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<https://doi.org/10.1057/s41599-025-05903-8>

OPEN

The impact of smart wearable product influence elements on health promotion behaviors

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The rise of Smart Wearable Health Products (SWHP) offers fresh perspectives on solving societal health issues in light of wearable computing and personalized healthcare. However, more investigation is needed to clarify the exact processes by which smart wearables affect users' health results. To examine how the technological and esthetic components of SWHP affect users' psychological processes and health promotion behaviors (HPB), the study uses a multidisciplinary approach to build a stimulus-organism-response (SOR) model. A total of 506 valid samples were gathered, and structural equation modeling was used to analyze the data. The findings show that data management, social interaction, and esthetic pleasure considerably impact users' positive affect (PA) and that PA partially mediates their relationship with HPB. Besides, users' self-efficacy and HPB are influenced by their perceptions of the technological and esthetic components. This study of the smart wearables' function mechanism provides a novel direction for the growth of the health technology industry chain and helps designers to further improve users' health-related usage and decision-making.

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Introduction

Over the past few years, health has become a significant social concern due to the high prevalence of chronic diseases and the aging population. As defined by the World Health Organization (Seid et al. 2000), health is a condition of whole physical, mental, and social well-being rather than just the absence of illness or infirmity. Although physical health is a state of an individual's physiological integrity, the significance of exercise has been less widely recognized due to changes in work schedules and the emergence of bad lifestyles (Chiang et al. 2014; Rabin and Bock 2011). To improve it, physical activity evaluation is critical. Studies have shown that the accelerating development of technology and digitalization significantly impact health (Iyawa et al. 2016; Popkova et al. 2022). For decades, various computerized interventions have been used to promote health (Mattila et al. 2013). To solve the problem, digital health technology is revolutionizing how we track and enhance our health (Topol 2011).

As the main subcategories of digital health technology, wearable technology facilitates a range of end-user domains, including personal care (Luo and Gao 2021), lifestyle computing (Standoli et al. 2016), clinical decision (Beg et al. 2022), and encouragement of active and healthy lives (Dunn et al. 2018). The Internet of Things' (IoT) explosive growth is propelling the development of small electronic and computational devices that can be integrated into a person's body (Niknejad et al. 2020). People are beginning to use these devices to measure vital signs, body signals, location, environment, and movement (Cheng and Mitomo 2017; Park et al. 2018). For their part, product makers are constantly working to improve the software and hardware of their goods, and proliferating applications to meet consumer needs (Park 2020). There are no standards set for categorizing wearable devices. Entertainment, lifestyle, fitness, medical, industrial, and gaming are the six categories included in the classification scheme proposed by Dimou et al. (2017). Yang et al. (2016) offered a different approach to dividing wearable devices based on their form factor: watches, necklaces or wristbands, and head-mounted displays. According to the latest data from the global wearable tracker of International Data Corporation, 644.5 million wearable units will be shipped worldwide by 2027 (Sun et al. 2023).

Empirical evidence indicates that nearly half of wearable users discontinue use within 6 months (Canhoto and Arp 2017; Peng et al. 2021). Understanding whether wearable devices support the adoption of health promotion behaviors (HPB) is essential, as this shapes how the market evolves. Theoretically, Chib and Lin (2018) contend that mHealth research and the development of related practices (including smart wearable health products) have progressed through three phases: input, mechanism, and output (IMO). Current research on smart wearable health products (SWHP) has concentrated more heavily on technical elements (inputs), with limited attention to the underlying mechanisms (Noor et al. 2016; Rao 2019). Li et al. (2021) note that only a small number of studies have investigated the psychological processes involved in SWHP usage, particularly focusing on how wearable devices affect health behaviors from three angles: motivation, empowerment, and social influence. For instance, Nelson et al. (2016) introduced the concept of empowerment through the lens of self-regulation, describing it as the individual's belief in the ability to influence outcomes and to initiate and control behavior. Rupp et al. (2018) asserted that SWHP can satisfy fundamental psychological needs such as trust and motivational affordance, thereby supporting the uptake of health-related behaviors. Al-Emran et al. (2022) demonstrated that subjective norms positively affect smartwatch use, driven by their most impactful features. In short, the influence of SWHPs on the psychological dynamics of health behavior is complex and layered. These investigations have

identified links between the design features of smart wearables (input) and users' observed health behaviors (output), yet the psychological pathways involved have often been examined in isolation. Roos and Slavich (2023) observed that studies into the psychological aspects of wearables offer a more direct grasp of how mental factors relate to users' sustained behaviors and physiological outcomes over time in real-world settings. Moreover, recent findings in human decision-making suggest that affective factors such as mood and emotion also play a meaningful role (Huang et al. 2024).

Therefore, this study aims to integrate the mediating roles of positive affect and self-efficacy from the psychological standpoint of users. Drawing on a multidisciplinary framework grounded in the Stimulus-Organism-Response (SOR) model, it explores how various influence factors of SWHP shape health promotion behaviors, thereby addressing the limited focus on psychological mechanisms and user-based theories of HPB. Notably, existing research has often regarded only the internal features of SWHP as stimuli tied to environmental factors, overlooking the integrity of the product experience (Cho et al. 2019; Jung et al. 2021; Parboteeah et al. 2009). It is necessary to establish a unified model pathway to examine the psychological perceptions and health promotion behaviors of wearable users (Niknejad et al. 2020). This study investigates both the internal (technical) and external (esthetic) elements of SWHP to offer a more complete foundation for evaluating future wearable product design. The remainder of this paper is structured as follows: First, the study's hypotheses and conceptual model are presented, alongside a review of key theories such as SOR and HPB. Next, the methods for data collection and measurement are described. This is followed by the empirical results of the data analysis. Finally, the paper outlines the main findings, discusses both theoretical and practical implications, and notes the study's limitations.

Related work and hypotheses

SOR model. The Stimulus-Organism-Response model is the most predominant theory model for consumer behavior, which was initially introduced by Mehrabian and Russell (1974). It makes the assumption that different environmental cues serve as stimuli that ultimately prompt a response (Hu et al. 2016) by influencing a person's internal experience (organism). According to SOR theory, behavioral responses are elicited by external stimuli and are the consequence of core affective states that are ubiquitous in a multitude of situations (Russell and Pratt 1980). Human behavior can alter in response to environmental factors stimuli. Examples of this include health information behavior (Soroya et al. 2021), consumer purchasing behavior (Li et al. 2023), and social behavior (Amaya Rivas et al. 2022).

Health promotion behavior. Social development is essentially predicated on the maintenance and promotion of health (Raiyat et al. 2012). Based on Kim et al. (2000), health promotion is an approach that helps individuals achieve ideal states of physical, mental, social, and spiritual health. As defined by Walker et al. (1987), HPB is the maintenance of multidimensional patterns of behavior that support personal well-being, life satisfaction, and self-actualization. These patterns usually involve a variety of activities that aid in disease prevention and health status promotion. Research has indicated a strong correlation between individual health status and engaging propensity in HPB (Fang et al. 2024). Adolescent health (Musavian et al. 2014), chronic illness prevention (McLeroy et al. 1988), and older adults' quality of life (Pascucci et al. 2012) are all significantly enhanced by the encouragement of healthy promotion behaviors.

Positive affect. Affect is a generic term used to represent a subjective feeling, either positive or negative, that occurs at a specific moment (Wyer et al. 1999). It serves as a theoretical summary of moods and emotions, projecting them onto a contrasting dimension and distinguishing them based on their activation levels (Russell and Carroll 1999). Positive affect reflects the extent to which an individual exhibits enthusiasm, energy, and alertness. High energy, full attention, and enjoyable engagement are traits of high positive affect (Watson et al. 1988).

Positive emotions have been empirically supported in the impact on behavioral intentions by certain researchers (Berriche and Altay 2020; Jia and Cheng 2024). As shown by a related study, people who often experience positive affect are better equipped to handle trauma, enjoy good health (Shiota et al. 2021), and even live longer (Diener and Chan 2011). Venkatesh and Speier (1999) examined how moods influence employee motivation and desire to use specific computer technology. They found that people's intrinsic motivation and technology-using intention are enhanced in the short term by positive mood interventions. Wakefield (2015) used SOR theory in the context of TAM and demonstrated how technological stimuli directly impact people's usage intentions by generating both positive and negative affect.

Besides, Positive emotion and HPB were identified as strongly correlated by Lee and Kim (2019). By measuring the fluctuations of an individual's internal positive and negative emotions, Nylocks et al. (2019) demonstrated that the level of positive emotion within individuals was directly connected with future health promotion behaviors. There are also additional studies that point out the inverse connection between HPB and affect. For example, Schultchen et al. (2019) discovered that while positive affect rises with increased physical activity, the ensuing stress and negative affect decrease. Thus, the following hypothesis is proposed:

H1: Positive affect positively influences health promotion behaviors when using SWHP.

Self-efficacy. Bandura (1997) originally defined self-efficacy as the belief in one's ability to organize and execute the actions needed to achieve a specific goal. As a significant determinant of behavioral change, self-efficacy influences the initial determination to participate in the behavior, the effort exerted, and persistence in the face of challenges. It has now become a key factor in social health and personality psychology. Optimistic beliefs about one's ability to resist temptation and adopt a healthy lifestyle are referred to as health-related self-efficacy (Schwarzer and Renner 2009). According to scientists, numerous biological processes that mediate human health and disease are thought to be influenced by self-efficacy (Bandura 2014). It should ideally be raised by evidence-based digital health tools (SWHP, WAT) that emphasize health behaviors (Abernethy et al. 2022). Stajkovic and Luthans (1998) indicated that a person's chances of reaching their goals increase with their perceived level of self-efficacy.

An excessive level of self-efficacy is necessary for long-term behavior modifications, and merely disseminating health-related information does not always lead to the desired action from the user. A meta-analysis has demonstrated that self-efficacy affects a person's propensity to carry out a specific action (Guntzville et al. 2017; Kim 2024). At present, self-efficacy exerts two principal influences on health outcomes: the first is to affect physiological stress responses, and the second is to modify how health-related behaviors are performed. Research on SWHP in healthcare has revealed that self-efficacy is a core factor in user involvement with health-related applications and devices (Asimakopoulos et al. 2017). Along with guiding the adoption of HPB and strongly predicting engagement in health promotion lifestyles

(Grembowski et al. 1993; Jackson et al. 2007; Resnick and Nigg 2003), it also mediates the relationship between behavior results and technological usage (Myneni et al. 2016). Thus, the following hypothesis is proposed:

H2: Self-efficacy positively influences health promotion behaviors when using SWHP.

Data management. Data management includes the process of collecting, analyzing, updating, and information searching (James et al. 2019). It provides performance feedback by monitoring users' activities and attitudes (Suh and Li 2022). Information processing can be directly impacted by a person's emotional state. On the other hand, an individual's affect may alter because of information processing (Mantello et al. 2023). Jafarlou et al. (2023) experimentally illustrated the feasibility of using the SWHP to continually track users' sleep, metabolism, and physical activity patterns to predict positive affect. Kim (2021) found that a wearable device that shows a user's workout progress can boost their positive emotions and lower the negative ones.

Individual information based on personal traits will surely be necessary for the future development of e-health tools. It has been shown that the development of information technology promotes better self-management and self-efficacy (Ilioudi et al. 2010). By Liu et al. (2020), using activity trackers to regularly review data has been proposed to enhance user efficacy. Choe et al. (2013) investigated how self-efficacy was impacted by the data presentation and framing during data collection. Williams and French (2011) demonstrated that providing users with specific instructions about when, where, and how to perform exercise behaviors was also associated with increased self-efficacy. Moreover, researchers have found how self-efficacy dynamics while seeking information online (Chiou and Wan 2007). Through the process of collecting, evaluating, and searching for data, users can increase their ability to self-perception. Thus, the following hypothesis is proposed:

H3a-b: Data management positively influences positive affect (H3a) and self-efficacy (H3b) when using SWHP.

H3c: Positive affect mediates the relationship between data management and health promotion behaviors when using SWHP.

H3d: Self-efficacy mediates the relationship between data management and health promotion behaviors when using SWHP.

Exercise control. Reminders, rewards, and goal management are all part of exercise control (James et al. 2019). It gives users authority over behaviors associated with health like eating, running, keeping early hours, and taking regular medications. Sweatcoin has been used to illustrate how reward apps can raise positive affect and exercise levels (Lemola et al. 2021). In addition, when self-tracking users engage in physical activities, performance feedback is used to assess how well their current goals are being met, which in turn stimulates both positive and negative replies (Prasopoulou 2017).

Exercise self-efficacy and exercise behavior have been shown to be related, and that beliefs formed during interventions are critical in sustaining exercise behavior (Neupert et al. 2009). As stated by Olander et al. (2013), one popular method for enhancing self-efficacy among elder people is integrating behavior change techniques (BCT) into the planning of fitness regimens. Devices with a variety of eHealth strategies that present instant information at vital decision-making or result points can be effective in changing user behavior and raising competence perceptions (Intille 2004; Prestwich et al. 2016; Spook et al. 2016). Further, multiple programmed algorithms can also be targeted to impact self-efficacy. For instance, Kranz et al. (2013) developed the GymSkill app to show users customized goals and maintain a

greater level of self-efficacy. Langrial and Lappalainen (2016) and Kuonanoja et al. (2015) investigated the effectiveness of certain BCTs in depressed patients' self-efficacy. Gualtieri et al. (2016) found that goal reminders, satisfaction reporting, and feedback on daily routines improved users' self-efficacy. Thus, the following hypothesis is proposed:

H4a-b: Exercise control positively influences positive affect (H4a) and self-efficacy (H4b) when using SWHP.

H4c: Positive affect mediates the relationship between exercise control and health promotion behaviors when using SWHP.

H4d: Self-efficacy mediates the relationship between exercise control and health promotion behaviors when using SWHP.

Social interaction. Social interactions include sharing, encouragement, competition, comparison, and coaching (James et al. 2019). Users can interact, learn, or compete with others in SWHP as well as share their data and experiences (Suh and Li 2022). Prior studies have indicated that positive emotions and health are related through the stress-buffering effects, as well as by fostering healthier habits and enhancing social interactions (Cohen and Pressman 2006; Ong 2010). Since we are social creatures, it is natural to interact and communicate with others in daily life (Castiello et al. 2010). As a result, wearable devices that integrate social components into their hardware may appeal to a variety of users (Koh et al. 2021). Additionally, popularity and interpersonal ties can stimulate positive emotions. For example, the position of the traditional gym personal trainer has been substantially replaced by the introduction of online coaching technology (Araujo 2018). This change may foster a more favorable affective disposition towards the device in use, leading to an overall positive experience of the technology (Muntaner-Mas et al. 2019). Social cues like other users' experiences, views, and progress can also have a positive impact on users' perceptions, affect, and attitudes (Hosseinpour and Terlutter 2019).

Encouraging social interaction as a key element of SWHP design for people who exhibit social isolation and loneliness can aid in removing obstacles to greater physical exercise (Fan et al. 2012). Regarding the wearables' social characteristics, Rieder et al. (2021) discussed vicarious experience, which is the notion that people believe they can do it after seeing someone else complete it or learning that someone else can do it. Users are encouraged to equal or exceed the performance of others by this engagement and sense of competition, which also helps to increase self-efficacy. Compared to extra long-term research, family support contributed to increased self-efficacy when utilizing e-health interventions (McCormack et al. 2022), and Kettunen et al. (2020) explored how digital coaching affected users' self-efficacy in physical activity within the setting of online coaching. Thus, the following hypothesis is proposed:

H5a-b: Social interaction positively influences positive affect (H5a) and self-efficacy (H5b) when using SWHP.

H5c: Positive affect mediates the relationship between social interaction and health promotion behaviors when using SWHP.

H5d: Self-efficacy mediates the relationship between social interaction and health promotion behaviors when using SWHP.

Esthetic pleasure. Hekkert (2006) argues that any type of experience has an esthetic component. The technology and functionality of SWHP used to be the sole factors driving user purchases. Nowadays, users are beginning to incorporate design features and their associated psychological benefits into the scope (Pateman et al. 2018; Maragiannis and Ashford 2019). A pleasant subjective experience focused on an object that is unaffected by outside reasoning and has the potential to raise the object's evaluation as a favorable esthetic response is known as esthetic

pleasure (Reber et al. 2004). Cho et al. (2019) found that both technical and esthetic features of smartwatches were positively correlated with feelings of enjoyment. From an esthetic point of view, Wang and Hsu (2020) showed how the screen shape and interface design of a smartwatch might influence positive emotional reactions from users. Lee (2022) examined consumer evaluations of the visual esthetics of wearable devices and discovered that the visual experience has a positive impact on consumers' enjoyment.

Furthermore, components like the appearance, fonts, and colors of SWHP can affect someone's feelings toward participation in physical activity. The design and esthetic appeal of wearable devices may draw in young individuals (Dehghani et al. 2018). The size, configuration, and unique characteristics of a device can have an enormous effect on the user's propensity to keep using it (Hsiao and Chen 2018; Jung et al. 2016). In a general way, an individual's sensory impressions of themselves can trigger suitable actions. Self-efficacy is a measure of one's capacity toward performing some particular action. Some fields have corroborated this in both directions. For instance, Lee et al. (2015) discovered that the self-efficacy of wearable AR users was positively correlated with esthetic experience. Miller (2011) noticed that esthetic design interventions increased users' self-assessment time and task performance, and this ultimately affected users' competence and behaviors. Thus, the following hypothesis is proposed:

H6a-b: Esthetic pleasure positively influences positive affect (H6a) and self-efficacy (H6b) when using SWHP.

H6c: Positive affect mediates the relationship between esthetic pleasure and health promotion behaviors when using SWHP.

H6d: Self-efficacy mediates the relationship between esthetic pleasure and health promotion behaviors when using SWHP.

The model relies on the assumption that health promotion behaviors may be influenced by the technical and esthetic elements of SWHP (see Fig. 1). It is proposed that the relationship between technical esthetic elements and HPB is mediated by the user's positive affect and self-efficacy.

Methods and analysis

Data collection. Data were collected on the star platform by online questionnaire between 23 July and 9 September 2024 (<https://www.sojump.com>). Participants were recruited through (1) targeted postings in WeChat health-related groups and (2) electronic invitations sent to university students and faculty. Before accessing the questionnaire, all participants were required to read an informed consent page stating the purpose of the study, the voluntary nature of participation, and measures of anonymity. Only those who ticked the checkboxes to obtain explicit consent were allowed to proceed. The questionnaire took approximately 8 min to complete. The study was ethically approved, no personally identifiable information was collected, and participants could withdraw at any stage without penalty. Participants who meet the user criteria and complete the questionnaire will get extra prizes. It includes (1) a red packet worth 8.80 yuan; (2) a red packet worth 5.50 yuan; (3) six bottles of yogurt; or (4) thank you for participation. A total of 542 questionnaires were returned. Excluding the questionnaires with abnormal answer times and overly consistent responses, the final valid data was 506, with an effective recovery rate of 93.4%. Fulfilling the suggested criteria for statistical evaluation (Hair et al. 2012).

In the survey, most participants had attained advanced education (Bachelor degree and above, $n = 435$, 86%). And the female respondents were in a greater percentage ($n = 318$, 62.8%), which reflected the current marketing trend that women's

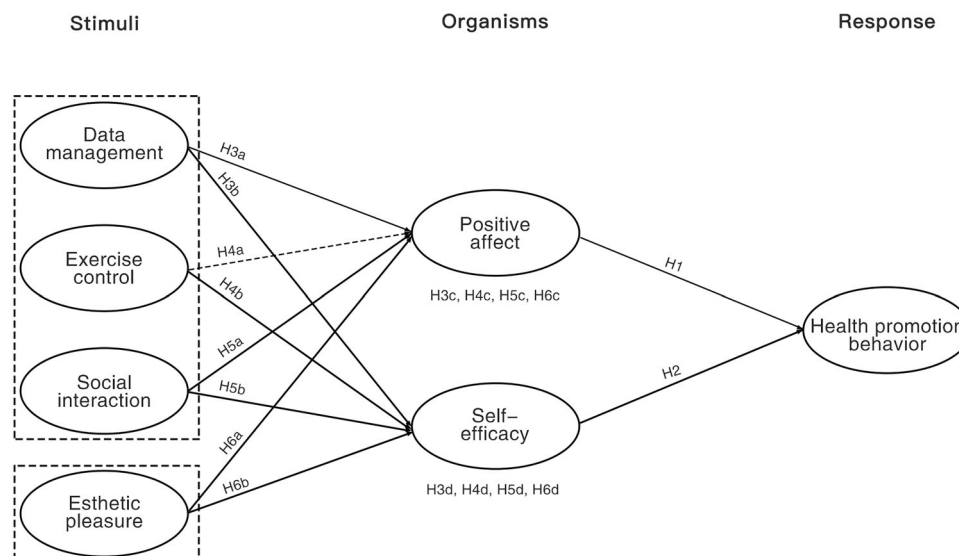


Fig. 1 Research model. The path relationships of the constructed research model. This figure is self-drawn by the author.

ownership of wearable devices is significantly higher than men's (Shandhi et al. 2024). Meanwhile, over half of the users had been with SWHP for less than a year ($n = 265$, 52.4%, shown in Table 1).

Measurement development. The study's structure was assessed by a five-point Likert scale that ranged from "1 = totally disagree" to "5 = totally agree". Each of the selected measures came from previous empirical research and was appropriately adapted for the SWHP setting. In particular, the technical elements of the SWHP were derived from the research executed by James et al. (2019). The esthetic elements were derived from the research executed by Blijlevens et al. (2017). In terms of the user's psychological variables, positive affect was measured by Watson et al. (1988), and self-efficacy was measured by Becker et al. (1993). Finally, the HPB scale was obtained from Walker et al. (1995). All of the variables' data were collected before the demographic information.

Results

Common method bias test. As all variables measured in the study were self-reported by SWHP users, there is a possibility of common method bias in the data obtained from the analyzes. According to Podsakoff et al. (2003), the Harman's one-factor analysis was conducted (software package: IBM SPSS Statistics 27.0). We extracted seven factors with eigenvalues greater than 1, and the first factor accounted for 35.367% of the total variance, illustrating the data did not exhibit serious common method bias. Meanwhile, the fit data of the one-factor model and measurement model were compared through the Amos 28.0. The fit of the one-factor model ($X^2/df = 10.496$, $RMSEA = 0.137$) was much lower than the proposed model ($X^2/df = 1.710$, $RMSEA = 0.037$). It further supports that the control of common method bias in this paper is appropriate.

Reliability and validity. The research used the software IBM SPSS Statistics 27.0 and Amos 28.0 to test the reliability and validity. Table 2 showed that Cronbach's alpha and CR values for all variables exceeded the acceptable standard of 0.7, indicating a satisfactory level of internal reliability for the scale (Nunnally and Bernstein 2010). The factor loadings exceeded 0.6 (Jia et al. 2024;

Ozdemir et al. 2022; Polyportis and Pahos 2025; Sang et al. 2023; Sivarajah et al. 2024; Song and Kim 2022), and AVE exceeded 0.5 (Bagozzi et al. 1991; Fornell and Larcker 1981), suggesting an adequate convergent validity.

Then, we examined the model fit. The following is the overall index: $X^2/df = 1.710$, $RMSEA = 0.037$, $TLI = 0.963$, $CFI = 0.967$, $IFI = 0.967$, $SRMR = 0.038$. As posited by Byrne et al. (1998), the model is deemed satisfactory if the CFI exceeds 0.9 and the RMSEA is below 0.08. This indicates that the measurement and the model are well aligned. In accordance with Fornell and Larcker (1981), Table 3 presents data's discriminant validity. And HTMT (Henseler et al. 2015) was additionally conducted to avoid the limitations (shown in Table 4). Table 5 shows the correlation coefficients, the Means, and SD.

Test of structural model. After controlling the age variable in demographic traits (Chandrasekaran et al. 2020), the path relationships were investigated. The influence elements of SWHP still have a significant impact on HPB. Figure 2 displays the findings. Data management ($\beta = 0.138$, $p < 0.01$), social interaction ($\beta = 0.254$, $p < 0.001$), and esthetic pleasure ($\beta = 0.388$, $p < 0.001$) significantly influence user's positive affect, which verifies H3a, H5a, H6a respectively. H4a is not supported by the limited correlation between exercise control and positive affect ($\beta = 0.069$, $p > 0.05$). Data management ($\beta = 0.198$, $p < 0.001$), exercise control ($\beta = 0.213$, $p < 0.001$), social interaction ($\beta = 0.169$, $p < 0.001$), and esthetic pleasure ($\beta = 0.319$, $p < 0.001$) were discovered to have an outstanding effect on self-efficacy, indicating H3b–H6b. Meanwhile, both positive affect ($\beta = 0.148$, $p < 0.01$) and self-efficacy ($\beta = 0.221$, $p < 0.001$) noticeable impact on HPB, confirming H1 and H2 (summarized in Table 6).

Mediation effects. Finally, the study used a Bootstrap mediation effects test to further examine whether the impact of the technical and esthetic components of SWHP on health promotion behaviors is contributed by positive affect and self-efficacy. If the confidence interval excludes zero, it will indicate a significant mediation effect (Hayes 2017). Tables 7 and 8 show that self-efficacy was a partial mediation between the technical esthetic elements of SWHP and HPB. The association between HPB and data management, social interaction, and esthetic pleasure was

Table 1 Demographics characteristic of participants.

Demographics	Categories	Frequency	Percentage
Sex	Male	188	37.2%
	Female	318	62.8%
Education	Junior high and below	5	1.0%
	High school	5	1.0%
	Associate degree	61	12.1%
	Bachelor degree and above	435	86.0%
Age(Years)	18-30	368	72.7%
	31-40	54	10.7%
	41-50	20	4.0%
	51-60	17	3.4%
	Above 60	47	9.3%
Occupation	Government-sponsored institution	83	16.4%
	Private sector	58	11.5%
	State-owned sector	46	9.1%
	Self-employed sector	45	8.9%
	Retirees	39	7.7%
	Student	229	45.3%
	Others	6	1.2%
Monthly disposable income	3000 Chinese yuan and below	128	25.3%
	3001-6000 Chinese yuan	171	33.8%
	6001-9000 Chinese yuan	109	21.5%
	Above 9000 Chinese yuan	98	19.4%
health status	Healthy or in good condition	340	67.2%
	Average health	100	19.8%
	Chronic patient	63	12.5%
	Major disease	3	0.6%
SWHP brands	Xiaomi	120	23.7%
	Huawei	103	20.4%
	Apple	209	41.3%
	Samsung	27	5.3%
	Keep	45	8.9%
	Others	2	0.4%
Exercise frequency	3 times/month and below	136	26.9%
	4-8 times/month	143	28.3%
	9-16 times/month	144	28.5%
	16 times/month and above	83	16.4%
Usage experience	6 months and below	141	27.9%
	6-12 months	124	24.5%
	13-18 months	79	15.6%
	19-24 months	48	9.5%
	24 months and above	114	22.5%

partially mediated by positive affect, but there was no evidence of a link between exercise control and HPB.

Discussion

Key findings. Many organizations have been compelled to develop and refine technological capabilities that exceed consumer expectations, driven by dependence on advanced mobile technologies (Jocovski et al. 2020). Yet, for health technologies to deliver real impact, users must begin to internalize the benefits of physical activity. The halo effect describes a situation where the visual appeal of an interface, device, or on-screen character

positively influences users' perceptions of a product's intelligence and reliability (Fogg 2003; Kwak et al. 2019; Lindgaard et al. 2011). This suggests that the use of fitness equipment can be shaped by internal psychological factors triggered by external cues. To explore how technical and esthetic elements affect users' affective responses, sense of efficacy, and HPB, this study introduces a theoretical model.

First, both positive affect and self-efficacy had a significant impact on HPB (H1, H2). This indicates that positive affect can trigger immediate behavioral outcomes. Organisms are self-organizing systems (Colombetti 2003); emotionally charged information from the outside world becomes embedded in the individual and, once internalized, can lead to behavioral benefits. These benefits strengthen the user's affective feedback loop, creating a circular mechanism that helps sustain HPB over time. Additionally, the observed link between self-efficacy and HPB aligns with the findings of Ebstrup et al. (2011) and Morowatisharifabad et al. (2006). In the context of fitness technologies, once individuals believe they can successfully carry out a health-related activity, they not only experience a shift in motivational intent but also follow through with actual behavioral execution. This mirrors attribution theory (Weiner 1985), where attributing success to one's own abilities leads to continued effort and long-term behavioral commitment.

Second, data management was found to have a strong influence on users' positive affect and self-efficacy (H3a, H3b). This result shows a slight departure from earlier studies (Andersen et al. 2020). While the unpredictability of data collection and the ambiguity in task feedback can provoke negative emotions like fear or anxiety, enjoyment emerges when the presented data aligns with the user's self-concept. This lends further support to the work of Boldi et al. (2024). Additionally, users' expectations regarding self-regulation are met through data presentation (Lim and Noh 2017). This supports the value of wearables for activity monitoring, which can prompt users to form health-related cognitive responses. When given sufficient time and motivation, individuals tend to engage with persuasive information in a more deliberate and detailed way (Petty and Cacioppo 1986).

Third, exercise control had difficulty triggering positive affect in users, though it showed a strong association with self-efficacy (H4a, H4b). This indicates that device functions such as rewards, reminders, and goal management did not meet expectations in terms of stimulating positive affect, and in some cases may have led to unintended emotional responses. For instance, overly frequent or mechanistic reminders can cause resistance. According to digital common sense, users tend to prefer services that feel personalized (Kim 2021). The emotional responses tied to reward anticipation differ from those evoked by reward satisfaction. A product will contribute to positive affect only when it aligns closely with the user's individual needs and preferences (Hassenzahl et al. 2015). Meanwhile, external control mechanisms can encourage users to engage in health-related activities (Azizan et al. 2013; Gür et al. 2020). This subtle behavioral shaping reflects the influence of ISA, which steers behavioral decisions and can increase user autonomy in pursuing desired outcomes (Burr et al. 2018). When users deviate from expected behaviors, they may experience small penalties, such as increased cognitive burden or information overload.

Fourth, social interaction was found to stimulate both positive affect and self-efficacy (H5a, H5b). This supports the idea that emotional support can be cultivated within online fitness communities (Zellars and Perrewé 2001). The stability and quality of social relationships play a key role in emotional regulation and balance (Lopes et al. 2011). Those with strong social ties are more likely to respond positively to exercise-related stress and emotional fluctuations. Additionally, individuals tend

Table 2 Measurement model evaluation results.

Construct	Items	Factor loading	Cronbach's α	AVE	CR
Data management	DM1: Gather my exercise data.	0.816	0.887	0.612	0.888
	DM2: Analyze my exercise data.	0.738			
	DM3: Provide me with messages about my exercise progress.	0.807			
	DM4: Search for exercise information (e.g., exercise routes, new exercise routines, etc.).	0.769			
	DM5: Browse exercise information (e.g., exercise routes, new exercise routines, etc.).	0.780			
Exercise control	EC1: Set my exercise goals.	0.821	0.893	0.628	0.894
	EC2: Establish my exercise goals.	0.821			
	EC3: Remind me to do an exercise activity.	0.814			
	EC4: Prompt me when I need to perform an exercise activity.	0.786			
	EC5: Receive rewards (e.g., discounts, points, badges, etc.) for my exercise activities.	0.714			
Social interaction	SI1: Share my exercise data in a public forum (e.g., leaderboard, ranking, social media).	0.817	0.884	0.655	0.884
	SI2: Receive encouraging messages regarding my exercise activities from others.	0.789			
	SI3: Receive expert advice about my exercise regimen from a live coach.	0.815			
	SI4: Have exercise contests with other individuals.	0.816			
Esthetic pleasure	AP1: This is an attractive design	0.791	0.887	0.663	0.887
	AP2: This is representative of a design	0.843			
	AP3: This is a novel design	0.823			
	AP4: This is an orderly design	0.801			
Positive affect	PA1: I feel attentive	0.777	0.899	0.642	0.900
	PA2: I feel enthusiastic	0.812			
	PA3: I feel excited	0.813			
	PA4: I feel proud	0.804			
	PA5: I feel strong	0.799			
Health self-efficacy	SE1: Do exercises that are good for me	0.847	0.884	0.669	0.890
	SE2: Fit exercises into my regular routine	0.802			
	SE3: Eat a balanced diet	0.717			
	SE4: Watch for negative changes in my body's condition	0.896			
Health promotion behavior	HP1: Discuss my health concerns with health professionals.	0.661	0.875	0.540	0.875
	HP2: Get exercise during usual daily activities (such as walking during lunch, using stairs instead of elevators, parking car away from destination, and walking).	0.780			
	HP3: Choose a diet low in fat, saturated fat, and cholesterol.	0.711			
	HP4: Feel I am growing and changing in positive ways.	0.781			
	HP5: Maintain meaningful and fulfilling relationships with others.	0.721			
	HP6: Take some time for relaxation each day.	0.749			

Table 3 Construct correlations and discriminant validity.

Variable	DM	EC	SI	AP	PA	SE	HPB
DM	0.782						
EC	0.338	0.792					
SI	0.193	0.385	0.809				
AP	0.324	0.417	0.425	0.815			
PA	0.328	0.369	0.466	0.554	0.801		
SE	0.401	0.474	0.414	0.528	0.606	0.818	
HPB	0.465	0.529	0.516	0.639	0.606	0.648	0.735

Diagonal elements represent the square roots of the AVE. Off-diagonal elements indicate the correlations between constructs. To confirm discriminant validity, diagonal elements should exceed the off-diagonal elements.

Table 4 Heterotrait-monotrait ratio (HTMT).

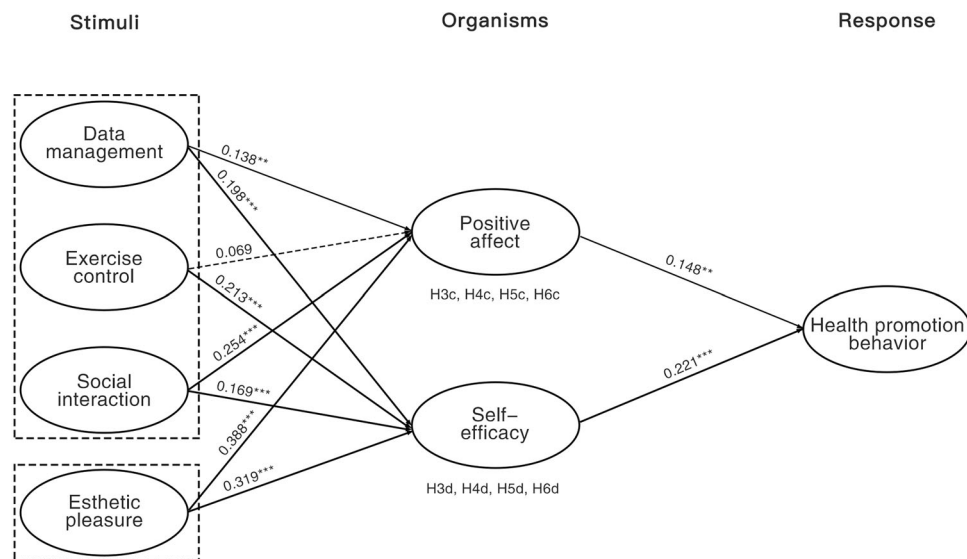
Variable	DM	EC	SI	AP	PA	SE	HPB
DM							
EC	0.299						
SI	0.169	0.344					
AP	0.288	0.380	0.374				
PA	0.294	0.331	0.414	0.499			
SE	0.350	0.426	0.384	0.476	0.552		
HPB	0.398	0.471	0.465	0.567	0.543	0.576	

to cluster into groups. Social feedback strengthens users' confidence in their capabilities (Kashian and Liu 2020), making social interaction a meaningful mechanism for sustaining behavioral engagement rather than a peripheral feature.

Fifth, consistent with earlier research (Phillips and Baumgartner 2002), esthetic pleasure was found to contribute to users' positive affect and self-efficacy (H6a, H6b). Esthetic attributes stimulate cognitive engagement, which may affect how individuals act and feel. This mirrors hedonism, where user experience is shaped by item's utilitarian standards. When a product's core features meet hedonic expectations, users often

Table 5 Means standard deviations and correlations.

	Means	SD	DM	EC	SI	AP	PA	SE	HPB
DM	3.337	0.941	1						
EC	3.262	0.935	0.299**	1					
SI	3.071	0.965	0.170**	0.345**	1				
AP	3.355	0.956	0.287**	0.379**	0.375**	1			
PA	3.206	0.868	0.294**	0.330**	0.415**	0.498**	1		
SE	3.318	0.880	0.349**	0.425**	0.386**	0.475**	0.551**	1	
HPB	3.259	0.802	0.399**	0.470**	0.464**	0.567**	0.542**	0.577**	1

indicates $p < 0.01$.Fig. 2 Estimates of a path analysis.** The test results of the model's path relationships. *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$. This figure is self-drawn by the author.**Table 6 Summary of the hypotheses testing results.**

Hypothesis	Path	Standardized estimates	C.R.	p	Result
H1	PA → HPB	0.148	3.079	0.002	Accepted
H2	SE → HPB	0.221	4.481	***	Accepted
H3a	DM → PA	0.138	3.067	0.002	Accepted
H3b	DM → SE	0.198	4.454	***	Accepted
H4a	EC → PA	0.069	1.418	0.156	Rejected
H4b	EC → SE	0.213	4.366	***	Accepted
H5a	SI → PA	0.254	5.182	***	Accepted
H5b	SI → SE	0.169	3.576	***	Accepted
H6a	AP → PA	0.388	7.256	***	Accepted
H6b	AP → SE	0.319	6.298	***	Accepted

*** $p < 0.001$.**Table 7 The result of direct effects.**

Construct	Effect	Boot SE	95% LLCI	95% ULCI	p value
DM → HPB	0.165	0.042	0.081	0.244	0.001
EC → HPB	0.148	0.044	0.058	0.236	0.001
SI → HPB	0.160	0.045	0.072	0.250	0.001
AP → HPB	0.258	0.055	0.153	0.368	0.001

Table 8 The result of mediating effects.

Construct	Effect	Boot SE	95% LLCI	95% ULCI	p value
DM → PA → HPB	0.020	0.011	0.004	0.045	0.007
DM → SE → HPB	0.044	0.017	0.015	0.082	0.002
EC → PA → HPB	0.010	0.009	-0.004	0.031	0.185
EC → SE → HPB	0.047	0.018	0.015	0.084	0.002
SI → PA → HPB	0.038	0.016	0.010	0.072	0.004
SI → SE → HPB	0.037	0.016	0.011	0.074	0.002
AP → PA → HPB	0.057	0.022	0.018	0.106	0.004
AP → SE → HPB	0.070	0.022	0.030	0.115	0.001

experience excitement and satisfaction, encouraging positive word-of-mouth (Chitturi et al. 2008). Interestingly, numerous studies have shown that wearables with appealing designs and distinctive visual structures, viewed as fashion items, significantly increase both adoption rates and usage time (Karahanoglu and Erbuğ 2011; Bölen 2020). This supports findings related to self-efficacy.

Finally, the link between HPB and technical esthetic aspects was significantly mediated by self-efficacy (H3d, H4d, H5d, H6d), indicating that individuals with higher self-efficacy are more likely to adopt positive HPB and express confidence in the technical esthetic of SWHP (Silva and Lautert 2010). This suggests that users are more inclined to take action when they hold strong beliefs in the effectiveness of the product itself.

Moreover, using exercise control features to promote HPB requires more than just the presence of positive affect (H4c). Combined with earlier findings (H4a), this points to a weak connection between positive affect and exercise control. When HPB falls short of expectations, the influence of positive affect is reduced. However, positive affect served as a meaningful mediator between other technical esthetic elements and HPB (H3c, H5c, H6c). This indicates that the motivational value of HPB increases when positive affect is experienced within the functional design (Van Cappellen et al. 2018). As a result, SWHP may consider this when designing emotion centered approaches aimed at supporting lasting behavioral change.

Theoretical implications. This study contributes to theory in several ways: First, in contrast to earlier research that focused primarily on technical features, this work includes esthetic pleasure to examine how both internal and external elements impact users' affect, efficacy, and HPB. Esthetics have been shown to capture users' attention and maintain interest in system use (Mirdehghani and Monadjemi 2009). A comprehensive assessment of a product's design characteristics helps shape the dimensions of self-expression, which in turn shapes behavior (Kumar and Noble 2016). Second, this study extends the scope of the SOR model by broadening the interpretation of stimuli and organism components to fit the current dataset. Previous investigations into user interaction with SWHP have largely relied on frameworks such as social cognitive theory, self-regulation, self-determination, and the theory of planned behavior (Fallon et al. 2019; Gowin et al. 2019; Kerner and Goodyear 2017; Shafique et al. 2019). In contrast, research using the SOR model remains limited. Furthermore, the traditional input-mechanism-output (IMO) framework has often failed to give adequate consideration to users' psychological mechanisms. Many existing studies have reduced user psychology to a single metric—such as motivation or attitude—overlooking how emotional cognition contributes to decision-making biases. To address this, the present study incorporates positive affect into the model, expanding its explanatory depth. Finally, this work improves the literature by highlighting the importance of technical esthetic in shaping HPB and demonstrating the mediating roles of positive affect and self-efficacy in driving users' engagement in HPB.

Managerial implications. This study identified three key technical elements of SWHP that influence users' HPB via positive affect or self-efficacy. In terms of data management, developers should consider users' current behaviors and personal histories, delivering contextualized data analysis in a clear and intuitive manner. Doing so helps maintain positive affect and build self-efficacy. Information should be streamlined—limited to one or a few SWHP pages—so users can make timely, accurate behavioral decisions with ease. For instance, Solos outdoor sunglasses allow users to adjust displayed content and alerts based on fitness level and cycling habits. Beginners can focus on basic metrics like speed and heart rate, while advanced users may prefer detailed cycling statistics. Implementing a feedback system based on regular surveys can help tailor advice to specific user needs. Fine-tuning data to reflect user perception can lead to more effective emotional and behavioral outcomes. In terms of exercise control, reducing the psychological distance between user and designer is essential for achieving high performance and positive affect. Personalized settings should allow users to fully adjust the device's rewards and notification functions. For example, Fitbit offers more than just points or badges, users who complete targeted challenges can unlock apps that would otherwise require payment. Sustained self-efficacy can also be supported by reinforcing

behavioral cues. The BreatheWear Shawl, for example, applies gentle pressure during deep breathing, creating a sensation similar to a “hug” that reassures the user and promotes calm breathing. This kind of subtle connection to behavioral performance can be one of the most effective ways to activate dormant motivation and encourage consistent health promotion. In the area of social interaction, incorporating social media into health interventions can help maintain user engagement and lead to improved adherence to healthy behaviors (Stragier et al. 2016). Real-time mood analysis systems, along with dedicated emotional feedback panels, can encourage participation by offering timely, supportive responses. As shown in MIT's EQ-Radio, which uses electrical skin activity (EDA) combined with AI to assess emotional states, integrating existing social platforms can increase user confidence and translate it into sustained HPB. Though still a novel idea, we suggest that future work explore the development of features such as “emotional mates.”

Second, the findings on esthetic components show that the visual appeal of wearable products is closely tied to both pleasure and meaning, acting as a source of user satisfaction. Users were drawn to SWHP due to its distinctive appearance and design structure. Unlike core technical functions such as alerts and monitoring, the visual identity of the device may play a vital role in distinguishing and shaping the uniqueness of SWHPs. Designers can tap into multi-sensory experiences to increase product character and appeal, incorporating contemporary design elements and distinctive product details such as textures or patterns that contribute to customer satisfaction, brand loyalty, and behavioral engagement. Furthermore, to consistently highlight user effort and progress, the device's structural design could integrate materials and colors that convey positivity and achievement. For example, the RM 65-01 McLaren W1 draws on the visual language of the iconic W1 supercar, presenting a bold, high-performance esthetic that symbolizes a pursuit of speed and boundaries.

Limitations and future research

This study has several limitations. First, it was conducted in China and distributed online. The sample concentrated on young, healthy individuals mostly, which restricts the generalizability of the findings. Future research could compare the role of psychological variables in influencing HPB across different demographic groups and cultural settings. Second, although this research was intended to cover all SWHP, most participants belonged to the bracelet group, largely due to the commonality of these devices. As SWHP continue to evolve, changes in their functions may affect how they are assessed. Third, in aiming for clarity and reliability, the study limited the broader applicability of some items. Future work could focus on refining these items through improved formulation or by dividing them into clearer sub-dimensions, which may help sharpen their distinctiveness. Additional evaluations could also be made using separate scales for certain items. For instance, Gibbons and Buunk's (1999) Social Comparison Disposition Scale could be used to further examine individual differences. Finally, while the study controlled for the impact of age on the relationship between SWHP elements and HPB, it did not apply detailed stratified sampling or subgroup analysis. Future studies may broaden the sampling scope to examine how dynamic changes in age and health conditions interact to influence the outcomes of wearable device usage.

Conclusion

By integrating the SOR model with the IMO framework of mobile health development, the technical and esthetic elements of SWHP are identified in this study as a significant influencing factors for

the psychological mechanisms and health promotion behaviors of users. Data management, social interaction, and esthetic pleasure induce positive affect in users, with such affect exerting influence on health promotion behaviors through the partial mediating effect. Exercise control plays no role in the prediction of positive affect, nor is any significant mediating effect observed between the two. Self-efficacy is significantly related to the technical and esthetic elements of SWHP (data management, exercise control, social interaction and esthetic pleasure), playing a partial mediating role in the relationship between the above elements and HPB.

These findings provide valuable reference for the practical implications of SWHP. In terms of product development, it is crucial not only to focus attention on the professionalism in functionalities and shape esthetics, but also to enhance the positive affect and sustainable self-efficacy brought about by the technical and esthetic characteristics of the product. In terms of brand marketing, it is necessary to carry out the intervention of positive affect and self-efficacy through data management, exercise control, social interaction and esthetic pleasure elements for a direction shift in brand marketing from focusing a tool or product to a health partner, which extends brand marketing dimension. In terms of industrial development, the results of this study gain insights into the sustainable development of SWHP and the long-term impact of users' health promotion behaviors.

Data availability

Data supporting the findings of this article will be made available by the authors, without undue reservation.

Received: 9 December 2024; Accepted: 2 September 2025;

Published online: 15 October 2025

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Acknowledgements

This work was supported by the Humanities Pre-Research Project from Donghua University in China (grant no. 107-10-454 0108013) and the Municipal Key Course Program for Higher Education Institutions in Shanghai (grant no. 107-10-0108072).

Author contributions

CW contributed to the conceptual design of the study; PL guided the questionnaire design and data collection; YF and CW were responsible for collecting and analyzing the data; YF wrote the first draft of the manuscript; All authors revised previous versions of the manuscript and were involved in reading and approving the submitted manuscript.

Competing interests

The authors declare no competing interests.

Ethical approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Donghua University on May 16, 2024 (Ethics approval number: DHUEC-FZ-2024-04).

Informed consent

Written informed consent was not necessary for this survey in compliance with institutional and national regulations (e.g., the *Regulations on the Administration of National Network and Data Security* require written personal consent only for sensitive financial account information). There was an online informed consent for participation. The study was conducted on 23 July 2024. It was completely voluntary and participants had the right to withdraw at any time without any negative consequences (e.g., prior to starting the survey, participants need to read and select the "accept" option to continue the questionnaire). The scope of the consent includes participation in the study, use of the collected data for academic research purposes only, and publication of the anonymized results. All data will be stored confidentially and used in strict accordance with the restrictions outlined in the consent statement.

Additional information

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1057/s41599-025-05903-8>.

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