Designing Auditory Feedback from Wearable Weightlifting Devices

Mengyue Pan
School of Informatics and Computing
Indiana University
Indianapolis, IN, USA
zoepan@umail.iu.edu

Sagar Salvi
School of Informatics and Computing
Indiana University
Indianapolis, IN, USA
ssalvis@umail.iu.edu

Erin Brady
School of Informatics and Computing
Indiana University
Indianapolis, IN, USA
brady@iupui.edu

In submission to CHI 2018 Late-Breaking Work Track.

Abstract
While wearable devices for fitness have gained broad popularity, most are focused on tracking general activity types rather than correcting exercise form, which is extremely important for weightlifters. We interviewed 7 frequent gym-goers about their opinion and expectations for feedback from wearable devices for weightlifting. We describe their desired feedback, and how their expectations and concerns could be balanced in future wearable fitness technologies.

Author Keywords
Weightlifting; wearable device; exercise form; feedback

Introduction
People often go to the gym with clear goals – to lose weight, gain strength, or build body tone. To achieve these goals, they may use exercise machines which target specific muscle groups – but these machines require precise movements which may be hard for newcomers to learn properly and avoid injury. Even elite weightlifters were reported having acute or chronic injuries through performing weightlifting incorrectly [2].

Wearable devices have been designed to allow exercisers to track daily activity, or to assist individuals in correct exercise forms. However, most of the academic work in this area has focused on how to

Figure 1: Commercial fitness tracking devices (top to bottom: FitBit, SenseVest, Polar Heartrate, and Sunnto T4).

improve the precision of activity recognition for these exercises [4,7]. There has not been detailed research on the types of feedback these devices could offer users that would lead to better workout experiences and help users maximize their exercise efficiency.

In our paper, we describe a study with 7 active gym users around their reactions to videos of the prototype Ollinfit, a commercial wearable device that corrects exercise forms as users performing weightlifting. Based on brainstorming with our participants around expected features of workout wearables, we provide suggestions to improve the feedback of these devices. For example, the feedback could provide tailored, motivating information like a personal trainer do to inspire the learner; or could provide users with analytical data to inform them about their exercise trend and predictions. These findings have greater implications for any real-time, precise feedback on task performance.

Related Work

Many devices have been used by individuals to measure calorie burn rates and daily steps taken, and to record body temperature, heart rate, or performance while exercising (**Figure 1**). While the wrist-worn FitBit device is best known publicly, other devices also collect data and provide feedback to assess the quality of physical activity. The SenseVest is a sensor integrated into a shirt, that records a user's body temperature and heartrates and sends the data to a remote computer for them to analyze. The Polar Heartrate monitor combines a wrist-worn and chest-worn unit which monitors users' heart rate and calorie burns. Once the calorie burns reach a certain amount, the device begins to beep to alert the user. The Sunnto T4 monitors physical parameters such as heart rates, burn calories, speeds and distances, and makes suggestions about adjustments in the user's workout routine (along with an estimation on how the workout improves user's aerobic fitness).

Within the academic world, applications have been developed to encourage healthy exercise routines. Buttussi et al. introduced MOPET [1], a mobile system combines wearable devices and a virtual trainer to navigate users, give real-time feedbacks and suggest physical activities for users while exercising outdoors. Other systems may be designed to motivate physical activity, such as the UbiFit Garden [3], which combines mobile phone with an on-body sensor to recognize physical activities. The range of the activities that could be inferred by the system was large, but heavily relied on physical location for context and could not detect specific activity-level mistakes.

Other projects explored detecting specific activities precisely using wearable devices. Those works mainly focused on detecting mistakes from the exercise and activity recognition. Kowsar et al. [4] designed a system that could detect deviation from the right performance. Velloso et al. [6] used a model-based system which could adjust its parameters for different users and activities to detect mistakes during weight-lifting to improve the weight-lifting performance of users. Those system or application mainly focused on activity recognition and mistake detection. In addition, there are works focused on users' feedbacks on using wearable devices to do exercise. Rector et al. [5] designed eyes-free yoga to help blind or low-vision individuals to learn yoga poses with the audio instructor for 6 standing yoga poses and got useful and customized feedbacks for future works. In this paper, we mainly focused on the feedback of the experience using those wearable devices to provide better instructions for users.

Methods

Study Design

We conducted interviews with frequent gym users focused on participants' experience with wearable devices, their reaction to the video of the Ollinfit device, their ideal feature about the wearable devices and problems within the devices. Participants were compensated with a $20 digital Amazon gift card. This study was approved by our institution's IRB, and the interviews lasted from 15-30 minutes.

Recruiting

We reached out to the National Institute for Fitness and Sport (NIFS), adjacent to the IUPUI campus in Indianapolis, to recruit participants who have experience of exercise. We set a table in the entrance hallway of the facility to recruit participants for interviews. We recruited 4 participants from NIFS. We additionally sent messages to our contacts through social media platforms (like WeChat) to recruit participants that we knew were frequent gym users. 3 participants were recruited directly.

Participants

We recruited 7 participants who had experience of weight-lifting in our study. There were 5 females and 2 males. Their average age were 23.8 years with a range between 21 to 27 years. All had exercised frequently for at least 2 years, and all went to gym between 3-7 days a week. All participants 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 either from certificated personal trainers, and another was trained by a friend with personal training experience.

Responses to Existing Workout Technology

Below we described our results of participants' experience on wearable exercise devises. Then discussed their enjoyable and customized feedbacks for future development of the devise.

Experience with Technologies

We explored participants' experience on 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 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 consume, which helped them to lose weight or gain muscle.

Quote 1:
"I would really use my phone for – sometimes I just record or just do notes like how much I lifted, so I could try to lift a little bit more the next week or something". *–P5*

Quote 2:
"I like the idea that it has the feedback to actually correct you a little bit, because the video we have right now, it's just 'follow the other movements', so there's no way for them to tell you if the gestures are incorrect". *–P2*

Quote 3:
"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?" *–P1*

Quote 4:
"…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… it can help me to correct my, you know, my movements" *–P3*

Another participant manually recorded the activities they did at the gym by taking notes on their phone without a specific application. This participant used their occasional notes as motivation for future workouts (**Quote 1**, in the sidebar).

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

In addition to traditional ways of 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.

Reaction to the Ollinfit
All of 7 participants thought the Ollinfit was cool or helpful, especially the device could correct users' poses after each pose were finished through audio feedbacks (**Quote 2**).

Users could correct their movements by themselves and exercise effectively with verbal corrections.

Some participants even asked how does the device work, they want 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, 1 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 (**Quote 3**).

1 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 (**Quote 4**).

Expectations for Future Workout Technology
Based on their prior experiences with workout technologies, and their exposure to the Ollinfit device, we asked participants to ideate about potential features and challenges of workout devices that would help them in their exercise routines.

Desired Features of Future Devices
POSITIVE FEEDBACK: Feedback is important for users to correct their movements, and 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. T his response may reveal that gym-goers are highly sensitive to potential judgement by workout technologies, and felt that negative or even neutral

Quote 5:
"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, than the previous one, it should tell me, and I don't need it to tell me all the time". –*P2*

Quote 6:
"…not something that is designed for everyone – I want some customized and personalized design that can learn my habits, it learns my schedule, it learns my eating and everything and generates exercise plan just for myself". –*P2*

Quote 7:
"The only [problem] I could forsee is that some people when they are in the gym, they get embarrassed when some people tell them how to do something. So if you could have that go through headphones or something to tell people, to tell them correct it or something." –*P5*

feedback might discourage them from using a fitness device (**Quote 5**).

PERSONALIZED DESIGN: Individuals have different goals during exercise (such as lose weight, gain muscle, train glutes), diverse eating habit. It would be perfect to maximize work-out results by learning users' eating, training habits and generating personalized plans for them (**Quote 6**).

UPLOAD NEW WORKOUTS: 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.

HEADPHONES: 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 (**Quote 7**).

Concerns about Workout Devices
Despite the potential of these devices, users listed a number of potential concerns that might arise.

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.

Discussion
Our participants' responses revealed a number of important values and concerns for workout technology design, such as concerns over being judged at the gym and a desire for a realistic training experiences. Below, we provide initial ideas on how these values could be incorporated into new corrective workout technologies.

REAL-TIME FEEDBACK: Real-time feedback should be positive and motivating, similar to the feedback provided by human physical trainers. The repetitive robotic feedback could be replaced by a real human voice with emotional and positive feedback, such as "you're doing better this time, keep going". This feedback should be dynamic, such as incremental feedback according to the performance of users – starting with very short instruction on how to correct a movement; but increasing feedback if the error continues. Feedback could also teach users by giving reasoning or what kind of injury could be caused if the error continues.

POST-SET FEEDBACK: Weightlifting combines short periods of physical motion with breaks between sets of exercise repetitions. These breaks provide a valuable opportunity to offer this additional information, like reasoning behind workouts or specific goals, while addressing concerns about privacy and distraction. During the breaks, the device could offer some knowledge via video, which users could observe for a short period through headphones.

POST-WORKOUT FEEDBACK: The device should record how many sets, reps, and weights were used each time to allow for in-the-moment workout adjustment. However, this data is also useful for long-term fitness improvement and reflective analysis. Analyzing the data could motivate users by highlighting improvements, such as showing improvements on the home page. This data also lends itself to generating predictions and trends, such as offering users with graphs of their ideal versus realistic calorie burns or monitoring changes in exercise patterns and offering future workouts suggestions accordingly.

Future Work

In the future, we plan to implement and test the feedback suggestions provided above through a Wizard of Oz prototype. Additionally, this work could extend to other demographics – Rector et al. [5] note that blind and low-vision individuals tend to perform less physical activity than sighted peers, which can cause problems such as obesity or mental health. We hope to design a device which could help people with visual impairments to do weightlifting in the gym or at their home to help them be more active and reduce health problems.

References

1. Fabio Buttussi, Luca Chittaro, and Daniele Nadalutti. 2006. Bringing mobile guides and fitness activities together: a solution based on an embodied virtual trainer. In *Proceedings of the 8th conference on Human-computer interaction with mobile devices and services*, 29–36.
2. Gregg Calhoon and Andrew C Fry. 1999. Injury rates and profiles of elite competitive weightlifters. *Journal of athletic training* 34, 3: 232.
3. Sunny Consolvo, David W. McDonald, Tammy Toscos, Mike Y. Chen, Jon Froehlich, Beverly Harrison, Predrag Klasnja, Anthony LaMarca, Louis LeGrand, and Ryan Libby. 2008. Activity sensing in the wild: a field trial of ubifit garden. In *Proceedings of the SIGCHI conference on human factors in computing systems*, 1797–1806.
4. Yousef Kowsar, Masud Moshtaghi, Eduardo Velloso, Lars Kulik, and Christopher Leckie. 2016. Detecting unseen anomalies in weight training exercises. In *Proceedings of the 28th Australian Conference on Computer-Human Interaction*, 517–526.
5. Kyle Rector, Cynthia L. Bennett, and Julie A. Kientz. 2013. Eyes-free yoga: an exergame using depth cameras for blind & low vision exercise. In *Proceedings of the 15th International ACM SIGACCESS Conference on Computers and Accessibility*, 12.
6. Eduardo Velloso, Andreas Bulling, Hans Gellersen, Wallace Ugulino, and Hugo Fuks. 2013. Qualitative activity recognition of weight lifting exercises. In *Proceedings of the 4th Augmented Human International Conference*, 116–123.
7. Darragh Whelan, Martin O'Reilly, Tomás E. Ward, Eamonn Delahunt, and Brian Caulfield. 2016. Evaluating performance of the lunge exercise with multiple and individual inertial measurement units. In *Proceedings of the 10th EAI International Conference on Pervasive Computing Technologies for Healthcare*, 101–108.