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Article

SitFit: A core fitness tracker for improved sit-up accuracy and injury prevention

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Abstract: This study investigated the students' perceptions of a self-paced fitness program that is integrated with SitFit, a fitness tracker that measures body inclination during sit-up exercises, and their acceptance of digital innovation in physical education. The data was gathered from a survey of 1001 Thai undergraduates. Results revealed that attitudes toward using the technology and the perceived ease of use were important predictors of behavioral intention to use the sit-up fitness tracker. consistent with previous TAM studies. Subsequently, SitFit was developed based on exercise principles and expert advice to enable users to exercise more effectively while reducing injury risk.

Keywords: sit-up fitness tracker; fitness tracker wearable device; technology acceptance model (TAM); fitness training program; abdominal muscle strength; digital innovation; Structural equation modeling (SEM)

1. Introduction

The aging population and the rising disease prevalence among youth drive a rapid need for wearable health monitoring devices. And wearable physiological monitoring offers comprehensive health data (Wei et al., 2024). These devices allow users to monitor various physical activity and health metrics such as step counts, calories burned, heart rate, sleep patterns, and more (George, et al., 2023). Wearable fitness trackers provide immediate feedback and data analysis, serving to motivate and guide people in the pursuit of their exercise goals (Orhan and Serin, 2019; Wongvibulsin et al., 2019).

As these technologies become more advanced and ubisquitous, it is important to understand the factors that drive their acceptance and adoption by users. Previous research in this domain has applied theoretical models like the technology acceptance model (TAM) to examine the key determinants of wearables acceptance. Studies have shown that perceived usefulness—the degree to which users believe a wearable device will enhance their fitness or health—is a critical factor influencing attitudes and adoption intentions (Dehghani, 2018).

Another salient factor is perceived ease of use, which refers to how effortless a person perceives the operation and interaction with the wearable technology to be (Davis, 1989). Devices that are intuitive and require minimal effort to set up and use are more likely to gain user acceptance (Gao et al., 2015; Hein and Rauschnabel, 2016). Beyond these core factors from TAM, other variables like enjoyment, social influences, privacy concerns, and demographic characteristics have also been explored in the context of wearables adoption (Gao et al., 2015; Lunney et al., 2016).

This study aims to contribute to this area by examining user acceptance of an innovative wearable device called SitFit, specifically designed to track and optimize sit-up exercises. By integrating quantitative and qualitative methods, the research investigates the key factors driving SitFit's acceptance and evaluates its potential for enhancing abdominal muscle training and exercise experiences.

This study presented the following research questions:

- What is the level of acceptance of digital technologies in physical education among students?
- What are the specifications of self-training devices integrated with digital health innovation to support abdominal muscle strength?

2. Literature review

2.1. Self-guided fitness programming

Evidence-based fitness programs incorporate structured warm-ups, resistance training at targeted intensities matched to individual strength levels, and controlled cool-downs to restore homeostasis (ACSM 2021; Chang et al. 2020). Such programming empowers independent practice while providing appropriate scaffolding for progressive overload as clients improve. Customized apps and wearables now allow remote delivery of personalized home exercise routines. However, reliance on limited user feedback poses risks without objective performance data.

2.2. Biofeedback for exercise testing and training

Sophisticated motion capture tools used in high performance training facilities provide biomechanical feedback on technique, force output, and workload at high resolutions to optimize athletic development and prevent injury (Balsalobre-Fernández et al., 2018). However, such systems remain inaccessible for most recreational trainees. Consumer-focused wearables capturing basic activity metrics dominant public fitness technology markets (Ackland, 2022). Recent research demonstrates potentials to evaluate complex exercise with instrumented garments (Cust et al., 2019), but user-friendly implementation remains limited. Clear opportunities exist around purpose-built wearables delivering biomechanically-relevant performance feedback.

2.3. Risks of improper abdominal training

While abdominal strengthening provides manifold benefits, overly aggressive training can precipitate injuries (Calatayud et al., 2015). Violent spinal flexion can overload passive tissues beyond physiological limits or create asymmetric imbalances around dysfunctional segments (McGill and Karpowicz, 2009). Experts thus emphasize controlled progression under previse technique guidance to ensure safety (Santana, 2001). This helps engrain proper motor patterns while gradually enhancing dynamic joint control and active muscle tensions.

2.4. Physical fitness training program

The American College of Sport Medicine (ACSM) recommends the Physical Fitness Training Program (Liguori et al., 2021). This is a program for body development designed to facilitate the efficient performance of activities. The program comprises the following steps: (1) Test the basic physical fitness and then record the results in the fitness record form. (2) Organize an exercise program at the level corresponding to the fitness level and start exercising following the plan or method that has been created. (3) Record the date and posture of exercises. (4) Exercise for the specific time and number of times each week. The duration or the number of repetitions specified in the following week can increase. (5) Following program completion, a physical fitness test is repeated to evaluate the progress and organize a new program. (6) Record the fitness test result and exercise level on fitness record form and continue to exercise.

The sit-up test program has been developed to train and test the abdominal muscle strength. The sit-up strength test does not require repeating sit-ups. Abdominal strength is required as an indicator of core strength. Consequently, core stability and lower back support are considered when testing (Moazzami and Khoshraftar, 2011). There are three primary training principles of abdominal strength development: (1) Overload Principle is the most important of weight training because weight as resistance make muscle cells work more than normal in daily life. Excess weight stimulates the growth and strength of muscles. (2) Progressive Resistance Principle—muscles must be trained by weight as resistance. The more weight is used, the more muscles are stimulated and grow. (3) Principle of Specificity—the muscle training must study the muscles which are beneficial to the movement of exercise activities (Bompa and Calcina, 1994).

2.5. Digital health innovation

Digital health innovation is applied with the mechanics of human motion by sensors integrated with new materials and textile technology. This innovation positively affects human health, reduces negative behavior, and creates training motivation. Furthermore, health technology applies health knowledge and skills through devices, technologies, and digital systems to assist users in tracking, organizing, and improving their health behaviors and self-care through quality reporting. This will potentially facilitate users. The new development system (World Health Organization, 2020) changes health behaviors by linking healthcare with new technology, providing reliable information related to health, and encouraging people to stay physically fit and remain healthy. In addition, the new development system enables people to conveniently focus on their healthcare (Orhan and Serin, 2019; Wongvibulsin et al., 2019) and secure health information (Canada Health Infoway, 2021).

2.6. Technology acceptance perspectives.

The technology acceptance model (TAM) provides a robust framework for evaluating and predicting adoption of interactive systems across uses cases (Davis, 1989). It posits that perceived ease-of-use and usefulness represent main drivers of usage intentions and acceptance behaviors. In generally, TAM has four variables: perceived usefulness (PU), perceived ease of use (PE), attitude toward use (AT), and behavioral intention to use (BI), (Davis, 1989).

PU is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989, p. 320). PU affected the main factors of the TAM model and the basic variance which impacted to modern technology acceptance (Weng, 2016). Furthermore, the use of a wearable healthcare device would be beneficial to users' health. Previous studies on wearable healthcare devices found that the intention to use technology was influenced by perceived benefits (Dehghani, 2018; Yang et al., 2016; Zhang et al., 2017). Therefore, consumers would perceive usefulness of the healthcare wearable devices when they realize the benefits associated with their usage.

PE refers to "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, p. 320). Davis (1989) presented the TAM model and highlighted that each person's motivation of technology acceptance is influenced by these factors. Consequently, a previous empirical study discovered that individuals' use of modern technology in various contexts was influenced both indirectly and directly by the BI (Yadegaridehkordi et al., 2018). This is consistent with the context of wearable technology (Hein and Rauschnabel, 2016). Therefore, modern technology acceptance, including wearable healthcare devices, depends on the ease of use and application.

AT affected the idea or the belief and the trend of a person's behavioral expression (Ajzen, 2011; Ajzen and Fishbein, 2004). Badrinarayanan et al. (2014) explained that attitude affects one's intentions to choose products. Therefore, attitudes are meant to reflect a person's behavioral beliefs about the potential consequences of an action.

BI affected each person's willingness to present their behaviors. There were three primary intentions: (1) BI to use when having a chance (Lee et al., 2005), (2) BI to use continuously (Lou et al., 2005), and (3) BI towards positive speech to advise others (Turel et al., 2010). In the TAM model, the behavioral intention determined the factor of AU. Willett et al. (2019) stated that BI composed of (1) intention of use, (2) trend of use, and (3) plan to use.

The user's acceptance of a wearable healthcare device was significantly influenced by AU's impact on perceived value (Yang et al., 2016). Additionally, it affected the attention of physical and mental improvement, including the willingness of regular device usage (Kekade et al., 2018).

Therefore, our hypotheses are as follows (**Figure 1**):

H1: Perceived usefulness (PU) has a significant positive relationship to attitude (AT) to use the sit-ups fitness tracker.

H2: Perceived ease of use (PE) has a significant positive relationship to attitude (AT) to use the sit-ups fitness tracker.

H3: Attitude (AT) has a significant positive relationship to behavior intention (BI) to use the sit-ups fitness tracker.

H4: Behavior intention (BI) has a significant positive relationship to actual use (AU) to use the sit-ups fitness tracker.

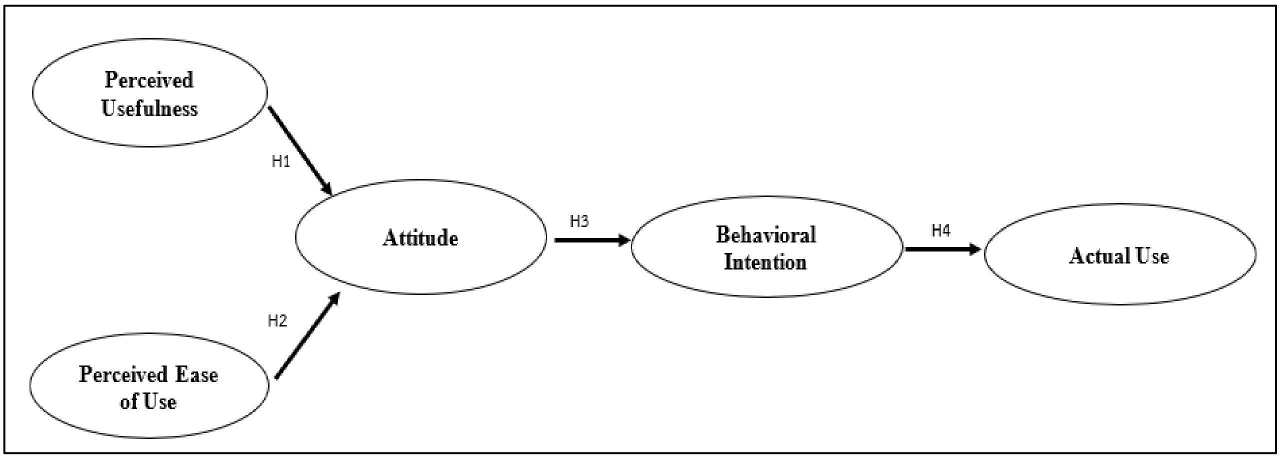


Figure 1. Research framework and hypotheses.

3. Methodology

The questionnaire survey was used to gather quantitative data about TAM. For the development of SitFit, experts in digital health innovation were interviewed to gather qualitative data. The details are provided below:

3.1. Sample and data collection

3.1.1. Qualitative data

Qualitative data were gathered through interviews with five experts to determine the content validity (Lynn, 1986), including experts on fitness training programs, digital innovation, muscle strength and research methodology, selected by the researchers from a thorough sample group with the qualification of having at least five years of expertise in the relevant field.

3.1.2. Quantitative data

Data gathered from expert interviews were analyzed using content analysis. Qualitative data were combined with quantitative data to create a prototype of SitFit, which is a sit-up tracker wearable device. Subsequently, a pilot study of SitFit was conducted. The five universities were selected through a multistage sampling design to ensure geographic diversity and represent various types of higher education institutions in Thailand, allowing for a broader understanding of undergraduate perceptions regarding the SitFit program. This approach aimed to gather data from a wide cross-section of students, enhancing the study's relevance. First-year students were excluded from the study due to their lack of familiarity with university fitness programs, as they are still adjusting to their new environment and may not have established exercise routines. Additionally, first-year students tend to drop off fitness programs more frequently and have more universities to choose from than students in higher years, which could affect the study's findings. This exclusion helps ensure data consistency and reliability by focusing on students who have more experience and engagement with physical education, leading to more insightful feedback on the self-paced fitness initiative.

To collect data, we conducted a survey of undergraduate students in Thailand using a multistage sampling design. The population is undergraduate students because they are an ideal demographic for this study due to their physical development stage, openness to digital technology, and engagement in health and fitness. The first-stage sampling included purposive sampling to select 12 provinces from four regions in Thailand. In the second stage of sample selection, five universities from each province were chosen. The total number of respondents was 1001, with an 85% response rate (a total of 1178 students). Prior to the study, participants were informed of the objectives of the research and their right to withdraw at any time. Among the total participants, 52% were male and 48% were female. The participants' ages ranged from 21–22 years (45.3%), 19–20 years (42.1%), 23 years and over (11.8%), and 17–18 years (0.8%). The sampling group was divided into second-year (32%), third-year (26%), fourth-year (20.2%), and fifth-year students (10.3%). The questionnaire was used to collect data and was utilized to assess PU (perceived usefulness), PEU (perceived ease of use), ATT (attitude), and BI (behavioural Intention), which was particularly modified from Fred D. Davis's work in 1989. The survey was separated into five sections: (1) PU, (2) AT, (3) PE, (4) BI, and (5) AU. Each section had five items for a total of 25 items, and the items were rated on a seven-point Likert scale.

3.2. Data analysis

3.2.1. Qualitative data

Data gathered from expert interviews were analyzed using content analysis. Qualitative data were combined with quantitative data to create a prototype of SitFit, which is a sit-up tracker wearable device. Subsequently, a pilot study of SitFit was conducted.

3.2.2. Quantitative data

To analyze the reliability and validity of the instrument, Cronbach's alpha (α) was used to measure the reliability of each item, and each item's score must above 0.70. This shows the reliability and internally consistent of the instrument (Hair et al., 2014). Then, to investigate convergent validity, composite reliability (CR) and average variance extracted (AVE) were used. CR values must be greater than 0.70 for all measurement items, and AVE values need to be greater than 0.5 to indicate that the measurement questions accurately reflect the characteristics of each variable in the model (Fornell and Larcker, 1981). Discriminant validity is used to measure the extent to which constructs are distinct from one another (Hair et al., 2014). The test is valid when the square root of the AVE is greater than the correlation coefficients (Fornell and Larcker, 1981). The descriptive statistics, including the mean and standard deviation for each variable, were generated using SPSS 22.

The structural equation modeling (SEM) was utilized to examine the proposed hypotheses, whereas LISREL 8.80 was employed to analyze the research model. The criteria to indicate fit robustness in the SEM analysis are the goodness-of-fit (GFI), the normed fit index (NFI), comparative fit index (CFI), adjusted goodness-of-fit index (AGFI), root mean square residual (RMR), and root mean square error of approximation (RMSEA). The data fit is excellent when the values for NFI, CFI, GFI, and AGFI are greater than 0.95. An excellent data fit for RMR and RMSEA requires values below 0.05, whereas an acceptable fit requires values below 0.08 (Hair et al., 2014; Schumacker and Lomax, 2016).

4. Analysis and results

4.1. Qualitative results

The expert interview's consent analysis reveals that the Sit-Up Fitness Tracker is a chest strap that measures the torso's angle during sit-ups. When the user performs a sit-up and achieves the standard or desired angle, an alarm will sound to indicate the correct posture and the level of lower back muscle lift from the ground. It should also include functions that indicate the strength level of the abdominal muscles, the appropriate duration of sit-ups for each age group, and other related functions.

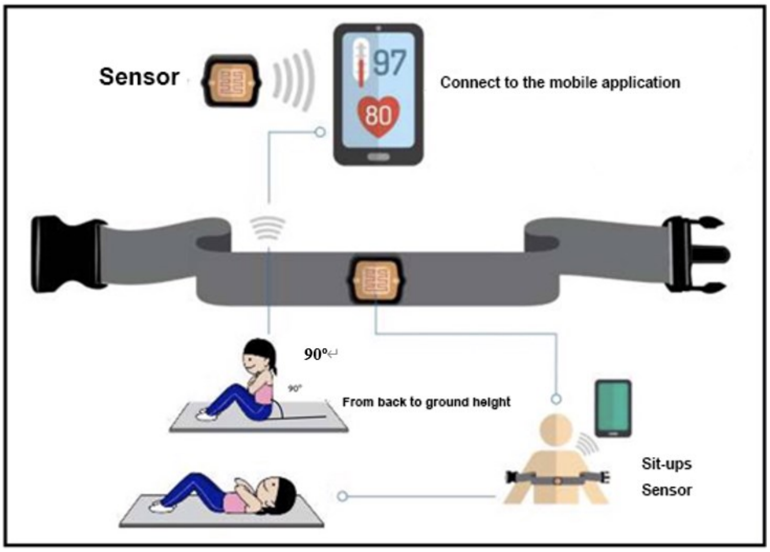
The device works in conjunction with a smartphone to enhance the convenience and effectiveness of sit-ups, making it simple to use and allowing users to perform exercises independently without the risk of injury.

4.1.1. SitFit

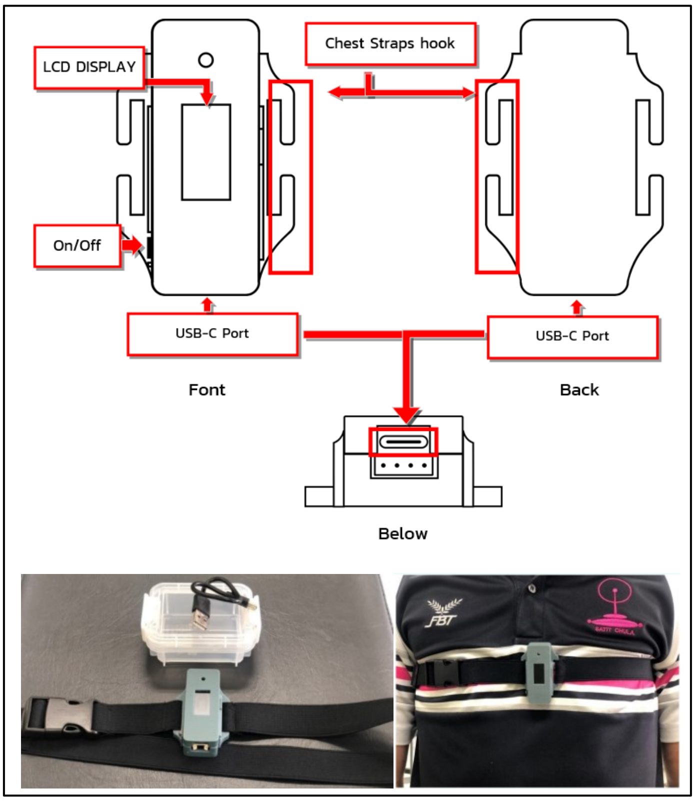
SitFit is a sit-up fitness tracker that measures body incline when performing sit-ups. This tracker was created based on the observation that improper sit-ups cause back pain. Previous studies have suggested that raising the upper body to a 90-degree angle will not cause back pain during sit-ups (Todingan et al., 2016). SitFit helps users exercise more accurately. Moreover, SitFit enables users perform sit-ups without an assistant holding their ankles. This is a proper sit-up posture, which strengthens abdominal muscles (Stamford, 1997; Ujuagu et al., 2020). Holding your ankles while performing sit-ups improves your leg muscles, not your abdominal muscles.

The function of SitFit is to detect the correct angle when completing sit-ups using a digital system. A warning alarm sounds when a sit-up reaches the standard angle (**Figure 2**) to indicate the sit-up posture and the level at which the lower back muscles are lifted.

The SitFit set comprises a sit-up fitness tracker for measuring posture, a chest strap, a power button, and a USB-Type C port for charging (**Figure 2**). Additionally, it requires a smartphone and the SiFit application to increase the effectiveness of sit-ups (**Figure 3**). With a SitFit, users can independently practice sit-ups without risking injury.



(a) A fitness tracking system designed to monitor and assist with performing sit-ups.



(b) Wearable Fitness Tracker with Chest Strap and USB-C Connectivity.

Figure 2. SitFit devices **(a)** A fitness tracking system designed to monitor and assist with performing sit-ups; **(b)** Wearable Fitness Tracker with Chest Strap and USB-C Connectivity.

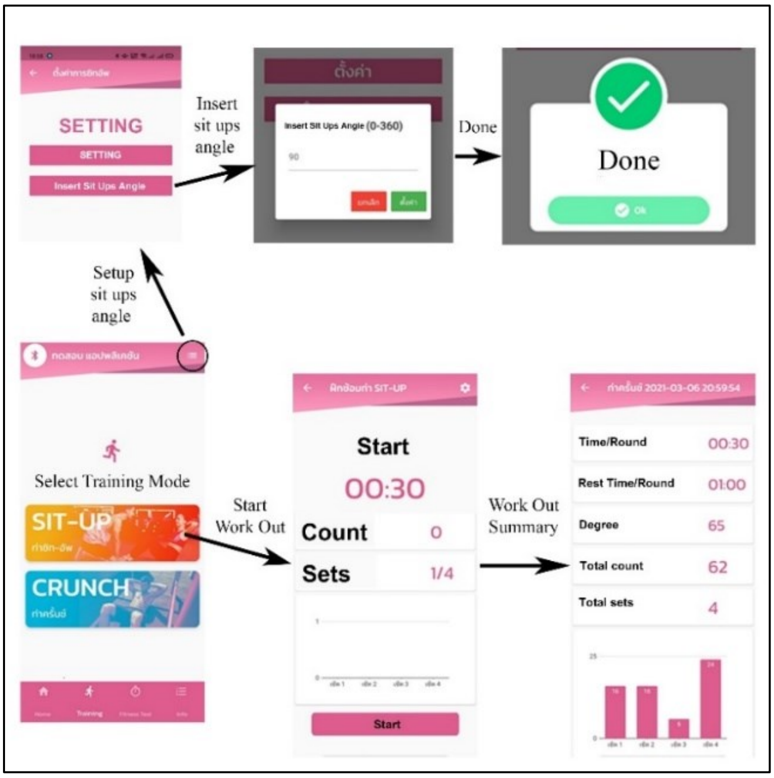


Figure 3. SitFit application.

4.1.2. SitFit implementation

The SitFit was implemented with 60 undergraduates aged 18–24. This age range is suitable for strength-building activities at moderate to maximum intensity across all muscle groups (World Health Organization, 2020). The samples were divided into two equal groups of 30 participants. First group: Using SitFit with a training program. Second group: Using only a training program. Participants were required to participate in the program for six weeks, three days per week, for a total of 18 days. SitFit implementation requires the self-paced fitness program to effectively increase the individual strength of abdominal muscles. The program details are as follows:

The self-paced fitness program consisted of a three-times-per-week sit-up training program (for a total of six weeks). Each session comprised three primary activities: 1) warm-up exercises, 2) practice sit-ups, and 3) cool-down exercises. The overall duration was 30 min. Each week, the warm-up and cool-down exercises were performed in varied positions to increase abdominal muscular strength as shown in.

Table 1. Self-paced fitness program.

Week	Activity	
1	Warm-up exercises	1) Neck stretch 2) Knee-to-elbow march 3) Side-to-side chops
	Sit-up practice	Practice sit-ups by lifting your upper body up to form a 90-degree angle. Next, lie down on your back until both sides of the scapula are on the ground. Then, do this repeatedly. Sit up for 4 sets, resting 1 minute between sets. Times per set: $M \leq 25$ and $W \leq 18$
	Cool-down exercises	1) Overhead stretch 2) Chest stretch 3) Toe touch
2	Warm-up exercises	1) Neck stretch 2) Triceps stretch 3) Knee-to-elbow march
	Sit-up practice	Practice sit-ups by lifting your upper body up to form a 90-degree angle. Next, lie down on your back until both sides of the scapula are on the ground. Then, do this repeatedly. Sit up for 4 sets, resting 1 minute between sets. Times per set: $M \leq 31$ and $W \leq 25$
	Cool-down exercises	1) Hip flexor stretches 2) Child's pose 3) Cobra pose 4) Thigh hug
3	Warm-up exercises	1) Neck stretch 2) Sitting twists 3) Cat cow stretch
	Sit-up practice	Practice sit-ups by lifting your upper body up to form a 90-degree angle. Next, lie down on your back until both sides of the scapula are on the ground. Then, do this repeatedly. Sit up for 4 sets, resting 1 minute between sets. Times per set: $M \leq 35$ and $W \leq 29$
	Cool-down exercises	1) Walking low lunges 2) Lower back rotations 3) Child's pose

Table 1. (*Continued*).

Week	Activity	
4	Warm-up exercises	1) Neck stretch 2) Triceps stretch 3) Cat cow stretch
	Sit-up practice	Practice sit-ups by lifting your upper body up to form a 90-degree angle. Next, lie down on your back until both sides of the scapula are on the ground. Then, do this repeatedly. Sit up for 4 sets, resting 1 minute between sets. Times per set: $M \leq 39$ and $W \leq 33$
	Cool-down exercises	1) Walking hams and Quads stretch 2) Hip flexor stretches 3) Child's pose
5	Warm-up exercises	1) Neck roll 2) Triceps stretch 3) Lower back rotations
	Sit-up practice	Practice sit-ups by lifting your upper body up to form a 90-degree angle. Next, lie down on your back until both sides of the scapula are on the ground. Then, do this repeatedly. Sit up for 4 sets, resting 1 minute between sets. Times per set: $M \leq 44$ and $W \leq 37$
	Cool-down exercises	1) Hip circle 2) Arm swings 3) Sitting squad stretch 4) Lower back rotations
6	Warm-up exercises	1) Neck stretch 2) Knee-to-elbow march 3) Sitting twists
	Sit-up practice	Practice sit-ups by lifting your upper body up to form a 90-degree angle. Next, lie down on your back until both sides of the scapula are on the ground. Then, do this repeatedly. Sit up for 4 sets, resting 1 minute between sets. Times per set: M ≤ 49 and W ≤ 43
	Cool-down exercises	1) Overhead stretch 2) Chest stretch 3) Toe touch 4) Child's pose

Note: M = men, W = women.

The results indicated that the average mean score after using the self-paced fitness program with SitFit ($\bar{x}$ = 31.43, S.D. = 7.13) was greater than before using it ($\bar{x}$ = 22.67, S.D. = 6.21). This was statistically significant at 0.05. Additionally, the undergraduate students exhibited high satisfaction levels following the use of SitFit with the self-paced fitness program. Below are some students' opinions on using SitFit with the self-paced fitness program:

Table 2. Evidences from the implementation.

Student A:	"SitFit helps track exercise. It makes me focus on posture and abdominal contractions that effectively build abdominal muscles. With this SitFit, I have a clear exercise goal, and it motivates me to exercise."
Student B:	"At first, the device seemed complicated. I found it quite easy to use after trying it. It enables us to exercise more consistently."
Student C:	"Once you get used to it, the device is easy to use. Just plug in the charger before starting to use. Fasten the strap to your body, set up the app, and start using it. It is very convenient."

From the research results, this study demonstrated the SitFit's effectiveness in increasing abdominal muscle strength. The results encourage students to use SitFit, especially those who wish to strengthen their abdominal muscles. The highest value from technology acceptance model (TAM) was that attitude affected behavioral intention (H3; $\beta = 0.88$; $p < 0.001$). The result of investigation was users' attitudes influenced the willingness to use wearable devices, which aligned with the findings of previous studies (Bakhshian and Lee, 2022; Huarng et al., 2022). Attitudes toward wearable devices were influenced by perceived usefulness and perceived ease of use. According to Ahn and Park (2022), wearable devices that provide useful functions with a simpler user interface are critical for positive user attitudes.

Additionally, Lunney et al. (2016) mentioned that if users have a positive attitude toward a wearable device, they are more likely to continue using it. This result also aligned with the qualitative data that the implementation of SitFit revealed that attitudes were significantly influenced the intention of use. Initially, many students did not believe that SitFit would work effectively. However, following its use, they discovered that it helped maintain the correct sit-up posture and was easy to use. Thus, they desired to use it regularly,the evidences were presented in **Table 2**

The effective use of SitFit requires the involvement of the self-paced fitness program. This program provides multiple advantages for performing sit-ups. First, it helps users develop their abdominal muscle strength. Muscle strength training should be a specificity of training that focuses on the training of movements, skills, muscle groups, and the cardiovascular system for a specific sport or activity to maximize performance (Lindberg, 2022). Second, users have a better understanding of how to perform sit-ups properly. Users are aware of the proper sit-up form. After completing this six-week program, they will have developed physical skills .

The program provided warm-up and cool-down activities. This educates users on the importance of warm-up and cool-down exercises during a workout. A proper warm-up is important for enhancing the effectiveness and safety of a workout, whereas a proper cool-down returns the body's temperature, blood pressure, and heart rate to normal levels (Chang et al., 2020; Frey, 2022). Last, the self-paced fitness program instructs users how to perform proper sit-up forms. Although it is not possible to avoid bodily injuries while exercising, proper exercise positions can prevent and reduce injury (Petushek et al., 2019). The proper workout position by SitFit reduces the risk of long-term injury and pain (Optimum health solutions, 2018). People gain long-term benefits from exercising correctly and regularly. This is evident by their improved ability to perform daily activities and prevent injury, reduce the risk of diseases, strengthen bones and muscles, and increase their chances of living longer (Elmagd, 2016; Piercy et al., 2018; Reiner et al., 2013). Furthermore, maintaining proper exercise form helps increase physical fitness, including agility, balance, coordination, power, reaction time, and speed (Davis et al., 2000; Haff and Triplett, 2016).

Furthermore, SitFit can be used for students interested in joining the military or police academy. The candidate fitness assessment (CFA) is one of the requirements for admission to such academies (Smith, 2019). The CFA evaluates not only strength and endurance but also athletic potential. Sit-ups is one of the CFA test areas. Students can individually practice the correct sit-up position using SitiFit with a self-paced fitness program and strengthen their abdominal muscles. In addition, in the military or police academy, a physical fitness test (PFT) takes place every year or twice each fiscal year (Smith, 2021). SitFit can facilitate the sit-up event by detecting whether the cadets are in the correct sit-up degree position. In addition to being convenient, it promotes more accuracy and test fairness. In conclusion, SitFit can be applied as a decision-aid technology on sit-up testing (Collins, 2012).

4.2. Quantitative results

4.2.1. Analysis of the measurement model

Table 3. Summary of factor analysis items, reliability, and convergent validity.

Measurement scale	Factor loading	Alphaa	CRb	AVEc
Perceived usefulness		0.945	0.943	0.768
1. Sit-up test devices benefit sit-ups (PU1).	0.772			
2. Sit-up test devices' usage improves health behaviors (PU2).	0.779			
3. Sit-up test devices control and improve self-health (PU3).	0.776			
4. Sit-up test devices assist sit-ups better (PU4).	0.765			
5. Sit-up test devices help in correcting body posture (PU5).	0.769			
Perceived ease of use		0.940	0.938	0.750
6. The usage method of Sit-up test devices is easy to learn (PE1).	0.798			
7. Sit-up test devices incorporate easy working steps (PE2).	0.807			
8. Sit-up test devices are workable at expert level (PE3).	0.772			
9. Sit-up test devices are easily adjusted to format usage forms as desired (PE4).	0.797			
10. Sit-up test devices are easier to maintain (PE5)	0.793			
Attitude		0.953	0.951	0.796
11. Sit-up test devices create confusion while performing sit-ups (AT1).	0.835			
12. Sit-up test devices create anxiety while performing sit-ups (AT2).	0.832			
13. Sit-up test devices create discomfort while performing sit-ups (AT3).	0.842			
14. Sit-up test devices facilitate in performing a successful sit-up. (AT4).	0.836			
15. Sit-up test devices provide the results you need (AT5).	0.849			
Behavioral intention		0.950	0.947	0.782
16. I intend to use Sit-up test devices every time when I do sit-ups (BI1).	0.836			
17. I intend to increase Sit-up test devices in the future (BI2).	0.833			
18. I intend to study all menus of application (BI3).	0.851			
19. I plan to purchase more Sit-up test devices in the future (BI4).	0.829			
20. I plan to buy better quality Sit-up test devices in the future (BI5).	0.816			
Actual use		0.958	0.956	0.814
21. I use Sit-up test devices more often than others in my family (AU1).	0.732			
22. Using Sit-up test devices makes me better understand my health (AU2).	0.790			
23. I use Sit-up test devices at full capacity (AU3).	0.808			
24. Using Sit-up test devices always keeps me strong (AU4).	0.797			
25. Using Sit-up test devices helps me exercise more rapidly and more efficiently (AU5).	0.813			

[a] Cronbach's alpha. [b] composite reliability. [c] average variance extracted.

The study investigated the acceptability of the measurement model, thereby evaluating the reliability of individual items, internal consistency between the items, convergent validity, and discriminant validity of the model. Results of the internal consistency reliability between the items and the convergent validity of the model were presented in **Table 3**. Cronbach's alpha values for all the constructs exceeded a minimum threshold of 0.70, ranging from 0.940 to 0.958. Therefore, it is satisfactory. The results of CR were between 0.943 and 0.956. The values reached a minimum threshold of 0.70, suggesting that all the structures can be considered. Furthermore, the AVE in all the variables was between 0.750 and 0.814. The results exceeded a minimum threshold of 0.50, which is acceptable for convergent validity.

The results of discriminant validity are shown in **Table 4**. The square roots of AVE values (bold numbers in the diagonal) were reported to be higher than the squared correlations of the associated construct. This indicates that the measurements have sufficient discriminant validity.

Table 4. Discriminant validity of the measurement model.

	PU	PE	AT	BI	AU
PU	0.876				
PE	0.817	0.866			
AT	0.723	0.790	0.892		
BI	0.740	0.677	0.606	0.884	
AU	0.754	0.732	0.648	0.784	0.902

4.2.2. Analysis of the structural model

The model's fit was examined before analyzing the structural model's paths. The absolute fit indexes were used to evaluate how well the model fit the empirical data as shown in **Table 5**.

Table 5. Goodness-of-fit statistics between model components and empirical data.

Fit measure	Criteria	Measurement	Results
X^2/df	<2.00–5.00	2.55	Pass
CFI	≥0.95	1.00	Pass
GFI	≥0.95	0.95	Pass
AGFI	≥0.90	0.92	Pass
NFI	≥0.95	1.00	Pass
RMSEA	<0.05	0.039	Pass
SRMR	≤0.05	0.032	Pass

The analysis found that PU directly influenced AT (H1), valued at 0.34 ($p < 0.001$). In addition, the PE directly influenced AT (H2), valued at 0.53 ($p < 0.001$). Furthermore, AT directly influenced BI (H3), valued at 0.88 ($p < 0.001$), and the value of BI directly influenced AU, which equaled to 0.84 ($p < 0.001$, **Figure 4**). The results of quantitative data revealed that people accepted digital innovation in physical education. We found that the effects of the "attitudes" and "ease of use" variable on the behavioral intention to adopt the sit-ups fitness tracker. As shown in **Figure 4**, The influence of the variable "attitudes" is significantly important than that of the independent variables. This finding highlights the substantial significance of the "attitudes" variable in explaining the variance within the acceptance model. It means among other variables an individual's attitudes toward the sit-ups fitness tracker emerge as a primary determinant exerting a notable influence on their intention to adopt this device. These results confirm theories advocating the pivotal role of attitudes in shaping intention such as theory of reasoned action and theory of planned behavior (Ajzen, 1991). Fishbein and Ajzen (1977) demonstrate that specific attitudes, such as those pertaining to a wearable fitness tracker, are a robust predictor of corresponding behaviors. Given the pronounced influence of the "attitudes" variable in explaining individuals' intentions, a thorough analysis was conducted to examine how other independent variables are associated with the 'attitudes' variable (**Table 3**). We found that the device usage with the feeling of "confusion", "anxiety" and "discomfort" was negatively associated with attitudes. However, "facilitation" and "the good result" to improve health status were positively associated. It is likely these variables exert a direct influence on adoption intention through the "attitudes" variable. We also found that the perceived ease of use had a statistically significant association with the intention to adopt the sit-ups fitness tracker. This may indicate that individuals who initially show less intention to use this device might opt for adoption if they perceive it as easy to use. This suggests that the perceived ease of use can act as a compelling factor influencing their decision to adopt the device. This result is similar to pervious study of new technology adoption such as Davis (1989), Gao et al. (2015) and Lunney et al. (2016).

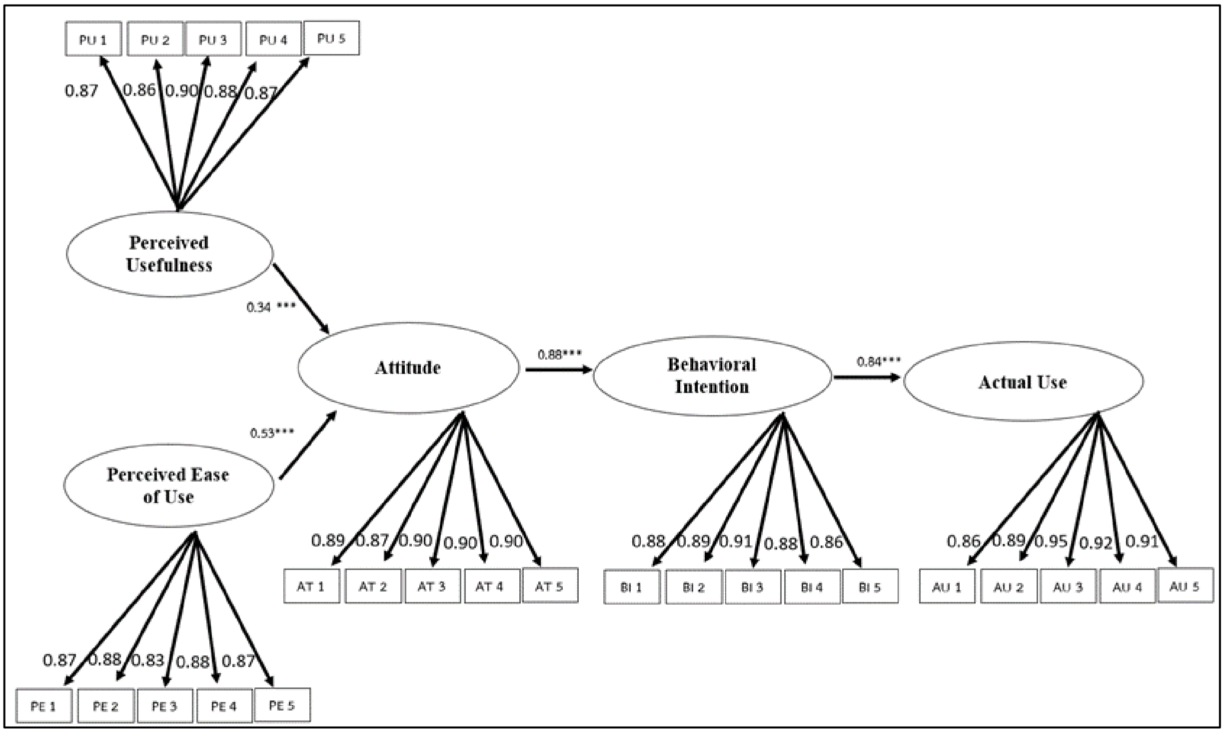


Figure 4. Structural equation modeling analysis for technology acceptance model in digital physical education.

*** $p < 0.001$.

The specialists who contributed qualitative data recommended the following improvements: (1) enhancing the stability of the connection between SitFit and its application, (2) conducting investigations and making improvements to software faults, and (3) substituting the participants with generic individuals. In addition, participants need to be of the same age as the general population and have similar exercise habits. Moreover, findings from a preliminary investigation concluded that individuals comprehend the correct technique for executing a sit-up and are capable of enhancing their abdominal strength. Thus, the quantitative data and findings from the pilot study were utilized to establish the implementation of SitFit.

5. Discussion

This study provides significant additions to the current state of research on wearable fitness technology and its incorporation into self-paced exercise programmes. The findings provide valuable insights into the main factors that influence the acceptance and adoption of SitFit, an innovative device used to measure sit-up exercises.

A primary finding was the outsized influence of user attitudes on behavioral intentions to use SitFit. The study found that attitudes were the strongest predictor of intentions, accounting for a large portion of the variance explained in the technology acceptance model. This aligns with well-established theories of reasoned action and planned behavior, which posit that attitudes play a central role in shaping volitional behaviors (Ajzen, 1991; Fishbein and Ajzen, 1977). As noted by Lunney et al. (2016), when users develop positive attitudes toward a wearable device, they are more likely to continue using it over time. The qualitative data further corroborated this, with participants initially skeptical but then expressing high satisfaction after using SitFit and desiring to integrate it into their regular exercise routines.

Interestingly, both perceived usefulness and perceived ease of use emerged as key antecedents driving these favorable attitudes. Echoing prior research (Ahn and Park, 2022; Bakhshian and Lee, 2022), the results suggest that wearable fitness technologies need to deliver tangible benefits to users while also maintaining a simple, intuitive user experience. SitFit appears to have achieved this balance, with participants highlighting its ability to provide objective feedback and guidance on proper sit-up form, as well as the ease of setup and usage.

The synergistic integration of SitFit with a structured self-paced exercise program is another notable aspect of this work. As noted by Lindberg (2022), specificity of training is crucial for maximizing performance improvements, particularly for activities like sit-ups that require mastery of proper technique. The comprehensive program designed in this study, incorporating targeted warm-ups, progressive overload in sit-up repetitions, and thoughtful cool-downs, likely played a key role in enhancing participants' abdominal muscle strength and exercise execution. This aligns with recommendations from exercise science experts emphasizing the importance of evidence-based programming for improving fitness and reducing injury risk (Chang et al., 2020; Frey, 2022; Petushek et al., 2019).

Beyond the fitness benefits, the authors also highlight the potential utility of SitFit for specific populations, such as those preparing for military or law enforcement physical fitness assessments. As noted by Smith (2019, 2021), sit-up performance is a critical component of these evaluations, and tools like SitFit could provide valuable training assistance and objective scoring. This extends the relevance of the current findings to a broader set of stakeholders beyond the general fitness enthusiast demographic. Overall, this study makes a compelling case for the value of purpose-built wearable technologies integrated with structured exercise programming. By systematically examining user perceptions and objectively measuring outcomes, the authors have generated insights that can inform the design and deployment of future generations of smart fitness devices. As these technologies continue to evolve, ongoing research of this nature will be crucial for ensuring they meet the needs and expectations of diverse user groups.

6. Limitations and future studies

In order to ascertain the adaptability and advantages of SitFit for a variety of fitness requirements, future research could investigate its efficacy across various age groups. The long-term impact on abdominal strength, injury prevention, and overall fitness could be evaluated through longitudinal studies. Furthermore, research could investigate the potential of SitFit in specialized environments, such as military training, and its integration with broader exercise programs. Customizable features for various fitness levels, as well as enhancements to user experience and interface design, are areas that merit further investigation. Finally, future research could also examine the extent to which SitFit contributes to the improvement of exercise motivation in comparison to conventional methods and other fitness monitors.

7. Conclusion

In a study with 30 undergraduates aged 18–24 using SitFit with a self-paced fitness program over 6 weeks, results showed improved abdominal muscle strength and proper sit-up form compared to before using SitFit. Users reported high satisfaction, indicating SitFit's market readiness.

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