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How Exercise Data Sharing among Family Members of Different Generations Impacts Individual Exercise and Family Interaction

THESIS

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MASTER OF SCIENCE

in Information and Computer Science

by

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Thesis Committee:
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DEDICATION

To

To my parents and grandparents,

who have been a source of inspiration and the reason why I started this research,

and my boyfriend, Qiancheng,

who has been accompanying, tolerating, supporting, and encouraging me during graduate school and life.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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I would especially like to thank all of my participants, who had regarded me as their families for at least two weeks, as they did not mind the trouble to participate in my research, and willing to share their data, experience, thoughts, and feelings with me.

Lastly, I would like to acknowledge the help of my boyfriend, Qiancheng Wu, who had contributed his talented programming skills to help me build the WeChat mini-program.

ABSTRACT OF THE THESIS

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By

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Master of Science in Information and Computer Science

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Associate Professor Yunan Chen, Chair

In recent years, there are a small but increasing number of personal informatics studies conducted in family settings. Most of these studies were conducted between adult parents and minor children. However, it is unclear how introducing fitness tracking into an intergenerational family influences individual exercise behaviors and family interactions. I address this gap through a mixed-method study based on the usage of WeRun, a fitness data sharing plugin embedded in the pervasive social networking app WeChat, with eight intergenerational families. This study finds that family tracking motivated participants to engage in physical exercise and family interaction. Nevertheless, family members were concern about potential privacy and independence issues. They also worried about the potential health issues resulting from becoming motivated to exercise beyond an appropriate level. This study demonstrates the unique challenges when designing to support fitness tracking for intergenerational families. This study advances the understanding of the influence of family tracking on different generations.

CHAPTER 1 – INTRODUCTION

In recent years, an increasing number of studies have focused on tracking behaviors not only conducted by individuals but also happened in selected groups. These types of tracking and sharing that related to social interactions could happen in online support communities [16, 43], tracking applications with comparison and sharing features [5, 48], and health-related collaboration [3, 15, 17, 20, 32, 33, 36, 44, 47, 49]. Compared with other age groups, the elderly are more likely to self-track [2]. Self-tracking tools with data sharing features have opportunities to facilitate communications about health conditions between older adults and their adult children [2]. While most self-tracking research has focused on individuals, there is a small but increasing number of studies conducted in family settings. Previous research on family tracking has discussed eating habits [27, 42], sleep qualities [35], family-focused exercise games [41], and care-related behaviors [50]. These studies suggested that tracking in a family context could increase social support and help families build awareness, reflect on health behaviors, and set goals. However, these family tracking studies were mostly conducted between adult parents and minor children, or between family members of the same generation. This work focuses on a system of tracking and sharing fitness data in intergenerational families for the purpose of maintaining or improving the health of the entire family. This study generates insights about how older adults and their family members experience group tracking in the family setting and understand the effects of this tracking behavior. I specifically ask the following questions:

RQ1. To what extend will fitness tracking between the elderly and their adult children influence individual exercise behaviors and interactions between family members?

RQ2. How will family tracking influence family members of different generations (the elderly, the middle-aged, and the young people)?

RQ3. What insights can we draw from this study for the design, implementation, and evaluation of fitness applications which support family tracking and users of different age?

To investigate these questions, I conducted a mixed-method study using WeRun from July of 2018 to April of 2019. This study involves interviews, chatlog content analyses, and step data analyses. Unlike independent fitness self-tracking applications, WeRun is embedded in WeChat, a messaging and social media app which was widely used in China, and built on pre-existing social relationships on WeChat. WeRun imports fitness data from compatible fitness tracking tools (e.g., Apple Health) and automatically shares real-time fitness data with all contacts of a WeChat account who have signed up with WeRun. WeRun imports and displays the step data only for the day. With the low technical barrier, WeRun is an ideal tool for all family members to exchange fitness data. Gui et al. [14] interviewed 32 WeRun users to understand how people shared fitness data in pre-existing social networks. This study extends the focus on understanding the impacts of people sharing fitness data in family social relationships.

I recruited eight family units (27 people) in total. Each family unit consisted of at least three adult individuals (18 or above), including at least one person who was 60 or older. For inclusion in the study, the older adults either were healthy or had slight functional impairments but remained autonomous. Participants who were recruited as part of a family unit were asked to share their daily step counts collected by WeRun in their family

chat group within the WeChat app for at least two weeks. I found that participants use the number of steps taken by them and their families as a proxy to help them to quantify daily activities, understand exercise patterns, and measure health conditions. In their family chat group, they talked about their physical exercise and daily activities. Participants also expressed encouragement and concern to other family members. Sometimes, they would ask for help when facing technical difficulties. By analyzing participants' step data and chatlog data, I found that family tracking activities motivated them to engage in physical exercise and family interaction. Although tracking daily step data in a family setting provided multiple motivations for exercise and interaction, some participants were also concerned about potential privacy and independence issues. They also worried about the potential health issues resulting from becoming motivated by data to exercise beyond the level that would be appropriate.

Our study contributes to the HCI community by extending existing knowledge on fitness tracking in a family context and investigating the different expectations among the participants of different age to family tracking activities. Finally, I provide recommendations for the design of tracking tools that support intergenerational families.

CHAPTER 2 – RELATED WORK

2.1 Self-tracking for physical activity

Technology, such as mobile phones or pedometers, has the potential to change exercise behavior and promote physical activity [11].

Prior research has developed models to identify stages, barriers, and challenges in the self-tracking process [9, 24, 40]. Li et al. [24] summarize an iterative process model of personal informatics as composed of five stages: preparation, collection, integration, reflection, and action. People could meet challenges and barriers in any stage, which would cascade into later stages [24]. Epstein et al. [9] categorized lived informatics model based on Li's model by grouping the stages of collection, integration, and reflection into one iteration, and adding stages of deciding, selecting, lapsing, and resuming tracking.

The stage of deciding is when someone decides they want to track. People choose how they would like to track and what tools they would use in the stage of selecting and preparation. In the stage of collection, people record target data using selected artifacts. Integration processes data for further analysis and reflection. Many studies focused on the stage of reflection, which is an essential step to health behavior change. In this stage, users enhance their self-awareness [1], set realistic behavioral change goals [23], and increase self-control while promoting positive behavior [25]. Reflection is time-consuming and in many cases, people need motivation to do so [10]. Action changes could occur in or after collection, integration, and reflection [9, 24]. Konstanti and Karapanos [21] categorized three types of action changes towards increasing walk activities: directly increasing walking distances

(e.g., take longer walking routes or add lunch walks), switching habits to ones that promoted physical activity (e.g., take the stairs rather than the elevator), and action changes triggered by users' interactions with the device (e.g., take an extra walk if close to the goal).

Researchers also demonstrated some challenges for fitness tracking to trigger behavioral changes. One of the major challenges is data incompleteness and inaccuracy [45]. In Tang et al.'s study [45], some participants noticed contradicting information, which eventually led to mistrust of the results. Systems producing questionable data are less likely to be trusted, and thus they are less useful as a behavior change tool [11]. One potential solution to data incompleteness and inaccuracy is presenting uncertainty to users. In this way, data appear more accurate and precise, which could alleviate users' anxiety when they found the app information did not match their knowledge [6, 18]. Other challenges could be boredom and unpredictable schedule [34]. In their study, some participants reported that lack of novelty could lead to boredom, which demotivated them to follow through on their plans. Most of their participants mentioned experiences about canceling a planned physical activity because of an unforeseen event. This situation happened especially to participants living with their families. They needed to coordinate with other family members and plan around others' activities while making their own plans for exercise because their schedules were directly influenced by other family members' schedules.

2.2 Self-tracking and social interaction

It is common to see self-tracking behaviors involving social interaction. Most of the self-tracking tools are designed primarily for individuals, and many of them include features for

comparison, competition, and social sharing [5, 8, 22, 26, 28, 29, 40]. People could share data and information or join in an online support group with their friends using these self-tracking tools. Another form of social interaction happens when user collect and post their personal informatics data through social awareness streams (SAS) to pursue emotional support or show their identity as someone who engages in these activities [4, 13, 31, 46].

Previous studies found that some of the participants who were using social features were more motivated and more engaging than those not engaged in social interactions [37, 38]. However, other participants did not be influenced and motivated because they were reluctant to use those social features [30], or some influences cancel each other out [29].

Epstein et al. [8] summarize five reasons why people would like to share their fitness data: request for information (e.g. seeking recommendations or advice), desire for emotional support (e.g. seeking emotional support from people who have similar experience), seeking motivation or accountability from an audience (e.g. making commitments, creating competitions, or forming collaboration), motivating or informing the sharing audience (e.g. sharing a location to recommend a good place or to inform nearby friends), and impression management (e.g. presenting a public image of being active and fit).

2.3 Sharing fitness data with pre-existing social networks: WeRun

WeChat is a mobile application developed by Internet giant Tencent in 2011. The core affordances of WeChat are communication and connectedness. People can use it to chat with each other through text, video, and audio. WeChat also provides other channels such as a personal homepage, called “Moment,” for users to disseminate and receive news and

information. Recently, WeChat has expanded into fields of payment, shopping, games, and mini application platforms. According to the Seventh annual Tencent Global Partner Conference held in 2017, the largest growing user group of WeChat is the elderly.

WeRun is a fitness plugin built into WeChat. Different from independent fitness self-tracking applications, WeRun is embedded in WeChat and built on pre-existing social relationships on WeChat. WeRun imports fitness data from compatible fitness tracking tools (e.g., Apple Health) and automatically shares real-time fitness data with all contacts of a WeChat account who have signed up with WeRun. WeRun imports and displays the step data only for the day. With the low technical barrier, WeRun is an ideal tool for all family members to exchange fitness data.

Based on WeChat networks, WeRun has many social functions. WeRun Ranking automatically ranks the daily steps of users and their contacts who also use WeRun. The person who has most steps can set the cover photo of the WeRun page, which can be seen by other contacts. Users can “like” each other’s step counts. Users can “follow” a specific contact, which allows the contact’s step count to appear on top of their WeRun pages. Users can also send their step data to their friends in WeChat messages or post it on their “Moments.” WeRun sends a summary of users' daily step counts as a form of leaderboard at 10 pm every day.

Gui et al. [14] interviewed 32 WeRun users to understand how people shared fitness data in pre-existing social networks. They found that participants did not attach much importance to the accuracy of fitness tracking data provided by WeRun. Most of the time, competition was not a strong motivation for WeRun users to track fitness data. They were

aware that their contacts usually have diverse ages, occupations, health statuses, and lifestyles. They consider the individual situations when interpreting and comparing contacts' step counts. Private issues caused by sharing fitness data in the context of WeRun are determined by the social relationships between users and their contacts. Gui et al. [14] found that sharing fitness data with pre-existing social networks, such as WeRun, has the potential to promote social interaction. It created more topics for users to talk with their contacts on WeChat, thus enhancing communication opportunities.

2.4 Fitness tracking in a family context

While most self-tracking research has focused on personal informatics, there is a small but increasing number of studies conducted in a family context.

Lukoff et al. [27] designed a food tracking tool for family to track and share their meals for family members. They found that the most common form of support which their participants provide to family members was tangible support (e.g., Take action to help a family member eat healthily). Pina et al. [35] conducted research to learn practices in tracking and sharing sleep data among family members. They identified the importance of making shared goals and understanding individual differences as keys to family tracking experiences. Grimes et al. [12] studied how did participants reflected on their family members' health and found that families' overlapping routines provide opportunities for reflection. Schaefbauer et al. [42] focused on how families improved their eating habits together. They found that snack journaling helped families to be more aware of others' snacking behaviors and to engage in positive social interactions about healthy eating. Saksono et al. [41] explored how family games can motivate exercise. Yamashita et al. [50]

designed a tracking tool for family caregivers to record care receivers' activities and conditions. Their findings demonstrated that a family tracking tool has the potential to increase family communication. These studies demonstrated that tracking in a family context could increase social support and help families build awareness, reflect on health behaviors, and set goals.

A concept of caring-through-data was introduced in Kaziunas et al.'s study [19]. The relationship between care and data is multiple. Both care and data can mean many different things depending on the particulars of family, social contexts, and life stages [19]. Kaziunas et al. [19] found glimpses of people maneuvering data in ways to promote empathy, relational intimacy, and compassion.

Among these studies, participants also expressed privacy concerns about sharing their data with other family members. Yamashita et al. [51] found that sharing patients' private information with family caregivers might cause negative feelings of surveillance and violation of trust.

2.5 Self-tracking and social interaction for older adults

Although the gradual impairments of physical and mental ability limit the elderly, compared with moving in with adult children or into a care institution, they are more willing to remain in their original residences for as long as possible. Leaving their home and moving in a caregiver place can limit the autonomy of older adults and increase feels of disenfranchisement and socio-cognitive limitations by providing unnecessary assistance [2]. The goal of "aging in place" research is to empower the elderly to maintain

independence in their residences for the long term. Self-care activities for health management are the necessary factor for successful “aging in place.” One way to conduct health management by older adults themselves is regular self-tracking of health indicators, such as blood pressure [2].

Compared with other age groups, the elderly are significantly more likely to self-track, more likely to use paper or medical devices, and much less likely to use computers and mobile tools. For the elderly, the most common goal is to self-track are identifying abnormalities in their health condition [2].

Caldeira et al. [2] found that self-tracking tools, which have integrated functions for sharing data within individuals’ social networks, have opportunities to assist the communication about health conditions between the older adults and their adult children.

CHAPTER 3 – METHODOLOGY

To understand how older adults and their family members experience tracking and sharing fitness data and understand the effects of this family tracking activity. I conducted a mixed-method study using WeRun from July of 2018 to April of 2019. This study involves interviews, chatlog content analyses, and step data analyses. Figure 3.1 shows the procedure of the study.

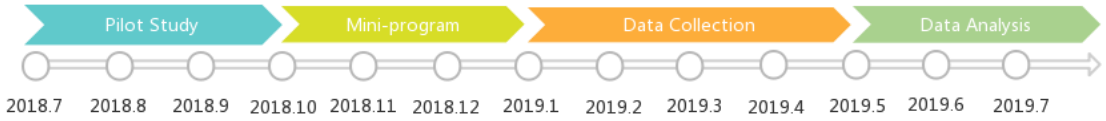

Figure 3.1. The procedure of the study

I used a snowball sampling technique to recruit participants. I posted a poster on WeChat "Moment" to recruit participants. I also asked our friends whether they would like to participate, and then asked whether they could refer someone to us. I recruited family units by asking participants to invite their family members. All participants were Mandarin speakers. Most of them were in China when participating this study.

I defined the generations of participants by their working status. In China, the common retirement age is no later than 60 years old. Therefore, I defined the elderly in this study were above 60 years old and had retired. The middle-aged were in their 40s or 50s and still working. The young participants were around 20 years old and still in college.

Table 3.1. Demographics of study participants

Family	Participants	If live together during the study time	Identity	Age	Gender	Relationship
	A1		The elderly	>80	M	Grandfather
	A2		Middle-aged	>40	F	Daughter
	A3		Middle-aged	>50	F	Daughter
A	A4	live in the same city but separate	The young	>18	F	Granddaughter
	B1		The elderly	>70	M	Father
	B2		The elderly	>70	F	Mother
B	B3	live in the same city but separate	Middle-aged	>40	F	Daughter
	C1		The elderly	>80	M	Grandfather
	C2		The elderly	>70	F	Grandmother
	C3		Middle-aged	>40	M	Son
	C4		Middle-aged	>40	M	Son
C	C5	live in the same city but separate	The young	>20	M	Grandson
	D1		The elderly	>60	M	Father
	D2		The elderly	>50	F	Mother
D	D3	live in different cities	The young	>20	F	Daughter
	E1		The elderly	>70	F	Mother
	E2		Middle-aged	>50	F	Daughter
E	E3	live in different cities	Middle-aged	>50	M	Son-in-law
	F1		The elderly	>80	F	Mother
	F2		Middle-aged	>40	F	Daughter-in-law
F	F3	live together	Middle-aged	>40	M	Son
	G1		The elderly	>80	F	Father
	G2		The elderly	>70	M	Mother
G	G3	live in different cities	Middle-aged	>50	F	Daughter
	H1		Middle-aged	>60	F	Father
	H2		Middle-aged	>60	M	Mother
H	H3	live together	The young	>20	F	Daughter

A total of eight family units (27 people) were recruited. Each family unit consisted of at least three adult individuals (18 or above), including at least one person who was 60 or older. Among the 27 participants, 11 were the elderly, 12 were the middle-aged, and four were young participants. The older adults mentioned in this paper were those who were healthy or had slight functional impairments but remain autonomous. Table 3.1 shows the demographic information of the participants.

I have conducted a pilot study before the real study. I use family has unit of analysis both for the pilot study and the actual study. With an aim to understand the influence of using WeRun on elderly users and their family members, the pilot study interviewed and analyzed four family samples. The official study, with a larger sample (n=8), based on the results of the pilot study, was modified to focus more on the experiences and effects of tracking and sharing fitness data with family members.

3.1 Pilot study

In the pilot study, participants who were recruited as part of a family unit were asked to interact in a family group chat within the WeChat app. The period of the pilot study for each family lasted at least four weeks. The pilot study process was designed as Figure 3.2a.

We first conducted an online focus group interview with each family group and asked about their exercise habits. Then, I asked each family to share and discuss their daily exercise in a chat group for at least two weeks without using WeRun. After that, each family unit was asked to track their daily steps by WeRun, and share and discuss it in the group chat for another two weeks. At the end of the first two weeks and the second two weeks, I conducted an interview individually with each family members regarding their experiences and opinions about fitness tracking and sharing.

The results of the pilot study shown that the use of the WeRun did not affect the behaviors of the participants. On the one hand, it was because most of them used additional tracking applications besides WeRun in the first two weeks. On the other hand, the impacts of family interactions were much more significant than tracking activities alone. After two weeks,

some participants started to drop out of the study and did not positively engage anymore. Therefore, I adjusted the study period from four weeks to two weeks and asked participants to use WeRun from the beginning to the end.

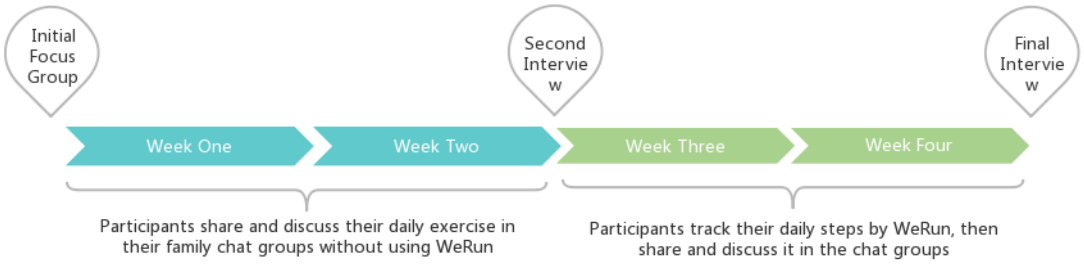

Figure 3.2a. The process of the pilot study

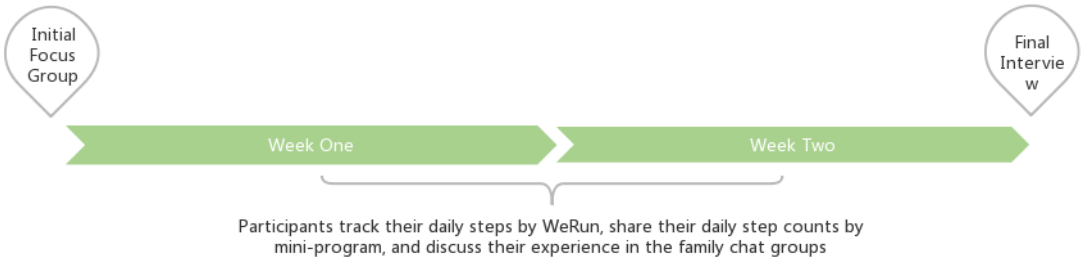

Figure 3.2b. The process of the formal study

3.2 Study design

In this study, participants were asked to share their daily step counts collected by WeRun in their family chat group within the WeChat app. For each family unit, the participation lasted at least two weeks. During the study, I invited our participants to join in newly built family chat groups and asked them to track their daily step counts using WeRun. With their

permissions, I collected some of their group conversations and their daily step counts in the period before and during the study. At the beginning of the study, I conducted online focus interview with each family. At the end of the two weeks, I interviewed each participants individually through WeChat voice call. The study process was designed as Figure 3.2b.

I first conducted a group-based interview with each family group. They were asked some baseline questions related to demographic information (e.g. age, gender, relationships with each other), exercise habits, previous tracking behaviors, communication methods and frequency, and daily routines.

Then, I built a chat group within the WeChat app for each family unit and invited family members to join in their family groups. They were expected to track their daily step counts using WeRun for at least two weeks. I also encouraged the participants to share and discuss their daily steps, schedule, and mood in the WeChat group. I was present in each family group during the whole study and had access to group conversation logs.

Although WeRun can record one's daily step counts for the last 30 days, our participants reported that they had never paid attention to their data history and had no idea where to access this information. WeRun does not support users to acquire other users' precise step record as well, which increased the difficulty to gather participants' step data. To lower the technical threshold for the elderly to use WeRun, and also to facilitate the researcher to collect step data, we had developed and launched a WeChat mini-program. WeChat mini-program is a "sub-application" within the WeChat ecosystem, which means any user could access our mini-program via WeChat App. The launched mini-program is shown in Figure

3.3. Through the mini-program, users could easily acquire not only their daily step counts but also their step counts trend for the latest month. After participants authorized the mini-program to access their step count history, we could collect the data in the backstage.

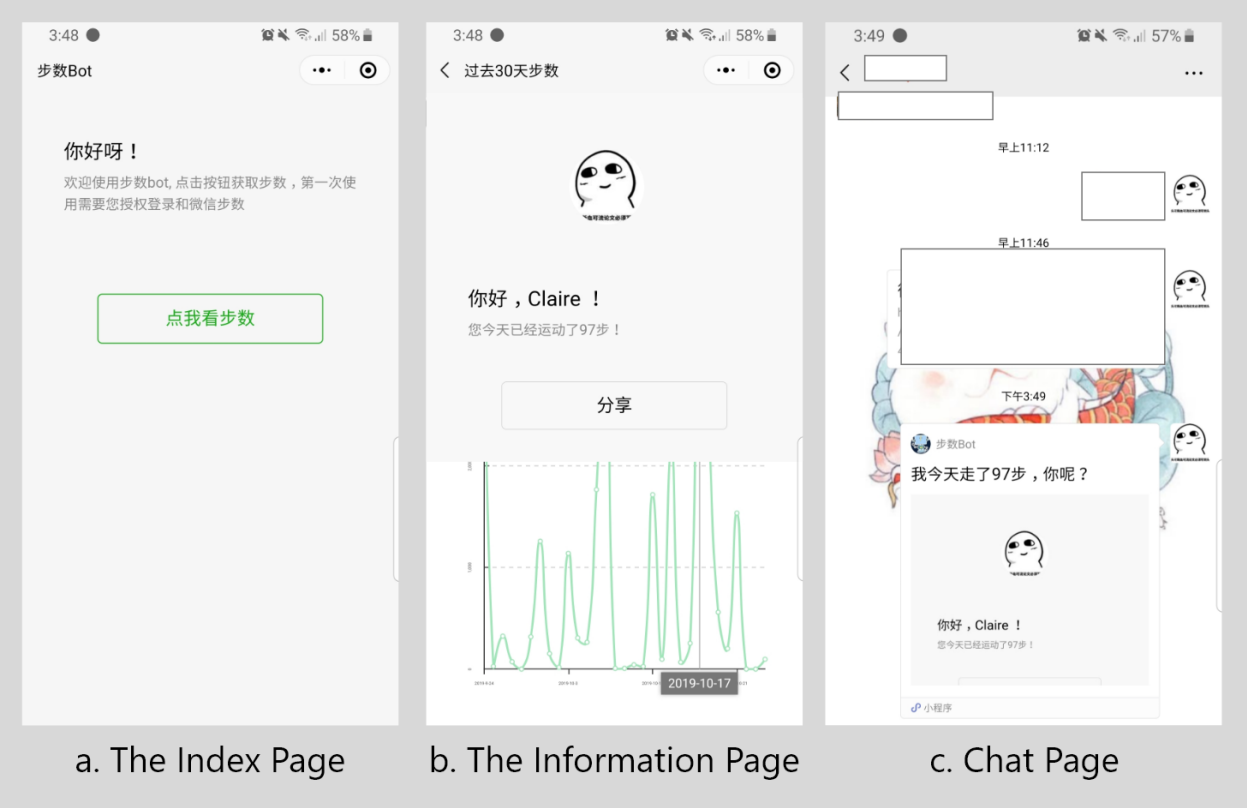

Figure 3.3. Interfaces of the mini-program (a) The index page: This is the index page of the mini-program. This page contains a warm greeting and a request for accessing users' data. If users click the green box, which means they authorized the mini-program to acquire their data. (b) The information page: This page shows user's daily step records of the latest 30 days. Users could interact with the line chart to check the precise date, and step counts. Users could share their step records by clicking the grey box in the middle. (c) Chat page: After users share their step records through the mini-program, the system sent a card contains their step counts to other users. Other users could access the mini-program by clicking the shared card.

At the end of the study, I conducted a semi-structured individual interview for at least 30 minutes with each family member regarding their opinions and experiences during the study weeks about fitness tracking and sharing. Some of the interview questions are:

- The physical exercise experience during the study:
    - How frequently did you exercise in the last two weeks?
    - What physical exercise do you usually do?
    - Do you know the exercise habits of your family members?
    - Do you feel satisfied with the current situation of you and your family members' physical exercise?
- Family interactions generated from family tracking activities:
    - How frequently did you talk to your family members in the last two weeks?
    - What have you usually talk about?
- Other feedback and comment:
    - Have you felt any difficulties to persist the routine physical exercise or persist the communication with your family members about the WeRun step tracking? How did you solve the difficulties?
    - Tell me some stories that happened during the participation that you thought were interesting.

3.3 Data analysis

3.3.1 Interview and chatlog content analysis

All the interviews and chatlog conversations were collected in Mandarin. I then employed a grounded theory approach to analyze the interview and chatlog data.

I read all interview transcripts and chatlog conversations, and then used my initial understanding to generate a starting list of codes. I then returned to the data to conduct a systematic axial coding and identified the emergent themes. After several iterations of coding, I identified and

categorized themes that emerged naturally, which I present in the findings. I then returned to the transcripts to find related quotes and later translated them into English.

After generated the themes of participants' chatlog conversations, I returned back to tag each message sent by them with the emerged themes. Each message could be tagged with multiple themes. Then, I counted the number of messages under each tag.

This work was not a controlled study, but an explorative study in which I trialed an embedded function in the wild. Therefore, the lessons learned are discursive and reflective.

3.3.2 Step counts and chatlog number analysis

Due to technical issues and privacy concerns, some participants did not authorize the mini-program to access their step counts before and during the study. I eventually collected 550 step count records and 576 chatlog records from 21 participants.

Among the 550 step count records, 408 were generated after participants joined the study and 142 were generated before the study. The elderly contributed 230 step count records. Middle-aged participants generated 301 records. Young participants generated 19 step count records.

191 of 576 chatlog records were collected from the elderly. 345 chatlog records were collected from the middle-aged. 40 chatlog records were collected from the young participants. The data index is shown in Table 3.2 below.

Table 3.2. Step counts and chatlog data index

Age	Population	Period	Step count records	Chatlog records
The elderly	8	Before	51	NA
		After	179	191
		Sum	230	191
Middle age	11	Before	91	NA
		After	210	345
		Sum	301	345
Young	2	Before	NA	NA
		After	19	40
		Sum	19	40
Sum	21	Before	142	NA
		After	408	576
		Sum	550	576

To examine the effects of family tracking on individual behaviors and interactions between family members, I employed several analyses between family chatlogs and daily step counts. First, with an aim to examine the effects of the family tracking activities on participants' exercise behaviors, I compared the number of step counts people had taken after they started family tracking to the number of before. Second, to understand and characterize the topics that participants discussed during the family tracking activities, I identified and visualized high-frequency words mentioned by them and categorized four major interaction types. Third, to test the effects of family tracking activities on individual exercise behaviors and family interactions, I conducted groups of multilinear regression analyses and multinomial regression analyses.

CHAPTER 4 – FINDINGS

4.1 Reflection of daily step counts during family tracking

4.1.1 Individual physical exercise changing after family tracking

Since starting tracking and sharing step data in their family groups, most participants were more willing to exercise than before. Some of them transferred the willingness to action while some did not. I first presented a descriptive analysis to examine participants' daily step counts. Two-Samples Wilcoxon Test shows that participants' daily step counts generated when participating in the family tracking groups (Mdn= 7444, SD= 6808.541) was significantly more than that before the study (Mdn= 8818, SD= 6096.253), W = 25132, p-value = 0.02<0.05. The average daily step counts were 9045 before participating and 9989 when participating.

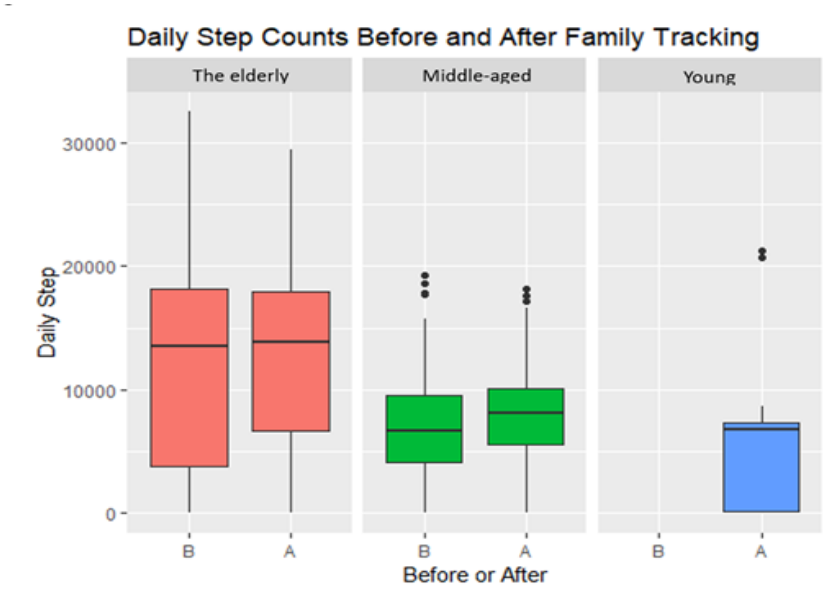

Figure 4.1. Daily step counts of the three age groups before and after participating in the study

Analyzing step data by age groups, the median daily steps of the elderly (Mdn= 13745) is significantly higher than that of the middle-aged (Mdn=7805), W=47472, p=0. The researcher could not access to the daily step data of the young participants before they had participated in the study because they chose not to use our mini-program. Instead, they had their own way to track and share daily step counts, such as taking screenshots of the WeRun leaderboard, taking pictures of their pedometer, and sharing more vivid integration results from other fitness applications. Therefore, I only discuss the step count changes of the elderly and middle-aged participants here. The range of daily step counts took by the elderly were various (SD=7553.358, Min=25, Max=32487), whereas the middle-aged people tended to have smaller range of daily step counts (SD=3914.313, Min=2, Max=19234). One explanation could be that the recommended daily exercise goals for the elderly are various depending on personal health conditions, while the middle-aged people relatively have more regular daily schedules and similar physical strength. Figure 4.1 shows the comparisons of the daily step counts of three age groups before and during participating in the study. Older participants' daily step counts generated during family tracking (Mdn=13846) did not differ significantly from that before the activity (Mdn=13496), W = 4083, p = 0.25. However, middle-aged participants' daily step counts nearly significantly increased after participating (Mdn=6629) in the family tracking groups than before (Mdn=8087), W = 8368.5, p = 0.08.

The results indicate that family tracking influenced more on the middle-aged than the elderly as the aspect of physical exercise. One reason mentioned in interviews is that most

of the elderly already had their solid routine exercise habits. It was difficult for them to change their decade's long habits in several weeks. A middle-aged participants (C3) interpreted his parents' exercise habits, *"The elderly are retired and have more time, and they are likely to have a long-timed exercise habit. Therefore, the elderly's exercise is stable and will not be influenced by new factors…However, middle-aged people like us are too busy to exercise regularly."* For the elderly who had not formed routine exercise habits, I found that the effect of the family tracking activity was even more significant on them than on the middle-aged participants. The reason was also mentioned in interviews. Participants believed that the elderly who had retired have more free time to conduct physical exercise than middle-aged people. For example, an older adult participant (F1) exercised and walked far more than before participating in the study. As F3, F1's son-in-law, said, *"F1 always stayed at home before, now my wife (F2) and I encourage her to go out more and visit more places, as exercising."*

For the middle-aged participants, tracking and sharing daily step counts with family members promoted their physical exercise. Most of them chose to change commuting ways to increase their physical exercise. A2 and E2 chose to bike or walk to work instead of taking buses or driving. A3 took off the bus one stop ahead and walked to work. D2 went to a further restaurant for lunch to take some extra walks. For some participants who had more free time, the changes were more obvious. For example, F3 was taking his annual leave during the study time. He went to the gym every day and took a three-day cycling trip in this annual leave. He thought it was this family tracking activity made him think about exercise all the time. F3 reported that, although he had the habit of exercising in the gym regularly during weekdays, he stayed home all day at the same time last year when he once

on vacation. *"At the same time last year, I basically stayed at home all day. However, this year, because of this activity, I, though on vacation, persisted in exercising every day in the gym. (F1)"*

4.1.2 Step data as a proxy to quantify daily activity and physical exercise

Participants started to add more interpretations to step data. They started to pay attention to the step counts and recall their daily schedules. Reflecting on daily steps helped them to quantify daily activities and understand exercise patterns of them and their family members.

Most participants could relate the number of step counts they have taken to their daily activities and predict their daily step counts based on their daily schedules. In the final interview, an older participant (C1) could tell how many steps his daily activities could produce. *"For example, exercise in the morning will take 10000 steps. Pick up my grandson and buy groceries will contribute another 10000 steps.(C1)"* Middle-aged participants could tell the number of steps they took during the commuting and work. They then realized how many steps left to their daily goals so that they could adjust their schedule to take some extra walks to meet the goals. For example, B3 noticed that she could take 5000 steps on the way to work and home, and 3000 steps during work. Therefore, she planned to walk in the evening after work for another 2000 steps in order to achieve the goal of 10000 steps.

Participants understood themselves better by reflecting on their step data. Some of our participants were aware that daily activities, such as commuting, shopping, and housework, could be counted as exercise because those activities contributed step counts. C2, an older participant, was aware that housework and playing with her granddaughter could also be

regarded as exercise, *"I was happy when I saw the step counts taken during my housework. I thought I lacked exercise before, but now, I know I'm just in a good exercise condition."* For other participants, seeing their step counts made them realized that they needed to do more exercise. For example, a young participant (K3) wondered if she was too indoorsy when she saw her daily step records of the last month. Then, she started thinking about doing some exercise the next day. *"If I just stayed at home and took only hundreds of steps, I didn't feel really want to say anything in the group. Then, I was looking at my step data records in the previous weeks, I felt I was too indoorsy. At that time, I was thinking why not go out tomorrow. Actually, I was very happy when I collected a lot of step counts. (K3)"*

At the end of the study, most participants figured out the most appropriate amount of exercise per day for them and the number of steps corresponding to that exercise amount. They then set a reasonable number of step counts as their daily exercise goals, rather than using a suggested vague range of daily step counts. When asked why set 5000 steps as a daily goals, A1, an older participant mentioned that he did an experiment to test how many steps he had taken while doing his morning exercise, *"Because going out to the park, playing a little bit Taichi, walking back and forth, I tried, that is more than 5000 steps. (A1)"* Another older participant (E1) set her daily exercise goal based on her body feeling and the observation of her daily step records. *"6000 to 7000 steps is my daily goal. If I walked more than 7000 steps, I would feel really tired, and my leg would feel uncomfortable. So I tried not to walk that much."*

4.1.3 Step data as a scale to measure health condition

Tracking and sharing daily step count helped participants to know better about their family members. In final interviews, most participants could tell their family members' exercise habits more precisely than before. They could perceive others' schedules by observing their step counts. For example, B3, a middle-aged participant, once asked her parents (B1 and B2) if they went out together because their step counts were similar.

People could sense their families' health conditions by observing the step data. A young participant A4 said in her interview, *"if you walk less today, which means you might be concentrating on one thing and could not move, or you were just lazy, which can reflect a person's physical and mental condition. (A4)"* A middle-aged participant (B3) would feel comfort and relieved when she was aware that her parents (B1 and B2) were in good condition by observing their step counts. *"Since we were not visiting or calling my parents every day, it was difficult for me to track my parents' condition in time. However, with the group, I can know my parents' condition through their step data and the messages they have posted. Unless on special weather, their step counts should always in that level. As long as I saw they posted their exercise in time and the data is around the normal level, I knew nothing bad happened, and I felt comfort. (B3)"* Similarly, B2 was happy to learn their child (B3) was in good health from the step data. *"There are several people in our family group who can see each other's step counts. We don't need to ask each other if they're okay. Why? I'm sure they'll be all right when I see how many steps they've taken. We don't need to worry about it. (B2)"*

On the basis of understanding the conditions of each other, participants would take care of their family members. I will discuss family interactions related to caregiving and care receiving in the section 4.2.

4.1.4 Data accuracy as the prerequisite

As opposed to Gui et al.'s [14] study, which has suggested that WeRun user did not place much value on the accuracy of fitness tracking data, our participants thought the accuracy of step counts was a prerequisite of family tracking activities. They expected the step counts to be basically correct but do not have to be particularly accurate. A middle-aged participant (C3) questioned the accuracy of the step data counted by algorithms. Several months before the study, he bought a new pedometer, which was more expensive and more advanced than his old one. The daily step counts recorded by the new pedometer were less than his old one. He said, *"I admitted that I was influenced by the data. When I wore the new pedometer and saw the step counts were not as many as I expected, I felt a little bit stressed and depressed. I understand that the algorithm used in the new one could be more accurate than the old one, but the new pedometer is too 'harsh'"* C3 thought it was very important to make sure the algorithm is correct because other interactions were based on the step counts, *"All the interactions and judgments are based on daily steps. Therefore, the accuracy of the algorithm is very important to us."*

Other participants were also influenced by the accuracy of the recorded daily step counts. F2 once doubted the accuracy of her spouse's (F3) step counts because F3 usually exercised a lot. F3 then explained that his step counts were much lower than usual because he exercised indoors on bad weather. B3 was worried about her mother (B2) when B2's

step counts were much less than usual. Then, B3 realized that most of the time, the abnormal small number of step counts was because WeRun failed to acquire data from her mother's pedometer.

The elderly also cared about the accuracy of the step data. They sent messages in the group to ask for help when they found that their WeRun records were far less than they had anticipated. For example, when an older participant's (C1) pedometer and WeRun were disconnected, he immediately asked his children to solve the problem for him because C1 would feel disappointed if his step counts were not recorded due to technical issues.

4.1.5 Measuring exercise only by daily step counts is single and one-sided

Tracking daily step counts is a way to quantify the exercise amount and assist people to set a more clear exercise goal. However, some participants gradually realized that a single standard was not enough to reflect physical exercise. They felt that they had paid more attention to the statistic rather than the actual experience. Their purpose has become one of maximizing number of steps instead of enjoying physical exercise or maintaining health. A young participant (D3) recalled in her final interview, *"Before using WeRun (to track and share step counts with family members), I sometimes thought about going out and jogging two laps at night. After jogging, I might share my experience with them. It could be some feelings after exercising or anything else. Especially after jogging outside, I would see some new scenery, or see something interesting that I wanted to share with my parents. But after using WeChat (to track and share step counts with family members), I might only focus on the number of steps, not on the experience itself."*

When trying to achieve a certain amount of step counts, participants also have other concerns, such as avoiding potential sports injury or over-exercising. For example, one older participant (K2) who underwent a leg surgery a year before said, *"I would receive a lot of encouragement and feel happy and a sense of achievement when I reached 10000 steps. But in the meantime, I also worried if I over-exercised, which was bad for my leg."* A pair of brothers (C3 and C4) talked about how to avoid potential sports injuries.

C3: "I've been playing badminton for two hours tonight... But suddenly I thought jogging is a better way to do exercise. It doesn't hurt your knees."
C4: "Jogging is better, good for knees if jog on a synthetic running track."
C3: "Can only say it (jog on synthetic running track) doesn't hurt (knees)."

C3 then gradually changed his physical exercise from playing badminton to jogging to avoid potential knee injury.

4.2 Family tracking produced new interactions and influenced communications

4.2.1 Interactions produced by family tracking

By analyzing the average number of messages sent per week, I found that the middle-aged group was the driving force of their family interaction online. They sent 115.53 messages on average per week, while the older participants sent 55.57 and the younger participants only sent 19.67 messages per week.

In analyzing our participants' chat logs, several topics of discussion in the exercise-themed family group were identified. Participants talked about not only their physical exercise, but also their daily activities, moods, reflections, and concerns for other family members. I

conducted a content analysis to understand the topics that participants mentioned during the study period and a descriptive analysis to compare the differences between the three age groups. Figure 4.2 is the tag cloud of the words participants mentioned in conversations with their family members. Some frequently mentioned topics are: physical activity, daily experience, weather, health care and well-being, encouragement and motivation, technical difficulties, and mood.

Figure 4.2. Tag cloud showing the frequency of words mentioned in family tracking conversations. Word size reflects the frequency of being mentioned.

Four most common types of family interactions were categorized from the frequently mentioned topics. Figure 4.3 demonstrates the frequency of each primary interaction happened. Calculated by the number of messages related to each type of interaction, from the most frequent to least, the order of the types of interactions are: share physical exercise

experience and daily activities (75%), learn new features or knowledge (11%), give and receive encouragement (6%), and give and receive care (8%).

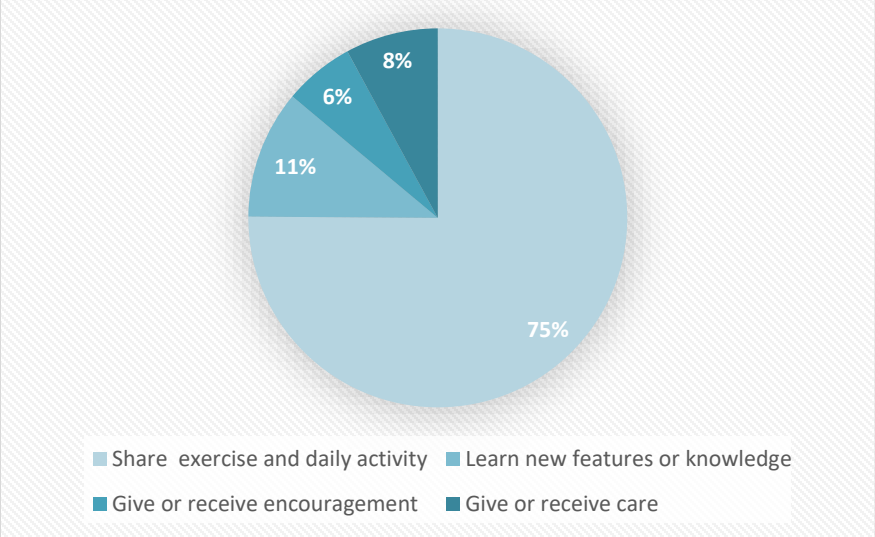

Figure 4.3. The percentage of each primary interaction happened in all family tracking groups per week

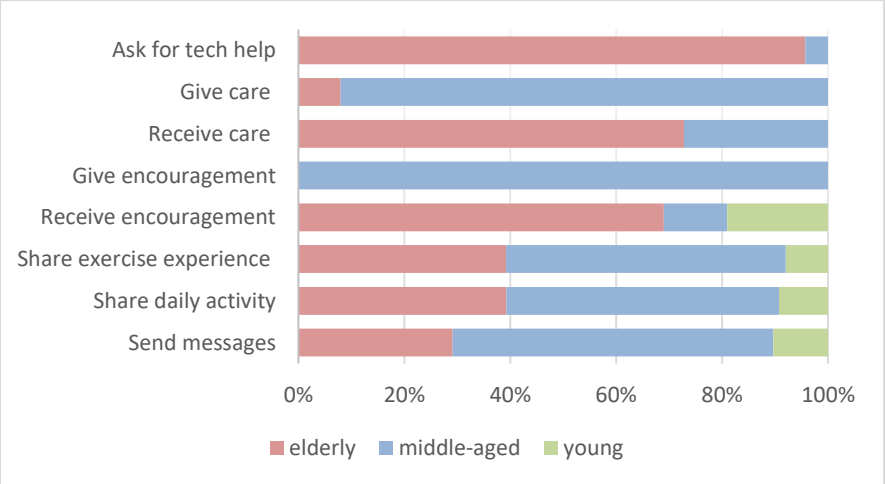

Figure 4.4. The percentage of the three age groups participated in each interaction happened in all family tracking groups per week

Share physical exercise experience and daily activities

We could tell from Figure 4.4 that all three generations had shared their daily activities and exercise experience with their families. In analyzing the chatlog content, I found that most of the participants shared their physical exercise experience every day. They not only posted their daily step counts but also explained what activities had generated these steps.

Some of the physical exercises could be recorded by pedometers, such as walking, jogging, ball sports, dance, but some exercises could not. When participants did exercises that could not be captured by pedometers, such as mat exercise, yoga, and tai chi, they would explain more about what they had done and why the data shown in WeRun could not represent the actual amount of exercising.

After participants realized that their routine activities could also be considered as exercise as those activities contributed many steps, they shared methods that they used to maximize the fitness effect of their daily activities. For example, a middle-aged participant (A2) shared that she got off the bus one stop ahead and deliberately walked to work. A young participant (A4) who was in college reported that she deliberately went to the farther library to study in order to walk more, *"…went to school in the morning to study but I did not go to the study room, I specially went to the farther library, so today I have 6000 steps! (A4)"*

Give and receive encouragement

Figure 4.4 shows that all the messages related to encouraging came from the middle-aged and were sent to all three age groups. Family members encouraged each other by sending texts, memes, and thumbs-up when they achieved their exercise goals and showed high

step counts. For example, one adult child (G3) texted her parents and said, *"I didn't expect that you could exercise that much, walk 20000 to 30000 per day. I thought that you were just doing your regular activities every day. Now I knew my mom was the leader in her dance group and I am proud of you. (G3)"*

Besides sending encouragement when family members did good in exercising, the participants from one family also played a role in mutual supervision when they noticed their family members walked less than expected. The middle-aged participants first asked the reason why their family members walked less and then encouraged them to continue exercising if they could. For example, an adult child (F3) noticed that his mother (F1) always stayed at home, so he encouraged her to go out more often to visit friends and visit scenic spots.

Give and receive care

Comparing the involvements of three age groups in care-related interactions (shown in Figure 4.4), I found that the middle-aged group is more likely to give care (92%), while the elderly tend to receive care (73%).

The middle-aged often reminded their family members when the weather was not suitable for outdoor activity. Adult children reminded their parents to *"be careful of slippery roads on rainy days"* and *"not to go outside until the weather turned good."* Many participants reminded each other on extremely cold or smoggy days to *"avoid unnecessary outdoor activity"* and *"protect yourself when you have to go out."*

They also conveyed their care by asking questions when they noticed unusual data. Middle-aged participants would ask if anything went wrong when they saw the daily step counts of their family members were much lower than the normal level. For example, a middle-aged participant (C3) would express concerns to his father if he found his father's step counts were less than usual, *"If I noticed that my father was not the first on the leaderboard, which he usually would be, I would start to pay attention if my father said anything in the group. If my father was not the first on the leaderboard for two days, I would call him to ask if everything was all right."*

Adult children also reminded their parents to avoid over-exercise and sports injury when they noticed their parents walked more than usual.

(The first few days of the study)

B2: "I've taken 17191 steps today, and 26400 steps yesterday."

B3: "Why are you walking so much?"

B2: "Yes, one lap of the playground is 400 meters. I walked on the outside runway, plus the distance went (to the playground) and back (home). I walked for over an hour."

B3: "But don't walk too much. This is only a test (family tracking study). Healthy comes first."

(Several days later)

B2: "11131 steps today." (B2 normally will walk around 20000 steps per day)

B3: "Mom, why you didn't have many step counts today?"

B2: "I slept over this morning, and it was too cold to go out, so I walked less today."

B3: "That is it. Don't go out for exercise in the cold morning."

(The next day)

B2: "I walked 32487 today."

B3: "Mom, you exercised too much today."

Conversations related to care could also be triggered when people shared their daily activities. For example, when an elderly couple (G1 and G2) mentioned that they walked more than usual because G2 accompanied G1 to see an ophthalmologist and get a prescription for a pair of eyeglasses, their daughter (G3) was worried about her father's (G1) eyes and asked why he had needed to have an eye test and get new glasses.

Although the middle-aged generation often gave care to other family members, they were not always playing the role of caregiver, and the elderly were not always care receivers. For example, in group E, the older participant (E1), who lived geographically separated from her daughter, often expressed care about her daughter (E2) and reminded E2 to sleep on time when she noticed her daughter was replying to messages at midnight.

Learn new features or knowledge

As Figure 4.4 shows, most of the requests for technical help were sent by older adults. They were unfamiliar with WeChat and WeRun at the beginning of the study. Their adult children then taught them how to use WeRun, how to send voice messages, and how to share daily step counts. Older adults were also curious about WeRun and wanted to learn more functions in WeChat. For example, one older participant (G2) was curious about memes that other families were using in their groups. Her daughter (G3) then explained memes to G2 and taught her how to download and send memes.

Participants could learn not only technical skills but also physical exercising tricks. They shared healthy tips, exercise skills, and other resources for their families. For example, A2 mentioned she was using a fitness application to assist her doing mat exercise. Her sister (A3) was very curious about the application, *"@A2, is Hot Fitness (the name of the fitness application) difficult to do? Can I do (use) it?"* A2 then introduced Hot Fitness to A3 and taught her how to use it, *"Hot Fitness is a fitness app. Download it through your mobile phone app store. It has a variety of fitness courses. Choose the right course for you to download, then you can start exercising… You also need to have a yoga mat."*

4.2.2 Factors limiting interactions in family tracking

While the family tracking activity encouraged communications and interactions, I found some factors could limit interactions on some occasions.

In this study, the size of the family group is an influential factor in family interaction. Participants from a bigger group interacted more than those from a smaller group in this family tracing activity. In a bigger family group where family members were not very close to each other and did not communicate frequently before participated in the study, tracking and sharing daily step counts significantly enhanced communication. However, for a smaller and closer family group where they already had routine conversations, this activity would influence their daily topics, broke the routine dialogues, and made the intuitive expression become a forced task.

Even for the family who were excited to participate in the beginning, their attention diminished as time went by. One participant (A3) noticed that their family did not speak as frequent as the beginning as the study drew to an end, *"Adults are like children, we cannot*

pay attention to certain things for a very long time. We might not be as interested in it as the beginning after seven days."

Although most the elderly had learned how to use WeChat and WeRun after several days participated in the study, some of them were still influenced by the unfamiliarity of the technology. An older participant (C1) said he could not use WeChat, WeRun, and his pedometer skillfully. Therefore, he preferred to read others' messages and listen to what others said, but was reluctant to share his own experience and feelings, *"I posted the steps counts online every day. I only like to read (other's text), only like to listen (to other's voice messages), do not like to send (messages), do not like to send things. Because I'm a little slow, I don't want to send things."*

For younger participants who were in their 20s, the reasons for the reluctance to engage were more complicated. They worried about whether the family tracking activity would invade their independence and privacy. A4, a 19-year-old college student, felt stressed and supervised by her father because her father would always "like" her on the step leaderboard. She thought the "like" meant *"I know what you have done and where you have been these days."* A4 said, *"But my father and I haven't communicated in WeChat for a long time, and we haven't talked about exercise. I sometimes suddenly saw a long list of his 'likes' to my step counts. He just 'liked' me every day. I wondered if he just wanted to get my attention, or if he deliberately found me in his contact list of three or five hundred people, and gave me a 'like'. It made me feel as if I was being watched."* Younger participants also had difficulties engaging in the conversations because of fragmented attention. It was difficult for them to engage in conversation because they lacked a whole period of time to read all

chat records and keep up with the topics. A4 said it is difficult for her to perceive information and keep up with topics because she received too many voice messages every day from her family group. Therefore, A4 just randomly picked and listened to some voice messages to briefly understand the conversation. *"I didn't know if they said something individually or they had a specific topic, and then everyone started talking. If I was going to capture the topic, I had to listen to every voice message, which was especially time-consuming. Most of the time I was in a classroom or library. It was inconvenient for me to listen to voice messages because sometimes the receiver and the external key switched automatically, then I had to listen to a voice many times."*

4.3 The influence of family tracking on physical exercise and family interactions

The first part of this section introduces covariables affecting physical exercise and family interaction. These covariables were not generated from the family tracking activity, and therefore need to be controlled. The next two parts introduce the influences of family tracking activities on individual exercise and family interaction. The last part discusses the interrelationships between individual physical exercise and family interactions.

4.3.1 Covariables affecting physical exercise and family interaction

Covariables affecting physical exercise

This study was conducted mostly in the winter of 2018 and the spring of 2019. The weather was getting warmer, so it more or less affected participants' physical exercise. When examining the impacts of family tracking on family interactions and individual physical exercise, it is necessary to control covariables such as weather and temperature.

I predicted that some of the possible influential factors related to individual exercise behaviors are individual differences, weather, temperature, and air quality. I also considered the effect of the day of the week because some participants reported that they walked less on weekends than on weekdays. In more detail, variables I predicted which could influence daily step data are minimum and maximum temperature of the day, air quality (excellent, good, mild pollution, moderate pollution, severe pollution, and serious pollution), weather (sunny, cloudy, rainy, snowy, smoggy, et.al), and participants' ID number which was a variable reflected individual differences on exercising preference. I filtered irrelevant variables by AIC in Backward Elimination regressions. Then, I conducted multilinear regression analyses to examine how the relevant variables affected participants' daily step counts.

In general, daily step counts generated by the participants (both before and after joining in the study) were significantly ($p<0.05$) related to their ID number and the weather of the day. Other factors mentioned above had no significant effects on step counts. Comparing the analyses results of different age groups, the daily step counts generated by the elderly were more likely to be affected by weather ($p<0.05$), while the middle-aged were more likely to be affected by air quality of the day ($p<0.05$) and the day of the week ($p<0.1$). Instead of being affected by cold or rainy, middle-aged participants tended to walk less on weekends or when the air quality was poor. The results show that the daily step data of the younger participants was only significantly related to individual differences.

Therefore, weather, air quality, day of the week, and individual differences are the covariables that I need to control for when examining the impacts of family tracking on physical exercise.

Covariables affecting family interaction

In section 4.2.2, I discussed several factors that could limit interactions in family tracking. Among those factors, diminished attention and the number of participants in one family group could be identified as covariables that need to be controlled. I added the number of days after joining in the study as a variable to test if the interaction decreased as their attention waned. The effects of different family sizes on the results can be included in the effects of individual differences. I controlled the impact of family size by controlling the impact of ID on the results. I also considered weather, temperature, and air quality as possible variables related to family interaction. I then filtered irrelevant variables by AIC in Backward Elimination regressions and conducted multilinear regression analyses to examine how the relevant variables related to the numbers of messages participants sent to their families per day.

The analysis result shows that the number of messages was significantly ($p<0.05$) correlated with individual differences, the number of days after joining, and the temperature of the day. By analyzing possible covariables and the number of messages sent from three different age groups, I found that the frequency of the elderly sending messages was only determined by their individual differences ($p<0.05$). After controlling for individual differences, the middle-aged participants were more likely to interact with their family members when the weather was warmer. They were also more likely to be

influenced by diminished attention. They tended to send fewer messages the longer they have participated in the study. For young participants, the frequency of sending messages increased on weekends.

To further examine the extent to which different explanatory variables related to the four primary interactions mentioned above, I conducted a group of multinomial logistic regression analyses. The frequency of the elderly and the middle-aged sharing their exercise experience and daily activity was significantly ($p<0.05$) positively correlated to the air pollution level for the day and negatively correlated to the number of days joining. They were more likely to mention their experience on heavy air pollution days. The frequency of the caregiving conversations was significantly ($p<0.05$) higher on weekends than on weekdays and were not influenced by diminished attention. Specifically, the elderly were more likely ($p<0.05$) to receive care from their families on a day of poor air quality, while the middle-aged were more likely ($p<0.05$) to give care on weekends. Compared to the possible negative effects of rainy or cold weather, participants cared more about the potential harm of heavy air pollution on their family members.

Therefore, weather, temperature, air quality, day of the week, the number of days after joining, and individual differences are the covariables that we need to control for when examining the impacts of family tracking on family interaction.

4.3.2 The influence of family tracking activities on physical exercise

Family tracking activities motivated participants to conduct physical exercise. These motivations are emotions and family atmosphere.

Emotions which motivated physical exercise

Most of the participants experienced positive emotions, such as pride, happiness, and a sense of achievement, during the study period. These positive emotions motivated them to keep exercising and achieve their daily goals. Participants were proud of themselves when they took so many steps that they were the ones who walked the most in the family, as well as they broke their record for the maximum number of daily steps.

Most of our older participants gained a sense of achievement from tracking and sharing daily step counts. Although the statistical analysis shows that their daily steps were not significantly increased after participating, their efforts on physical exercise were recognized and approved by family members around them. For the elderly, family tracking did not necessarily result in an increase in frequency, intensity, or duration of exercise but helped them experience the joy of exercise. For example, an older participant, C1, became very interested in physical exercise, rather than only regarding it as a habit. *"I really enjoyed sharing my daily in the group, receiving others' feedback, and tracking others' activities."* An older couple B1 and B2 gave a reason why they felt happy when tracking and sharing, *"This is a virtuous circle. If we walked a lot today and showed on the top of the step leaderboard, my family members would encourage us and gave us a thumb up. Then, we would feel really happy and have a sense of achievement. If we exercised regularly and in a good mood all the time, we would have a healthy lifestyle. Then, we would feel good about ourselves and keep exercising."* An elderly participant (B2) realized that her sharing of accomplishing exercise goals would encourage younger family members to exercise more. B2 said, *"My daughter once told me, she was impressed that I could walk that many steps (20000) every day. She will learn from me and start walking regularly every day."*

Besides the positive emotions mentioned above, there are other types of emotions occurred in family tracking which could motivate physical exercise, such as embarrassment. Some participants expressed their embarrassment when their step counts were still zero or they were the one who had the least number of step count. For example, participant A2 once felt embarrassed when her daily steps were still zero, *"I got up late this morning because I stayed up too late yesterday... I did a (course on) Hot Fitness after I got up... And then I stayed at home all the time. So today's step count is still zero, I'm a little bit embarrassed."* To avoid the embarrassment of sharing a step count which was far below others' steps, some of them would do extra exercise to walk more until they reached an acceptable number, *"Sometimes I was lazy and wanted to skip the exercise, but when I realized that I needed to share my data in the group, I knew I had to finish the exercise plan."*

The family atmosphere motivating individual exercise behavior

The family atmosphere of joint efforts, comparing, and competition motivated physical exercise.

Family tracking activities created an atmosphere of joint efforts to stick with exercise goals. Family members supervised and prompted each other to keep exercising. A middle-aged participant F3 said, *"Since we joined the group, we regarded this as a serious task which we had to accomplish. Therefore, this group provides a constraint for us to exercise and engage in the group."* Similar situations happened for F2, *"What I was thinking is that everyone is holding on, and I cannot slow them down. So sometimes when I felt that my step counts were not enough, I would walk a few more during my lunchtime."*

For some participants, the willingness to exercise was stronger when seeing the data of themselves and their family members. Recording and sharing daily steps in family groups motivated exercise by providing a straightforward and convenient way to compare amounts of exercise between family members. Most of the participants would compare their step counts with other family members. By comparing, some participants would reflect on themselves if they had exercised enough. A young participant (D3) said, *"Seeing others' steps would remind and encourage me to exercise, because I kept comparing myself with others. I kept this in mind every day, and I would think about running at night if I found I did not have enough steps."*

The comparison sometimes would end up as a competition. An elderly participant (C1) regarded the family tracking activity as a competition and had a desire to win, *"I admitted that I cared about the daily step rank in my family. I paid attention to the leaderboard and others' exercise progress every day. I regarded this as a competition and I always want to be the winner."* The atmosphere of competition also influenced an older couple, B1 and B2, *"Anyway, as we get older, we are willing to compete and do not want to fall behind. So, we walked a little more every day than before."*

4.3.3 The influence of family tracking on family relationship and interaction

Through the interview analysis, I found that the family tracking activity has the potential to promote family relationships and interactions by providing an opportunity for family members to understand others, express themselves, and help each other.

Notice, aware, and understand family members better

We mentioned in section 4.1.3 that participants could be aware of their family members' health and fitness conditions by observing their daily step counts. In this section, we focus on how participants were aware of their family members' conditions by observing their messages. These activities helped participants to understand better about their family members' health conditions, attitudes, and emotions.

Adult children were aware of the physical and mental condition of their parents by the text messages and voice messages sent by the elderly. For example, a middle-aged participant (A2) relied on the voice messages sent by her father (A1) to perceive her father's condition, *"I would hear my father's voice message every day as soon as he sent. I had to listen, it's a relief when I found that he's in a good mood and good health condition."*

Some participants noticed the attitudes and practices of their families towards the tracking and sharing activity. Most of the adult children noticed that their parents attached great importance to this activity. They interpreted this phenomenon as their parents regarded the activity as a task not only to be completed but also to be done well because they lacked goals and hoped to get attention. The adult children also realized that, although people of their age did not attach more importance to the activity than the elderly, they were influenced more on physical exercise than their parents. For example, C3 interpreted the influence of family tracking on his father (C1) and his brother (C4), *"I think, for my dad, his exercise performance was recognized by others, it would bring him satisfaction, which did not necessarily result in an increase of exercise time or intensity because his physical exercise had*

been relatively regular…For example, my brother may be the most obvious one. He can run ten kilometers an hour now and he runs a lot every day. He is the most obvious one."

Sharing and discussing experiences brought the family members closer and enabled the participants to capture the emotions of their families. For example, A2 was aware of her daughter's (A4) sense of achievement about being active, *"What she (A4) was most proud of is that she volunteered for two days (in a marathon competition), and then she spoke more in the group, and she walked more steps."*

Family tracking enhancing online interaction and communication

Participants felt that they communicated more with their family members after starting tracking and sharing step counts in their family group.

The family tracking activity enhanced their communication by providing a platform on which they could share their feelings and thoughts with their families anytime. All of the participating families had their original WeChat group, but they only sent messages to that group on special occasions, such as asking for help, sharing travel pictures, or sharing funny things about their babies. In the original family chat group, members often did not know what to say if they had nothing important to communicate. They were also afraid to disturb others if they sent too many messages. However, in the tracking-themed chat group, they could start a conversation at any time because they had specific topics -- daily step counts and physical exercise. The topic of physical exercise played a role of the icebreaker; the icebreaker topic then could lead to other conversations. For example, when talking about their physical exercise and daily experience, an elderly participant (E1) mentioned that she and her husband walked a lot because they went to buy a new hearing aid. Their

daughter E2 had not known this before, and she kept asking E1 why they needed a new hearing aid, if they felt uncomfortable with the old ones, and if they needed any help.

The family tracking activity promoted interactions between family members of different generations because it helped the elderly to overcome the technical barrier. In the initial interviews, we found that all of the middle-aged and the young participants contacted their family members mostly through WeChat. Only if they had something important or urgent to discuss, would they communicate through phone or in person. However, in the beginning, most of the older participants could not use WeChat skillfully. They could receive and read information, but they did not know how to send a message or make a voice call through WeChat. Participating in the family groups encouraged the elderly to learn and practice using WeChat to communicate with their family members. A middle-aged participant (G3) mentioned that she and her parents talked more than before because her parents became proactively shared and discussed in the WeChat group after they mastered the messaging functions of WeChat *"I taught them how to use WeChat before, but they often forgot. In these two weeks, they practiced every day to send text and voice messages in the group; now they fully mastered the chat functions in WeChat."*

Online interaction leading to offline interaction

We found that family tracking activities not only enhanced online communications and interactions but also promoted offline interactions between family members.

Some participants became more willing to share their feelings with their families as the activity drew to an end. Some participants expressed their desire to interact in-person with their family members during the activity. One elderly participant (A1) expressed to his

children that he would like to invite them to visit him and have dinner together, *"I went out for a walk after two o'clock and had a haircut, at least (I walked) over 5000 (steps)… I felt OK. It just I will be alone this evening, (I am) waiting to see if anyone will come back to have dinner with me."* His daughter A2 immediately replied to her father, *"I'm going back to dinner with Dad. (Smile)"*

Because of the characteristics of some physical exercise, it was difficult for people to explain and demonstrate their experiences through WeChat. Instead, they planned to meet, demonstrate, and communicate in person. In the final interview, a young participant (A4) mentioned that she would like to remind her mother (A2) to warm-up before running, and relax and stretch after running. She felt it was difficult to explain the stretch poses and skills through WeChat. A4 then planned to meet A2 to show and teach her some ways to warm-up and stretch, *"I hope my mother could remember to warm up before jogging and relax and stretch after that. But it's useless to say it now because you need to pay attention to poses and skills when you stretch and relax. It's best if we could jog together, then when we finished our exercise, we could stretch together. It is easier to teach her those poses and skills in that way so that she could prevent cramp and strain."*

It was very common that younger family members visited their parents to teach them to use WeRun and WeChat. Most of the family groups have encountered the situation where an elderly participant was not familiar with some features of WeChat and WeRun, and it was difficult for other family members to explain and demonstrate the feature through WeChat or phone. For example, B3 visited her parents (B1 and B2) several times to help them update step data from pedometers to WeRun. B3 recalled in her final interview, *"One*

day, my dad's (B1) pedometer didn't work well, he immediately asked me when would I go visit them. Dad (B1) asked me, 'why my bracelet is not in sync (with WeRun). Look at how many step counts I have in the bracelet, but how less on WeChat.' Anyway, because the elderly are a bit like children, he always says, 'I have to show my number of steps, I don't care, I just want to have this.'"

4.3.4 The interrelationships between physical exercise and family interactions

In both the quantitative and interview analyses, I found that there was a positive link between participants' physical exercise and their interactions with family members. However, it is difficult to determine causality. In this section, I discuss the bidirectional effects of individual exercise and family interactions on the same day, the effects of family interactions on individual exercise on the following day, in conversely, the effects of individual exercise on family interactions in the following day.

The bidirectional effects of individual exercise and family interactions

With an aim to understand the bidirectional effects of individual exercise and family interactions within the same day on each other, I conducted a group of multilinear regression analyses with the response variable as the participant's daily step counts and the explanatory variable as the number of messages the participant sent on the same day. According to previous analyses, some possible covariables which need to be controlled are individual differences (ID), the number of days after joining in, day of the week, weather, air quality, and daily temperature. While I did not find a significant relationship between the number of messages and the step counts generated on the same day for all three age groups combined, I did find a significant ($p<0.05$) link between these two variables for the

middle-aged and for young people. The step counts generated from the middle-aged participants was significantly positively correlated to the number of messages they had sent. For the young participants, the relationship was negative.

To further examine the relationship between different types of interactions and individual exercise, I conducted a group of multinomial logistic regression analyses. The explanatory variables are categorical variables and describe whether the participants had engaged in the four primary types of interactions. The response variable is the participant's step count on the same day when the interactions happened. The possibility of sharing exercise experience was significantly ($p<0.05$) negatively correlated to the step counts taken on the day. The possible explanations emerged from interviews and participants' conversations. They were more likely to share their exercise experience if the amount of exercise could not be measured by step counts, such as strength training, biking, and yoga. For example, a middle-aged participant (F3) went for a bike riding marathon. He shared his experience with his family, *"I walked less than 1000 steps today. However, we left Weinan City around 8:40 this morning and rode back to Xi'an. We had been riding all the time, so the number of steps was less. When I came back, I packed up and went to bed, and when I woke up, my eyes were swollen. After riding 320 kilometers for two and a half days, I'm really tired."*

Except for the middle-aged, who were the driving force behind giving encouragement, the possibility of receiving encouragement for the other two age groups was significantly ($p<0.05$) positively correlated to their step counts on the day. I found a near significantly ($p<0.1$) negative link between the care messages the elderly had received and their step counts on the day. The results are consistent with what participants expressed in

interviews. Participants would ask their family members if anything went wrong when they saw that their family members' daily step counts were much lower than expectations.

These results support a positive link between individual exercise behaviors and family interactions on the same day. It is hard to say which one came first or if they mutually influenced each other. Our next step is to test if there was any causal relationship between these family interactions and individual physical exercise.

Family interaction influencing individual exercise

To examine the effects of family interactions on individual exercise, I analyzed participants' daily step counts taken on a given day and their interactions that happened a day before. I considered the step data generated on the same day when the interactions happened as a controlled variable.

I first conducted a group of multilinear regression analyses with the response variable as the participant's daily step counts taken on a given day and the explanatory variable as the number of messages the participant sent a day before. The analyses results show that, for all age groups, step counts taken on a given day had a strong ($p<0.05$) positive correlation with the number of messages sent a day before, which means that the more participants had interacted with their families, the more they tended to walk on the next day.

I then conducted multinomial logistic regression analyses to examine the effect of different types of family interactions on participants' exercise. In this analysis, the response variable is the participant's step counts taken on a given day. The explanatory variables are categorical variables, and describe whether the participants had engaged in the four

primary types of interactions a day before. I found that receiving encouragement from family members could prompt participants to walk more on the next day. Participants' daily step counts were positively correlated ($p<0.1$) to the encouragement they had received a day before. This relationship became strong ($p<0.05$) after excluding the middle-aged participants who only received 10% of all encouragements. The result demonstrates that receiving encouragement from family members motivated participants to engage in physical exercise the next day.

We also found in the interviews that family members' support and encouragement could help participants overcome boredom and laziness toward exercise. F3 said that the physical exercise was tedious, but sharing experience and getting feedback from others helped him to persist, *"The most obvious thing was when I exercised at the gym, during my exercise, I really hoped that, for example, sending a picture or something of me doing exercise and (letting others) give it a 'like', would at least be a boost and a motivation for me. After all, I exercise five days a week, after all, I have to fight with my body and my fatigue."* Compared to the middle-aged, the elderly were more eager to be encouraged. C1 expressed the disappointment of his efforts not being recognized, *"I was the first [one who had the largest number of daily steps] most of the time, but there were few 'likes'. Grandma (C2) walked less, but once she walked 17 or 18 thousand steps, there were a lot of people 'liking' her. I was the number one every day, but no one 'likes' me. Grandma (C2) walked less, I exercised during all my life, I never rest, I walked the most every day, but no one 'likes' me. It's just that I'm not very popular."*

Increasing exercise prompting family interactions

To study the effects of physical exercise on family interactions, I conducted a group of multilinear regression analyses between the number of messages participants had sent on a given day and their step counts taken a day before. The controlled variables included the step data taken on the same day as the interactions happened. I found a significant positive correlation ($p<0.05$) between the number of messages sent on a given day and the step counts taken a day before. The result shows that the more our participants exercised, the more they would interact with their families the next day. For example, a young participant (D3) noticed that as long as she exercised, she would remember to talk in the group. D3 thought the communication after exercise was important. She said, *"Sharing and interacting with my parents helped me to recall the exercise experience instead of obsessing with the statistics."*

Oddly, for young participants, the number of messages they sent was negatively correlated ($p<0.1$) to the step counts they walked on the same day, but positively correlated to the step counts taken the day before. It seemed that the young people were more likely to share their experience a day after they exercised. There were no explanation for this phenomenon mentioned in interviews.

CHAPTER 5 – DISCUSSION

The findings presented the influence and effects of tracking as a family on participants' exercise behaviors and their family interactions. In this chapter, I will further categorize the emergent themes by the different stages of personal informatics models (Li et al., 2010; Epstein et al., 2015). The results illustrate specialties, challenges, and opportunities that present themselves when designers aim to support fitness tracking for intergenerational families. Tracking as an intergenerational family is different from tracking as an individual: because (1) participants need to reflect on, interact with, and take action based on not only their own data but also their family members' data, and (2) different generations have different expectations and preferences with fitness tracking and social practices.

5.1 The differences between tracking as a family and tracking as an individual

Prior research had developed models to identify stages of personal informatics. Li et al. [24] summarized an iterative process model as composed of five stages: preparation, collection, integration, reflection, and action. Epstein et al. [9] categorized a lived informatics model based on Li's model by grouping the stages of collection, integration, and reflection, and adding stages of deciding, selecting, lapsing, and resuming. This section uses these models to demonstrate the differences between tracking as a family and tracking as an individual. At the stage of integration and reflection, participants could access the information generated by their family members. At the stage of action, they started to take action based on the reflection results of their own data (e.g. step counts and sent messages) as well as their family members' data. Similarly, at the stage of lapsing, people could either stop tracking or quit the online family group.

5.1.1 Collection and Integration

In Li et al.'s model, the stage of collection is when people collect information about themselves, and integration is the stage where the information collected is prepared, combined, and transformed for the user to reflect on. In this study, participants were asked to share their daily step counts in their family chat group within the WeChat app. Fitness tracking tools (e.g. WeRun, the mini-program, and participants' pedometer bands) automatically collected and integrated their daily step data. Therefore, the stage of collection and integration were system-driven in this family tracking activity. Participants in this study did not track on behalf of their family members. While at the stage of integration, everyone's data is processed separately but presented together.

The findings support the importance of gaining trust from users toward the results of collection and integration. In a family context, the accuracy of tracked data is essential because it reflects not only individuals' conditions but also their cared ones'. Family members reminded, cared for, and encouraged each other based on their reflection on the collected information. They expected the recorded step counts to be basically accurate.

When designing tools to support family tracking, it is necessary to make sure the collection and integration results are accurate and trusted by users. Some of my participants were looking for a description of how WeRun collected and processed their data because sometimes they found that the results shown by WeRun did not match their expectations. In previous studies [6, 18], researchers found that vague information could help participants make better decisions and alleviate anxiety when the demonstrated information did not match their knowledge. Designers could provide brief introductions of

how they processed data as well as use a range or a percentage instead of the exact number to represent the results.

It will be helpful if a tracking tool could identify unusual data caused by internal factors (e.g., the health or mood of participants) and unusual data caused by external factors (e.g., weather and technical issues). In this study, unusual data, such as too many or too few steps, triggered interactions between family members. Most of the time, the unusual data was caused by external factors, but sometimes it meant that the producer of the data might be in a different condition than usual, thus would need help. Besides showing data visualization or statistical results, it will be helpful if the tool could eliminate noise, and send reminders to users when detecting abnormal conditions.

5.1.2 Reflection

The reflection stage is when users reflect on their personal information. When tracking in a family context, this stage may involve checking, exploring, and interacting with information collected from not only the individual but also their family members.

Many studies focused on the stage of reflection, which is an essential step to health behavior change. In this stage, users enhance their self-awareness [1], set realistic behavioral change goals [23], and increase self-control while promoting positive behavior [25]. These findings also apply in the family setting. Participants enhanced their awareness of their family members. They knew the number of daily step counts that their cared ones need to take to maintain health. Comparing step counts among family members also helped participants to increase self-control while promoting positive behavior.

In this study, reflecting on family members' data helped participants to know better about their family members' health conditions, habits, and emotions. In final interviews, most participants could tell their family members' exercise habits more precisely than before. They could perceive others' schedules by observing their step counts.

For some participants, the willingness to exercise was stronger when seeing the data of themselves and their family members. Tracking and sharing daily step count in family groups motivated exercise by providing a straightforward and convenient way to compare the amount of exercise between family members. By comparing, participants would reflect whether if they had exercised enough.

The challenge in this stage is to integrate data across family members to support reflection. However, family members, especially those from different generations, have different or even competing expectations and preferences. Designers need to be careful with potential tensions and negative impacts of family tracking. In section 5.2, I will discuss the differences between the three age groups in family tracking in detail.

5.1.3 Action

The action stage is the stage when people take action with their findings of reflection. In this study, participants changed actions related to physical exercise as well as family interactions.

After reflecting on their daily step data, participants could realize how many steps left to their daily goals so that they could adjust their schedule to take some extra walk to meet the goals. Konstanti and Karapanos [21] categorized three types of action changes towards

increasing walk activities. I found two of these categories also apply in the family setting: directly increasing walking distances (e.g. D2 went to a further restaurant for lunch to take some extra walk.) and switching habits to ones that promoted physical activity (e.g. A2 and E2 chose to bike or walk to work instead of taking buses or drive). The third type of action change is actions triggered by users' interactions with the device. In the family setting, action changes towards increasing walk activities can also be triggered by interactions between family members (e.g. D3 jogged at night after realizing that she did not have enough steps when compared with others). Besides trying to achieve a certain amount of step counts, they also learned from each other to take action to avoid potential sports injury and over-exercising.

Participants also changed their actions related to family interactions. I categorize actions observed in this study as share, care, and cheer.

Share

Participants would share their experience, understanding, and feeling to others after reflecting on their daily step counts. The findings show that the more participants exercised, the more they would share with their families the next day. Similarly, the more they had talked with their families on a given day, the more they tended to walk the following day.

Most participants shared their exercise experience every day. They not only posted their daily step counts but also explained what activities had generated these steps. They shared health tips, exercise skills, and methods of maximizing the fitness effects of daily activities with their families. When participants did exercises that could not be captured by

pedometers, they would share more about what they had done and why the data could not represent the actual amount of exercising. Some participants became more willing to share their feelings with their families as the activity drew to an end.

In this study, participants tended to share their experiences at a fixed time of the day. Most of them started to talk to their families between 8 pm to 11 pm. When asked when they usually sent messages to their family group, a middle-aged participant (F2) answered, *"It must be late at night, because at night (F3 interrupted F2 and said, 'we're free to spend time on cell phones') it finished collecting the number of steps of the day... Sometimes I forgot at night, I then would make it up on the next day morning."* Another middle-aged participant E2 said, *"I would remember to talk in the group when I received the summary of daily steps sent by WeRun at 10 pm every day."* Some older participants liked to send their first message of the day before lunch, which is the time when they finished their morning exercise.

Care

Participants expressed care to their families when they noticed abnormal patterns from their families' information. The frequency of caregiving conversations happened did not decrease with the increase in the number of days they had participated in this study. Participants paid attention to their family members' conditions all the time during the family tracking activity.

Based on understanding the conditions of each other, participants would take care of their family members. Conversations related to care were triggered when people observed unusual events – bad weather, too many or too few daily steps, special schedule and experience, and messages sent at an unusual time. For example, when someone in the

family (mostly the elderly) walked too many steps, their families would express care to the family member and remind them not to exercise more than they need.

Cheer

Participants would cheer their families when they found their family members to have achieved exercise goals, showed high step counts, or mastered a feature of WeRun. They cheered each other by sending texts, memes, and thumbs-up.

The analysis results show that receiving encouragement from families could prompt participants to take more steps on the next day. Family members' support and encouragement could help participants overcome boredom and laziness in order to keep exercising.

One design requirement at the stage of action is to support and encourage interactions among family members. Designers can remind and encourage users to speak in their chat groups by sending them a summary of daily fitness information at night. They can use leaderboards, badges, or virtual rewards to remind family members to cheer for each other when someone achieved their goals or made significant progress. It will also be helpful if the tool could send reminders to users when detecting abnormal conditions.

5.1.4 Lapse

The lapsing stage occurs when one stops actively using a self-tracking tool. In a family context, lapsing could mean stopping tracking personal data (e.g. stopping using WeRun) or stopping sharing collected information with family members (e.g. quitting from the family WeChat group).

In this study, one factor led to stopping using WeRun was the realization that a single standard was not enough to reflect physical exercise. Some participants felt that they had paid more attention to the statistics than the experience itself. Their purpose had become one of maximizing the number of steps instead of enjoying physical exercise or maintaining health.

Factors that could lead to quitting from the family WeChat group were diminished attention and interest. Even for the participants who were excited in the beginning, their attention diminished as time went by. For a closer family group where they already had routine conversations, this activity would influence their daily topics, broke the routine dialogues, and made spontaneous expression become a forced task.

The challenge in this stage is that different generations tend to have different reasons for the lapse. Sometimes, these different reasons are even contradictory to each other. For example, the elderly preferred using voice messages to communicate with others, while the young people felt listening to voice messages time-consuming, and thus they preferred using text messages. In the next section, I will discuss the differences between the three age groups in family tracking.

5.2 The different performances among the three generations

5.2.1 The Elderly

The older adults who participated in this study were healthy or had slight functional impairments but remained autonomous. Even so, the physical conditions of the elderly were diverse, so the range of daily step counts taken by them was various. For the elderly,

family tracking did not necessarily increase the frequency, intensity or duration of exercise but helped them experience the joy of exercise.

Elderly participants' daily step counts generated during family tracking did not differ significantly from before the activity. One reason mentioned in interviews is that most of the elderly already had routine exercise habits. It was difficult for them to change their decade-long habits in several weeks. Although they did not walk more than before, their efforts on physical exercise were recognized and approved by family members. Therefore, they had gained a sense of achievement from tracking and sharing daily step counts.

In this study, some older adults were influenced by the unfamiliarity of the technology. WeRun can import fitness data from compatible fitness tracking applications and automatically share real-time fitness data with family members. However, some participants, especially the elderly, preferred to wear a pedometer band instead of carrying a mobile phone everywhere. They then had to pair their pedometer band to their mobile phone by Bluetooth to update the records to WeRun. Although users bear little responsibility in acquiring, processing, visualizing, and sharing the collected step counts, it was still a challenge for the elderly to update their records from pedometers to WeRun.

When the elderly found that their WeRun records were far less than they had anticipated and they did not know how to fix it, they would send messages in the group to ask for help. They attached great importance to the family tracking activity and regarded the activity as a task not only to be completed but also to be done well, so they would feel disappointed if their step counts were not recorded because of technical issues.

When designing fitness tracking applications for the elderly, designers need to help them gain a sense of achievement, reduce the complexity of procedures, guide them to learn and practice the features, as well as provide a convenient platform for them to ask for help from their families.

5.2.2 The Middle-aged

Compared to the elderly, the middle-aged had more similar physical strength, so they tended to have similar levels of daily step counts. It turned out that the middle-aged people were most influenced by the family tracking activity on the aspect of physical exercise, although they claimed that they did not attach much importance to it. However, they were also more likely to be influenced by diminished attention, as they tended to send fewer messages the longer they had participated in the study.

Tracking and sharing daily step count with family members promoted middle-aged participants to engage in physical exercise. Most of them chose to change commuting ways to increase their physical exercise. For some middle-aged participants who had more free time, the changes were more obvious.

The findings show that they walked less on weekends because they had to go to work on weekdays and preferred to have a rest at home on weekends. Middle-aged participants tended to walk less when the air quality was poor, because they believed that polluted air is more harmful to their health than the exercise would be beneficial.

The middle-aged group was the driving force of their family interaction. All of the messages of giving encouragement and 90% of the messages of giving care were sent from the

middle-aged. Besides support their families online, they often visited their parents for the purpose of teaching them to use WeRun and WeChat.

It would be helpful if a family tracking tool could support middle-aged users by motivating them to track and share, providing advice of maximizing the fitness effect of daily activities, and supporting them to assist the elderly users.

5.2.3 The Young

Compared to their parents and grandparents, who would attach more importance to the collective value of their family, the young participants would pay more attention to their independence. The young participants were also more familiar with recent technologies. Instead of finishing tasks of the family tracking activity, they had their own way to track and share daily step counts, such as taking screenshots of the WeRun leaderboard, taking pictures of their pedometer, and sharing more vivid integration results from other fitness applications.

When reflecting on others' messages, it was difficult for young participants to engage in conversations because they preferred communicating with texts and memes, but the other two age groups preferred using voice messages. The young participants reported that they did not have time to listen to every voice message and keep up with the topics. They also worried that the family tracking activity would invade their independence and privacy.

It is a challenge to support all generations who have different expectations and preferences with fitness tracking and social practices. Designers need to be mindful of conflicts and potential tensions between the three age groups.

CHAPTER 6 – CONCLUSION

This study focused on a system of intergenerational family tracking and sharing fitness data to maintaining or improving the health of the entire family. I conducted a mixed-method study based on the usage of WeRun with eight intergenerational families (27 people in total). This study involved interviews, chatlog content analyses, and step data analyses. I found that family tracking activities motivated participants to engage in physical exercise and family interactions. Participants used the number of steps taken by them and their families as a proxy to help them quantify daily activities, understand exercise patterns, and measure health conditions. In the family online chat group, they talked about physical exercise and daily activities, expressed encouragements and concerns, and requested for help. However, some participants were concerned about potential privacy and independence issues. They also worried about the potential health issues resulting from becoming motivated by data to exercise beyond the level that would be appropriate. These results illustrated that designing to support fitness tracking for intergenerational families is unique and challenging because: (1) participants need to reflect on, interact with, and take action based on not only their own data but also their family members' data, and (2) different generations have different expectations and preferences with fitness tracking and social practices. Therefore, designers need to be mindful of conflicts and potential tensions among the three age groups.

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APPENDIX – IRB STUDY INFORMATION SHEET

University of California, Irvine
加州大学欧文分校
Study Information Sheet
研究信息说明
Social Media Use for Physical Fitness among Chinese People
针对中国用户通过社交媒体的健身设备使用的研究

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- You are being asked to participate in a research study to understand Chinese people's practices of using social media to track and promote physical activities.
- 您被邀请参与一项研究，研究目的是了解中国用户使用社交网络来追踪健身运动状况。

- Your family group is eligible to participate in this study if there are at least 3 members in the group; all are Chinese; at least 18 years of age; use social media and fitness tracking devices; and at least one member is 60 or older.
- 如果您的家庭符合以下条件，则您满足参与此项研究的条件：至少 3 名 18 周岁以上的成员；全部说中文；使用社交网络和运动追踪设备；至少有 1 名 60 周岁以上的成员。

- The research procedures involve audio-taped interviews and focus group interviews that will last approximately half of an hour online or at a location convenient for you, and online participant observation of your messages and fitness-related activities on a WeChat group. The study will last two weeks, and interviews and focus groups will take place at the end of the study. There will be also an interview at the beginning of the study.

- 这项研究会涉及到大约半小时的在线访谈和焦点小组访谈，也可以在您觉得比较方便的场所的访谈，访谈将会被记录。这项研究也会涉及到对您与健身有关的微信活动的在线观察。整个研究将经历两周周时间。研究人员会在研究的开始与最后对您进行访谈与小组访谈。

- Possible risks/discomforts associated with the study are that you may get tired or bored during the interview. In addition, there is a potential for breach of confidentiality.
- 您可能会在研究中感受到疲劳或者厌倦。 这项研究也有可能会侵犯您的隐私。

- There are no direct benefits from participation in the study. However, this study may help you understand your motivation behind sharing fitness data and further benefit future goal-setting and strategy-making.
- 您的参与不会为您带来直接的收益。但是这项研究可能会帮助您了解您分享运动健身数据的动机，并且有益于您对于未来的运动健身的目标设定和决策制定。

- You will not be compensated for your participation in this research study.
- 您的参与不会得到金钱补偿。

- All research data collected will be stored securely and audio recordings will be kept on researchers' computers. These data will be transcribed within one week after the interviews are recorded, and destroyed after the publication/presentation. Participant names will not be published; instead we will use pseudonyms.
- 所有数据都会安全保存，访谈录音会被保存在研究人员的电脑上。这些数据在访谈之后一周内会誊写出来，并且在相关论文发表或相关陈述做完之后销毁。我们不会公布参与者的姓名，而会使用假名代替。

- The research team and authorized UCI personnel may have access to your study records to protect your safety and welfare. Any information derived from this research project that personally identifies you will not be voluntarily released or disclosed by these entities without your separate consent, except as specifically required by law.
- 为保护您的安全和利益，只有本项目研究人员及经加州大学欧文分校授权的人员有权查看与您相关的研究数据。本研究项目中任何与您身份相关的信息在法律要求的情况之外不会未经您允许而被公布或泄露给第三方。

- If you have any comments, concerns, or questions regarding the conduct of this research please contact the researchers listed at the top of this form.
- 如果您有任何关于这次研究的评论、顾虑或者问题，请通过页首的联系方式来联系研究人员。

- Please contact UCI's Office of Research by phone, (949) 824-6662, by e-mail at IRB@research.uci.edu or at 5171 California Avenue, Suite 150, Irvine, CA 92617 if you are unable to reach the researchers listed at the top of the form and have general questions; have concerns or complaints about the research; have questions about your rights as a research subject; or have general comments or suggestions.

- 如果您有对此项研究的一般问题、疑惑、投诉、关于研究参与者的权利的问题、评论和建议，却无法通过页首的联系方式联系到任何研究人员，请通过以下方式联系加州大学欧文分校研究办公室。电话：(949) 824-6662 邮箱：IRB@research.uci.edu。地址 5171 California Avenue, Suite 150, Irvine, CA 92617。

- Participation in this study is voluntary. There is no cost to you for participating. You may choose to skip a question or a study procedure. You may refuse to participate or discontinue your involvement at any time without penalty. You are free to withdraw from this study at any time. If you decide to withdraw from this study you should notify the research team immediately.
- 参与此项研究为自愿行为。您不需要任何花费来参与这项研究。您可以选择跳过任何问题或者研究步骤。您也可以拒绝参与或者在任何时候无需赔偿地终止参与。您也可以在任何时候退出研究。如果您决定退出研究，请您及时通知研究人员。