Adolescent Self-reflection Process through Self-recording on Multiple Health Metrics: Qualitative Study

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Abstract

Background: Self-recording is an effective behavior change technology which has long been used in diverse health contexts. Recent technological advancements have broadened its applications. While previous studies have explored its role and benefits in enhancing self-awareness and informed decision-making, relatively little attention has been given to its potential in addressing the multidimensional nature of health with various health metrics.

Objective: Our study investigates the process of self-recording in adolescent health, recognizing the connections between lifestyle behaviors and mental health. Specifically, we aim to incorporate both behavioral and emotional health metrics into the self-recording process. Grounded in self-regulation theory, we explore how adolescents record lifestyle behaviors and emotions, and how they inform and implement health management strategies.

Methods: We conducted a qualitative study using grounded theory methodology. Data were collected through individual semi-structured interviews with 17 adolescents, who recorded their emotions and behaviors over four weeks using a prototype application. Analysis followed iterative phases of coding, constant comparison, and theme saturation. This process revealed how adolescents engage in self-recording for behaviors and emotions, as well as their failures and potential system support strategies. We further examined the relevance of the identified themes to theoretical constructs in self-regulation theory.

Results: Under self-regulation theory, we gained insights into how adolescents manage their health through self-recording. Findings suggested variability in the self-recording process, in relation to specific health metrics of lifestyle behaviors and emotions. Adolescents focused on evaluating behaviors for management purposes, while exploring the causes underlying emotional experiences. Throughout the health management, which involved modifying behavior or distancing from triggering factors, they monitored progress and outcomes, demonstrating a self-experimental approach. Uncertainty emerged as a barrier throughout the self-regulation process, suggesting that self-recording systems for adolescents should prioritize strategies to address these uncertainties. Additionally, the self-recording system demonstrated interventional effects in aiding future planning and fostering a sense of relatedness among users.

Conclusions: This study offers a theoretical framework for adolescents' self-recording process on diverse health metrics. By integrating self-regulation theory, we suggest the stepwise process from recording lifestyle behaviors and emotions to health management behaviors. Through exploring potential features and health-supportive effects, our findings contribute to the development of digital self-recording systems that address various health metrics in adolescent health.

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Trial Registration:

Keywords: self-recording; self-tracking; self-regulation; personal informatics; adolescent; digital health; qualitative study; grounded theory;

Introduction

Self-recording has long been practiced in health domain, and recent technological advancements have expanded its applications (1-3). Engaging in self-recording and reviewing the recorded data can substantially enhance health by fostering self-awareness and guiding decision-making through

reflection (4-7). While existing studies often narrow their focus to specific diseases or behaviors, it's essential to view health as a holistic outcome. Lifestyle behavior problems frequently overlap, and mental health closely correlates with these behaviors (8-10) For the self-recording process to be fully effective, it is crucial to recognize these relationships and integrate diverse health metrics (11-13).

As the importance of considering the multifaceted characteristics of an individual's health has gained attention, a few studies have explored visual presentation for various health indicators. In the field of human-computer interaction, researchers have focused on designing effective ways for users to engage with their self-recorded health data (15-18). For instance, one study involved presenting data in a narrative format, making it easier for individuals to understand and relate to their health information (11). Another study explored methods to convey and comprehend correlations between different sleep-related health metrics by applying visual cues (19).

These studies are meaningful as they reveal the necessity of differentiated approach to the various metrics that constitute health. Moreover, they suggest practical ways for individuals to engage with and interpret health data. However, focus of these insights lies on the outcomes, despite self-recording being characterized by the concurrent data collection and reflection, thereby necessitating a comprehensive discussion of the process as a whole [14, 54]. Specifically, it is crucial to understand how multifaceted health metrics are constructed through self-recording and to explore the unique experiences of success and failure, as well as the strategies employed to overcome these challenges [55].

To address this gap, our study aims to observe self-recording patterns for emotional and behavioral aspects of health. We will explore how individuals record these indicators, extract insights, and implement health behaviors accordingly. Furthermore, we will identify factors that facilitate or hinder this process and explore system features that support self-recording for multifaceted health indicators. To ensure our qualitative findings are grounded in evidence-based understandings, we introduce the concept of self-regulation theory (20). This theory emphasizes self-improvement rooted in self-awareness, providing a robust framework for interpreting our findings.

Self-regulation Theory Framework

Self-regulation refers to the ability to manage thoughts, emotions, and behaviors to navigate toward desired goals, which supports positive health behaviors (21). Given this study's focus on self-recordings, we've chosen self-regulation theory developed by Zimmerman for its structured framework of goal-setting through reflection and subsequent performances (20). Zimmerman's self-regulation theory is a comprehensive framework that covers how individuals control their own learning and behavior through a cyclical model encompassing three phases: forethought, performance, and self-reflection.

In the forethought phase, learners engage in task analysis by setting specific goals and planning strategic approaches to achieve them. This phase is characterized by self-motivation beliefs, including self-efficacy, outcome expectations, intrinsic interest, and goal orientation. During the performance phase, learners employ self-control strategies such as self-instruction, imagery, attention focusing, and time management to maintain concentration and motivation. Simultaneously, they practice self-observation, systematically monitoring their performance and recording their progress to ensure alignment with their goals [20, 22, 23].

The self-reflection phase involves self-judgment, where learners critically evaluate their performance by comparing it against their predefined goals and standards, and engage in causal attribution to discern the reasons behind their successes or failures [20, 24]. Following this, self-reaction occurs,

where learners experience emotional responses such as satisfaction or dissatisfaction, and make adaptive inferences to refine their strategies and goals. Positive outcomes lead to enhanced self-efficacy and further motivation, while negative outcomes prompt re-evaluation and adjustment of strategies to better align with future goals.

This continuous feedback loop ensures that each phase informs and improves the others, enabling a dynamic process of learning and self-improvement. By organizing our study around the phases of self-regulation and their associated constructs, we anticipate to investigate the dynamics of adolescents' perceptions and behaviors during self-recording. Our aim is to analyze and gain deeper insights into specific processes leading to the benefits of self-recording, aligning with a series of phases outlined in the theory.

Adolescent Health and Self-recording

Self-recording provides health benefits by increasing awareness of emotions and behaviors, which is often applied as an important therapeutic step across various clinical domains (25, 26, 51). As smartphones become more integrated into daily life, many adolescents already use mobile applications to monitor and improve their health (27-29). Leveraging these technologies, researches on digital self-recording systems have shown that adolescents readily engage with the technology and exhibit high compliance (30-31, 47).

Adolescence is an important developmental stage characterized by cognitive, physical, psychosocial, and emotional growth (32). This stage serves as a transition from childhood to adulthood, yet it is also a fragile period often involving exposure to stressful life events that can lead to decreased well-being and impaired mental health (33). With the significance of early intervention in addressing mental health challenges, particularly as adolescents develop coping mechanisms for daily stressors and negative emotions, researches have demonstrated the efficacy of digital self-recording in emotional well-being (34-36, 52, 53).

In a case study, self-recording system increased positive mood and coping strategies in the adult population under stress (37). Participants reported heightened emotional self-awareness and were able to internalize therapeutic strategies. Similarly, a randomized control trial examined the relationship between self-recording and depressive symptoms in adolescents (38). Through self-recording, adolescents learned to identify and differentiate emotions within different contexts, effectively communicate emotions to others, and make informed decisions (38, 39).

Behavioral patterns set during adolescence can significantly influence their health and increase the risk for developing chronic diseases in adulthood (10, 40). Addressing these behaviors is crucial, as they often co-occur and emerge during adolescence (8, 42-44). Evidence suggests that digital self-recording can also benefit physical health (21). A study on overweight or obese adolescents revealed clinically significant weight loss achieved through a diet self-recording program (45). A meta-review study highlighted that behavior change techniques involving self-recording can decrease sedentary behavior and increase moderate to vigorous physical activity (46, 49).

As outlined above, the use of digital self-recording systems has shown promise in enhancing emotional self-awareness, coping strategies, and overall health behaviors. This study aims to implement digital self-recording system and closely examine the entire process as adolescents engage in self-recording of emotions and daily behaviors over a period of four weeks.

Methods

Participants

A total of 17 adolescents, aged 12 to 18, participated in this study, comprising three males and 14 females. Eligibility criteria included attending secondary or higher education in Korea and having no issues using mobile phones. Researchers explained the purpose and procedure of the study and obtained written consent from those who agreed to participate. The study was approved by the Yonsei University Institutional Review Board and all participants received compensation of 100,000 KRW upon completion.

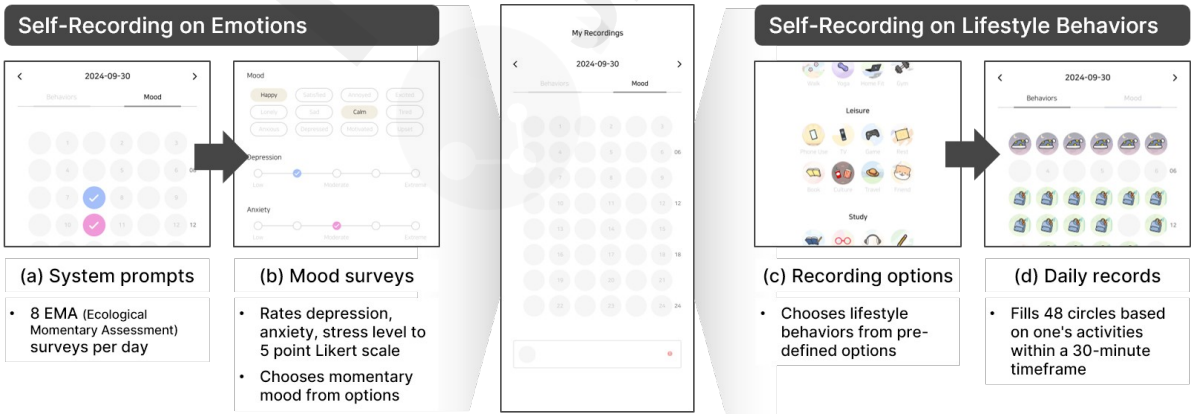
Study Design

Participants were instructed to record their emotions and daily activities over four weeks using an application prototype. This application served as a data platform designed to collect digital phenotypes. Passive digital phenotypes were collected through device sensors where the application was installed, while active digital phenotypes were gathered from the voluntary records provided by the participants. After the use, the participants took part in a semi-structured interview lasting approximately 60 minutes to share their experiences with the application.

Emotion recording employed the Ecological Momentary Assessment method, which captures the real-time emotional experiences [41, 50]. The application prompted participants with a questionnaire distributed up to eight times a day, covering inquiries about mood disorders such as depression, anxiety, and stress, with an assessment of overall mood. Mood disorders were rated on a 5-point Likert scale, where higher scores indicated more severe emotional distress. Additionally, participants assessed their overall mood by selecting from adjective options such as 'happy,' 'sad,' and 'angry.'

Simultaneously, participants logged their daily activities at 30-minute intervals using the same application. To ensure consistency in data collection and analysis, we offered predefined options which were verified to adequately reflect various aspects of adolescent life. The application featured a daily recording screen with 48 circles, each representing a 30-minute time slot. Upon clicking a circle, adolescents were presented with predefined options categorized under the major heading of sleep, exercise, study, and leisure, with sub-categories like 'nap,' 'smartphone use,' and 'self-study.'

Figure 1. Process of self-recording on the application prototype



Data Collection and Analysis

Data collection and analysis followed a systematic, iterative, and concurrent approach, as suggested by Charmaz (48). Data were gathered through individual semi-structured interviews conducted via

video conferencing services or by telephone, with recordings immediately transcribed for analysis.

In the first step of open coding, segments of the transcripts were coded into categories until these categories accounted for all variations in the data. Subsequently, selective coding was undertaken to identify relationships between the categories. Finally, axial coding aimed to identify core categories and organize them into broader themes.

After capturing important themes related to our research questions on the journey of self-recording emotions and lifestyle behaviors, we mapped these themes to the theoretical taxonomy of self-regulation theory. The categories within each theme were compared to descriptions of theoretical constructs to determine their relevance.

Results

Process of Self-recording on Emotions and Behaviors

Our study aimed to develop an understanding of the self-recording process that arose while interacting with a multi-dimensional health data. Results revealed stepwise behaviors stemming from self-recording, with significant differences observed between lifestyle behaviors and emotions. Based on the three phases and constructs of the self-regulation theory, the research results are summarized as follows.

Figure 2. Summary of the self-recording process on emotions and behaviors

Self-reflection Phase

The self-reflection phase consisted of two key components: perception and evaluation. Perception entailed acknowledging factual data, while evaluation involved transforming it into meaningful information. Adolescents gained perception regarding emotions and lifestyle behaviors through either self-recording or reviewing records. Subsequently, they evaluated these perceived aspects based on personal criteria.

Regarding their behaviors, adolescents mainly perceived the type of behavior they engaged in, its frequency, duration, and the specific timestamps on which they performed the daily activities. By synthesizing these data points, they identified recurring lifestyle behavior patterns and evaluated whether these behaviors aligned with their ideals or universally recommended standards.

In terms of emotions, adolescents primarily perceived the emotional valence and intensity by reviewing their records. Unlike lifestyle behaviors, which focused on appropriateness, the evaluation of emotions centered on understanding the underlying causes. Adolescents placed greater importance on unraveling the reasons behind their psychological struggles rather than determining their

acceptability.

During the process of identifying these causes, adolescents identified the causality between life and emotion by integrating information acquired through a series of perception and evaluation processes. If the information obtained from emotional records was insufficient to pinpoint the cause, adolescents turned to additional sources, such as their recorded lifestyle behaviors.

They would reflect on their behaviors and circumstances surrounding the emotional episodes to gain deeper understanding of what may have contributed to their emotional distress. In cases where these sources did not provide clarity, adolescents sought external information, such as recent events or experiences, to help contextualize their emotional experiences and identify potential triggers.

Forethought Phase

In the forethought phase, adolescents established goals and behavioral strategies to address emotional and behavioral problems identified from prior self-reflection. They noted that emotional disorders not only cause discomfort but also adversely impact behaviors, thereby necessitating resolution. Hence, their overarching goal was to alleviate high levels of depression, anxiety, and stress, with sub-goals and specific behavioral strategies varying based on the factors influencing these mood disorders.

When adolescents identified life behavior issues like irregular sleep, excessive media use, or insufficient leisure as triggers for emotional disorders, they took proactive steps to address these behaviors. Here, the criteria used to evaluate behaviors during the self-reflection phase served as the ideal point to be reached, guiding adolescents' goal-setting process. Subsequent strategic planning focused on reinforcing positive lifestyle behaviors while modifying or eliminating negative ones.

Emotional disorders sometimes originated from factors beyond life behavior, such as external circumstances. In such instances, where adolescents had limited control over the cause, their goal shifted to alleviating the influence of these factors on their emotions. Specific strategies included distancing themselves from influential individuals or situations, engaging in activities aimed at positively altering their emotions, and creating environments conducive to better emotional experiences.

Performance Phase

In the performance phase, adolescents pursued their previously established goals and plans. When emotional disorders were linked to lifestyle behaviors, their strategies focused on changing them. Conversely, if emotional disorders were triggered by external factors, such as interpersonal conflicts or stressful situations, adolescents aimed to mitigate the impact by distancing themselves from the causes or counteracting negative emotions with positive ones.

In both scenarios, adolescents recalled and implemented their goals and strategies. Some managed this mentally, continuously reflecting on their objectives and progress. Others employed more structured approaches, documenting their plans and tracking their progress with tools like planners and notes. This documentation provided a tangible reminder of their commitments and a clear framework for their actions.

This implementation was followed by the cycle of self-monitoring and adjustment, which enabled adolescents to stay focused and adapt their strategies as needed. Specifically, when modifying lifestyle behaviors, adolescents assessed whether their actions led to actual improvements. In cases where they directly addressed the emotional states, they evaluated whether their strategies

successfully induced positive emotions or reduced negative ones.

If their actions did not produce the expected effects, adolescents iteratively adjusted their plans to identify effective actions to achieve desired outcomes. This trial-and-error process, also termed as self-experimentation, involves testing, reinforcing, or revising plans based on their outcomes. This approach allowed adolescents to continually refine their strategies, optimizing their management of both lifestyle behaviors and emotional well-being.

Table 1. Findings on self-recording process and relevant theoretical constructs

Self-regulation theory		Interview findings
Phase	Constructs	Descriptions
Self-reflection		
	Self-evaluation	Lifestyle behaviors were assessed for appropriateness
		Emotions were examined for underlying triggers
	Causal attribution	Behavioral and emotional data were integrated to contextualize emotions
	Self-reaction	Outcomes for health management effort were evaluated post performance
Forethought		
	Goal setting	Lifestyle behaviors were managed through behavior modification
		Controllable causes were addressed through behavior execution
		Uncontrollable causes were mitigated to reduce their impact
	Strategic planning	Positive behaviors were reinforced, and negative behaviors were adjusted
		Positive emotions were amplified, and negative emotions were neutralized
	Self-efficacy	Emotional triggers were assessed for controllability
Performance		
	Task Strategies	Actions leading to positive emotions were consistently pursued.
		Steps to avoid triggers for negative emotions were deliberately taken.
	Self-recording	Progress were recorded either mentally or manually
	Metacognitive monitoring	Goals and strategies were revised based on improvements

Identified Barriers in Self-recording Process

Despite the findings align with previous studies and theories, not all participants successfully engaged in the process of self-regulation. While some adolescents effectively reflected on their emotions and behaviors through self-recording, set and pursued health management goals, and reflected on the outcomes, others partially or entirely failed in the process. The factors contributing to these failures were analyzed as follows, with the overarching theme of 'uncertainty.'

Uncertainties in Self-reflection Phase

During the phase of self-reflection, where adolescents perceive and evaluate their emotions and lifestyle behaviors, distinct uncertainties emerged. Regarding lifestyle behaviors, uncertainty arose from unclear evaluation criteria. Adolescents often struggled to assess the appropriateness of their behaviors when faced with ambiguous standards. Without objective criteria, such as socio-culturally accepted norms or clear personal goals, the assessment became challenging, significantly impeding their transition to the next phase of self-regulation.

Another uncertainty was about the causes of emotions. Adolescents often failed to accurately identify or misidentified the causes of their emotions. Compounded with the psychological instability of adolescence, pinpointing the reasons behind emotional triggers was particularly difficult, hindering effective emotional issues resolution. For example, an adolescent stressed from lack of sleep might incorrectly focus on securing enough sleep while overlooking the underlying issue of late-night smartphone use, thereby failing to resolve the emotional problem.

Uncertainties in Forethought Phase

The forethought phase presented challenges regarding the uncertainty in task setting. Adolescents struggled to determine which specific aspects of their behavior or circumstances needed alteration to improve their emotional well-being. This uncertainty about what to change led to indecisiveness and a lack of direction in their goal-setting and planning efforts. Moreover, they frequently lacked the necessary resources—emotional, cognitive, or environmental—to devise potential changes in their lifestyle behaviors, leading some to abandon planning altogether.

There was also uncertainty about outcome expectations. The unpredictability of outcomes often made adolescents hesitant to set goals to manage their emotional problems. They noted that if their efforts did not lead to improvements, it would confirm their insecurities. Fronted with this uncertainty, they often relied on instant, verified means of emotional management, such as gaming, phone use, or sleeping. Although they expressed a desire to engage in other activities, they feared that exploring new methods would take too long, ultimately wasting their time and effort.

Uncertainties in Performance Phase

In the performance phase, there was uncertainty in the process. Adolescents sought external acknowledgment and validation to reassure themselves of following the correct steps in managing their emotions. This external validation acted as positive reinforcement, encouraging persistence even when immediate results were not apparent. Without this reinforcement, many adolescents lost motivation. Some reported to have experienced a chain reaction of demotivation occurring if one person stops updating progress.

Furthermore, we could observe uncertainty about the effectiveness. Adolescents required tangible evidence that their efforts were yielding expected changes. Doubts about abilities and strategy arose when significant improvements were not observed, making it difficult to sustain participation in problem-solving strategies. While self-tracking provided some benefits, if the tracking results mainly highlighted failures, their self-efficacy diminished, leading them to give up on making further efforts altogether.

Table 2. Findings on self-recording barriers, explanations, and relevant theoretical constructs

Phase	Uncertainty	Explanation	Constructs
Self-reflection			

	Uncertainty in evaluation	Lacks a personal sense of direction Lacks external criteria for evaluation	Self-evaluation
	Uncertainty about causes	Struggles to identify emotional triggers Misidentifies emotional triggers	Causal attribution
Forethought			
	Uncertainty in strategies	Unsure about necessary adjustments Struggles to devise practical changes in routine	Goal setting Strategic planning
	Uncertainty about expected outcomes	Finds it challenging to anticipate outcomes Reluctant to experiment with new approaches	Self-efficacy Outcome expectations
Performance			
	Uncertainty in progress	Finds it difficult to recognize ongoing behaviors	Self-Instruction Imagery
	Uncertainty in improvements	Struggles to be aware of own emotions Repeated failures reduce motivation	Metacognitive monitoring

Design Implications for Self-recording System

Based on the observations of the study participants' self-recording processes, we identified design implications for system features aimed at reducing uncertainties and thereby preventing failures. During the analysis, participants were divided into two groups according to their success and failures in self-regulation. For adolescents who successfully self-regulated, we focused on inferring the cognitive processes and strategies they employed to succeed. Conversely, for those who failed, we investigated the reasons behind their failures and their expectations towards the system.

Design Implication 1: Introducing Unaware Self

To reduce uncertainty in self-reflection, it was essential to help adolescents identify the causes of their emotional problems. This understanding was a crucial precursor to developing and implementing strategies for addressing these issues. Our interview findings revealed that adolescents who successfully identified their emotional triggers recorded their levels of depression, anxiety, and stress while simultaneously contemplating the reasons behind them. This immediate reflection on the cause at the moment of recording prevented delays that might cloud their understanding.

From these observations, we derived a design implication: developing a feature that enables adolescents to record their lifestyle behaviors alongside their emotions. For instance, incorporating prompts like "Why did you experience this emotion?" can provide space for adolescents to note the causes of their feelings. Even if they don't respond to the prompt every time, the presence of the question can nurture the habit of self-reflection by consistently encouraging them to consider the reasons behind their emotions.

Additionally, some adolescents expressed interest in a system that could predict emotional triggers

preemptively. Recent research suggests that digital phenotypes—behavioral and psychological data collected through digital devices—can be used to build AI models capable of predicting emotional problems. By developing a function that leverages both active digital phenotypes (data recorded directly by adolescents) and passive digital phenotypes (data automatically collected through device sensors), we can create a system that significantly aids in identifying the causes of adolescents' emotional triggers.

Design Implication 2: Managing Controllable Factors

Next, the uncertainty regarding the forethought phase required tailored strategies. According to our interview results, the causes of emotional problems often stemmed from factors that individuals could control, such as personal behavior, as well as factors beyond their control, such as the influences of others or external circumstances.

Adolescents responded to controllable factors by modifying their behavior, emphasizing the importance of developing feasible action plans tailored to their daily lives. Those who successfully planned did not stop at the abstract intention of "modifying behavior," but instead considered specific actions they could incorporate into daily routines. The applicability of these actions was crucial, as it determined the details on how the actions could be executed.

In a similar context, some adolescents expressed a desire for a system that could collaboratively set goals and behavioral plans with them. Additionally, they hoped the system would compare their behavior during emotional problems with their behavior when they were not experiencing such issues, identifying specific areas for improvements. This comparison could highlight patterns and differences in their actions, providing insight into which behaviors might contribute to or alleviate their emotional problems.

Accordingly, a proposed system function could not only predict and present potential emotional triggers but also guide adolescents in modifying their behavior. This could include showing expected changes in a "What if X" format, where "X" represents a proposed change in behavior. By simulating the expected outcomes of these changes, the system can inform adolescents about actionable behaviors they can adopt in their daily lives. Additionally, seeing the potential effects of these changes can help adolescents reconsider their motivation and commitment to implementing these behaviors.

Design Implication 3: Managing Uncontrollable Factors

Adolescents often responded to uncontrollable factors by either distancing themselves from the situation, suppressing their emotions, or engaging in activities believed to induce positive emotions. For instance, they may avoid negative emotions by avoiding individuals who caused emotional distress or seek refuge in sleep. However, strategies that involved ignoring situations or emotions were found to be less effective because they failed to address the underlying issues.

Commonly mentioned activities to induce positive emotions among adolescents included smartphone use and interactions with friends. However, socializing often demanded significant time commitments, which was not always feasible. Moreover, some adolescents perceived that smartphone use exacerbated their emotional problems rather than alleviating them.

Adolescents who effectively managed negative emotions often possessed insight into specific behaviors that reliably elicit positive emotions for them. These individuals had a clear understanding of what activities bring them joy and contentment, as well as the duration required for such actions. As a result, they could respond appropriately to negative emotions by actively seeking out these

positive experiences.

Therefore, the possible system function should aim to identify which particular behavior or context elicit positive emotions for each individual, and present them as options accordingly. By unique emotional responses and contexts, personalized recommendations can be generated to address emotional distress. This approach involves suggesting activities known to induce positive emotions, thereby empowering adolescents to proactively manage their emotional well-being.

Design Implication 4: Sustained and Dynamic Support

During the performance stage, adolescents faced uncertainties in both process and effectiveness. Successful adolescents highlighted the importance of consistently implementing coping plans and engaging in repetitive actions. These practices not only cultivated problem-solving habits but also instilled a sense of control and stability in their lives. Keeping track of their performance through records served as tangible evidence of their commitment, thereby reducing uncertainty in the process. To address these challenges, we recommend incorporating a system feature to monitor plan implementation, enabling adolescents to recognize their progress in addressing emotional problems more effectively.

Furthermore, adolescents sought validation regarding the effectiveness of their coping plans. Reflecting on their emotional experiences allowed them to gain deeper insights into how their efforts influenced their emotional well-being. The system can facilitate this process by prompting adolescents to record and review their emotional response immediately after taking certain actions. Additionally, it can visually demonstrate the effectiveness of the plans by presenting changes in emotions and behavioral data. This feedback mechanism is expected to provide valuable insights and encouragement, motivating adolescents to persist in managing their emotional well-being effectively.

Another important factor in terms of persistence was the way the system interacted. Adolescents recognized that they could succeed or fail in implementing the plan, and sometimes adjustments to the plan were necessary. However, they noted that a system providing a consistent and static response to these varied situations might impede regular performance. Repeated failure to adhere to the plan led some adolescents to adopt a passive attitude toward solving emotional problems, and in severe cases, they even considered giving up.

Therefore, it's essential for the system to provide support, ensuring adolescents do not feel burdened by their inability to follow the plan. Rather than focusing on what they failed to do, adolescents preferred to be encouraged to try again with reassurance that "it's okay." When unable to implement the plan, adolescents were already aware of their shortcomings and sought comfort instead of repetitive confirmation. They also desired assistance in counteracting frustration, learning to recognize small positive changes that may have gone unnoticed.

Table 3. Self-recording system features to reduce uncertainties

Uncertainty Type	Design implications	System features
Uncertainty in evaluation		
	Present data in an intuitive format to facilitate evaluation.	Visualize the current state and goal state simultaneously
	Support self-evaluation of appropriateness	Provide a variety of information that can serve as assessment criteria

Uncertainty about causes		
	Support the identification of emotional triggers	Predict potential causes for emotional states based on personal data history
	Assist in linking behaviors and emotions	Offer contextual data alongside emotional data
Uncertainty in strategies		
	Assist in determining areas for improvement	Predict and explain behavioral or emotional issues Compare data from periods of good and poor health
	Outline specific action plans to be executed	Provide suggestions for substituting behaviors within current routine
Uncertainty about expected outcomes		
	Help understand changes in behavior and emotion	Predict potential changes based on tracked actions and previous data
Uncertainty in progress		
	Foster metacognition through self-recording	Prompt the recording of behaviors and emotions after specific actions
	Assist in following self-instructions on progress	Provide external validation of day-to-day efforts
Uncertainty in improvements		
	Help grasp improvements from effort	Outline changes in behavior and emotion through visualized data
	Prevent dwelling on failure and suggest success	Responsively highlight positive changes in response to success

Discussion

Principal Findings

Our study focused on exploring the behavioral and emotional aspects of adolescent health and investigated their engagement in relevant self-recording. Employing self-regulation theory, the study delved into the steps adolescents undertake to establish and execute health management through self-recording, offering a nuanced understanding of their perceptions and actions throughout the process.

Findings revealed that adolescents' self-recording process varied depending on the health metrics. They mainly concentrated on assessing the appropriateness of their behaviors and identifying areas for improvement, while delving into the causes of their emotional experiences. Adolescents frequently related their reflections on emotions with their lifestyle behaviors, suggesting an interconnected relationship between them.

Subsequent management strategies also differed. For behaviors, adolescents aimed at implementing behavioral changes, while for emotions, they first evaluated the feasibility of controlling the underlying causes before devising appropriate strategies. Controllable factors were addressed

through behavior correction, whereas factors beyond their control were mitigated by minimizing their impact.

Lastly, the performance step could be summarized as self-experiment. Adolescents tracked the results and responses towards their performance of health care strategies, modifying them if the results were unsatisfactory. This process illustrated a blurred boundary between the performance and reflection stages, involving continuous self-assessment and adjustment based on the outcomes achieved.

Barriers and Solutions in Self-reflection Phases

We also uncovered factors contributing to failures within the self-regulation process under the overarching concept of uncertainty. Throughout the phases of self-regulation, uncertainty acted as a barrier, making it challenging or even hindering adolescents' progress to the subsequent phase. The specifics and nature of these uncertainties varied according to the characteristics of each phase and its subordinate constructs.

Given these challenges, we explored system features that could potentially alleviate the uncertainty and help adolescents successfully engage in health management through self-recording. Among the adolescents in the study, those who successfully participated in the self-regulation process served as examples, while feedback from those who struggled was used as suggestions for system enhancements.

The system features primarily centered around providing information beyond adolescents' immediate cognition. This included criteria for behavioral evaluation and informing adolescents about their behaviors, particularly during emotional challenges. Adolescents also expected the system to collaborate in setting health management goals and strategies, with timely prompts to self-record the process and outcomes.

Moreover, suggestions were made for leveraging artificial intelligence. Adolescents anticipated that the system could preemptively predict the causes of their emotions and foresee the outcomes of specific actions. Additionally, design implications for system interactions involved providing dynamic support based on adolescents' performance levels, thereby facilitating continuous health management.

Interventional Effects of Self-recording System

Our research team identified interventional effects of the self-recording system, which served as the primary tool in this study. Adolescents' feedback highlighted that self-recording helped them establish future plans. While documenting their lifestyle behaviors, participants often mentally mapped out future actions, with some even pre-emptively recording these plans and subsequently assessing their actions against their initial intentions.

Furthermore, the application featured interactive notifications, including friendly greetings like "Good morning," "Did you have a good day at school?" and "How was your dinner?" Adolescents noted that these interactions made them feel as though the system was aware of their lives, fostering a sense of relatedness. This perception of being cared for encouraged a greater willingness to engage with the system and helped alleviate emotional distress.

Limitations

Our research has the following limitations. The prototype application developed by the researchers excluded market-available self-recording services. However, using the same application for all

participants facilitated comparison and controlled for external influences. Additionally, because few systems comprehensively cover both emotions and lifestyle behaviors, a custom application was necessary to address our specific research questions accurately.

The data obtained in this study were manually coded and analyzed. Despite the involvement of multiple researchers and an iterative coding process to ensure objectivity, unrecognized subjectivity may have influenced the results. Grounded theory research typically concludes when new insights cease to emerge, which may explain the relatively small sample size of 17 participants.

Furthermore, this study focused on adolescents attending regular classes in Korea, so the findings may have limited generalizability due to the socio-cultural characteristics of this population and the relatively higher proportion of female participants. The gender imbalance can be contextualized by the higher incidence of emotional disabilities experienced among female adolescents globally.

Conclusions

This study empirically presents a theoretical framework for adolescents' engagement in the self-recording process of multiple health metrics. By aligning our observations with the constructs of self-regulation theory, we systematically analyze the steps involved in self-recording leading to health management behaviors, focusing on behavior and emotional regulation. We extend our findings to explore the causes of failure and identify design implications for digital self-recording systems to effectively support this process. The study thus informs the development of digital self-recording system that addresses multiple health metrics for adolescents.

Acknowledgements

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Conflicts of Interest

The first author and co-authors are employees of the company (HAII Corp.), founded by their supervisor. The study was conducted using software designed by the company, and conflicts of interest may arise due to the affiliation with the company.

Abbreviations

Multimedia Appendix 1

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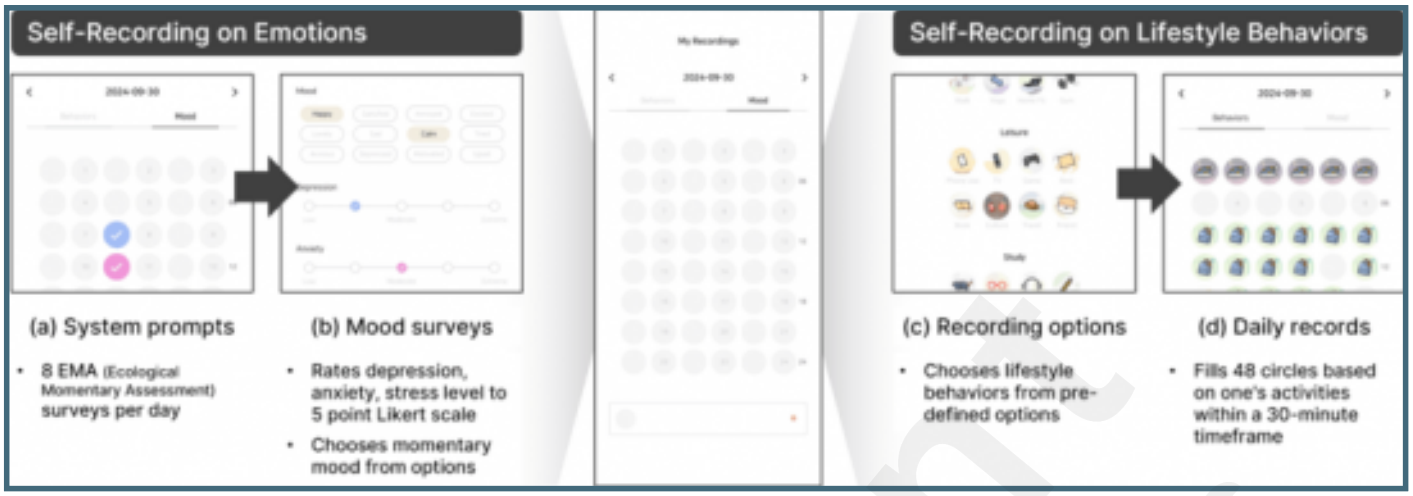
Supplementary Files

Figures

Process of self-recording on the application prototype.



Summary of the self-recording process on emotions and behaviors.