# WE GOT THE BEAT!

## What is the most accurate way to monitor heart rate?

## Introduction

I received an Itouch sport smartwatch this past Christmas. When I returned to school I realized many other classmates had received Smartwatches, Fitbits, and other fitness trackers. That night I did some research on fitness trackers; the smartwatch industry has boomed and an estimated 40 million people in the United States have smartwatches or fitness trackers. That got me thinking, for all the users of smartwatch/fitness watches, is it money well spent? Are fitness tracker watches accurate?

I knew in order to test smartwatches I would need to have both controlled and manipulated variables. I decided to test my Itouch Smartwatch and borrow my grandma's Fitbit. My mom works in radiology, and she took me along to the hospital with her. She taught me the correct way to measure pulse manually. From a physician I was shown how to use and measure pulse with an ultrasound doppler probe. Due to the accuracy and ease of use, I decided to make the ultrasound doppler my standard to which the other methods would be compared.

## Hypothesis

**My hypothesis is that manually measuring the radial pulse will be the most accurate method of monitoring heart rate (when compared to pulse monitoring done by smartwatches/fitness trackers).**

I believe that my hypothesis will be correct because:

1. Physicians, nurses and medical assistants check a patient's pulse manually (feeling the pulse at the wrist and counting the beats).
2. Most smartwatches use mostly photoplesmography to record pulse (heart rate). This technology is not accurate if it cannot detect the volume changes in the radial artery. The fit of the watch (loose compared to well-fitting) and the person's skin (sweaty compared to dry) can affect the accuracy.
3. Online studies have shown that PPG (photoplesmography) is affected negatively by movement, most users of smartwatches use them to record their heart rate during activities

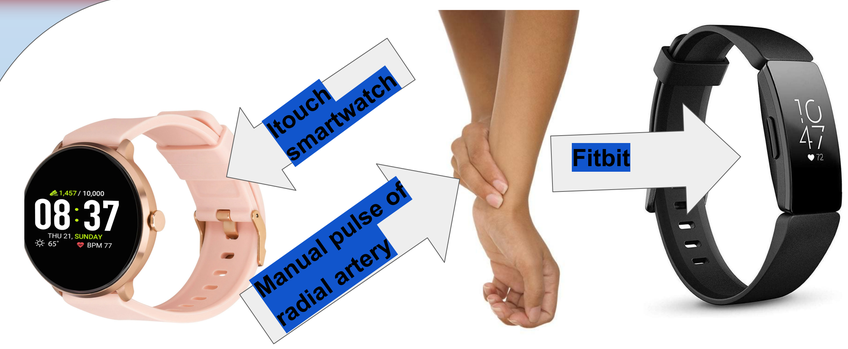
## Background

To come up with my big question, I had to learn more about pulse, fitness trackers, and the science behind it all.
First of all, what is pulse? Pulse is the heart rate, measured in beats per minute. "As blood rushes through your arteries, the arteries expand and contract in response to the pressure generated by your heart. This creates a pulse that can be felt in arteries that lie close to the skin." (The Fantastic Body, Bennett.) My mom, a medical professional, taught me how to take a person's manual pulse. First, with two fingers, gently feel for a pulse on a person's wrist, closest to the thumb side. Count the number of beats you feel in fifteen seconds. Multiply that number by four. That will give you the beats per minute.

I was curious about other medical methods to measure pulse. A physician at a local hospital showed me how to find and measure a pulse by using an ultrasound doppler. I learned to use a hand-held doppler monitor. This device can be used to detect fetal heart beats or pulses in superficial blood vessels. "It uses the Doppler effect to provide an audible simulation of the heartbeat. Some models also display the heart rate in beats per minute." (Wikipedia, Doppler Fetal Monitor, 2019).

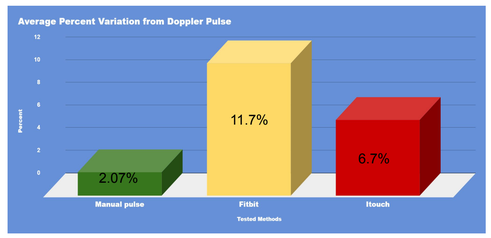
It was at this point that I began to set up my experiment. I would question the accuracy of smartwatches/fitness trackers as compared to a manual pulse. To test accuracy, I would need the most accurate method to compare my variables to. According to Dr. Mouhammed Joumaa, a cardiovascular surgeon at Ascension Hospital, "Ultrasound doppler is one of the most accurate means of measuring heart rate...as the doppler signal is recordable evidence." (Dr. Mouhammed Joumaa, 2020).

During the experiment I learned about how Fitbits and Smartwatches monitor heart rate. Fitbits and other smartwatches use optical heart-rate monitoring or PPG. An optical heart rate monitor detects a pulse by shining a light through the skin to see blood flow. Photoplethysmography, or PPG, detects the changes in pulse by illuminating the skin with the light from a light-emitting diode or LED, and then measuring the amount of light reflected. According to The Conversation, "The red blood cells in your system reflect red light and absorb the green light at any time...green LED and photodiode sensors at the back measure the flow of blood. These sensors measure the amount of blood flowing through your wrist at any given time." (The Conversation, para.7)










Testing my participant

Doppler & Gel

## The Data

**I performed steps two through four on each of the ten participants three times. To analyze my data I calculated the percent that each method differed or varied from the doppler pulse. I did this by using the formula below:**

[ Pulse by the tested method +/-Participant's Doppler Pulse] ➗ Doppler Pulse

For example, if the participant's doppler pulse was 80, and the Fitbit pulse was 86...
I took 86 and subtracted 80. That would equal 6. I took 6 and divided by 80. That would equal 0.075. That means that the Fitbit pulse varied or differed from the doppler pulse by 7.5 %!

After determining the percent that each method varied, I calculated the average. I did this by adding each varied percent together from each pulse method and dividing by thirty (the number of tests done from each method-10 people, 3 test runs). This data showed me which method of monitoring pulse is the most accurate when compared to the ultrasound pulse doppler.

After three trials, my hypothesis was supported by my data. The manual pulse varied from the ultrasound doppler pulse by 2.07%. The Fitbit varied from the ultrasound doppler pulse by 11.7%. The Itouch Smartwatch pulse varied from the ultrasound doppler pulse 6.7 %. This shows that the manual pulse has the least variation to the doppler pulse (most accurate) when compared to the fitness tracker/smartwatch pulses.

TEST RUN 1#

| Patient | Ultrasound Doppler Pulse | Manual Pulse | Manual Pulse Differ % |
|---|---|---|---|
| #1 F34 | 84 | 84 | 0 |
| #2 F48 | 68 | 72 | 5.9 |
| #3 F40 | 76 | 76 | 0 |
| #4 F32 | 72 | 72 | 0 |
| #5 F31 | 84 | 84 | 0 |
| #6 F36 | 84 | 84 | 0 |
| #7 F41 | 80 | 84 | 4.8 |
| #8 F50 | 68 | 68 | 0 |
| #9 F48 | 64 | 64 | 0 |
| #10 F47 | 72 | 76 | 5.6 |

| Patient | Ultrasound Doppler Pulse | Fitbit | Fitbit Differ % |
|---|---|---|---|
| #1 F34 | 84 | 75 | 12 |
| #2 F48 | 68 | 72 | 5.9 |
| #3 F40 | 76 | 97 | 27.6 |
| #4 F32 | 72 | 61 | 15.3 |
| #5 F31 | 84 | 73 | 13.1 |
| #6 F36 | 84 | 81 | 3.6 |
| #7 F41 | 80 | 83 | 3.8 |
| #8 F50 | 68 | 75 | 10.3 |
| #9 F48 | 64 | 68 | 6.2 |
| #10 F47 | 72 | 79 | 9.7 |

| Patient | Ultrasound Doppler Pulse | Itouch Smartwatch | Itouch Smartwatch Differs % |
|---|---|---|---|
| #1 F34 | 84 | 77 | 8.3 |
| #2 F48 | 68 | 71 | 4.4 |
| #3 F40 | 76 | 76 | 0 |
| #4 F32 | 72 | 59 | 18.1 |
| #5 F31 | 84 | 81 | 3.6 |
| #6 F36 | 84 | 80 | 4.8 |
| #7 F41 | 80 | 82 | 2.5 |
| #8 F50 | 68 | 65 | 4.4 |
| #9 F48 | 64 | 71 | 10.9 |
| #10 F47 | 72 | 76 | 5.5 |

TEST RUN 2#

| Patient | Ultrasound Doppler Pulse | Manual Pulse | Manual Pulse Differs % |
|---|---|---|---|
| #1 F34 | 84 | 83 | 1.2 |
| #2 F48 | 68 | 68 | 0 |
| #3 F40 | 76 | 76 | 0 |
| #4 F32 | 72 | 75 | 4.2 |
| #5 F31 | 84 | 83 | 1.4 |
| #6 F36 | 84 | 80 | 4.8 |
| #7 F41 | 80 | 78 | 2.5 |
| #8 F50 | 68 | 72 | 5.9 |
| #9 F48 | 64 | 64 | 0 |
| #10 F47 | 72 | 71 | 1.4 |

| Patient | Ultrasound Doppler Pulse | Fitbit | Fitbit Differs % |
|---|---|---|---|
| #1 F34 | 84 | 92 | 9.5 |
| #2 F48 | 68 | 86 | 26.5 |
| #3 F40 | 76 | 97 | 27.6 |
| #4 F32 | 72 | 80 | 11.1 |
| #5 F31 | 84 | 73 | 15.1 |
| #6 F36 | 84 | 81 | 3.5 |
| #7 F41 | 80 | 75 | 6.3 |
| #8 F50 | 68 | 75 | 10.3 |
| #9 F48 | 64 | 68 | 6.3 |
| #10 F47 | 72 | 75 | 4.2 |

| Patient | Ultrasound Doppler Pulse | Itouch Smartwatch | Itouch Smartwatch Differs % |
|---|---|---|---|
| #1 F34 | 84 | 87 | 3.6 |
| #2 F48 | 68 | 86 | 26.5 |
| #3 F40 | 76 | 76 | 0 |
| #4 F32 | 72 | 76 | 5.6 |
| #5 F31 | 84 | 81 | 3.5 |
| #6 F36 | 84 | 80 | 4.8 |
| #7 F41 | 80 | 71 | 11.3 |
| #8 F50 | 68 | 67 | 1.5 |
| #9 F48 | 64 | 67 | 4.7 |
| #10 F47 | 72 | 73 | 1.4 |

TEST RUN 3#

| Patient | Ultrasound Doppler Pulse | Manual Pulse | Manual Pulse Differs % |
|---|---|---|---|
| #1 F34 | 84 | 88 | 4.8 |
| #2 F48 | 68 | 64 | 5.9 |
| #3 F40 | 76 | 76 | 0 |
| #4 F32 | 72 | 74 | 2.7 |
| #5 F31 | 84 | 81 | 3.6 |
| #6 F36 | 84 | 80 | 4.8 |
| #7 F41 | 80 | 80 | 0 |
| #8 F50 | 68 | 67 | 1.5 |
| #9 F48 | 64 | 63 | 1.2 |
| #10 F47 | 72 | 72 | 0 |

| Patient | Ultrasound Doppler Pulse | Fitbit | Fitbit Differs % |
|---|---|---|---|
| #1 F34 | 84 | 88 | 4.8 |
| #2 F48 | 68 | 83 | 22.1 |
| #3 F40 | 76 | 88 | 15.8 |
| #4 F32 | 72 | 79 | 9.7 |
| #5 F31 | 84 | 72 | 14.3 |
| #6 F36 | 84 | 83 | 1.2 |
| #7 F41 | 80 | 75 | 6.3 |
| #8 F50 | 68 | 86 | 26.5 |
| #9 F48 | 64 | 76 | 18.8 |
| #10 F47 | 72 | 75 | 4.2 |

| Patient | Ultrasound Doppler Pulse | Itouch Smartwatch | Itouch Smartwatch Differs % |
|---|---|---|---|
| #1 F34 | 84 | 86 | 2.4 |
| #2 F48 | 68 | 85 | 25.0 |
| #3 F40 | 76 | 86 | 13.2 |
| #4 F32 | 72 | 75 | 4.2 |
| #5 F31 | 84 | 75 | 10.7 |
| #6 F36 | 84 | 81 | 3.6 |
| #7 F41 | 80 | 82 | 2.5 |
| #8 F50 | 68 | 66 | 2.9 |
| #9 F48 | 64 | 68 | 6.3 |
| #10 F47 | 72 | 73 | 1.4 |

## Variables

**Manipulated Variables:** The tested methods of monitoring pulse

- Manual pulse
- Fitbit pulse
- Itouch Smartwatch pulse

**Controlled Variables:** The procedure followed to test participants

- Participants all were tested at rest
- Participants had each method tested on their left radial artery
- All methods were tested for 15 seconds
- 1 minute of rest between testing methods
- Each participant's own ultrasound doppler pulse

**Responding Variable**

The responding variable is the variation of accuracy compared to the ultrasound doppler pulse. The variation is calculated as a percentage of accuracy among all test participants.

## Procedure

**I performed my experiment with the following steps on each of my 10 test participants:**

1. Ask participant to lay down on an exam bed. After one minute, apply ultrasound gel on the left wrist of the participant and find the radial artery with the ultrasound doppler probe. Listen and count the beats heard for 15 seconds (recorded by stopwatch). Take the number of beats heard and multiply by four to get the number of beats per minute. Record pulse (beats per minute) in a log book. Clean gel off the participant's wrist.
2. After one minute of rest feel at the left wrist for the participant's left radial artery. Count the beats felt for 15 seconds as recorded by the stopwatch. Take that number of beats and multiply by four to get the number of beats per minute. Record pulse (beats per minute) in a log book.
3. Have the participant put the Fitbit on their left wrist and wait for 1 minute of rest. Record the beats per minute as read by the Fitbit. Record pulse (beats per minute) in a log book.
4. Have the participant put the Itouch Smartwatch on their left wrist and wait for 1 minute of rest. Record the beats per minute as read by the Itouch Smartwatch. Record pulse (beats per minute) in a log book.

## Conclusion

I accept my hypothesis that manual pulse is the most accurate method of monitoring heart rate when compared to pulse done by smartwatches or fitness trackers).
The experiment data supported my hypothesis.
When compared to my standard method, the ultrasound doppler pulse, the manual pulse varied by only 2.07%. The Itouch smartwatch varied by 6.7%. The Fitbit was the most inaccurate, varying from the doppler pulse by 11.7 %. The lower the percentage, the closer the method is to accuracy. The manual pulse was the most accurate method of monitoring radial pulse. Taking a manual pulse is simple, free, and accurate.

My project is important because an estimated 40 million people in the United States have smartwatches or fitness trackers. By doing this experiment I was able to show that smartwatches or fitness trackers do not always accurately monitor pulse. I acknowledge that consumers are using these devices for more than just pulse monitoring. These devices have a clock, can monitor sleep, and they even have a pedometer. In the future, a possible experiment could be testing the accuracy of the pedometer function of a fitness tracker.

I will continue to wear my smartwatch to count my steps. I know that if I want to accurately check my pulse I can do it manually!