Designing for Self-Efficacy from Novices to Experts for Wearable Fitness Technologies

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ABSTRACT

Wearable fitness devices play an important role in allowing users to monitor their health and get instructions and feedback during fitness activities. However, most current wearable fitness devices focus on measuring general activity levels instead of correcting precision movements and forms, and are not tailored for users with different levels of exercise expertise. In this paper, we interviewed 7 experienced gym-goers and 7 novices to explore how wearable devices could support their weightlifting practices and goals. We then use Bandura's theory of self-efficacy to categorize potential design features of wearable devices to support weightlifting forms. Our findings indicate that users have different needs for these devices to support self-efficacy based on their current level of expertise, and that certain components of self-efficacy theory, like vicarious experiences, can be further utilized to promote this self-efficacy. These findings may have broader implications for the design of technologies to foster behavior change

CCS Concepts

• Human-centered computing~Empirical studies in ubiquitous and mobile computing

KEYWORDS

Fitness technology; wearables; behavior change.

1 INTRODUCTION

As people grow more aware of their personal health and appearance, they often join a gym to participate in exercise. Their goals often include losing weight, building muscle, relieve stress and reaching a desired level of overall fitness [22]. In order to reach their goals, they must build new habits related to regularly working outs and eating nutritiously. Weightlifting can be a significant component of those goals.

However, performing accurate weightlifting forms is often hard for novices who have just started this type of exercise, and even experienced gym-goers have reported acute or chronic injuries due to performing incorrect weightlifting forms [8]. Moreover, achieving the fitness goals are more than precise work-out forms and healthy diet. It's a process of behavior change, only continuous work-out could help the users to reach their fitness goals.

Wearable devices have been designed to help with instructing users on proper exercise forms [25] and keeping track of daily health conditions [18]. Some specific wearable devices are designed to correct weightlifting forms with sets of plans generated by devices based on users' physical figurations, gender, age and personal information.

However, those devices simply focus on users' ultimate goals other than their usage of the devices. Different users might have different demands of using those devices. For example, new gym-goers might have less knowledge about weight-lifting forms or any other exercise knowledge, they mainly use the device to learn exercise knowledge such as new forms and appropriate diet with the combination of correcting function. While experienced gym goers primarily utilize the devices for correcting and monitoring their forms to keep them on good track. However, most of the devices draw attentions on generating work-out plans and helping with healthy diet, few of them focus on how to help users, especially novices, to learn proper forms and continuously motivated users committing to exercise and eventually reach their goals.

In this paper, we interviewed 7 experienced gym-goers and 7 novices to learn about their needs and expectations from wearable fitness devices. We introduced them to existing wearable fitness tools, and brainstormed with them to identify ideal features and concerns for these types of devices.

To understand these findings, we re-analyzed our data through the lens of Bandura's principles of self-efficacy [3], which include enactive mastery experiences, vicarious experiences, verbal persuasion, and physiological and affective states. While prior work has studied self-efficacy as one component of behavior change, our work focuses explicitly on how these four principles can guide design of wearable devices for holistic fitness across different levels of expertise.

In this work, we differentiate between the needs and practices of people with different levels of expertise in weightlifting, and the impact their expertise had on their experiences of self-efficacy. These findings may have broader implications for the design and study of technologies for behavior change, especially in settings where users encounter challenges that vary over time.

2 RELATED WORK

Research and commercial devices have focused on developing fitness technology to help people lose weights, count steps, and

other overall physical activities [15]. Tudor-Lock et al. Indicated the pedometers could be used as a tracking device and a feedback tool with the combination of record keeping tools. They conducted a program called The First Step for 8 weeks with sedentary individuals who have type 2 diabetes. The results were shown that the pedometers could be used to measure and motivate physical activity [40]. Also Bravata et al. improved that the use of pedometers not only could increase physical activities, but also come with improvements of health, such as decrease in blood pressure and other body mass index [6].

Purpura et al. analyzed 33 technology-based programs for weight loss, most of the program give the users initial assessment by asking their weight, height, age to calculate the BMI, then having them set desired goals. All of the programs require users to record their exercise time, nutrition intake and weight during the program. Some programs generates inspirational quotes or sharing successful stories to aspire the users. Few of the programs have forums or social medias for users to communicate or set group goals [32]. Except from physical activity, nutrition intake and sleep quality weigh tons in improving health. The link between nutrition. MyFitnessPal is a smart App and website which could determine and track users' calories intake and provide users with nutrition plans based on their physical status for motivation. The Keep is also an app which generates fitness goals based on users' daily consumes and calories intake, plus it includes forums for users to share their fitness story, food pictures to motivate the other users.

2.1 Fitness Behaviors

People want to become more fit either for extrinsic motives such as appearance and weight control or for intrinsic motives like health improvements and challenges [22]. Among those, weightlifting appears to be a good physical activity achieving these goals due to its report on multiple benefits [16]. However, weightlifting is a learning and on-going process, improper equipment use and inaccurate performance might cause accidental injuries or permanent ones [30]. Moreover, the research shows, there is a 50% dropout rate within the first 6 months [12].

One resource that people can leverage to change their fitness behaviors is personal trainers. Personal trainers are workout professionals who can offer structured workout plans tailored to the individual, and in-time feedback on workout performance. Moreover, the research has shown one-by-one personal training could change individual's attitude and thereby increasing physical activities [27]. However, hiring a personal trainer is often prohibitively expensive, meaning that most fitness novices do not have access to the resources that they can provide.

2.2 Role of Self-Efficacy for Changing Fitness Behaviors

A major role of a trainer or other workout resources is to improve an individual's *self-efficacy* about their workout ability. Self-efficacy focused on beliefs about one person's ability in specific settings [2]. Where it could help beginners build up confidence in coping with adversity, as well as intermediate exerciser to push to the next level, and assist the experienced exerciser to overcome dramatic setbacks such as injuries [20]. There are four resources of constructing self-efficacy: Enactive mastery experience, Vicarious experience, Verbal persuasion and Physiological and affective states, which we will describe later in this paper.

Below, we describe the role of self-efficacy in behavior change theories, and introduce findings about how self-efficacy improves fitness behaviors, to motivate our selection of self-efficacy as a frame for future design for wearable fitness technologies.

2.2.1 Self-Efficacy as a Component of Theories of Behavior Change

Behavior change theories are attempts to explain why behaviors change. In recent years, there are growing interests in the application of these theories in the areas of health, education, and sustainability [17,35]. Since all the behavior changes require individual to take action, incentives and confidences remain important during the long-term process where self-efficacy could make a difference.

The Health Belief Model relates to the belief in health concerns, current behavior would impact further health conditions and whether recommended health suggestion is beneficial to the issues after taking action [2]. The self-efficacy doesn't weight as much if the problems are only one-time thing such as one-time immunization or screen test, but for long-term behavior change like smoking cessation, eating or exercise, individuals need to build good deal of confidence during the process of transformation [34].

Transtheoretical theory involved 6 stages of progress of health behavior change: Precontemplation, Contemplation, Preparation, Action, Maintenance and Termination where the preparation, action and maintenance stages require high efficacy for individuals to take their steps to make changes and keep away from relapsing to former behavior [31].

Social Cognitive Theory (SCT) describes a dynamic, ongoing process in which personal factors, environmental factors, and human behavior exert influence upon each other. Self-efficacy is one of the factors contributed to behavior change in the SCT. Individual could achieve behavior changes when encounter barriers if they have a sense of self-efficacy [28].

Each of these theories identifies self-efficacy as a major component of the process of change or transformation of a person's health behaviors.

2.2.2 Self-efficacy in Fitness Performance

Additionally, literature around sports and exercise has shown that self-efficacy plays a major role in predicting future performance. A person's self-efficacy founds to be an important variable of predicting performance in sports even requiring a high degree of physical skills [26]. As well as the relationship between self-efficacy and performance is directly proportional. Studies has been shown individuals with high self-efficacy tend to reach better performances than those with lower one in sports area. Even when face with difficulties, higher self-efficacy ones are

inclined to overcome barriers more positively thereby having better performances than lower ones [43].

2.3 HCI Technologies for Behavior Change

There has been explosion of HCI research on behavior change in recent years including physical activity, smoking cessations, diabetes, healthy diet and so on. Klasnja et al. proposed a way of how to evaluate the technologies for behavior change within HCI context [23]. Multiple researches have been draw attentions on how technologies could impact behavior change such as mobile messages, social media, ubiquitous computing and etc.

Korda et. al reviewed the effectiveness of social media involving the impacts on health behavior, the evidence concluded social media does have potential impacts on behavior change since its broad reach to audience. However, further studies needs to explore in what range the social media could impact, how to deploy the methods in a more effective way [24]. Fjeldsoe et al. reviewed 14 studies of behavior change program, which focused on SMS-delivered interventions, related to health behavior change and clinical care. The study concluded positive aspects of short-term behavioral outcomes by means of interactive dialogue between patients and health professionals, but highlighted the demands for evaluation of preventive health behaviors [14].

2.2.3 Behavior Change in Physical Activity

Maintaining health behavior in long terms not only needs the assistance of wearable device for analysis and guidance but also needs individuals' stamina to insist which involves behavior change of users. Hence, studies have been applying the behavior change theories to evaluate the wearable device for physical activities, as well as incorporating behavior change theory to help individuals to initiate, develop and maintain physical activity.

Mercer et al. reviewed 7 wearable activity tracker, revealed most of the wearable activity trackers incorporated self-tracking and self-monitoring techniques to the device. However, 15 techniques which mainly related to self-efficacy theory are missing from the device, as well as planning and providing instructions techniques. The study also concluded most of the techniques has improved physical activity increase among older adults [28]. Wang et al. tested whether daily messages serves as prompts to increase physical activity, the results indicates simply by providing wearable device/sensor to increase physical activity level or daily automated text messages for encouragements are insufficient. Future engagement of technology might be needed to achieve targeted physical activity levels and the text message should be more personalized focusing on feedbacks and performance [42].

Consolvo el at. summarized 8 design strategies supporting lifestyle behavior change through physical activity based on Presentation of Self in Everyday Life and Cognitive Dissonance Theory [11]. Then she implemented the strategies into the Ubifit Grarden System which is a mobile system motivates users' daily activities and provide instructions, the feedbacks from participants confirmed the implemented design strategies helped users to maintain physical activity [10]. Toscos el at. Designed Click Clique, a mobile phone technology motivates teenage girls to exercise and maintain a healthy lifestyle by asking them sharing step counts between friends resulted in positive feedbacks [39].

2.4 Wearable Devices for Physical Activity

Studies have been drawn attentions on wearable device for physical activity focused on detecting, recognize and counting free-weightlifting or weightlifting forms. Morris et al. built a system which achieve recognizing, counting and segmenting exercise with high precision [29]. Chang et al. incorporated an accelerometer into a glove and wrist to test 9 types of exercises resulted in high exercise type of recognition and low miscount rate [9]. Velloso el at. implemented C# framework for development on Microsoft Kinect sensor and successfully tested upon 3 types of upper body exercise for activity specification, mistake detection with fairly high accuracy and user feedback reflected above average standards [41]. Rector el at. developed a system help low-vision individuals to learn 6 Yoga poses while accessing auditory feedback based on their performance [33].

Another aspect of wearable devices developed to support daily lifestyle activities and health. Those devices mainly record users' heart rate, walk steps, calorie burns, body temperatures and other parameters for data collection and health analyze. FitBit is a wristband known for all-day activity track and combined with the app to support personalized work-out plan and sleep quality analyze. The Polar Heartrate Monitor is a combination of chest-worn and wrist-worn device which monitor users' heartrate and calorie burns, then give users' aural feedbacks when heartrate level reach a certain level. The Sunnto T4 could make suggestions for users' work-out routine by monitoring heart rate, calorie burns, speed and distance. Buttussi et al. introduced MOPET, a system of wearable devices and a virtual trainer to help runners navigate a route, get real-time feedback and suggest physical activities for users while exercising outdoors [7]

3 STUDY 1: WEARABLE TECHNOLOGIES FOR ACTIVE WEIGHTLIFTERS

3.1 Methods

3.1.1 Interview Design

We conducted interviews with 7 frequent gym-goers. We asked their experiences within the gyms in terms of how they learn proper weight-lifting forms, do they have gym partners to train with and technologies they use for exercise.

To guide this discussion, we used the Ollinfit as a elicitation tool. The Ollinfit is an in-development weightlifting aid that combines a mobile app and 3 wearable sensors on the chest, legs, and wrist. The sensors provide vibrate feedback to help users correct their form, provide post-workout details about technique, and records weightlifting process. The reason we chose the Ollinfit is that most commercial wearable devices focused on monitoring users' health status, few of them devoted into specific fitness activities such as weightlifting. Since this device is not yet commercially available, we showed our participants a video of the device to gauge their impressions.

Then we displayed them the video of the Ollinfit and asked about their reaction to the Ollinfit video and their ideal features, potential problems of the devices.

3.1.2 Recruitment

We recruited 7 participants with exercise experience in collaboration with the National Institute for Fitness and Sport (NIFS). We set up a table in the entrance of the facility and recruited 4 participants. We additionally sent messages to our contacts on social media platforms to recruit participants we knew were frequent gym users. 3 participants were recruited directly.

3.1.3 Participants

All of the participants had experience of weight-lifting (5 female, 2 male) in our study. Their average age was 23.8 years with a range between 21 to 27 years. 7 participants exercised frequently for at least 2 years, and all went to gym between 3-7 days a week. They all performed weightlifting as part of their exercise routine, but some of them engaged in other forms of exercise, such as cardio activities or group courses like Zumba.

Due to NIFS's proximity to the IUPUI campus, all of our participants were students (4 undergrads, 1 Masters student, and 2 PhD students). Three of the undergraduate students were in majors related to physical activity, where they have learned specific fitness techniques. 2 participants learned the right way of doing weightlifting from certificated personal trainers, 1 was trained by a friend with personal training experience, 1 learned the forms from high school courses.

3.2 Findings

3.2.1 Experience with Technologies

We explored participants' experience using exercise devices before showing them the video of the Ollinfit. Two participants had not used any exercise technologies at the gym before. The other participants had used a mix of manual or automatic recording technologies to track their fitness practices.

One participant had used MyFitnessPal, a free smartphone app, to record calorie input, manage their diet, and plan workout sessions. This information allowed them to accurately evaluate how many calories they burned from daily life activities or from working out, and be aware of the calories they consumed, which helped them to lose weight or gain muscle.

Another participant manually recorded the activities they did at the gym by taking notes on their phone without a specific fitness-oriented application. This participant used their occasional notes as motivation for future workouts.

> *"I would really use my phone for is, eh, sometimes I just record or just doing notes like how much I lifted , so I could try to lift a little bit more the next week or something." (E5)*

2 participants had experience using a Fitbit to record data either during exercise or outside of the gym. Another participant used a wearable device on her chest to record performance during her exercise classes, so she could access data after her classes.

In addition to traditional resources for learning how to correctly perform workout activities, all of our participants noted that they also learned exercise forms from watching videos on YouTube. One participant additionally used Instagram, a photo and video-based social media platform, to learn how to perform different exercises. These responses indicate that online social platforms can be a resource for gym users to be introduced to movements or poses, but do not provide any opportunity for real-time or post-workout feedback on the correctness of moves performed.

3.2.2 Response to existing technologies

All 7 participants thought the Ollinfit was an interesting or helpful device, especially since it could correct users' poses through audio feedback.

> *"I like the idea that it has the feedbacks to actually correct you a little bit, because the video we have right now it's just follow the others movements, so there's no way for them to tell you if the gestures are incorrect." (E2)*

Our respondents felt that with the Ollinfit, they could correct their movements by themselves and exercise effectively with verbal corrections.

Some participants asked how the device works, curious to know how accurate the device could be because of the diversity of individuals and exercises. Due to the difference of body structure between individuals, one participants noted whether the device could monitor all of the users' movements and gave right directions according to their body structure. Another participant mentioned whether the device could monitor the whole body, since it only has 3 sensors, she doubted the device could detect all the muscle movements across the whole body in order to provide precise feedbacks.

> *"So if you do a core exercise, it involves lots of muscle movements. Where I should put the sensors on? How can it monitor other muscles?" (E1)*

One participant asked whether the device could upload new programs and the device could monitor new movements. There are multiple new movements developed overtime, some new movements are the combination of basic poses, and some movements are created with new forms. The participant hoped that she could upload new forms and the device could detect new forms and correct her:

> *"If it can load programs, then I definitely can learn something I've never done before, but if it can't, it still can be helpful, like I can learn something from YouTube, it can help me to correct my, you know, my movements" (E3)*

3.3 Desired Features

Participants identified a number of features they would want in a wearable technology for weightlifting.

Positive Feedback: Feedback is important for users to correct their movements, positive feedback can motivate users and direct them in a good way to exercise. The Ollinfit corrects users' movements by telling users what to do, sometimes even repeating phrases several times which makes users feel upset. This response may reveal that gym-goers are highly sensitive to potential judgement by workout technologies, and felt that negative or even

neutral feedback might discourage them from using a fitness device.

> *"Instead of telling me "it's not right, it's not right" , because I know I'm not right, but if I'm doing something better than before or than the previously one, it should tell me, and I don't need it to tell me all the time ". (E2)*

Personalized Design: Individuals have different goals (such as losing weight, gain muscle, train glutes), and diverse eating habit during exercise. It would be perfect to maximize work-out results by learning users' eating, training habits and generating personalized plans for them.

> *"...not something that is design for everyone, I want some customized and personalize design, it can learn my habit, it learns my schedule it learns my eating and everything and generate exercise plan just for myself" (E2)*

Customizability: Based on our interviews, all of our participants learned exercise forms from YouTube or other social media like Instagram. Those media could only show them correct movements, but does not include the ability to correct mistakes. Due to the performance diversity of weightlifting, there are always new movements been created or combined with several other forms. So, if the users could upload new forms they learned from social media or somewhere else to the device, it would maximize their exercise efficiency.

Privacy: The Ollinfit did not show headphone compatibility for users. As the device gives feedback, others around the user could hear the voice which may make the users feel embarrassed.

> *"The only thing I could foresee is like that some people when they are in gym, they get embarrassed when some people tell them how to do something. So if you could like, have that go through headphone or something to tell people, to tell them correct it or something, " (E5)*

3.4 Concerns

Physical Injury: The Ollinfit corrects users' movements through audio feedback. Since the Ollinfit was mainly designed for weight-lifting, stimulating targeted muscle could maximize work-out results. Hence, some users may exercise with heavy loads in order to stimulate their muscles. But the Ollinfit cannot not detect each users' maximum and minimum endurance of loads - as users try to perform at a higher level of weight, injury might occur that could not be prevented.

Distraction: One participant noted that auditory feedback could distract him depending on how many times and when the system gave feedback. If the device starts to give feedback loudly and abruptly when users are focused on training, it might startle the users, and repetition may distract users from training.

4 STUDY 2: WEARABLE TECHNOLOGIES FOR NON-WEIGHTLIFTERS

Building off our findings with expert weightlifters, we designed a second study, utilizing scenario prompts, with non-weightlifters – either people who were new to weightlifting, or had tried it previously but not succeeded in forming a habit.

4.1 Methods

4.1.1 Interview Design

We asked participants about their fitness experience, such as how they learned the knowledge about specific activities, but not limited to weightlifting since some novices don't have weightlifting experience before, then we started to explore their interests on weightlifting, the reasons behind perform weightlifting or not, how they learn the forms, and in what ways they wish to learn the forms.

Since novices don't have much knowledge about weightlifting, we developed scenarios to help them put themselves in the box and imagine as much as they could to provide suggestions or point out pros/cons of the scenarios. We designed 2 different storyboards for each scenario: work-out preparation (pre-workout), message notification (during work-out) and correction (post-workout). Then selected 1 storyboard from each scenario and combined and randomly assign to each participant. (No repeat combination). Participants were asked few questions after they finished each scenario.

After scenarios, we showed our participants the video of Ollinfit, and asked them to combine with the scenarios to talk about their reaction, idea features, future problems of the Ollinfit.

4.1.2 Recruitment

All of the participants were recruited from the WeChat where we posted our posters for recruitments. 3 of the interviews were conducted on WeChat where we sent the participants the video link and scenarios before conducting the interviews. Others were conducted in-person.

4.1.3 Participants

We recruited 7 participants (4 female, 3 male) who had no or little experience of weight-lifting. There average age was 25.8 with a range from 23 to 29 years old. Due to author's WeChat group, almost all our participants are students (1 undergraduate, 2 master, 3PhD) except one participant is currently working at a pharmaceutical company.

3 out of 7 novice participants didn't performed any weightlifting forms instead diverse exercise such as swimming, Yoga, cycling and basketball from professional coaches and books. The rest of 4 participants have performed weightlifting before, in which 1 just started performing weight-lifting 1 week ago with the instructions on an App called KEEP before our interview, 1 only performed squats where she learned the forms from Instagram pictures and videos. Another 2 performed the weightlifting forms sporadically, they learned the forms from their friends who have experience on weightlifting.

4.1.4 Scenarios

To prompt discussion and ideation around the form factor of wearable technologies, we generated a set of scenarios to give to participants (based on expert participant experiences from Study 1). These scenarios are presented in full in **Table 1**. During the study, we also provided participants with sketched images representing the scenario.

Scenario 1: Preparing to Lift Weights	
Context: Recently Eric wants to lose some weights, then he decided to go to the gym and do some lifting, but he's new to this area, he has no basic knowledge of weightlifting forms.	
Online Sources	Wearable Devices
He thought maybe some tutorials on the Youtube in terms of fitness would teach him some forms. Then he searched "weightlifting for beginners", he selected one video labeled with "absolute beginners". He watched the video and the trainer is very good at explaining how to perform the forms, and what muscle groups he needs to stimulate while doing this. He followed the video carefully and perform the exercises, and he felt quite confidence about working-out in gym tomorrow.	*Eric bought a wearable device to guide him to perform forms. The wearable device is connected to a fitness app where it would ask users about their personal figuration, experience with fitness and desired goals and evaluate users' level, then automatically generate a plan for users, users could customize the plan as well if they don't want to perform some exercise. Eric wears this device as he goes to the gym, he's confidence about the device and the effort it would bring to him.*
Scenario 2: Getting Feedback	
Context: After preparing for the gym yesterday. Eric is quite confident to go to the gym with a wearable device.	
Haptic Feedback	Auditory Feedback
The wearable device is connected to an app which would show Eric what movements he will be performing, the errors he made during the gym and how to correct. He needs to wear 3 sensors on his leg, arm and wrist, so the sensor could detect all the muscle movements through the body. He follows the instruction carefully as he work-outs. Then the device starts to vibrate on his wrist, so he knows he's making mistakes. He tries to adjust his wrist position, but the vibrations continue to indicate that he is making a mistake.	*The wearable device could correct him during his work-out with auditory feedbacks by headphones. He needs to wear 3 sensors on his leg, arm and wrist, so the sensor could detect all the muscle movements through the body. He follows the instruction carefully as he work-outs. Then the device starts to guide him because he performs something wrong by announcing through the headphones, "You need to hold your wrist straighter while raising the dumbbells". The device continues to announce this to him step by step, but he cannot figure out how to correct his position.*
Scenario 3: Correction	
Visual Correction	Auditory Correction
Eric is performing the exercise forms in the gym, suddenly the sensor starts to vibe, which means he's doing improper forms. Then he stops and sit to check out the app. The app gives him a heat-map of his body indicating which area goes wrong and suggesting ways to correct through text. After checking the errors, he restarts his workout to do it again.	*Eric is performing the exercise forms in the gym, suddenly the device starts to talk "Eric, please raise your right arms higher than your shoulder". He tries so hard to make it right, but no matter how hard he tried, he can't do it. The device seem to realize his problem, then the device said "Eric, you're doing a great job so far, how about take a break and drink some water?" During his break he listened to the device explain to him where he went wrong and how to improve.*

Table 1: Scenarios used in Study 2. Each participant was given one of the two scenarios for preparing, getting feedback, and corrections.

4.2 Findings

4.2.1 Exercise Experiences

We explored participants' diverse interests in fitness to understand their experience with different fitness activities and the way they initiated those activities. All of our participants showed interests in fitness activities and have been or had performed those activities before.

2 participants initiated their fitness activities from courses or experienced friends. For example, N1 played basketball for fun and continuously exercising over 7-8 years, he learned the skills from a summer camp. N2 had experience of learning swimming from a summer course and sometimes jogging around campus. N5 does weight-lifting forms 2 times a week for 2 years, he learned those forms by asking friends who are experts at weight-lifting in the gyms.

5 participants learned their fitness activity by themselves through different resources such as fitness apps, social media and books. N3 used an app called KEEP which generates fitness plans for users based on their physical conditions and goals, and instructs users to perform moves through video or pictures. She mainly followed the plans and instructions doing indoor cycling and using a pair of 5 pounds of dumbbell for aerobics to lose weights. N4 had some experience performing aerobics where he learned the forms from just Googling, but he stopped 4-5 years ago. N6 has been doing Yoga for over 10 years. She learned Yoga forms from a book with video instructions. N7 is interested in weight-lifting but didn't know many forms, so she only performs squats using techniques she learned on Instagram.

We then discussed our participants' weightlifting experience to get to know their motivations. Two (N1, N6) participants are not really into weightlifting. N1 mainly focused on basketball, he doesn't feel there's an urgent need to perform weightlifting. Besides, he doesn't want to be too muscular. N6 said she doesn't have the motivation to perform the weightlifting.

The other five participants are interested in performing weightlifting. 2 (N2, N3) out of 5 participants doesn't have any experience of weightlifting. N2 thought performing weightlifting is beneficial mentally and physically, but she doesn't know how

to begin, also she feels a little shy performing weightlifting in the gym, because people might judge. N3 is interested in weightlifting due to her awareness of that weightlifting might double her effectiveness of losing weight. 3 out of 5 participants already have experience of performing weightlifting forms to different extents. N7 only performs squats, because she said though she's interested in weightlifting, she doesn't know what other forms' names as well as she doesn't have lots of time to do it. N4 performed the weightlifting forms 4-5 years ago simply wanted to keep shaped, but stopped due to his physical condition. N5 performs weightlifting regularly within these 2 years and has the same motivation as N4 had.

4.2.3 Response to existing technologies

Below, we combined participants' responses of scenarios and the Ollinfit video's which involves how they react to the Ollinfit, what are the ideal features they want from the technology and what are their concerns with the technology to summarize their response to the technology.

Most of the participants thought the device is helpful and like the real-time auditory feedbacks, especially mentioned the device as "*a real coach besides you*" (N3), a desire shared by many participants. Participants would prefer this over asking for help, since they were afraid of being judged by experts or people nearby:

> *"I don't wanna ask other people beside me, you know, to teach me how to do it. I think they're also trainer, but then it's kinda embarrassing me to go to like "hey, do you know how to do squat", you know people might say like squat is so easy, why would you even want someone to show you." (N7).*

However, some participants hold their conservative ideas about the device, due to the reason they thought the device won't suit users who don't have experience in weightlifting and it would be more precise to have experienced partners or coaches beside to show the forms:

> *"Well, I don't think it's something for the beginners, but if you've already have an understanding on this thing (weightlifting), " (N6)*

4.3 Desired Features

4.3.1 During Preparation

Participants wish the device could generate personalized work-out plans based on more detailed information such as their physical condition, training experience and life habits, instead of simply asking their age, gender and frequency of training.

Given the fact that the device could generate work-out plans and correct work-out forms during exercise, some participants still hold conservative points. They felt asking a friend or someone who's experienced to tell them how to do or show them the movements might be easier due to the fact they don't have basic knowledge about weightlifting, the plan-generation and correction functions won't help much. For example:

> *"I don't think it's something for the beginners, but if you've already have an understanding on this thing(weightlifting), it would be helpful to keep you with the training. " (N6)*

Before going to the gym, individual who has never been to the gym might be confused about the machines. There are tons of machines in the gym, novice would feel overwhelmed at first, because the device only provides them with pictures or videos of forms and they don't know about the machines:

> *"Let's see that device (said) work for your legs, but like one could be like for you calve, one for your thigh, but then he could accidently like, I don't know, he could mistake the machine. Cause some of the machine in the gym look kinda similar." (N7)*

Most of the forms might involve the usage of machines. For someone who's new to the gym, they might won't recognize the right machines, and it would take them some time to find out which is the right one and how to use it. In turn, it would compromise their training efficiency.

Physically well-prepared helps users to perform weight-lifting forms more precisely with high efficiency. However, achieving fitness goals is a long-lasting performance. Users need to be mentally well-prepared as well. 2 of our participants mentioned users need to be motivated constantly or they might give up.

> *"If there are some sort of way to, you know, make him stick to the plan, stick to what he wants that would be great, otherwise he might bail out". (N4)*

One participant even mentioned a way to keep her motivated:

> *"I'm interested in what if I keep doing this, what does my future look like. It can provide me short term goal and long term goal, if they are combined together, it could help me to commit to the exercise. " (N2).*

4.3.2 During Work-out

Auditory feedbacks was welcomed by most of the participants, because it could instruct them how to perform and correct forms. But some participants thought the auditory instructions are not specific enough due to the fact that some movements are hard to express only through the auditory, plus they are new to the field, which makes them harder to understand and stick to the auditory. They would like some visualized instructions, a short video which could demonstrate the target muscle group may help them to understand where exactly they went wrong and how to focus on the right area. For example, participant N6 suggested:

> *"I would like something to visualize my movements, hmm, like you can have some 3D glasses that you can see all your muscles and how they work together and how the movements of your muscles make your forms right or wrong, then it would be more, like clearly than simply audio device." (N6).*

Conversely, the results varied from different person, one participant said he doesn't feel like reading and watching instructions while he sweats a lot during training. He prefers to listen to the instructions.

2 participants mentioned the repeating auditory correction might be frustrating and "*significantly impact the attitude or enthusiasm towards the weightlifting*" (N4). They suggested the auditory could be interactive with the users instead of giving instructions in one direction. For example,

"if the device said my wrist is not in the right position and I couldn't figure out how to dismiss this notification. I hope there are some options which I can hit the button and say "I don't know where I did wrong, can you give me more information or can you please just ignore this?" " (N3)

Building up users' confidence during the training is also important especially for beginners, which would further help them to commit to the exercise. Materializing users' hard works could be a good way to stimulate them. As one of our participant suggested:

"It can score your work, if you follow the devices' direction, the scores grow up, it would help you build some confidence" (N1).

4.3.3 Post-Work out

Reaching fitness goals are not just about exercising, life habits weights the same. Beginners might don't have or have little knowledge about how to eat or rest properly. Inappropriate eating diet or lack of sleep would get in their way of achieving goals. Hence, the device could provide users with personized diet and good habits to keep on with their goals.

"A person who works-out might cares about the diet or the supplements after or before they work-out, a bunch of hydrates must be taken. After workout, there's protein or carbohydrates you need to take. But this device mainly focused on the position, if this device could collaborate those information and interpreted that would be great." (N4)

4.4 Concerns

Accuracy: One participant concerned about how precise the device could be to detect users' forms. He worried that the device might not be accurate enough that he is performing the right form while the device regards as wrong forms:

"I can come up with the scenario like actually I did the right thing and this device keep telling me I did wrong thing. If that happens, that will be very annoying." (N3)

Form Factor: N5 expressed his dislike of the 3 sensors. He thought 3 sensors are too much to put on while training. However, the auditory feedbacks are highly welcomed by most of our participants, though it still has some space to improve. If the voice feedbacks are not given at the right time or given too many times, users might get annoyed or distracted which impact their training. For example, while the user is highly focusing on the dead-lifting, the voice feedbacks pop up abruptly, user might feel distracted. As one participant mentioned:

"You need to consider what is the proper voice reminder, how many times you wanna give the users, what is the best time to remind the users. "

5. SELF-EFFICACY IN WEARABLE FITNESS TECHNOLOGIES

Below, we apply self-efficacy theory to guide the design prompts for wearable device for weightlifting, because as long as people feel confident about their capabilities, the possibilities of success committing to fitness activity will increase.

5.1 Enactive Mastery Experience

"Enactive mastery experiences (also known as 'performance accomplishments') are psychological states through which a learner organizes his or her own set of beliefs regarding ability from a variety of sources." [38]

Before users are engaged in performance, especially for novices, the device needs to provide them with ambient knowledge about how to perform correct weightlifting forms, how to set realistic goals and how they manage their diet before and after training.

Setting realistic goals is one of the most important steps for novices. Because beginners usually don't have much understanding of their capabilities and how the exercise will impact their body, they may set unrealistic goals which would disappoint them if they can't perform movements successfully. This result would directly impact their self-efficacy. The device needs to assist their users to fully understand their physical conditions by asking the users to answer their physical conditions in details other than just limited to their age, gender, frequency of exercise. In terms of setting their initial goals, if the users' goals are irrational, the device could gently inform users then provide them with other goals or options based on their body condition. For example, if the user weights 200Lb and wish to lose 50LBs within a month, which is almost impossible, even if he/she can, this would not be beneficial to his/her body both physically and mentally. Under this condition, the device could provide users with plausible plans such as losing 50 LB in 6 months or losing 10 LBs within a month.

As the scenarios showed, half of our participants felt confident that Eric would be well prepared for his first day training due to the reason that he watched some guidance from Internet. However, the wearable device is less useful compared to the pictures and videos. But the device could be used to help users to remember forms by emphasizing important details which most of the users might forget according to the database while instructing the users, because one of our participants mentioned:

"I may not remember as much as I learned from it. So I feel like I have to constantly go back watching the video again and again in order to do the right thing." (N3, Scenario S1A)

If users forget the details or perform wrong forms while training, the results might differ or won't reach their expectation, eventually impact their confidence of training.

Even though the device could provide users with voice instructions to correct forms, N7 still didn't feel confident performing in the gym, this is especially true for novices who haven't been to the gym before or not a lot of times. They may know how to perform the right forms and what forms they will be performing today, but when they reach to the gym, the machines are overwhelming, they need time to figure out which is the right machine to use and how to use it, which is also true for experienced gym-goers, once they shifted to another gyms, the machines varied a little bit from the old ones. The device could be connected to different gyms and their machines, and guide the

users which machine to use in the gyms and send them some videos of how to use the machines before the gyms. Also, the device could give users options to select if the machines are occupied, experienced users might find another way out, but novices might feel worried and don't know what to do except for waiting.

5.2 Vicarious Experiences

> *"Modeling success is an effective means of promoting self-efficacy because people judge their abilities by comparing themselves to individuals that they believe are like themselves." [38]*

Users are curious about what their body configuration would be like if they stick to the plan, this would help them commit to the exercise and having a realistic view of the result. As one of our participant pointed out:

> *"I can just see what happens to him, what experience he got, I can imagine if I'm doing the same thing like him. I can compare." (N2)*

Visualizing the result from other (under their permission) user who shares the same physical status as they do helps individuals to be well-prepared both physically and mentally. Novices usually don't know their physical status well at the beginning and are prone to have unrealistic goals, their confidence would be impacted if they fail to reach the expectations. Showing the realistic results from others enables them to better understand their ultimate goals and how much efforts they need to devote. However, experienced individuals could view others results to judge whether the plan generated by the device meet their goals, if not, they could modify the plan to see which results they desire.

Viewing others' results helps users to get better understandings of the plan, whereas seeing the future versions of themselves is more persuasive. Due to the difference between individuals, the ultimate results vary from persons due to their diverse living habits and genetics despite they shared the same plans and physical status. Creating future versions of the users based on their physical condition, diet, exercise and other habits could offer them more rational expectation other than only viewing other users' results.

5.3 Verbal Persuasion

> *"Verbal persuasion is simply encouraging the learners to build up their confidence by giving learner useful feedbacks, encouragements and reminding learners about their previous success." [38]*

Both novices and experienced pointed out if the device keeps informing wrong movements and repeated multiple times would impact their confidence and they feel annoying, because the users know they are performing wrong movements once the feedbacks were given. The breaks during each set would be the most valuable time for providing the users with additional feedbacks such as why they did wrong with the last sets, how to correct it. Users need to know the reasons behind to prevent performing incorrect forms again. Simply by pointing out the wrong movements during training would distract users' focus and disappoint users if they only heard about correcting forms without knowing the why. The device could send the users a video or a picture to explain the reasons during each set. In turn, users would be well-prepared for next sets and will make less wrong movements. The forms of information could vary based on different users. For novice users, a video might be more explanatory, because some instructions tend to use terminologies that beginners can't understand. For experienced users, the information could be simple texts to highlight the key points or hot maps to indicate the muscles. In short, the device could give users options to select the best way to instruct them during breaks.

Reminding users their previous success history would help users to build high self-efficacy. The device could record how many sets, weights, reps user achieved each time for data analysis. The data could be used to generating user's improvements and display on their homepage as encouragements, or as future prediction.

5.4 Physiological and Affective States

> *"Physiological and affective states is to enhance physical status, reduce stress levels, and negative emotional proclivities and correct misinterpretations of bodily states." [38]*

Bodily sensations are experienced differently induced rather than developed naturally. [36]. A pleasant sensation would develop positive physical states, vice versa. Thus, the device could serve as a way to guide and maintain users' pleasant status. Novices are prone to have negative status due to the lack of confidence of performing weightlifting forms even though the device prepared them with knowledge, the problem is not about knowledge per se but how they evaluate their capabilities. By scoring each form or exercise performance, the device could assist users to better understand their capabilities. If it detects continuously failure of performance, the score could be higher than it should be, but combine with reasonable explanations of failure. This feature could be applied to experienced ones as well. Despite they have better understanding of their abilities and limits, scores could also be served as a signal of improvements, because they know how to deal with the failures.

Moreover, evoking past success enable individuals to keep good moods while training and maximize efficiency as much as possible. The device could remind users' achievements such as how many sets, reps and weights they did last time before training to convince them of their capabilities and their ability to take further step.

Moods also impact individuals' judgements of personal efficacy [4]. Study has been shown that music could enhance emotional states and increase work-out outputs during training [21]. In fact, most individuals listen to music during their work-out and the feedbacks are applied through headphones. The device provides users with music they prefer or automatically select music according to the intensity and tempo of exercise during

training. Once the device detects incorrect forms, the background of music could be faded away and replaced by auditory feedbacks.

Mood states can bias attention and affect how events are interpreted [5,19]. Mismatch between moods and exercise plan might end up with lower performance and eventually debilitate perceived self-efficacy. The device could pay attention on users' current moods before engaging in exercising by recording users' moods. Before starting, the device could ask users' moods, then customize the plan for users according to his/her current mood and needs. For example, the user could select their mood – sad, tired, happy–and the intensity of work-out or the form of work-out to better cater their needs.

5 DISCUSSION

Our results complement prior work which focuses on using verbal persuasion for self-efficacy. However, much of this work does not incorporate the other three components of Bandura's theory. In this paper, we propose strategies to incorporate all of these components holistically in order to provide users with a well-rounded experience of using wearable device for training instead of receiving feedbacks.

Despite participants' diverse demands, most were in agreement that they wished to have a device that could just be like a real trainer stand by who could provide them with specific training plans, understand their exercise behaviors and current moods for training, motivate them as needed in the right time and so on.

5.1 Dynamic, In-time Feedback

Based on our findings, the wearable device should be more dynamic, creating interactive dialogue with users if user encounter problems such as not being able to correct their forms after multiple reminders from the devices. This experience would better replicate the experience of working with a personal trainer, a service that many of our participants desired to have but could not afford or make time for.

5.2 Iterative Workout Plans for Growth

While we did summarized features for novices and experienced users, there's still a lack of method to differentiate novices from experienced trainers since users might don't have knowledge of judging their abilities, overestimate or underestimate their abilities. For example, if the user under-estimate his ability, the device might generate a plan which is for novices. The plan might have some knowledges overlaps with his current exercise knowledge but not something new for him to learn.

Also, there is a gray area that exists in the transformation from being a novice to being an expert.. The transformation is a gradual process, users might keep learning knowledges not just limited to the devices. As a result, their level of experience is hard to determine only by monitoring their training sessions. Simply judging from the device to determine exercise plans and asking users to follow fixed plans might not be efficient enough for users due to overlapping knowledges. Hence, should the device not only learn users' past experience but also follow up with their current knowledges could provide them with more precise and efficient plan for training and learning.

This kind of iterative trial and adjustment of workout plans, based on both short-term and longer-term goals, is commonly done by professional trainers. These trainers will evaluate a new client's abilities, help them set realistic goals, and continue to refine these goals as the client grows. A workout technology that helps users iterate on their plans would replicate the experience of working with a trainer, and could promote better mastery experiences by choosing achievable goals for a particular workout session.

5.3 Technologies for Other Domains

Finally, our findings might generalize to other types of technology such as weight loss program which require long-term efforts of reaching goals. Self-efficacy plays a major role in coping with individuals to give over barriers physically and mentally. applying the verbal persuasion and vicarious experience could encourage individual to achieve their goals more positively and prevent relapse during the process.

Self-efficacy can also play an important role in achieving rehabilitation outcomes for people with injuries or disabilities [37]. Beyond improving their performing on physical strength or mobility tasks, higher self-efficacy is also correlated with feeling less pain from injury, and experiencing less depression after an injury or disability is acquired [1]. As a result, the principles we used in this paper may also be useful for individuals engaging in non-linear journeys of recovery and self-management of their disabilities [13].

5.4 Limitations and Future Work

Our findings are limited by the fact that our participants could not use the real Ollinfit tool, since it remains in development. Otherwise, more details could be observed and different feedbacks might be given. Also, while we focused on applying the principles self-efficacy for behavior change, we didn't consider ways to bring the user back as they encounter relapse. Future work needs explore how the device could prevent and help the users to recover from the relapse.

6 CONCLUSION

In this paper, we describe the benefits and challenges that non-weightlifters and active weightlifters anticipated would occur when using wearable fitness technologies. We use Bandura's principles of self-efficacy to guide our analysis of these findings and identify techniques to design fitness technologies which increase self-efficacy for weightlifters of different levels of expertise. These findings could generalize to other interactive technologies for behavior change, or for individuals undergoing rehabilitation after injury.

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