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Review

# Digital Physical Activity Interventions for Mental Health Promotion and Reduction of Addictive Behaviors: Integrative Comprehensive Review with a Focus on Personalization and Implementation

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## Abstract

Digital interventions can increase reach and continuity of physical activity promotion, but evidence remains fragmented across mental health and addictive behaviors. We conducted a comprehensive integrative review supported by structured searches (2015–2026) in biomedical, psychological, multidisciplinary and technology-oriented databases, complemented by backward/forward snowballing. Eligible studies included digital interventions in which physical activity (or sedentary reduction) was a core component and that reported mental health outcomes (e.g., depression, anxiety, stress, well-being) and/or addiction-related outcomes (e.g., craving, consumption, lapses/relapse, treatment retention). We synthesized findings thematically by intervention typology (apps, wearables, hybrid models with human support, and adaptive approaches) and by key active ingredients (goal setting, self-monitoring, feedback, reinforcement, planning, and engagement strategies). Overall, most studies targeted mental health outcomes and used app-based multicomponent programs, sometimes complemented by wearables, with generally short follow-up and heterogeneous engagement metrics. Evidence in addictions was more context-specific and concentrated in alcohol treatment and opioid agonist therapy settings, supporting feasibility and a plausible role for physical activity as a coping strategy. Advanced personalization frameworks (EMA/EMI/JITAI) provide a clear implementation pathway, but are less consistently operationalized when physical activity is the central therapeutic component. This review highlights practical design recommendations and research priorities for scalable, safe, and equity-oriented digital physical activity interventions in mental health promotion and relapse prevention.

**Keywords:** behavior change; relapse prevention; craving; self-monitoring; implementation and equity

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## 1. Introduction

Physical activity is a central determinant of health and well-being. The evidence is consistent in the prevention and reduction of depressive and anxious symptoms, at different ages and contexts (1,2). It also improves sleep, stress regulation and quality of life. Therefore, it is a relevant instrument for the promotion of mental health in public health (3).

Mental disorders and addictive behaviors continue to contribute markedly to the global burden of disease (4,5). Comorbidity is frequent and clinically relevant. Depression and anxiety are associated with a higher risk of consumption and a higher probability of relapse (6). Chronic stress and sleep disruption often appear as common pathways. Craving, in turn, is a nuclear mechanism. It is not static. It fluctuates throughout the day and is sensitive to context, emotions and environmental stimuli (7).

Physical activity can act on several processes that are relevant in this domain. It can reduce stress reactivity and improve sleep architecture (8). It can increase self-efficacy and self-regulation capacity (2). In some populations, it can also modulate reward circuits and contribute to greater inhibitory control (9). In addition, when it is structured and sustained over time, it can create alternative routines and reinforce social support, with an impact on maintaining change (1,3).

Despite these advantages, there is a recurring problem. Adherence is limited and maintenance is difficult, especially in people with psychological distress, greater impulsivity or less social support (10,11). This challenge is particularly evident in contexts of vulnerability, where logistical and economic barriers are strongest (10). Thus, the question is not just whether physical activity “works”. It is also how to ensure that it is initiated, maintained and integrated into real care and health promotion pathways.

On the other hand, digital technologies offer a practical opportunity to respond to part of this challenge (12). They can increase reach and continuity, through apps, platforms, and hybrid models with remote monitoring (13). They facilitate self-monitoring, goal setting, and feedback. They can also incorporate coaching and social support, reducing barriers to access. An additional, increasingly relevant value is the possibility of real-time data collection, combining brief self-report with passive sensor data, including movement and sleep patterns (14,15).

In this context, the paradigm of real-time adaptive interventions, often referred to as Just-In-Time Adaptive Interventions (JITAI), is of particular interest (16). The principle is to deliver the right support, at the right time and in the right context. This logic is especially suited to dynamic risk such as stress, sleep deprivation, and increased craving (17). An intervention can identify windows of greater vulnerability and suggest physical activity micro-interventions, adjusting goals and strategies responsively (18). It can also reinforce protective behaviors when the risk is lower, supporting maintenance in the medium term (16).

Despite the potential, the evidence remains fragmented (17). Studies vary in the type of technology, the type and dose of physical activity, and the quality of engagement metrics (16). They also vary in outcomes and time horizons. There are interventions focused on mental health, others focused on consumption, and others with combined goals. There are also marked differences between interventions for young people and adults in a clinical context (19,20). This heterogeneity makes it difficult to read in an integrated way and limits translation for programs and services (21).

Added to this are equity, privacy, and security challenges (22). Digital literacy and access to devices are not uniform. In mental health and addictions, the collection and use of data can involve sensitive information, requiring transparency, data minimization, and clear governance. It is also necessary to consider unwanted effects, such as poorly timed messages, rigid goals that induce guilt, or gamification strategies that reduce intrinsic motivation (17,21).

In this framework, a comprehensive integrative review oriented towards implementation is needed. It is not enough to ask, “is there effectiveness?”. It is important to understand “in whom”, “under what conditions” and “with what components”. It is also important to clarify how these interventions can be integrated into health promotion programs and clinical services, with quality and safety. Thus, this review aims to organize and critically synthesize the evidence on digital physical activity interventions to promote mental health and reduce addictive behaviors, integrating mechanisms, active components and implementation factors, with operational recommendations for practice and research.

## 2. Methods

### 2.1. Design of the Review

A comprehensive integrative review was carried out, supported by structured literature research and explicit selection criteria. The aim was to critically synthesize the available evidence on digital interventions to promote physical activity with an impact on mental health outcomes and/or

addictive behaviors, integrating results from studies with different methodological designs and implementation contexts.

## 2.2. Sources of Information

The search was conducted in biomedical, psychological, and multidisciplinary databases, including PubMed/MEDLINE, Scopus, Web of Science Core Collection, and PsycINFO. To capture interventions with a higher technology component, the research was complemented with technology-oriented databases, such as IEEE Xplore and/or ACM Digital Library, when relevant to wearables, sensors, and adaptive interventions.

## 2.3. Research Strategy

A search strategy based on four domains of terms was used:

1. Physical activity/exercise (e.g., physical activity, exercise, walking, aerobic, resistance training);
2. Digital Health and technologies (e.g., mHealth, mobile health, app, smartphone, wearable, activity tracker, digital intervention);
3. Mental health (e.g., depression, anxiety, stress, wellbeing, sleep);
4. Addictive behaviors and relapse (e.g., addiction, substance use, craving, relapse, gaming, gambling, problematic smartphone use).

The combinations of terms were adapted to each database. Boolean operators (AND/OR) and truncations were used when applicable. To maximize sensitivity, synonyms and close terms were included, maintaining specificity through the mandatory combination of: (i) physical activity/exercise, (ii) digital component, and (iii) mental health outcomes and/or addictions.

The electronic search was complemented by a manual search of the reference lists of included studies (backward snowballing) and by identification of citing studies where appropriate (forward snowballing), with the aim of reducing the risk of missing relevant studies.

## 2.4. Time Period and Languages

Considering the evolution of the digital ecosystem and the maturation of mHealth, a main time window was defined from 2015 to 2026. Articles in English were considered, and, when identified and relevant, also in Portuguese and Spanish. No country-by-country restriction was applied.

## 2.5. Eligibility Criteria

### 2.5.1. Inclusion Criteria

Studies that met all the following criteria were included:

- Intervention: intervention with a digital component aimed at promoting physical activity and/or reducing sedentary lifestyle, including apps, platforms, wearables, SMS/notifications, digital telecoaching, or adaptive interventions (e.g., JITAI/EMI).
- Population: adolescents, young adults, or adults with (i) symptoms or diagnosis of mental health disorders (e.g., depression, anxiety, stress, psychological distress), and/or (ii) addictive disorders/behaviors (substances and/or behavioral), or populations at relevant risk for relapse.
- Outcomes: reporting at least one mental health outcome (e.g., depression, anxiety, stress, wellbeing), and/or outcomes linked to addictions (e.g., craving, consumption, lapses/relapse, retention in treatment), and/or complementary outcomes with clinical relevance (sleep, quality of life, functioning).
- Type of publication: empirical studies (qualitative or quantitative) and relevant reviews, when useful for contextualization and identification of gaps.

### 2.5.2. Exclusion Criteria

The following were excluded:

- Studies in which the technology was used only for measurement/monitoring, without an interventional component.
- Digital interventions with no physical activity component (e.g. only digital psychotherapeutic content).
- Protocols without results (can be kept only for discussion of trends and future design, if they are particularly informative).
- Animal or laboratory studies with no relevance to health promotion in humans.

### 2.6. Study Selection Process

All records were exported to a bibliographic manager and duplicates were removed. The selection took place in two phases:

1. Sorting by title and abstract, to exclude clearly irrelevant records;
2. Full-text evaluation, with systematic application of eligibility criteria.

Inclusion/exclusion decisions were recorded. Disagreements were resolved by consensus, with reassessment of the full text when necessary. The selection process has been documented in such a way as to allow for the transparent presentation of the screening flow.

### 2.7. Data Extraction

An extraction grid with predefined dimensions was developed, applied consistently to the included studies:

- Identification (authors, year, country) and context (clinical, community, school/university);
- Study design (RCT, pragmatic, pre-post, pilot, implementation, qualitative);
- Characterization of the sample (n, age, sex/gender when reported, clinical criteria, comorbidities);
- Target condition (mental health; addictions; combined) and setting (treatment/inpatient/outpatient/community);
- Core technology (app, wearable, telecoaching, platform, JITAI/EMI/EMA) and intervention architecture;
- Active components and behavioral change techniques (e.g. goals, self-monitoring, feedback, reinforcement, social support, gamification, coaching, self-regulatory content);
- Prescription of physical activity (type, intensity when available, frequency, duration, progression, supervision);
- Personalization (level, signals used, rules/decision, micro-interventions, timing);
- Outcomes and instruments (mental health, craving, consumption/relapse, sleep, quality of life, functioning);
- Engagement and adherence (use, retention, participation in PA, abandonment, acceptability);
- Implementation indicators (barriers/enablers, resources, loyalty, equity, privacy/security).

### 2.8. Data Summary

An integrative thematic synthesis was carried out, appropriate to the expected heterogeneity in the designs and metrics. Studies were organized by type of digital intervention (apps, wearables, telecoaching/hybrids, JITAI/EMI) and by primary objective (mental health promotion, risk reduction/relapse, combined interventions).

The interpretation of the results privileged:

- Consistency of effects by outcome domain (mental health, craving/consumption, sleep, quality of life);
- Relationship between active components and engagement/adherence;

- Implementation conditions associated with greater feasibility and sustainability (e.g. integration into services, intensity of human support, technological accessibility).

When comparability between studies was limited, the results were presented in a narrative manner, with emphasis on the direction and plausibility of the effects, avoiding undue generalizations.

### 2.9. Considerations on Methodological Quality

Although integrative reviews do not, by definition, require a formal assessment of risk of bias, an indicative assessment of quality and reporting was considered, based on study design, clarity of intervention, completeness of metrics, and presence of follow-up. This assessment was used to contextualize the robustness of the findings, not to systematically exclude studies.

### 2.10. Ethical Considerations

Ethical approval was not required, since the review used only published literature. However, relevant ethical implications for the topic were considered, namely privacy, data governance and security in digital interventions aimed at vulnerable populations.

## 3. Results

The literature search identified a set of studies that evaluate digital interventions aimed at promoting physical activity with mental health objectives and/or reducing addictive behaviors. After removal of duplicates and application of eligibility criteria, a body of evidence consisting of studies with heterogeneous designs, including randomized controlled trials, pragmatic studies, pre-post, feasibility/pilot studies and implementation evaluations was included.

In general, the studies are distributed in different contexts (clinical, community, school/university) and by different age groups. There is a predominance of interventions focused on mobile apps (23–25), often complemented by wearables or digital self-monitoring strategies (26–30). The follow-up time horizon tends to be short, with a lower proportion of studies reporting maintenance of effects after the end of the program (23–28,30,31).

### 3.1. Populations and Contexts of Intervention

Included populations range from individuals with symptoms of depression, anxiety, or stress (24,25,32–34), to populations with addictive disorders/behaviors, including substance use and, in some cases, behavioral dependencies (26,27,30,31,35). In a clinical context, interventions are often integrated into broader programs, with remote or hybrid professional follow-up (26,27,30,31,36). In a community and school/university context, the approach tends to privilege self-monitoring strategies, progressive goals and digital feedback (33,37,38).

Psychological comorbidity emerges as a cross-cutting aspect. In several studies, mental health outcomes are assessed in parallel with behavioral indicators (e.g., craving, drinking episodes, lapses, or behavioral proxies), which reinforces the rationale for integrated interventions (27).

### 3.2. Types of Digital Intervention

In the set analyzed, four dominant typologies emerge:

- (i) Goal-focused and self-monitoring mobile apps.

These interventions include goal setting (e.g., steps/day or minutes/week), activity logging, and automatic feedback. In several cases, they incorporate psychoeducational content on stress, sleep and self-regulation (23,25,26,32,36).

- (ii) Interventions with wearables and sensor-based feedback.

Wearables are used to track movement and, in some cases, sleep-related metrics. Feedback tends to be more frequent and “situational”, supporting goal adjustments and reinforcement of adherence.

In some programs, the wearable component works as an “objective test” and motivational element (27,28,31,39).

- (iii) Hybrid models with human support.

In some clinical settings, interventions include human support to strengthen adherence, clarify objectives, and reduce barriers, complementing digital tools and/or self-monitoring. This support can take mild forms (check-ins, guidance, and follow-up during treatment), especially in populations with greater vulnerability and risk of abandonment (26,30,36).

- (iv) Real-time adaptive interventions (JITAI/EMI).

These interventions seek to adapt content and timing based on cues (brief self-report, context, activity patterns, sometimes sleep). In the corpus analyzed, real-time adaptation still appears in a limited and heterogeneous way. The synthesis literature on JITAI in mobile interventions for physical activity reinforces the need to make explicit tailoring variables, decision rules, and implementation fidelity (16,18,21).

### 3.3. Active Components and Behavioral Change Techniques

Most interventions use a common core of techniques: goal setting, self-monitoring, feedback, and reinforcement (cf. (40)). Planning components (action planning and coping), motivational messages and reminders are frequent. Social support is operationalized in different ways, from digital groups to progress-sharing features, although not always with clear evidence of incremental benefit (41).

Gamification appears in some interventions, but with a variable design. When well aligned with gradual goals and meaningful feedback, it can support engagement. When excessively competitive or rigidly performance-oriented, it can introduce friction in populations with greater symptomatology or emotional vulnerability, and should be applied with caution.

### 3.4. Physical Activity Prescription: Type, Dose and Progression

The prescription tends to favor light to moderate aerobic activity (e.g., walking), often operationalized by steps/day (27,29–31). There is a lower proportion of interventions with explicit prescription of intensity based on physiological parameters. Progression is generally incremental and adapted to previous performance, although it is not always described in detail.

When there is a supervised or telecoaching component, there is greater detail in the prescription and greater attention to individual barriers, including fatigue, mood symptoms, and contextual constraints (38). In populations with addictive behaviors, prescription is sometimes articulated with craving management and with alternative routines at critical times of the day (27).

### 3.5. Outcomes and Metrics: Mental Health, Addictions, Sleep and Engagement

Mental health outcomes include measures of depression, anxiety, stress, and psychological well-being (23–25,32,33,36,38,41). In additions, indicators of craving, consumption (frequency/quantity), lapses and, in some cases, relapse appear (26,27,31). Sleep appears as a relevant outcome, but with variation in the form of measurement (self-report versus wearable metrics).

Engagement is reported frequently, but in a heterogeneous way (26,32,36,41). In some studies, it is limited to app usage metrics (logins, time, completed modules). In others, it includes behavioral adherence (minutes of activity, steps, participation in sessions). The lack of standardization limits comparisons and reinforces the need for harmonized minimum reporting.

### 3.6. Personalization and JITAI: signals, DECISIONS and Micro-Interventions

Personalization takes place mainly at basic and intermediate levels. At a basic level, it adjusts goals based on past performance. At an intermediate level, it adapts content and recommendations based on reported preferences, barriers, and progress. In the corpus analyzed, advanced real-time

personalization is less frequent and is not always described in sufficient detail to allow replication, reinforcing the importance of transparent reporting of adaptation logic and active components (23–25,32,38,40).

Recommendations tend to favor short and feasible actions (e.g., short walks, sedentary breaks, simple exercises), with the adequacy of the context and the user's ability being decisive for acceptance and adherence (40).

### 3.7. Implementation, Equity, Privacy and Security

In addition to outcomes, the literature highlights implementation and equity challenges relevant to vulnerable populations. Implementation is conditioned by individual factors (literacy, motivation, symptoms), technological factors (usability, friction, reliability of sensors) and contextual factors (time, environment, social support). Equity is critical, especially when access to smartphones, mobile data, or wearables is not guaranteed (42,43).

Data privacy and governance are particularly sensitive in this area. Collecting activity, sleep, and context patterns can be useful for personalization, but it requires transparency, minimization, and clear criteria for storage, access, and use (42,44). In mental health and addictions, a “privacy-by-design” approach should be considered a requirement rather than optional.

## 4. Discussion

This comprehensive integrative review synthesizes evidence on digital interventions that promote physical activity with potential impact on mental health outcomes and/or addictive behaviors, and organizes the field by technological typologies and intervention components. Three overarching messages emerge.

First, most digital physical activity interventions rely on established behavioral change mechanisms (goal setting, self-monitoring, feedback, reinforcement, and planning) implemented through apps, web-based platforms, and sometimes wearables. This is consistent with broader evidence that physical activity can prevent or reduce anxiety and depressive symptoms and improve well-being, and with the recognized role of self-regulation processes in sustaining physical activity and reducing sedentary behavior (1,3,9,40). Within digital formats specifically, narrative and meta-analytic evidence indicates that multicomponent “lifestyle” interventions can improve depression, anxiety, stress and well-being, although effect sizes and durability vary (45). The implication is not that “technology causes improvement” per se, but that digital delivery can operationalize core behavior-change ingredients at scale, while supporting adherence through monitoring and feedback loops (12–14,40,45).

Second, when the focus shifts to addictive behaviors, the empirical base of interventions in which physical activity is the central therapeutic component and is digitally supported remains narrower and more context-specific than the mental health literature. Studies targeting alcohol use disorders illustrate a plausible pathway: wearable-supported lifestyle physical activity can be developed and delivered in treatment settings, and digital physical activity apps can be feasible for patients in alcohol treatment (26,27,31,35). Evidence from methadone maintenance also suggests feasibility of structured physical activity programs supported by digital self-monitoring (e.g., via trackers), including in populations with substantial vulnerability and complex clinical profiles (30). However, in contrast to the mental health space where multiple RCTs and workplace/community trials exist, the number of controlled trials in addictions with physical activity as the main intervention ingredient is still limited, and follow-up is often short (26,30,31,45). This asymmetry should be acknowledged explicitly because it constrains how strongly we can generalize about relapse prevention effects driven by digital physical activity alone.

Third, advanced personalization; particularly architectures grounded in EMA/EMI and JITAI principles, appears more developed in the broader ecosystem of digital addiction interventions than in programs where physical activity is the central component. Conceptually, JITAIs are designed to deliver “the right support at the right time in the right context,” and frameworks emphasize decision

rules, tailoring variables, and ongoing adaptation (18). Systematic and qualitative syntheses show that, in mental health, JITAI implementation is still evolving, with major gaps in operationalization, reporting, and real-world deployment (17,21). In addictions, clinical digital recovery support services delivered via smartphone demonstrate the feasibility of self-managed, time-sensitive support, and systematic reviews summarize how EMI approaches can be used to reduce addictive behaviors (46,47). In parallel, reviews and checklists of EMA/EMI studies highlight the importance of transparent reporting of tailoring logic and delivery characteristics; precisely because “personalization” can otherwise become a vague claim (44). Together, these sources support a central opportunity: to translate the sophistication of EMA/EMI and JITAI design (well-articulated for addictions and mental health) into digital physical activity interventions, while keeping the behavioral prescription simple and safe (16–18,44,46,47).

#### *4.1. Plausible Mechanisms and Why Digital Physical Activity May Matter*

Physical activity effects on mental health and addiction-relevant processes are plausible and multidimensional. At least four pathways are salient.

Stress regulation is central. Depression/anxiety relapse prevention literature indicates that stress-related pathways and maintenance processes are clinically meaningful, and physical activity may reduce stress reactivity while improving coping capacity (6,8). In addictions, craving is a core mechanism linked to environmental cues and affective states, and an intervention that reduces negative affect or increases perceived control can plausibly reduce vulnerability to high-risk moments (7). Sleep is another relevant pathway: physical activity has been associated with changes in sleep architecture and mood in naturalistic settings, supporting the rationale for integrating sleep-related targets or monitoring into behavior change interventions (8). Affective pathways are also important: acute changes in tension and mood following activity can make physical activity a credible “microintervention” candidate; particularly in addictions where momentary risk fluctuates and is context dependent (7,16–18). Finally, self-efficacy and self-regulation support maintenance. Classic work on adherence highlights that sustaining physical activity is difficult, especially under distress and low support (10,11). Cognitive control models further indicate that self-regulation processes influence physical activity and sedentary behavior, which aligns with using goal setting and feedback to build manageable routines (9,40).

These pathways interact. Stress and sleep can influence impulsivity and affective states, which in turn shape craving dynamics (7,8). (7,8). Therefore, interventions are more likely to be effective when they align their outcomes and delivery logic with a plausible mechanism (e.g., stress/craving coping vs general lifestyle improvement) rather than treating “steps/day” as an end in itself (7,40).

#### *4.2. What Seems to Work and Under What Conditions*

The synthesis suggests that three conditions tend to accompany more robust outcomes: (i) clear and gradual goals, (ii) self-monitoring with actionable feedback, and (iii) low friction in execution.

Goal setting is a consistent component across successful interventions. In digital physical activity programs for depression and related outcomes, RCT evidence shows that structured programs delivered via smartphone or web platforms can improve depressive symptoms, stress, psychological well-being, and quality of life when goals are feasible and intervention content supports engagement (23–25,33,38). In workplace and community-relevant contexts, application-based exercise has also been tested in clinical trials with outcomes including depressive symptoms and burnout (41). However, the field also shows heterogeneity in adherence and follow-up, reinforcing that the way targets are framed and adapted matters for sustainability (10,11,45).

Self-monitoring is beneficial when data are translated into decisions. Reviews of smartphone-based physical activity interventions for mental health emphasize that the “untapped potential” often lies in better tailoring of feedback and in aligning intervention prompts with user context and burden (40). Emerging approaches also incorporate passive monitoring and predictive models for depression/anxiety signals in real-world users, suggesting a pathway for more context-aware

delivery, although evidence is still early and feasibility-driven (32). In practice, the distinction between “tracking” and “intervention” should be explicit: tracking alone is not sufficient; the intervention value emerges when monitoring supports self-regulation and timely action (12,40,44).

Low friction is decisive. Adherence limitations are well documented, and digital technologies are often framed as mechanisms to reduce access barriers (10–13). In clinically vulnerable populations, structured support can stabilize routines. This appears particularly relevant in addictions, where feasibility trials of digital physical activity interventions in alcohol treatment and peer-facilitated approaches in methadone maintenance show that human support (professional or peer-based) can be part of the intervention architecture (26,27,30,31). This aligns with the broader evidence that maintenance and relapse prevention require sustained processes rather than one-off gains (6,10,11).

#### 4.3. *Advanced Personalization: Opportunity, Risk, and Where Protocols Fit*

Personalization should be treated pragmatically. There is a gradient between basic tailoring (adjusting goals based on past behavior), intermediate tailoring (adapting content to barriers/preferences), and advanced tailoring (EMA/EMI/JITAI). Frameworks emphasize that JITAI require explicit specification of tailoring variables, decision points, and intervention options (18). Yet, syntheses of JITAI in physical activity and mental health highlight persistent gaps in reporting, implementation fidelity, and translation to routine care (16,17,21). In addictions, EMI approaches are increasingly systematized, with evidence from clinical trials of smartphone-based recovery support and systematic reviews of EMIs aimed at addictive behaviors (46,47). Complementary work in SUD mHealth also points to rapid growth and to the need for careful consideration of engagement and clinical integration (43).

At the same time, advanced personalization introduces risks. Complexity can reduce scalability. Poorly timed notifications may increase burden or distress. In vulnerable populations, privacy and data governance become central, particularly when contextual and behavioral patterns are collected. Equity concerns also matter: access to devices, data plans, and wearables is not uniform, and JITAI implementation must be aligned with public health equity goals (22,43). Here, protocols without results are best treated as “pipeline evidence”: they inform design trends (e.g., remote delivery, data-driven personalization) but should not be used as efficacy evidence in Results. This distinction is consistent with reporting checklists and with the current maturity of the literature (44). In practice, protocols and early-stage trials in depression/anxiety digital interventions can be used to frame future directions and methodological needs, not to support outcome claims (28,29,48,49).

#### 4.4. *Implications for Health Promotion and Services*

Digital physical activity interventions can support mental health promotion, and potentially contribute to relapse prevention, if they are designed for adherence, safety, and implementation constraints. For clinical services, light hybrid models are plausible: simple prescriptions, self-monitoring, and brief check-ins focused on barriers, coping, and routine building. This is aligned with feasibility evidence in addiction treatment contexts and with the broader adherence literature (10,26,30). In addiction services, framing physical activity as a functional coping tool for stress and craving may be more acceptable than a performance-oriented framing (7,27). For community and occupational contexts, scalability and equity should guide design choices: interventions dependent on expensive devices may exacerbate inequities, while smartphone-based designs can support broader reach (12–14,22,41).

For research, priorities are clear: longer follow-up to test maintenance; minimal harmonization of outcomes (mental health, craving/consumption, sleep, quality of life, engagement); and pragmatic or hybrid effectiveness-implementation designs (6,43–45). In parallel, the field should progress in staged personalization: build robust basic/intermediate tailoring first, then test more adaptive systems with explicit governance and risk assessment (18,22,44).

#### 4.5. Limitations

The heterogeneity of interventions, technologies, outcomes and engagement measures limits direct comparisons and prevents strong generalizations. Digital adherence is often reported via app-use metrics, which may not reflect behavioral adherence to physical activity (40,44). Follow-up is frequently short, limiting inference on maintenance and relapse prevention (10,45). Moreover, evidence in addictions with physical activity as the central and digitally supported component is narrower than in mental health, requiring caution in interpretation and clear separation between efficacy claims and design recommendations (26,30,31,43). Finally, equity, privacy and governance remain critical constraints, particularly when interventions rely on contextual data, passive sensing, or adaptive delivery (22,42–44).

## 5. Conclusions

Digital interventions to promote physical activity are a promising avenue to support the promotion of mental health and, in selected contexts, contribute to the prevention of relapse into addictive behaviors. The available evidence suggests benefits mainly in depression, anxiety, stress and well-being, usually through multicomponent programs (goals, self-monitoring, feedback). However, the heterogeneity of interventions and metrics, as well as the often short follow-up, limit conclusions about maintenance.

In additions, the evidence is more restricted and concentrated in some clinical settings, but supports the rationale of physical activity as a functional coping strategy for stress, negative affect and craving. A future priority is to integrate EMA/EMI/JITAI principles into physical activity interventions, with pragmatic design, harmonized outcomes, and evaluation of implementation, privacy, and equity.

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## Abbreviations

The following abbreviations are used in this manuscript:

EMA	Ecological Momentary Assessment
EMI	Ecological Momentary Intervention
JITAI	Just-In-Time Adaptive Intervention
SUD	Substance Use Disorder

## References

1. Moreno-Peral P, Pino-Postigo A, Conejo-Ceron S, Bellon D, Rodriguez-Martin B, Martinez-Vizcaino V, et al. Effectiveness of physical activity in primary prevention of anxiety: systematic review and meta-analysis of randomized controlled trials. *Int J Environ Res Public Health*. 2022;19(3):1813.
2. Ströhle A. Physical activity, exercise, depression and anxiety disorders. *J Neural Transm*. 2009;116(6):777–84.

3. Mahindru A, Patil P, Agrawal V. Role of physical activity on mental health and well-being: a review. *Cureus*. 2023;15(1):e33475.
4. Collaborators GBD 2019 MD. Global, regional, and national burden of 12 mental disorders in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet Psychiatry*. 2022;9(2):137–50.
5. Rehm J, Shield KD. Global burden of disease and the impact of mental and addictive disorders. *Curr Psychiatry Rep*. 2019;21(2):10.
6. Krijnen-de Bruin E, Scholten W, Muntingh A, Maarsingh O, van Meijel B, van Straten A, et al. Psychological interventions to prevent relapse in anxiety and depression: A systematic review and meta-analysis. *PLoS One*. 2022;17(8):e0272200.
7. Ray LA, Roche DJO. Neurobiology of craving: current findings and new directions. *Curr Addict Rep*. 2018;5(2):102–9.
8. Zapalac K, Miller M, Champagne FA, Schnyer DM, Baird B. The effects of physical activity on sleep architecture and mood in naturalistic environments. *Sci Rep*. 2024;14(1):5637.
9. Buckley J, Cohen JD, Kramer AF, McAuley E, Mullen SP. Cognitive control in the self-regulation of physical activity and sedentary behavior. *Front Hum Neurosci*. 2014;8:747.
10. Dishman RK, Buckworth J. Adherence to physical activity. In: *Physical activity and mental health*. Taylor & Francis; 2013. p. 63–80.
11. Jefferis BJ, Sartini C, Lee IM, Choi M, Amuzu A, Gutierrez C, et al. Adherence to physical activity guidelines in older adults, using objectively measured physical activity in a population-based study. *BMC Public Health*. 2014;14(1):382.
12. Albergoni A, Hettinga FJ, La Torre A, Bonato M, Sartor F. The role of technology in adherence to physical activity programs in patients with chronic diseases experiencing fatigue: a systematic review. *Sports medicine-open*. 2019;5(1):41.
13. Chaddha A, Jackson EA, Richardson CR, Franklin BA. Technology to help promote physical activity. *American journal of cardiology*. 2017;119(1):149–52.
14. Moran J, Kelly G, Haberlin C, Mockler D, Broderick J. The use of eHealth to promote physical activity in people with mental health conditions: a systematic review. *HRB Open Res*. 2018;1:5.
15. Liu Y, Zhang H, Xu R. The impact of technology on promoting physical activities and mental health: a gender-based study. *BMC Psychol*. 2023;11(1):298.
16. Wunsch K, Eckert T, Fiedler J, Woll A. Just-in-time adaptive interventions in mobile physical activity interventions-A synthesis of frameworks and future directions. *Eur Health Psychol*. 2022;22(4):834–42.
17. van Genugten CR, Thong MSY, Van Ballegooijen W, Kleiboer AM, Spruijt-Metz D, Smit AC, et al. Beyond the current state of just-in-time adaptive interventions in mental health: a qualitative systematic review. *Front Digit Health*. 2025;7:1460167.
18. Nahum-Shani I, Smith SN, Spring BJ, Collins LM, Witkiewitz K, Tewari A, et al. Just-in-time adaptive interventions (JITAs) in mobile health: key components and design principles for ongoing health behavior support. *Annals of behavioral medicine*. 2016;1–17.
19. Guan KW, Amara M, Cortiana V, Khan I, Gürbüz S, Iorio C, et al. Towards Participatory Precision Health: Systematic Review and Co-designed Guidelines For Adolescent Just-in-time Adaptive Interventions. *medRxiv*. 2025;2025–9.
20. Mair JL, Hayes LD, Campbell AK, Buchan DS, Easton C, Sculthorpe N. A personalized smartphone-delivered just-in-time adaptive intervention (JitaBug) to increase physical activity in older adults: mixed methods feasibility study. *JMIR Form Res*. 2022;6(4):e34662.
21. Hardeman W, Houghton J, Lane K, Jones A, Naughton F. A systematic review of just-in-time adaptive interventions (JITAs) to promote physical activity. *International Journal of Behavioral Nutrition and Physical Activity*. 2019;16(1):31.
22. Zainal NH, Liu X, Leong U, Yan X, Chakraborty B. Bridging innovation and equity: advancing public health through just-in-time adaptive interventions. *Annu Rev Public Health*. 2025;46(1):43–68.

23. Wong VWH, Ho FYY, Shi NK, Tong JTY, Chung KF, Yeung WF, et al. Smartphone-delivered multicomponent lifestyle medicine intervention for depressive symptoms: A randomized controlled trial. *J Consult Clin Psychol*. 2021;89(12):970.
24. Kim H, O'Sullivan DM. Effect of a smartphone-based physical intervention on depression, fitness factors and movement characteristics in adults. *BMC Public Health*. 2024;24(1):2597.
25. Kim H, Lee K, Lee YH, Park Y, Park Y, Yu Y, et al. The effectiveness of a mobile phone-based physical activity program for treating depression, stress, psychological well-being, and quality of life among adults: quantitative study. *JMIR Mhealth Uhealth*. 2023;11:e46286.
26. Abrantes AM, Meshesha LZ, E Blevins C, Battle CL, Lindsay C, Marsh E, et al. A smartphone physical activity app for patients in alcohol treatment: single-arm feasibility trial. *JMIR Form Res*. 2022;6(10):e35926.
27. Abrantes AM, Blevins CE, Battle CL, Read JP, Gordon AL, Stein MD. Developing a Fitbit-supported lifestyle physical activity intervention for depressed alcohol dependent women. *J Subst Abuse Treat*. 2017;80:88–97.
28. Nadal C, Earley C, Enrique A, Vigano N, Sas C, Richards D, et al. Integration of a smartwatch within an internet-delivered intervention for depression: Protocol for a feasibility randomized controlled trial on acceptance. *Contemp Clin Trials*. 2021;103:106323.
29. Takano A, Ono K, Nozawa K, Sato M, Onuki M, Sese J, et al. Wearable sensor and mobile app-based mHealth approach for investigating substance use and related factors in daily life: Protocol for an ecological momentary assessment study. *JMIR Res Protoc*. 2023;12(1):e44275.
30. Abrantes AM, Van Noppen D, Bailey G, Uebelacker LA, Buman M, Stein MD. A feasibility study of a peer-facilitated physical activity intervention in methadone maintenance. *Ment Health Phys Act*. 2021;21:100419.
31. Abrantes AM, Browne J, Stein MD, Anderson B, Iacoi S, Barter S, et al. A lifestyle physical activity intervention for women in alcohol treatment: A pilot randomized controlled trial. *Journal of substance use and addiction treatment*. 2024;163:209406.
32. Watanabe K, Okusa S, Sato M, Miura H, Morimoto M, Tsutsumi A. mHealth intervention to promote physical activity among employees using a deep learning model for passive monitoring of depression and anxiety: single-arm feasibility trial. *JMIR Form Res*. 2023;7(1):e51334.
33. Murray A, Marenus M, Cahuas A, Friedman K, Ottensoser H, Kumaravel V, et al. The impact of web-based physical activity interventions on depression and anxiety among college students: randomized experimental trial. *JMIR Form Res*. 2022;6(4):e31839.
34. Danielsen KK, Øydna MH, Strømmer S, Haugjord K. "It's more than just exercise": Tailored exercise at a community-based activity center as a liminal space along the road to mental health recovery and citizenship. *Int J Environ Res Public Health*. 2021;18(19):10516.
35. Abrantes AM, Blevins C, Lindsay C, Battle CL, Buman MP, Agu E, et al. Formative work in the development of a physical activity smartphone app targeted for patients with alcohol use disorders. *Psychol Sport Exerc*. 2019;41:162–71.
36. Große J, Huppertz C, Röh A, Oertel V, Andresen S, Schade N, et al. Step away from depression—results from a multicenter randomized clinical trial with a pedometer intervention during and after inpatient treatment of depression. *Eur Arch Psychiatry Clin Neurosci*. 2024;274(3):709–21.
37. Jeong S, Cha C, Nam S, Song J. The effects of mobile technology-based support on young women with depressive symptoms: A block randomized controlled trial. *Medicine*. 2024;103(1):e36748.
38. Vandelanotte C, Duncan MJ, Plotnikoff RC, Rebar A, Alley S, Schoeppe S, et al. Impact of a web-based personally tailored physical activity intervention on depression, anxiety, stress and quality of life: Secondary outcomes from a randomized controlled trial. *Ment Health Phys Act*. 2022;23:100477.
39. Dang K, Ritvo P, Katz J, Gratzner D, Knyahnytska Y, Ortiz A, et al. The role of daily steps in the treatment of major depressive disorder: secondary analysis of a randomized controlled trial of a 6-month internet-based, mindfulness-based cognitive behavioral therapy intervention for youth. *Interact J Med Res*. 2023;12(1):e46419.
40. Bernstein EE, Wolfe EC, Hugueneel BM, Wilhelm S. Lessons and untapped potential of smartphone-based physical activity interventions for mental health: Narrative review. *JMIR Mhealth Uhealth*. 2024;12(1):e45860.

41. Boucher VG, Haight BL, Hives BA, Zumbo BD, Merali-Dewji A, Hutton S, et al. Effects of 12 weeks of at-home, application-based exercise on health care workers' depressive symptoms, burnout, and absenteeism: a randomized clinical trial. *JAMA Psychiatry*. 2023;80(11):1101–9.
42. Carreiro S, Ramanand P, Taylor M, Leach R, Stapp J, Sherestha S, et al. Evaluation of a digital tool for detecting stress and craving in SUD recovery: An observational trial of accuracy and engagement. *Drug Alcohol Depend*. 2024;261:111353.
43. Businelle MS, Perski O, Hébert ET, Kendzor DE. Mobile health interventions for substance use disorders. *Annu Rev Clin Psychol*. 2024;20.
44. Dao KP, De Cocker K, Tong HL, Kocaballi AB, Chow C, Laranjo L. Smartphone-delivered ecological momentary interventions based on ecological momentary assessments to promote health behaviors: systematic review and adapted checklist for reporting ecological momentary assessment and intervention studies. *JMIR Mhealth Uhealth*. 2021;9(11):e22890.
45. Brinsley J, O'Connor EJ, Singh B, McKeon G, Curtis R, Ferguson T, et al. Effectiveness of digital lifestyle interventions on depression, anxiety, stress, and well-being: systematic review and meta-analysis. *J Med Internet Res*. 2025;27:e56975.
46. Scott CK, Dennis ML, Johnson KA, Grella CE. A randomized clinical trial of smartphone self-managed recovery support services. *J Subst Abuse Treat*. 2020;117:108089.
47. Lo CKM, Chan EWW, Chan EYC, Cho YW. Ecological Momentary Interventions To Reduce Addictive Behaviors: A Systematic Review. *Curr Addict Rep*. 2025;12(1):49.
48. Tassone VK, Quesnel DA, Parkington K, Rueda A, Martin J, Lee GH, et al. Improving adherence to physical activity in treatment-resistant depression: Protocol for a pilot randomized controlled trial of a remotely delivered program. *PLoS One*. 2025;20(9):e0330848.
49. Fatouros P, Tsirmpas C, Andrikopoulos D, Kaplow S, Kontoangelos K, Papageorgiou C. Randomized controlled study of a digital data driven intervention for depressive and generalized anxiety symptoms. *NPJ Digit Med*. 2025;8(1):113.

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