Weightlifting Wearable

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Traditional weightlifting exercises are incredibly beneficial to one's body, however, if done incorrectly with improper form, it can be counterproductive and even harmful. Beginners who are new to the sport of Weightlifting might not have the resources to give them proper feedback on whether or not they are performing each repetition of a lift correctly, therefore, we will design a haptic weightlifting wearable that helps beginners to even experienced weightlifters on keeping track of the repetitions of correctly performed lifts. The wearable will have accelerometers, and other sensors to measure the movement of the arm during a lift. We get information from the user's leg angle displacement and speed of movement to decided whether or not they are performing a lift correctly and there will be many feedback systems that will tell the user whether or not they are doing a proper lift. We will consult with physical trainers and other experts in this field in order to correctly calibrate the sleeve to be able to discern a proper repetition of a lift from a poor repetition.

1 INTRODUCTION

The United states for the past several decades has been a place where the people have been getting more and more unhealthy. The focus on consumerism, the shift towards more white collar jobs, and the lack of emphasis on the importance of exercises has all played a role in the decline of the overall health of the population. However, in the recent decade, there has been a shift towards a more health conscious lifestyle and trends like vegan diets, cross fit, and the ketogenic diets are becoming more and more popular within the population of the United States. Among the current lifestyle trends that are being adopted by many Americans, weightlifting is quickly becoming one of the most popular forms of exercise for people to get in shape. According to a study done by Dave Smith,and Stewart Bruce-Low, that was published in the Journal of Exercise Physiology, besides the obvious benefit of gaining muscle mass, weight training has been found to help increase resting metabolic rates, increase the amount of fat burned, increase the levels of testosterone, and help regulate and decrease symptoms of anxiety and depression. Recent research has also debunked myths with negative connotations about weightlifting. As a result, a growing number of people have looked towards weightlifting as their main mean of exercise. However, despite the myriad of benefits that as result of weightlifting, a huge deterrent that affects many beginners is the increased risks for injuries sustained from poor lifting techniques and form. Common injuries among novice weightlifters like tendinitis, herniated discs, and pulled muscles, are easily preventable if the right precautions are taken. Things like proper lifting form, breathing techniques, and a proper warm up are all it needs to take to prevent these injuries.

Our motivation is to encourage more people into the sport of weightlifting and help alleviate the worries of many beginners on sustaining injuries by focusing on the importance of lifting with proper for and performing a good repetition. The current situation the many beginner find themselves in is that they begin performing technically difficult lifts without an experts feedback. This results in the beginner becoming more comfortable with lifting improperly which could ultimately lead to serious injuries. The problem is that with out proper feedback, on each repetition of a lift, the lifter would start to develop a poor habit. Currently, beginner lifters would need to go to a gym and hire a personal trainer to help them through each exercises. While this is a great way for novice lifters to develop good technique and form, not a lot of people can afford paying a personal trainer. On top of that, some people might not

enjoy having to rely on a person every time they want to get a workout done. Something that might still be a problem to consider would be being able to identify "good" pain and "bad" pain. Weightlifting is inherently going to be hard and painful. Some of the pain experience by the lift is going to be the pain of muscle fibers being broken. This is good because in order for muscles to grow, they first must need to be broken. The pain that happens in tendons, ligaments, and joints is pain that you would want to avoid. For many physical trainers, it is hard to accurately pinpoint the the exact source of a certain type of pain, and with out this, it becomes hard to really know whether or not the client is actually doing productive repetitions. This remains an open challenge as there are currently no reliable way to figure out and pinpoint the exact source of pain on a person's body. Despite this, a lot could be done to prevent and alleviate pain from injuries just by focusing on lifting with proper form and technique.

Our solution is to come up with a haptic weightlifting wearable that measures the form of a person's lift and provides feedback to the user via vibrations motors, and visual representations on a mobile app, to help the user record and track good repetitions being done on lifting exercises. This haptic wearable device will allow users to receive feedback on certain lifts in order to let them know whether or not their previous repetition is good. This removes the reliance on having someone, like a personal trainer, always being there to monitor a person's repetitions, as the system it self would allow to use to work out and improve alone. Our current goal is to work on the system focusing on the leg squats a the main lifting function. The wearable will be attached to a comfortable item of clothing like compression sleeves or leggings.The current implementation of the system is a proof of concept. We want to show that if it works for something life a leg squat, this system can be used for many other different types of lifts and exercises. With the help of this device, we hope to achieve our intent in helping those who can't reliably obtain proper feedback information on lifting techniques, while still wanting to strive and work towards a healthier body.

2 RELATED WORK

Throughout the design process the team looked into many similar studies and projects. Some aimed to solve the same process of correcting physical form, but approached it using different devices like the Microsoft Kinect. We also came across studies that detected hand motions, but with infrared sensors instead of the tools we use. We were able to distinguish the research into two of the following categories: Health and Safety Focused and General Movement Focused.

2.1 Health and Fitness Focused Wearables

There exist many health wearables already being developed, Akshay Nambi developed a concept similar to ours in that it is also a wearable band. Nambi's design also has the multi sensor format that our proposed arm band will employ, however they used 3-axis accelerometer, gyroscope and a magnetometer on each band. Nambi's research focuses heavily on therapeutic lunges that will be done in your own home, making its focus health related. Our design will employ the use of different technologies and focus on upper body motions, unlike the heavy focus on lunges that Nambi's implementation focused on. [4]

Another related work is a piece done by researcher Velloso, in his paper he details a system that aims to correct user form and increase the accuracy of correct form recognition. Through his work we see that what we are trying to accomplish is feasible. Velloso's research differs from ours in that it uses a variety of sensors that we do not. A belt, a glove, an armband, and a traceable dumbell. Our implementation excels at creating an easy to use workout assistant

while this work if implemented for an everyday user would prove tedious and cumbersome. [7]

An application of motion tracking implemented by researcher Aminian describes a solution that could compete with camera tracking using on body sensors like gyroscopes and accelerometers. This implementation focuses on the monitoring of elderly and tracking their movements over a long period of time in order to asses factors like fall-risk in that category of people. Our proposed solution is less intrusive and is only required to be used through the duration of the workout with an instantaneous response. [8]

In an effort to assist weightlifters in assessing their form, researcher Chatzitofis employs the Microsoft Kinect to identify deficiencies in Olympic style lifts. Chatzitofis is assessing a compound exercise that uses the entirety of the human body with a Kinect camera. The proposed implementation from our team does not use the kinect and will not be targeting full body exercises. In addition, researcher Srisen addressed the deficiencies in the kinect by developing a joint identifying software to better aid projects like the one Chatzitofis directed. [1] [6]

2.2 General Movement Focused

Research Pan has developed her own health wearable, however her paper details responses by a group of gym-goers and what is desirable in a gym wearable. This work can not only aid us in the future development of the product, but also shows that there is interest and room for improvement in the current field. One of the judgements cast by the test subject was that Pan's implementation was not personal and could cause embarrassment due to its appearance and emitted sounds. Our implementation addresses these concerns by being form fitting and allowing the audio feedback to be from the mobile app which can be muted or redirected to headphones. [5]

A piece of work by Korpela demonstrates the ability for long periods of use for wearable systems. Korpela developed a low energy method of tracking motion in this paper, which could be applied when implementing our design. Korpela uses devices that we would be using and this adds to the feasibility of our product. Users do not want to be held up by a charger, this would ensure that multiple charges can be held by our product if implemented with his in future work. [3]

Researcher Hardegger comes up with a solution to map out floor plans by using a tracking solution and wrist sensor. Not only could we implement this with our product if we partnered with a chain of gymnasiums, it would allow the detection of exercises to be better refined. It would be hard to do the exercise 'Skull Crushers' at the rope pulling station. Hardegger uses this fact in his paper, he states that certain motions are recorded in higher frequency when near certain physical objects. In this case, it would be the gym equipment. [2]

3 DESIGN

3.1 User Stories

The weightlifting team has created its user stories with its focus on the users interaction with the device.

As a user it is important for me to be able to pair my wearable and phone easily. This would reduce stress and give a positive user experience. For this reason one of our epic user stories is to allow for easy connection between the devices. Some potential ways we explored the features allowed by this story are to control wearable settings like vibration

strength and LED brightness through a settings view in the application. Thus the user story of creating an application where settings can be manipulated was created. When using an application, we would like for information to be present there as well, and in a manner that is satisfying to read and interact with. This also became a user story.

Not only was their software user stories, we are also concerned with the effects of the physical presence of our wearable on our users. Concerns with wearables are commonly about style and inability to conform to a users tastes. We thought of a user story to satisfy this, a user should not be burdened by the wearable. This can include emotional things like embarrassment, a wearable that is a body suit would violate this, and physical aspects such as being too heavy or uncomfortable. In addition to a user having a positive experience with the physical appearance and wear, we really liked the idea of having strong haptic feedback to encourage correct form and had that included as a story. Initially we discussed abrupt burst for incorrect actions, which also became a user story.

3.2 Pilot Studies

Our pilot study will be conducted with a regular gym go-er to see how it fares for someone who is passionate and active in the lifting community. Once our proof-of-concept wearable has been developed, we plan to request feedback on wear, appearance, and usefulness. Wear would include some of the goals we included in our user story such as how comfortable it is and how pleasant is it to look at and wear. Usefulness will encompass the main usability points of the wearable, here we will be looking at how well we are able to detect incorrect form and request feedback on how it changed the way the pilot user conducted their workout. Finally, we would look for feedback on what the user thinks can be done better and how often they believe they would use this wearable.

3.3 Interviews and Observations

According to researcher Pan, gym users would like a variety of things from their wearable. It should not be an embarrassing piece to wear, as going to the gym can be a social event and users are vulnerable to criticism in the gym environment. In addition to not affecting the user's social interactions, users would like wearables that complement their shape or are personalized to their body type. Our wearable accomplishes this by being a form fitting band that upon initial proof of concept will come in one color but further work will allow for different color bands.

One interview that we conducted gave us critical feedback on the basis of our wearable. We initially were aiming to conceive an pants wearable to detect correct bicep curl motions, an interview with an experienced lifter ended up revealing that far more data points would be needed to reach a conclusion on correct form. The misunderstanding that we had of the problem space led us to redirect our design and with feedback from the interviewee ended on the current design of a wearable aimed at correcting squatting form.

3.4 Prototyping

Because the focus of our product is to help correct lifting form, our prototypes have all been centered around common exercises that are often performed wrong. The first iteration of our work was based around the squat that targets the legs. Initially, we thought of sweat bands as easy ways to house the sensors, they weren't common but they were able to be worn in the places we needed them. What turned us away from this is the lack of simplicity. A user would have to remember each of these pants on the way to the gym, and then place them each correctly. We looked to see what kind of wear was common in the weight room and noticed that pants could house the data gathering tools we needed to proceed. A pair of pants could be designed to indicate a 'top side' and a 'bottom side' to ease the use of the sensors for

the researchers, while allowing for the simplicity of one object. Once we were made aware of the problems with our idea, we pivoted to another common exercise done wrong, squats. The presence of bands worn on the legs was a great motivator to keep the old design. While we proceed in our research we are open to alter the design, some alternative designs we've discussed are a pants like wearable that is skin tight allowing for shorts and pants to be worn above them.

4 SYSTEM

The product will be split into two parts. The phone application will be used as a medium to interface with the wearable technology sleeves while the wearable sleeves act as the mechanism to measure and compute the motion occurring in real time. The aim of the phone application is to be used as a storage and tracking interface for a personfis activities in order to assist people in logging the information, and the transmission of information between the phone and the pants will be taken care of over Bluetooth technology. The interface focuses on visualization of the Bluetooth connection and feedback from the device in order to show a personfis quality of the squat. The wearable pants is equipped with an raspberry pi zero w microcomputer with an inertial measurement unit reading accelerometer data. Using the microcomputer and the accelerometers, we have recorded the accelerometer data of squats from physical trainers. The squats they performed are then separated into two categories labeled good and bad. Then using a classifier we determined the center point for those two sets of data. When a user decided to pick up the pair of pants and record a squat, that squat is then measured against the two centers of the labeled data and is given a label itself, good or bad, based off of the distance between the centers. The classifier is implemented very similarly to a classifier used in machine learning. Here the points collected from a squat, or multiple ones server as the data points on a certain space. Each squat, both good and bad are plotted on the mathematical space and a center point for the data is calculated. Here the center point is the average off all the labeled squats, both good and bad. When the participant comes in and does a set of squats, it is converted into a matrix and the normal vector between the input squat and the good and bad squats are calculated. The one it's closest too is determined to be the right one and that data is sent to the phone. Although this system generally works, it can be faulty in the sense that there is only one good squat and one bad squat center point. If we were to perform a bad squat that is different than the labeled bad squats then it would still return good squat. In order to fix this we need to label a whole lot more data, and calculate a whole lot more bad squat center points in order to more accurately determine the quality of the squat performed by the user. The system we have for the most part gives seemingly accurate results of generalized good and bad squats. If a squat is good then it would return on the phone a "Good Squat" message, if something is wrong, mainly not going low enough or violent shaking, then it returns a "Bad Squat" message. A user would have the app on their phone and pair it with the raspberry pi. Once connected, the app would open and the user would press the start button. Once the button is pressed the pi would start reading the data and recording it. Once the user stops his rep, he would press the stop button and the data would stop recording. Once the data has stopped, the server on the pi would calculated the distance between the rep and the stored averages of the good an bad data. The app then returns a good or bad squat to the user so they know if they are performing the squats correctly or not.

5 RESULTS

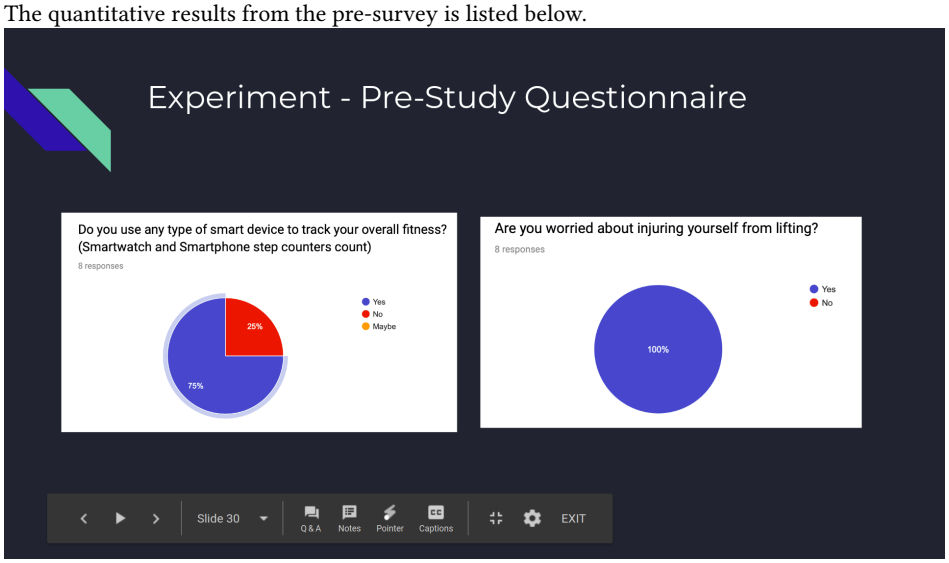
The purpose of our evaluation was to see if the concept of a wearable giving feedback to weightlifting was a good idea among users, especially beginners who would wear it. In order to better understand the opinion of the common man, we needed to evaluate people, those with and without weightlifting experience in order to gain feedback on whether or

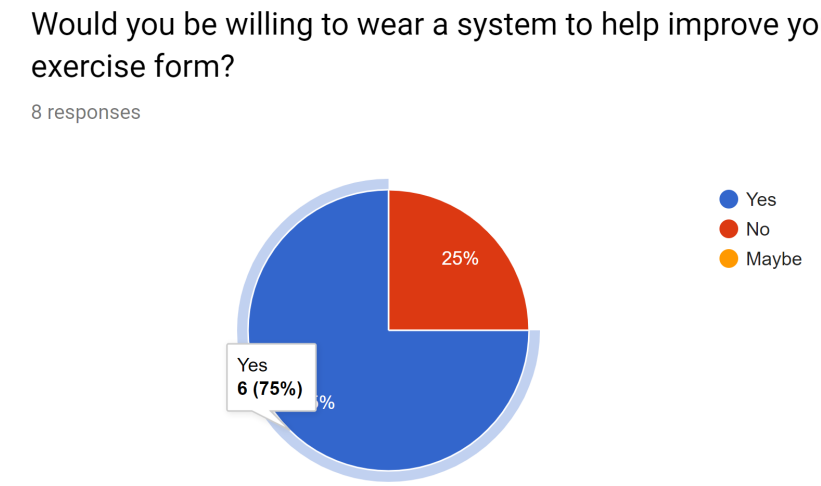
not the concept of our system would be desirable and profitable. We recruited about 8 participants with 4 of them being male and 4 of them being female. The average age of the participants were around 21 years old and all of them are in their senior years of graduating. Before conducting the actual study, we had a pre-study questionnaire that they had to fill out. This questionnaire gave us information such as age, lifting experience, whether or not they used their phones during a workout or if they are worried about injuring themselves during the workout.

In order to perform the evaluations, the systems needed to be setup with the user walking into a room and fill out the pre-study questionnaire. Afterwards the user would put on the system and perform 10 squats each while using a designated phone. After the user understands how the system works and gets an opinion, they would then answer a post question survey and give us their opinions on the system. In total, the evaluation lasted around 15-20 minutes for each participant as they weren't require to do much for fulfill our needs.

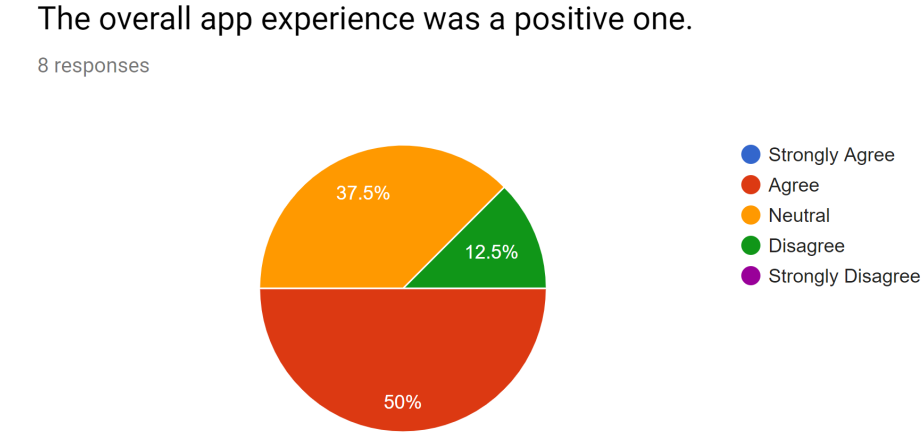
What we are currently doing is making a system to supplement or replace the need for a personal trainer. Currently, in order to perform certain lift, you would need a personal trainer to watch your form and technique to make sure you do not injure yourself doing the squats. Here, the comparison we are making is whether or not having this wearable is giving a more or less pleasant experience than the traditional method of having a personal trainer. Many beginners to this activity have stated that they feel intimidated by personal trainers and would rather get feedback in a less intrusive way. Here the questions asked by our pre and post study surveys are factors in determining the overall experience of the weightlifting wearable. The metric we are using in this case is less objective and more subjective based off the user's experience with the system itself. We are able to quantify this measurement by asking the participants to represent their opinions, as best as they can in a numerical format from a scale of 1 to 5. This way of quantifying the data collected on the opinions of our system can easily be used visualize and analyze them.

The quantitative results from the pre-survey is listed below.



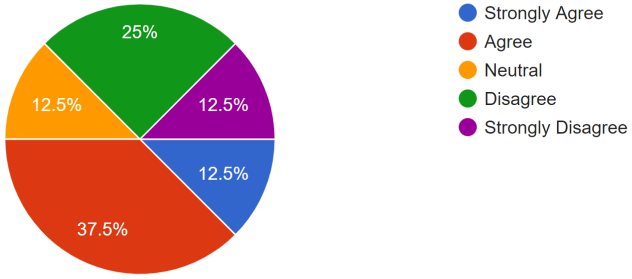


The quantitative results from the post-survey are listed below.



The hardware was bulky and cumbersome.

8 responses



The qualitative data taken was mainly a result from the post-survey. Here the data is in the form of answers to questions in regarding the wearable.

Is there anything you particularly disliked from the system?

7 responses

Not properly working
None
No feedback
Wasn't what I expected but I'm sure if given enough time it would be good
The phone app was a bit simple, and would like to see some progress to a goal or some sort of gamification.
I would like some more real time stats
It would be nice to hide the wires, but that's about it.

Is there anything you particularly liked from the system?

7 responses

Good idea
None
Really good idea if implemented well.
Although it wasn't removed during the study, it would be neat to be able to change the position of the sensors for different exercises
the low profile was not the best, but I understand it is in development phases
It looked like more sensors could be included and that would be cool to be wired up with sensors.

6 DISCUSSION

The results from the user testing were as expected from our system. While we understood that our system wasn't fully implemented in the way we imagined, a lot of the results given by the users reflected the quality of our system, however a good majority of them also reflected the quality of the idea of our system. Looking at the pre-study questionnaire,we see that a good majority of the participants have experience with smart devices used to track overall fitness, and that all of them are worried about lifting injuries. From this we can concluded that the need for our wearable lifting system isn't that bad of an idea and might be something that could be profitable in the market if implemented and marketed well enough. The participants have also shown to be interested in a wearable that helps them watch proper lifting form in order to prevent injuries. When asked about the overall experience of the wearable, a large majority of them mentioned that it was a positive experience while a few mentioned that it wasn't. From this, we could tell that the choice in using squatting pants to record and give proper feedback on lifting form is one that would be profitable. However, when asked about the bulkiness of the pants, we received mixed reviews. In the end we concluded from this that we could have worked better on wire management and using a lighter battery pack to charge the raspberry pi and the sensor. The participants mentioned that they were interested in the system but felt there was a numerous number of things they felt off about the system. Things ranged from not working properly, to no feedback, to wanting real time data feedback was given and they overall felt that the system itself needed more properly working features. We couldn't implement a lot of the things they wanted because of the time constraint of the class and the setback from notch sensors delivery. These things would be something we would consider for future work. The positive feedback from the participants stated that they felt this was a good idea and could potentially be successful if implemented well.

Looking at the system, the thing that people like the most, was the idea of this lifting wearable. What worked here was a system that gave feedback on squat forms and the intent behind it was to correctly guide a beginner into doing good squats.

The haptic feedback feature was something that we really thought we could complete within the time-frame given. However, due to the setback of the notch sensors, we weren't able to give complete this task despite the fact that it is an uniquely identifying feature of this system. We feel that if implemented well, it we would receive a lot more positive

feedback on our system. Based off of our user data and the amount of positive feedback we have received we have concluded that the idea of our system is one that has potential to be great, but the lack of features and the current implementation brings it back down a couple of levels. There is a lot more that could be done on this project and we feel as though if we had more time and had less obstacles, we could have done a better job implementing the system and getting more features on it.

7 FUTURE WORK

Due to unforeseen circumstances a number of setbacks are presented to the overall project. These came in the form of hardware changes and overall system modification. If there was two more weeks it would be possible to complete the project in a more refined manner by making additions to the hardware and really train the squatting algorithm further.

The system would go from using one raspberry pi with an adafruit sensor to a system that uses five raspberry pies, each fitted with an adafruit sensor and one of them with a seven-segment digital counter circuit. Being able to use five sensors would allow the algorithm to receive exponentially more data to work with. This would help train the algorithm to develop a precise model for a squat and allow us to categorize the types of issues with an incorrect squat, and be able to guide a user towards improving their form in a precise manner. The counter would allow the user to stay off of their mobile device and keep track of the amount of repetitions that have been performed. Another issue brought up by our users is reducing the size of the sensors. Decreasing the bulkiness would allow users to use the system without worrying about letting anyone know that a person was currently using the system.

One of the biggest changes that would be need to be made would be the addition of haptic feedback through the use of multiple vibration sensors. These sensors could be used to inform a user when they have reached a desirable position or if a squat was performed incorrectly. Break time's could be signaled with the use of a a specific vibration and the duration of the break could be tracked with a vibration every second that is allotted for the break.

The app would be changed to be more interactive and would focus on the gamification of the process as well as establishing goal tracking for the user. Gamification would allow the user to interact with the app in a more effective manner and tracking would motivate the user to work towards a goal and improving their form in the process. Allowing the user to use the system completely hands free would be another goal to work towards in order to make the system as least invasive as possible by allowing them to use the system without constantly having to be on their mobile device. Displaying a users goals and allowing users to compete with friends in order to promote and motivate people to stay active through competition.

8 CONCLUSION

Weightlifting has been shown to be incredibly benefit to improving health, however improper form could lead to long lasting injuries. A problem many beginners find is that they need a trainer to be with them to monitor the form of their squats, dead-lifts, and other lifts in order to make sure that they remain injury free. However, this restricts people's time to the schedule of the trainer and as a result, could discourage beginners from weightlifting. We decided to create a system that gives feedback the form of certain weightlifting exercises. The current system uses a sensor to calculate the acclerometer data. It then uses the data and compare to pre-labeled good and bad squat data to determine if the squat performed is one that is done with proper or improper form. The data is classified by looking at labeled data and determining averages among them. The learning labeled data are ones performed by experts in lifting techniques, and have provided both good and bad form squats to train the classifier. The data is compared to the labeled data and is determined based off of shortest distance. The user then gets a feedback from the phone telling them whether or not

the squat was done properly.After receiving feedback from user studies, we've concluded that even though there could be more features implemented on the system, the overall idea and design is something that shows promise.

A PROJECT MANAGEMENT

A.1 Implementation Schedule

Wearables Team : The Perfect Rep

= an automatically calculated cell

TASK NAME	START DATE	END DATE	START ON DAY*	DURATION * (WORK DAYS)	TEAM MEMBER	PERCENT COMPLETE
Research Topics						
Wearable Clothing Evolution	1/29	1/31	2	3	Daniel	100%
Fitness Tracking	1/29	1/31	2	3	Dawson	100%
Joint Angle Measurement	1/29	1/31	2	3	Jose	100%
User App Interfaces	1/29	1/31	2	3	Jason	50%
Personal Training Cost/Benefits	1/29	1/31	2	3	Jose	50%
Wearable Sleeve						
Design Wearable Sleeve	2/4	2/15	6	12	Daniel	80%
smartphone	2/9	2/10	11	2	Daniel	0%
Measurement	2/16	2/20	18	5	Jose	0%
Counter	2/20	2/22	22	3	Dawson	0%
Placement	2/6	2/8	8	3	Daniel	0%
Mobile Application						
Design UX/UI	2/10	2/15	12	6	Jose	70%
Develop Functionality	2/14	2/22	16	9	Jason	0%
Finalize UI	2/23	2/25	25	3	Jason & Jose	0%
Test Connectivity	2/9	2/10	11	2	Dawson	0%
Finalize Design	2/15	2/15	17	1	Dawson	0%
Testing						
Develop a Proper Test	2/15	2/22	17	8	Dawson	30%
Consulting Personal Trainers	2/4	2/10	6	7	Jose	10%
Update UX UI	3/1	3/5	31	5	Jose & Jason	0%
Sleeve Testing	3/1	3/25	31	25	Daniel	0%
Documentation						
IRB documentation	1/29	1/31	0	3	Jose	20%
Final Paper	1/29	1/31	0	3	All	0%
Final Presentation	1/29	1/31	0	3	All	0%
User Studies	1/29	1/31	0	3	All	0%

A.2 Validation and Testing Procedures

To validate and test our device, we will conduct a user study where the users will lift weights while wearing the device and give us feedback. Also, we will consult with personal trainers to ensure that we are correctly monitoring the form.

A.3 Division of Labor and Responsibilities

(1) Design Wearable Pants (Jose)
(2) Enable Connectivity to smartphone (Daniel)
(3) Design UX/UI (Daniel)
(4) Develop Functionality (Jason)
(5) Finalize UI (Jason & Jose)
(6) Test Connectivity (Jason,Daniel,Jose)
(7) Finalize Design (Jose)
(8) Develop a Proper Test (Jason, Daniel, Jose)
(9) Consulting Personal Trainers (Jose)
(10) Sleeve Testing (Daniel, Jason, Jose)
(11) Train Classifier (Jason)

A.4 Budget Costs

Total cost: $302.88

Item: Compression Sleeve
Description: Compression sleeve for arm
Quantity: 2(1 medium 2 pack, 1 large 2 pack)
Stock number: B00HTUJIN4
Unit price: $19.98
Total price: $39.96
Intended Purpose: base of the product

Item: Arduino Lilypad USB Plus
Description: Microcontroller
Quantity: 4
Unit price: $25.95

Total price: $103.80
Intended purpose: Base processing unit

Item: Accelerometer
Description: triaxial recording device
Quantity: 10
Unit price: $5.50

Total price: $55.00
Intended purpose: One of 2 inputs used to calculate joint angle.

Item: Serial Slave Module
Description: bluetooth module
Quantity: 4
Unit price: $6.29
Total price: $25.16
Intended purpose: connect sleeve to mobile device

Item: Vibration Motors
Description: Vibration Motor 11000 RPM
Quantity: 20
Unit price: $1.95
Total price: $39.00
Intended purpose: Necessary for vibration

Item: LEDs
Description: multicolored LEDâĂŹs
Quantity: 1
Unit price: $6.99
Total price: $6.99
Intended purpose: Useful for connection feedback

Item: LED Number pad
Description: 2 Pcs 4 bit LED Number Display
Quantity: 2
Unit price: $5.49
Total price: $10.98
Relation of item to project: Needed for rep display on sleeve.

Item: Set of Weights
Description: 10lb Dumbbells
Quantity: 1 Pair
Unit price: $21.99
Total price: $21.99
Intended purpose: Needed for testing the arm movements

Item: Adafruit 9-DOF Absolute Orientation IMU Fusion Breakout - BNO055
Quantity: 5

Price for each : 34.99

Item: Raspberry Pi Zero W
Description: microcomputer
Quantity: 3
Unit price: $20.95
Total price: $62.85
Intended purpose: Needed for running sensors and calculating data analysis.

B ENGINEERING STANDARD

B.1 Environmental and Health/Safety Concerns

B.1.1 Environmental Concerns. There are no environmental concerns related to our project.

B.1.2 Health/Safety Concerns. One safety concern of our project is to ensure that the user is still safe while lifting weights. Another safety concern is to ensure that the intensity of the vibration received from the sleeve is not unnatural and does not cause the user to drop the weight.

B.2 Social, Political, and Ethical Concerns

B.2.1 Social Concerns. A social concern related to our project is will it be adopted by users because it is different from what is normal.

B.2.2 Political Concerns. There are no political concerns related to our project.

B.2.3 Ethical Concerns. Because we are testing the device with users, we must ensure that they are treated ethically.

B.3 Manufacturability, Sustainability, and Economics

B.3.1 Manufacturability. Our project has good manufacturability because it is only made up of a few components, so the manufacturing process will be simple.

B.3.2 Sustainability. Our project has good sustainability because weightlifting is a common activity that is not going anywhere, so there will always be demand for our device.

B.3.3 Economics. Since weightlifting is a common activity that will remain prevalent, so there will be demand for our device for the foreseeable future.

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