Technological Factors that Influence User Compliance with Behavior Change Support Systems: A Systematic Review

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Abstract

This study sought to identify technological factors that influence user compliance with physical activity behavior change support systems (BCSS). Systematic searches in 5 databases were conducted to identify studies that have investigated user compliance with physical activity BCSS. Following the application of predefined exclusion criteria, 20 articles were deemed relevant for inclusion. Through a synthesis of the intended outcomes described in these articles, two forms of compliance behaviors were identified: program compliance (aimed at making the users comply with the prompt from the BCSS) and behavior compliance (aimed at making the users' behavior correspond with the PA recommendation of the BCSS). This review also identified three categories of technological factors influencing compliance: user experience, persuasive systems features, and other behavior change strategies. This review highlights the importance of tailoring and prioritizing certain technological factors based on compliance behaviors.

Keywords: Compliance, Physical Activity, Behavior Change Support Systems, Persuasive Systems Design.

1. Introduction

Behavior change support systems are effective in promoting physical activity (Ekpezu et al., 2023). However, the long-term effectiveness of the physical activity outcomes from these systems is hindered by users' low compliance. Users do not comply with the prompts or requests from the BCSS to perform a physical activity voluntarily. Over 50% of physical activity BCSS users stop complying with the system within three months of downloading it (Valenzuela et al., 2018). However, these statistics may either be overestimated or underestimated. This is because users may not always carry or wear a BCSS, hence the BCSS may objectively measure user non-compliance while the user is subjectively measuring compliance. To ensure that the positive physical activity outcomes can be directly attributed to the effectiveness of a BCSS, an accurate assessment of factors that influence user compliance is needed.

Accordingly, systematic reviews have been conducted to summarize evidence on the factors that influence user compliance with physical activity BCSS. However, these reviews are limited. Some are generic and encompass various health behaviors (Kelders et al., 2012), while others are constrained by the technological context. That is, they are focused on a specific technological application such as mHealth-based interventions only (Yang et al., 2022) or mobile apps only (Yang et al., 2020), wearable trackers only (Marin et al., 2019), or they focused on patients with a specific chronic disease (Albergoni et al., 2019). Due to the limitations in scope, technology, and user context, it is challenging to generalize the factors influencing user compliance in prior studies to physical activity BCSS.

Motivated by the relevance of this topic in BCSS research, this study aimed to perform a systematic review to identify technological factors that influence user compliance with physical activity BCSS. To achieve this aim, two notable frameworks in BCSS research were adopted, namely the persuasive systems design (PSD) framework by Oinas-Kukkonen and Harjumaa (2009) and the outcome/change (O/C) matrix by Oinas-Kukkonen (2010). More specifically, this review will use these frameworks to analyze the persuasion content (such as the persuasion intent and the persuasion event) and the persuasive features of the physical activity BCSS that are intended to promote user compliance. Analyzing the persuasion intent includes identifying the persuaders and the change type. That is if the BCSS is intended for compliance change, behavior change, or attitude change. Analyzing the persuasion event includes identifying the contexts of use, the users, as well as the technology. As for analyzing the persuasive features, this will entail identifying systems features that fall into any of the four categories of persuasive system design principles namely primary task support,

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dialogue support, credibility support, and social support. Furthermore, this review will seek to identify what technological factors are considered to be significant determinants of user compliance in the BCSS studies that will be analyzed.

The rest of the paper is organized as follows: Section 2 will discuss the review methods and study selection criteria. Sections 3 to 5 will discuss the results, the findings, and conclusions respectively.

2. Methods

2.1. Identification of studies

To identify relevant studies, a systematic literature search was conducted in 5 electronic databases: Scopus, PubMed, Medline, CINAHL, and Cochrane Library. The search was limited to empirical studies published between 2010 and 2022, and the search strategy was based on the Population, Intervention, Comparison, Outcome (PICO) approach of which 3 search domains were identified. The search domains included Population (people aged 18 years and above), Intervention (BCSS for physical activity), and Outcomes (compliance change or behavior change). Search terms were customized to the selected databases and comprised of terms related to determinants (predictors, determinants, barriers, facilitators, constructs); compliance (adherence, compliance, nonadherence, noncompliance, relapse, attrition, dropout, engagement, disengagement); physical activity (exercise, physical activity, sports, fitness); BCSS (digital, smartphone, app, web-based, internet, mHealth, eHealth, mobile health, electronic health, online, technology); and intervention (intervention, program, treatment, therapy). It is important to note that, considering the plethora of approaches to investigate the behavioral outcomes of BCSS, the search for eligible studies was not limited to any specific study design.

2.2. Inclusion and exclusion criteria

This systematic review was restricted to studies on user compliance with BCSS that promote physical activity. Studies were considered eligible for inclusion/exclusion if they met the criteria presented in Table 1.

Table 1: Inclusion and exclusion criteria

Criteria	Inclusion criteria	Exclusion criteria
Search filter: year, publication type, publication stage, and language	Studies written in English and published in peer-reviewed journals between the years 2010 and 2022.	Unpublished studies, conference papers, book chapters, review papers, editorials, posters, and articles not written in English, and published earlier than 2010.
Participants	Study participants must be humans aged 18 years and above. Study participants must be required to use the BCSS for a specified period.	Non-human participants or participants less than 18 years old. Adherence guidelines for health care professionals or relatives of the patients.
Intervention	Studies that used technology to deliver physical activity or exercise programs.	The intervention was not delivered by technology or focused on health behavior interventions other than physical activity.
Outcomes	The primary outcome is compliance with the BCSS or the recommended physical activity.	Studies predicting a medical condition or the success of an intervention on clinical outcomes.

Figure 1 shows the PRISMA flow diagram and provides details of the study identification, screening, and selection process. During the initial search of the databases, the results were refined by years, document type, publication stage, source type, and languages. These resulted in 11543 records.

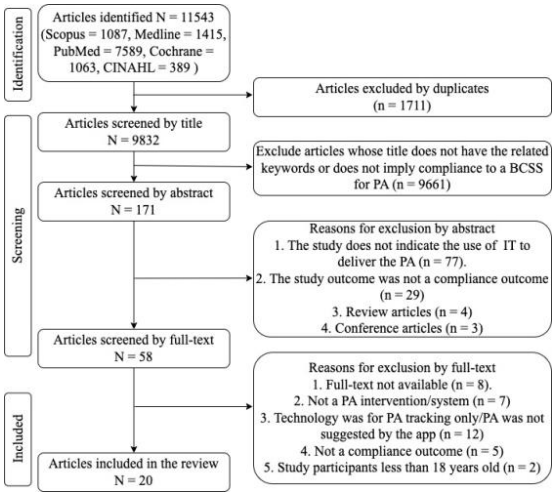

Figure 1: Flow diagram for article search and selection

These results were exported and then collated into a single MS Excel spreadsheet to extract unique articles. The exclusion by duplicates yielded 9832 unique articles, out of which 9661 were excluded on the basis that the article title did not meet the inclusion criteria. A further 113 were excluded based on the article abstract. The full text of the remaining 58 articles was assessed and 38 articles were excluded for reasons such as the physical activity not being delivered by technology. On the instance that the suitability of a study for a particular screening phase was debatable among the researchers, such a study was included in the next phase for further evaluation.

2.3. Data extraction

The data extraction was primarily guided by the persuasive system design (PSD) model and the outcome/change (O/C) matrix proposed by Oinas-Kukkonen and Harjumaa (2009) and Oinas-Kukkonen (2010) respectively. These are well-established and predominantly used frameworks for evaluating BCSS (Merz et al., 2021). The extracted data items included the persuasion intent (the primary aim of the study and the intended change), technology context (names and features of the technological platform), user context (condition and age of the participants), use context (what problem domain features were addressed by the system), persuasive system design features (based on the technical content and not the content of a computer-mediated interaction e.g., incentives for participation were not coded as rewards), and factors that influence compliance.

3. Results and findings

3.1. Study characteristics

Of the 20 included articles, five were published in the year 2020, four in 2021, and two each in the years 2022, 2019, 2017, and 2013. The years 2016, 2012, and 2010 had one article per year. Studies were conducted in Australia, the USA, and the Netherlands (n = 4 per country), Sweden, Germany, and Switzerland (n =2 per country), and the rest from Saudi Arabia and Spain. The 20 included articles were of different study designs namely randomized control trials (n =8), nonrandomized control trials (n = 6), quantitative descriptive studies (n = 3), and mixed methods studies (n = 3). The duration of the interventions lasted between 3 weeks and 52 weeks including the follow-up period for RCT studies. Refer to the Appendix for summaries of the study characteristics. The included studies will have designated IDs from 1 to 20.

3.2. Persuasion context: the intent

Persuader: All the included studies stated the primary objective of the study. This indicates that the research teams for the included articles are the principal persuaders. Twenty distinct physical activity BCSS were identified from the 20 included studies. There were either existing health/fitness apps available in the Google Play Store or iPhone operating system (iOS), or physical activity apps developed specifically for the study by its researchers. The studies were aimed at examining/identifying factors that predict or improve compliance with the BCSS (n = 9), evaluating the effectiveness of the BCSS in improving compliance (n = 9), and developing automatic compliance prediction or classification models (n = 2). Stating the study aim also indicates that there was a motive to persuade the users of the system.

Change type: Based on the primary/secondary outcomes of the included studies, the user context, and descriptions of the interventions, the expected outcomes of the physical activity apps were mapped to the outcome/change (O/C) matrix. The O/C matrix developed by Oinas-Kukkonen (2010) highlights three categories of behavior change; compliance change (C-Change), behavior change (B-Change), and attitude change (A-Change), and three potential outcomes; formation (F-Outcome), alteration (A-Outcome) and reinforcement (R-Outcome). It was observed that the 20 apps were targeted at:

i. C-Change (n = 10): aimed at making the users comply with the physical activity prompt from the BCSS i.e., program compliance.

ii. B-Change (n = 7): aimed at making the user's behavior correspond with the physical activity recommendation of the BCSS i.e., behavior compliance.

iii. Both B-Change and C-Change (n = 3). Refer to Table 2.

Table 2: Distribution of the intended O/C

O/C	Compliance Change	Behavior Change
F-O	**F/C** (Vries et al., 2017; Wanner et al., 2010; Wilroy et al., 2021; Zhou et al., 2019).	**F/B** (Bossen et al., 2013; Höchsmann et al., 2019; Lambert et al., 2017).
A-O	**A/C** (Alasfour & Almarwani, 2022; Reijen et al., 2016; Silveira et al., 2013; Simpson et al., 2020; Sun et al., 2021; Svingen et al., 2021; Wurst et al., 2020)	**A/B** (Albergoni et al., 2019; Bennell et al., 2020; Duong et al., 2022; Watson et al., 2012; Wilroy et al., 2021)
R-O	**R/C** (Bastidas et al., 2021)	**R/B** (Silveira et al., 2013; Wanner et al., 2010)
F-O= Form-Outcome, A-O = Alteration Outcome and R-O = Reinforcement Outcome)		

As shown in Table 2, apps targeted at B-Change were expected to form a physical activity compliance behavior (F/B), alter a physical activity behavior (A/B), and reinforce a physical activity behavior (R/B). Those targeted at C-Change were expected to form an act of complying with the physical activity BCSS (F/C), alter an act of complying with the physical activity BCSS (A/C), and reinforce an act of complying with the BCSS. Also, some of the apps were targeted at both B-Change and C-Change as their primary or secondary outcomes. In relation to the focus of this study, we refer to the C-Change as

program compliance, and the B-Change as behavior compliance. Existing literature (Albergoni et al., 2020) has described such change types as program adherence and volume adherence respectively.

3.3. Persuasion context: the event

Use context: All the articles reported the use of context. That is the reason for using information systems to promote physical activity or to deliver a physical activity program. For studies whose change type was compliance change, their predominant reason for using information systems was to improve compliance, monitor compliance, and predict compliance. Those for behavior change were used to reinforce, maintain, or promote physical activity and healthy lifestyles. While those for both compliance and behavior change were used to eliminate barriers to app use, promote compliance, promote physical activity, and monitor app use. These descriptions enabled an understanding of the kind of interaction within the BCSS and to what extent the potential outcomes may be attributed to the BCSS.

Furthermore, it was observed that the BCSS provided different forms of physical activities and exercises that were tailored to the preferences and characteristics of its users. Users with medical conditions were generally requested to perform predefined progressive strengthening/mobility/range of motion/flexibility/balancing exercises, while users without medical conditions had the freedom to select their exercise goals or follow predefined programs including moderate (walking) to vigorous (brisk walking, biking) physical activities.

User context: This information was extracted to identify the characteristics of the system users or study participants. Out of the 20 physical activity BCSS, thirteen were targeted at people with specific medical conditions (musculoskeletal conditions including knee/hip/joint osteoarthritis, spinal cord injuries, and impaired balance), four on existing users of physical activity BCSS with no disease and who were physically active, and three on physically inactive older adults with no specific disease.

Technology context: The technology context of all the included articles was explicitly stated and illustrated with screenshots of the app interface or a flowchart of the development of the app and its contents. The BCSS were installed on different technological platforms including web-based apps on tablets only (n = 8), web-based and mobile-based apps (n = 1), mobile apps for either iOS (n = 4), Android (n =1) or both iOS and Android (n = 3), gamified apps (n = 2) and semi-interactive SMS (n = 1). All the systems sought to persuade the users to achieve the desired outcomes or set goals. In addition to the aforementioned platforms, some of the studies used activity trackers, multimedia-based content including images and video, and health coaching via communication channels including text messages, email, and Zoom calls for monitoring of participant compliance behavior and for providing counsel and feedback.

3.4. Persuasive features

As mentioned earlier, the PSD framework was adopted to evaluate the persuasive features of the 20 physical activity BCSS. This framework describes how to design systems to motivate behavior change based on the four categories of PSD principles namely primary task support, dialogue support, credibility support, and social support. Existing literature has also argued that these features may facilitate both compliance change and behavior change. The various PSD features identified in the 20 physical activity apps of the included studies are presented in Figure 2. The shaded areas represent the persuasive features identified in the BCSS of the included articles.

Primary task support features provide a means to support users in performing the recommended physical activity. The identified features included personalization (15/20), self-monitoring (11/20), tailoring (10/20), reduction (8/20), and tunneling (2/20). Personalization was the most used feature in this category, and it was implemented as individualized exercise plans/workouts and feedback tailored to the user's characteristics, goals, progress, fitness levels, and compliance with the program or the behavior (physical activity). These implementations were observed to prevent the system or the persuaders from setting unrealistic and overwhelming goals for the users that may reduce the user's motivation to either behavior change or compliance change. It also facilitated a correct assessment of each user's compliance behavior. Self-monitoring was the second most used in this category, and it enabled the system users to visualize their progress and compliance behavior in real time. The visualizations were implemented in different forms such as a count of repetitions (e.g., step counts), compliance score, histograms, or pie charts to show completed workouts and activity levels, and plant growth stages to reflect progress towards a goal.

The physical activity routines in the BCSS were tailored for people with specific medical conditions (e.g., patients with an ankle sprain, knee osteoarthritis, and those on wheelchairs), age groups (e.g., older adults), culture, and gender (e.g., older Saudi Arabian women), level of technology acquaintance, and level

of exercise progression (e.g., intermediate level or expert level). The PACE app (Albergoni et al., 2020) in particular was developed in co-creation with older adults and with specific attention to their needs and preferences. It was also observed that the apps provided a means to reduce the users' efforts in carrying out the recommended physical activities (reduction) and also a means to progressively guide them towards achieving and maintaining daily activity levels (tunneling). This entailed the provision of instructional videos and indications on how to perform a specific exercise, the breaking down and explanation of every new routine, and the gradual incorporation of new and complex exercise routines. These features enable users to perform the suggested physical activity correctly.

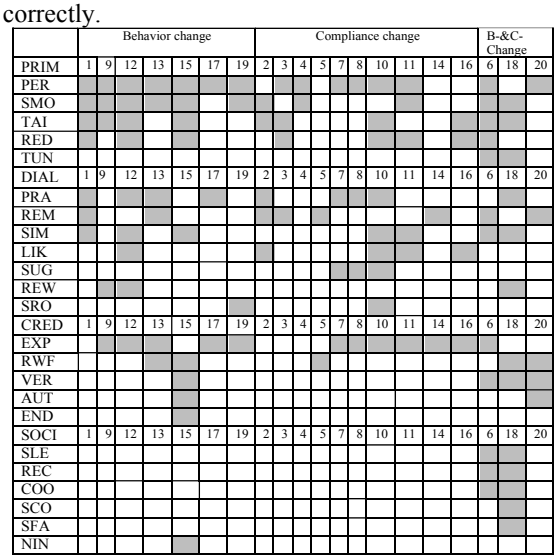

Figure 2: Persuasive features identified in BCSS discussed in the included articles. *Numbers 1 to 20 = designated IDs for each included article (see appendix). PRIM = primary task support, PER = personalization, SMO = self-monitoring, TAI = tailoring, RED = reduction, TUN = tunneling, DIAL = dialogue support, REM = reminder, PRA = praise, SIM = similarity, LIK = liking, SUG = suggestion, REW= rewards, SRO = social role, CRED = credibility support, EXP = expertise, AUT = authority, VER = verifiability, RWF = real-world feel, END = 3rd party endorsement, SOCI, SLE = social learning, REC = recognition, COO = cooperation, SCO = social comparison, SFA = social facilitation, NIN = normative influence.*

Dialogue support features provide a means to help users achieve their physical activity goals via computer-human interactions. All the features of this category (suggestion, reminders, praise, rewards, liking, similarity, and social role) were identified in the BCSS. Users received recommendations and tips on physical activities to be performed (Suggestion); alerts and notifications at pre-specified times to exercise (Reminders); motivational feedback on performance after each completed exercise session (Praise); and rewards in the form of water and building materials for gamified physical activity apps (Rewards). Some of the BCSS were designed with appealing features to increase attractiveness, fun, ease of use, and pleasure (Liking). They were also designed with metaphors that represented real-world scenarios and familiar environments that the users could identify with (Similarity). They included humanized animals exhibiting laziness or moodiness, locally recognizable mountains, and video clips imaging older persons carrying out the exercise. Users also had access to an animated virtual exercise advisor or physiotherapist (Social role) that provided behavior change support. The various implementations of the dialogue support feature provided positive reinforcement to the users to sustain their compliance with the BCSS (compliance change) as well as increase physical activity compliance (behavior change).

Credibility support features seek to increase the users' perceptions of the believability and reliability of the BCSS. Due to the subjective nature of some of the features in this category, not all the features (e.g., trustworthiness and surface credibility) were identified. However, this does not directly imply their absence in the BCSS. Expertise was the most used feature in this category. The content of the apps was based on guidelines from renowned health organizations (e.g., the American College of Sports Medicine, WHO, the American College of Sports Medicine, and European Association for Cardiovascular Prevention & Rehabilitation principles of exercise training, and the Dutch guidelines for physical activity. Other forms of expertise included developing the apps based on behavior change theories (e.g., social cognitive theory, self-determination theory), motivational and volitional strategies, and the involvement of physiotherapists, behavior change experts, and software developers in the app development process. The apps also provided information on health promotion articles and their core values. Third-party endorsement by the WHO was observed in only one app, while some apps referenced statements from renowned authoritative health institutions such as the WHO and the SWISS HePa. This indicated the presence of the authority feature in the apps. Information about the developers, the organization, and their partners, and a means for the users to contact them with features such as "contact us", "help", "about us", and "summary" menus were also provided by 5 of the apps. This indicated the presence of a real-world feel feature.

Social support features provide a means of supporting users via social influence. The features in

this category were observed mostly in studies whose intended change was both compliance and behavior change. Only one feature (normative influence) was observed for the BCSS whose intended change was behavior change, while the BCSS whose intended change was compliance change did not utilize any social support feature. The social support features are generally sparsely used in physical activity BCSS. Perhaps, this may be attributed to the negative user sentiments associated with it in behavior change (Nutrokpor et al., 2021).

It was observed that BCSS whose intended change was behavior change had more primary task support features than those intended for compliance change. These findings corroborate findings from existing reviews (Lehto & Oinas-Kukkonen, 2015; Shevchuk et al., 2019) regarding the predominant use of primary task support features in promoting behavior change. The limited use of these features also aligns with Kelders et al.'s (2012) claim that the primary task support features focuses on the activity of interest and not the process, making them less suitable for promoting compliance change. Furthermore, though the dialogue support features were less reflected in BCSS whose intended change is behavior change than primary task support, they were extensively employed in those intended for compliance change. This finding further supports Kelders et al.'s (2012) claim that the extensive use of dialogue support features is associated with better compliance.

3.5. Factors that influence user compliance

Different factors, spanning personal factors, contextual factors, and technology factors were identified from the included studies as factors that significantly influenced either program compliance (i.e., BCSS whose intended change is compliance change) or behavior compliance (i.e., BCSS whose intended change is behavior change). Given the scope of this review, specific attention was given to only technological factors. These technological factors were subsequently grouped into three categories namely user experience features, persuasive systems features, and other behavior change strategies (refer to Table 3).

Table 3: Technology factors influencing compliance/behavior change

Technological factors	Association with program/behavior compliance
User experience	Self-efficacy (Duong et al., 2022; Zhou et al., 2019), perceived risk of over-activity (Albergoni et al., 2020), interest/enjoyment (Höchsmann et al., 2019), perceived competence (Höchsmann et al., 2019), perceived usefulness (Lambert et al., 2017; Simpson et al., 2020), perceived satisfaction (Lambert et al., 2017; Mansson et al., 2020), intention to use (Lambert et al., 2017), convenience (Alasfour & Almarwani, 2022), perceived enjoyment (Simpson et al., 2020), ease of use (Simpson et al., 2020; Vries et al., 2017), attractiveness (Reijen et al., 2016)
Persuasive systems features	Personalization (Höchsmann et al., 2019), rewards (Höchsmann et al., 2019), similarity (Höchsmann et al., 2019), expertise (Bossen et al., 2013), social role (Vries et al., 2017; Watson et al., 2012), reminders (Alasfour & Almarwani, 2022; Vries et al., 2017; Wanner et al., 2010), liking (Alasfour & Almarwani, 2022), similarity (Alasfour & Almarwani, 2022), self-monitoring (Vries et al., 2017), Social learning, social comparison, recognition, and social facilitation (Silveira et al., 2013)
Other behavior change strategies	Social support (Bossen et al., 2013), feedback, and accountability (Simpson et al., 2020)

Behavior compliance was observed to be influenced by the three categories of technological factors. User experience features were the most reflected features for behavior compliance, and they included higher technology self-efficacy, perceived risk of over-activity, perceived competence, perceived usefulness, perceived satisfaction, and intention to use. Persuasive systems features included personalization, self-monitoring, rewards, similarity, social role, and expertise. Only social support from friends and family was reflected in the other behavior change strategy category.

Program compliance was influenced by user experience features such as ease of use, perceived satisfaction, perceived benefit, perceived enjoyment, and usability. When examining the persuasive systems features that influence program compliance, only dialogue support features (reminders, social role, similarity, and liking) were found to be determinants of program compliance. This observation is consistent with the findings in section 3.4, which highlighted the prominence of dialogue support features in studies on program compliance. Within the category of other behavior change strategies, only feedback and accountability were identified. Whereas the provision of feedback by a therapist has been extensively examined as a determinant of compliance behavior, accountability is a rarely explored factor. Oussedik et al. (2017) posit that incorporating accountability into compliance models will enhance user compliance.

For studies that sought to promote both program compliance and behavior compliance e.g., (Silveira et al., 2013; Wanner et al., 2010), dialogue support (e.g., reminders) and social support features were reflected as persuasive features that influenced user compliance. Interestingly, the social support features (including social learning, social comparison, recognition, social

facilitation, and cooperation) were reported to be more effective than primary task support features in motivating the users to comply with the prompts from the BCSS, continue their usage of BCSS, as well as reinforce their physical activity behavior. This implies that creating a social environment within a BCSS where users can support each other, interact with one another, and share experiences plays a pivotal role in encouraging both program compliance and behavior compliance. Providing an enabling environment where users can observe, learn, and imitate the behavior of other active users within a BCSS has the potential to improve compliance behavior (Ekpezu et al., 2023). User experience features included the first visit to the BCSS, starting a tailored module, and the amount of time spent in the tailored modules.

It is important to note that the effect of the three categories of technological factors (i.e., user experience, persuasive features, and other behavior change strategies) on user compliance varied across studies. Some studies such as Svingen et al. (2021) found inconclusive evidence regarding the influence of persuasive features and user experience features on user compliance. In Svingen et al.'s (2021) study, the BCSS did not improve user compliance. Similarly, Höchsmann et al. (2019) were inconclusive as to what behavior change strategies influenced user compliance. Regardless, user experience features accounted for the vast majority of technological factors that influence user compliance, followed by persuasive features, and then other behavior change strategies.

3.6. Implication of findings

The results from this review underscore the challenges of improving user compliance within physical activity BCSS using technological factors. The varying use of user experience features, persuasive features, and other behavior change strategies in physical activity BCSS points to the multifaceted nature of compliance behavior and the need to strike a balance between these features. Also, the inconsistencies in the effect of persuasive features and user experience features on user compliance as demonstrated in Svingen et al.'s (2021) study, suggest that these factors may not universally drive compliance in all implementations of physical activity BCSS. This highlights the need for designers and researchers to systematically consider the contexts and the intended change types when designing physical activity BCSS. Perhaps, designers and researchers may consider iterative design processes that involve continuous evaluation of user compliance behavior and adaptation based on real-world outcomes. Furthermore, the inconclusive evidence found in Höchsmann et al.'s (2019) study regarding what behavior change strategies influenced user compliance points to the fact that there are research gaps that elucidate the direct relationship between certain technological factors and compliance outcomes.

Overall, findings from this review provide practical recommendations on which technological factors to prioritize when designing BCSS to promote a high compliance rate to program compliance, behavior compliance, or both program compliance and behavior compliance. It provides designers and researchers with insights into how persuasive features may be tailored to different compliance behavior types. Furthermore, by applying the PSD framework and the O/C matrix in the evaluation of physical activity BCSS, this review points to the feasibility of adopting these frameworks for evaluating BCSS in other domains.

4. Conclusions

This review provided a systematic analysis of the persuasion intent, persuasive event, persuasive features, and factors influencing compliance in physical activity BCSS that seeks to promote user compliance. The primary focus was on outlining the persuasive features that are used in BCSS that seek to promote user compliance and identifying technological factors that influence user compliance. From the 20 included articles, two classes of compliance behavior namely program compliance and behavior compliance were identified. In addition, the persuasive features and technological factors associated with each class of compliance behavior were highlighted.

The review results suggest that for physical activity BCSS targeted at behavior compliance, more attention should be given to primary task support features, followed by dialogue support, credibility support, and in rare cases social support. Whereas for program compliance, more attention should be given to dialogue support features, followed by primary task support features, and credibility support, but no social support features. Evidently, primary task support features focuses on the activity or behavior itself, while dialogue support reinforces the processes that lead to sustained compliance with the BCSS.

Furthermore, the review outcomes suggest that there are 27 emerging technological factors categorized into three groups i.e., user experience, persuasive features, and other behavior change strategies. However, the current emphasis is primarily on user experience and persuasive features. The influence of other behavior change strategies such as

accountability to a virtual coach show positive prospects in improving user compliance. Since this was observed in only one out of the 20 included articles and is also a rarely studied construct in compliance models, further investigations to examine the efficacy of this strategy are recommended. Specifically, in BCSS that allows a simulation of human behavior e.g., a virtual reality environment.

A limitation of this review may lie in the study selection inclusion criteria. By exclusively considering only journal articles, relevant conference articles that may provide more insights may have been overlooked. In addition, the identified persuasive features may not be exhaustive. Most of the persuasive features were coded based on the BCSS descriptions in the included studies and in a few instances, based on the BCSS.

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Appendix: Characteristics of the PA BCSS

ID	Ref	Persuasion Intent	[a]Name of the app and [b]technology context
1	(Duong et al., 2022)	To explore person-level predictors of adherence to a step-count intervention	[a] PhysiApp [b] Mobile app on iPad (iOS)
2	(Alasfour & Almarwani, 2022)	To examine the effect of a fitness app on adherence to home exercise programs	[a] My Dear Knee app [b] Mobile app for Android and iOS devices
3	(Sun et al., 2021)	To examine the effectiveness of the mobile app in motivating adherence to exercise plans	[an] ActiveTrack [b] Mobile app for iPhone users only (iOS)
4	(Bastidas et al., 2021)	To design an automatic classification of users as adherent and non-adherent	[a]Mammoth Hunters (MH) [b] Mobile app for Android
5	(Svingen et al., 2021)	To evaluate the effect of an app on exercise adherence, range of motion, and self-efficacy compared to standard rehabilitation	[a]Böjsenskada (flexor tendon injury) [b] Mobile app for Android and iOS devices
6	(Wilroy et al., 2021)	To examine the potential mediators of adherence to home-based exercise	[a]SUPER-HEALTH app [b] Web app installed on tablets
7	(Wurst et al., 2020)	To examine the effect of incentives and their moderators on program adherence to a PA intervention	[a] Fitness Coach [b] Web-based app
8	(Bennell et al., 2020)	To evaluate the effect of a theoretically informed 24 weeks SMS program on self-reported adherence to a prescribed exercise program	[a] ADHERE [b]automated, semi-interactive SMS-based – mobile phone
9	(Albergoni et al., 2020)	To gather adherence data and identify its associated determinants	[a] PACE app [b]LENOVO Tablet
10	(Mansson et al., 2020)	To explore older adults' participation in a 4-month self-managed fall prevention exercise intervention	[a] Safe Step app [b]web based or mobile app
11	(Simpson et al., 2020)	To investigate the feasibility of a remotely delivered exercise program on adherence	[a]Mini Mountain climb game [b]Gamified app installed on tablets and connected via Bluetooth to a chair-based sensor
12	(Höchsmann et al., 2019)	To investigate the feasibility of behavior change technique-based smartphone games in improving PA adherence and intrinsic motivation.	[a]"Mission: Schweinehund" [b]Gamified smartphone app
13	(Zhou et al., 2019)	To develop and test adherence prediction models using objectively measured PA data	[a] mPED app [b] mobile app for iOS
14	(Vries et al., 2017)	To identify the determinants of adherence to the online component of e-Exercise	[a] e-Exercise [b] web-based app
15	(Lambert et al., 2017)	To investigate the efficacy of an app with remote support in improving adherence compared to paper handouts	[a]app associated with www.physiotherapyexercises.com [b] web-based app
16	(Reijen et al., 2016)	To evaluate the effectiveness of an interactive mobile app in promoting higher compliance with the neuromuscular training program	[a] 'Strengthen your ankle' app [b]Mobile app for Android and iOS devices
17	(Bossen et al., 2013)	To identify factors that facilitate or impede the usage of web-based PA intervention	[a] Join2move [b] web-based app
18	(Silveira et al., 2013)	To investigate which information technology-mediated motivation strategies increased adherence to physical exercise training plans	[a] ActiveLifestyle [b] tablet-based app for iOS
19	(Watson et al., 2012)	To evaluate the effectiveness of virtual coaching compared with the use of pedometers and website alone in improving PA levels	[a]ActiHealth website and computer-animated virtual coach software [b] web-based installed on computers
20	(Wanner et al., 2010)	To assess and compare user characteristics and adherence to a website in an open-access context	[a]Active-online [b] web-based app

PA= physical activity