การศึกษานำร่องของแอปพลิเคชัน "รู้เท่าทันความเครียด" โดยใช้แนวคิดการบำบัดด้วยการยอมรับ และพันธสัญญาเป็นฐานเพื่อส่งเสริมการคิดเชิงบวก และลดการรับรู้ความเครียดในวัยรุ่นกลุ่มเสี่ยง

A Pilot Study of "Be Aware of Stress" Application Base on Acceptance and Commitment Therapy Concept in Promoting Positive Thinking and Reducing Perceived Stress for At-risk Adolescents

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Original Article

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บทคัดย่อ

วัตถุประสงค์: เพื่อพัฒนาแอปพลิเคชัน "รู้เท่าทันความเครียด" สำหรับวัยรุ่นกลุ่มเสี่ยงต่อการเกิดปัญหาสุขภาพจิตจากความเครียดและศึกษาความเป็นไปได้ของการใช้งาน **วิธีการศึกษา:** การวิจัยกึ่งทดลองแบบ 1 กลุ่มวัดผลก่อนและหลังการทดลองนี้แบ่งเป็น 2 ระยะ คือ 1) พัฒนาแอปพลิเคชันตามกรอบแนวคิดการบำบัดด้วยการยอมรับและพันธะสัญญา และ 2) ทดสอบความเป็นไปได้ของการนำไปใช้ กลุ่มตัวอย่างเป็นวัยรุ่นที่ศึกษาระดับชั้นมัธยมศึกษาตอนต้น เดือนธันวาคม พ.ศ. 2566 จำนวน 10 คนที่มีภาวะเครียดระดับปานกลางขึ้นไปที่ประเมินด้วยแบบคัดกรองความเครียดเบื้องต้นของกรมสุขภาพจิต (ST-5) และมีสมาร์ตโฟนในระบบปฏิบัติการแอนดรอยด์ เลือกแบบเฉพาะเจาะจงจากโรงเรียนขยายโอกาสแห่งหนึ่งในภาคตะวันออกของประเทศไทย ผู้ทรงคุณวุฒิใช้แบบประเมินการใช้งานแอปพลิเคชันบนมือถือ ส่วนวัยรุ่นตอบแบบสอบถามการคิดเชิงบวกสำหรับนักเรียนชั้นมัธยมศึกษา และแบบวัดการรับรู้ความเครียด ก่อนและหลังทดลองใช้ 4 สัปดาห์ และแบบวัดความพึงพอใจต่อการใช้งานแอปพลิเคชันบนมือถือ (ความเป็นไปได้) ที่หลังทดลองใช้ ทดสอบความแตกต่างด้วยสถิติทีแบบไม่อิสระ **ผลการศึกษา:** การทำงานของแอปพลิเคชันทั้ง 6 ฟังก์ชันผ่านการประเมินจากผู้ทรงคุณวุฒิในระดับดี (mean = 4.41 ± 0.68) วัยรุ่นมีความพึงพอใจต่อแอปพลิเคชันระดับสูง (mean = 4.06 ± 0.77) มีระดับการคิดเชิงบวกเพิ่มขึ้น (P-value = 0.008) และการรับรู้ความเครียดลดลง (P-value = 0.002) **สรุป:** แอปพลิเคชัน "รู้เท่าทันความเครียด" มีความเป็นไปได้ในการนำไปใช้เพื่อส่งเสริมการคิดเชิงบวกและลดความเครียดในวัยรุ่นกลุ่มเสี่ยง ควรวิจัยเชิงทดลองอย่างเคร่งครัดในกลุ่มตัวอย่างขนาดใหญ่เพื่อยืนยันประสิทธิผลของแอปพลิเคชันต่อไป

คำสำคัญ: แอปพลิเคชันบนมือถือ; แอนดรอยด์; การบำบัดด้วยการยอมรับและพันธสัญญา; การคิดเชิงบวก; การรับรู้ความเครียด; วัยรุ่น; ไทย

Abstract

Objective: To develop the **"Be Aware of Stress"** application and test its feasibility. **Method:** Quasi-experimental study with one-group pretest-posttest design was conducted with 2 phases of developing the application by integrating the concept of Acceptance and Commitment Therapy (ACT) and testing its feasibility. The sample included ten adolescents who were studying at junior high school in December 2023. They had at least moderate level of stress as screened through ST-5 and owned an android operative system smartphone. They were purposely recruited from an opportunity expansion school in the eastern part of Thailand. Experts rated the application using guidelines for evaluating the usability of m-Health. Adolescents completed Positive Thinking Test for High School Student and Perceived Stress Questionnaire before and after the 4-week trial, and Satisfaction Scale towards the Mobile Application (feasibility) after the trial. Pre- and post-trial scores were compared using paired t-test. **Results:** All 6 functional components of this Android smartphone application evaluated by the experts were at a good level (mean = 4.41 ± 0.68). Adolescents' satisfaction with this application was at the high level (mean = 4.06 ± 0.77). After using this application, participants had significantly higher positive thinking scores (P-value = 0.008) and lower perceived stress scores (P-value = 0.002). **Conclusion:** It was feasible to use the **"Be Aware of Stress"** application to improve positive thinking and perceived stress among at-risk adolescents. Vigorous experimental research on larger sample should be conducted to further confirm the effectiveness of this application.

Key words: smartphone application, Android; Acceptance and Commitment Therapy, positive thinking, perceived stress, adolescents; Thai

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http://ejournals.swu.ac.th/index.php/pharm/index

Introduction

Adolescence is an age where physical, mental, and emotional changes occur rapidly. Therefore, transition from childhood to adulthood is considered an important period of life. There are changes in family, society, and the environment around these adolescents which cause them to experience stress. Sometimes the changes cause them to be unable to adjust in facing the problems that arise.[1] Accumulated stress affects physiological changes in the brain functions, nervous system, and immune system. The physical illness that occurred form stress, called stress-related disorders, are

related to cancer, type 1 diabetes, and skin diseases.[2] For consequences of stress in mental health, the finding showed that depression, anxiety, suicide, substance use, and antisocial behavior were significantly correlated with stress.[3]

In Thailand, it is known that stress is an important factor in the development of depression, leading to a higher risk of suicide. The prevalence of depression resulting from stress among Thai adolescents between the ages of 15 - 24 is approximately 0.3 - 2.1%, and the suicide rate is as high as 3.2%.[4] In addition, in fiscal year 2022, data from the Surveillance Report on those who attempted to harm themselves in the case of non-fatality (506 s Report) were taken for analyzing and comparing rates of suicide attempts by specific age groups. It was found that these adolescents or students aged 15 - 19 years had a higher suicide attempt rate than other age groups, amounting to 224.34 per 100,000 populations.[5] These statistics reflect the low efficiency in adapting to stress and preparation for dealing with stress among adolescents, and is a prime concern.

Stress is a person's perception of stimuli that affect their thoughts and behaviors, leading to adaptation towards stressful conditions. Lazarus and Folkman stated that perceived stress in daily life is a condition in response to events or demands that the person perceived as dangerous or life threatening and beyond their ability to cope.[6] The concept of cognitive and behavior therapy (CBT) addresses the psychological construct related to the relationships among thoughts, emotions, and behaviors. Individuals with psychopathologies might interpret unpresented situations through "automatic thoughts" which were considered as distorted, inaccurate and unhelpful thinking. Such thought patterns linked to distress emotion and maladaptive coping behavior.[7] Positive thinking is the one dimension of positive psychology. Thinking positively makes individuals perceive stress as less threatening by change of perceptions, beliefs, and feelings. The individuals know how to choose in taking advantage of the positive aspects that are concealed in such things and create strong morale and motivation to act in a good direction which are beneficial to the persons themselves and to others.[8]

Previous studies had clearly affirmed that positive thinking is associated with good mental health condition namely, a sense of self-confidence, a better coping with stress and a stronger resilience. In addition, positive thinking also had positive relationship with reducing the risk of cardiovascular disease and metabolic syndrome.[9] In the social aspect, those with positive thinking are more likely to succeed in life than those with negative thought because they learn to be adaptable in their interactions with others and also know how to forgive and maintain long-lasting relationships with others.[10]

From a review of the current literature related to therapies in promoting positive thinking, it was found that there is a third wave of cognitive-behavioral therapy called mindfulness-based psychotherapy which expands on the context of cognitive-behavioral therapy (CBT). The most common in the past decade includes Mindfulness-Based Stress Reduction (MBSR) and Mindfulness-Based Cognitive Therapy (MBCT). Moreover, mindfulness principles have been integrated into other notable therapeutic interventions such as Dialectical Behavioral Therapy (DBT) and Acceptance and Commitment Therapy (ACT). The core principles of mindfulness are increased emotional awareness and regulation, cognitive flexibility, and goals-based behaviors. These principles driven by mindfulness and acceptance strategies for enhancing individual to recognizing their negative thoughts and feelings as just a mental state. It is only what is known, not the self, which helps a person reduce obsessive thinking about things that happened in the past or worry about what will happen in the future. These would help reduce inappropriate adjustments and thought suppression, which is a cause of depression and anxiety.[11]

Mindfulness therapy is recognized as an effective based intervention to promote positive thinking and reduce perceived stress. Nevertheless, these therapies had some limitation in applying with adolescents. Healthcare providers should consider different stages of development according to the adolescents' age, duration, number, and frequency of therapeutic sessions as well as the person who delivers the intervention, type of exercises and intervention modality. It was found that MBSR and MBCT require expertise, trainer or supervisor to practice regularly. For DBT, it is suitable for face-to-face therapy.[12] Due to these limitations from previous study, the researchers considered the ACT model as a framework for developing the application. A systematic review and meta-analysis of interventions based on ACT model for stress reduction supported by the results of randomized controlled trials indicated the statistics significant decreasing perception of stress in child and adolescent.[13]

Acceptance and Commitment Therapy (ACT) focuses on developing psychological flexibility in order to create positive thoughts and foster the ability to live in the present without escape or avoidance. It could be achieved by applying 6 important principles including 1) acceptance, 2) cognitive diffusion, 3) being present, 4) awareness of oneself as context (self as context), 5) giving value, and 6) committed action.[14] These principles are suitable as a guideline for helping adolescents manage their stress. This is because the ACT therapeutic processes are simplified to allow persons to become aware of their affects without denying or avoiding it. Individuals realize these thoughts can be transformed into more realistic, rational, and constructive perspectives.[15] This is in line with studies revealing that encouraging adolescents to accept and adjust their perspectives on problems or situations that cause their own stress without avoiding them, could create positive thoughts towards the problems and find methods for relieving the tensions. These can be done by focusing on managing emotions through the use of various strategies such as meditation, muscle relaxation, imagining an atmosphere that brings happiness.[13]

With the advancement of information technology which plays a greater role in daily life, adolescents have quick access to information where smartphones have become a part of their daily lifestyle. Using information technology to help manage stress is one way for coping and preventing mental health problems. Currently, it is found that mobile applications are widely used to help in taking care of adolescents' stress both nationally and internationally. For example, the Department of Mental Health, Ministry of Public Health of Thailand has developed the "Smile Hub" application and the "Mental Health Check Up 6 Packages" application as tools to help citizens assess their stress and screen for risk of initial stress problems.[16] In countries other than Thailand, a systematic search of using mobile health technology in App stores found that of a total of 433 different mobile apps for stress management, most belonged to the "stress relaxation" apps. Based on methodology, only 1.2% fell under "integral methodology" was based on ACT model. Applications like Pacifica, Calm, or SAM based their full program on acceptance and commitment techniques and introduced the user to a self-learning introspection process while at the same time offered tools for the self-management of the stress.[17] However, such applications were developed for working people and chronically ill people. They are not specific to adolescents.

In this present study, the researchers aimed to develop a smartphone application that would help relieve and manage stress by focusing on creating positive thinking by applying the concepts of Acceptance and Commitment Therapy (ACT). The smartphone application would be able to assess and analyze the individual's stress levels, train the individuals to modify their perceptions of stress, and provide emotional relaxation. We developed a smartphone application entitled "Be aware of stress" for Thai adolescents who are at risk of developing mental health problems.

Specifically, in this pilot study, we aimed to 1) develop a smartphone application to promote positive thinking and reduce perceived stress in at-risk adolescents, 2) determine feasibility of using the application in terms of user retention, satisfaction with the use of application, users' acceptance, and the benefits of using the application, and 3) determine the effectiveness of the application on the levels of positive thinking and stress perception levels of at-risk Thai adolescents (i.e., pre-post scores comparisons).

Conceptually the researchers designed the application's functions based on the basic principles of the Acceptance and Commitment Therapy (ACT) postulated by Hayes, stress-related, and smartphone application development. The promotion of positive thinking and stress management by the application was through two important processes. Each process contains three steps to help develop positive thinking and reduce adolescents' perceptions of stress as follows.[14,18,19]

The first process, mindfulness and acceptance, was the development of the ability to consciously live in the present and recognize the reality of the situation that occurs. It was divided into 3 steps as follows. In the first step, **Acceptance**, a training skill named as exposure exercise with self-acceptance without escaping or avoiding, the application had a process to assess stress based on one's own perception and compare it with the one through reliable measurement tools. This would enable adolescents to recognize and accept their own stress realistically. In the second step, **Cognitive diffusion**, a process of observing and distinguishing between thoughts and language processes through self-reflection similar to the theory of cognitive therapy. Activities within this application included using games to practice asking questions

to examine ideas. In addition, using game activities to weigh the truth of ideas allows adolescents to consider the reality of language defined as stress and the meaning that arises from fusing ideas with reality or not and how. The third step, **Being present**, is being aware of the present by knowing oneself according to context (i.e., self as process). This application uses relaxation techniques to develop mindfulness which were obtained from literature reviews, emotional distraction through the use of music therapy, and determining awareness through tree planting games.

The **second process** was related to **commitment and behavior change**. It is a process of developing a way of life which is in line with a person's values and goals. It consists of 3 steps. The first step, **self as context**, is being consciously aware of whether the persons have negative or positive thoughts. The application therefore tracks daily stress-causing thoughts and summarizes the levels of stress. These approaches help keep adolescents abreast of changes in their thinking. The second step, **defining valued dimensions**, is a process of finding thoughts or beliefs that are one's true desires and create a direction and values in life. The application let the users specify events that could make them happy, and their personal motto and goals for the next month. This information appeared every time that the users were registered to use the application to remind them of the determination and intention to act according to the resolution which was linked to the third or final step. In the third step, **committed action**, the process was to take happy values and start to create goals, then plan the action step by step and evaluate the results and specify the methods to reach their goals. Through the two processes, positive thinking could be fostered, and stress could be less perceived. For feasibility of the application, user retention, satisfaction, acceptance, and perceived benefits could be manifested (Figure 1).
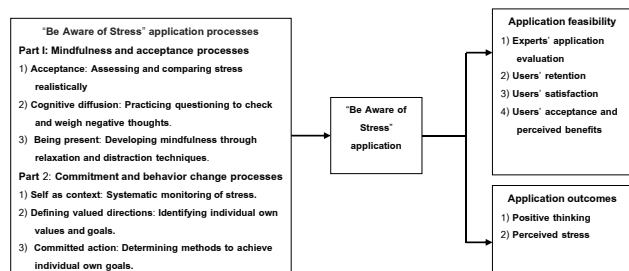

Figure 1 Research conceptual framework.

We hypothesized that scores of positive thinking and perceived stress after the use of the application would increase (one-group pre-post comparisons). For the development aspect, the application would have functions at a good or higher level by the experts and have the possibility of being used in terms of users' retention, satisfaction acceptance and perceived benefits.

Methods

In this pilot study, one group of junior high school students was tested with no control group. For further full experimental study, two groups of junior high school students from the other school were tested (i.e., test and control groups). Results of the full experimental phase will be published elsewhere.

This pilot study was divided into 2 phases. In phase 1 which was the application development, it involved planning, designing, and building the application. The application was examined for its quality by the selected experts. Revisions according to the experts' recommendations were made. In phase 2, feasibility of application's use was determined. The revised application was tested in a group of test users. Effectiveness of the application, i.e., level of positive thinking and perceived stress before and after using the application was determined using a one-group pre-posttest design.

The study population was at-risk adolescents studying at junior high school level of an opportunity expansion school in the eastern part of Thailand. The sample was those in the study population who were selected by purposive sampling based on the eligibility criteria. They had to be 10 - 19 years old, had never been diagnosed with any psychiatric illnesses, and had to be able to read or communicate in Thai language. They had to be at risk of developing mental health problems as indicated by the score of 5 or more of the Department of Mental Health Stress Assessment (ST-5). They had to have their own smartphone running on Android operating system and be willing to voluntarily participate in this study. However, those adolescents whose parents did not consent were excluded. Participants with the following criteria were discontinued: participants who were 1) with a loss of stress monitoring for more than 20% of the study period, 2) unable to be followed up, or 3) with physical or mental disorders that required treatment while participating in the study.

Data collection was performed in December 2023. According to Kieser and Wassmer (1996), it was suggested that a minimum of 10 - 20 participants per arm for feasibility test of an intervention.[20] Furthermore, from the literature review pertinent to specifying the sample size used in pilot study of intervention, 5 - 10 participants per arm are acceptable.[21] Therefore, 10 adolescents were recruited for this one-group pilot study.

Research instruments

The study had instruments for developing the application and collecting data. The application was entitled "**Be aware of stress**." The researcher outlined the basic structure of the application (i.e., platform) and its functions based on the ACT concept for promoting positive thinking and reducing perceived stress. The application was divided into 2 parts and 6 basic principles as follows.

In **Part 1, mindfulness and acceptance process** consisted of 3 basic principles namely the principle of acceptance, the principle of cognitive diffusion, and the principle of being present. For **the principle of acceptance**, the researcher developed the function regarding *"Stress assessment system"* to allow the users to assess and compare their perceived and actual stress. This system contained 2 processes of stress assessment specifically the assessment according to one's own perception and the assessment using a standardized questionnaire.

Based on **the principle of cognitive diffusion**, the researcher developed a working function entitled *"Stress management"* in which the users could practice asking questions to check and weigh their own unrealistic thoughts and find information to support positive thoughts. When users assessed their stress, if they found that there was a high level of stress as indicated in the application system, the application would suggest ways to deal with negative thoughts called "negative thought modification." This included adjusting their perception to positive thinking through a game of examining thoughts by using Socratic questioning and weighing positive and negative thoughts by using the weighing of thoughts game.

In the last principle, i.e., **the principle of being present**, the function entitled *"Stress management"*, was built to help users develop mindfulness through relaxation and emotional distraction techniques. When the user assessed his or her own stress and found that there was a moderate level of stress, the system would recommend various forms of emotional focused coping including imagination therapy, and distraction therapy through games and music therapy.

In **Part 2** of the application with the use of **commitment and behavior change processes**, 3 basic principles were applied namely the principle of being aware of changes, the principle of defining a valuable direction, and the principle of performing commitments. In **the principle of being aware of changes**, with the "self as context" the researcher developed a working function entitled *"Usage setting"* to allow users to systematically track their stress. The users used the function of *"Stress assessment notification"* to set the automatic notification time to learn their current stress levels. The function *"Stress tracking calendar"* was for tracking and summarizing stress frequency at each level in the past week. The presentation in chart form allowed the users to see the trend of their stress levels.

With **the principle of defining a valuable direction**, the function of *"My personal data"* was developed to allow users to identify their own values and goals. This information will appear every time there is a login notification for the daily stress assessment in order to remind the users of their goals or values.

The last principle was **the principle of performing commitments – so called "committed action."** The researcher developed the function of *"My personal data"* to allow users to determine how to lead to their own goals in the next month. When the user evaluated the success of their goals, they could adjust their own suitable methods.

Before entering the application, the users must enter a password code for maintaining security and privacy. However, in the first time for login, the system will require the user to follow steps 1 - 6 to complete the first login. In addition, from the literature review, the researcher developed a function entitled "*My Assistant*" which was a helping system when users assessed their stress and found that they had high levels of stress and the inability to resolve it on their own. The system would guide them and help them connect with the online system of the Department of Mental Health's 1323 Mental Health Hotline, Ministry of Public Health and the consulting experts. The researchers also developed the working function of *"Stress experts (GURU)"* to provide mental health education so called psychoeducation towards

stress and stress management along with a knowledge manual for self-study.

The second set of tools were data collection forms for 1) application usability assessment for the experts and 2) questionnaires collecting demographic characteristics, assessing positive thinking and perceived stress, and satisfaction of the participants.

The experts assessed the usability of the application using the criteria called Guidelines for evaluating the usability of m-Health of the Healthcare Information and Management Systems Society (HIMSS). The criteria consists of 25 items assessing 4 areas specifically **1) system usability** or the overall use towards health application systems (6 items), **2) efficiency** or the speed of application and the completeness of the system in various activities (5 items), **3) effectiveness** which was the accuracy of information, the ease of the application use, and the user interface (7 items), and **4) user satisfaction** or satisfaction with the ability of the application to answer questions, solve problems, or facilitate users in terms of health (7 items). The response was a 5-point Likert-type scale ranging from 1-very low to 5-very high. With the possible average total score of 1 – 5 points, levels of satisfaction were categorized as very low, low, moderate, high, and very high (1.00 – 1.50, 1.51 – 2.50, 2.51 – 3.50, 3.51 – 4.50, and 4.51 – 5.00, respectively). The internal consistency reliability was good with a Cronbach's alpha coefficient of 0.88.[22]

For the **adolescent participants**, demographic characteristics affecting perception of stress in adolescents were collected. These characteristics included age, gender, grade level, congenital diseases, and residential type and the history of substance use in the past 6 months. The demographic characteristics questionnaire and the following questionnaires were self-administered.

Positive thinking was assessed **using the Positive Thinking Test for High School Students** developed by Thepmong.[23] It was initially developed from Ventrella's characteristics of positive thinking persons.[24] It consists of 42 questions covering 6 elements of positive thinking process namely self-confidence, self-control, optimism, earnestness, confrontation with problems and obstacles, open-mindedness and hospitality. The response was on a 5-point rating scale ranging from 1 to 5 points ranging from 1- the least, to 2-low, 3-moderate, 4-a lot of, and 5-the most. With the possible total

scores of 42 - 210 points, levels of positive thinking were categorized as very low, low, moderate, high, and very high ($\leq$ 129, 130 – 151, 152 – 173, 174 – 195, $\geq$ 196 points, respectively). Internal consistency reliability in the past study[23], as well as the present study, was high (Cronbach's alpha coefficients of 0.95[23] and 0.97, respectively).

Perceived stress was assessed using **the Perceived Stress Questionnaire (PSQ)** developed by Levenstein and others.[25] It was translated into Thai by Wicharawat.[26] It consists of 30 questions with 22 and 8 negative and positive statements, respectively. The response was a 4-point Likert-type scale ranging from 1-feeling occurs regularly, to 2-frequently, 3-sometimes, and 4-never for positive statements, and in the reverse order for negative ones. With the possible total scores of 30 - 120 points, levels of perceived stress were categorized as low, moderate and high (30 – 60, 61 – 90, and 91 - 120 points, respectively). Internal consistency reliability in the past study[26], as well as the present study, was high (Cronbach's alpha coefficient of 0.87 for both studies).

Lastly, user **satisfaction with the usability** of mobile applications was assessed using the scale developed by the Healthcare Information and Management Systems Society. The scale was based on the Theory of Acceptance and Use of Technology (UTAUT). The scale was translated into Thai language by Lapponampai and Pamonsinlapatham.[22] It had 4 dimensions including intent to use (7 items), ease of application use (6 items), social influence (6 items), and expectation for technology (6 items). The response was a 5-point Likert-type scale ranging from 1-the least satisfied, to 2-slightly satisfied, 3-moderately satisfied, 4-very satisfied, and 5-the most satisfied. With the possible average total score of 1 – 5 points, levels of satisfaction were categorized as very low, low, moderate, high, and very low (1.00 – 1.50, 1.51 – 2.50, 2.51 – 3.50, 3.51 – 4.50, and 4.51 – 5.00 points, respectively). Internal consistency reliability in the past study[23], as well as the present study, was high (Cronbach's alpha coefficients of 0.86[22] and 0.87, respectively).

Instrument validity

The validity of the application was examined and criticized by 3 experts, specifically a psychiatrist, an information technology specialist and an education/psychology specialist. These experts were asked to check for the correctness and completeness of this application. Improvements according to

the experts' advice were made. The modified application was tested with 10 adolescent participants who met the inclusion criteria to test its feasibility in terms of users' retention, acceptance and perceived benefit and satisfaction with the use of this application. After the trial of application use, the same 10 adolescent participants were asked to participate in a focus group interview to check face validity in terms of its consistency towards needs and purposes of using this application.

Human subject protection

This research was approved by the Burapha University research ethics review board (approval number: HS074/2566/C1, 16 November 2023). The study was permitted by the director of an opportunity expansion school for data collection. In the process of inviting the students to participate, the researchers explained the objectives, study details, risks and benefits and gave an opportunity to ask questions. If the adolescents were willing to participate in this study, the researchers then asked the adolescents and their parents to sign the consent form. They could refuse or withdraw from this study at any time without affecting their studies. Anonymity and confidentiality were also addressed in which only the researchers could access, and analyses of published data was done in an overall manner.

Application development

Literature and research documents relating to the model to develop positive thinking and reduce stress in adolescents were extracted and empirical evidence was analyzed and synthesized for application development. Once the first application was completed, it was examined by 3 experts for validity and accuracy. Modifications were made according to the experts' recommendations.

Application test and data collection

Before the application test, the researcher carried out pre-test on positive thinking and perceived stress. The researchers met the prospective student participants at the study school during the school guidance session, so the regular class hours were not disrupted. The classroom teacher was asked to provide participation information to students who might be interested in participating in this study. The researchers introduced themselves and checked the prospective participants for eligibility. Once eligible, the participants were provided with objectives, process, and voluntary and anonymity nature of the study. The researchers obtained written informed consent and permission from the parents. The participants were instructed to complete the self-administered questionnaire which took about 60 minutes.

The researchers assigned participants to login for the smartphone application every day for the 1-month trial period. The researchers checked the participant's usage from the registration database system namely, registration code and duration of time usage. Once the participants used the application for 4 weeks, the researchers scheduled an appointment for re-assessment on positive thinking and perceived stress. Satisfaction with the application was also obtained using the questionnaire and group interviews with open-ended questions. Suggestions for improving the application were obtained and used for further modification.

Data analysis

The researchers checked whether participants registered for using this application in at least 80% of the trial days. Returned questionnaires were checked for completeness. Descriptive statistics including mean with standard deviation and frequency with percentage were used to summarize demographic characteristics and study variables. Scores of positive thinking and perceived stress before and after the application use were compared using paired t test or Wilcoxon signed rank test, as appropriate.

Results

The researchers developed the application with 6 functions including 1) my personal data, 2) stress tracking calendar, 3) stress management, 4) my assistant, 5) stress guru (experts), and 6) function settings and other platforms related to each function (Figure 2). A manual was also created.

The developed application was then evaluated for its quality by 3 experts. It was found that the overall quality evaluation results were at a good level (mean = 4.41 ± 0.68). For individuals dimensions, system usage, efficiency, effectiveness, and user satisfaction were at good, good, very good, and very good level, respectively (mean = 4.33 ± 0.60, 4.20 ± 1.04, 4.52 ± 0.59, and 4.57 ± 0.49 points, respectively).
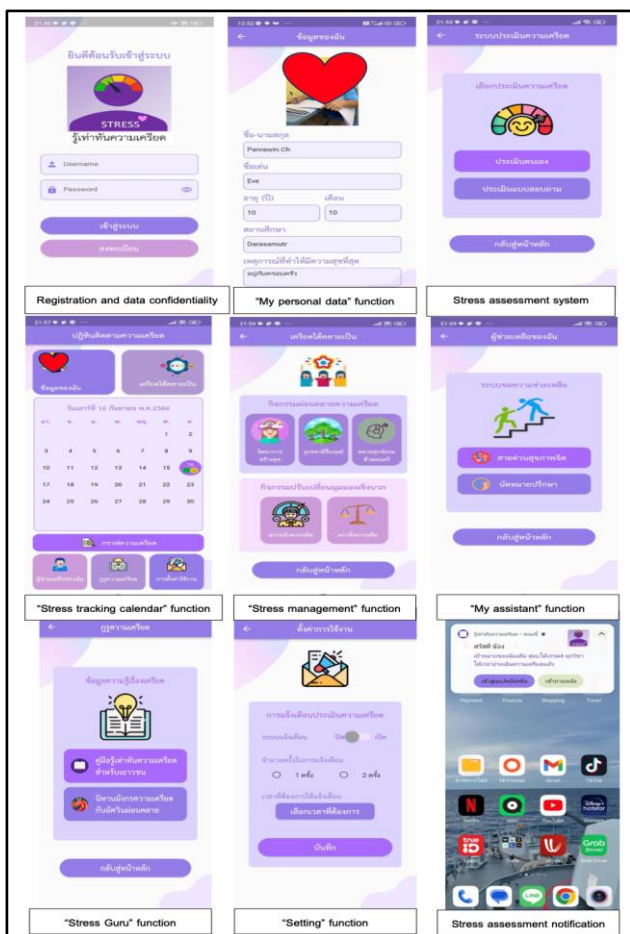
Figure 2 Operating functions in smartphone application "Be Aware of Stress."

Based on the experts' suggestions, the interpretation of results shown in the application should be based on the principles of ACT therapy. In addition, the users should be instructed to review their own thought realistically with no judgement. For modification activities to promote positive changes, they should also be realistic. The experts also recommended that relevant thoughts were best realized at the time of emerging stress with acceptance and no avoidance.

The test in adolescent participants

Of the 10 adolescent participants, the majority was female (90.0%). They were 14 ± 1.05 years old by average. Their education was at grade 9 (40%), followed by grade 7 and 8 (30% equally). Cumulative grade point average (GPA) was in the range of 2.01 - 3.00 (50%), followed by 3.01 - 3.50 (40%). Most reported no congenital diseases (90%), lived with their parents (90%), and had no history of drug use (90%). For those reporting the use of drugs, they used e-cigarettes.

Screening perceived stress for eligibility based on ST-5 assessment was at a high level (mean = 9.80 ± 3.65 points).

For the **feasibility of the application usage**, at the end of the 4th week of the trial, all 10 users (100%) had logged in for at least 80% of the total number of specified trial days. For application **satisfaction**, the participants had a high level of satisfaction (mean = 4.06 ± 0.77 points). Individual aspects of usage satisfaction were as follows. For the **first dimension** of **intent to use**, it was at a high level (mean = 3.91 ± 0.94 points). The users stated that the provided information in the application helps them understand stress and provides them with basic self-care methods for stress relief including the safety in keeping information confidential. For the second dimension, ease of application use, it was at a high level (mean = 4.15 ± 0.75 points). The users stated that the functions in this application are not so complicated because they could follow the users' manual that specify the steps of using in detail. Direct access when receiving notifications makes it convenient and fast.

The **third dimension** of **social influence** was also at a high level (mean = 4.10 ± 0.62 points). The users stated that when their parents learned that the application was being trialed, they supported it because they saw the benefits of the stress-relieving activities and developing positive thinking. In addition, for the usage problems, they could ask for help from the application developers immediately.

The **fourth dimension** of **expectation for technology** was at a high level (mean = 4.07 ± 1.08 points). The users mentioned that they intended to continue using the application and would like to recommend their friends to download the application as well. In addition, the participants also suggested improving application functions by adding a greater variety of games that can be used to relieve stress, adding functions for writing and expressing their feelings. Some users encountered problems in which the application was not stable enough for older smartphones.

For focus group results on users' acceptance and perceived benefits, the users reported that this application was consistent with the users' objectives and needs. This is because the application's functions helped adolescents who were at risk of stress become aware of their own stress levels. It also help the users have appropriate ways to manage their stress according to stress severity. For example, it helped

them review and re-evaluate their thoughts in various aspects in a more positive manner.

Effects of the application on perceived stress and positive thinking

The mean score of **positive thinking** after the application use (154.50 $\pm$ 23.90 points) was significantly higher than that before the use (145.10 $\pm$ 25.48 points) (t_9 = 2.97, P-value = 0.008), with a large effect size (Cohen's of 0.94). For **perceived stress**, mean score after the application use (71.00 $\pm$ 9.06 points) was significantly lower than that before the use (77.90 $\pm$ 9.45 points) (t_9 = 3.98, P-value = 0.002) with a very large effect size (Cohen's d of 1.26).

Discussions and Conclusion

In this one-group pilot study, the smartphone application named "Be Aware of Stress" was found to be feasible and preliminarily beneficial for Thai adolescents at risk of mental health problems. The Theory of Acceptance and Use of Technology (UTAUT) mentioned that the user retention rates can reflect user feasibility.[27] This conclusion was supported by the information from application database user tracking. It was found all participants (100%) used the application every day. However, 82.47% of them logged in exactly at the scheduled notification time; while the rest (17.53%) did not.

Smartphones are serving as communication devices that are essential in daily life with various functions and applications. It also facilitates searching for information for learning and solving problems. In line with a study on smartphone usage behaviors among Thai adolescents, smartphone usage behavior patterns were classified according to 7 purposes of use namely communication, entertainment, data searching, social network, emergency, education and facility.[28] Smartphones for searching for health information and facilitating health care of importance.[28] Since the application was based on Android operating system, it offered advantages. As high as 70.74% of Thai smartphone users used Android-based phones with an increase of 1.2% from 2021.[29] A wide variety of Android-based smartphones offered a wide range of cost. Using applications towards health and fitness is ranked 7th out of the 10th most popular downloads on google store, both with and without fee.[29]

Based on the Technology Acceptance Model (TAM), the ability to respond to users' needs affects the perception of usefulness and maintenance of continuous usage behavior.[30] This application served the demand of mental health service very well. The users' satisfaction with the application was at a high level indicating that the functions contained in this application were able to serve the users' needs in increasing positive thinking and reducing perceived stress. For example, "stress management" function provided the users a way to manage their stress according to the stress severity. As a result, there was a positive attitude towards the use as well as the continuous access. From the qualitative data from the group discussions, the users would continue to use this application even after the trial period and recommend their peers to use it. Applications built with an effective framework such as ours will make users aware of their benefits and be satisfied with the use. In the study of Li and colleagues, 44 applications have been developed to reduce stress, anxiety, and promote stress management during the COVID-19 outbreak based on stress relaxation model. The results showed that the users had good satisfaction with average score of 3.66 (SD = 0.47).[31]

The application offered improvement in perceived stress and positive thinking. This application was driven by the six core principles of ACT model namely acceptance, cognitive diffusion, being present, self as context, values, and committed action to increase psychological flexibility. These principles enhance a person's ability to be fully present in the moment and to change or maintain the behavior, and ultimately to be a conscious human being.[18]

From our results, the application users had an increase in the mean scores of positive thinking (P-value = 0.008) and a decrease in those of perceived stress (P-value = 0.002). These supported the preliminary effectiveness of the application in accordance with ACT model which deserves further full experiment.

This application helped promote positive thinking and reduce perceived stress possibly through acceptance. Specifically, ones acknowledge that such stress occurs every day in the sense of "allowing it to happen and not resisting, avoiding or trying to control it." Hence, ones gradually let their thoughts and feelings about the stress that arise gradually subside. It could also help separate ideas by giving adolescents a new understanding that "Thoughts are just words or stories that occur within the mind, may or may not be true." Through such understanding, a person can observe

those thoughts without necessarily believing or responding to them and emerging with a new perspective on thoughts that cause stress. Furthermore, this application contains the participants' own paths and encourages them to carry out their commitments with determination, dedication and hope, and never give up in the face of problems. Our findings are consistent with a systematic literature review and meta-analysis which found that eight studies with 976 participants revealed significant small main effect (Hedges' g: -0.20; 95% confidence interval: -0.36, -0.05]), indicating that the interventions based on ACT resulted in greater reduction of stress in adolescent compared to control conditions.[13] In our study, positive thinking and perceived stress were found to have large and very effect sizes, respectively (Cohen's of 0.94 and 1.26, respectively). Even with a small sample size, this could suggest that the application could have a sizable benefit for adolescents.

Moreover, the working functions contained in this application also helped reduce perceived stress. This could be done through applying strategies to distract from the stressful situation using various activities such as imagination therapy and music therapy. This cultivated being mindful or being in the moment for the adolescents towards the present. The adolescents used self as context by acknowledging but not getting overwhelmed by the problematic thoughts and feelings. This would in turn help reduce stress.[11] Our conducts and findings are consistent with the study by Hwang and Jo who developed a stress management program entitled "Mobile App-Based Stress-Management Program."[32] They developed the program based on a literature review regarding activities that help reduce and alleviate stress, including music focused on healing, meditation, management training. breathing methods and yoga interventions. After the 4-week trial, 26 participants had a significant decrease in their perceived stress scores (P-value = 0.035).[32] The study of Coelhoso and others developed an application called "The well-being mobile application" based on the concept of managing psychological stress by using relaxation training, breathing techniques, meditation, and positive psychology by practicing positive self-talk.[33] The outcomes among 250 working-age women were measured before, and at 4 and 8 weeks after the intervention. Participants had decreased perceived stress scores ($F_{2,426}$ = 5.50; P-value = 0.004).[33]

Another important therapeutic effect of this application is that it contributed to knowledge development relevant to stress. This would help reduce the level of stress as perceived by adolescents. A psycho-educational program is one of the strategies to facilitate individuals' adjustment and manage stress. A psycho-educational program is formed in a way individual resources and skills are reinforced so that these persons cope with their difficulties better.[34] The study of Weber, Lorenz and Hemmings who developed an application for providing psychoeducation in promoting mental health aimed at reducing stress.[35] It contains health information related to the principles of healthy sleep, and the principles of time management, building relationships with others, creative communication, working happily and positive thinking. After 6 weeks of program participation, 532 participants had a statistically significant decrease in their perceived stress with P-value < 0.05.[35]

This study has certain limitations. We only investigated the adolescents who were at risk of developing mental health problems caused by stress. Therefore, the study results may not be generalized to those adolescents who had mental illness. As a pilot study with a small sample size, confidence in the results could be relatively limited. There is a need for further developing and testing its effectiveness of the applications for adolescents with mental disorder or combined with face-to-face intervention as well as other operating systems apart from Android systems are also recommended.

For medical service, the application could be an alternative service model for medical facilities and educational institutions to promote self-care of adolescents' mental health by enhancing knowledge, positive attitude, and self-efficacy regarding to stress management. It could also be used to monitor the severity of mental health problem from stress.

It is recommended that more rigorous experimental research should be conducted to confirm the effectiveness of this kind of application using a larger sample size and including a comparison group. Tracking the users' level of positive thinking and perceived stress after long term use of this application is also recommended.

In conclusion, the results obtained from this study affirmed that the smartphone application "Be Aware of Stress" based on Acceptance and Commitment Therapy (ACT)" was feasible and preliminarily effective. It increased positive thinking and reduced perceived stress among adolescents who were at risk

of developing mental health problems caused by stress. Further verification and enhancing applications' functions that meet the needs of the users, adolescents in particular, is recommended.

References

1. Mancini GF, Meijer OC, Campolongo P. Stress in adolescence as a first hit in stress-related disease development: Timing and context are crucial. Front Neuroendocrinol 2023;69:101065. (doi: 10.1016/j.yfrne.2023.101065)

2. Mousikou M, Kyriakou A, Skordis N. Stress and growth in children and adolescents. Horm Res Paediatr 2023;96(1):25-33. (doi: 10.1159/000521074)

3. Krapić N, Hudek KJ, Kardum I. Stress in adolescence: Effects on development. In: Wright DJ (ed.). Stress in adolescence: Effects on Development. 2nd ed. Oxford. International Encyclopedia of the Social & Behavioral Sciences, 2015. (doi: 10.1016/B978-0-08-097086-8.23031-6)

4. Chaniang S, Klongdee K, Jompaeng Y. Suicide prevention: A qualitative study with Thai secondary school students. Belitung Nurs J 2022;8(1):60-66. (doi: 10.33546/bnj.1746)

5. Vichianchai V, Kasemvilas S. Discovery of intentional self-harm patterns from suicide and self-harm surveillance reports. Healthc Inform Res 2022;28(4):319-331. (doi: 10.4258/hir.2022.28.4.319)

6. Lazarus RS, Folkman S. Transactional theory and research on emotions and coping. Eur J Pers 1987;1(3):141-169. (doi. org/10.1002/per.2410010304)

7. Beck JS, Fleming S. A brief history of Aaron T. Beck, MD, and cognitive behavior therapy. Clin Psychol Eur 2021;3(2):e6701. (doi: 10.32872/cpe.6701)

8. Naseem Z, Ruhi K. Positive thinking in coping with stress and health outcomes: Literature review. J Res Reflect Educ 2010;4(1):42-61.

9. Malinowska-Cieślik M, Mazur J, Nałęcz H, Małkowska-Szkutnik A. Social and behavioral predictors of adolescents' positive attitude towards life and self. Int J Environ Res Public Health 2019;16(22):4404. (doi: 10.3390/ijerph16224404)

10. Caprara GV, Steca P, Gerbino M, Pacielloi M, Vecchio GM. Looking for adolescents' well-being: self-efficacy beliefs as determinants of positive thinking and happiness. Epidemiol Psichiatr Soc 2006;15(1):30-43. (doi: 10.1017/s1121189x00002013)

11. Hofmann SG, Gómez AF. Mindfulness-based interventions for anxiety and depression. Psychiatr Clin North Am 2017;40(4):739-749. (doi: 10.1016/j.psc.2017.08.008)

12. Porter B, Oyanadel C, Sáez-Delgado F, Andaur A, Peñate W. Systematic review of mindfulness-based interventions in child-adolescent population: A developmental perspective. Eur J Investig Health Psychol Educ 2022;12(8):1220-1243. (doi: 10.3390/ejihpe12080085)

13. Binder F, Mehl R, Resch F, Kaess M, Koenig J. Interventions based on acceptance and commitment therapy for stress reduction in children and adolescents: A systematic review and meta-analysis of randomized controlled trials. Psychopathology 2023;21:1-17. (doi: 10.1159/000535048)

14. Hayes SC, Levin ME, Plumb-Vilardaga J, Villatte JL, Pistorello J. Acceptance and commitment therapy and contextual behavioral science: examining the progress of a distinctive model of behavioral and cognitive therapy. Behav Ther 2013;44(2):180-98. (doi: 10.1016/j.beth.2009.08.002)

15. Coyne LW, McHugh L, Martinez ER. Acceptance and commitment therapy (ACT): advances and applications with children, adolescents, and families. Child Adolesc Psychiatr Clin N Am 2011;20(2):379-399. (doi: 10.1016/j.chc.2011.01.010)

16. Department of Mental Health. Public mental health for human dignity, newsletter. Thailand. Nonthaburi, 2016. (in Thai)

17. Blázquez Martín D, De La Torre I, Garcia-Zapirain B, Lopez-Coronado M, Rodrigues J. Managing and controlling stress using mHealth: Systematic search in App Stores. JMIR Mhealth Uhealth 2018;6(5):e111. (doi: 10.2196/mhealth.8866)

18. Hayes SC. Acceptance and commitment therapy, relational frame theory, and the third wave of behavioral and cognitive therapies - republished article. Behav Ther 2016;47(6):869-885. (doi: 10.1016/j.beth.2016.11.006)

19. Anagnostou M, Drigas A. Mobile applications for stress management. Sci Electron Arch 2022;15(2):58-63. (doi: doi.org/10.36560/15220221507)

20. Kieser M, Wassmer G. On the use of the upper confidence limit for the variance from a pilot sample for sample size determination. Biometr J 1996;38(8):941–949. (doi: doi.org/10.1002/bimj.4710380806)

21. Totton N, Lin J, Julious S, Chowdhury M, Brand A. A review of sample sizes for UK pilot and feasibility studies on the ISRCTN registry from 2013 to 2020. Pilot Feasibil Stud 2023;9(1):188. (doi: 10.1186/s40814-023-01416-w)

22. Lapponampai W, Pamonsinlapatham P. Application program for Anti-HIV drug self-management on android smartphone. Thai J Sci Technol 2018;27(4): 738-750. (in Thai)

23. Thepmong M, Prachanban P. A construction of positive thinking test for high school students. J Educ Innov 2020;24(1):226-235. (in Thai)

24. Ventrella S. The power of positive thinking in business. 2001. (Accessed on Apr. 22, 2023, at https://www.perlego.com/book/780921/the-power-of-positive-thinking-in-business-ten-traits-for-maximum-results-pdf)

25. Levenstein S, Prantera C, Varvo V, et al. Development of the perceived stress questionnaire: A new tool for psychosomatic research. J Psychosom Res 1993;37(1):19-32. (doi: 10.1016/0022-3999(93)90120-5)

26. Wachirawat W, Hanucharurnkul S, Suriyawongpaisal P, et al. Stress, but not Helicobacter pylori, is associated with peptic ulcer disease in a Thai population. J Med Assoc Thai 2003; 86(7):672-685.

27. Liu Y, Lu X, Zhao G, Li C, Shi J. Adoption of mobile health services using the unified theory of acceptance and use of technology model: Self-efficacy and privacy concerns. Front Psychol 2022;13:944976. (doi: 10.3389/fpsyg.2022.944976)

28. Faculty of Science, Khon Kaen University. Behavior and factors of smartphone usage among adolescents. 2024. (Accessed on Jan. 9, 2024, at https://sc2.kku.ac.th/stat/statweb/images/Eventpic/60/Seminar/01_6_.pdf) (in Thai)

29. Digital Government Development Agency. Six government health care applications in mobile phones. 2022. (Accessed on Oct. 30, 2022, at https://www.dga.or.th/document-sharing/infographic/49470) (in Thai)

30. Al-Adwan AS, Li N, Al-Adwan A, Abbasi GA, Albelbisi NA, Habibi A. Extending the technology acceptance model (TAM) to predict university students' intentions to use metaverse-based learning platforms. Educ Inf Technol (Dordr) 2023:1-33. (doi: 10.1007/s10639-023-11816-3)

31. Li LSE, Wong LL, Yap KY. Quality evaluation of stress, anxiety and depression apps for COVID-19. J Affect Disord Rep 2021;6:100255. (doi: 10.1016/j.jadr.2021.100255)

32. Hwang WJ, Jo HH. Evaluation of the effectiveness of mobile app-based stress-management program: A randomized controlled trial. Int J Environ Res Public Health 2019;16(21):4270. (doi: 10.3390/ijerph16214270)

33. Coelhoso CC, Tobo PR, Lacerda SS, et al. A new mental health mobile app for well-being and stress reduction in working women: Randomized controlled trial. J Med Internet Res 2019;21(11):e14269. (doi: 10.2196/14269)

34. Hassan Bani Ahmad T, Meric M, Ayasrah M. The effect of psychoeducational stress management interventions on students stress reduction: Systematic review. Educ Cult Psychol Stud J 2022;25:41-57. (doi: 10.7358/ecps-2022-025)

35. Weber S, Lorenz C, Hemmings N. Improving stress and positive mental health at work via an app-based intervention: A large-scale multi-center randomized control trial. Front Psychol 2019;10:2745. (doi: 10.3389/fpsyg.2019.02745)