). These findings confirm that trajectories of withdrawal symptoms across different behaviors are not always homogenous. However, it is important to note that because withdrawal symptoms also decreased similarly for gaming and mobile phone use non-abstaining control groups (Eide et al., 2018; Evans et al., 2018), third-variable explanations for the decrease in symptoms (e.g., daily self-monitoring) need to be ruled out.

Notable overlaps in negative abstinence effects across the behaviors included boredom (social media use and gaming), anxiety (mobile phone use and exercise), and FoMO (mobile phone use and social media use). However, craving was, by a significant extent, the most common abstinence-induced addiction-related symptom across the studies – found to varying extents across gambling, gaming, mobile phone use, and social media use studies. Historically, there has been some debate within substance addiction research as to whether craving should constitute a withdrawal symptom or not. For example, the DSM-IV (American Psychiatric Association, 1994) removed craving as a nicotine withdrawal symptom partially because craving also manifests during non-abstinence situations

(Schmulewitz et al., 2013) with craving having later been added to the DSM-5 tobacco use disorder criteria as a separate criterion from withdrawal (American Psychiatric Association, 2013). However, smoking research demonstrates that craving tends to intensify during abstinence periods (Shiffman, West & Gilbert, 2004), suggesting that there is a difference between craving under non-abstinence conditions and abstinence conditions. Similarly, theoretical models of addiction have posited that there is a difference between 'cue-elicited craving', resulting from a conditioned response to cues, and 'withdrawal craving', resulting from an unconditioned response to abstinence (Drummond, 2000). This distinction suggests that while craving may be conceptualized separately from withdrawal, it also makes sense to conceptualize craving as a component of withdrawal. Given that craving is an often-reported withdrawal symptom across different substances including cannabis (Haney, 2005) and nicotine (Piper, 2015), it would be unsurprising if craving also emerged as a key withdrawal symptom across different behavioral addictions. Thus, it is important that behavioral addiction researchers account for craving in future abstinence studies.

It is noteworthy that withdrawal-like symptoms appeared to be present across four behaviors (i.e., exercise, social media, mobile phone use, and gaming) even for regular users who had no apparent indication of problematic use or addiction. Although these effects were found to be more pronounced for both exercise and gaming among addicted participants, the finding that habitual engagement in these behaviors has the ability to produce withdrawal-like symptoms is significant because it raises the possibility that some regular users may have developed enough of a dependency on the behavior such that negative affective states occur once the behavior has ceased. While these reactions may indeed be indicative of a masked underlying pathological dependency on the behavior (i.e., addiction), there is also the possibility that withdrawal-like symptoms may also result from a non-pathological dependency on the behavior. For instance, dependency on mobile phone use might be the

result of an increasing reliance on technology within society at large for day-to-day communication (Kuss, 2017). Or, negative emotional reactions might be expected to result from not being able to engage in a valued healthy activity (e.g., exercise; Szabo, 1995). It could also be that an over-reliance on a single behavior (e.g., gaming or social media use) to achieve a specific mood-modifying function (e.g., entertainment) could naturally result in boredom during abstinence (e.g., King et al., 2016; Stieger & Lewetz, 2018). In short, the presence of withdrawal-like symptoms during abstinence may indicate that there is some level of dependency on the behavior, but this does not automatically mean that the dependency is pathological or indicative of an underlying addiction. Ultimately, withdrawal symptoms alone are insufficient to determine the presence of addiction – it would be necessary to investigate whether other addiction symptoms (e.g., relapse and continued engagement in the behavior despite negative consequences) are present as well.

Relapse

In contrast to withdrawal and craving, relapse was not directly examined by the majority of the studies reviewed. Only two studies set out to directly investigate relapse in relation to pornography use (Fernandez et al., 2017) and social media use (Stieger & Lewetz, 2018). Most studies reported compliance and non-compliance rates with the abstinence protocols and rarely interpreted them in relation to potential relapses, except four studies (King et al., 2018; Skierkowski & Wood, 2012; Turel & Cavagnaro, 2018; Turel et al., 2018). Most studies were primarily concerned with achieving abstinence compliance to isolate the effects of abstinence in order to observe withdrawal symptomatology. Consequently, investigating lapses or relapses over an abstinence period has been relatively neglected within behavioral addiction research. Possible relationships between withdrawal symptoms and relapse were also rarely investigated, apart from a few social media studies (Baumer et al., 2015; Maier et al., 2015; Sheldon et al., 2011; Turel et al., 2018) and one gaming study (King

et al., 2018) that provided some indication that relapse/reversion behaviors may be motivated, to some extent, by the relief of negative affective states during abstinence.

In the present review, non-compliance rates with the abstinence protocol were evaluated as an indicator of potential relapses. Abstinence non-compliance was found to varying extents across exercise, gaming, social media, mobile phone use, and pornography studies. Rates as high as 59% non-compliance with a seven-day protocol were reported in a non-clinical sample of social media users (Stieger & Lewetz, 2018). There are of course many reasons for non-compliance – perhaps due to participants not committing fully to the abstinence protocol for various reasons, such as not being intrinsically motivated to abstain in the first place. However, for some participants, non-compliance with abstinence might be indicative of genuine relapses, suggesting the presence of compulsivity even among regular users who have no apparent problematic use. Interestingly, perfect compliance with an 84-hour self-restraint protocol was reported even among gamers with IGD symptoms (King et al., 2016), but up to 83% of participants with IGD symptoms in a separate sample were unable to maintain abstinence for a seven-day period (King et al., 2018). These disparate findings could be reasonably attributed to the duration of the abstinence period, where individuals with compulsive use might be able to maintain abstinence for a specific time period, but relapse only once a specific time threshold is passed.

Benefits and counterproductive consequences of abstinence

Another aim of the review was to assess the extent to which short-term abstinence may have utility as a potential intervention for problematic behaviors. While largely preliminary, findings of the present review suggest that short-term abstinence might have specific benefits for specific problematic behaviors (gaming, social media use, mobile phone use, and pornography use). As a general caveat, it is important to note that positive effects were only observed in studies where abstinence was voluntary in nature. It is possible that

any benefits of abstinence may to some extent be contingent on the individual feeling self-directed and in control over the abstinence experience.

Evidence of three different kinds of positive effects was found to varying extent depending on the behavior. First, there is some indication that abstinence might alleviate negative effects attributed to habitual engagement in the behavior for social media use (Tromholt et al., 2016; Turel et al., 2018), mobile phone use (Cutino & Nees, 2017), pornography use (Lambert et al., 2012; Negash et al., 2015), and exercise (Crossman et al., 1987). Second, abstaining from the behavior might facilitate self-awareness and insight into an individual's relationship with the behavior, including how the behavior may have been causing problems (pornography use – Fernandez et al., 2017; gaming – Evans et al., 2018; King et al., 2017). Third, abstaining from the behavior may lead to positive behavioral changes, both in terms of increased engagement in other activities during abstinence, and reductions in the behavior post-abstinence (gaming – Evans et al., 2018; King et al., 2016). Preliminary findings from a gaming study (i.e., King et al., 2017) in particular are encouraging because this study appears to be the first to formally propose short-term abstinence as a clinical intervention for gaming, demonstrating clinically significant improvements in IGD symptoms within an IGD sample. This finding suggests that short-term abstinence could be a potentially useful intervention for other problematic behaviors as well – a possibility which future research needs to validate.

Caution is nonetheless warranted with regards to potential benefits of an abstinence period. Thorough examination of adverse effects resulting from abstinence is necessary before any conclusions can be drawn about its utility as an intervention. Three kinds of potentially adverse effects should be highlighted for future research to explore further. First, research would need to account for potential 'rebound effects', which can be defined as an increase in post-abstinence engagement in the behavior compared to baseline (see e.g.,

Burish, Maisto, Cooper & Sobell, 1981, and Carey, Carey & Maisto, 1988, for investigations of rebound effects in relation to temporary abstinence from alcohol). A 'rebound effect' was found in one sample in relation to social media use for a specific subset of users (Sheldon et al., 2011) and warrants further examination in future research across different behaviors. Second, compensatory behaviors that are engaged in to deal with unpleasant feelings during an abstinence period (cf., Castro-Calvo et al., 2018) would also need to be accounted for by future research, in case there is potential switching to harmful alternative behaviors. Third, it is possible that abstinence may be beneficial only for specific problematic behaviors but may be counterproductive for others. Exercise is a good example to illustrate this point – positive effects were minimal and negative effects were substantial across the studies. Exercise has many health benefits that would be lost through abstinence, and it is plausible that any supposed benefit of abstinence gained might not outweigh the negative health impacts resulting from not exercising at all. It is also uncertain as to whether the act of abstaining in and of itself from specific behaviors (especially behaviors that are linked to innate biological drives, such as food and sex) might lead to the development of dysfunctional attitudes towards the behavior themselves (Coleman, 1990; Kingston & Firestone, 2008; Schulte et al., 2016). These concerns do not appear to have been empirically examined so far in the literature and research is needed to investigate their validity. Hence, generalizations about benefits across behaviors cannot be assumed.

Methodological considerations and recommendations for future research

Findings from the present review suggest that the effects of abstinence from different potential behavioral addictions remains largely underexplored when compared to substance abuse research. Future behavioral addiction research would especially benefit from adapting methodologies used successfully within substance addiction research. Given that nicotine/tobacco is likely the most extensively studied substance in relation to abstinence

effects with good methodological rigor (Ferguson & Shiffman, 2011; West & Gossop, 1994), key examples of smoking studies are provided as reference for this section.

Determining the presence and nature of withdrawal symptomatology in relation to different potential behavioral addictions would be a logical first step. Instead of using a primarily deductive approach where withdrawal symptoms are assumed to be homogenous across behaviors – open-ended questions would be useful for theory-building and mapping out idiosyncrasies of the abstinence experience across different behaviors. Specific quantitative measures of withdrawal would then need to be developed according to the specific behavior. Investigating the natural history and trajectory of withdrawal would be the next step (e.g., Shiffman et al., 2006).

Many of the studies included in the present review administered outcome measures at the end of an abstinence period, which is not optimal because self-reports would likely be substantially influenced by recall bias. Wherever possible, it is recommended that ecological momentary assessment (EMA; Shiffman, Stone & Hufford, 2008) or at least daily diaries be used to ensure accuracy of self-reports across the abstinence period. EMA is increasingly being used in substance abuse research, with its fine temporal resolution rendering it particularly useful for investigating withdrawal symptoms, craving, and lapses and the inter-relationships between these (Ferguson & Shiffman, 2011). EMA is especially useful for observing temporal sequences, such as the antecedents of a lapse (e.g., how negative affect may be intensified in hours leading up to a lapse; Shiffman & Waters, 2004). This has the potential to answer research questions about whether withdrawal symptoms are predictive of lapses, and if so, which components of withdrawal (e.g., Piper et al., 2011), whether lapses in turn increase withdrawal-related symptoms (e.g., Robinson et al., 2019), and how lapses might lead to relapses (e.g., Kirchner, Shiffman,& Wileyto, 2012). Any potentially useful or counterproductive benefits may profit from open-ended exploration by asking participants

about their perceptions of positive and negative aspects of the abstinence period (e.g., Evans et al., 2018; King et al., 2016). Any compensatory behaviors engaged in during abstinence would also need to be accounted for, and a post-abstinence period may be important for observing any potential behavioral rebound effects.

In terms of participant samples, comparisons between regular non-problematic users, and problematic users may be of interest in determining whether withdrawal symptoms, craving, and/or relapse are also present in regular users. Accounting for intrinsic motivation in participants is also important because research has shown that there are important psychological differences between experimenter-induced abstinence and genuine quit attempts (Hughes, 2007c). However, as Kaptsis et al. (2016) have acknowledged, using clinical samples without first adequately understanding possible adverse effects in non-clinical populations is premature and should be avoided. Nonetheless, the goal over time would be to adopt these protocols for clinical samples, as these would likely demonstrate the strongest addiction symptomatology, and would have the most to gain from such an intervention.

Abstinence duration employed would likely depend on the regularity of the behavior. For example, mobile phone use may require shorter abstinence periods when compared to exercise because 'regular' mobile phone use would generally be engaged in with greater frequency (e.g., in total a few hours daily) compared to 'regular' exercise (e.g., five times a week). Ultimately, optimal duration would also depend on allowing abstinence to be of sufficient length to allow for emergence of addiction-related symptomatology, but not too long that participant recruitment and/or attrition might become a problem (Szabo, 1998). It might also be worth experimenting with different variations of abstinence manipulations – for example, abstinence at a stretch over a specific period of time (e.g., one week) versus intermittent abstinence (e.g., every alternate day over a two-week period). Partial abstinence

from specific behaviors could also be explored in order to compare whether it might have similar or differing effects to complete abstinence (e.g., instead of complete abstinence, abstaining only from a specific game, specific SNS, or a specific form of gambling).

Limitations

Limitations of the present review need to be highlighted. In order to limit the search results to a manageable number, the initial search term used to identify studies related to abstinence was "abstinen*" and did not include terminology that has been used interchangeably within the literature to describe a state of non-engagement in the behavior, e.g., 'restriction' or 'deprivation'. Studies that did use alternative terms were identified primarily through reference lists of included papers and systematic reviews, and as a result, some studies might have been missed (e.g., in terms of food/eating, studies might use the term 'food deprivation' or 'fasting' instead of 'abstinence'). However, from a practical standpoint it was not feasible to account for all variations of synonymous terms. Thus, the search strategy used is a limitation. Our inclusion of only prospective studies (and the exclusion of retrospective or cross-sectional studies) might result in an incomplete picture of addiction symptomatology (as reported in the literature across these different kinds of studies) for the different behaviors. However, the present review was not meant to be an exhaustive review of withdrawal symptoms, craving, and relapse – but to evaluate these symptoms only as they present themselves prospectively over short-term abstinence periods.

Conclusion

Generally, findings of the present review demonstrated that there is a paucity of prospective studies investigating abstinence effects in relation to different potential behavioral addictions, except for exercise. Findings suggest that withdrawal-related symptomatology can be observed for exercise more reliably than the other behaviors. Craving appears to be a key abstinence-induced symptom that needs to be explored in greater depth

within future abstinence studies. Importantly, the examination of relapse under abstinence conditions has generally been underexplored within behavioral addiction research. Finally, some preliminary evidence suggests that short-term abstinence may have benefits and could be useful as a clinical intervention for specific problematic behaviors. However, more empirical research is needed to more clearly understand positive effects and potential mechanisms of change, along with potential counterproductive or adverse consequences before its utility as a clinical intervention can be adequately determined.

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Appendix A

Summary of study characteristics

Study	Participants	Procedure	Design/ type	Key outcome measures	Relevant findings	Theoretical interpretation of effects	Addiction framework considered?	Withdrawal/ craving assessed?	Relapse assessed?
Exercise (n = 22)									
Baekel and (1970)	14 college students; exercised ≥ 3 times/week	All participants instructed to abstain from exercising for one month	EXP; SR	Exercise Deprivation Questionnaire	Deprivation resulted in increased sexual tension, anxiety, needs to be with others; decreased appetite and quality of sleep	Non-addiction-related psychological effects	No	IND	NA
Thaxton (1982)	33 'habitual' runners (24 M, 9 F, M_{age} = 36.0); ran ≥ 5 times/week for past 1 year	Random assignment to deprived group (instructed to abstain from running for 24 hours) or non-deprived group (ran for 30 minutes)	EXP; SR	POMS (McNair, Lorr & Droppleman, 1971), galvanic skin response (GSR; as measure of tension)	Non-pre-tested deprived group had higher depression and GSR scores than non-pre-tested non-deprived group. No significant differences for anxiety, vigor and fatigue scores	Addiction-related withdrawal	Yes	DIR	NA
Crossman et al. (1987) Study 1	31 runners (15 M and 16F, M_{age} = 17.0); ran M = 42 miles/week	All participants tested 26-30 hours after last exercise	N; SR	STAI (Spielberger, Gorsuch & Lushene, 1970), 13-item mood scale (Polivy, 1981)	No overall deprivation main effects. Deprivation effects varied as a function of gender and level of competition – males and athletes competing at higher levels had more negative moods than females and athletes competing at lower levels during layoff, who had more positive moods.	Addiction-related withdrawal Possible relief from fatigue	Yes	DIR	NA
Crossman et al. (1987) Study 2	20 swimmers (8 M, 12 F, M_{age} = 14.3), swam M = 8 km/day	All participants instructed to abstain from exercise for 5 days	EXP; SR	STAI (Spielberger et al., 1970), 14-item mood scale (Polivy, 1981)	No overall deprivation main effects. Deprivation effects varied as a function of gender and level of competition – males and athletes competing at higher levels had	Addiction-related withdrawal Possible relief from fatigue	Yes	DIR	NA

					more negative moods than females and athletes competing at lower levels during layoff, who had more positive moods				
Morris et al. (1990)	40 male runners (M_{age} = 37.0); ran ≥ 3 times/week for 10 miles for past 3 months	Random assignment to deprived group (instructed to abstain from running for 2 weeks) or control group. Preceded by 2-week baseline and post-abstinence exercise as usual	EXP; SR	GHQ-28 (Goldberg & Hillier, 1979), Zung Anxiety and Depression Scales (Zung, 1974), daily exercise diary	Somatic symptoms, anxiety, insomnia and feelings of being under strain were greater in the deprived group than in the control group after both the first and second weeks of deprivation. Symptoms of depression and anxiety were greater in the deprived group at the end of the second week Perfect abstinence compliance reported	Addiction-related withdrawal, or beneficial effects of exercise lost due to abstinence	Yes	DIR	IND
Gauvin & Szabo (1992)	21 college students (14 M, 7 F, M_{age} = 23.6, *SD* = 5.40); exercised ≥3 times/week in past 4 months	Random assignment to experimental condition (instructed to abstain from exercise for 7 days) or control condition (exercise as usual)	EXP; SR	Well-Being Questionnaire	Participants in exercise deprivation group reported more physical symptoms than at baseline and compared to the control group during and following deprivation. No differences were found on psychological well-being.	Cannot conclude abstinence effects due to addiction-related withdrawal because no indication of exercise addiction in participants	Yes	DIR	NA
Szabo & Gauvin (1992)	24 university students (16 M, 8 F, M_{age} = 23.5, *SD* 1.05); exercised *M* =8.25 hours/week over 5-6 months	Random assignment to experimental condition (instructed to abstain from exercise for 7 days) or control condition (exercise as usual)	EXP; SR	Heart rate, mental arithmetic test as stress task	Exercise deprivation did not have an effect on stress response	No support for exercise-stress response link	No	IND	NA
Conboy (1994)	61 runners (51 M, 10 F, M_{age} = 34.6, *SD* = 10.02)	All participants completed 10 'run days' and 2-5 'no-run days' (instructed not to change their	N; SR	POMS (McNair et al., 1971), Commitment to Running scale (Carmack & Martens, 1979)	Participants reported more dysphoria (i.e., increase in tension, depression, anger, fatigue, confusion and total mood disturbance, and decrease in vigor)	Addiction-related withdrawal Emotional strength – exercise as 'positive addiction'	Yes	DIR	NA

		schedule in any way)			on 'no run' compared to 'run' days. Commitment or dependence, on their own, did not predict dysphoria. High commitment-high dependence runners least prone to dysphoria, low-commitment-high dependence runners most prone to dysphoria			
Mondin et al. (1996)	10 'habitual' runners (6 M, 4 F, M_{age} = 37.0, *SD* = 4.5); exercised 6-7 days/week	All participants instructed to abstain from exercise for 3 days. Preceded by 1-day baseline and 1-day post-abstinence exercise as usual	EXP; SR	POMS (McNair et al., 1971), STAI (Spielberger et al., 1970), Depression Adjective Checklist (Lubin, Hornstra & Dean, 1978), 24-h history questionnaire (sleep, physical health, exercise, well-being,	Exercise deprivation resulted in increased total mood disturbance, state anxiety, tension, depression and confusion, and decreased vigor. By Day 3, anxiety, tension, depression and total mood disturbance decreased	Non-addiction related 'withdrawal' Decrease in symptoms by third day possibly due to anticipation of exercise	Yes	IND	NA
Szabo and Parkin (2001)	20 martial artists (10 M, 10 F, M_{age} = 28.4, *SD* = 6.6); trained *M* = 3.6 times/ week	All participants underwent 14-day baseline period, 4-day pre-deprivation, 7-day deprivation (instructed to abstain from exercise), 3-day post-deprivation period	EXP; SR	Well-Being Questionnaire (Gauvin & Szabo, 1992), abbreviated version of POMS (Grove & Prapavessis, 1992)	During deprivation, increases observed in anger, depression, negative affect, tension, and total mood disturbance, and decreases observed in positive affect and vigor Perfect abstinence compliance reported	Non-addiction related 'withdrawal'	No	IND	IND
Aidman & Woollard (2003)	60 runners, (30 M, 30 F, M_{age} = 24.2); trained ≥ 5 times weekly	Random assignment to exercise-deprived group (instructed to abstain from exercise for one day) or control group (exercise as usual)	EXP; SR	POMS (McNair et al., 1971), resting heart rate (as measure of anxiety)	Exercise-deprived group reported increased depression, anger, fatigue, confusion and resting heart rate, and reduced vigor within 24 hours of missing training session.	Addiction-related withdrawal	Yes	DIR	NA

Glass et al. (2004)	18 healthy adults (11 F, 7 M, M_{age} = 25.2, *SD* = 3.25); exercised at least 4 hours/week	All participants asked to abstain from exercise for 7 days	EXP; SR	Short form of McGill Pain Questionnaire (Melzack, 1987), MFI (Smets, Garssen, Bonke & De Haes, 1995), Beck Depression Inventory (Beck, Ward, Mendelson, Mock & Erbaugh, 1961), STAI (Spielberger et al., 1970)	8 participants developed somatic symptoms after 1 week of abstinence, including fatigue, pain and mood disturbances	Hypoactive function of biological stress response system	No	IND	NA
Berlin et al. (2006)	40 regular exercisers (25 F, 15 M, M_{age} = 31.3, *SD* = 7.5); exercised ≥ 3 times /week	Random assignment to exercise deprivation group (instructed to abstain for 2 weeks) or control group (exercise as usual)	EXP; SR	POMS, Beck Depression Inventory-II (Beck, Steer & Brown, 1996), MFI (Smets et al., 1995)	Deprivation group experienced increased fatigue, depression and negative mood states	Negative mental health effects Fatigue – decreased fitness levels	No	IND	NA
Weinstein et al. (2007)	40 regular exercisers (25 F, 15 M; M_{age} = 31.3, *SD* = 7.5); exercised ≥ 3 times /week in past 6 months	Random assignment to exercise deprivation group (instructed to abstain from exercise for 2 weeks) or control group (exercise as usual)	EXP; SR	POMS, Beck Depression Inventory-II (Beck et al., 1996), MFI (Smets et al., 1995)	Deprivation resulted in higher negative mood scores compared to control	Reduced baseline parasympathetic activity	No	IND	NA
Hausenblas et al. (2008)	40 regular exercisers (14 M, 26 F, M_{age} = 20.5, *SD* = 2.5)	All participants underwent 3 days of regular exercise routine, followed by 3 days of exercise deprivation	EXP; SR	Exercised-induced feeling inventory (EFI; Gauvin & Rejeski, 1993)	Positive engagement and revitalization greater on 'true' abstinence days as opposed to non-abstinence days. Lower exercise dependence participants had greater positive engagement, revitalization and tranquility.	Non-addiction-related withdrawal Possible relief from obligation	Yes	IND	IND

					7.5% of participants did not comply with abstinence protocol				
Kop et al. (2008)	40 regular exercisers (25 F, 15 M, M_{age} = 31.3); ≥3 times /week in past 6 months	Random assignment to exercise deprivation (instructed to abstain from exercise for 2 weeks) or control group (continued exercise)	EXP; SR	POMS (McNair et al., 1971), Beck Depression Inventory-II (Beck et al., 1996), MFI (Smets et al., 1995), heart-rate variability-based indices as a measure of autonomic nervous system activity	Deprivation group had increased negative mood symptoms and fatigue compared to control group	Responses not associated with changes in inflammatory markers	No	IND	NA
Niven et al. (2008)	58 female regular exercisers (M_{age} = 26.1, *SD* = 8.2)	Random assignment to abstinence (instructed to abstain for 3 days) or control group (exercise as usual)	EXP; SR	UWIST-Mood Adjective Checklist (Matthews, Jones & Chamberlain, 1990), Body Dissatisfaction Scale from the Eating Disorder Inventory (Garner, Olmsted & Polivy, 1983)	Abstinence group had decrease in hedonic tone and energetic arousal and increase in tense arousal (affect disturbances) and increased body dissatisfaction compared to control group Perfect abstinence compliance reported	Negative mental health effects	No	IND	IND
Poole et al. (2011)	26 regular exercisers (13 M, 13 F, M_{age} = 25.5, *SD* = 4.5); ≥3 times /week in past 6 months	Random assignment to deprivation group (instructed to abstain from exercise for 2 weeks) or control group (continued exercise)	EXP; SR	POMS (McNair et al., 1971), GHQ-28 (Goldberg & Hillier, 1979), inflammatory markers from plasma, heart rate variability	Deprivation group had significant increases in negative mood	Mood increases related to decreases in IL-6 (cytokine) concentration	No	IND	NA
Zeller et al. (2011)	26 regular exercisers (18 M, 8 F, M_{age} = 41.7, *SD* = 11.1); exercised ≥ 4 times/week	All participants instructed to abstain from exercise for 7 days	EXP; SR	Medical Outcomes Study Short Form-36 physical and health scales (Ware, Kosinski & Keller, 1994), rheumatological (non-articular	Significant decrease in quality of life, and increase in non-articular tenderness observed following exercise deprivation	Hypoactive function of biological stress response system	No	IND	NA

				tenderness) measurement					
Ablin et al. (2013)	94 regular exercisers (48 M, 44 F, M_{age} = 27.2, SD = 5.6); ran ≥ 5 times/week	Random assignment to one of four groups (1) exercise restriction (2) sleep restriction (6 hours nightly); (3) both; (4) neither (control). Restriction period 10 days.	EXP; SR	Short form of McGill Pain Questionnaire (Melzack, 1987), MFI (Smets et al., 1995), Center for Epidemiological Studies Depression Scale (CES-D; Radloff, 1977), Perceived Stress Scale (Cohen & Williamson, 1988), STAI (Spielberger et al., 1970), POMS (McNair et al., 1971), Multiple Ability Self-Report Questionnaire (Seidenberg, Haltiner, Taylor, Hermann & Wyler, 1994), Modified Somatic Symptoms Perceptions Questionnaire (Main, 1983), Psychomotor Vigilance Task (Dinges & Powell, 1985)	Exercise deprivation resulted in increased fatigue, but no changes in mood.	Negative health effect	No	IND	NA
Antunes et al. (2016)	18 male regular runners (age range = 18 – 40); exercised ≥ 5 times/week	All participants instructed to abstain from exercise for 7 – 14 days	EXP; SR	Brunel Mood Scale (BRUMS; Rohlfs et al., 2008), physical and biochemical measures	Exercise addiction group, compared to control group, showed increase in depression, confusion, anger, fatigue and decreased vigor that improved post-exercise	Addiction-related withdrawal Exercise addiction – possible dysfunctional endocannabinoid system	Yes	DIR	NA
Krivoschekov & Lushni	50 professional male athletes (M_{age} = 23.2, SD = 1.5)	Athletes tested under two conditions: (1) during active training sessions; (2) during	EXP; SR	Hospital Anxiety and Depression Scale (Zigmond & Snaith, 1983);	Athletes with exercise addiction, compared to athletes without exercise addiction are characterized by lower brain bioelectric activity,	Addiction-related withdrawal	Yes	DIR	NA

kov (2017)		exercise deprivation (7 days)		psychophysiological measures	growth in the muscular tension, increased sympathetic activity, and elevated levels of anxiety and depression.				
Gambling (n = 2)									
Tavares et al. (2005)	150 treatment-seeking patients (62 M, 88F); 49 pathological gamblers (PG; M_{age} = 45.4, *SD* = 11.3), 101 alcohol-dependent subjects (ADS; M_{age} = 40.7, *SD* = 11.4)	Participants monitored by phone to ensure between 5 – 21 days of abstinence achieved from any mood-altering substance and from gambling	N; SR	Weiss Craving Scale (Weiss, Griffin & Hufford, 1995), PACS (Flannery, Volpicelli & Pettinati, 1999), Beck Anxiety Inventory (Beck, Epstein, Brown & Steer, 1988), Beck Depression Inventory (Beck et al., 1961)	PGs had higher craving scores compared to ADS. Alcohol craving correlated with both depression and anxiety, but gambling craving correlated only with depression.	Addiction-related craving	Yes	DIR	NA
de Castro et al. (2007)	92 treatment-seeking patients (46 M, 46F); 50 pathological gamblers (PG; M_{age} = 45.0, *SD* = 9.9) and 42 alcohol-dependent subjects (ADS; M_{age} = 43.0, *SD* = 10.6)	Participants monitored by phone to ensure between 5 – 21 days of abstinence achieved from any mood-altering substance and from gambling	N; SR	Weiss Craving Scale (Weiss et al., 1995), PACS (Flannery et al., 1999), Positive and Negative Affect Scale Extended Form (PANAS X; Watson & Clark, 1994), Self-Report Social Adjustment Scale-Revised (SAS-R; Gorenstein et al., 2002)	PGs had higher craving scores compared to ADS. Gambling craving more dependent on external factors and related to an unpleasant dearousing state, while alcohol craving associated with internal cues and unpleasant arousing state	Addiction-related craving	Yes	DIR	NA
Gaming (n = 7)									
King et al. (2016)	24 regular gamers (20 M, 4 F, M_{age} = 24.6, *SD* = 5.8); 9 met criteria for Internet Gaming Disorder (IGD)	All participants instructed to abstain from gaming for 84 hours	EXP; SR	Qualitative survey consisting of 13 open-ended questions	Reactions to abstinence characterized by boredom and drive for mental stimulation; DSM-5 IGD withdrawal symptoms (i.e., sadness, anxiety, irritability) very rarely observed	Addiction-related withdrawal Abstinence useful intervention	Yes	DIR	IND

					Perceived positive effects included free time used for other activities, increase in insight into harms of gaming, positive modifications to gaming activity post-abstinence Participants reported total compliance with abstinence protocol				
Kaptsis et al. (2016)	24 regular gamers (20 M, 4 F, M_{age} = 24.6, *SD* = 5.8); 9 met criteria for IGD	All participants instructed to abstain from gaming for 84 hours	EXP; SR	Internet Gaming Withdrawal Scale (IGWS) – modified version of PACS (Flannery et al., 1999), Depression, Anxiety and Stress Scales (DASS-21; Lovibond & Lovibond, 1995), PANAS (Watson et al. 1988)	Although IGD group had generally higher withdrawal scores than non-IGD group, withdrawal symptoms, affect, and psychological distress declined over time in both groups. Implications that 'withdrawal'-related symptomatology is stronger when gaming compared to when not gaming. Participants reported total compliance with abstinence protocol	Addiction-related withdrawal	Yes	DIR	IND
King et al. (2017)	24 regular gamers (20 M, 4 F, M_{age} = 24.6, *SD* = 5.8); 9 met criteria for IGD	All participants instructed to abstain from gaming for 84 hours	EXP; SR	Internet gaming activity (hours), Internet Gaming Cognition Scale (IGCS), IGD criteria checklist	Clinically significant improvement in IGD symptoms in 75% of IGD group at 28-day follow-up. 63% of IGD group showed reliable change in maladaptive gaming cognitions, and 38% of IGD group achieved reliable reduction of time spent gaming. Non-IGD group experienced reliable improvements in IGD symptoms for 38% of participants Participants reported total compliance with abstinence	Abstinence useful intervention Potential role of self-monitoring in producing benefits	Yes	NA	IND

					protocol				
King et al. (2018)	186 help-seeking problematic gamers (177 M, 9 F, M_{age} = 23.4, *SD* = 5.2); all met five or more criteria for IGD	All participants reported willingness to attempt to abstain from games for 7 days	N; SR	Internet gaming activity, IGD criteria checklist, Internet Gaming Withdrawal Scale (IGWS) – modified version of PACS (Flannery et al., 1999), Depression, Anxiety and Stress Scales (DASS-21; Lovibond & Lovibond, 1995), gaming activity during abstinence period	83% of participants reported abstinence non-adherence or study dropout ('non-abstainers') Non-abstainers reported greater tendency to play action shooting games and to endorse IGD withdrawal criterion at baseline Number of days abstinent during abstinence not related to age, amount of gaming, IGD symptoms, craving, and mood symptoms	Abstinence non-adherence possibly related to addiction-related withdrawal, structural characteristics of games	Yes	DIR	DIR
Evans et al. (2018)	37 habitual (daily) adolescent gamers referred by concerned parents (34 M, 3 F, M_{age} = 14.8, *SD* = 1.6); 3 met criteria for IGD, 9 'at-risk'	Random assignment to abstinence condition (instructed to abstain from gaming for 84 hours) or control condition (instructed to play games as usual)	EXP; SR	Internet Gaming Withdrawal Scale (IGWS) – modified version of PACS (Flannery et al., 1999), Depression, Anxiety and Stress Scales (DASS-21; Lovibond & Lovibond, 1995), PANAS (Watson et al., 1988), 8-open ended feedback questions	Both groups greater withdrawal symptom scores at baseline than at any other point and significant reduction in withdrawal symptoms post-baseline maintained at 7-day follow up. Craving may be driven more by factors other than mere actual time spent playing Perceived effects of abstinence boredom, increase in other valued activities, attitude shifts towards gaming, and decrease in gaming post-abstinence	Addiction-related withdrawal Abstinence useful intervention Potential role of self-monitoring in producing effects	Yes	DIR	IND
Dong et al. (2019a)	103 regular game users (RGU). 23 met criteria for IGD after 1 year (RGU_IGD; M_{age} = 22.34, *SD* = 2.1);	All participants experienced sudden deprivation from gaming immediately after 20 minutes of uninterrupted play	EXP; IVSP	Game craving questionnaire (modified from brief version of Questionnaire of Smoking Urges; Cox, Tiffany & Christen,	RGU_IGD subjects, compared with RGU_RGU subjects, showed relatively increased bilateral lentiform nucleus activations following gaming during deprivation versus prior to gaming. Lentiform activation during	Addiction-related craving-related processes	Yes	DIR	NA

	compared to 23 who did not (RGU_RGU; M_{age} = 22.87, SD = 2.2)			2001), cue-elicited craving task, fMRI scan	deprivation was associated with cue-induced craving in RGU_IGD group and the development of IGD one year later.				
Dong et al. (2019b)	119 university students (63 M, 56 F, $M_{age} \approx 21.0$); 65 recreational game users (RGU); 54 with IGD	All participants instructed to play game lasting 20 minutes, and experienced both 4-minute conditions: (1) Gaming condition - once 'enemy encountered'; (2) mandatory break condition – internet connection interrupted	EXP; IVSP	Game craving questionnaire (modified from brief version of Questionnaire of Smoking Urges; Cox et al., 2001), fMRI scan	Males and females with IGD differ in terms of craving related functional connectivity, with the gaming condition possibly more relevant for males and the mandatory break condition more relevant for females in distinguishing IGD from RGU.	Addiction-related craving-related processes	Yes	DIR	NA
Mobile phone use (n = 6)									
Skierkowski & Wood (2012)	23 university students (13 F, 10 M, age 18-23 years)	Participants identified as high or low users (based on a median split of baseline texting averages) randomly assigned to a 3- or 5-day period of restricted texting (instructed to abstain from text messaging during restriction period)	EXP; SR	Mixed-method survey consisting of questions related to frequencies and patterns of alternative behaviors, non-compliance and anxiety	High text users had more thoughts about texting compared to low text users. No difference in anxiety between high and low text users. Most qualitative responses to restriction period included terms related to 'anxiety', although no difference between high text users and low text users on anxiety. No difference in anxiety between 3 and 5 day conditions. No difference in compliance between high text and low text users – possible dishonest reporting due to fear of not receiving full participation	Non-pathological reliance on technology for communication	Yes	IND	IND

					credit				
Cheever et al. (2014)	163 university students (83 M, 80 F, M_{age} = 24.4, *SD* = 6.1)	Random assignment to either have mobile phone removed from possession, or allowed to keep phone but silence it and keep it out of sight (both conditions for 60 minutes)	EXP; SR/VSP	STAI (Spielberger et al., 1970)	Participants reported more anxiety over time, regardless of condition. Heavy daily users reported more anxiety over time, while moderate daily users reported more anxiety over time only when their device was removed. Low daily users reported no change in anxiety over time.	Separation anxiety or fear of missing out (FoMO; Przybylski et al., 2013)	Yes	IND	NA
Clayton et al. (2015)	41 university students (30 F, 11 M, M_{age} = 21.2, *SD* = 3.78)	All participants underwent both experimental conditions (but randomly assigned to different orders): (1) word search puzzle with iPhone in possession, (2) word search puzzle without iPhone while it was ringing (both conditions 5 minutes)	EXP; IVSP	Objects Incorporated into the "Extended Self" scale (Sivadas & Machleit, 1994), six item short form of STAI (Marteau & Bekker, 1992), blood pressure as measure of anxiety, heart rate as measure of defensive responding to iPhone ringing, aversive and appetitive activation items, word search puzzle task	When participants were not allowed to answer their ringing iPhones during word search puzzle, heart rate and blood pressure increased, self-reported feelings of anxiety and unpleasantness increased, and self-reported extended self and performance on cognitive task decreased.	iPhone as 'extension of self', based on 'extended-self' theory (Belk, 2013)	No	IND	NA
Sapacz et al. (2016)	152 university students (35 M, 117 F, 85% of participants age range 18 – 24)	Random assignment to one of four conditions (all 3 – 5 minutes): (1) Phones taken away from participants out of the room; (2) Asked to place their phones on their tables but not	EXP; SR/VSP	STAI (Spielberger et al., 1970)	State anxiety only increased when participants had their phones in front of them but were instructed not to use them. High levels of baseline mobile phone use did not predict increased anxiety within experimental conditions	Cannot conclude increased anxiety due to addiction-related withdrawal Possible 'attachment' to phone	Yes	DIR	NA

		use them; (3) Asked to put their phones either in their pockets or backpacks and not use them; (4) Not given any instructions about cell phone use							
Cutino & Nees (2017)	87 university students (61 F, 26 M, M_{age} = 19.48, *SD* = 1.17)	Random assignment to restricted mobile access (asked to turn phone in) or control condition, during 60-minute study session	EXP; VSP	STAI (Spielberger et al., 1970), attainment of study goals, problematic mobile phone use (PMPU)	Anxiety did not differ between participants in restricted vs. control condition Participants with higher PMPU in the abstinence condition did not show greater increases in anxiety over the study session compared to all other participants Participants in restricted condition self-reported attainment of 12% more of their study goals compared to control condition	No evidence of addiction-related withdrawal Alleviation of negative effects attributed to mobile phone use	Yes	DIR	NA
Eide et al. (2018)	127 university students (92 F, 35 M, M_{age} = 25.0, *SD* = 4.5)	Randomly assigned to 72-hour restriction condition (handed in smartphone to be kept in a secure locked cabinet) or control condition.	EXP; VSP	Smartphone Withdrawal Scale (modified version of Cigarette Withdrawal Scale; CWS; Etter, 2005), Fear of Missing Out Scale (FoMOS; Przybylski, Murayama, DeHaan & Gladwell, 2013), PANAS (Watson et al., 1988), open-ended qualitative question about challenges of	Restriction group experienced greater withdrawal symptoms and FoMO compared to control group. Withdrawal symptoms, FoMO and positive affect reduced significantly over time, regardless of condition. Restriction not related to positive or negative affect	Addiction-related withdrawal	Yes	DIR	NA

		restriction							
Pornography use (n = 3)									
Lambert et al. (2012) (Study 3)	20 university students (10 M, 10 F, age range 18 – 24); used pornography >1/month	Random assignment to either abstinence condition (instructed to abstain from pornography for 3 weeks) or control condition (instructed to abstain from favorite food)	EXP; SR	Measure of relationship commitment, frequency of pornography use	Abstinence from pornography group reported a higher percentage chance of being with their partners in the future compared to control condition Frequency of use during abstinence M = 1.42, SD = .67	Alleviation of negative effects attributed to pornography use	Yes	NA	IND
Negash et al. (2015) (Study 2)	37 university students (24 M, 13 F, age range 18 – 28); used pornography > 1/month	Random assignment to either abstinence condition (instructed to abstain from pornography for 3 weeks) or control condition (instructed to abstain from favorite food)	EXP; SR	Delay discounting task, frequency of pornography use	Pornography abstinence group chose larger, later rewards more frequently compared to favorite food abstinence group Frequency of use during abstinence *M* = 1.53, *SD* = .83	Alleviation of negative affects attributed to pornography use	Yes	NA	IND
Fernandez et al. (2017)	76 male pornography users (M_{age} = 22.7, *SD* =3.45); used pornography *M* = 4.84 times in past 2 weeks	All participants instructed to abstain from pornography for 14 days	EXP; SR	Frequency of pornography use and abstinence effort items, Cyber Pornography Use Inventory-9 (CPUI-9; Grubbs, Volk, Exline & Pargament, 2015)	Abstinence effort predicted greater perceived compulsivity, possible mediating role of craving (not explicitly assessed). May reflect insight into actual compulsivity in own behavior. Failed abstinence attempts when abstinence effort was high (i.e., relapse) predicted perceived compulsivity scores Frequency of use during abstinence	Addiction-related relapse and potentially craving. Abstinence useful behavioral experiment.	Yes	IND	DIR

					M = 2.50, SD = 2.92				
Social media use (n = 7)									
Sheldon et al. (2011)	98 university students (36 M, 33 F)	All participants experienced both conditions: (1) instructed not to use Facebook for 48 hours; (2) free to use Facebook for 48 hours	EXP; SR	Six-item relatedness need-satisfaction measure (Sheldon & Gunz, 2009), frequency of Facebook use	Sense of connection declined during abstinence Participants with larger increases in disconnection during deprivation period engaged in more usage during the free-choice period, even compared to baseline 23% of participants logged into Facebook during deprivation period	Use motivated by negative affect	Yes	IND	IND
Baumer et al. (2015)	3539 participants (1670 F, 1608 M)	Voluntary participation in "99 Days of Freedom" pledge to abstain from Facebook for 99 days	N; SR	Mixed-methods survey consisting of questions relating to feelings, friends' reactions, best and worst things that happened, average mood, adjectives to describe experience, reversion to Facebook, changes in social relationships	'Addiction-associated feelings' (e.g., withdrawal, craving, limited self-control) predicted likelihood of reversion to Facebook Positive moods while off Facebook decreased likelihood of reversion to Facebook, while negative moods while off Facebook increased likelihood of reversion to Facebook	Addiction-related withdrawal Use motivated by negative affect	Yes	DIR	IND
Maier et al. (2015)	82 university students (40 F, 42 M, M_{age} = 27.7); used Facebook *M* = 70.3 minutes/day	All participants instructed not to use Facebook for 14 days, but were free to use alternative social networking sites	EXP; VSP	Measures of SNS-stress creators, SNS-exhaustion, switching-stress creators, switching-exhaustion, discontinuous usage	Stress associated with switching away from Facebook during abstinence period reduced intentions to discontinue use of Facebook	Use motivated by negative affect	No	IND	IND

				intention and behavior					
Tromholt (2016)	1095 Facebook users (942 F, 153 M, M_{age} = 34.0, *SD* = 8.74); spent approximately 1 hour on Facebook daily	Random assignment to treatment group (instructed to abstain from Facebook for 7 days) or control group (Facebook as usual)	EXP; SR	Life satisfaction item, five items from Center for Epidemiologic Studies Depression (CES-D) Scale (Radloff, 1977), four items from PANAS (Watson, Clark & Tellegen, 1988)	Abstinence group reported greater life satisfaction and greater affective well-being compared to control group. Effects greater for heavy Facebook users, passive Facebook users and users who tend to envy others on Facebook 13% of participants reported non-compliance	Alleviation of negative effects attributed to social media use	No	IND	IND
Stieger & Lewetz (2018)	152 participants (107 F, 45 M, M_{age} = 27.4, *SD* = 11.9); average daily social media use *M* = 65 minutes	All participants instructed to abstain from social media for 7 days (only phone calls, SMS or email allowed), preceded by 4-day baseline (social media use as usual), and followed by 4-day post-intervention (social media use as usual)	EXP; SR	Positive and Negative Affect Schedule-Short Form (I-PANAS-SF; Thompson, 2007), single items – craving, boredom, frequency and duration of social media use, feeling of social pressure to be on social media	During abstinence period, boredom and craving (conceptualized as withdrawal symptoms) and social pressure to use social media increased. No increase in effects in post-intervention phase compared to baseline. No significant effect of abstinence on affect. 59% of participants used social media at least once during deprivation period (conceptualized as relapse)	Addiction-related withdrawal FoMO possible explanation for social pressure to use social media	Yes	DIR	DIR
Turel et al. (2018)	555 university students (238 F, 317 M, M_{age} = 24.01); used Facebook as their primary social networking site	Random assignment to treatment group (instructed to abstain for Facebook for 7 days) or control group	EXP; SR	Short version of Perceived Stress Scale (PSS; Cohen, Kamarck & Mermelstein, 1983), self-report item of number of days successfully abstained, Bergen Facebook Addiction Scale (BFAS; Andreassen, Torsheim, Brunborg &	Reduction in perceived stress following social media abstinence; effect more pronounced for excessive users 38.2% did not manage successful complete abstinence for whole 7 days. People with excessive use and higher stress during abstinence were less successful at maintaining abstinence	Alleviation of negative effects attributed to social media use Use motivated by negative affect	Yes	IND	IND

				Pallesen, 2012)					
Turel & Cavagnaro (2018)	415 university students (229 M, 186 F, age 19 - 49); use Facebook as primary social networking site	Random assignment to treatment group (instructed to abstain from Facebook for 7 days) or control group	EXP; SR	Time distortion (ratio of estimated time over actual time), change in time distortion (ratio of time distortion at t2 over time distortion at t1), Facebook use	Significant increase in time distortion observed for treatment group – both normal and "at-risk for addiction" users developed upward time distortion after abstinence. Post-abstinence bias was significantly more pronounced for "at-risk" users. Participants who 'relapsed' earlier had larger increases in time distortion In treatment group 36.4% did not manage to abstain for whole week	Addiction-related 'homeostasis violation'	Yes	IND	IND

Note: DIR: directly assessed (effects conceptualized explicitly as withdrawal/craving/relapse); EXP: experimentally manipulated; GHQ-28: General Health Questionnaire-28; IND: indirectly assessed (effects not conceptualized explicitly as withdrawal/craving/relapse); IVSP: involuntary separation; MFI: Multidimensional Fatigue Inventory; PACS: Penn Alcohol Craving Scale; PANAS: Positive and Negative Affect Schedule; POMS: Profile of Mood States; N: naturally occurring; NA: not assessed; SR: self-restraint; STAI: State Trait Anxiety Inventory; VSP: voluntary separation.

Appendix B

References for outcome measures used in included studies

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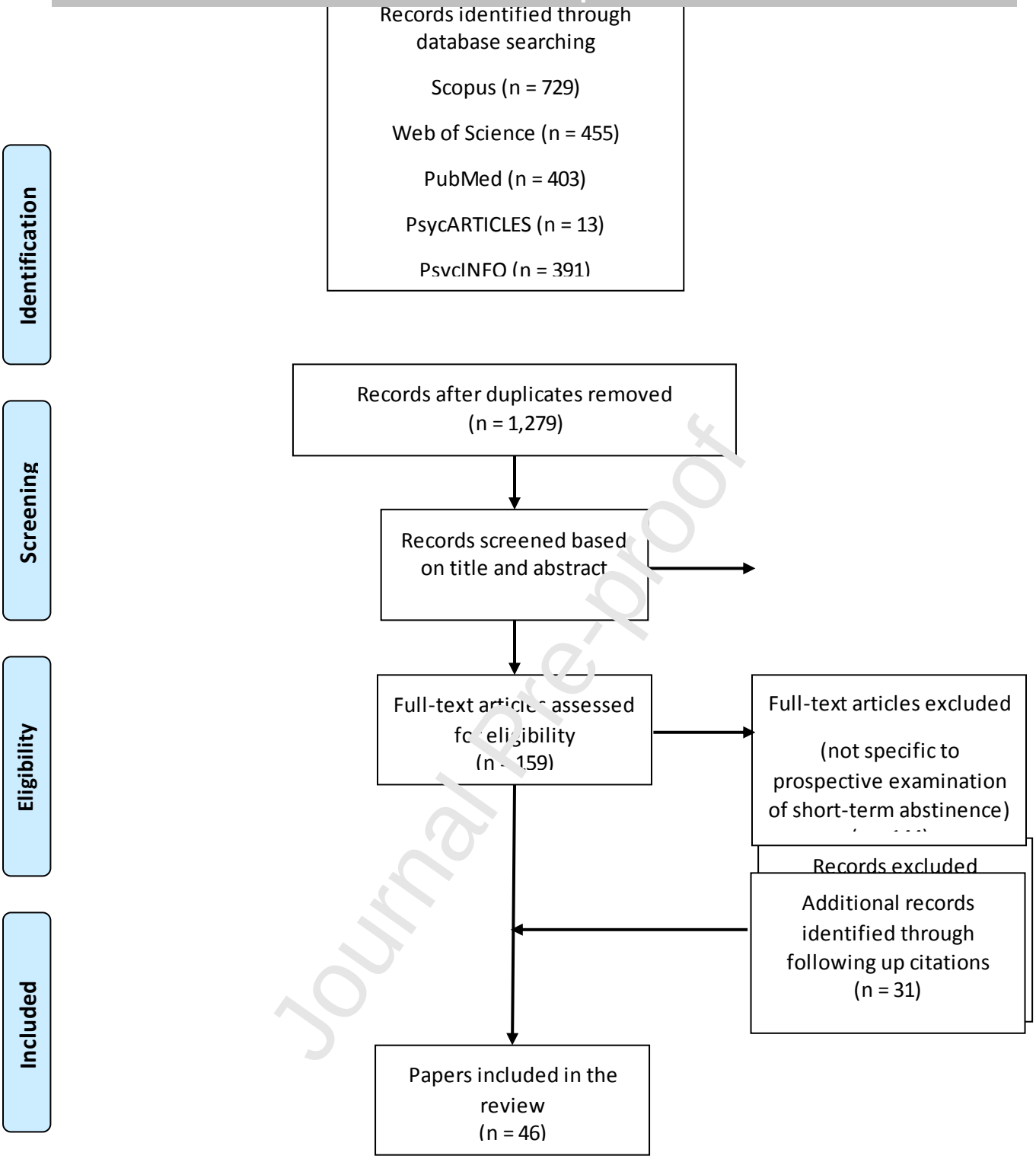

Fig. 1. PRISMA flow diagram depicting the systematic search process

Table 1

Summary of abstinence effects across behaviors

	Abstinence protocols (duration, type)	Negative cognitive-affective/physical effects	Negative behavioral effects	Positive effec
Exercise (n = 22)	24 hrs[2,41] 26-30hrs[10] 2-5 days[9] 3 days[20,29,32] 5 days[10] 7 days[18, 19,26, 38,39,46] 7-14 days[3] 10 days[1] 2 wks[6,25,30,33,45] 1 month[4] *SR*(all)	↑Depression[2,6,9,25,29,30,39,41,45] ↑Total mood disturbance (POMS)[6,9,25,29,33,39,45] ↑Fatigue[1,2,6,9,19,25,45] ↑Tension[2,9,29, 39] ↑Anxiety[4,29,30] ↑Anger[2,9,39] ↑Confusion[2,9,29] ↑Somatic symptoms[18,30] ↑Psychological distress[33] ↑Need to be with others[4] ↑Tense arousal[32] ↑Sexual tension[4] ↑Galvanic skin response[41] ↑Body dissatisfaction[32] ↑Heart rate[39] ↑Insomnia[30] ↑Pain[19] ↑Non-articular tenderness[46] ↑Strained feelings[30] ↓Vigor[2,9, 29, 39] ↓Appetite[4] ↓ Sleep quality[4] ↓ Hedonic tone, energetic arousal[32] ↓Quality of life[46] ↓ Positive affect <u>Moderating/interaction effects</u> • Males, higher competition levels ↑negative moods[10] Low commitment-high dependence runners ↑mood disturbances[9] • Hypoactive biological stress response system↑fatigue, ↑pain, ↑mood disturbances[19] • Exercise addiction ↑anxiety[26], ↑tension[2], ↑anger[2,3], ↑depression[2,3,26], ↑heart rate[2], ↑sympathetic activity[26], ↑confusion[2,3], ↑fatigue[3], ↓bioelectrical activity[26], ↓vigor[3] <u>Trajectory of effects</u> • By Day 3, anxiety, tension, depression and total mood disturbance decreased[29] • Somatic symptoms (wk 1) preceded onset of cognitive-affective symptoms (wk 2)[6,30]	<u>Abstinence non-compliance rates</u>: 0%[30,32,39], 7.5%[20]	<u>Moderating/in</u> • Fema comp ↑pos • High depe comm ↓mo • 'True days enga revit (com exerc • Low ↑pos enga revit tranq
Gambling (n = 2)	5 – 21 days[12,40] *SR*[12,40]	Gambling craving more severe than alcohol craving[12,40], dependent on external factors[12], related to unpleasant arousing state[12] and depression[40]	NR	
Gaming	4 mins[14]	↑Boredom[16, 22]	<u>Abstinence non-</u>	↑Insight/attitu

(n = 7)	84 hrs[16, 21,22,23] *IVSP*[13,14] *SR*[16,21,22,23]	↑Drive for mental stimulation[22] ↑Craving[22] Moderating/interaction effects • IGD group ↑lentiform activation[13], ↑withdrawal symptoms[21] • Females ↑RGU-IGD differences in craving-related functional connectivity[14] Trajectory of effects • Withdrawal symptoms declined over time in both abstinence and control groups[16] • Withdrawal symptoms declined over time in both IGD and non-IGD groups[21]	compliance rates: 0%[21, 22, 23], 83%[24] Use of action shooting games, endorsement of IGD withdrawal criterion at baseline ↑abstinence non-adherence[24]	towards gami ↑Positive cha post-abstinen ↑Free time fo activities[16, 22] ↓IGD sympto ↓Maladaptive cognitions[23]
Mobile phone use (n = 6)	3-5 mins[34] 5 mins[8] 60 mins[7,11] 72 hrs[15] 3/5 days[36] *SR*[36] *VSP*[11,15] *IVSP*[8] *SR/VSP*[7,34]	↑Anxiety[7, 8, 36] ↑Unpleasantness[8] ↑Withdrawal symptoms[15] ↑FoMO[15] ↓Cognitive performance[8] ↓Extended self[8] Moderating/interaction effects • High text users ↑thoughts of texting[36] • When phone in sight ↑anxiety[34] • Heavy daily users ↑anxiety; moderate daily users ↑anxiety only for *VSP* condition[7] Trajectory of effects • Withdrawal symptoms and FoMO reduced over time for abstinence and control groups[15]	NR	↑Attainment o
Pornography use (n = 3)	14 days[17] 3 weeks[27,31] *SR*[17,27,31]	↑Perceived compulsivity[17]	Frequency of use during abstinence: *M* = 2.50, *SD* = 2.92[17] *M* = 1.42, *SD* = .67[27] *M* = 1.53, *SD* = .83[31] Self-reported compulsivity predicted by number of relapses when abstinence effort high[17]	↑Relationship ↑Perceived co may reflect in compulsivity behavior[17] ↓Delay discou
Social media use (n = 7)	48 hrs[35] 7 days[37, 42, 43, 44] 14 days[28] 99 days[5] *SR*[5, 35, 37, 42, 43, 44] *VSP*[28]	↑Subjective feelings of 'withdrawal'[5] ↑Boredom[37] ↑Craving[37] ↑Social pressure to use social media[37] ↑Time distortion[43] ↓Sense of connection[35] Moderating/interaction effects • Users at-risk for social media addiction ↑post-abstinence time distortion[43]	Abstinence non-compliance rates: 13%[42], 23%[35], 31%[5], 36.4%[43], 38.2%[44], 59%[37] Greater disconnection during abstinence ↑usage post-abstinence[35] Baseline frequency of use,	↑Life satisfac ↑Affective we ↓Perceived st Moderating/in • Heav users othe satis ↑affe

	negative moods during abstinence, addiction-related feelings ↑likelihood of reversion[5] Facebook switching-stress during abstinence ↓intentions to discontinue use[28] Excessive use[44], higher stress during abstinence[44], increase in time distortion during abstinence[43] ↓abstinence length	being • Exces ↓per

Note:
↑ indicates significant increase compared to baseline/significantly greater compared to comparison group/significant positive association/perceived abstinence-induced increase; ↓ indicates significant decrease compared to baseline/significantly lower compared to comparison group/significant negative association/perceived abstinence-induced reduction; FoMO: fear of missing out; IGD: Internet Gaming Disorder; *IVSP*: involuntary separation; NR: no/none reported; POMS: Profile of Mood States; RGU: recreational game use; *SR*: self-restraint; *VSP*: voluntary separation.

Studies: 1: Ablin et al. (2013); 2: Aidman & Woollard (2003); 3: Antunes et al. (2016); 4: Baekeland (1970); 5: Baumer et al. (2015); 6: Berlin et al. (2006); 7: Cheever et al. (2014); 8: Clayton et al. (2015); 9: Conboy (1994); 10: Crossman et al. (1987); 11: Cutino & Nees (2017); 12: de Castro et al. (2007); 13: Dong et al. (2019a); 14: Dong et al. (2019b); 15: Eide et al. (2018); 16: Evans et al. (2018); 17: Fernandez et al. (2017); 18: Gauvin & Szabo (1992); 19: Glass et al. (2004); 20: Hausenblas et al. (2008); 21: Kaptsis et al. (2016); 22: King et al. (2016); 23: King et al. (2017); 24: King et al. (2018); 25: Kop et al. (2008); 26: Krivoschekov & Lushnikov (2017); 27: Lambert et al. (2012); 28: Maier et al. (2015); 29: Mondin et al. (1996); 30: Morris et al. (1990); 31: Negash et al. (2015); 32: Niven et al. (2008); 33: Poole et al. (2011); 34: Sapacz et al. (2016); 35: Sheldon et al. (2011); 36: Skierkowski & Wood (2012); 37: Stieger & Lewetz (2018); 38: Szabo & Gauvin (1992); 39: Szabo and Parkin (2001); 40: Tavares et al. (2007); 41: Thaxton (1982); 42: Tromholt (2016); 43: Turel & Cavagnaro (2018); 44: Turel et al. (2018); 45: Weinstein et al. (2007); 46: Zeller et al. (2011)

Highlights

- Withdrawal-like symptoms manifested to varying extents across the behaviors, but most clearly for exercise.
- Craving was the most common abstinence-induced effect across multiple behaviors.
- Abstinence non-compliance rates provided evidence of possible relapses across some behaviors, particularly social media use.
- Benefits of abstinence included alleviation of negative effects attributed to the behavior, insight, and positive behavioral changes.
- These benefits were not necessarily generalizable across behaviors.

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DPF and MDG designed the study. DPF conducted the systematic search, data extraction, and wrote the first draft of the manuscript under the supervision of MDG. MDG and DJK contributed to revisions of the manuscript. All authors have approved the final manuscript.

Conflict of interest

All authors declare that they have no conflicts of interest.