Peer Influence on the Engagement of Fitness Tracker Usage: A Diabetes and Obesity Study

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Abstract— **Maintaining a physically active lifestyle is important for diabetic and obese patients, but how to motivate them to exercise and engage them in the long run remains a challenging issue. We aim to motivate their activities using fitness trackers and prevent relapse using peer influence. We conducted a study with diabetic and obese patients who used an activity tracker for four months. The 16 patients participated either as an individual or with a buddy. During the first month, most participants reported that they were motivated to conduct moderate-intensity activities. In the following three months, their number of steps significantly dropped, but the decrease is higher in the Individual condition than the Peer condition. The frequency of activity tracking slightly increased for patients exercising with a buddy, but significantly decreased for those participating as individuals. Patients with a buddy reported that competition, working out together, and nudging each other motivated them to exercise and keep monitoring their physical activities.**

Keywords*— *physical exercise; activity tracker; engagement; peer influence; diabetes; obesity

I. Introduction

Type II diabetes, which accounts for around 90% of all diabetes worldwide, has become a prevalent epidemic in the recent decades [21]. The marked increase in the prevalence of type II diabetes coincides with the alarming rise in obesity [8, 9, 20]. Google's newly established healthcare lab (Google Life Sciences) has made diabetes its major target and is actively developing contact lenses to monitor glucose levels from tears [19]. Academic researchers are also designing and evaluating applications to empower diabetic patients to proactively monitor their health and change their lifestyles.

Meanwhile, according to the World Health Organization, a large proportion of diabetes and obesity cases are preventable with healthy lifestyles, such as maintaining normal body weight and engaging in regular physical activities [23]. However, it is challenging for patients to integrate physical activities into their daily lives [16], and even more difficult to for them to prevent relapse and maintain physical activities in the long run [20]. One promising solution comes outside the context of diabetes research is activity tracking and persuasive technologies. These technologies are demonstrated to effectively motivate general users to exercise by making them aware of their activity levels. However, recent studies showed mixed findings regarding whether or not users sustain in their use of activity trackers in the long run [4, 7].

In this study, we aim to investigate the effectiveness of these technologies in motivating *diabetic and obese patients*. Additionally, inspired by findings on the positive roles of peer influence in behavior change, this study also seeks out to investigate whether peer influence helps diabetic and obese patients sustain monitoring their physical activities.

We conducted a four-month user study with 16 diabetic and obese patients who used an activity tracker by themselves or with a buddy. Our results show that participants became aware of their sedentary lifestyles and started to perform more activities. We also found that the levels of exercise decreased after the early acquisition phase, but peer influence helped participants prevent relapse in monitoring activities. Our study validated previous findings on the effectiveness of activity-tracking technologies and social influence, and further applied those findings in the diabetic and obese care. We also derived implications for transferring behavior-change technologies for the general population to patients.

II. Related Work

A majority of current technologies that support obesity and diabetes management focus on weight management, glucose monitoring, decision support [13, 16], and lifestyle support [2]. Regarding lifestyle support, in particular, having a physically active lifestyle results in significant reduction in obesity and type II diabetes development [20]. However, it is difficult to introduce exercise habits into diabetics' sedentary lifestyles and exercise habits tend to relapse in a short time [16, 20]. According to Whittemore et al., the main reasons for inactivity included perceived difficulty in exercise, feelings of tiredness, multimedia distractions, lack of time, and lack of facilities [20]. Few patients with diabetes participate in physical activity. Even

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for those who do, the level of intensity is low, and many factors distracted patients from exercise [18].

Outside of the context of diabetic research, one promising solution is the recent rise of activity tracking tools and persuasive technologies [5, 12]. A few studies also examined the situation of long-term engagement of the activity tracking technologies. Fritz et. al [7] found that users who had already adopted activity monitoring devices for a long term (e.g., 3 to 54 months) continued to derive value and motivation from the devices. By contrast, Clawson et al.'s study revealed disengagement and abandonment issues of fitness trackers [4]. A recent survey showed that one third of Americans who own a wearable device stop using it within the a few months [11]. These studies target the general population. Researchers have been actively designing technologies that motivate physical activities to prevent diabetes and obesity [17]. However, patients' engagement in monitoring their physical activities remains underexplored.

Recent work has identified peer influence as an essential motivator for users to perform physical activities in designing pervasive fitness applications [3, 5]. Peer influence, such as peer support, competition, cooperation, and sharing activity data, has been a clear motivator for wellness activities [3, 5, 15]. Regarding diabetic patients, clinical research also recommended that peer support provided by patients with same symptoms [20] as an important strategy to prevent relapse. Such support provides diabetics with psychosocial, emotional, appraisal and informational assistance in lifestyle changes [20]. In a few studies, peer support was associated with statistically significant improvements in glucose level control, body mass index (BMI), physical activities, and depression [6]. However, the effectiveness of peer support in engaging obese and diabetic patients in physical activities in the long term is understudied.

In this study, we aim to investigate the effectiveness of activity trackers in motivating *diabetic and obese patients* to exercise and the effects of peer influence in preventing relapse.

III. METHODOLOGY

A. Study Design

We used a mixed of within-subject and between-subject design to investigate whether participants' activity monitoring change over time and whether peer influence helps patients maintain a physically active lifestyle. The four-month study consisted of a one-month early acquisition phase (Phase I), followed by a three-month follow-up phase (Phase II) [20]. These two phases were meant to reflect the natural setting when a patient newly adopts a device and after using it for a longer period of time. Each patient served as their own baseline to compare the effects of early acquisition and long-term usage. To study how peer influence might impact patients' use of activity trackers, we divided participants into two experimental conditions:

- **Individual**: participants use activity trackers on their own;
- **Peer**: participants use activity trackers with another individual.

B. Participants and Materials

We recruited 21 patients from a primary healthcare center in a large city in Switzerland. They could have either joined the study alone or invited their spouse or a friend. Five patients withdrew from the study due to personal reasons. In the end, 16 patients participated in the study, including eight participants in the Individual condition and eight participants in the Peer condition (two pairs of friends and two couples). The participants comprised of eleven diabetics (five were also obese) and five obese and overweight. Among them, five were males and eleven were females, and their ages ranged from 25 to 73.

We provided each patient with a Fitbit One tracker as the experimental tool as well as the incentives for the study for multiple reasons. First, the tracker is unobtrusive and convenient to wear, and users can easily attach it to their clothes. Second, it provides relatively comprehensive data about physical activities, e.g., the number of steps and stairs, and calories burnt. Most importantly, Fitbit provides social features that enable users to add friends, view each other's steps, and send messages.

C. Procedure

Before the study, we invited each participant to the healthcare center for an information meeting. We briefed them about the goal and the procedure of the study. They signed a consent form and filled in a demographic questionnaire. We then interviewed them about their disease management and expectation for healthcare technologies. At the end of the meeting, we helped them set up a Fitbit account and explore the device. To reflect the natural setting when a patient uses a device, we told them that they could use Fitbit at their own will and could stop at any time. We also told them that we might follow up with them to understand their usage. We scheduled the second individual meeting after they used Fitbit for one month and asked them about their experience using Fitbit. We then contacted the patients for the third meeting three months later (when they have used the Fitbit for a total of four months). Having the two-phased study, we intended to learn whether participates kept using Fitbit and whether the device brought any changes to their lives in a longer period. The meetings were conducted in the patients' native language – one of the Swiss official languages. At least two researchers were present for the interviews to interact with the patients and take notes. All the interviews were audio-recorded.

D. Data Analysis

Participants' daily number of steps in the four-month study was collected using the Fitbit API. We employed the variable *tracking_status* to indicate whether a user is using Fitbit on a particular day. Specifically, we assume that as long as a user is wearing Fitbit, their daily step count will be larger than zero, and *tracking_status=1*; otherwise, the participant is not wearing Fitbit that day, and *tracking_status=0*. We conducted Linear Mixed-Effects Model (LMM) analyses in SPSS to compare users' usage and exercise levels in early acquisition and long-term phases and the impact of peer influence. LMM handled random and fixed effects and was appropriate to use since our participants had repeated measures over days of their number of steps. With *condition* (individual/peer) as a between-subjects variable, and *phase* (I/II) as a within-subject variable, we entered interaction terms of *condition x phase*. These two variables were fixed effects. Participants were as random effects. We first conducted an analysis by entering *tracking_status* as a dependent variable to compare the usage frequency of Fitbit tracker, defined as the mean of tracking_status. We then conducted a separate analysis by entering *steps* as a dependent variable to compare the number of steps.

In addition, we analyzed the one-month and the four-month interviews. We did so by transcribing the audio recordings and translating the transcription into English. Three researchers iteratively coded the qualitative data to find and reached a consensus on any salient issues related to the motivation, engagement, and use of Fitbit over the course of the study.

IV. Results

Overall, patients mentioned that Fitbit motivated them to exercise. The mean number of daily steps when they use Fitbit was 4477.2 (SD=4095, Max=22541, Min=4). We present patients' usage of fitness trackers during early acquisition phase based on interview data (Sect. IV.A). We then compare their usage and activity levels in early acquisition and follow-up phases (Sect. IV.B) and present the impact of peer influence in helping patients sustain in activity monitoring (Sec. IV.C) using quantitative results. We also report interview results to complement and explain the quantitative results.

A. Early Acquisition Usage

During the early acquisition usage phase (Phase I), some participants reported visible health and behavior changes during the first month. For example, P20 lost four kilograms since she started using Fitbit and intentionally walked more. P13, who is obese and diabetic, managed to reach an average of 70,000 steps per week, which he considered challenging to do in the past. P19 reported after the first month of Fitbit use: *"I always feel good after walking, and my glucose level becomes more regulated*." P10, who is in his 60s, reported, "*I am trying to exercise more because as I grow old many kinds of diseases appear. As I walk, I feel better*." Participants responded positively towards using activity trackers to motivate them to exercise.

Patients have been deliberately making small changes that enable them to exercise more. Some intentionally walked for some distance that used to be fully covered by public transportations. Some patients did not change their behavior all of a sudden. Instead, they chose to gradually reduce the proportion of laborsaving methods (e.g., buses and elevators) and increase the proportion of physical activities (e.g., walking and taking the stairs). As an example, P4 reported, "*The bus stop is just in front of the office but I decided to get off at the previous stop. I can walk slowly to the office."* Participants discovered that daily routine activities could lead to increased number of steps. They started to plan physical exercise while conducting their normal daily activities. Some participants, who used to consider physical activity as intensive training that required them to allocate a large chunk of time, in specific locations and with professional coaches, now discovered that moderate-intensity exercise could be pervasive and fulfilled within their choices.

B. Engagement in Long Term Usage

To study patients' engagement in activity monitoring in the long run, we compared the frequency of using Fitbit in Phase I and II. We studied the 16 participants who remained in the whole course of the study. The LMM test showed a significant main effect of *phase*: F(1,1582)=6.89, p=.009, Mean(I)=.833, SE=.075, Mean(II)=.747, SE=.075, meaning that the mean usage frequency is significantly lower in Phase II compared with Phase I. Thus, the patients' frequency in monitoring activities significantly dropped from the early acquisition phase.

We then compared users' number of steps in Phase I and II. Table I shows the mean steps of the two conditions in the two phases. We found a significant main effect of *phase*: F(1,1581)=25.3, p<.001, Mean(I)=5056, SE(I)=783, Mean(II)=4549, SE(II)=782, showing that daily step count significantly decreased from Phase I to Phase II.

TABLE I. Mean (Std. Error) of Daily Steps and Usage Frequency.

	Phase	Individual	Peer	Overall
Steps	I	5207 (803)	5379 (802)	5293 (567)
	II	3890 (786)	4734 (788)	4312 (556)
Usage	I	0.809 (0.07)	0.823 (.077)	0.816 (.055)
	II	0.686 (.075)	0.842 (.076)	0.764 (.053)

We then analyzed interview data to check the reasons for the decrease of usage frequency and step count. The main theme that emerged was the novelty effect [3] in the early acquisition period when participants started to use a technology to quantify their physical activities. For example, P19 mentioned after the first month of usage: *"It gets quite addictive to watch and to know every moment of the day, how many steps I have. I noticed that no one actually knows how many steps one usually have during the day, suddenly it was quite indicative."*

Participants also tended to forget about wearing Fitbit at some point. As P19 reported: "*It is a bit small. When I get old, I started to forget about things and couldn't find it. ... We are a big family and we have two phones, a lot of clothes at home and also many newspapers across. There* *needs to be a fixed place where you can put it [Fitbit] in order not to lose or forget about it. It would be better if it were integrated with the phone, or something that I will not forget it if I change clothes*." For another example, P21 forgot to wear Fitbit for a few days because he had been charging Fitbit and left it plugged in three or four days. Some participants did not wear it because of undesirable weather or unexpected life events. For example, P2 said: "*It fell a little bit in the wrong month with the holidays and all. I left three weeks to look after my mother who has Alzheimer's. So I did not wear it, but soon after I tell myself I walk like that brand a little more.*" Participants also tended not to wear Fitbit when they were physically inactive. As P10 said: *"I was not very motivated during the days when I was ill.*" Therefore, forgetting and staying physically inactive are the main reasons for the days when users did not wear Fitbit and monitor their activities.

C. Peer Influence

We compared the Individual condition and the Peer condition when using activity trackers in the two phases. The usage frequency in the Peer condition was slightly increased (2%) from Phase I to Phase II while decreased in the Individual Condition (12%). The results of the LMM analysis indicated a significant phase x condition interaction: $F(1,1582)=13.1$, $p<.001$, meaning the level of decrease is significantly different in two conditions. In other words, patients in the Individual Condition had experienced significantly more decrease of the usage frequency than those the Peer condition.

The number of daily steps decreased from Phase I to Phase II for both the Individual condition (Δstep = –1317) and the Peer condition (Δstep = –645). The results of the LMM test show a trend of significant interaction effect of *condition x phase*: $F(1,1581)=3.0$, $p=.085$, the decrease from Phase I to Phase II is marginally higher in the Individual condition than in the Peer condition.

The qualitative data provided evidence of how buddies nudged each other to exercise or wear Fitbit when they forgot. P1 said that her buddy frequently encouraged her to walk more: "*If it's sunny or a little warm, I may want to walk, but otherwise, I'm less tempted. I'm not the outdoor type. I tend to hibernate in winter. [name of her buddy] sometimes noticed that and forced me to do some exercise*." For another example, P10 said: "*I always check with my husband if he lives up to his and he has not forgotten to wear Fitbit. But I'm always behind him.*"

Participants in the Peer condition also benefited from competition and group activities. For P7 and P8, the one who had fewer steps would walk the dog as a "punishment" for losing the competition of that day. As P7 said, "*We had a lot of fun. We stimulated each other so that we get out and not stay indoors. When she had more, I think tomorrow I will do more anyway*." His wife, P8, also commented: "*We were looking at our steps every day, and the one who did more [exercise] would laugh at the one who did less. It was also funny, because even if we were together all day, the number of steps were not the same.*" Participants also arranged exercise together, such as walking outside. For P5, her husband was not interested in walking, but she usually took him for a walk anyways. *"I told him not to focus on walking, but look at the trees, they were beautiful. Then without noticing, we already walked for 45 minutes. He almost reached 5 kilometers that day. He said, 'Oh yeah, I would not have thought I could walk that much.'*" The above findings confirm with the studies of using social influence to motivate activities for the general population by Chen and Pu [3].

Some participants in the Individual condition also pointed out the need for a buddy. For example, P17 reported: "*If I find someone who also uses Fitbit, we can do activities together. Even if we do not meet, we can just see how many steps the person has done, and leave comments. I found this function on fitbit.com. There are diabetic groups formed in [name of an area] of Switzerland, who did this in an online forum. I started in the group for sharing and seeing others' progress, in order not to be the last of the group.*" He also sought to walk with his son, who also had diabetes but did not participate in this study. "*We live in Chatelaine, and from there to downtown and back it's about 10,000 [steps]. Walking like that, he does not need to take medication*." This shows patients' need for social support in maintaining behavioral changes.

Choosing the right buddies appeared to be important in the study. P4 in the Peer condition reported: "*I think it is the right person that I'm working with because we are both on the same level. If he is a sportive man, I would be frustrated. I could not do it with my husband, for example, because it makes sport too much for me. I cannot compare with him.*" For P18 in the Individual condition, "*Group work can be good as they can be bad. It depends on whom I'm working with. If that person encouraged me to do something, it will depend on what it is, if it is Zumba, sure that I would say no.*" The importance of choosing an appropriate buddy is also reflected in the findings of Maitland et al. [14] that investigated the role of social support for people in the process of weight management.

V. Design Considerations

Previous research has investigated the effectiveness of motivating users to exercise using fitness trackers and peer influence [3, 5, 15]. The fact that many of our findings comply with prior work implies the promising opportunity to apply technologies for behavior change designed for the general population (non-patients) to diabetic and obese patients. Meanwhile, we identify a few design considerations for the *obese and diabetic patient* group.

Motivate small and steady changes. In general, participants reported that they were motivated by Fitbit to exercise, especially moderate-intensity exercises like walking instead of high-intensity workout. Some patients reported that they could not do high-intensity exercises due to their diseases. Particularly, patients were motivated by small behavior changes. Some patients did not change their behavior all of a sudden. Instead, they chose to gradually reduce the proportion of laborsaving methods (e.g., buses and elevators) and increase the proportion of physical activities (e.g., walking and taking the stairs). While the above finding also applies for some of the general population, many non-patients also tend to perform high-intensity exercises. Clinical studies show that the main barriers for diabetic and obese patients to exercise include perceived difficulty in exercise, feelings of tiredness, lack of time, and lack of facilities [17]. Encouraging patients to perform moderate-intensity with a constant and steady effort seems to be more feasible for them. Therefore, it is essential to tailor the exercise goals to match patients' competence.

Design peer influence to prevent relapse. Participants' number of steps significantly dropped after the early acquisition phase. The relapse might be due to the novelty effects when users newly adopt a device and the decreasing enthusiasm after that period [10]. While participants in the Individual condition used Fitbit much less frequently after the early acquisition phase, the frequency of those in the Peer condition slightly increased in the long run. While not wearing does not necessarily mean not exercising, the frequency of wearing Fitbit reflects the frequency of monitoring activities. Sometimes they did not wear Fitbit because they stayed inactive and did not want to wear; sometimes they forgot to wear because the tracker was too small compared with other medical monitoring devices. Participants acknowledged their buddies for nudging them to stay active and track their activities. They were also motivated by comparing, competing, and arranging group activities with their peers. They reported the importance of choosing a buddy with comparable competence as well. The current online competition provided by fitness trackers is mainly designed for the general population, some of which have high exercise competence and intensity. For patient care, it is essential to provide a buddy system that targets patients with similar exercise competence and integrates social incentives to prevent relapse and engage them in exercising in the long run.

VI. Conclusion

The results of our study show that activity trackers are promising in motivating the physical activities for diabetic and obese patients – a population that is less studied. Additionally, peer influence, such as competition and group exercise, helps patients prevent relapse and engage in monitoring their activities in the long run. This paper shifts the focus of diabetic and obese healthcare from monitoring disease to maintaining healthy lifestyles. It also provides design considerations for translating lifestyle-change technologies for the general population to diabetic and obese patients.

This study has limitations. First, when comparing their steps, we included days when users' steps were zero. Although zero steps could be interpreted as not wearing Fitbit or not moving, users reported that not wearing was associated with physically inactive, such as staying at home. Second, we report the findings of the first four months; it is necessary to investigate users' engagement with exercise and activity tracking over a longer period. In the future, we plan to follow up with the patients to check whether and why they keep monitoring their activity levels. Third, we are aware of the limitations of the sample size in this study, and the participants in the peer conditions were mainly strong ties, e.g., couples or close friends. It is worth validating the results with more participants and investigating other types of relationships and their impact on behavior change.

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