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Enhancing Perceived Health Competence: The Impact of Persuasive Social Support Features in Health and Fitness Apps

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ABSTRACT

This study investigates how users' perception of persuasive social support features influences perceptions of their health competence in health and fitness apps. Within the support of existing theories/frameworks on social support, the study develops a research model and hypotheses. Quantitative data was collected from 469 health and fitness app users and analyzed using partial least squares structural equation modelling. The results demonstrates that providing users with a means to share their experiences out of the desire to boost their ego and gain social recognition as well as a means to learn new behaviors by observing and imitating other's behaviors within the app increases their confidence in their capabilities to perform and maintain positive health and fitness behaviors and outcomes using the app. The findings suggest that users' perception of their health competence can be significantly improved when social support features are incorporated into health and fitness apps.

KEYWORDS

Persuasive systems; behavior change support system; persuasive technology; health and fitness; physical activity; perceived competence

1. Introduction

Recent advancements in technology, particularly the emergence of persuasive systems have revolutionized the use of Information Systems for human behavior change without force or coercion. These systems utilize behavior change theories and social influence principles to create communities with peer-driven supporters who motivate each other to adopt healthy behaviors. Although these communities primarily comprises more observers than contributors (Tikka & Oinas-Kukkonen, 2017; Wiafe et al., 2020), an individual's perception of social support from observing and evaluating the actions of others in their network is a crucial driver of self-efficacy and health competence (Guan et al., 2021; Tikka & Oinas-Kukkonen, 2017). Social support is a vital antecedent to higher self-efficacy, which positively impacts an individual's competence (Bandura, 2004). It is pertinent to persuasive systems as users rely on support from their networks to manage their health behavior effectively (Tikka & Oinas-Kukkonen, 2017). Accordingly, a deeper understanding of social support in persuasive systems and its effect on user competence is now essential. Persuasive systems are information systems that are designed to persuade users to change their behavior and attitudes voluntarily (Oinas-Kukkonen & Harjumaa, 2009).

Previous research on persuasive systems has predominantly investigated such phenomenon using the persuasive systems design (PSD) framework by Oinas-Kukkonen and Harjumaa (2009). The PSD model provides a framework for designing and evaluating persuasive systems. It comprises of four categories of principles (namely primary task support, dialogue support, credibility support, and social support) that foster behavior change. And the social support principle is arguably a predictor of users' perceived health competence (Ekpezu et al., 2023; Oduor & Oinas-Kukkonen, 2021). The social support principle within persuasive systems leverages social influence strategies to promote positive health behaviors. These strategies incorporate supportive features such as observing others' behaviors, providing encouragement, recognizing achievements, and facilitating the sharing of information and achievements. However, the effect of specific social support features within persuasive systems on the perceived health competence of its users has not been largely explored (Kytö et al., 2022), and existing evidence has been contradictory.

On the one hand, some studies have demonstrated the positive influence of perceived social support as a PSD construct on self-efficacy and perceived competence (Ekpezu et al., 2023; Tikka & Oinas-Kukkonen, 2017). On the other hand, a conflicting viewpoint exists, as Oduor and Oinas-Kukkonen (2021) study showed that perceived social support does not influence users perceived health competence. Whereas users are sometimes indifferent in their perceptions of social support in persuasive systems (Alhammad et al., 2021), higher perceptions of its presence have also been reported to trigger negative emotions (Nutrokpor et al., 2021) and backfires that threaten the user's self-esteem (Ahmad et al., 2019; Orji et al., 2019). Silveira et al. (2013) argue that users perform better in the presence of social support than other PSD principles such as dialogue support.

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Perceived health competence is critical to driving behavior change in persuasive systems (Bachmann et al., 2016; Sheeran et al., 2021). According to Fishbein's (2000) integrative model, an individual's skills and abilities to perform a target behavior are one of the factors that will more likely influence the performance of that behavior. This study seeks to answer the research question, *how and to what extent do users' perceptions of the persuasive social support features influence perceptions of their health competence within health and fitness apps?* Health and fitness apps were considered because they predominantly support the potential opportunities presented by persuasive systems (Kim et al., 2023).

This study adopts the persuasive systems design (PSD) framework as its principal theoretical foundation. It explores the relationship between users' perceptions of the social support features within the PSD and their beliefs regarding their abilities to perform and maintain positive health behaviors. Perceived social support is antecedent to improving health competence among users of persuasive systems (Kytö et al., 2022). Thus, findings from this study will highlight how each social support feature impacts users' perceived health competence. The findings will also provide designers and researchers with an understanding of how to optimize the design and functionality of social support features within persuasive systems. This will facilitate the provision of tailored support mechanisms that will boost users' confidence towards the performance and maintenance of positive health behaviors.

The remainder of the paper is organized as follows. First, an overview of the theoretical framework that serves as the foundation for this study is provided. Building on the theoretical basis and contextualized arguments, a research model is developed, and hypotheses are formulated. This is followed by a description of the research design, the methods, and materials used for the study. In section 4, an assessment of the measurement and structural model is presented. Specifically, an analysis of the validity and reliability of the measurement model and the significance of the hypotheses are discussed. The mediation and subgroup analysis are also presented in section 4. This is followed by discussions, interpretations of findings, and the study limitations, whilst section 6 presents the conclusions derived from the study.

2. Related literature

2.1. The persuasive systems design framework

Persuasive systems are used to promote behavior change in various domains, and they utilize computer-mediated or computer-human persuasion to motivate users by integrating behavior change strategies to help achieve their goals. The Persuasive Systems Design (PSD) framework is the most used framework for designing and evaluating persuasive systems (Merz et al., 2021). It guides the analysis of the persuasion context including understanding users, uses, and technological factors that affect system design.

The framework provides a structure for designing and evaluating persuasive systems based on seven key postulates and four system principles. The four principles are primary task support, dialogue support, credibility support, and social support (Oinas-Kukkonen & Harjumaa, 2009). The primary task support principle provides support for system users to achieve their primary task and it is most often supported by the dialogue support principle, system credibility support principle, and social support principle. The dialogue support principle provides feedback and guidance to users through computer-human interaction, the credibility support principle focuses on providing a system that is believable and trustworthy, and the social support principle focuses on creating and providing a supportive community.

2.2. Perceived social support features and perceived health competence

The social support principle of the PSD consists of seven system features and these features have been widely used in the design of health and fitness apps (Orji & Moffatt, 2018). These features are social learning, social comparison, social facilitation, competition, normative influence, cooperation, and recognition. The system features are drawn from classical social psychology theories including the Social Facilitation Theory (Zajonc, 1965), Social Learning Theory (Bandura, 1971), Social Comparison (Festinger, 1954), the Focus of Normative Conduct (Cialdini et al., 1991), Recognition, Competition and Cooperation Theory (Malone & Lepper, 1987). Although the need for persuasive social support features in persuasive systems design is increasingly recognized by researchers and practitioners (Alhammad et al., 2021; Karppinen et al., 2016), there is a lack of explicit differentiation of how these features influence users' perceived competence (Yeoh et al., 2022).

In healthcare, perceived health competence refers to an individual's level of confidence in their ability to perform and maintain positive health behaviors and outcomes (Bachmann et al., 2016; Rodgers et al., 2014). While perceived health competence and self-efficacy are often used interchangeably, some researchers argue that self-efficacy is better suited for predicting specific behaviors in specific situations, whereas perceived health competence reflects the overall effectiveness of an individual's health behavior (Rodgers et al., 2014; Smith et al., 1995).

The relationship between the seven features of the persuasive social support principle has not received adequate research attention (Kytö et al., 2022; Yeoh et al., 2022), particularly on how they interact to influence users' perceived health competence. Previous studies (e.g., Rice et al., 2013; Shen et al., 2018) have examined social support as an undifferentiated social cognitive construct and focused on specific types of social support, such as parental or peer support. While these studies have shown that social support may influence competence levels, they did not consider social support as a PSD construct with distinct features. Issues regarding how each feature affects the user's perceived health competence are unknown. This may be a potential reason for the contradictory results in persuasive systems research. For instance, some studies (Ahmad et al., 2019; Orji et al., 2019) have identified persuasive social support

features such as competition, social comparison, and cooperation as facilitators of positive health behaviors. These features simplify the performance of a target behavior by challenging users to perform better and providing a sense of accomplishment for well-performed behaviors. Yet, Palant and Himmel (2019) have argued that these features may yield adverse effects, such as creating unnecessary tension within the user group, social isolation, inter-group tension, diminished self-esteem, and self-confidence. The application of social influence principles to drive behavior change might also lead to issues such as invasion of privacy, violation of personal boundaries, and unintended emotional consequences such as body shaming, pressure, resentment, and anxiety (Nutrokpor et al., 2021; Orji et al., 2019).

Consequently, there is a knowledge gap on which specific persuasive social support features are most effective in promoting perceptions of the competence levels of health and fitness app users. This study, therefore, examines how users' perceptions of each social support feature affect perceptions of their capabilities to perform and maintain positive health behaviors and outcomes within health and fitness apps.

3. Hypotheses formulation

The research model proposed in this study is shown in Figure 1, while the theoretical underpinnings of the constructs are summarized in Table 1. In the proposed model, all the relationships between the constructs are assumed to be positive. The model consists of perceived social facilitation, perceived social learning, perceived normative influence, perceived social comparison, perceived cooperation, perceived competition, perceived recognition, and perceived health competence. While these constructs are inherently generic, they have been specifically adapted and defined to align within the context of health and fitness apps.

3.1. Perceived social facilitation and perceived social learning

Users' perception of social facilitation features in health and fitness apps may influence their social learning behaviors. Perceived social facilitation is the extent to which health and fitness app users perceive that an app provides a means to identify other users who are engaging in the same behavior or activity. The Social Facilitation Theory (Zajonc, 1965) suggests that the presence of peers or non-peers can enhance an individual's performance of a specific behavior. This has been confirmed by Kim et al. (2023). An increase in arousal caused by the awareness of others' presence (i.e., audience-effect) plays a crucial role in social facilitation. Therefore, when health and fitness apps allow users to perceive that their actions are observed by other users, it may motivate users to increase or improve their performance. Audience-effect facilitates evaluation apprehension and makes users more self-conscious, leading to increased arousal and improved performance (Park et al., 2023). Similarly, a co-action effect (i.e., when users perform tasks alongside others doing the same task) may increase arousal and motivation (Park et al., 2023). This enhances user performance.

Both audience-effect and co-action effect leads to Social Learning. This is because these forms of social facilitation approaches provide an enabling environment for users to observe and learn from each other. Although Myers (2013) argues that this may either enhance or impair performance depending on the complexity of the task, identifying the performance of other users encourages some level of observation and learning from others (Aldenaini et al., 2023; Kim et al., 2023). In health and fitness apps, researchers have argued for a possible relationship between social facilitation and social learning (Park et al., 2023) since both activities

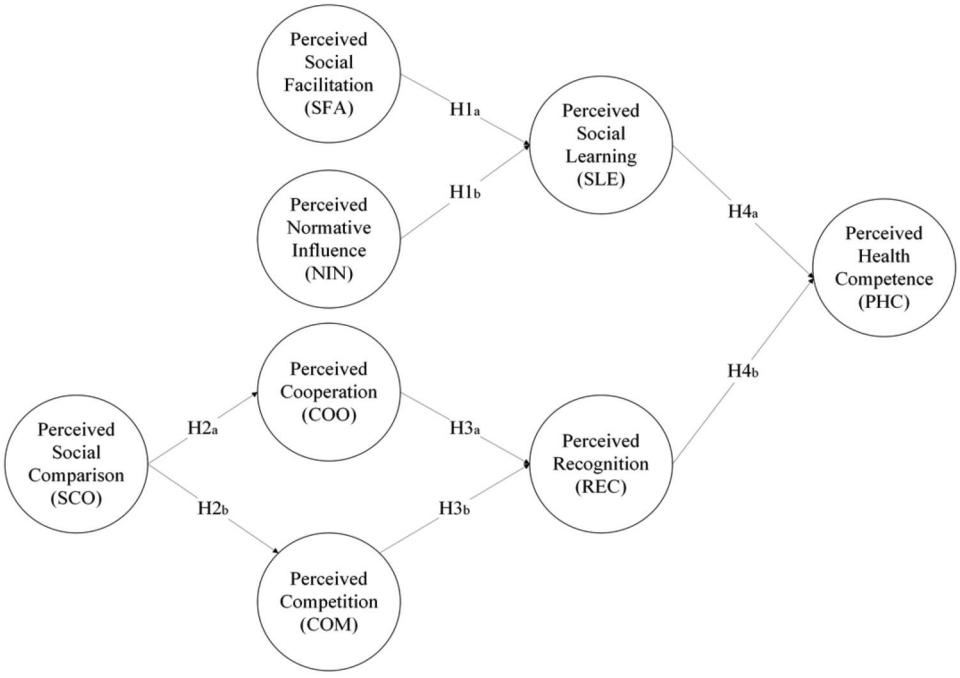

Figure 1. Proposed structural model.

Table 1. Theoretical background and working definitions of the constructs.

Construct	Definition	Working definitions as PSD constructs (Oinas-Kukkonen & Harjumaa, 2009)
Social facilitation	A considerable effect of the presence of others on an individual (Zajonc, 1965).	System users are more likely to perform a target behavior if they discern via the system that others are performing the behavior along with them.
Normative influence	Conforming to norms and experience in order to be accepted by peers (Cialdini et al., 1991).	A system may leverage peer pressure to increase the likelihood that a person will adopt a target behavior.
Social comparison	An individual's evaluation of himself based on the behavior of others (Festinger, 1954).	System users will have a greater motivation to perform the target behavior if they can compare their performance with the performance of other system users.
Cooperation	Striving together to achieve a common goal (Malone & Lepper, 1987)	A system can motivate users to adopt a target attitude or behavior by leveraging human beings' natural drive to cooperate.
Competition	Striving to achieve the same goal as others (Malone & Lepper, 1987)	A system can motivate users to adopt a target behavior or attitude by leveraging human beings' natural drive to compete.
Social learning	Learning a new behavior by observing how others perform the same behavior (Bandura, 1971).	A system user will be more motivated to perform a target behavior if (s)he can use a system to observe others performing the behavior.
Recognition	Gaining approval or acceptance from either competing or cooperating with others (Malone & Lepper, 1987).	By offering public recognition for an individual or group, a system can increase the likelihood that a person will adopt a target behavior.
Perceived health competence	The degree to which individuals feel capable of effectively managing their health outcomes (Smith et al., 1995).	The degree to which health and fitness app users feel capable of performing and maintaining positive health behaviors and outcomes – *authors' definition.*

involve the act of perceiving and monitoring the actions of other users within the app. For instance, social facilitation motivates users to train together in a virtual fitness environment (Far et al., 2015). And games that are designed to promote physical activities leverage social facilitation to improve learning (Park et al., 2023). Thus, when users perceive that they can identify other users performing physical activities or living healthier via an app, they are more likely to learn and imitate the actions of other app users. This study hypothesize that,

$H1_a$: Users' perception of social facilitation will influence their perception of social learning within health and fitness apps.

3.2. Perceived normative influence and perceived social learning

Users' perception of normative influence within health and fitness apps may shape their perception of social learning processes. Perceived normative influence is the extent to which health and fitness apps foster a sense of shared goals and establishes norms for behavior adoption. Norms are sources of influence on an individual's behavior and they are characterized by the perception of either what is done, or what is approved or disapproved by the majority of people within the same group (Cialdini et al., 1991). An individual's response to norms is dependent on the degree to which his/her attention is focused on that norm (Cialdini et al., 1991; Yeoh et al., 2022). The desire to gain social acceptance among peers leads to imitating and learning their behavior (Cialdini & Goldstein, 2004). This leads to learning through observing others.

Therefore, the perception of normative influence may facilitate the development of social learning behaviors among app users. As explained earlier, social learning is the process through which health and fitness app users observe and learn from the behaviors and actions of other users within the app. When users believe that an app connects them with like-minded peers who collectively endorse certain behaviors, they are more inclined to engage in observational learning, adapting their actions to align with the established norms. This interplay between perceived normative influence and social learning underscores the pivotal role that norm-setting features play in shaping users' behavior adoption and the learning mechanisms within health and fitness apps. In health and fitness apps, features that allow users to form peer-support communities for group discussion as well as allow users to share and view information and experiences from other users may promote social learning (Aldenaini et al., 2023). Thus, it is hypothesized that.

$H1_b$: Users' perception of normative influence will influence their perception of social learning within health and fitness apps.

3.3. Perceived social comparison, perceived cooperation, and perceived competition

The role of perceived social comparison in health and fitness apps extends beyond self-evaluation. It potentially shapes other users' perception of cooperation levels. Perceived social comparison is the extent to which health and fitness app users believe that an app has features that allow users to compare their performance with others. It involves self-evaluation and can result in either self-enhancement (when comparing oneself to those perceived as inferior) or self-improvement (when comparing oneself to those perceived as superior) (Festinger, 1954; Ha et al., 2023). The upward or downward comparison with others has both positive and negative effects on cooperation (Orji et al., 2019). Users may be more motivated to cooperate and work together with

those that they perceive as superior, and less likely to cooperate with those they perceive as inferior.

Health and fitness apps that allow users to share and compare their well-being goals with peers, may persuade them to emulate other user's behavior. For example, some apps provide users with the means to view and compare their performance (e.g., step count, calories burnt, distance walked) with other users via visual/graphical charts, comparison lists, and leaderboard ranking (Aldenaini et al., 2023; Kim et al., 2023). This facilitates closer interactions between users of the same app (Ahmad et al., 2019), and promotes social consistency and accountability among users (Orji et al., 2019). Therefore, this study hypothesizes that users' perception of social comparison in a health and fitness app will influence their perception of the level of cooperation with others using the app. That is,

$H2_a$: Users' perception of social comparison will influence their perception of cooperation within health and fitness apps.

Although the desire to comprehend oneself through comparison drives social comparison behaviors, the promotion of competition within health and fitness apps has the potential to intensify these tendencies (Garcia et al., 2013). Health and fitness apps promote competition by comparing the performance of users with high-performing peers and encouraging low-performing users to emulate the behavior of those who excel (Orji et al., 2019; Vlahu-Gjorgievska et al., 2019). The existence of features (e.g., leaderboard ranking, displaying a progress bar for the competitors, and sharing performance/progress via social networks) that promote competition in these apps stimulates social comparison (Aldenaini et al., 2023). Although studies have established a positive relationship between social comparison and competition within social networking sites (Garcia et al., 2013; Stibe & Oinas-Kukkonen, 2014), this relationship has not been empirically validated within health and fitness apps. This study therefore hypothesizes that:

$H2_b$: Users' perception of social comparison will influence their perception of competition within health and fitness apps.

3.4. Perceived cooperation, perceived competition, and perceived recognition

User's perception of cooperation and competition within health and fitness apps may influence their motivation and engagement levels, considering that humans are inclined to collaboration and rivalry. Perceived cooperation is the extent to which health and fitness app users believe that the app will facilitate opportunities for them to collaborate and offer mutual support to fellow users, while perceived competition is the degree to which users feel that the app will motivate their target behavior by providing opportunities for them to compete with others. Both cooperation and competition leverage the natural human drive for collaboration and competition and they provide intrinsic motivation that is only present in the presence of other people (Wolf et al., 2021). Health and fitness apps offer users the opportunity to compete individually or as group members, while cooperation emphasizes mutual support and group reinforcement.

Social competition may be implemented using gamified strategies, leaderboard ranking, sharing performance, and displaying progress bars for competitors (Aldenaini et al., 2023) whereas cooperation is implemented in the form of providing group tasks (Cibrian et al., 2016). Despite their difference, these two social support features complement each other (Orji et al., 2019). Competition and cooperation have been shown to increase users' sense of accomplishment (for their success or contribution) and recognition from other users (Wolf et al., 2021). This study hypothesizes the following:

$H3_a$: Users' perception of cooperation will influence their perception of recognition within health and fitness apps.

$H3_b$: Users' perception of competition will influence their perception of recognition within health and fitness apps.

3.5. Perceived social learning and perceived health competence

The provision of social learning features in health and fitness apps may foster behaviors through observation and imitation of proficient peers. This suggests that users perceiving the presence of social learning in these apps will also perceive that they are competent in performing the appropriate health behaviors. As explained previously, perceived social learning is the degree to which health and fitness app users feel that an app will enable them to learn new behaviors by observing and imitating other users. It involves acquiring new behaviors through observation and imitation of individuals with common interests particularly if the observed changes are positive (Bandura, 1971). However, the learner's ability to differentiate and acquire relevant behaviors from peers is dependent on the learner's competence (Whalen et al., 2018).

Health and fitness apps employ social learning by allowing users to observe and interact with other users, motivating them to adopt a positive attitude toward the observed behaviors and encouraging them to imitate these behaviors (Oinas-Kukkonen & Harjumaa, 2009). Therefore, it is reasonable to hypothesize that the act of observing and imitating the actions of an individual perceived as highly competent in a particular task is more likely to improve the learner's proficiency in effectively executing the same task. Thus,

$H4_a$: Users' perception of social learning will influence their perceptions of health competence within health and fitness apps.

3.6. Perceived recognition and perceived health competence

The act of sharing experiences in health and fitness apps is driven by a desire for self-esteem elevation and social validation, thus users' perception of recognition may facilitate their perception of their competence levels when using these

apps. Individuals share their experiences with the intent to elevate their self-esteem and garner attention and social validation (Oinas-Kukkonen & Oinas-Kukkonen, 2013). Recognition is a value that individuals obtain from gaining approval and acceptance from others and perceived recognition is the degree to which health and fitness app user feels that the app will increase their likelihood to change their behavior by receiving acknowledgment from other users. Positive recognition and support from peers can increase the likelihood that the user will adopt a target behavior and lead to self-awareness and a boost of self-esteem (Krause et al., 2021). Therefore, publicly recognizing well-performing users with badges and rewards via dashboards or leaderboards may reinforce them to continue performing and maintaining positive health behaviors. Existing evidence suggests that Twitter users who were publicly recognized with special titles were significantly more affirmative regarding their ability to improve the performance of positive behaviors (Stibe & Oinas-Kukkonen, 2012). Thus, it is hypothesized that.

$H4_b$: Users' perception of recognition will influence their perceptions of health competence within health and fitness apps.

4. Materials and methods

4.1. Measurement instrument

To examine the proposed relationships and measure its validity, data was collected using the Webropol platform. A combination of previously validated instruments such as the perceived health competence scale by Smith et al. (1995), which has been recently used in several studies e.g., (Cass et al., 2021) and other questions developed based on the existing theories were used. To ensure the appropriateness of the questions, clarity, reliability of constructs, and response duration, the questionnaire was pretested on 32 respondents (20 females and 12 males, ages between 26 and 35 years). These respondents requested changes in the Likert scale from 7 to 5, with an argument that the 7-point scale extends response time and may lead to respondents' withdrawal during data collection. Overall, the results of the pretest demonstrated acceptable levels of indicator loadings and construct reliabilities (Cronbach's Alpha). That is, all values were greater than 0.708. The measurement instruments were adopted for the main survey. Responses from the pre-test were deleted from Webropol before rolling out the main survey.

The questionnaire was written and administered in English. An opening question (i.e., Do you use any health and fitness app? [Yes/No]) was used to screen respondents who do not use any form of health and fitness app. Further questions were also used to further screen respondents' appropriateness for the study. See Figure 2 for a flowchart for the filtration of respondents. Subsequent questions sought to investigate their demographic information and their evaluations of the various constructs. At least three questions were used to measure each construct. Refer to Table 2 for the list of constructs and question items.

4.2. Data collection and respondents' demographics

Convenience sampling was used to recruit participants for the study. The survey link was shared via electronic mailing lists of several institutions. Participation was voluntary and all responses were anonymized. Data was collected in seven weeks. The decision to stop on the seventh week was based on the percentage of responses that were received in the fifth and sixth weeks. Approximately 3% of the data was received between these weeks. Thus, the decision to terminate the survey due to the observed lower turnout rate. A total of 678 responses were received.

After the selection, 469 valid responses were used for the analysis. Table 3 presents the descriptive statistics for the selected respondents (i.e., users of health apps). The majority of the respondents were males (71.86%), 84.64% were undergraduate students, and approximately 33.47% used health and fitness apps daily. About 29% of the respondents were weekly users, 25.16% were monthly users, and 11.73% were occasional users.

5. Data analysis and results

To test the research model, Partial Least Squares Structural Equation Modelling (PLS-SEM) was used. PLS-SEM was chosen due to the exploratory nature of the study and the non-normal distribution of the dataset. The SEMinR library in RStudio was utilized for the analysis. The RStudio application is an open-source integrated development environment (IDE) that enables the productive conduct of computational analyses using R language. The analysis involved an assessment of the measurement and structural model, a mediation analysis, and a subgroup analysis.

5.1. Measurement model assessment

The item loadings, the reliability and validity of the constructs were evaluated using the threshold values specified by Hair et al. (2022). All item loadings were substantially higher than the 0.708 thresholds (refer to Table 2). Cronbach's Alpha (CA) and Composite Reliability (CR) were used to assess internal consistency reliability. The results show that they were all greater than the 0.70 and less than the 0.95 recommended thresholds. The Average Variance Extracted (AVE) was also greater than the cut-off point of 0.50. Refer to Table 4. Thus, the model meets intrinsic reliability and convergent validity criteria.

Furthermore, the constructs' discriminant validity was assessed using one of the commonly used measures; the Fornell and Larcker (1981) criterion. Table 4 shows that the square root of the AVE for each construct was all greater than the correlations in the respective columns and rows. This indicates that the measurement model exhibited adequate discriminant validity.

5.2. Structural model assessment

Several measures were employed to assess the structural model. Firstly, the Variance Inflation Factor (VIF) was

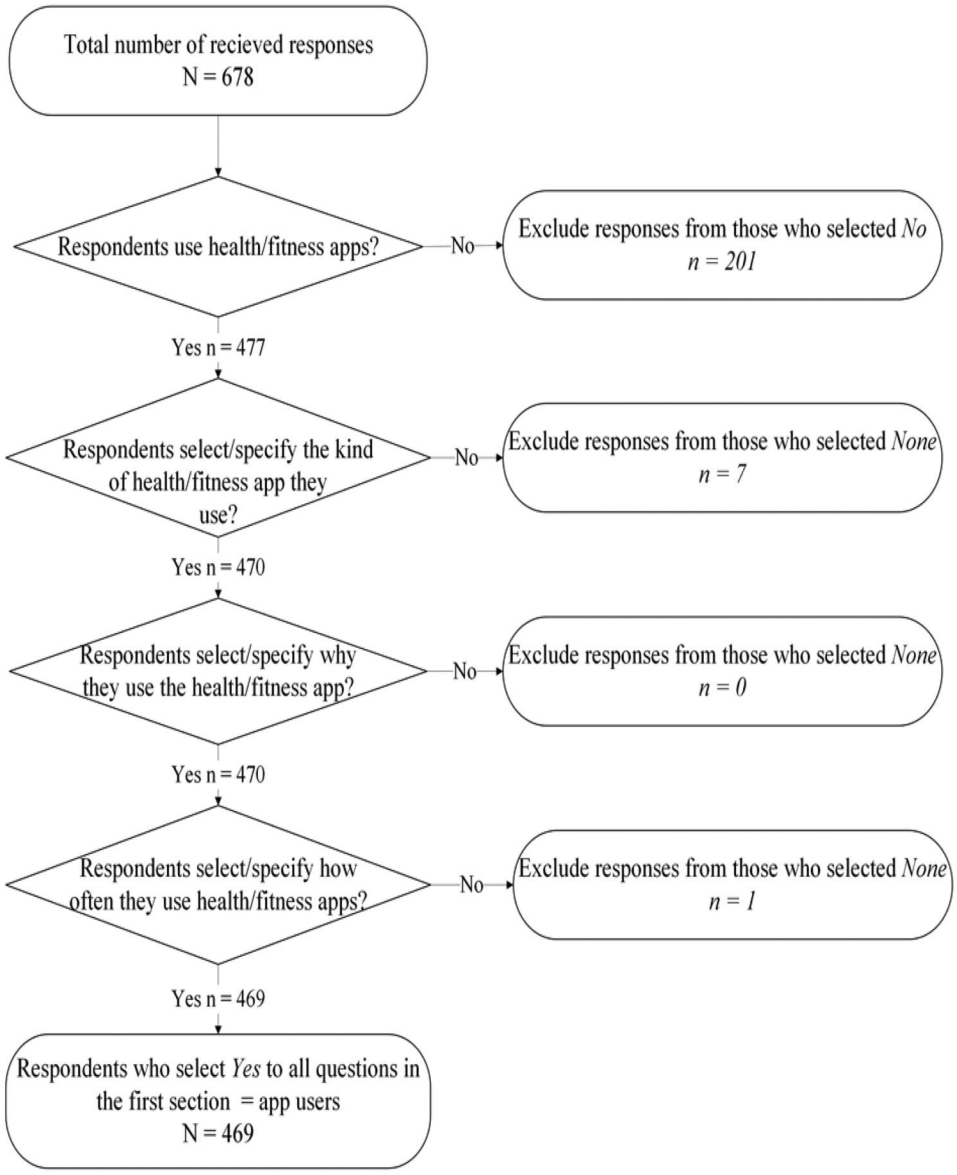

Figure 2. Flow diagram for selection of app users from the received responses.

evaluated, and it was found to be less than 3 (see Table 4), meeting the requirement specified by Hair et al. (2022). Consequently, no collinearity issues were detected in the structural model. A bootstrapping procedure with 5000 samples was used to compute the path coefficients (β), t-values, effect sizes (f^2), and exploratory power (R^2). Path coefficients (β) were deemed statistically significant if the t-values were above 1.96, as stipulated by Hair et al. (2022). Figure 3 shows that all the path coefficients were statistically significant, indicating that all the hypotheses (H1a to H4b) were supported.

To assess the practical relevance of the model, the effect sizes (f^2) were analyzed. Cohen's (1988) criteria was used to classify the effect sizes (f^2) as strong ($f^2 \geq 0.35$), moderate ($f^2 \geq 0.15$), weak ($f^2 \geq 0.02$), or irrelevant ($f^2 < 0.02$) depending on the respective contribution of the latent constructs on one another. In the structural model, there were two strong, three moderate, three weak, and zero irrelevant effect sizes (refer to Table 4). Hence, it can be concluded that the model has some practical relevance.

The explanatory power of the model was also evaluated by analyzing the R^2 of the endogenous constructs. Following the guidelines provided by Hair et al. (2022), R^2 values of 0.75, 0.50, and 0.25 can be considered substantial, moderate, and weak respectively. As shown in Figure 3, the R^2 values of the endogenous constructs (perceived cooperation, perceived competition, perceived social learning, and perceived recognition) can all be classified as moderate. Although the R^2 value of perceived health competence is low (0.171), such values are still deemed satisfactory since the explanatory power is dependent on the number of predictor constructs (Hair et al., 2022). Perceived social comparison explained 52% of variance in perceived cooperation and perceived competition respectively, while perceived social facilitation and perceived normative influence jointly explained about 54% of variance in perceived social learning. Over 59% of the variance

Table 2. Question items and loadings.

Constructs/source	Items	Load
Social facilitation (SFA) (Gaumer & LaFief, 2005; Oinas-Kukkonen & Harjumaa, 2009; Zajonc, 1965)	Health apps make it possible for me to know other users who are performing the same health behavior	0.772
	Being able to recognize users who are performing the same target health behavior increases my motivation to perform the target behavior	0.863
	Being aware of the presence of others while performing my target behavior affects my performance	0.792
	I perform my target behavior more efficiently in the presence of other users	0.749
Normative influence (NIN) (Cialdini et al., 1991; Janes & Olson, 2000; Oinas-Kukkonen & Harjumaa, 2009)	the health app brings together peers who have the same goal	0.818
	My likelihood to adopt a target health behavior goal is born out of the need to be accepted by my peers	0.880
	My health behavior is primarily guided by the health behavior of my peers	0.842
Social Comparison (SCO) (Festinger, 1954; Guyer & Vaughan-Johnston, 2018; Oinas-Kukkonen & Harjumaa, 2009)	Being able to compare my performance with that of others motivates me to perform my target health behavior.	0.877
	Being able to compare my performance with that of more active users motivates me to perform my target health behavior.	0.931
	Health apps enable me to compare my performance with the performance of other users who are less active than me	0.864
Cooperation (COO) (Malone & Lepper, 1987; Oinas-Kukkonen & Harjumaa, 2009)	health apps provide a means of cooperating with other users	0.806
	I get answers to my questions from other users	0.878
	The encouragement from other users motivates me to perform my target behavior	0.869
	Working together with my friends to achieve my behavioral goal makes it easier	0.735
Competition (COM) (Garcia et al., 2013; Oinas-Kukkonen & Harjumaa, 2009)	Health apps enable competition between users	0.852
	Competing with other health app users motivates me to adopt a target health behavior	0.922
Social Learning (SLE) (Bandura, 1971; Oinas-Kukkonen & Harjumaa, 2009)	Health apps enable me to observe others who are performing the same behavior.	0.871
	Health apps enable me to see the outcome/results of other users' health behavior.	0.880
	I am motivated to perform my target behavior when I see the outcome of other users' health behavior.	0.841
Recognition (REC) (Oinas-Kukkonen & Harjumaa, 2009; Stibe & Oinas-Kukkonen, 2014)	Personal stories of people who have succeeded in their health behavior goal motivate me to adopt a new health behavior	0.810
	Health apps provide public recognition to users based on their performance	0.887
	The likelihood to put a target behavior into practice increases when the health app offers public recognition for my performance	0.873
Perceived health competence (PHC) (Smith et al., 1995)	I am now satisfied with my healthy lifestyle	0.756
	I now succeed in the behavior change routines I undertake to improve my health	0.862
	I am now able to accomplish my health goals	0.873
	The outcome of my behavior goal increases my likelihood to maintain my new healthy lifestyle	0.807

Table 3. Demographics of respondents ($N = 469$).

Demographics	Value	Frequency	Percentage (%)
Sex	Male	337	71.86
	Female	132	28.14
Age	18–25	340	72.49
	26–35	97	20.68
	36 And above	32	6.82
Use frequency of apps	Daily users	157	33.47
	Weekly users	139	29.64
	Monthly users	118	25.16
	Occasional users	55	11.73
Education	Undergraduate	397	84.64
	Postgraduate	52	11.09
	Others	20	4.26

Table 4. Convergent/consistent reliabilities and discriminant validity.

	VIF	AVE	CA	CR	SFA	NIN	SCO	COO	COM	SLE	REC	PHC
SFA	1.947	0.632	0.809	0.873	0.795							
NIN	1.947	0.718	0.805	0.884	0.708	**0.847**						
SCO		0.794	0.869	0.920	0.728	0.622	**0.891**					
COO	1.971	0.679	0.841	0.894	0.757	0.595	0.725	**0.824**				
COM	1.971	0.788	0.736	0.881	0.685	0.608	0.690	0.665	0.887			
SLE	1.630	0.747	0.830	0.898	0.707	0.585	0.772	0.677	0.635	**0.864**		
REC	1.630	0.735	0.819	0.892	0.696	0.605	0.656	0.728	0.659	0.593	**0.857**	
PHC		0.682	0.844	0.895	0.310	0.246	0.378	0.373	0.340	0.384	0.368	0.826

VIF: variance inflation factor; AVE: average variance extracted; CA: composite reliability.

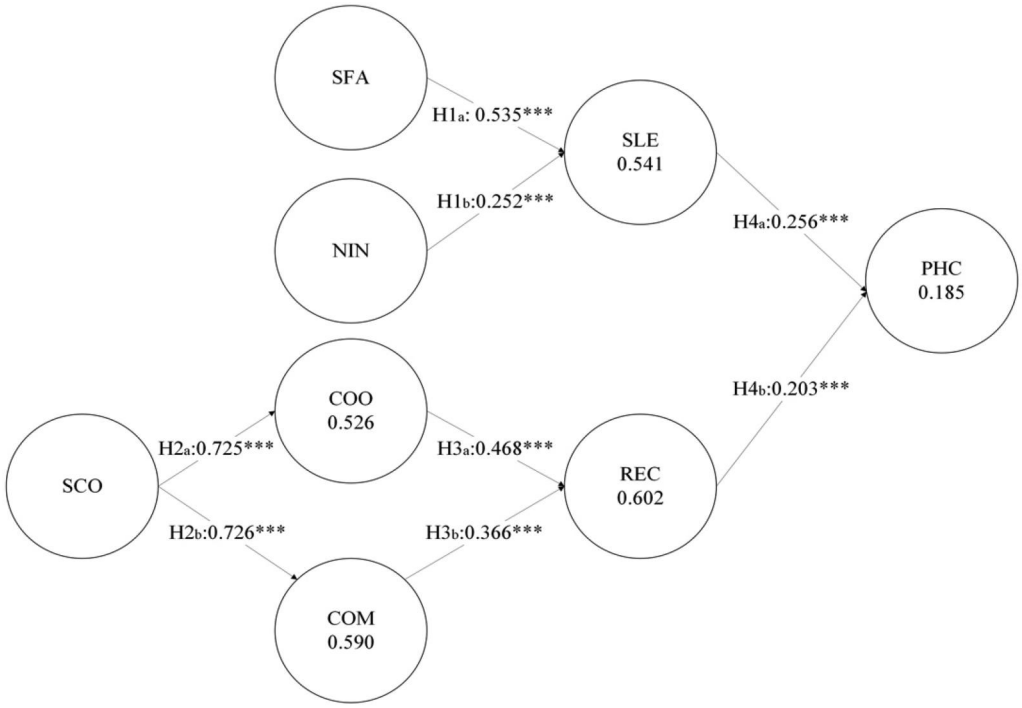

Figure 3. Structural model results for the full sample with path coefficients (β) and their significance and the R^2 values for endogenous constructs (path significance: $^{***}p < 0.001$).

in perceived recognition was jointly explained by perceived cooperation and perceived competition, and 17% of the variance in perceived health competence was jointly explained by perceived social learning and perceived recognition.

5.3. Subgroup analysis

To investigate changes in path coefficients across different groups, subgroup analysis was conducted. The full sample was divided into 2 primary subgroups: *gender (male and female)* and *frequency of use (daily users, weekly users, monthly users, and occasional users)*. Understanding these demographic variables is pertinent, as they play an indirect role in influencing behavior (Fishbein, 2000). Similar to the full sample, PLS-SEM analysis with 5000 samples was performed in the subgroups.

Results of the subgroup analysis revealed that there were slight differences between genders (refer to Table 5). Among females, the paths from perceived recognition to perceived health competence were negative but not statistically significant. Whereas for the males, all the path coefficients were statistically significant. It was also observed that the effect of perceived competition on perceived recognition was stronger in males than females. Whereas the effect of perceived competition on perceived recognition for males was supported at a significance level of 0.001, for females, it was supported at a significance level of 0.01. This affirms Oyibo et al. (2017) argument that males are more susceptible to competition than females.

Regarding the frequency of use subgroups, the primary changes were concentrated on the impact of perceived social learning and perceived recognition on perceived health competence. Specifically, for daily users, the path from perceived recognition to perceived health competence was not statistically significant, whereas, for weekly and occasional users, the path from perceived social learning to perceived health competence was not statistically significant. For monthly users, both perceived social learning and perceived recognition statistically influenced their perceived health competence. Other path coefficients were statistically significant (refer to Table 5).

The explanatory power (R^2) of the subgroups was evaluated and can be found in Table 6. Similar to the full sample, the R^2 values for the endogenous constructs in all subgroups (gender and frequency of use) were classified as moderate. That means that there were no significant differences in the explained variances between the full model and the subgroup samples.

5.4. Mediation analysis

To further investigate the roles of the social support constructs on perceived health competence, several mediated paths including a multiple-mediated path were created. The presence of mediation was determined by assessing the statistical significance of the relevant indirect and direct effects in the mediated model based on Zhao et al.'s (2010) criterion. The analyzed mediation path included:

- Mediated path 1: The indirect effect from perceived social facilitation (SFA) and perceived normative influence via perceived social learning (SLE) to perceived health competence (PHC)

Table 5. Path coefficients (β) for subgroup samples and the full sample.

	Gender		Frequency of use				Full sample	
Hypotheses	Males $n = 337$	Females $n = 132$	Daily $n = 157$	Weekly $n = 139$	Monthly $n = 118$	Occasional $n = 55$	Full sample $N = 469$	Effect size f^2
SFA→SLE	0.563***	0.493***	0.614***	0.647***	0.394***	0.419**	0.535***	0.310
NIN→SLE	0.235***	0.253**	0.193***	0.147*	0.363***	0.410**	0.252***	0.069
SCO→COO	0.731***	0.704***	0.729***	0.733***	0.729***	0.694***	0.725***	1.111
SCO→COM	0.720***	0.705***	0.785***	0.682***	0.652**	0.785***	0.726***	1.113
COO→REC	0.446***	0.517***	0.464***	0.528***	0.417**	0.463**	0.468***	0.270
COM→REC	0.364***	0.366**	0.413***	0.276*	0.357**	0.410**	0.366***	0.165
SLE→PHC	0.208***	0.340**	0.355***	0.164 ns	0.257**	0.127 ns	0.256***	0.049
REC→PHC	0.299***	−0.059 ns	0.051 ns	0.314**	0.243*	0.493**	0.203***	0.031

SCO: perceived social comparison; NIN: perceived normative influence; SFA: perceived social facilitation; COO: perceived cooperation; COM: perceived competition; SLE: perceived social learning; REC: perceived recognition; PHC: perceived health competence. Significant values: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; ns: non-significant.

Table 6. R^2 values for the subgroup samples and the full sample.

Endogenous constructs	Males $n = 337$	Females $n = 132$	Daily users $n = 157$	Weekly users $n = 139$	Monthly users $n = 118$	Occasional users $n = 55$	Full sample $N = 469$
Perceived cooperation (COO)	0.535	0.495	0.531	0.538	0.532	0.482	0.526
Perceived competition (COM)	0.518	0.496	0.616	0.465	0.425	0.617	0.527
Perceived social learning (SLE)	0.564	0.463	0.592	0.572	0.483	0.575	0.541
Perceived recognition (REC)	0.561	0.652	0.642	0.559	0.521	0.675	0.592
Perceived health competence (PHC)	0.209	0.096	0.152	0.189	0.197	0.337	0.171

- Mediated path 2: The indirect effect from perceived normative influence (NIN) via perceived social learning (SLE) to perceived health competence (PHC)
- Mediated path 3: The indirect effect from perceived social comparison (SCO) via perceived cooperation (COO) and perceived competition (COM) to perceived recognition (REC) -multiple mediated path,
- Mediated path 4: The indirect effect from perceived cooperation (COO) via perceived recognition (REC) to perceived health competence (PHC) and
- Mediated path 5: The indirect effect from perceived competition (COM) via perceived recognition (REC) to perceived health competence (PHC).

Results for all indirect pathways within the mediated relationship model are presented in Table 7. When inspecting the bootstrapped confidence intervals (Table 7), it was observed that the effects of mediated path 1 and mediated path 2 were statistically significant at the specified 5% level.

Following the mediation analysis procedure, the significance of the direct effect of these paths (mediated path 1 and 2) were also examined. The results in Table 8 show that the direct effects (path coefficient column of Table 8) from perceived social facilitation to perceived health competence is (−0.108) with a 95% confidence interval [−0.268, 0.050] and the direct effects from perceived normative influence to perceived health competence is (−0.057) with a 95% confidence interval [−0.202, 0.091]. As these intervals include zero and the T-statistics values being less than 1.96, we conclude that the effects of perceived social facilitation and perceived normative influence on perceived health competence is fully mediated by perceived social learning (i.e., an indirect only mediated).

Mediated paths 3 were statistically significant. That is, perceived social comparison (SCO) had 2 indirect effects from perceived cooperation (COO) or perceived competition (COM) to perceived recognition (REC). An assessment of the direct relationship between SCO on REC was also statistically significant. Table 8 shows that the direct effect from SCO to REC is (0.162) with a 95% confidence interval [0.060, 0.264]. This result indicates that both COO and COM partially mediates the effect of SCO on REC. Since both the indirect and direct effects were statistically significant, we further evaluated if COO and COM act as complementary or competitive mediators for the effect of SCO on REC. The results show that the product of the four paths (i.e., ["SCO", "REC"] * ["SCO", "COM"] * ["SCO", "COM"] * ["COO", "REC"]) is positive (0.02). Hence, we conclude that COO and COM act as complementary partial mediators in the relationship between SCO and REC.

For mediated paths 4 and 5, neither the total indirect effect nor the direct effect were statistically significant. Refer to Tables 7 and 8, respectively. Thus, for these mediated paths, a no-effect non-mediation exists. That is, the effect of perceived cooperation and perceived competition on perceived health competence was not mediated by perceived recognition.

6. Discussion, implications, and limitations

6.1. Discussion

The persuasive social support features provide a means of motivating persuasive systems users to change their health behaviors via social influence. However, evidence of its influence on the user's capabilities to perform and maintain positive health behaviors is not well established. This study examined how users' perception of persuasive social support features influence perceptions of their health competence within health and fitness apps. A structural model was proposed and tested, and the results suggest that all relationships were significant. Perceptions of social facilitation and

Table 7. Results of the total indirect effects and confidence intervals.

Mediated paths	Indirect effects	Path coefficient	*T*-statistics	2.5% CI	97.5% CI
Path 1	From SFA via SLE to PHC	0.119	3.488	0.054	0.188
Path 2	From NIN via SLE to PHC	0.056	2.988	0.023	0.096
Path 3	From SCO via (COO, COM) to REC	0.078	3.876	0.042	0.121
Path 4	From COO via REC to PHC	0.059	1.804	−0.006	0.123
Path 5	From COM via REC to PHC	0.044	1.688	−0.004	0.098

Table 8. Results of the direct effects and confidence intervals.

Paths	Path coefficient	*T* statistics	2.5% CI	97.5% CI
SFA → SLE	0.534	12.388	0.450	0.617
SFA → PHC	−0.108	−1.327	−0.269	0.049
NIN → SLE	0.253	5.771	0.167	0.339
NIN → PHC	−0.057	−0.764	−0.202	0.091
SCO → COO	0.725	28.435	0.674	0.773
SCO → COM	0.460	8.729	0.354	0.561
SCO → REC	0.162	3.090	0.060	0.264
COO → COM	0.366	6.661	0.258	0.474
COO → REC	0.399	6.670	0.282	0.516
COO → PHC	0.148	1.710	−0.016	0.321
COM → REC	0.296	4.554	0.168	0.423
COM → PHC	0.112	1.405	−0.040	0.273
SLE → PHC	0.224	3.636	0.102	0.343
REC → PHC	0.149	1.849	−0.016	0.300

normative influence were observed to significantly influence social learning; perceptions of social comparison significantly influenced cooperation and competition, and these two were observed to significantly influence perceived recognition. Finally, perceptions of social learning and recognition significantly influenced users' perception of their health competence within health and fitness apps.

Previous studies have shown that social learning influences social comparison, normative influence, perceived persuasiveness, and behavioral intention (Stibe et al., 2013), this study adds to the persuasive systems research, by showing that perceived social learning has a significant influence on the user's perception of their health competence within health and fitness apps ($H4_a$). This implies that an app that enables users to imitate and learn from each other is more likely to boost users' confidence in performing and maintaining positive health behaviors and outcomes effectively. This finding supports Vlahu-Gjorgievska et al. (2019) argument that sharing readings, progress, and performance within the app community through user profiles and message boards can enhance users' ability to perform positive health behaviors. By observing other users' behavior, users can assimilate and imitate similar behaviors, which leads to improved self-appraisal.

Perceived social learning was observed to be significantly influenced by perceived social facilitation (H1a) and perceived normative influence (H1b). These results suggest that when users perceive behavioral similarities among other users within a health and fitness app (e.g., a fitness or dietary challenge), they may perceive these behaviors as the norm, and these enhance opportunities for them to learn and imitate each other. As shown in the results of the mediation analysis, perceived social learning had an indirect impact on the relationship between perceived social facilitation and perceived health competence and between perceived normative influence and perceived health competence. This affirms Chung and Rimal (2016) argument that the influence of norms can be better understood by incorporating the mediating role of other perceptive variables. Thus, a user's perception of their health competence is not solely determined by conforming to be liked or accepted by user groups, but rather by combining this with an enhanced dominant response through imitating the behaviors of those who are perceived to be similar to theirs. These observations were found to hold for both male and female subgroups.

Evidently, findings from the mediation analysis indicate that perceived social learning has an indirect impact on the connections between perceived social facilitation and perceived health competence, as well as between perceived normative influence and perceived health competence. This finding substantiates Chung and Rimal (2016) claims that comprehending the impact of norms necessitates the integration of mediating perceptual variables. Accordingly, users' perception of their health competence does not solely depend on the desire to conform to social acceptance. This is consistent for male and female subgroups.

Findings from this study also demonstrate that perceived recognition has a significant impact on perceived health competence (H4b). This indicates that an app that acknowledges and celebrates the positive achievements of its users is likely to enhance their confidence in performing and maintaining the achieved health behaviors and outcomes. Specifically, recognition for positive achievement within health and fitness apps is an appropriate way to demonstrate desirable levels of health competence. This finding indicates that perceived recognition does not have a significant impact on perceptions of health competence among the female users' subgroups. These findings align with previous studies (e.g., (Bottomley et al., 2023)) on gender differences in perceived recognition in relation to perceived competence. Whereas male users exhibit greater confidence in their capabilities to perform positive health behaviors when they receive public recognition. Female users report lower recognition as reinforcements for positive achievements (Bottomley et al., 2021), hence they exhibit lesser competence compared to males.

While examining the factors that influence perceived recognition, it was found that perceived cooperation (H3a) and perceived competition (H3b) explained more than 50 percent of the variation in perceived recognition. These two constructs also partially mediated the relationship between perceived social comparison and perceived recognition. When an app enables users to compare their status and performance with other users within the same group (social comparison), it increases the likelihood of cooperation and competition. Prior studies have suggested that competition and social comparison can reduce the self-esteem of app

users, make them lose confidence in their abilities (Ahmad et al., 2019; Orji et al., 2019), as well as decrease their levels of satisfaction (Alhammad et al., 2021). It has also been argued that the presence of social comparison, cooperation, and competition in health apps can backfire and motivate unhealthy behaviors (Orji et al., 2019). The findings of this study suggest that these perceived indifferences and negative backfires can be mitigated by incorporating cooperation and competition features alongside social comparison features. In other words, users are more likely to turn their attention away from negative emotions and towards achieving public recognition by adopting and maintaining positive health behaviors when they perceive higher levels of social comparison and also derive satisfaction and excitement from participating in cooperative and competitive activities within an app. Notably, these findings are consistent across the male and female subgroups. Thus affirming Garcia et al. (2013) argument that there is an appreciable gender difference in how app users perceive competition, cooperation, and social comparison processes.

6.2. Implications

This study adds to the body of research on persuasive systems by providing empirical evidence on the importance of specific persuasive social support features within health and fitness apps on users' perceived health competence. It also provides a better understanding of how the social support features (as both independent and dependent variables) influence each other directly and indirectly through mediator variables (features). Specific findings in support of the hypotheses imply that:

Health and fitness app users can learn new behaviors when the app provides a means for them to identify other users who are performing similar activities. In addition, bringing users with the same goals together to form peer-support communities where they can share and view the experiences enhances the learning process. Also, when a health and fitness app leverages the natural tendency of humans to collaborate and compete with each other, it promotes comparison of performance and provides a means for users to share their experiences out of the desire to boost their ego, gain attention and social recognition. Finally, providing users with a means to share their experiences out of the desire to boost their ego, gain attention and social recognition as well as a means to learn new behaviors by observing and imitating others' behaviors within the app increases their confidence in their capabilities to perform and maintain positive health and fitness behaviors and outcomes using the app.

For designers and researchers, understanding how and to what extent each social support feature affects the users perceived health competence will inform the design of health and fitness apps that will improve engagement in positive health behaviors. Incorporating these features in a complementary manner may also encourage the adoption, compliance with, and continued use of health and fitness apps. That is, users who feel supported and confident in their capabilities to perform positive behaviors using an app are more likely to comply with the prompts from the app as well as continue using the app. Furthermore, the gender differences in the perceptions and effectiveness of the social support features (Table 5) may inform the design and development of tailored interventions that address the needs and preferences of specific users (males/females).

6.3. Strength and limitations

Whereas prior studies examined persuasive social support as a single construct and with a single hypothesis (e.g., social support positively affects perceived competence (Ekpezu et al., 2023; Oduor & Oinas-Kukkonen, 2021), the strength of this study lies in its focus on considering how each social support feature of the PSD framework (i.e., social learning, recognition, normative influence, social comparison, cooperation, competition, and social facilitation) affect the perceived health competence of health and fitness app users.

However, the generalizability of findings from this study may be limited by bias in the gender of the sample and other demographics (e.g., level of education). Over 70% of the sample were males, over 80% were undergraduate students, and 72% were aged between 18 and 25 years old. Additionally, the study evaluated several commercially available health and fitness apps rather than a specific app. On the one hand, this may be considered a weakness because research on persuasive systems is mostly focused on a study-specific artifact, whereas this study considered several commercially available apps. On the other hand, this may also be considered a strength because the respondents were at liberty to specify any app of their choice for the evaluation. Hence, they were not influenced by experimental factors (such as the presence of the researchers or fellow study participants) that may bias their responses. The results may be considered a reflection of trends and practices in a real-life context, considering that, the study's construct reliabilities and validities produced good values.

7. Conclusions

Health and fitness apps as the primary form of persuasive systems adopted in this study can change human behavior without force or deception. However, for these changes to be sustainable, it is important to consider and enhance the competence levels of app users. Perceived health competence is an appraisal of an individual's ability to perform and maintain positive health behaviors and outcomes. It is crucial for health behavior change, as it reflects an individual's perceived ability to perform healthy behaviors Therefore, it is a relevant factor of interest for persuasive systems designers and its users. This study therefore has made contributions to the understanding of persuasive social support features within health and fitness apps and how they influence users' perceived health competence. By investigating the relationships between perceived social learning, social facilitation, normative influence, social comparison, cooperation, competition, and recognition, it illuminated the

factors that shape user perceptions that interplay as they use health and fitness apps.

The findings emphasize the role of perceived social learning and how it enhances users' perceived health competence. This demonstrates the significance of providing opportunities for users to observe and emulate behaviors to boost their confidence in their proficiency in adopting positive health behaviors when using these apps. The outcomes also revealed how gender differences impact perceived recognition on perceived health competence, since male users appeared to derive greater confidence and competence from public recognition compared to their female counterparts.

In conclusion, this study advances the field of persuasive systems research by providing empirical evidence of the intricate relationships between specific persuasive social support features and users' perceived health competence within health and fitness apps. Yet, considering that the predictor constructs explained about 50% of the variance in perceived health competence, and the low explanatory power of the model due to the low number of predictor constructs, there is the need to examine other features of the PSD framework as factors that may explain the perceived health competence of persuasive system users.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

The data used in this study can be found using the link below.
SOCI _PHC dataset.csv

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