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Development and validation of the Chinese version of the adult sedentary behavior reduction intention questionnaire based on the theory of planned behavior

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Abstract

Prom The Chinese version of the Adult Sedentary Behavior Reduction Intention Questionnaire, a 16-item self-reported tool based on the Theory of Planned Behavior (TPB), was developed to assess adults' intentions to reduce sedentary behavior.

Measurement property Internal consistency is used to measure the reliability of the questionnaire, while content and structural validity are studied to assess its validity.

Design A mixed-methods exploratory sequential design with two phases.

Sample Adults aged over 18 years diagnosed with coronary heart disease, with a total daily sedentary time exceeding 6 h, normal cognitive function, and willingness to participate in the study were included.

Methods The study was conducted in two phases. In Phase 1, an initial item pool was developed through a literature review and refined using two rounds of Delphi expert consultation. Expert positivity, authority levels (Cr), coefficients of variation (CV), and Kendall's W coefficient were calculated to assess representativeness, credibility, and consensus. A pilot study evaluated face validity and finalized the scale. In Phase 2, a cross-sectional study involving 316 participants was conducted to assess psychometric properties. Reliability was evaluated using Cronbach's α and split-half reliability, while content validity was assessed using the content validity index (I-CVI). Construct validity was examined through confirmatory factor analysis (CFA).

Results Phase 1 resulted in a preliminary questionnaire with four dimensions and 16 items. Sixteen experts completed two rounds of Delphi consultation, with high response rates (85% and 94.1%) and authority levels (Cr = 0.88 and 0.91). Consensus was strong (CV = 0.05 ~ 0.23; Kendall's W = 0.338 and 0.382, $p < 0.001$). Phase 2 validation showed a Cronbach's α of 0.967, with individual dimensions ranging from 0.911 to 0.950. I-CVI ranged from 0.813 to 1. The adjusted model indices met the fitting criteria.

Conclusions The developed questionnaire is a reliable and valid tool for assessing Chinese adults' intentions to reduce sedentary behavior. Grounded in TPB, it provides a theoretical foundation for future intervention studies aimed at addressing sedentary lifestyles.

Keywords Theory of planned behavior, Sedentary behavior, Instrument development, Psychometric validation

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Introduction

With the rapid development of science and technology, changes in work patterns, leisure activities, and transportation have made sedentary behavior a global mainstream trend. Sedentary behavior, defined as activities such as reading, gossiping, watching TV, using computers, or commuting in a sitting or lying posture with energy expenditure below 1.5 metabolic equivalents (METs) [1], is prevalent worldwide. Unlike the definition of physical activity, which refers to any bodily movement produced by skeletal muscles that requires energy expenditure [2]. Physical activity and sedentary behavior are not antonyms. Even if individuals meet the recommended levels of physical activity (≥ 150 min/week), they may still accumulate excessive sedentary behavior, posing potential health risks [3, 4].

Data from the National Health and Nutrition Examination Survey (NHANES) indicate that US adults spend an average of 6 to 8 h per day sitting [5], consistent with findings from China (mean:7.8 ± 3.4 h/d) [6] and cross-European studies (ranging from 150 to 620 min per day) [7]. A cohort study by Beller et al. [8] further revealed trends in sedentary behavior among European populations from 2013 to 2022, showing increased sedentary time among middle-aged individuals (21–65 years), decreased time among adolescents (15–20 years), and stable levels among the elderly (66 + years), with a notable rise among middle-aged individuals of lower socioeconomic status.

Sedentary behavior is particularly prevalent among individuals with chronic diseases. The Study on Global Ageing and Adult Health (SAGE) found that 10.8% of people with chronic diseases in six countries, including China, exhibited high sedentary behavior (≥ 8 h/d) [9]. Those with cardiovascular disease (e.g., angina pectoris, coronary heart disease) spend up to 9.6–10.1 h per day sedentary [10], while individuals with diabetes average 12.5 h daily [11]. Prolonged sedentary time is strongly associated with an increased risk of non-communicable diseases (NCDs), including ischemic heart disease, diabetes, cancer, chronic obstructive pulmonary disease [12]. Wu et al. [13] systematically reviewed evidence linking sedentary behavior to a higher risk of metabolic syndrome, independent of physical activity levels. Similarly, Li et al. [14] analyzed 105,677 participants across income levels and found that individuals with sedentary time exceeding eight hours per day had significantly higher cardiovascular disease morbidity (HR: 1.21; 95% CI: 1.10–1.34) and mortality (HR: 1.20; 95% CI: 1.10–1.31) compared to those with less than four hours of sedentary time.

Given these findings, reducing sedentary behavior has been recognized as a feasible strategy for preventing and managing chronic NCDs [15]. The World Health Organization (WHO) and countries such as the United Kingdom and Italy have issued guidelines recommending that adults minimize sedentary time [2, 16]. For example, Canadian 24-Hour Movement Guidelines advise limiting sedentary time to less than eight hours daily, including no more than three hours of recreational screen time [16]. These recommendations underscore the importance of exploring factors influencing sedentary behavior to develop targeted policies and interventions, ultimately promoting public health and preventing NCDs.

Current research presents inconsistent evidence on association between demographic factors (e.g., age, sex, ethnicity, occupation, socioeconomic status) and sedentary behavior [6, 17–19]. However, compared to immutable factors such as age, gender, and age-related declines in physical function, psychosocial factors are often the most effective entry point for behavioral interventions [20]. The Theory of Planned Behavior (TPB), a psychosocial framework, serves as a core structure for measuring behavioral intention, subjective norms, attitudes and perceived behavioral control, and is widely used to analyze the psychosocial factors influencing behavior and explain individual decision-making processes [21]. Initially proposed by Ajzen in 1985 as an extension of the Theory of Reasoned Action [22], TPB addresses the limitation of the original theory in explaining behaviors not fully under volitional control [21].

TPB posits that behavior is driven by behavioral intention, which is shaped by three key factors: attitudes, subjective norms, and perceived behavioral control [21]. Behavioral intention defined as the motivation to perform a specific behavior in the near future [23]. Attitudes reflect an individual's positive or negative evaluation of performing a behavior [23, 24]. Subjective norms capture the perceived social pressure to engage or not engage in a behavior [23, 24]. Perceived behavioral control refers to an individual's assessment of the ease or difficulty of performing a behavior, which can directly or indirectly influence behavior depending on the alignment between perceived and actual control [23–25]. Generally, more positive attitudes, stronger subjective norms, and greater perceived behavioral control led to stronger behavioral intentions [24]. The framework is shown in Fig. 1 [26].

A literature review revealed that TPB has been widely applied in the field of health behavior management, such as physical activity [27, 28], healthy eating [29, 30], medication adherence [31, 32], and smoking cessation [33]. González et al. developed a physical activity scale based on TPB [34]. However, since sedentary behavior and physical activity are fundamentally distinct, reducing sedentary behavior cannot be simply equated with increasing physical activity. Therefore, this scale is not

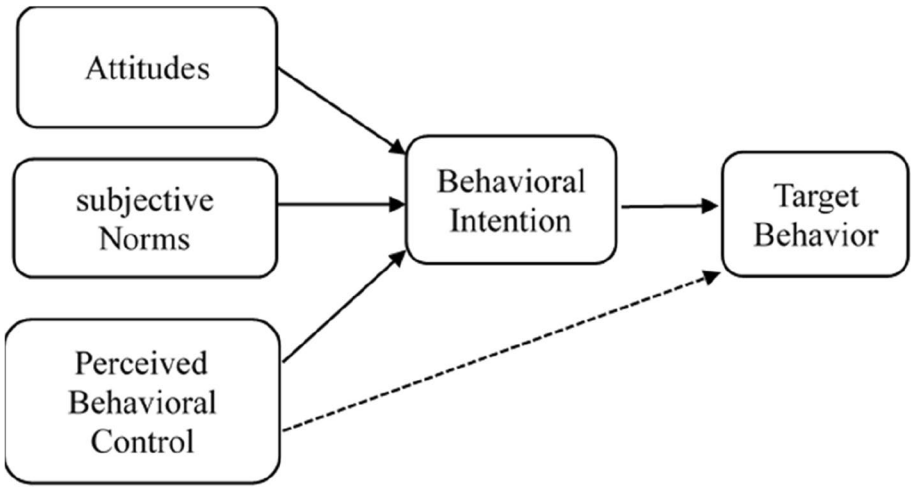

Fig. 1 Theoretical framework of the theory of planned behavior

suitable for assessing the intention to reduce sedentary behavior. Prapavessis et al. [35] demonstrated the utility of social cognitive structures based on the TPB in understanding sedentary intentions and behaviors, complementing ecological models that focus solely on the influence of environmental factors on individual sedentary behavior. However, this study was limited to elucidating the role of TPB variables in engagement in sedentary behavior and could not explain their role in reducing sedentary behavior. To the best of our knowledge, no relevant studies have reported the development and validation of an effective TPB scale to assess the intentions or motivations of adults to reduce sedentary behavior, especially among the Chinese population.

Aim

This study was undertaken in two phases. The aim of Phase 1 is to develop a Chinese version of the Adult Sedentary Behavior Reduction Intention Questionnaire based on TPB through a literature review and expert consultations. The aim of Phase 2 is to validate the psychometric properties of the Chinese version of the questionnaire.

Methods

This methodological study is composed of the following two sequential phases (Fig. 2).

Phase 1–Item generation and questionnaire development

Phase 1 adopted an exploratory research design, utilizing a literature review and 2–3 rounds of the Delphi expert consultation method to develop the item pool [36]. By summarizing the experts' opinions, the questionnaire will be revised and improved. After a small-sample pilot study, the modified version of the Adult Reducing Sedentary Behavior Intention Questionnaire will be formed.

Translation and cultural adaptation

The questionnaire development adhered to "Constructing a TPB Questionnaire: Conceptual and Methodological Considerations" [25] and "Constructing Questionnaires Based on the Theory of Planned Behavior" [37]. To ensure accurate comprehension of the guidelines, the research team undertook a translation process involving independent direct translation and back-translation [38]. This process was conducted by a nursing PhD with overseas study experience and another researcher. The translated texts were compared, and discrepancies were identified and adjusted to form a revised translation. Subsequently, a nursing PhD currently studying abroad performed the back-translation, which was again compared and adjusted by the initial translators. This resulted in a Chinese version of the guideline suitable for reference. From a cross-cultural perspective, no significant cultural differences were identified that necessitated modifications to the Chinese version of the guideline.

Literature review

A literature review was conducted using Chinese databases such as CNKI, Wanfang, VIP, and Chinese BioMedical Literature Database, and English databases, including PubMed, Web of Science, CINAHL, and Embase. The keywords include "sedentary behavior", "sitting" "behavior change", "TPB", "scale" and "questionnaire". The search period ranged from December 2016 to December 2021.

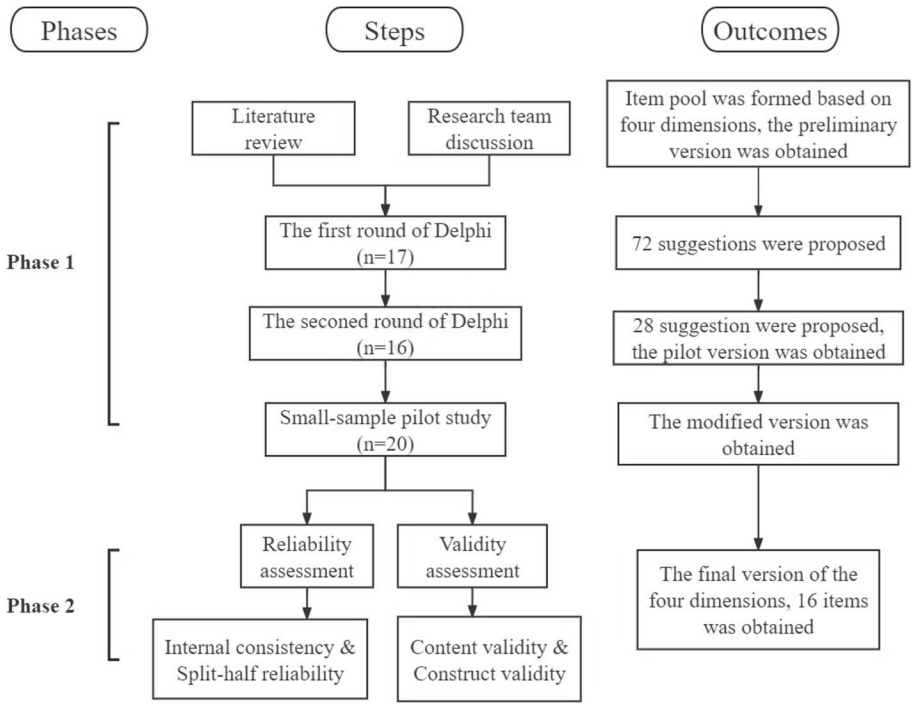

Fig. 2 The flowchart of the study

Eligibility criteria included peer-reviewed Chinese or English studies in the field related to the construction of TPB-based questionnaires and sedentary behavior, while excluding grey literature, conference abstract, editorial, and letter. The research team categorized identified references by TPB constructs, independently extracted scale items, and resolved discrepancies through research team discussions to develop the item pool. Final items were retained only if they met three criteria: (a) theoretical alignment with TPB, (b) relevance to sedentary behavior reduction, and (c) linguistic and cultural appropriateness for the target population.

Delphi technique

In order to reach a consensus on the item pool developed in the previous step, the Delphi expert consultation method was employed to solicit experts' opinions. Each subsequent round of inquiry was conducted based on the analysis and revision of the previous round's feedback.

Experts were chosen through expert sampling, where individuals with relevant knowledge or experience were interviewed or asked for their opinions. Typically, the preferred number of experts ranges from 10 to 15 [39].In current study, experts were selected nationwide in China, with the inclusion criteria being: a) Possessing a high academic level and practical experience in research fields such as physical activity, sedentary behavior, sports rehabilitation, chronic disease management, or psychology; b) Being familiar with TPB or having participated in the process of constructing a TPB questionnaire. To provide constructive suggestions for the development of a comprehensive item pool, generally, 10–15 experts were chosen.

The expert consultation questionnaire consisted of four parts. The first part introduced the background, objectives, and significance of this study. In the second part, experts were asked to rate the level of importance of each item on a 5-point Likert questionnaire (ranging from "absolutely important" to "not important at all" is "5–1"), as well as evaluate the correlation between items and dimensions on a 4-point Likert questionnaire (ranging from "strongly correlated" to "uncorrelated" is "4–1"). Experts were also encouraged to provide suggestions for unclear or improvable items. The third part was a self-assessment of the experts' authority level (Cr), with judgment criteria (Ca) including practical experience, theoretical analysis, reference to domestic and foreign literature, and intuitive feelings. The degree of influence was classified as major, moderate, or minor. The familiarity level (Cs) ranged from "very familiar" to "very unfamiliar". The fourth part was a survey of experts' basic information, including gender, age, education, workplace, research field, etc.

Experts were contacted through email or WeChat to distribute the consultation questionnaires. After each round, the scores and opinions of the experts were collected, and

the research team discussed and revised the preliminary questionnaire accordingly. The next round of expert consultation was then conducted until expert opinions converged. Data entry and statistical analysis were performed using Excel 2019 and the Statistical Package for the Social Sciences (SPSS) version 26.0. The positivity and authority level of experts (Cr) were calculated to reflect the representativeness and credibility of the Delphi expert consultation. The coefficient of variation (CV) and Kendall's W coefficient were used to indicate the degree of consensus among experts. Taking into account the specific opinions of the experts, the research team ultimately decided on the addition, deletion, or modification of items through discussion.

Research team discussion

After conducting a literature review and Delphi consultation, the research team developed the initial questionnaire through structured group discussions. Items were retained based on Delphi scores (coefficient of variation, $CV \leq 0.25$), and each expert opinion was systematically evaluated through a line-by-line review against three criteria: theoretical consistency, cultural adaptability, and operational feasibility. Subsequently, the research team collaboratively revised the items according to expert feedback. In cases of disagreement, external experts were consulted to reach consensus.

Pilot study

Using convenience sampling, a small-sample pilot study was conducted between April 11 and April 30, 2022, involving 20 adults from community health centers with daily total sedentary behavior duration of ≥ 6 h, to examine the face validity of the questionnaire. Since the primary purpose of the pilot study was to preliminarily assess the face validity and feasibility of the scale rather than to conduct rigorous statistical analysis, a sample size of 20 was deemed sufficient to identify obvious issues while adhering to resource and time constraints [40]. Face validity was assessed through two-phase cognitive interviews [41]. Firstly, Participants verbalized comprehension processes while completing the questionnaire. Secondly, probing questions were used to further explore participants' understanding and to assess the alignment of their responses with the intended constructs of the TPB (e.g., "How do you define sedentary behavior?" Or "Please list daily activities that you consider sedentary."). Additionally, each item was rated on a 5-point Likert scale (unclear = 1, very clear = 5). Items with mean scores < 4.0 underwent iterative revision.

Items that participants found unclear or inappropriately expressed were recorded. Then the research team discussed the participants' opinions and suggestions for modifications, adjusting the wording of the items accordingly.

Phase2–Reliability and validity of the questionnaire

To validate the psychometric properties of the questionnaire, content and construct validity as well as the reliability were assessed.

Participants

Phase 2 employed a cross-sectional research design and used convenience sampling to select participants. Inclusion criteria: (a) confirmed diagnosed as coronary heart disease by a cardiovascular specialist through ECG, Holter monitoring, cardiac ultrasound, coronary CT, or coronary angiography, with a diagnosis duration of ≥6 months; (b) 18 years or older; (c) daily total sedentary behavior duration of ≥6 hours (assessed using the Chinese Adult Sedentary Behavior Questionnaire); (d) normal cognitive ability and capable of completing the questionnaire independently or with the help of the researcher; (e) voluntarily participates and signs an informed consent form.

Exclusion criteria: (a) with severe hearing impairment that significantly affects communication; (b) with various primary mental disorders; (c) have difficulties with language or communication that hinder cooperation; (d) with motor function impairments; (e) with serious diseases affecting major organs or systems.

Based on the questionnaire with 16 items obtained from phase 1, the minimum required sample size is calculated to be 160, following the 10:1 rule [42]. However, confirmatory factor analysis required a sample size of more than 200 cases [43]. Considering 20% of invalid questionnaires [43], a minimum sample size of 240 was required in this study.

Measurements

For the psychometric validation analysis, the participants were administered the following measures along with the refined version of the TPB questionnaire obtained in the preceding phase 1.

The general demographic questionnaire includes variables that may influence sedentary behavior, such as age, gender, education level, and marital status etc.

Chinese Adult Sedentary Behavior Questionnaire, developed by Tian and Gu [44], was used to screen the participants whose average daily total sedentary behavior duration ≥6h. This questionnaire consists of 10 items that assesses the number of days in a week and the time spent on the 10 common sedentary behaviors. The questionnaire has a good test-retest reliability of 0.82 and a correlation coefficient of 0.51 ($P<0.001$) with accelerometers, demonstrating satisfactory reliability and validity.

Data collection

This study conducted a questionnaire survey among participants in the cardiovascular unit in a tertiary hospital who met the aforementioned inclusion and exclusion criteria between May and September 2022. Researchers informed each participant about the purpose and significance of the study and asked them to sign the informed consent form. It took approximately 10–15 minutes to complete a questionnaire.

Statistical analysis

Data were analyzed using SPSS version 26.0 and confirmatory factor analysis (CFA) was carried out by the AMOS program, version 24.0.

Reliability assessment

Reliability refers to the stability and consistency of the results measured by the questionnaire tool, including internal consistency and split-half reliability [45].

Internal consistency is an indicator of how well the different items measure the same issue, typically measured by calculating Cronbach's α coefficient. As recommended by Price [46], the Cronbach's α coefficient for each dimension should be >0.60, and the overall questionnaire Cronbach's α coefficient should be >0.7, which is considered to have good reliability.

Split-half reliability refers to dividing the questionnaire items into two parts and calculating the correlation between the scores of the two parts, where value >0.70 is deemed to indicate adequacy of internal consistency of the items [46].

Validity assessment

Validity is an estimate of how well an instrument measures what it is supposed to measure, including both content and construct validity [46].

Content validity is a subjective assessment conducted by experts in the relevant field to determine the appropriateness of the items in relation to the subject matter [45]. In this study, content validity was evaluated by the 16 experts from the second Delphi round. They provided comprehensive ratings on the clarity, importance, and relevance of the items, with a scoring range of 1–4. Content validity was represented by the item-level content validity index (I-CVI). When the I-CVI is ≥ 0.78, it indicates that the questionnaire has good content validity [47].

Construct validity was assessed by CFA. Under the known theoretical framework, the maximum likelihood estimation method is used to establish a model for parameter estimation, verifying the degree of fit between the model and the data. Using the following parameters as indices of good fit: χ^2/df (CMIN/*df*) less than 3, Root Square Error of Approximation (RMSEA) less than 0.08; Goodness of Fit Index (GFI), Adjusted Goodness of Fit Index (AGFI), Normed Fit Index (NFI), Incremental Fit Index (IFI), Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) of more than 0.90 [48].

Results

Phase 1

The results of the item pool

Ajzen suggests using the TACT elements (Target, Action, Context, and Time) to define the target behaviors [25]. Typically, there are no restrictions on "Context" and "Time" to obtain information in different environmental backgrounds and a broader time range. In this study, the target behavior is defined as "reduce sedentary behavior time in the next 7 days", in which "reduce sedentary behavior time" is the "Target", "reduce sedentary behavior" is the "Action", "in the next 7 days" is the "Time" and "Context" is not limited. Furthermore, the target behavior adheres to the principle of compatibility, ensuring alignment with the theoretical framework.

Ajzen [25] and Francis et al. [37] proposed principles for constructing items of the TPB. For instance, behavioral intention items were developed using stems such as "I expect/I want/I plan/I intend + target behavior", while attitude items employed bipolar adjectives (e.g., useful-useless, pleasant-unpleasant, good-bad) to capture instrumental, experiential, and overall evaluations of the behavior. Guided by these principles, the research team categorized identified references [34, 35, 49–53], independently extracted scale items, and resolved discrepancies through three rounds of discussions to develop the item pool. Existing items were adapted, while novel items addressing context-specific gaps were drafted. After further refinement and selection by the research team, the questionnaire included four dimensions and 16 items, as shown in Table 1.

Lastly, Ajzen [25] suggests that items of different dimensions should be interwoven and presented non-sequentially in the final questionnaire. Therefore, in the final version of the questionnaire, the items will be arranged in a non-sequential order.

Demographics of the expert panel

The Delphi method was conducted from January to April 2022, with experts from eight provinces and regions in China, including Zhejiang, Shanghai, and Beijing. The experts were all from higher education institutions or tertiary hospitals and held Master's and PhD degrees, covering fields such as physical activity, education, psychology, nursing, and chronic disease management. 17 participated in the first round of the expert consultation, and one expert chose to withdraw during the second

Table 1 The item pool based on four dimensions

Dimension	Item	Scoring
Behavioral Intention	1. I plan to reduce the sedentary behavior time in the next 7 days	strongly disagree = 1; strongly agree = 7
	2. I want to reduce the sedentary behavior time in the next 7 days	strongly disagree = 1; strongly agree = 7
	3. I will try to reduce the sedentary behavior time in the next 7 days	strongly disagree = 1; strongly agree = 7
Attitudes	4. For me, reducing the sedentary behavior time in the next 7 days is	4.1 harmful = 1; beneficial = 7
		4.2 worthless = 1; valuable = 7
		4.3 unpleasant = 1; pleasant = 7
		4.4 unenjoyable = 1; enjoyable = 7
		4.5 bad = 1; good = 7
Subjective Norms	5. Most people who are important to me (family/friends/doctor) think that reduce sedentary behavior time in the next 7 days	I should not = 1; I should = 7
	6. It is expected of me that I reduce the sedentary behavior time in the next 7 days	strongly disagree = 1; strongly agree = 7
	7. Most people who are important to me (family/friends/doctor) will reduce the sedentary behavior time in the next 7 days	strongly disagree = 1; strongly agree = 7
	8. The surrounding people like me reduce the sedentary behavior time in the next 7 days	strongly disagree = 1; strongly agree = 7
Perceived Behavioral Control	9. For me, reducing the sedentary behavior time in the next 7 days is	difficult = 1; easy = 7
	10. I am confident that I could reduce the sedentary behavior time in the next 7 days	strongly disagree = 1; strongly agree = 7
	11. It is mostly up to me whether or not I reduce the sedentary behavior time in the next 7 days	strongly disagree = 1; strongly agree = 7
	12. Reducing the sedentary behavior time in the next 7 days is within my control	strongly disagree = 1; strongly agree = 7

round, leaving 16 experts completing the second round of consultation. Among these experts, 5 were male (29.41%) and 12 were female (70.59%). The average age was 45.65 ± 8.27 years. 41.18% of the experts had a Master's degree and 58.85% had a PhD degree. 64.71% of the experts held senior professional titles and 35.29% held vice-senior professional degree. The average work experience was 21.24 ± 9.26 years. The further details are shown in Table 2.

Statistical analysis results of the Delphi method

The positivity of experts is generally expressed by the questionnaire recovery rate and the expert opinion proposal rate. In this study, the recovery rate of the first and second round was 85% and 94.1%, respectively, and the expert opinion proposal rate was 88.2% and 68.8%, respectively, indicating a relatively high level of positivity from the experts.

The authority level of experts (Cr) is calculated based on their judgment basis for the items (Ca) and their familiarity with the survey content (Cs). $Cr \geq 0.7$ indicates acceptable expert authority. The results of this study showed that Cr in the first and second rounds were 0.88 and 0.91, respectively, indicating a high level of expert authority.

$$Calculation\ Formula: Cr = (Cs + Ca)/2$$

The degree of experts' coordination is represented by the coefficient of variation (CV) and Kendall's coefficient (Kendall's W). $CV < 0.25$ and Kendall's W ranging between 0 and 1 indicate better expert consensus. In the first and second rounds of expert inquiries, the CV values were 0.05–0.16 and 0.05–0.23, respectively, while Kendall's W values were 0.382 and 0.338, respectively, $P < 0.001$.

Results of item modification for the questionnaire

In the first round of expert consultation, a total of 15 experts provided 72 suggestions, including clarifications, additions, deletions, and modifications of the item expressions.

Most of the suggestions were related to clarifying the item expressions, making them more in line with daily language habits. For example, in the attitudes dimension, four experts proposed changing item 4.4 from "enjoyable" and "unenjoyable" to "uncomfortable" and "comfortable", respectively. Additionally, four experts suggested changing "bad" in item 4.5 to "a bad thing" and "good" to "a good thing".

Table 2 Demographic characteristics of the experts

Characteristics	Round 1 n (%)
Gender	
Male	5 (29.41)
Female	12 (70.59)
Age	
30–39	5 (29.41)
40–49	6 (35.29)
50	6 (35.29)
Education	
Bachelor degree	0 (0)
Master degree	7 (41.18)
PhD degree	10 (58.82)
Job title	
Senior	11 (64.71)
Vice-senior	6 (35.29)
Professional area	
Physical activity	4 (23.53)
Health management	4 (23.53)
Pedagogy	6 (35.29)
Psychology	2 (11.76)
Nursing	7 (41.18)
Work Experience(years)	
< 10	1 (5.88)
10–19	5 (29.41)
20–29	7 (41.18)
≥ 30	3 (17.65)
Work unit	
Colleges and universities	10 (58.82)
Class A tertiary hospital	7 (41.18)
Location	
Zhejiang	6 (35.29)
Shanghai	3 (17.65)
Beijing	2 (11.76)
Shandong	2 (11.76)
Anhui	1 (5.88)
Shanxi	1 (5.88)
Hainan	1 (5.88)
Taiwan	1 (5.88)

Some aimed to improve the items by modifying them to reflect the connotations of subjective norms better. For instance, one expert pointed out that the subjective norms dimension should cover the following relevant attributes, such as others' demonstrations, persuasion, social influence, and the impact of others. Two additional items were therefore added to the subjective norm dimension, i.e. "The entire society is advocating to reduce or interrupt sedentary behavior by standing, walking, or other physical activities" and "I should respond to the prevailing social trend to reduce or interrupt sedentary behavior in the next 7 days by standing, walking, or engaging in other physical activities". Two other experts recommended revising items 7 and 8 (which were used to predict the behavior choices of surrounding people/important others in the next 7 days) to describe whether surrounding people/important others perform the target behavior, which can better reflect the concept of subjective norms. Therefore, items 7 and 8 are respectively revised to "My family members often reduce or interrupt sedentary behavior time by standing, walking or other physical activities" and "My close friends often reduce or interrupt sedentary behavior time by standing, walking or other physical activities". Item 11 in the perceived behavioral control dimension was deleted due to its overlapping meaning with item 12.

Some experts pointed out that the definition of the target behavior should be further enriched, such as by specifying how to reduce sedentary behavior. After discussion within the research team, the target behavior was changed from the original "reduce sedentary behavior time in the next 7 days" to "reduce or interrupt sedentary behavior in the next 7 days through standing, walking, or other physical activities".

Two experts suggested that there should be a time limit for "reduce" and "interrupt" sedentary behavior in the questionnaire. Currently, the most widely accepted definition of sedentary behavior comes from the Sedentary Behavior Research Network (SBRN), which describes it as any waking behavior characterized by an energy expenditure of less than 1.5 metabolic equivalents (METs), performed while sitting or lying posture [1]. However, there is currently no international consensus on the threshold and interruption time for sedentary behavior. According to the previous research conducted by our team [54], the results showed that screen time is often regarded as a marker for total sedentary time. Exceeding 5–6 h per day of screen time and over 10–11 h per day of total sedentary time poses similar risks to cardiovascular health. Given that screen time currently occupies a significant portion of people's daily routines, exceeding the threshold of 6 h per day can result in health risks. Moreover, studies have indicated that for individuals engaging in more than 6 h of sedentary behavior daily, replacing sitting with walking or moderate-to-vigorous physical activity yields greater benefits [55]. Therefore, the threshold for sedentary behavior in this study is set at 6 h.

While numerous studies have shown that regularly breaking up sedentary behavior through standing, walking, or light physical activity can significantly improve related health indicators [55–57], there is currently no consensus on quantitative data, such as the duration of

uninterrupted sitting or the intervals for breaking up sedentary time. Several researches suggest that walking for 2 to 5 min after every 30 min of sitting can markedly improve vascular function and metabolic markers, promoting cardiovascular health [58–61]. As a result, this study's scale sets the thresholds for uninterrupted sitting and breaks at 30 min and 5 min, respectively.

The research team members reviewed and summarized relevant literature and operationally defined "reduce" as "reduce daily sedentary behavior to less than 6 h" and "interrupt" as "interrupt continuous sedentary behavior and engaging in physical activities, such as standing, walking, or other exercises for 5 min after every 30 min of continuous sedentary behavior". Related explanations were added to the preamble of the questionnaire.

In the second round, a total of 11 experts provided 28 suggestions, which did not include any addition or deletion of items. The suggestions mainly focused on minor modifications to the item expressions or scoring settings, and therefore the consultation was stopped. Relevant suggestions included the expression "in the next 7 days" changed to "next week". However, "7 days" is more specific in terms of time expression than "next week", so this suggestion was not adopted. Based on expert opinion, to make the scoring more understandable for the participants, the 7-point Likert of the questionnaire was changed to 5-point Likert. Items were further refined in response to the experts' suggestions.

The results of the pilot study

During the pilot study stage, a total of 25 questionnaires were distributed, with 20 returned, achieving a response rate of 80%. Over half (75%) of the participants were males and the mean age of the pilot study participants was 61.50 ± 12.55 years. The proportion of participants who were currently married was 95%, while 45% had a primary school education or lower. Additionally, 55% were retired, and 60% lived in urban areas. A total of 45% lived either with their spouse or with both their spouse and children. The majority of participants (90%) reported having one or more chronic illnesses. Participant characteristics are presented in Table 3.

Participants were invited to evaluate the pilot version of the questionnaire to assess the face validity. The results of cognitive interviews indicated that participants consistently interpreted key terms, and no participants reported difficulties in understanding item phrasing. Additionally, the Likert scores for each item were four or above, showing good clarity of the questionnaire. Based on these results, no further modifications were made to the items at this stage.

Table 3 Pilot study participants characteristics ($n = 20$)

Characteristics	n (%)
Age	
18–35	1 (5.0)
36–50	3 (15.0)
51–65	6 (30.0)
66–80	9 (45.0)
Sex	
Male	15 (75.0)
Female	5 (25.0)
Education	
Primary school and below	9 (45.0)
Junior high school	6 (30.0)
Senior high school	4 (20.0)
Bachelor'degree or above	1 (5.0)
Marital status	
Unmarried	0 (0.0)
Married	19 (95.0)
Divorced or widowed	1 (5.0)
Vocational status	
Be on the job	5 (25.0)
Unemployed	4 (20.0)
Retirement	11 (55.0)
Current residence	
Urban	12 (60.0)
Rural	8 (40.0)
Living Situation	
Live alone	2 (10.0)
Live with spouse	9 (45.0)
Live with children	0 (0.0)
Live with spouse and children	9 (45.0)
Number of concurrent chronic diseases	
0	2 (10.0)
1	6 (30.0)
2	9 (45.0)
≥ 3	3 (15.0)

In summary, after two rounds of Delphi and a pilot study, the questionnaire of the Chinese version of the "Adult Sedentary Behavior Reduction Intention Questionnaire Based on the Theory of Planned Behavior" includes four dimensions: behavioral intention, subjective norms, attitudes, and perceived behavioral control, with a total of 16 items.

Phase 2

The results of questionnaire completion

A total of 439 questionnaires were distributed in this study, of which 316 were valid, with a valid recovery rate of 75.4%.

Demographic characteristics of participants

The average age of the 316 study participants (71.8% male) was 63.53 ± 10.51 years. Of these, 294 (93%) were married, 127 participants (40.2%) were retirees, 166 (52.5%) lived in urban areas,140 (44.3%) resided with their spouse and children, and 277(87.7%) had at least one accompanying chronic disease, as detailed in Table 4.

The results of reliability and validity analysis

Reliability results The overall Cronbach's α coefficient for the questionnaire in this study was 0.967, while the Cronbach's α coefficients for each dimension ranged from 0.911 to 0.950.

Table 4 Participants' characteristics ($n = 316$)

Characteristics	n (%)
Age	
18–35	3 (0.9)
36–50	35 (11.1)
51–65	130 (41.1)
66–80	148 (46.8)
Sex	
Male	227 (71.8)
Female	89 (28.2)
Education	
Primary school and below	135 (42.7)
Junior high school	101 (32.0)
Senior high school	43 (13.6)
Bachelor' degree or above	37 (11.7)
Marital status	
Unmarried	1 (0.3)
Married	294 (93.0)
Divorced or widowed	21 (6.7)
Vocational status	
Be on the job	75 (23.7)
Unemployed	127 (40.2)
Retirement	114 (36.1)
Current residence	
Urban	166 (52.5)
Rural	150 (47.5)
Living Situation	
Live alone	33 (10.4)
Live with spouse	125 (39.6)
Live with children	18 (5.7)
Live with spouse and children	140 (44.3)
Number of concurrent chronic diseases	
0	39 (12.3)
1	131 (41.5)
2	88 (27.8)
≥ 3	58 (18.4)

Content validity Based on the ratings of the 16 experts, the I-CVI values for each item ranged from 0.813 to 1, suggesting a good overall evaluation of item content by the experts.

Confirmatory factor analysis As the initial model fit was not satisfactory, modifications were made to the model based on theoretical and practical significance, in conjunction with the Modification Index (MI). Following the MI values, suggested paths were incrementally added to the model in order of their impact on the model, and the modified model was re-run. The initial model diagram is outlined in Fig. 3. After the addition of 9 paths, the final model diagram is presented in Fig. 4, and the final model fit results are shown in Table 5.

The path coefficients between items and factors, and between factors, as well as factor loadings, are also methods for assessing the model fit. Generally, path coefficients range from 0.4 to 0.9. In this study, the standardized path coefficients between items and factors ranged from 0.653 to 1.086, and those between factors ranged from 0.697 to 0.894, achieving acceptable goodness of fit, as shown in Table 6 and Table 7.

After conducting reliability and validity testing, the final version of The Adult Sedentary Behavior Reduction Intention Questionnaire Based on TPB was developed, comprising four dimensions and 16 items. The dimensions include behavioral intention (3 items), subjective norms (6 items), attitudes (4 items), and perceived behavioral control (3 items), as presented in Table 8.

Discussion

In the current study, we presented the development and psychometric evaluation of a TPB-based instrument designed to investigate the determinants of reducing sedentary behavior among adults. The study comprises two phases. Phase 1 involves the preliminary formulation of the questionnaire item pool through a literature review, followed by two Delphi rounds and a small-sample pilot study. Building on phase 1, phase 2 further psychometrically validates the questionnaire. The results showed that the questionnaire is reliable and effective, and can be used as a formal questionnaire for promotion and application.

The Adult Sedentary Behavior Reduction Intention Questionnaire, based on TPB, consists of four dimensions and 16 items. These dimensions are behavioral intention (3 items), subjective norms (6 items), attitudes (4 items), and perceived behavioral control (3 items).

We believe this questionnaire was scientifically developed and will play a significant role in future research

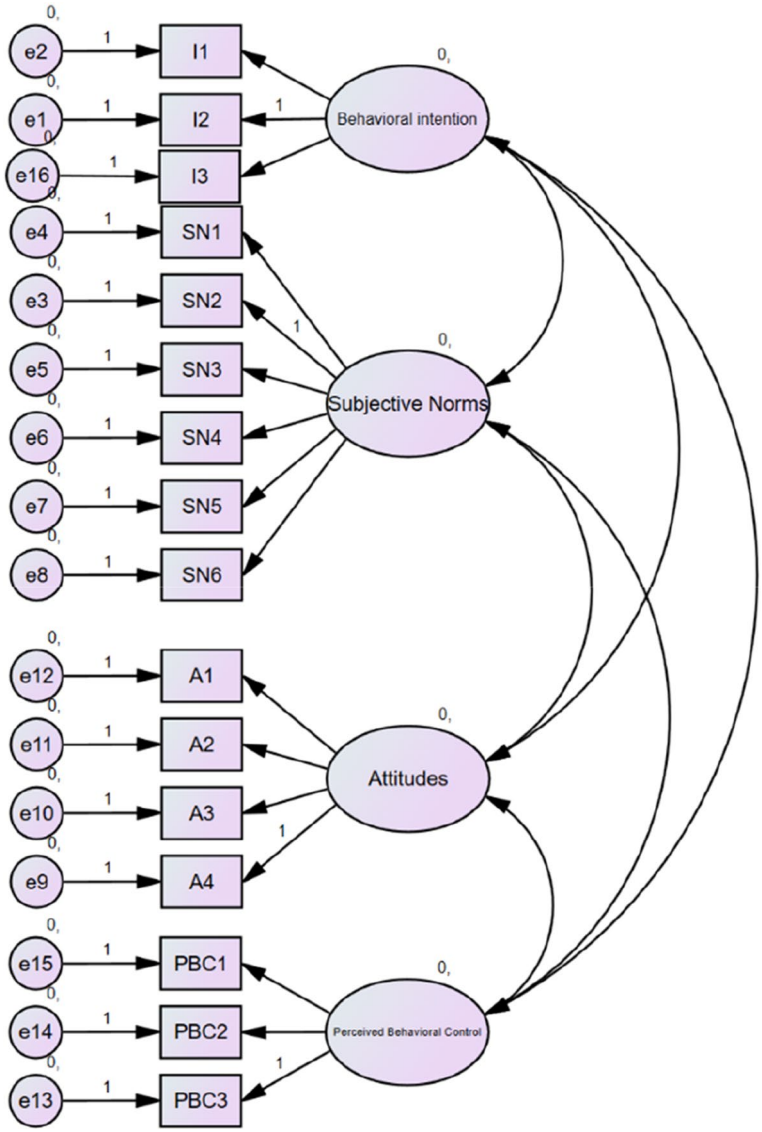

Fig. 3 Initial model diagram

regarding sedentary behavior. First, we strictly followed the questionnaire development and validation process to ensure the new questionnaire's psychometric properties. Based on an extensive literature review on the TPB theoretical framework and sedentary behavior, the questionnaire development guidelines authored by Ajzen [25], and Francis et al. [37], we initially generated a pool of scale items following the prescribed steps and principles outlined in the manuals. Secondly, we applied the Delphi expert consultation method, collecting expert opinions through multiple rounds of anonymous questionnaires to gradually reach a consensus on the scale item. In numerous previous studies on scale development, the Delphi method has consistently been regarded as a reliable approach for enriching and refining scale content [62–64]. After two rounds of Delphi expert consultations, we consolidated the expert's feedback to refine the item content further. In selecting experts, we carefully chose those who were authoritative with specializations spanning physical activity, education, psychology, and chronic disease management by reading their publications and national-funded projects. We also tried to select experts from as many provinces in China as possible to increase its representativeness. Those experts provided valuable and constructive suggestions for the further improvement and revision of the questionnaire. For instance, experts pointed out that the content of the subjective norms dimension was insufficient. Therefore, we added two

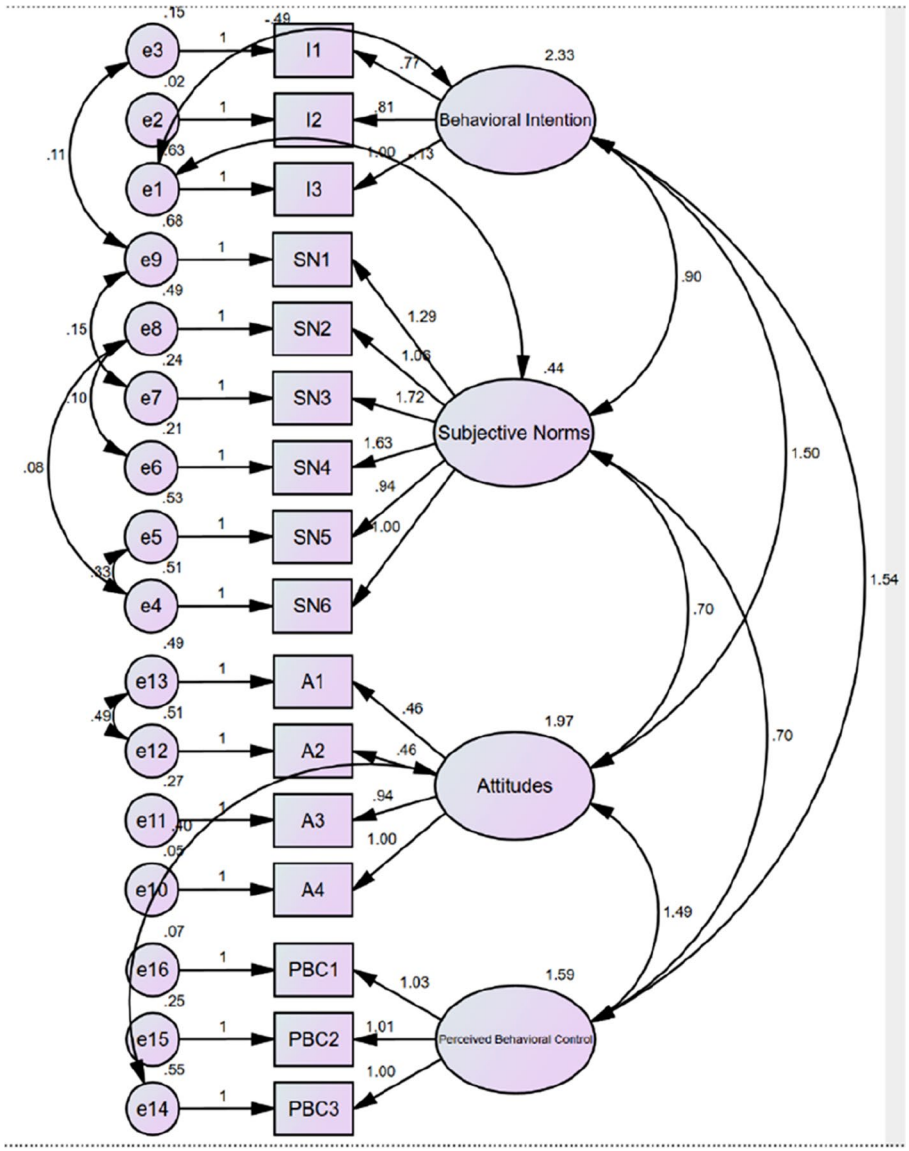

Fig. 4 Final model diagram

Table 5 Model fitting parameters

Fitting parameter	χ^2/df	GFI	AGFI	IFI	NFI	TLI	CFI	RMSEA
Initial model	19.363	0.668	0.540	0.752	0.742	0.696	0.752	0.241
Modified model	2.931	0.906	0.857	0.976	0.965	0.968	0.976	0.078
Acceptable criteria	< 5.00	> 0.90	> 0.90	> 0.90	> 0.90	> 0.90	> 0.90	< 0.08

additional items in this dimension to reflect the impact of social influence on individual behavior. This is consistent with the results of a conformity trial carried out by Asch SE [65], which powerfully illustrates the impact of overt social forces on individual decision-making and behavior. Individuals conform to behaviors consistent with social pressure to gain approval and be liked, which precisely reflects the influence of norms [66].

Cronbach's α coefficient, content validity, and confirmatory factor analysis were employed to analyze the

Table 6 The path coefficient test results of each factor and item ($n = 316$)

Item		Factor	Unstandardized	*S.E*	*C.R*	*P*	Standardized
I1	<---	F1	0.769	0.033	23.469	< 0.001	0.950
I2	<---	F1	0.808	0.031	26.280	< 0.001	0.993
I3	<---	F1	1.000				0.806
SN1	<---	F2	1.285	0.109	11.822	< 0.001	0.718
SN2	<---	F2	1.062	0.083	12.761	< 0.001	0.711
SN3	<---	F2	1.716	0.116	14.779	< 0.001	0.918
SN4	<---	F2	1.631	1.110	14.818	< 0.001	0.921
SN5	<---	F2	0.943	0.053	17.921	< 0.001	0.653
SN6	<---	F2	1.000				0.681
A1	<---	F3	0.461	0.029	16.010	< 0.001	0.680
A2	<---	F3	0.460	0.029	15.672	< 0.001	0.672
A3	<---	F3	0.940	0.024	39.265	< 0.001	0.931
A4	<---	F3	1.000				0.987
PBC1	<---	F4	1.031	0.037	27.595	< 0.001	0.980
PBC2	<---	F4	1.012	0.041	24.754	< 0.001	0.931
PBC3	<---	F4	1.000				0.863

Table 7 The path coefficient test results between factors ($n = 316$)

Factor		Factor	Unstandardized	*S.E*	*C.R*	*P*	Standardized
F1	<---	F2	0.904	0.091	9.984	< 0.001	0.894
F2	<---	F3	0.703	0.079	8.873	< 0.001	0.755
F4	<---	F3	1.487	0.154	9.640	< 0.001	0.840
F1	<---	F3	1.495	0.139	10.731	< 0.001	0.697
F4	<---	F1	1.538	0.142	10.808	< 0.001	0.800
F4	<---	F2	0.702	0.080	8.815	< 0.001	0.841

reliability and validity of the questionnaire, respectively. We found that the factors derived from the TPB questionnaire demonstrated satisfactory internal consistency. The Cronbach's α for these factors fell within a relatively high range, comparable to those of commonly accepted standardized scales [67]. Numerous studies in previous psychometric research have used Cronbach's α to verify the internal consistency of instruments [68–71].

The robust psychometric properties exhibited by the items in this questionnaire can be attributed to the study being grounded in a solid theoretical framework of TPB and systematically completed according to the criteria outlined in the manual "Constructing a TPB Questionnaire: Conceptual and Methodological Considerations" [25] and "Constructing Questionnaires Based on The Theory of Planned Behavior" [37], which in turn ensures the validity of the questionnaire's content.

The questionnaire developed in this study is one of the few focusing on the psychosocial determinants of reducing sedentary behavior in adults. Scales constructed to reflect the psychosocial determinants of sedentary behavior driven by theoretical frameworks remain scarce. We carefully selected TPB to build our questionnaire for two reasons. On the one hand, TPB is widely used to explain the association between intention and behaviors [72, 73]. On the other hand, TPB provided explicit instructions for the questionnaire guides [25, 37], which helped produce the initial statements by simply changing the targeted behavior. In recent years, scholars have begun to focus on the association between sedentary behavior and psychosocial factors, some researchers used the theoretical framework to establish questionnaires targeting sedentary behavior. Motl et al. [74] created the Sedentary Behavior Change Questionnaire (SBCQ) based on social-cognitive theory, consisting of 12 items. Consistent with this current questionnaire development approach, their research team also thoroughly reviewed previous studies on the targeted behavior and theoretical framework and engaged in extensive discussions to develop the initial items of the scale. Unfortunately, although this study obtained adequate internal consistency, the scale did not undergo a Delphi expert

Table 8 The Adult Sedentary Behavior Reduction Intention Questionnaire Based on TPB (final version-with sequential order)

Dimension	Item	Scoring
Behavioral Intention	1. I want to reduce or interrupt sedentary behavior in the next 7 days by standing, walking, or other physical activities	strongly disagree = 1; strongly agree = 5
	2. I will try to reduce or interrupt sedentary behavior in the next 7 days by standing, walking, or other physical activities	strongly disagree = 1; strongly agree = 5
	3. I am determined to reduce or interrupt sedentary behavior in the next 7 days by standing, walking, or other physical activities	strongly disagree = 1; strongly agree = 5
Attitudes	4. For me, reduce or interrupt sedentary behavior time by standing, walking or other physical activities, is	4.1 harmful = 1; beneficial = 5
		4.2 worthless = 1; valuable = 5
		4.3 uncomfortable = 1; comfortable = 5
		4.4 a bad thing = 1; a good thing = 5
Subjective Norms	5.Most people who are important to me (family/friends/doctor) think that reduce or interrupt sedentary behavior in the next 7 days by standing, walking, or other physical activities	I should not = 1; I should = 5
	6.The entire society is advocating to reduce or interrupt sedentary behavior by standing, walking, or other physical activities	strongly disagree = 1; strongly agree = 5
	7. It is expected of me that I reduce the sedentary behavior time in the next 7 days	strongly disagree = 1; strongly agree = 5
	8. I should respond to the prevailing social trend to reduce or interrupt sedentary behavior in the next 7 days by standing, walking, or other physical activities	strongly disagree = 1; strongly agree = 5
	9. My family members often reduce or interrupt their sedentary behavior by standing, walking or other physical activities	strongly disagree = 1; strongly agree = 5
	10. My close friends often reduce or interrupt their sedentary behavior by standing, walking or other physical activities	strongly disagree = 1; strongly agree = 5
Perceived Behavioral Control	11. For me, reduce or interrupt sedentary behavior time by standing, walking or other physical activities, is	difficult = 1; easy = 5
	12. I am confident that I could reduce or interrupt sedentary behavior in the next 7 days by standing, walking, or other physical activities	strongly disagree = 1; strongly agree = 5
	13. Reduce or interrupt sedentary behavior in the next 7 days by standing, walking, or other physical activities is within my control	strongly disagree = 1; strongly agree = 7

Notes: 1.Sedentary behavior refers to activities such as reading, gossiping, watching TV, using computers, and taking transportation vehicles in a sitting or lying posture while awake, characterized by energy expenditure of less than 1.5 metabolic equivalents (METs); 2.In this questionnaire, "reduce" refers to "reduce daily sedentary behavior to less than 6 h" and "interrupt" refers to "interrupt continuous sedentary behavior and engaging in physical activities, such as standing, walking, or other exercises for 5 min after every 30 min of continuous sedentary behavior"

consultation nor a content validity evaluation, which may affect its effectiveness in practical application. Howlett et al. [75] developed a scale based on the COM-B theory to measure the determinants of sedentary behavior, consisting of three constructs: motivation, capability, and opportunity. These constructs correspond to the dimensions of behavioral intention, perceived behavioral control, and subjective norms in the TPB theory applied in our study. Their research selected the most appropriate theoretical measures for each construct; however, most of these measures were primarily related to physical activity, and the items were adapted from other health behaviors, which may limit their applicability to sedentary behavior. Although the study provided internal consistency data for each tool from previous research, it did not further explore internal consistency or validity within the population of their study. Prapavessis et al. [35] designed a 23-item scale based on TPB to assess attitudes, subjective norms, perceived behavioral control, and intentions related to sedentary time. The strength of this study is that it distinguishes between voluntary and involuntary sedentary behavior on weekdays and weekends, creating five TPB models for different sedentary behavior patterns. However, this measure has not undergone a rigorous process to establish the reliability and validity of its scores.

Due to the setbacks mentioned above, the previous questionnaires may limit its effectiveness in predicting or explaining the psychosocial determinants of sedentary behavior. The current questionnaire is expected to fill the current knowledge gap in the study of sedentary behavior and the application of TPB. It provides researchers and professionals from various health promotion fields with a reliable and valid instrument for measurement.

Limitations

The present study has the following limitations. Firstly, the initial development of the questionnaire has not yet involved conducting qualitative interviews to obtain more in-depth item content. Secondly, since no universally accepted valid questionnaire has been found as a benchmark, the reliability test of criterion-related validity for our questionnaire has not been conducted. Thirdly, the items in this questionnaire were designed for adults in a broad sense and did not specifically target individuals with different disease attributes. Fourthly, although our goal was to develop a widely applicable tool, the psychometric properties of the measurement scale were assessed in the coronary heart disease population rather than in a general healthy population, which may limit the generalizability of our findings. Fifthly, this study was conducted within the context of Chinese culture, and the results may be biased when applied in other countries. In the future, the current questionnaire may have the potential to be translated into different languages and widely applied across various populations after meticulous testing.

Conclusions

The Adult Sedentary Behavior Reduction Intention Questionnaire Based on TPB developed in this study demonstrates good reliability and validity, enabling researchers to assess the level of adults' intentions to reduce sedentary behavior. It may also provide new perspectives for future customized intervention programs on the basis of their behavioral determinants.

Abbreviations

TPB	Theory of Planned Behavior
I-CVI	The item-level content validity index
NHANES	National Health and Nutrition Examination Survey
SAGE	The Study on Global Ageing and Adult Health
NCDs	Non-communicable Diseases
WHO	The World Health Organization
SPSS	Statistical Package for the Social Sciences
Cr	Consensus Ratio
CV	Coefficient of Variation
CFA	Confirmatory Factor Analysis
RMSEA	Root Square Error of Approximation
GFI	Goodness of Fit Index
AGFI	Adjusted Goodness of Fit Index
NFI	Normed Fit Index
IFI	Incremental Fit Index
CFI	Comparative Fit Index
TLI	Tucker-Lewis Index
MI	Modification Index
SBCQ	Sedentary Behavior Change Questionnaire

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12889-025-22301-6.

Supplementary Material 1

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Authors' contributions

JY: Methodology, Conceptualization, Data Collection, Formal Analysis and Writing – Original Draft. YL: Methodology, Develop Item Pool, Preliminary Questionnaire Formation and Writing – Review and Edit. LY: Methodology, Conceptualization, Supervision, Formal Analysis and Writing – Review and Edit. All authors conducted a thorough review of the manuscript and approved its final version.

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Data availability

The datasets are not publicly available due to ethical requirements. They are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This study was performed in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) and the protocol was approved by the Ethical Review Board of Sir Run Run Shaw Hospital, Zhejiang University School of Medicine (approval date: 02/07/2022, approval number: KY20220207-31). Informed consent was obtained from all participants. Data anonymity and privacy were ensured throughout the study.

Consent for publication

Not applicable.

Competing interest

The authors declare no competing interests.

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