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Wearable ring device for post-exercise syncope

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Abstract. The ponderance of post-exercise syncope is shown in this paper through listing the possibility of post-exercise syncope among all kinds of syncope cases. Some inventions that have developed to monitor the post-exercise syncope are listed and compared in this work, including the cooling-down method, mobile health applications, and wearable devices. This paper shows the idea of improving the Oura Ring device to alert users not to sit right after dense exercises through measuring the user's heart rate as well as movement through sensors. By using the system usability scale, the expected feedback is shown with a range of numbers 1 to 5. Having an average expected usability score over 68, the ring device is expected to be helpful to users though some limits still involve in this device, such as some movements could not be measured clearly due to the shape of the device.

Keywords: post-exercise syncope, heart rate, Oura Ring, system usability scale.

1. Introduction

Syncope, also called fainting, is a health problem that people experience a loss of consciousness for a short period of time. It most often occurs when blood pressure or heart rate suddenly drops. There are several causes for this health problem, ranging from non-life-threating factors, like strong emotions and heavy sweating, to serious factors, such as slow heart rate (a condition called bradycardia) and fast heart rate (a condition called tachycardia). Owing to different causes, syncope can be separated into vasovagal syncope (also called neurocardiogenic syncope), cardiac syncope, and some other types. In this paper, it is mainly focused on post-exercise syncope, which is part of the vasovagal syncope. Post-exercise syncope is defined to be the loss of consciousness or the development of presyncopal signs and symptoms during physical activities or recoveries from exercise [1]. It is estimated that the incidence of neutropenic syncope following a routine treadmill test may be between 0.3 percent and 3 percent [2]. However, when a passive head-up tilt test is performed immediately after a treadmill test, this percentage can increase up to a range of 50 percent to 70 percent [2,3]. Moreover,it has been reported that by Soteriades et al., according to Framingham Heart Study data, the incidence of syncope was first reported as 6.2 cases per 1000 person-years among participants living in the Framingham community. Among them, 21.2% cases were vasovagal syncope, 9.5% cases were cardiac syncope, 9.4% cases were orthostatic, and 36.6% were unexplained.[4]

Besides the rate of having vasovagal syncope, it has been observed that on many sports-related classes, such as ballet and physical exercise, it is very common for students to sit down right after dense exercise, even though their teachers repeat "take a cool down" for several times. During exercise, the cardiovascular and respiratory systems are very active, providing blood and oxygen to the exercising

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muscles. If they stop immediately after exercise, there will be more likely to have a sudden drop on heart rate, which will further lead to the post-exercise syncope.

2. Literature Review

Syncope, the common health problem among all human beings, has been studied by many scientists. Research has shown that the overall incidence rate of syncope reported for the first time was 6.2 cases per 1000 person-years. The incidence increased with age, increasing dramatically at the age of 70. In both males and females, the age-adjusted incidence rate was 7.2 cases per 1000 person-years. Age-adjusted incidence was almost twice as common with cardiovascular disease as in participants without cardiovascular disease (10.6 vs. 6.4 per 1000 person-years). The incidence rate of vasovagal syncope was 1.31 cases per 1000 person-years, compared with the rate of orthostatic syncope which is 0.58 cases per 1000 person-years. Assuming a constant incidence rate over time, researchers calculated a cumulative syncope incidence of 6 percent over 10 years.[4] Some research and technologies have been introduced.

2.1. Research

2.1.1. Inspiratory Threshold Device. In a paper, Alisha mentions a small lightweight disposable plastic inspiratory threshold device, which is a device that can reduce the severity of upright symptoms during a squatting test as well as in central hypovolemia caused by negative pressure of the lower body.[5] With the help from this device, users are capable to experience a lower drop in blood pressure; therefore, the probability for post-exercise syncope to happen is reported to be decreased.

2.1.2. Initial Therapy. Due to the initial therapy of vasovagal syncope being non-pharmacological, Rose recommends in a paper that Aerobic and isometric exercises of the upper and lower limbs reduce the recurrence of vasovagal syncope. Tilt training compared with conventional treatment shows limited efficacy in controlled studies. The use of compression stockings in the lower limbs may be recommended, however it has limited efficacy and poor adherence. [6]

2.2. Cool Down

A recent survey among collegiate athletic trainers in the USA found that a cool-down is recommended by 89% of the trainers.[7] To some extent, this could help prevent the post-exercise syncope. It has been suggested that an active cool-down may prevent post-exercise syncope and cardiovascular complications by: (1) increasing blood flow to the heart and brain due to the contractions of the muscles, [7,8] (2) decreasing blood pooling in the lower extremities, and (3) theoretically preventing an increase in the partial pressure of arterial carbon dioxide. [5] Taking cool down exercise, including walking stretching could be a method to help people calm down and peace their heart rate after dense exercise; therefore, prevent syncope.

2.3. Mobile Health Apps

There have already been many health detecting apps, like Google fitness, Samsung health, in all types of app stores on users' mobile phones. Most of them are intended to have similar function. Some very popular functions are step collection, heart rate detecting, and temperature sensing, aiming to monitor users' health condition.

2.3.1. Google Fit. Google Fit is a health detect mobile app which is available on Google app store. It takes telling people how many exercises they require to keep fit as its goal. able to detect people's heart rate and let people check their health data. Moreover, Google Fit together with AHA and WHO help monitor the number of users' physical exercises in order to make sure whether the user reaches the AHA and WHO's recommended amount of physical activity or not. That amount has been shown to reduce the risk of heart disease, improve sleep, and increase overall mental health condition.

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2.3.2. Apple Fitness. For Apple users, there is a built-in application called Apple Fitness. This app allows users to set up their own goal for physical exercises, check their calorie consumption, steps and distance they travel. It even provides users with videos about physical activities to follow every day.

Figure 1. Google Fit.

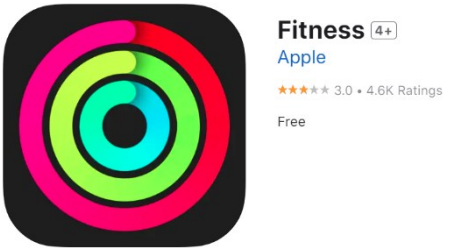

Figure 2. Apple Fitness.

2.4. Mobile Health Devices

In the market, there has been several wearable devices to help monitor user's health condition. Some popular ones, for example, Apple Watch, Oura Ring.

2.4.1. Apple Watch. Apple Watch has been a very popular mobile device which can monitor user's health condition while using. It contains irregular rhythm notification, high and low heart rate notifications, ECG sensors (not all types of Apple Watch contain this sensor), and some other systems. These systems allow the Apple Watch device to alarm the user when the heart rate is too high or too low, or some other health conditions. The device is able to be connected to the user's mobile phone through Bluetooth and post data collected to mobile health devices downloaded on the user's mobile phone, including Apple Fitness and Google Fit.

2.4.2. Rods and Cons' Smart Glasses

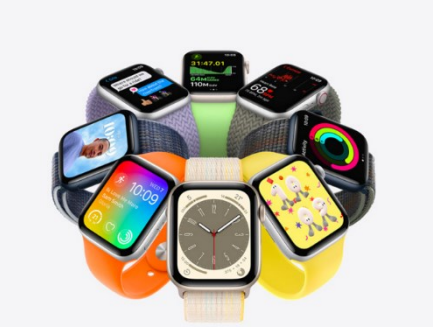

Figure 3. Apple Watch.

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This device has an outlook as a pair of glasses and is connected to user's mobile phone through Bluetooth. The smart glasses allow surgeons, medical device specialists, and other experts to collaborate remotely before, during, and after surgeries; moreover, surgeons are able to share information as well as their personal opinions. In addition, data clock system on the glasses help improve the security of user's data. However, this device mainly focuses it users on people who are specialized in medicine and healthcare instead of patients.

2.5. Limits

Although there has already been many devices and apps introduced for mobile health, some limits appear through the using process. For those mobile health apps shown in the app store, some of them are a little bit not that useful. Just as the Apple Fitness. It is true that this app allows users to clearly look at their health condition, such as their heart rate and calorie consumption, but it cannot provide information about disease, or allow users to ask directly to expertise about their health problems. Such kinds of fitness devices mainly focus on monitoring users' health conditions but not providing users with self-treatment abilities. Also, the same thing happens on Google Fit and some other apps. It is more likely to find that getting ability to get contact with an expertise is not provided on, or in another word, is separated from, most health detecting apps. For those wearable health devices, Apple Watch could provide the alarm system as it is able to warn users if they sit for a long time, but it also alarms when the user is sleeping. The Smart Glasses is a very convenient device as it is similar to a pair of glasses, which allows users to wear it in daytime, but it is mainly used in medical surgeries for expertise, not for patients or normal people in their daily life.

Figure 4. Rods and Cons' Smart Glasses.

3. Conceptual Framework

Facts that would lead to post-exercise syncope could be classified into cognition and behavior. For cognition aspect, some people know nothing about post-exercise syncope. As a result, the impact of sitting down right after dense exercises on post-exercising syncope would not be noticed by those people; therefore, without any prevention, the probability for them to experience this syncope is more likely to be higher. like taking a cool down to prevent. For behavior aspect, there is some people that have already know about post-exercise syncope and how sitting down influence the syncope, but they still do not take it seriously or still sit down after workout. A similar result will be got under this condition. Through this paper and device, it is hoped that more people could realize this health problem and do something,

4. Methodology

To help people prevent post-exercise syncope and cardiovascular complications, I plan to improve Oura Ring, a ring-like wearable device. This light beautiful wearable device contains PPG sensor, NTC sensor, and 3D accelerometer. Through the 3D accelerometer and PPG sensor contain in the device, the Ring has already been able to monitor users' movements and detect users' heart rate. The Oura Ring collects data from users and post the data through Bluetooth to the user's account on the Oura app.

What I do is to add a system that allows the Ring to prevent users from directly sitting down after dense exercises which would further lead to post-exercise syncope. Owning to there being a 3D accelerometer to detects whether the user is moving or not, or is going to sit or not, the users' movement

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could be identified into exercising or sitting. If the user's activity turns from exercising to sitting, the device will send an alarm to the Oura app on the mobile phone to warn the user not to sit immediately but to do some cool down for about five to ten minutes, for example the easiest one—walking. After cooling down, which is about five to ten minutes, when the PPG sensor inside the Ring monitors that the user's heart rate back to normal, another alarm will be sent to the Oura app in order to tell that it is able to sit down. With such an alarm system, users of Oura Ring would be able to prevent post-exercise syncope to some extent.

5. Data Analysis

System usability scale

The system useability scale in Graph 1 shows the table I sent to users in order to get their feedback.

Table 1. system usability scale.

Questions		**Agreeable**				
1	I think that I will be happy to use this system very often.	1	2	3	4	5
2	I find the system over complicated.	1	2	3	4	5
3	I thought the system is easy to use.	1	2	3	4	5
4	I think that I will require technical support in order to use this system.	1	2	3	4	5
5	I find the various features of this system to be well integrated.	1	2	3	4	5
6	I think there is too much inconsistency in this system.	1	2	3	4	5
7	I could imagine that most people will learn to use this system very quickly.	1	2	3	4	5
8	I find this system a pain in the ass to use.	1	2	3	4	5
9	I felt very confident using the system.	1	2	3	4	5
10	I think there are a lot of things to learn before I can deal with this system.	1	2	3	4	5

Table 2 shows an average score I got from the system usability scale which I provided to users.

Table 2. expected usability score.

Questions		**Average Agreeable**
1	I think that I will be happy to use this system very often.	4.47
2	I find the system over complicated.	1.54
3	I thought the system is easy to use.	4.21
4	I think that I will require technical support in order to use this system.	1.36
5	I find the various features of this system to be well integrated.	3.76
6	I think there is too much inconsistency in this system.	1.73
7	I could imagine that most people will learn to use this system very quickly.	4.38
8	I find this system a pain in the ass to use.	1.03
9	I felt very confident using the system.	3.95
10	I think there are a lot of things to learn before I can deal with this system.	1.81

$$SUS = ((score\ for\ Q1 - 1) + (5 - score\ for\ Q2) + (score\ for\ Q3 - 1) + (5 - score\ for\ Q4) + (score\ for\ Q5 - 1) + (5 - score\ for\ Q6) + (score\ for\ Q7 - 1) + (5 - score\ for\ Q8) + (score\ for\ Q9 - 1) + (5 - score\ for\ Q10)) * 2.5$$

From Graph 2, it is easy to calculate that the average total score for the system usability scale is 83.25. It has been mentioned in John Brook's paper that if the score for the system of usability scale is over 68 which is the average score for the system of usability scale, this device could be considered to be better than the average.[9] For this wearable ring device which earned a score of 83.25, it could be a pretty usable device for a wide range of people.

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6. Conclusion

Based on my expectation, the system is going to be acceptable to user. As the wearable device is like a ring, the ring-like device will not impact users' daily lives. The small and light ring would not disturb users, no matter they are exercising or sleeping or doing something else. However, there are still some places could be improved. Limited by the wearable device has a design like a ring, some exercises might not be monitored accurately. Although it has been mentioned that people could add more data about those exercises that could not be well detected through other apps, including Google Fit or Apple Fitness, the process is slightly complexing. I would like to try some other types of sensors to detect the users' movements in the future. A camera might be helpful as the device would be able to detect physical activities by "looking" at the users which might improve the accuracy of the data and alarm at the same time.

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