Effectiveness of parent-based electronic health (eHealth) intervention on physical activity, dietary behaviors and sleep in preschoolers: A randomized controlled trial protocol

Peng Zhou, Huiqi Song, Patrick WC Lau, Lei Shi, Jingjing Wang

Submitted to: JMIR Research Protocols
on: March 13, 2024

Table of Contents

Effectiveness of parent-based electronic health (eHealth) intervention on physical activity, dietary behaviors and sleep in preschoolers: A randomized controlled trial protocol

Peng Zhou[1] PhD; Huiqi Song[2] PhD; Patrick WC Lau[1] Prof Dr; Lei Shi[3] Prof Dr; Jingjing Wang[4] Prof Dr

[1]Hong Kong Baptist University Hong Kong HK
[2]The Jockey Club School of Public Health and Primary Care, The Chinese University of Hong Kong Hong Kong HK
[3]Beijing Normal University-Hong Kong Baptist University United International College Zhuhai CN
[4]Mass Sports Research Center, China Institute of Sport Science Beijing CN

Corresponding Author:
Patrick WC Lau Prof Dr
Hong Kong Baptist University
Room AAB 1103, 11/F, Academic and Administration Building, Baptist University Road Campus, Hong Kong Baptist University, Kowloon Tong, Hong Kong
Hong Kong
HK

Abstract

Background: Preschoolers' lifestyles have become physically inactive and sedentary, their eating habits unhealthy, and their sleep routines increasingly disturbed. Parent-based interventions have shown promising to improve physical activity (PA), dietary behaviors (DB), and reducing sleep problems of preschoolers. However, because of the recognized obstacles of face-to-face approach (such as travel costs and time commitment), easy access and lower costs make electronic health (eHealth) interventions appealing. Previous studies that examined the effectiveness of parent-based eHealth on preschooler's PA, DB, and sleep have either emphasized on one variable or failed to balance the dosage of PA, DB, and sleep modules or consider the intervention sequence during the intervention period and there is an acknowledged gap in parent-based eHealth interventions which target preschoolers raised in Chinese cultural contexts.

Objective: To investigate the effectiveness of parent-based eHealth intervention on Chinese preschoolers' PA, DB, and sleep problems.

Methods: This two-arm parallel randomized controlled trial comprises a 12-week intervention with a 12-week follow-up. 206 parent-child dyads will be randomized to either eHealth intervention group or control group. Participants allocated to the eHealth intervention will receive 12 interactive modules on PA, DB, and sleep, with each module delivered on a weekly basis to reduce the sequence effect on variable outcomes. The intervention is grounded upon Social Cognitive Theory and will be delivered through social media, where parents can obtain valid and updated educational information, social rapport, and interact with other group members and facilitators. Participants in the control group will receive weekly brochures on PA, DB, and sleep recommendations from the kindergarten teachers, but they will not receive any interactive components. Data will be collected at baseline, 3 months, and 6 months. The primary outcome will be the preschooler's physical activity. The secondary outcomes will be the preschooler's dietary behaviors, preschooler's sleep duration, and preschooler's sleep problems, parent's PA, parenting style, and parental feeding style.

Results: The baseline and posttest data of this study were conducted from October 2023 to March 2024, and the follow-up data will be completed by August 2024. The project team has completed data collection on 238 preschoolers at the baseline and posttest. The results are expected to be published in 2025.

Conclusions: The parent-based eHealth intervention has potential to overcome the aforementioned barriers of face-to-face interventions, which will offer a novel approach for promoting healthy lifestyle of preschoolers. If found to be efficacious, the prevalence of unhealthy lifestyles among preschoolers may be alleviated at a low cost, which not only has a positive influence on the health of the individual and the well-being of the family but also reduces the financial pressure on society to treat diseases caused by poor lifestyle habits. Clinical Trial: ClinicalTrial.gov Protocol Registration and Results System (PRS): NCT06025019

(JMIR Preprints 13/03/2024:58344)
DOI: https://doi.org/10.2196/preprints.58344

Preprint Settings

1) Would you like to publish your submitted manuscript as preprint?

✓ **Please make my preprint PDF available to anyone at any time (recommended).**
Please make my preprint PDF available only to logged-in users; I understand that my title and abstract will remain visible to all users.
Only make the preprint title and abstract visible.
No, I do not wish to publish my submitted manuscript as a preprint.

2) If accepted for publication in a JMIR journal, would you like the PDF to be visible to the public?

✓ **Yes, please make my accepted manuscript PDF available to anyone at any time (Recommended).**
Yes, but please make my accepted manuscript PDF available only to logged-in users; I understand that the title and abstract will remain v
Yes, but only make the title and abstract visible (see Important note, above). I understand that if I later pay to participate in <a href="http

Original Manuscript

Effectiveness of parent-based electronic health (eHealth) intervention on physical activity, dietary behaviors and sleep in preschoolers: A randomized controlled trial protocol

Peng Zhou[1], Jingjing Wang[2], Huiqi Song[3], Lei Shi[4], Patrick W.C. Lau[1*]

1. Department of Sport, Physical Education and Health. Hong Kong Baptist University, Hong Kong, China
2. Mass Sports Research Center, China Institute of Sport Science, Beijing, China.
3. The Jockey Club School of Public Health and Primary Care, the Chinese University of Hong Kong
4. Beijing Normal University-Hong Kong Baptist University United International College, China

*Correspondence: wclau@hkbu.edu.hk

Abstract

Background: Preschoolers' lifestyles have become physically inactive and sedentary, their eating habits unhealthy, and their sleep routines increasingly disturbed. Parent-based interventions have shown promising to improve physical activity (PA), dietary behaviors (DB), and reducing sleep problems of preschoolers. However, because of the recognized obstacles of face-to-face approach (such as travel costs and time commitment), easy access and lower costs make electronic health (eHealth) interventions appealing. Previous studies that examined the effectiveness of parent-based eHealth on preschooler's PA, DB, and sleep have either emphasized on one variable or failed to balance the dosage of PA, DB, and sleep modules or consider the intervention sequence during the intervention period and there is an acknowledged gap in parent-based eHealth interventions which target preschoolers raised in Chinese cultural contexts.

Objective: To investigate the effectiveness of parent-based eHealth intervention on Chinese preschoolers' PA, DB, and sleep problems.

Methods: This two-arm parallel randomized controlled trial comprises a 12-week intervention with a 12-week follow-up. 206 parent-child dyads will be randomized to either eHealth intervention group or control group. Participants allocated to the eHealth intervention will receive 12 interactive modules on PA, DB, and sleep, with each module delivered on a weekly basis to reduce the sequence effect on variable outcomes. The intervention is grounded upon Social Cognitive Theory and will be delivered through social media, where parents can obtain valid and updated educational information, social rapport, and interact with other group members and facilitators. Participants in the control group will receive weekly brochures on PA, DB, and sleep recommendations from the kindergarten teachers, but they will not receive any interactive components. Data will be collected at baseline, 3 months, and 6 months. The primary outcome will be the preschooler's physical activity. The secondary outcomes will be the preschooler's dietary behaviors, preschooler's sleep duration, and preschooler's sleep problems, parent's PA, parenting style, and parental feeding style.

Results: Parent-child dyads were recruited in September 2023. Baseline and posttest data collection occurred from October 2023 to March 2024. The follow-up data will be completed in June 2024. Results of the study are expected to be published in 2025.

Discussion: The parent-based eHealth intervention has potential to overcome the aforementioned barriers of face-to-face interventions, which will offer a novel approach for promoting healthy lifestyle of preschoolers. If found to be efficacious, the prevalence of unhealthy lifestyles among preschoolers may be alleviated at a low cost, which not only has a positive influence on the health of the individual and the well-being of the family but also reduces the financial pressure on society to treat diseases caused by poor lifestyle habits.

Trial registration: ClinicalTrial.gov Protocol Registration and Results System (PRS): NCT06025019.

Keywords: physical activity, dietary behavior, sleep, electronic health, eHealth, preschoolers, parenting

Introduction

People's lifestyle affects their health and well-being [1]. The main lifestyle dimensions of physical

activity (PA), dietary behaviors (DB), and sleep have played a pivotal role in decreased cardiovascular risk [2], brain growth velocity [3], prevention of mental disorder [4], social interaction [5], and improvement in the central nervous system [6]. These dimensions appear to be interrelated. PA brings about substantial benefits not only in reducing high-fat calorie consumption [1], but in improving sleep patterns and increasing sleep duration [7]. Longer nighttime sleep duration was associated with a less frequent intake of fast foods and sugar-sweetened beverages [8] while people with sufficient sleep quality were more likely to form active lifestyles [9]. In the past few decades, individuals' lifestyles have become physically inactive and sedentary [10], their eating habits unhealthy [11], and their sleep routines increasingly disturbed [12]. These changes have led to an ever-increasing prevalence of non-communicable diseases such as diabetes and obesity [13]. Therefore, an effective intervention is needed to reverse this negative trend. The previous study has indicated that preschool age may respond better to the treatment as the lifestyle behaviors in this period are malleable and less entrenched [14]. Lifestyles formed in the early years of life can track throughout the lifetime and influence lifelong health trajectories [15].

Parents have a profound impact on the healthy lifestyle of preschoolers and are the key agents of behavioral modification [16]. Parents provide the overwhelming majority of cues for PA, diet, and sleep routines and are responsible for role-modeling these behaviors to their children [17]. Preschoolers are particularly dependent on their parents since younger children have limited autonomy and rely on parental supervision [18]. A longitudinal study demonstrated that parents' influence on children's lifestyle may be attenuated as children age because peer interaction gradually became their preferred activity when they grow up [19].

Despite the importance of parental involvement, previous parent-based interventions involving home visits and in-person education have been associated with high attrition rate, with many relying on self-reported assessments and failure to use a randomized controlled study design [20], and lower recruitment [21]. Other limitations of delivering interventions face-to-face within the home have been the associated time commitment for participants [21], the need for childcare for other siblings [22], stigma, parental denial [23], the need to travel [24], and associated costs [23], which have hindered the intervention adoption and adherence, and ultimately the effectiveness of those programs. In response, electronic health (eHealth), which is defined as the cost-effective and secure use of information and communications technologies in support of health, including healthcare services, health surveillance, health literature, and health education, knowledge and research [25], has the potential to address these barriers [26], providing convenience and flexibility for parents and enabling parents to participate regardless of their geographic location [27]. Moreover, personalized information and feedback delivered via eHealth intervention may augment behavioral change strategy [28].

Efficacy trials that assessed the effectiveness of parent-based eHealth on preschoolers' PA, diet and sleep have been conducted in twelve studies [29-40]. Although these twelve studies have demonstrated that participants engaging in eHealth intervention significantly improved their healthy lifestyles, seven studies [29, 33, 35-38, 40] only concentrated on one variable, with two focusing on sleep, three focusing on fruit and vegetable intake, and two focusing on PA. A study by Lin et al [34] reported that disclosed intervention content between two groups may result in insignificant group-by-time changes in PA and diet. The remaining four studies [30-32, 39] have found a significant group-by-time difference in diet, but this effect was not found in PA and sleep. Possible reasons for this may be that these four studies involved more diet modules compared to PA and sleep modules. Overall, previous studies that examined the effectiveness of parent-based eHealth on preschooler's PA, diet, and sleep have either emphasized one variable or fail to balance the dosage of PA, diet, and sleep modules and consider the intervention sequence during the intervention period. Specifically, more exposure to the diet modules relative to the fewer PA modules may yield outcomes favoring the diet variables. When the posttest was conducted, parent-child dyads may be more familiar with the modules distributed at the end of the intervention period, thus producing favorable outcomes

regarding these modules' content compared to others.

Empirical relationships obtained in one culture may be a product of its milieu and may not be generalized to other countries [41]. Very little is currently known about whether the parent-based eHealth can effectively improve preschoolers' PA and diet and reduce sleep problems in China. In the past decade, the prevalence of physical inactivity, unhealthy diet patterns, and sleep problems among Chinese children has become serious. 70.1% of preschoolers do not meet the PA guidelines recommended by World Health Organization (WHO) (i.e., over 180 mins daily PA, including at least 60 mins moderate-to-vigorous PA) [42]. The total energy consumption in fat and sodium exceeds the Chinese Recommended Nutrient Intakes (RNIs) by 10% and 56%, respectively [43]. Over 61% of Chinese preschoolers experienced or are experiencing insufficient sleep and sleep problems (e.g., sleep onset latency) [44]. China has the largest population in the world, it would pose a heavy financial burden on society if implementing a traditional face-to-face intervention to improve the unhealthy lifestyles of preschoolers [44]. An effective and feasible intervention strategy is imperative to tackle these growing health problems.

Currently, the number of smartphone and internet users in China is 1.64 billion and 1028.74 million, respectively [45]. eHealth intervention addressing unhealthy lifestyles could be cost-effective and easily scaled up [46]. Furthermore, affected by Confucianism, Chinese parents emphasize 'training' (Guan), which refers to parents' control and demands [47]. 'Guan', a typical characteristic of Chinese parenting, may generate a profound impact on determining a child's lifestyle behaviors including PA, diet, and sleep [48]. Considering the shortcomings revealed in the study design of previous eHealth studies reviewed, high-quality, robust designed research studies to balance the intervention content and sequence are needed to determine the effectiveness of eHealth interventions to support behavior change in Chinese preschoolers, where parents are an agent of change.

Research objective:

This study aims to investigate the effectiveness of parent-based eHealth intervention on PA, DB and sleep of Chinese preschoolers.

Method

Study design

This study is a two-arm parallel single-blinded randomized controlled trial designed to promote preschoolers' PA, DB, and sleep problems by providing parents with relevant health information through the eHealth modality. The two arms comprise (1) eHealth intervention, which will deliver the evidence-based information and interactive components via social media (i.e., WeChat, similar to WhatsApp; and TikTok/Douyin, similar to YouTube). The interactive components include push notification, social rapport, influence agent, goal setting and personalized feedback. (2) Control group, which consists of printed evidence-based educational materials on standard recommendations for PA, diet, and sleep, without interactive components. The primary outcome will be the preschooler's PA. The secondary outcomes will be the preschooler's DB, preschooler's sleep duration and sleep problems, parent's PA, parenting style, and parental feeding style. The intervention will last 12 weeks with a 12-week follow-up. Based on the result of previous systematic review, the parent-based eHealth intervention duration varied from 8 weeks to 2 years, with over half studies being shorter than 12 weeks [49]. In this case, the 12-week intervention duration, which roughly coincides with the length of school semester in Chinese educational system of kindergartens (i.e., two 3-month semesters in one academic year), is considered sufficient for behavioral modification. The proposed flow of study design is shown in **Fig.1.** The study will follow the (CONSORT-EHEALTH) Consolidated Standards of Reporting Trials Statement for Randomized Trials: Improving and Standardizing evaluation reports of Web-based and Mobile Health interventions [50].

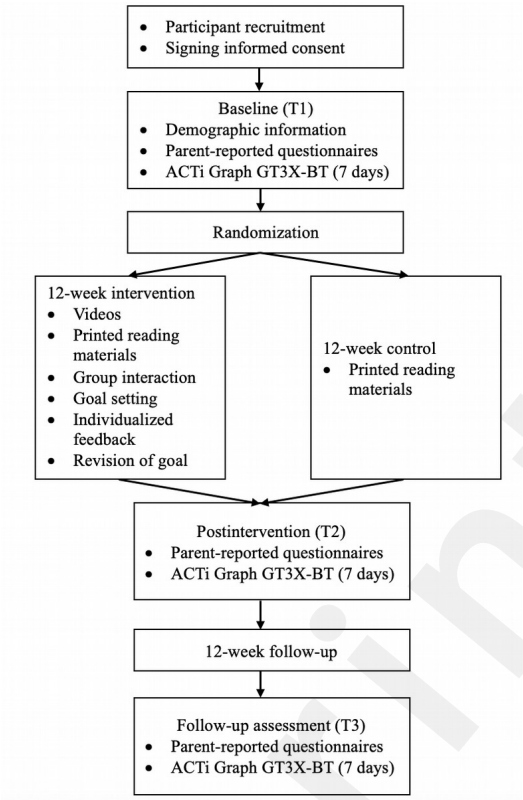


Fig. 1 Study design

Ethics and consent to participate

The study has been approved by Hong Kong Baptist University Research Ethic Committee (Reference No. SOSC-SPEH-2022-23_115). This study is prospectively registered at the ClinicalTrial.gov Protocol Registration and Results System (PRS): NCT06025019. Written informed consent will be obtained from all participants and/or their legal guardians. Personal data (i.e. gender, age, marital status), preschooler's PA, diet and sleeping behaviors, and family information (family economic status, parents' education level, family structure) will be collected. No other information of participant's identity will be recorded or disclosed. The data collected by the researchers will be destroyed after the project completed and published (within 7 years). In case of withdrawal, their data will be deleted in the data file immediately. Incentives (honorary certificates) will be offered to the family which would be judged as more active and healthier.

Participant recruitment and eligibility criteria

Parent-child dyads will be recruited from kindergartens in Guiyang, Guizhou province, China, with the support of Sun Yat-sen University and Guiyang Preschooler Education College. The entire recruitment process will be school based. Kindergartens teachers will be asked to send a message to the parents in their respective WeChat class group. The message will briefly introduce the objectives and significance of the study. Parents will respond "yes" or "no" of their intention/willingness to participate. Face-to-face meeting will be held to provide more details to those parents who agree to participate in the study especially on the measurement, and the benefits that parents will receive after the study. Parents will be asked to add the researcher's WeChat and sign the informed content at the end of parent meetings. The inclusion criteria are: (a) parents are beyond 21 years old and have 3-6-year-old children because the age range from 3 to 6 has been found to be a strong predictor of future health [51], (b) parental commitment to participate in the overall 6-month intervention, (c) parents have access to mobile technology, (d) parents and children must be healthy (refer to a state of physical, mental, social, intellectual, and emotional well-being and the absence of disease) based on the health assessment that is held by kindergartens on the commencement day of new semester, (e) in order to make preschoolers adequately expose to the parent-based intervention, parents must reside

with participating child for at least four days a week.

Randomization

Once the participants are recruited and baseline measurements are collected, participants will be randomly allocated to either intervention (eHealth group) or control group (traditional group) at a 1:1 ratio through a computer-generated list using the statistical software SPSS (IBM SPSS 27). The randomization is conducted by a researcher who is blinded to the intervention recruitment and delivery. Random allocation to either the eHealth group or the control group will not be informed to parents.

Theoretical foundation

The intervention is grounded upon Social Cognitive Theory (SCT), which considers learning as a social phenomenon that comes from a person's interaction with others through watching and observing [52]. Besides, considering the evidence that eHealth implemented directly to preschoolers may have adverse impacts on preschoolers' healthy lifestyle (e.g., disturbed sleep, myopia, increased screen time). Thus, a key component of this intervention is to involve parents in modeling health-promoting behaviors to their preschool-aged children. **Fig. 2** depicts how the intervention will be conducted. First of all, SCT proposes that an individual's behavioral modification can be influenced by personal factors, environmental factors, and behavioral factors [53]. These three factors describe what intervention content should be involved to induce behavioral modification. Specifically,

- Personal factor refers to an individual's self-efficacy to carry out a behavior, which is dependent on personality, knowledge, beliefs, self-perceptions, and expectations. Knowledge and beliefs of the importance of PA, DB, and sleep for preschoolers will be addressed through topic content of eHealth intervention (videos and reading materials).
- Environmental factor is defined as supportive environments which help an individual to conduct a behavior. Interaction with others by posting photos, videos and ideas concerning the healthy lifestyle will provide participants with vicarious learning. Communication, feedback, and reinforcement from other parents through social media platforms and from research staff through personalized interaction can provide parents with opportunities to practice the skills, potentially contributing to behavioral modification.
- Behavioral factor refers to the response by the individual once they have practiced carrying out a behavior. The parent will put the skills and behaviors into practice after goal setting and action plans. Positive reinforcement will be gained by monitoring progress with their goals and action plans and the personal benefits experienced.

Additionally, four processes for behavior change involved in SCT are attention, retention, reproduction, and motivation. If any one of these steps is missing, the learning and adapting of new behaviors will not take place. These four steps describe what intervention sequence should be followed to induce behavioral modification. Specifically,

- Attention, which is matched with personal factors, represents that individual cannot learn unless they pay attention to what is happening around them. Therefore, attention is tackled by providing printed educational materials and TikTok Videos delivered through WeChat [54].
- Retention, which is matched with environmental factors, represents that individual must not only recognize the observed behaviors but can also remember these behaviors at some later time. Therefore, retention is addressed by interactions with other participants through the WeChat Group to support parents to remember the content of videos and education materials. Besides, parents each week will receive 4 push notifications to reminder them the information of each interactive component (i.e., video/printed material, communication, goal setting, and feedback).
- Reproduction, which is matched with behavioural factors, represents that individual must be physically and mentally capable of producing the observed behaviors. Therefore, reproduction will be achieved through goal setting based on SMART (Specific, Measurable, Achievable, Relevant, and Time-bound) goal framework, action plans, and solutions to barriers.

- Motivation, which is matched with behavioral factors, relates to the interests and achievements of individual towards tasks and activities being put in place. Therefore, motivation is addressed by creating cognitive dissonance by parents describing current behaviors and asking parents to identify the positive consequences and expectations as a result of performing the planned behaviors.

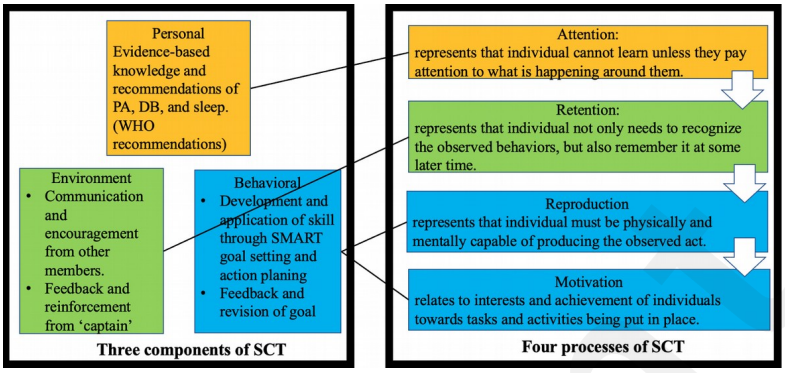


Fig. 2 SCT-based eHealth intervention

Intervention procedure

eHealth intervention comprises twelve interaction modules including PA (n=4), DB (n=4), and sleep (n=4). Each module will be rotated weekly to reduce the order effect on the outcome variables during the 12-week intervention period (i.e., PA, diet, sleep, PA, diet…). Given that previous social media studies recommendation indicated that five to nine members in a group will produce the desirable group interactive effect [55], the participants will be grouped into 26 WeChat groups (8 members involved in each WeChat group) by the researchers according to the sample size calculation. Given that facilitator has found to be important to potentially make the intervention more individualized and may be successful in behavioural change [56], teachers with expertise in PA, DB, and sleep who are working in the kindergartens will act as a facilitator, also known as a 'captain', in each WeChat group. Facilitators will be trained in a 5-hour workshop before the intervention and blinded to the study objectives. They will be responsible for sending videos, facilitating group interactions, responding to questions from parents, helping parents establish PA, diet, and sleep goals for their children, and providing feedback. Parents in each WeChat group will receive two self-monitoring text message in which they will be required to provide a "yes" or "no" response. The first message will be sent as a feedback message to evaluate the process toward the children's weekly goal on mid-week. An "N" response may elicit a skill-building response to adjust their goal or adopt alternatives to achieve their goal (e.g., try offering the same vegetable many times in different ways). If the parent responds "Y", the facilitator will generate a message to reinforce positive behaviors, such as "Be proud of yourself, you're getting your child off to a healthystart!". The second self-monitoring message will be sent on the weekend to assess goal attainment for the weekly target behavior before the new weekly theme is introduced. **Fig. 3** illustrates the intervention process of each module [57, 58]. **Table 1** indicates what specific content will be shared.

Consistent with SCT [52], the content of each module will follow four steps (**Fig.2** illustrates the intervention process of each module.):

1. Attention: (Reading educational material and watch TikTok/Douyin 3-minute video). Each video comprises Behaviour Change Techniques (BCTs), which are mapped onto SCT and critical for promoting behavior change [59-61]. It will be sent to parents at the beginning of each week, with each video containing goal setting and action plan, feedback, and monitoring, shaping knowledge, natural consequences, repetition and substitution, comparison of outcomes, reward and threat, antecedents, identity, and self-belief [54, 59].

2. Retention: (parent interaction). A meta-analysis assessing the psychological architecture and adherence factors of the online intervention indicated that intervention adherence is more likely to be

influenced by push factors, peer communications, and personal contact [62]. Parents will receive regular messages to remind them to watch videos and reading text. Facilitators and researchers will regularly share the questions and images related to the week's topic, aimed to stimulate discussion among parents [30]. For example, what is your child's current PA patterns? Does parent read the ingredient label of the foods while buying? It was anticipated that parents would gain the most benefits from actively participating (posting information or commenting) based on findings from previous research on online health discussion groups which has indicated that parents who wrote posts, commented, asked questions, and provided support to others achieved greater benefits than passive parents [63, 64]. If there are parents in the WeChat group who do not post or share, they will receive a reminder message sent by the facilitator via WeChat privately.

3. Reproduction: (Set goals and conduct behaviors). facilitator of each WeChat group will help parents set goals related to weekly topic based on SMART principles (Specific, Measurable, Achievable, Relevant, and Time-bound) [65]. Goals should be individualized and can be adjusted along with their child's and parent's progress in behavior changes. The facilitator of each WeChat group will inform the parents via private text messages of how to employ goal setting to help their children set PA, DB and sleep goals. Goal achievements are encouraged to share with other members in WeChat group or share to facilitator privately. Throughout the intervention period, the parents will be offered the possibility to interact on a regular basis by means of the WeChat with facilitator in order to discuss problems and raise questions regarding the promotion of PA, a healthy diet, and sleep for their child

4. Motivation: (Feedback and making changes). Feedback and subsequent revision of goals have been shown to be positively related to successful interventions of behavioral modification [66, 67]. Tailored feedback will be provided by RS with expertise in lifestyle (PA, DB, and sleep) based on the individual's goal, barriers identification, and solutions. RS will assist parents to revise their weekly theme-related goal following the SMART framework (Specific, Measurable, Achievable, Relevant, Time) [68].

Control group: Parent-child dyads assigned to this group will receive a weekly pamphlet on PA, DB, and sleep recommendations via their child, but they will not receive interactive components.

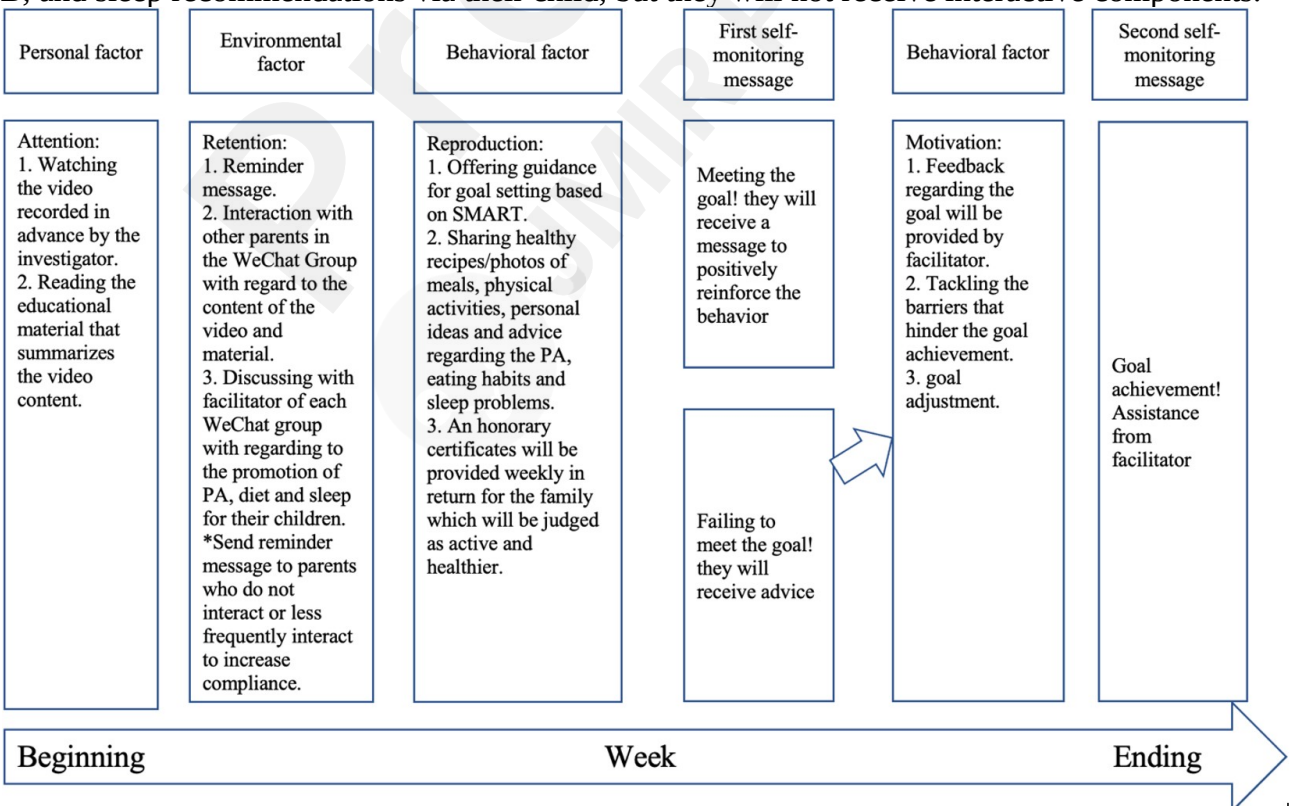


Fig. 3 Intervention mapping process of each module based on the four steps of SCT

Sample size

A recent systematic review and meta-analysis indicated a small but significant effect size for interventions to improve PA of children aged under 5 years [69]. Interventions that aimed to enhance DB and reduce sleep problems among preschoolers reported small to medium effect size [70, 71]. Based on the information, a priori analysis will be conducted using G*power 3.1.9.6 [72], a minimum sample size of 82 parent-child dyads in the intervention and control group respectively is required to detect a small effect size d of 0.3 with a power of 0.80 under the condition of an alpha level of 0.05. Considering the 20% potential attrition rate, 206 parent-child dyads in total are needed.

able 1: Intervention content of each module

eek & odule	Attention • (Personal factor) Path: Video & reading material.	Retention • (Environmental factor) Path: Interaction & discussion in WeChat group.	Reproduction • (Behavioral factor) Path: Current barriers. Suggestions. Goal setting.	Motivation (Behavioral factor) • Path: Feedback and goal adjustment.
eek 1 (PA) ***eveloping sic motor ills and reach ysical tivity goals***	What is PA? What is the difference between PA and PE? Why is it good for children? Current PA condition that preschoolers are performing. How much PA should children get? How can children get moving more? Goal setting. Tips.	Example: What is your child's current PA patterns? How much time does your child spend on TV, tablet, or smartphone?	Barriers: My child often keeps sedentary at home and school. He or she does not like PA. Homework discourages child to engage in PA.	Example: A consistent structured environment, where family members supported children in choosing an optimally challenging and realistic goal and breaking down goals into proximal (daily) and distal (weekly) PA targets, and providing praise and positive feedback on progress towards those goals. Time spent on screen time or sedentary behaviors can be reduced. Be physically active during the class recession or after school.
eek 2 (Diet) ***mponents of healthy diet***	Introduction to healthy eating. How much food consumed is good enough? Dietary structure regulations for preschool children. Goal setting. Tips.	Example: How much food do parent serve for child? Does parent read the ingredient label of the foods while buying?	Barriers: My child consumes less core food (e.g., wheat, grain). My child consumes less protein and vitamin.	Example: Increasing the proportion of fruit and vegetable consumption in daily life. Adjusting serving size. Recipe modification.
eek 3 leep) ***nsuring dequate sleep r preschool ildren***	Why sleep is important for the children's development? Sleep characteristics of preschoolers. The drawbacks of sleep deprivation. Recommended sleep duration for preschool children. What can parents do? Goal setting. Tips.	Example: What is your child sleeping pattern now? When does your child sleep every day?	Example: My child often refuses to sleep at night.	Example: Parents set a regular nightly bedtime for their young children.
eek 4 (PA) ***educing dentary time d increasing ysical tivity***	Introduction of sedentary behaviors. The Dangers of Sedentary Behavior. The current situation of sedentary behavior among young children. Recommended sedentary time for Preschoolers. Goal setting. Tips.	Example: How much time do parents spend on PA with their child?	Barriers: My child likes to be sedentary. My child prefers to watch TV when finishing the homework.	Example: Parents can replace their children's sedentary time at home, especially electronic screen use, by establishing physical play. Parents can get up every 30 minutes to physically stretch with their children while he or she reads and draws. Replace sedentary time by standing whenever possible. Engagement in PA instead of sedentary behaviors.
eek 5 (Diet)	What kinds of food should	Example: What	Barriers: My	Example: Parents can make a plan to buy

ealthy eating nd rational ood eating	preschoolers have? How much food should preschoolers have? When should preschoolers have their meals and snack? How can parents provide healthy meals? Goal setting. Tips.	snack and drinks are consumed in your house? Does your child drink juice instead of eating fruit?	child buys snack every time when going shopping.	the ingredients needed to make snacks, and lead children in the process of buying in the supermarket to explain to children the ingredients list of the food, which ingredients are healthy and which ingredients are harmful to the body, so that children can develop the ability to identify the nutrition of food.
Week 6 Sleep) ***ffective pproaches to elp preschool ildren fall leep***	What are the consequences of sleep deficits? What symptoms are there in children with sleep disorder? Sleep recommendation. Improving sleep environment. Goal setting. Tips.	Example: Are there any sleep problems in your child? (e.g., nightmare)	Example: My child gets snoring or dream talking sometimes.	Example: Parents can help their children sleep by telling them stories before they go to sleep, while not offering any food before bedtime.
Week 7 (PA) ***roviding a ide variety of xercise ctions to crease hysical ctivity***	Physical Activity and Intellectual Development. Variety of sports options	Example: Can your child be able to perform the motor skills?	Barriers: My child has difficulty following motor skills	Example: Parents should provide children with a variety of movement environments, so that they can fully experience the changes in the indoor and outdoor environments, as well as the differences between different movement interfaces, such as the ground, water, ice and snow.
Week 8 (Diet) ***educing ntake of ugar-weetened everages***	What are the sweetened beverages. large amounts of vitamin C and many minerals (such as iron, potassium, and magnesium) have been lost in the process of juicing fruits and vegetables. Secondly, juicing leads to a significant reduction of dietary fiber in the fruit itself. Goal setting. Tips.	Example: Introduction of the golden rule: Parents decide what, when, and how the child eats; the child decides whether and how much they eat.	Barriers: Parents serve a lots of juice instead of eating fruits and vegetables directly.	Example: Limit consumption of foods and beverages containing large amounts of sugar. Parents should try to encourage their toddlers to eat fruits and vegetables directly to help them develop healthy eating habits. Parents also need to know not to buy processed drinks for young children and not to store them in the home.
Week 9 Sleep) ***leep nvironment***	What is the optimal sleep environment for children? Why is environment important to sleep? What can parents do to create a cozy sleep environment for child? Goal setting. Tips.	Example: Being in a dark room is very good for preschoolers to fall asleep?	Barriers: My child often gets tired daytime even though he or she has gotten enough sleep at night.	Example: Parents are advised to create a dark environment while their children are sleeping and not to allow their children to use electronic screens before bedtime. Creating a quiet environment for children to sleep. Reading books or sing softly for your child.
Week 10 (PA) ***arental odeling to crease hysical ctivity***	Physical activity and mental health. What should parents do when it comes to increasing physical activity in young children? Parents should be actively involved in the physical activities of young children	Example: Do you often do exercises with your children when you are free?	Barriers: My child does not like to play outdoor activities.	Example: Parents can take 20 minutes of their own free time to work with their children indoors or outdoors on light, moderate or vigorous activities.
Week 11 Diet) ***arenting eding haviors***	Increase parental knowledge about the adverse effects of pressuring children to eat and offer foods as a reward. Increase parental knowledge about alternative positive feeding practices to increase children's interest and acceptance of healthy foods	Are you often resorting to fast food for a quick bite to eat?	Barriers: Advertisements attract child with their delicious and visually appealing food slogan.	Example: Are parents achieving goals? Weekly informative feedback (child's food intake). Reinforcement and encouragement. Parents may not use food as a reward. Do not force child to eat. Taking the child's satiety into consideration. Role modelling. Provision of information on appropriate foods, food texture, tastes of food, portion sizes.

		Help parents to identify child-related barriers regarding food refusal and how to overcome them using positive feeding practices. Foster parental self-regulation and self-efficacy to achieve changes in children's food intake and parental feeding practices according to their needs. Goal setting. Tips.			
Week 12 (Sleep) *The impact of parenting styles on young children's lifestyles*		Classification of parenting styles. Health consequences of sleep deprivation. The impact of different parenting styles on young children's lifestyles. Goal setting. Tips.	Example: How much does your child sleep every day? Does your child tired and sluggish during daytime?.	Barriers: My child is energetic and takes long time to fall asleep.	Example: Being physically active during the day helps child fall asleep more easily at night. Parents should establish a parenting style that centers on the healthy development of the child, i.e. authoritative parenting style.

Outcomes

Data collection will be conducted at T1: the baseline (one week before intervention). T2: 12 weeks post-intervention (at the end of intervention). T3: at the end of the 12-week follow-up period.
Instrument:

Demographic information

Parents: socioeconomic status (range of income, educational level, and occupational status), age, gender, and marital status will be collected.

Pre-schoolers: child's sex, age, weight, height, Body Mass Index (BMI). Preschoolers' weight will be measured using standard practices to the nearest 0.1 kilograms using calibrated measurement scales (Salter) and height is measured using a stadiometer (SECA) to the nearest 0.1 cm. BMI will be calculated with height and weight measurements. As sibship size has been observed to influence parenting behaviors, the number of children in the household will be collected.

Primary outcome (preschooler's physical activity)

Preschoolers' physical activity

The PA level and sedentary time will be objectively monitored using a tri-axial accelerometer ActiGraph GT3X-BT (ActiGraph, Pensacola, FL, USA). ActiGraph accelerometer has found to be valid and reliable to objectively measure PA levels in preschoolers [73]. The kindergarten teachers and parents will receive written and video instructions for the use of the accelerometer. In addition, parents will be asked to register an activity diary for both wear and non-wear time. The accelerometer wear will be checked by teachers on each school day. An accelerometer will be affixed to the participant's right wrist to monitor all activities for a period of seven continuous days except during periods of water-related activities or situations involving the risk of damage to the device, such as contact sports or self-defense. Data will be downloaded and initialized using and The ActiLife software (version 6.13) and analyzed in 1-s epochs. Valid wear time will be considered to be at least 16 hours of wear time over at least three days (two weekdays and one weekend day) [74]. Non-wear time will be defined by 60 consecutive minutes of zero count/minute, using ActiLife standard approaches. The accelerometer's activity counts will be categorized into different intensities (i.e., sedentary behavior, LPA, MPA, and VPA) by using the cut-off points: sedentary: <819 counts per minute (CPM); light: 820-3907 CPM; moderate: 3908-6111 CPM; and vigorous: ≥ 6112 CPM.

Secondary outcome (preschooler's dietary behaviors, preschooler's sleep duration, and preschooler's sleep problems; parent's physical activity, parenting style, and parental feeding style)
Preschoolers' dietary behavior

Children's dietary behaviors will be assessed using the Children's Eating Behavior Questionnaire (CEBQ), which has examined the validity of Chinese preschool-age children [75]. Parents will rate the frequency of their child's eating behaviors (5-point scale: 1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = always) in terms of eight domains (35 items): satiety responsiveness (e.g., My child gets full before his/her meal is finished), slowness in eating (e.g., My child finishes meal quickly), food fussiness (e.g., My child enjoys tasting new foods), food responsiveness (e.g., if allowed to, my child would eat too much), enjoyment of food (e.g., My child enjoys eating), desire to drink (e.g., if given the change, my child would always be having a drink), emotional undereating (e.g., My child eats more when he/she is happy), and emotional overeating (e.g., My child eats more when she/he has nothing else to do). The scales have high internal consistency reliability (The overall Cronbach Alpha is above 0.7).

Preschoolers' sleep duration and problems

- ActiGraph accelerometer will be used to examine children's sleep duration in conjunction with a parent-reported log sheet and nap schedule provided by kindergartens. Bedtime and wakeup time will be identified based on algorithm by Sadeh, Sharkey [76] and periods of sleep were estimated using algorithm by Tudor-Locke, Barreira [77]. Duration of nighttime sleep and daytime nap, bedtime, and wakeup time will be assessed using ActiLife software (version 6.13) in 60-s epochs and matched with the nap schedule filled out by kindergarten teachers and log sheets finished by parents. The total duration of sleep per day will be the sum of nighttime and daytime sleep.

- Chinese version of the Children's Sleep Habits Questionnaire (CSHQ) [78], a regular used parent survey to track kids between the age from 4 to 10 years, will be used assess preschoolers' sleep problems. It contains 33 items to form a different set of eight domains: bedtime resistance, sleep onset delay, sleep duration, sleep anxiety, night waking, parasomnia, sleep-disordered breathing, and daytime sleepiness. Each scored question is rated on a 3-point scale as "usually if something occurs 5 or more times in a week" (scored 3), "sometimes if something occurs 2-4 times in a week" (scored 2), "rarely if something occurs never or 1 time during a week" (scored 1). Higher scores represent greater sleep problems. The CSHQ has shown good reliability (Cronbach's Alpha is 0.73) and validity.

Preschoolers' screen time

Parents will be asked to answer the questions which estimate the usual amount of screen time for their children on a typical weekday and weekend to determine the average screen time per week. Questions are also involved the availability of screens and rules about screen entertainment. This questionnaire was used in previous study [23].

Parent's physical activity

The parent's PA will be assessed using the Chinese Version of the International Physical Activity-Short Form (IPAQ-SF). the questionnaire will ask about the time spent being physically active in the last 7 days through 7 questions. The IPAQ-SF data will be converted to metabolic equivalent task (MET) scores for each dimension or intensity of PA. To calculate the weekly PA (METmin/week), the number of total minutes dedicated to each activity class was multiple by the specific MET score for the activity, with 3.3 METs for walking, 4 METs for moderate physical activity (MPA), 6 METs for cycling, and 8 METs for vigorous activity (VPA). The IPAQ-SF has been shown to be a reliable and validated measure for assessing PA levels in Chinese cities (The overall Cronbach Alpha is 0.788) [79].

Parenting style

Parenting Style & Dimension Questionnaire, a self-report instrument designed to measure authoritarian (e.g., I yell when I disapprove of my child's behavior), authoritative (e.g., I am responsive to my child's feelings and needs), and permissive parenting style (e.g., I find it difficult to discipline my child) of 4-12 years old children's parents, will be used to evaluate the parenting styles. This scale comprises 32 items, with each item of the scale evaluated by the five points Likert described as "never", "once in a while", "about half of the time", "very often" and "always". The overall Cronbach Alpha is 0.87 [80].

Parenting feeding style

Parenting feeding style will be assessed using the Chinese Version of the Parent Feeding Style Questionnaire, which consists of 4 parts: instrumental feeding (4 items), emotional feeding (5 items), prompting or encouragement to eat (8 items), and control over eating (10 items). Respondents will be asked to choose from a 5-point Likert scale (ranging from "never" to "always"). For example, "I allow my child to choose which food to have for meals, I encourage my child to look forward to the meal." The average score on each scale will be calculated and a higher score indicated a greater tendency for parents to feed their children in that style [81]. The overall Cronbach's Alpha is 0.75.

Parents' self-efficacy

Parents' self-efficacy will be assessed using a previously used questionnaire [23], which has been translated back-to-back into simplified Chinese language. This questionnaire consists of 11 questions related to child's PA (4 items), DB (6 items) and sleep (1 item). For example, how confident are you that you can promote healthy eating habits for your child? Respondents were asked to select from a 10-point Likert scale (ranging from "not at all" to "to a very high degree"). The higher score for the sum of 11 questions, the higher self-efficacy parent has on their child's PA, DB, and sleep.

Statistical analysis

All statistical analyses will be conducted using IBM SPSS 27, and a two-sided P value <0.05 is considered statistically significant. Baseline characteristics between the intervention group and control group will be compared using the Chi-square test for categorical variables and analysis of variance (ANOVA) for continuous variables. The mixed model, which accounts for missing repeated measures, will be conducted with a two-level between-group factor (intervention and control) and a two-level within factor (post-intervention and follow-up assessment) repeated measures analysis of covariance (RM ANCOVA) to examine whether electronic health-based parenting intervention improves preschoolers' PA, DB, and sleep compared to the control group.

Results

Parent-child dyads were recruited in September 2023. Baseline and posttest data collection occurred from October 2023 to March 2024. The follow-up data will be completed in June 2024. The research team has completed data collection on 238 parent-child dyads and is currently analyzing the outcomes. Results of the study are expected to be published in 2025.

Discussion

Low compliance with a healthy lifestyle (e.g., physical activity, healthy dietary patterns, and sufficient sleep) undoubtfully exacerbates the likelihood of non-communicable diseases such as obesity [82]. Focusing preventive efforts on early childhood growth trajectories provides an opportunity to address the unhealthy lifestyle before individuals' lifestyles are entrenched [83]. Chinese parents emphasize high standards and a tendency to control their kids, this strong parenting influences may potentially affect the early life behaviors of Chinese children [84]. Given the current economic climate, time constraints are likely to intensify for parents making face-to-face intervention more problematic. The current study is delivered in an easy-access setting (i.e., WeChat,

monthly active users have reached 1.26 billion, accounting for 77% of internet users aged from 16 to 64. 70.2% of Chinese rank Douyin, known as TikTok in western countries, as the second favorite social media platform, refer to https://techcrunch.com/2020/09/22/tiktok-wechat-and-the-growing-digital-divide-between-the-u-s-and-china/) in which parents are already engaged, and likely to share what they learn through peer communication. Unfortunately, proven parent-based eHealth interventions against preschoolers' unhealthy lifestyles are not being practiced routinely in China. Therefore, the objective of this study is to assess the effectiveness of eHealth intervention in promoting Chinese preschoolers' PA, DB, and sleep where parents are the agent of change. This study draws on the success of previous studies. Randomized controlled trial remains the gold standard for evidence of the effectiveness of eHealth interventions [85]. Previous studies have indicated that longer intervention is more effective than shorter ones, possibly because longer intervention duration allow program content to be repeated and allow participants to internalize program materials [10, 86]. According to the previous systematic review, the intervention duration varied from 8 weeks to 2 years, with over half studies being shorter than 12 weeks [49]. In China, preschoolers attend kindergarten for two semesters over one year, with each semester lasting around 12 weeks. Gardner and colleagues [87] indicated that behavioral modification needs at least 2 to 3 months. As such, the 12-week intervention duration in this study which fits well in the semester time may be acceptable and feasible for parents and preschoolers. The waitlist control group is identified as having 'no intervention', which is likely to be unacceptable to participants and contributes to poor retention and follow-up, thus compromising the study's integrity [88]. A follow-up test helps assess whether any behavioral changes resulting from the parent-based eHealth intervention are sustained over time [89]. Considering that the different educational level (i.e., lower literacy *vs* better literacy) is associated with a poorer understanding of healthy information provided, the use of video in the present study may be beneficial for parents with lower educational backgrounds [90]. Some new delivery modes via smartphone include infographics (used to provide additional support for different topics), text-message (used to offer feedback messages) and social media discussion (i.e., parents have the opportunities to communicate with members of the cohorts as well as experts in the WeChat group) can be a promising way to provide parents with knowledge, goals, and advice to directly influence children's healthy lifestyle [30, 54]. The primary outcome of this proposed study is preschoolers' PA. PA has been considered dispensable and trivial because Chinese parents have subscribed to the concept that any activities including PA that compromise academic success and examination results should be eliminated [84]. This study not only may provide parents with the knowledge, skills, and confidence to create an environment for their child in which healthy behaviors (e.g., PA, DB, and sleep) are developed and flourished, but also may correct misleading concepts about PA. Parent's PA, parenting style, and parent feeding practices are involved in the secondary outcome because (1) previous studies have indicated that preschoolers with parents who are regularly engaged in PA were more than 5 times more likely to be active than peers whose parents were not physically active, suggesting parents' PA may be positively related to improved preschooler's PA [91]. (2) Parenting style (i.e., authoritative, authoritarian, permissive, and disengaged) is an important factor that potentially affects the lifestyle of young children. For example, the authoritative parental style was effective in improving healthy behaviors (i.e., PA, diet, and less sedentary behaviors) [92]. Tyler and colleagues [93] found that an authoritarian parental style was positively associated with preschoolers' sleep problems. (3) Parental feeding practices (e.g., high control overeating) were associated with child eating patterns [94] because preschoolers' food preferences and patterns have been found to be influenced by the foods parents provide at a young age and food persistence in children's meals. [95].

The present study has several strengths, including the randomized controlled trial design, calculation of sample size that ensures adequate statistical power, and objective and valid data collection methods for outcome measurements. Multiple lifestyle-related behaviors (i.e., PA, diet, sleep) are targeted in the intervention. The intervention delivery is grounded upon four behavioral modification

steps included in the SCT. A 3-month follow-up will determine whether the behavioral changes made during the intervention can be maintained. This study addresses many limitations summarized from previous studies, such as failure to either consider the imbalance of the intervention dose to bias the results or consider the sequence of the intervention contents to bias the results.

There are however some limitations. The parent-child dyads allocated to either the intervention or control group may be from same school, and it is, therefore, possible that intervention content may be contaminated, and the outcome of this intervention may not be generalized to preschoolers living in other cities in China. Due to the subjective measurement for the questionnaires, there is the potential for parents to intentionally or unintentionally misreport, however, this is common in all free-living studies examining behavioral measures [96].

This study will make an important contribution to the literature on the application and verification of eHealth intervention (e.g., social media) in cultivating healthy lifestyles (i.e., PA, DB, and sleep) of Chinese preschoolers, where parents are the agent of change. By applying theory-based (SCT) intervention with eHealth technology, a new perspective for future scientific health promotion will be obtained. China has a huge amount of population in the world, it would pose a heavy financial burden on society if implementing a traditional face-to-face intervention to improve the unhealthy lifestyles of preschoolers. According to China Internet Network Information Center, as of December 2023, around 78% Chinese people are connected to mobile devices with access to internet (including those living in rural and remote regions), potentially enabling widespread access regardless of geographic location. This intervention has the potential to broad reach as it addresses many obstacles associated with face-to-face delivery method. If found to be efficacious, the prevalence of unhealthy lifestyles among preschoolers may be alleviated at a low cost, which not only has a positive influence on the health of the individual and the well-being of the family, but also reduces the financial pressure on society to treat diseases caused by poor lifestyle habits.

Abbreviations

Physical activity (PA). Dietary behaviors (DB). Electronic health (eHealth). Social Cognitive Theory (SCT).

Statement

No generative AI was ever used throughout the writing process of the current study.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

1. Kussmann, M., L. Krause, and W. Siffert, *Nutrigenomics: where are we with genetic and epigenetic markers for disposition and susceptibility?* Nutrition reviews, 2010. **68**(s1): p. S38-S47.
2. García-Hermoso, A., et al., *Effects of Exercise Intervention on Health-Related Physical Fitness and Blood Pressure in Preschool Children: A Systematic Review and Meta-Analysis of Randomized Controlled Trials.* Sports medicine (Auckland), 2019. **50**(1): p. 187-203.
3. Fang, H., et al., *Relationship between Physical Activity and Physical Fitness in Preschool Children: A Cross-Sectional Study.* Biomed Res Int, 2017. **2017**: p. 9314026-8.
4. Gómez-Pinilla, F., *Brain foods: the effects of nutrients on brain function.* Nature reviews. Neuroscience, 2008. **9**(7): p. 568-578.
5. Lubans, D.R., R.C. Plotnikoff, and N.J. Lubans, *Review: A systematic review of the impact of physical activity programmes on social and emotional well-being in at-risk youth.* Child and Adolescent Mental Health, 2012. **17**(1): p. 2-13.
6. Akacem, L.D., et al., *The Timing of the Circadian Clock and Sleep Differ between Napping and Non-Napping Toddlers.* PloS one, 2015. **10**(4): p. e0125181-e0125181.
7. Lubans, D., et al., *Physical activity for cognitive and mental health in youth: a systematic*

review of mechanisms. Pediatrics, 2016. **138**(3).
8. Bathory, E. and S. Tomopoulos, *Sleep Regulation, Physiology and Development, Sleep Duration and Patterns, and Sleep Hygiene in Infants, Toddlers, and Preschool-Age Children.* Curr Probl Pediatr Adolesc Health Care, 2017. **47**(2): p. 29-42.
9. Yoong, S.L., et al., *A pilot randomized controlled trial examining the impact of a sleep intervention targeting home routines on young children's (3–6 years) physical activity.* Pediatric obesity, 2019. **14**(4): p. e12481-n/a.
10. Campbell, K.J. and K.D. Hesketh, *Strategies which aim to positively impact on weight, physical activity, diet and sedentary behaviours in children from zero to five years. A systematic review of the literature.* Obesity reviews, 2007. **8**(4): p. 327-338.
11. Hoelscher, D.M., et al., *Position of the Academy of Nutrition and Dietetics: interventions for the prevention and treatment of pediatric overweight and obesity.* J Acad Nutr Diet, 2013. **113**(10): p. 1375-94.
12. Franckle, R.L., et al., *Insufficient sleep among elementary and middle school students is linked with elevated soda consumption and other unhealthy dietary behaviors.* Preventive medicine, 2015. **74**: p. 36-41.
13. van der Kruk, J.J., et al., *Obesity: a systematic review on parental involvement in long-term European childhood weight control interventions with a nutritional focus.* Obesity reviews : an official journal of the International Association for the Study of Obesity, 2013. **14**(9): p. 745-760.
14. Farrow, C., et al., *Using repeated visual exposure, rewards and modelling in a mobile application to increase vegetable acceptance in children.* Appetite, 2019. **141**: p. 104327-104327.
15. Aadland, E., A.D. Okely, and A.K.O. Nilsen, *Trajectories of physical activity and sedentary time in Norwegian children aged 3-9 years: a 5-year longitudinal study.* The international journal of behavioral nutrition and physical activity, 2022. **19**(1): p. 67-67.
16. Baranowski, T., et al., *Dimensions of vegetable parenting practices among preschoolers.* Appetite, 2013. **69**: p. 89-93.
17. Agard, B., et al., *Moving Together: Understanding Parent Perceptions Related to Physical Activity and Motor Skill Development in Preschool Children.* International journal of environmental research and public health, 2021. **18**(17): p. 9196.
18. Luo, Y., et al., *Profiles of maternal and paternal parenting styles in Chinese families: Relations to preschoolers' psychological adjustment.* Children and youth services review, 2021. **121**: p. 105787.
19. Heinrichs, N., S. Kliem, and K. Hahlweg, *Four-Year Follow-Up of a Randomized Controlled Trial of Triple P Group for Parent and Child Outcomes.* Prev Sci, 2013. **15**(2): p. 233-245.
20. van Sluijs, E.M.F., S. Kriemler, and A.M. McMinn, *The effect of community and family interventions on young people's physical activity levels: a review of reviews and updated systematic review.* British journal of sports medicine, 2011. **45**(11): p. 914-922.
21. Knowlden, A.P. and M. Sharma, *Systematic review of family and home-based interventions targeting paediatric overweight and obesity.* Obesity reviews, 2012. **13**(6): p. 499-508.
22. Reinehr, T., et al., *An effective lifestyle intervention in overweight children: Findings from a randomized controlled trial on "Obeldicks light".* Clinical nutrition (Edinburgh, Scotland), 2010. **29**(3): p. 331-336.
23. Hammersley, M.L., R.A. Jones, and A.D. Okely, *Time2bHealthy – An online childhood obesity prevention program for preschool-aged children: A randomised controlled trial protocol.* Contemp Clin Trials, 2017. **61**: p. 73-80.
24. Grimes-Robison, C. and R.R. Evans, *Benefits and barriers to medically supervised pediatric weight-management programs.* Journal of Child Health Care, 2008. **12**(4): p. 329-343.
25. Newton, J.R.L., et al., *Parent-targeted mobile phone intervention to increase physical activity*

in sedentary children: randomized pilot trial. JMIR Mhealth Uhealth, 2014. **2**(4): p. e48-e48.
26. Short, C.E., et al., *Measuring Engagement in eHealth and mHealth Behavior Change Interventions: Viewpoint of Methodologies.* Journal of medical Internet research, 2018. **20**(11): p. e292-e292.
27. Park, L.G., et al., *Mobile Health Intervention Promoting Physical Activity in Adults Post Cardiac Rehabilitation: Pilot Randomized Controlled Trial.* JMIR Form Res, 2021. **5**(4): p. e20468-e20468.
28. Hammersley, M.L., R.A. Jones, and A.D. Okely, *Parent-Focused Childhood and Adolescent Overweight and Obesity eHealth Interventions: A Systematic Review and Meta-Analysis.* J Med Internet Res, 2016. **18**(7): p. e203-e203.
29. Haines, J., et al., *Healthy Habits, Happy Homes: Randomized Trial to Improve Household Routines for Obesity Prevention Among Preschool-Aged Children.* JAMA Pediatrics, 2013. **167**(11): p. 1072-1079.
30. Hammersley, M.L., et al., *An Internet-Based Childhood Obesity Prevention Program (Time2bHealthy) for Parents of Preschool-Aged Children: Randomized Controlled Trial.* J Med Internet Res, 2019. **21**(2): p. e11964-e11964.
31. Nyström, C.D., et al., *Mobile-based intervention intended to stop obesity in pre-school children: The MINISTOP RCT.* EUROPEAN JOURNAL OF PUBLIC HEALTH, 2017. **27**(suppl_3): p. 74.
32. Knowlden, A.P., et al., *Impact Evaluation of Enabling Mothers to Prevent Pediatric Obesity Through Web-Based Education and Reciprocal Determinism (EMPOWER) Randomized Control Trial.* Health education & behavior, 2015. **42**(2): p. 171-184.
33. Wyse, R., et al., *A cluster randomized controlled trial of a telephone-based parent intervention to increase preschoolers' fruit and vegetable consumption.* The American journal of clinical nutrition, 2012. **96**(1): p. 102-110.
34. Ling, J., et al., *Using Facebook in a Healthy Lifestyle Intervention: Feasibility and Preliminary Efficacy.* Western journal of nursing research, 2018. **40**(12): p. 1818-1842.
35. Nezami, B.T., et al., *Effect of the Smart Moms intervention on targeted mediators of change in child sugar-sweetened beverage intake.* Public Health, 2020. **182**: p. 193-198.
36. Marsh, S., et al., *Results of the 3 Pillars Study (3PS), a relationship-based programme targeting parent-child interactions, healthy lifestyle behaviours, and the home environment in parents of preschool-aged children: A pilot randomised controlled trial.* PLoS One, 2020. **15**(9): p. e0238977.
37. Bakırcı-Taylor, A.L., et al., *mHealth Improved Fruit and Vegetable Accessibility and Intake in Young Children.* J Nutr Educ Behav, 2019. **51**(5): p. 556-566.
38. Trost, S.G. and D.S. Brookes, *Effectiveness of a novel digital application to promote fundamental movement skills in 3-to 6-year-old children: A randomized controlled trial.* Journal of Sports Sciences, 2021. **39**(4): p. 453-459.
39. Hammersley, M.L., et al., *Translation of Two Healthy Eating and Active Living Support Programs for Parents of 2-6-Year-Old Children: Outcomes of the 'Time for Healthy Habits' Parallel Partially Randomised Preference Trial.* Nutrients, 2021. **13**(10).
40. Staiano, A.E., et al., *mHealth Intervention for Motor Skills: A Randomized Controlled Trial.* Pediatrics, 2022. **149**(5).
41. Lee, M.K., S. Baker, and D. Whitebread, *Culture-specific links between maternal executive function, parenting, and preschool children's executive function in South Korea.* British Journal of Educational Psychology, 2018. **88**(2): p. 216-235.
42. Fan, X. and Z.-B. Cao, *Physical activity among Chinese school-aged children： National prevalence estimates from the 2016 Physical Activity and Fitness in China The Youth Study.* Journal of sport and health science, 2017. **6**(4): p. 388-394.
43. Volger, S., et al., *Nutrient Intake and Dietary Patterns in Children 2.5-5 Years of Age with*

Picky Eating Behaviors and Low Weight-for-Height. Asia Pacific journal of clinical nutrition, 2013. **26**(1): p. 104-109.
44. Guan, H., et al., *Proportion of kindergarten children meeting the WHO guidelines on physical activity, sedentary behaviour and sleep and associations with adiposity in urban Beijing.* BMC pediatrics, 2020. **20**(1): p. 70-70.
45. Statista. *Number of mobile internet users in China from 2010 to 2021*. 2022 [cited 2022 2021]; Available from: https://www.statista.com/statistics/273973/number-of-mobile-internet-users-in-china/.
46. Rathore, V., et al., *Online Parenting Intervention for Children's Eating and Mealtime Behaviors: Protocol of a Randomized Controlled Trial.* Healthcare (Basel), 2022. **10**(5): p. 924.
47. Chen, F.-M. and T. Luster, *Factors Related to Parenting Practices in Taiwan.* Early child development and care, 2002. **172**(5): p. 413-430.
48. Stewart, S.M., et al., *Does the Chinese construct of guan export to the West?* International journal of psychology, 2002. **37**(2): p. 74-82.
49. Hammersley, M., R. Jones, and A. Okely, *Parent-focused childhood overweight and obesity eHealth interventions: A systematic review and meta-analysis.* Obesity research & clinical practice, 2019. **13**(1): p. 84-84.
50. Eysenbach, G., *CONSORT-EHEALTH: improving and standardizing evaluation reports of Web-based and mobile health interventions.* J Med Internet Res, 2011. **13**(4): p. e126-e126.
51. Brophy, S., et al., *Risk factors for childhood obesity at age 5: analysis of the millennium cohort study.* BMC public health, 2009. **9**(1): p. 467-467.
52. Young, M.D., et al., *Social cognitive theory and physical activity: a systematic review and meta-analysis.* OBES REV, 2014. **15**(12): p. 983-995.
53. Apperly, I.A., *Beyond Simulation–Theory and Theory–Theory: Why social cognitive neuroscience should use its own concepts to study "theory of mind"*. Cognition, 2008. **107**(1): p. 266-283.
54. Tripicchio, G.L., et al., *Development and Preliminary Feasibility of iByte4Health: A Mobile Health (mHealth) Pediatric Obesity Prevention Intervention to Engage Parents with Low-Income of Children 2-9 Years.* Nutrients, 2021. **13**(12).
55. Nyström, C.D., et al., *Mobile-based intervention intended to stop obesity in preschool-aged children: The MINISTOP randomized controlled trial.* AM J CLIN NUTR, 2017. **105**(6): p. 1327-1335.
56. Lau, P.W.C., et al., *The effectiveness of Facebook as a social network intervention to increase physical activity in Chinese young adults.* Frontiers in public health, 2022. **10**: p. 912327-912327.
57. WHO. *Healthy Diet*. 2020 [cited 2020 29 April]; Available from: https://www.who.int/news-room/fact-sheets/detail/healthy-diet.
58. WHO. *Guidelines on physical activity, sedentary behaviour and sleep for children under 5 years of age*. 2019 [cited 2019 April]; Available from: https://apps.who.int/iris/bitstream/handle/10665/325147/WHO-NMH-PND-2019.4-eng.pdf.
59. Michie, S., et al., *The Behavior Change Technique Taxonomy (v1) of 93 Hierarchically Clustered Techniques: Building an International Consensus for the Reporting of Behavior Change Interventions.* ann. behav. med, 2013. **46**(1): p. 81-95.
60. Bourne, J.E., et al., *Mapping behavior change techniques to characterize a social cognitive theory informed physical activity intervention for adults at risk of type 2 diabetes mellitus.* Transl Behav Med, 2020. **10**(3): p. 705-715.
61. Michie, S., et al., *Behaviour change techniques: the development and evaluation of a taxonomic method for reporting and describing behaviour change interventions (a suite of five studies involving consensus methods, randomised controlled trials and analysis of*

qualitative data). Health Technol Assess, 2015. **19**(99): p. 1-188.
62. Militello, L., et al., *Automated Behavioral Text Messaging and Face-to-Face Intervention for Parents of Overweight or Obese Preschool Children: Results From a Pilot Study.* JMIR Mhealth Uhealth, 2016. **4**(1): p. e21-e21.
63. Mo, P.K.H. and N.S. Coulson, *Empowering processes in online support groups among people living with HIV/AIDS: A comparative analysis of 'lurkers' and 'posters'.* Computers in human behavior, 2010. **26**(5): p. 1183-1193.
64. Oh, H.J. and B. Lee, *The Effect of Computer-Mediated Social Support in Online Communities on Patient Empowerment and Doctor-Patient Communication.* Health communication, 2012. **27**(1): p. 30-41.
65. Bovend'Eerdt, T.J.H., R.E. Botell, and D.T. Wade, *Writing SMART rehabilitation goals and achieving goal attainment scaling: a practical guide.* CLIN REHABIL, 2009. **23**(4): p. 352-361.
66. Estabrooks, P.A., et al., *The Frequency and Behavioral Outcomes of Goal Choices in the Self-management of Diabetes.* Diabetes Educ, 2005. **31**(3): p. 391-400.
67. Nothwehr, F. and J. Yang, *Goal setting frequency and the use of behavioral strategies related to diet and physical activity.* Health Educ Res, 2006. **22**(4): p. 532-538.
68. Locke, E.A. and G.P. Latham, *Building a practically useful theory of goal setting and task motivation. A 35-year odyssey.* Am Psychol, 2002. **57**(9): p. 705-717.
69. Hnatiuk, J.A., et al., *Interventions to increase physical activity in children 0-5 years old: a systematic review, meta-analysis and realist synthesis.* Obes Rev, 2019. **20**(1): p. 75-87.
70. Nezami, B.T., et al., *A mHealth randomized controlled trial to reduce sugar-sweetened beverage intake in preschool-aged children: Intervention to reduce sweetened beverages.* Pediatric obesity, 2018. **13**(11): p. 668-676.
71. Yoong, S.L., et al., *A pilot randomized controlled trial examining the impact of a sleep intervention targeting home routines on young children's (3-6 years) physical activity.* Pediatr Obes, 2019. **14**(4): p. e12481.
72. Faul, F., et al., *GPower 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences.* Behavior research methods, 2007. **39**(2): p. 175-191.
73. Leeger-Aschmann, C.S., et al., *Accelerometer-derived physical activity estimation in preschoolers – comparison of cut-point sets incorporating the vector magnitude vs the vertical axis.* BMC Public Health, 2019. **19**(1): p. 513.
74. Lau, P.W.C., et al., *24-Hour movement behaviors and executive functions in preschoolers: A compositional and isotemporal reallocation analysis.* Child Dev, 2023.
75. Zhou, N. and L. Sun, *Confirmatory factor analysis of the Children's Eating Behaviour Questionnaire in a Chinese urban preschooler sample.* 2021.
76. Sadeh, A., K.M. Sharkey, and M.A. Carskadon, *Activity-based sleep-wake identification: an empirical test of methodological issues.* Sleep, 1994. **17**(3): p. 201-7.
77. Tudor-Locke, C., et al., *Fully automated waist-worn accelerometer algorithm for detecting children's sleep-period time separate from 24-h physical activity or sedentary behaviors.* Appl Physiol Nutr Metab, 2014. **39**(1): p. 53-7.
78. Tan, T.X., et al., *Reliability and construct validity of the Children's Sleep Habits Questionnaire in Chinese kindergartners.* Sleep Health, 2018. **4**(1): p. 104-109.
79. Ren, Y.J., et al., *Validation of the Simplified Chinese-character Version of the International Physical Activity Questionnaire-Long Form in Urban Community-dwelling Adults□ a Cross-sectional Study in Hangzhou, China.* Biomedical and Environmental Sciences, 2017. **30**(4): p. 255-263.
80. Robinson, C.C., Mandleco, B., Olsen, S. F., Hart, G. H., *The parenting styles and dimensions questionnaire (PSDQ). Handbook of Family Measurement Techniques.* 2001. **3**: p. 319-321.
81. Tam, W., et al., *Chinese translation and validation of a parental feeding style questionnaire*

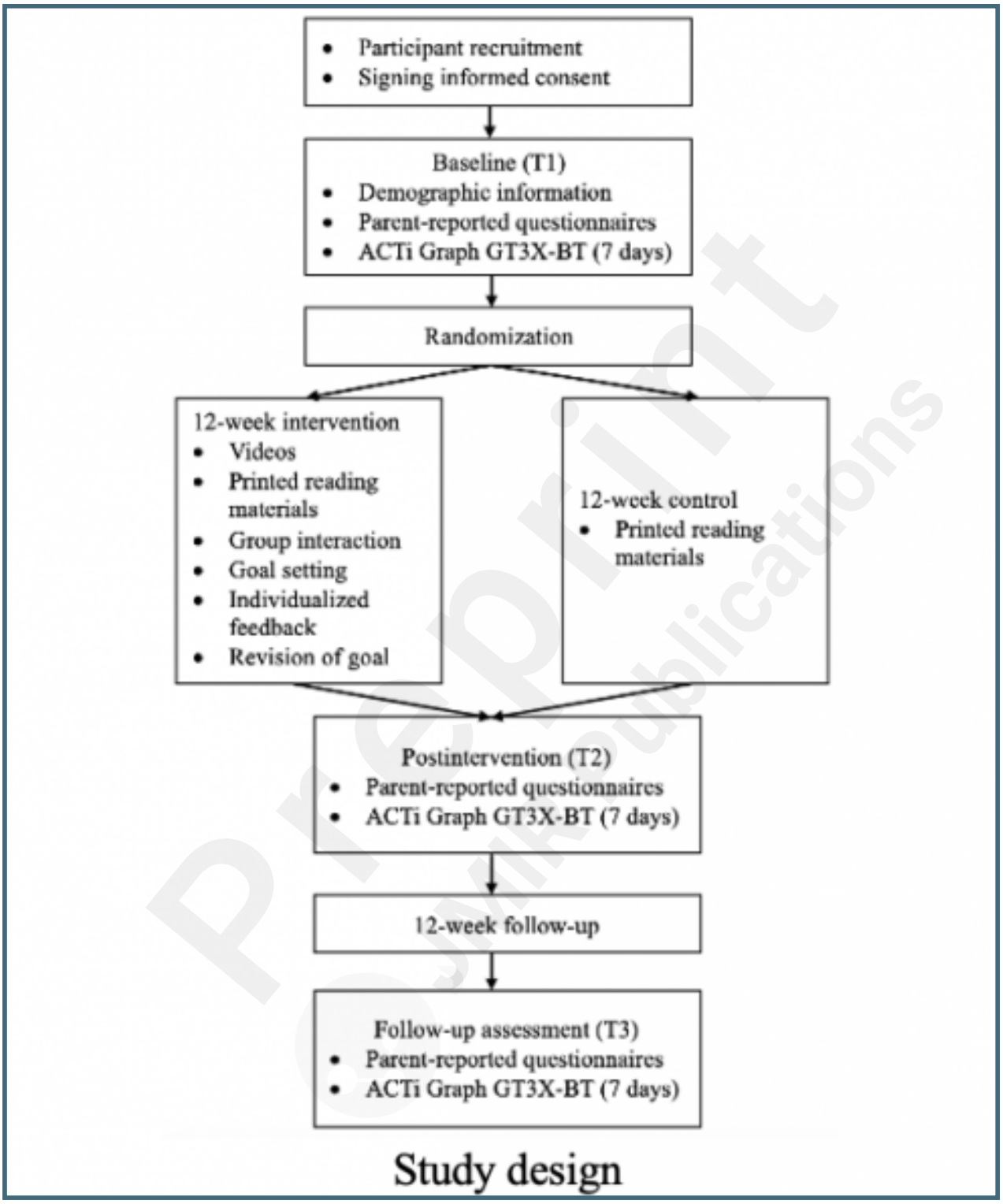
for parents of Hong Kong preschoolers. BMC Public Health, 2014. **14**(1): p. 1194-1194.
82. Tomaz, S.A., et al., *Body Mass Index, Physical Activity, Sedentary Behavior, Sleep, and Gross Motor Skill Proficiency in Preschool Children From a Low- to Middle-Income Urban Setting.* Journal of physical activity & health, 2019. **16**(7): p. 525-532.
83. Anderson-Lewis, C., et al., *mHealth Technology Use and Implications in Historically Underserved and Minority Populations in the United States: Systematic Literature Review.* JMIR mHealth and uHealth, 2018. **6**(6): p. e128-e128.
84. Ren, L., B.Y. Hu, and X. Zhang, *Disentangling the Relations Between Different Components of Family Socioeconomic Status and Chinese Preschoolers' School Readiness.* Family process, 2021. **60**(1): p. 216-234.
85. Barton, S., *Which Clinical Studies Provide The Best Evidence? The Best RCT Still Trumps The Best Observational Study.* BMJ (Online), 2000. **321**(7256): p. 255-256.
86. Yavuz, H.M., et al., *Interventions aimed at reducing obesity in early childhood: a meta-analysis of programs that involve parents.* Journal of child psychology and psychiatry, 2015. **56**(6): p. 677-692.
87. Gardner, B., P. Lally, and J. Wardle, *Making health habitual: the psychology of 'habit-formation' and general practice.* British journal of general practice, 2012. **62**(605): p. 664-666.
88. Jones, R.A., et al., *The HIKCUPS trial: a multi-site randomized controlled trial of a combined physical activity skill-development and dietary modification program in overweight and obese children.* BMC public health, 2007. **7**(1): p. 15-15.
89. Wen, L.M., et al., *Early intervention of multiple home visits to prevent childhood obesity in a disadvantaged population: a home-based randomised controlled trial (Healthy Beginnings Trial).* BMC public health, 2007. **7**(1): p. 76-76.
90. Silk, K.J.P., et al., *Increasing Nutrition Literacy: Testing the Effectiveness of Print, Web site, and Game Modalities.* Journal of nutrition education and behavior, 2008. **40**(1): p. 3-10.
91. Suen, Y.-n., E. Cerin, and S.-l. Wua, *Parental practices encouraging and discouraging physical activity in Hong Kong Chinese preschoolers.* Journal of physical activity & health, 2015. **12**(3): p. 361-369.
92. Olvera, N. and T.G. Power, *Brief Report: Parenting Styles and Obesity in Mexican American Children: A Longitudinal Study.* Journal of pediatric psychology, 2010. **35**(3): p. 243-249.
93. Tyler, D., et al., *Young Children's Sleep Problems: The Impact of Parental Distress and Parenting Style.* Journal of child and family studies, 2019. **28**(8): p. 2098-2106.
94. Harrist, A.W., et al., *What Developmental Science Can Contribute to a Transdisciplinary Understanding of Childhood Obesity: An Interpersonal and Intrapersonal Risk Model.* Child development perspectives, 2012. **6**(4): p. 445-455.
95. Lee Olstad, D. and L. McCargar, *Prevention of overweight and obesity in children under the age of 6 years.* Applied physiology, nutrition, and metabolism, 2009. **34**(4): p. 551-570.
96. Van Cauwenberghe, E., et al., *Patterns of physical activity and sedentary behaviour in preschool children.* Int J Behav Nutr Phys Act, 2012. **9**(1): p. 138-138.

Supplementary Files

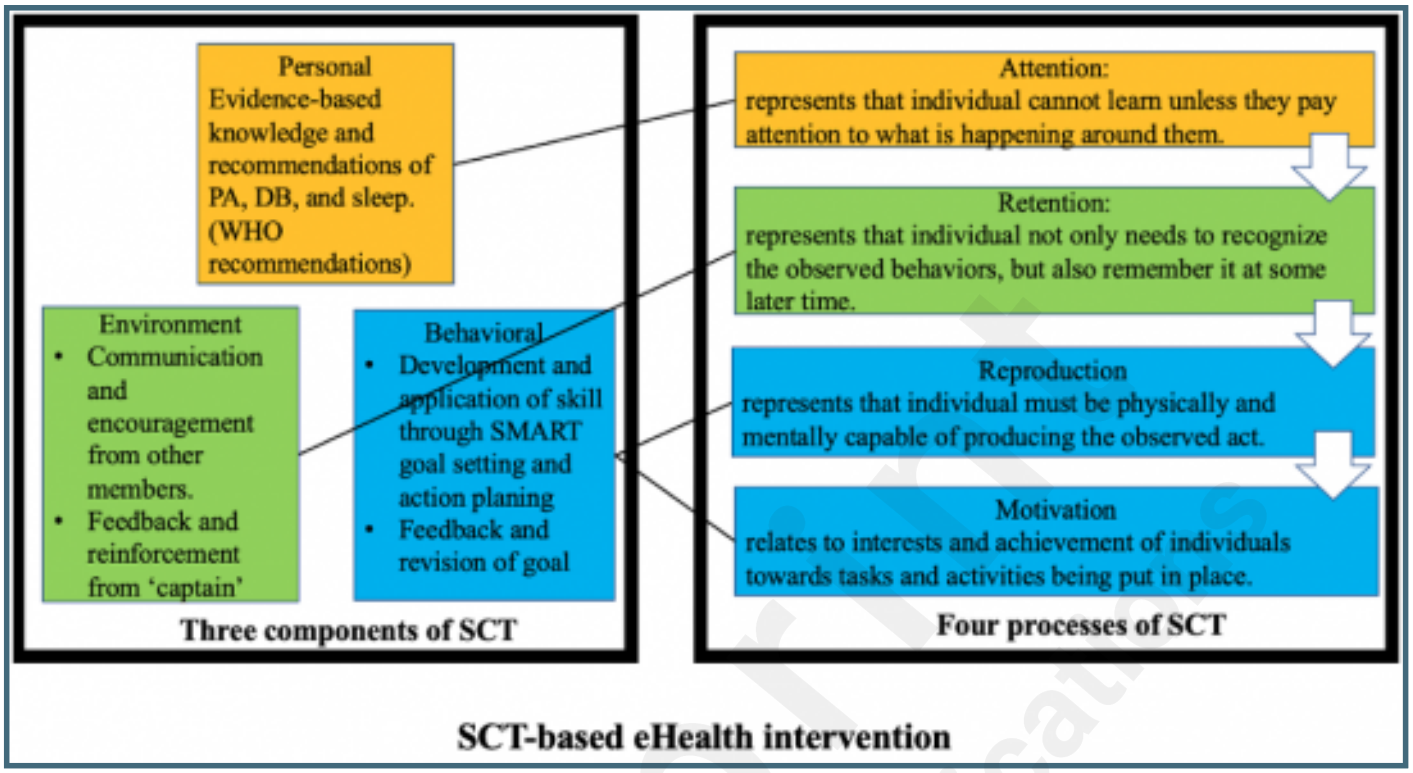
Response letter.
URL: http://asset.jmir.pub/assets/6a902c906d5cd41c31520b7d5312faad.docx

Figures

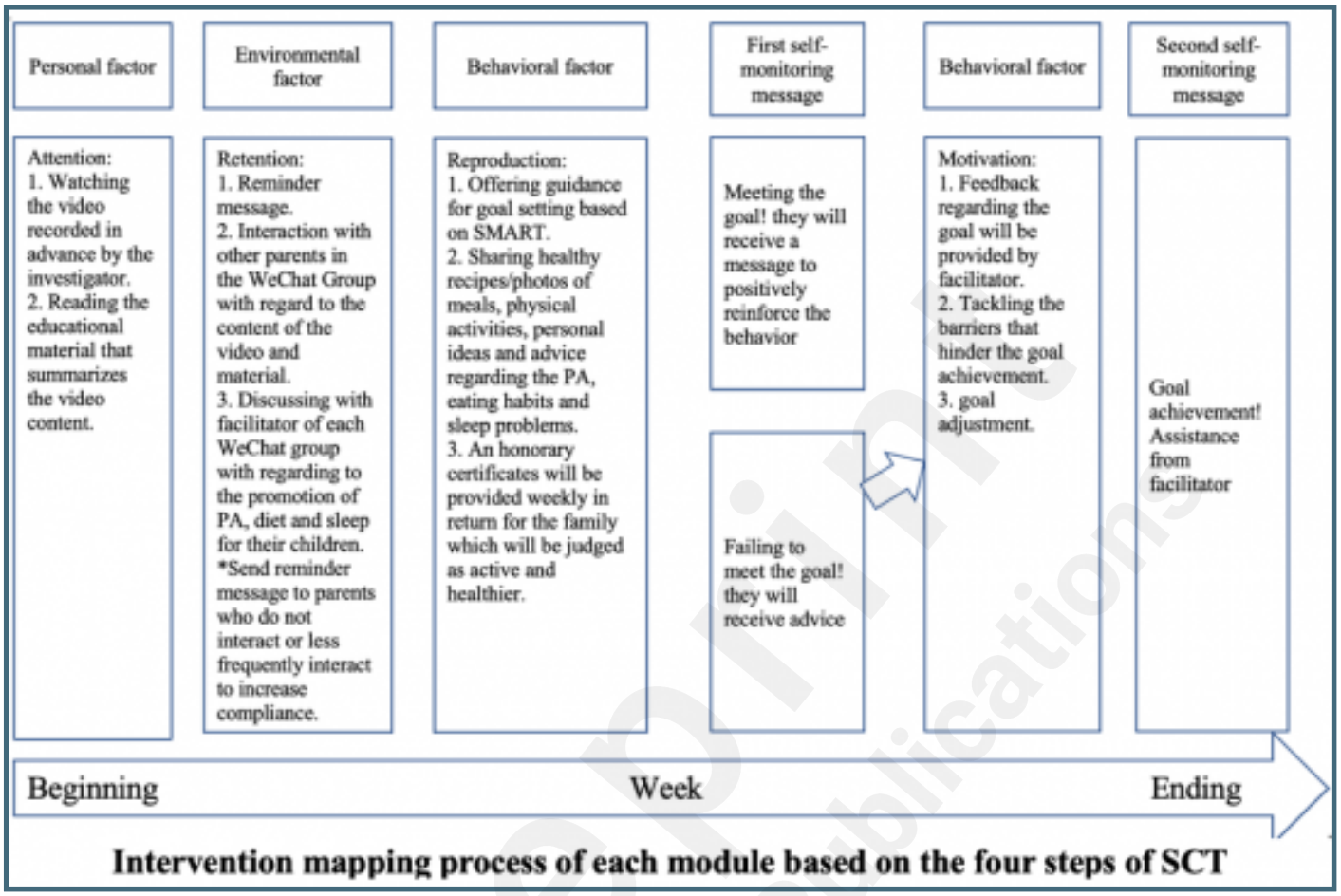
Study design.



SCT-based eHealth intervention.



Intervention mapping process.



Multimedia Appendixes

Consort-eHealth.
URL: http://asset.jmir.pub/assets/e82c47c45ca9b42ff2eb57574d2a2601.pdf

CONSORT (or other) checklists

Untitled.
URL: http://asset.jmir.pub/assets/80d64470cb13e7e19fc401c48ce0ae15.pdf