Introduction

Here we will be doing a case study on Bellabeat, a high-tech manufacturer of health-focused products for women. In this case, I will analyze smart device data from non-Bellabeat device to gain insights into how consumers are using their smart devices and then provide guide on marketing strategy for Bellabeat.

1. Ask

Business Tasks

- Analyze smart device usage data in order to gain insight into how consumers use non-Bellabeat smart devices, and then apply these insights in improving one of Bellabeat products.

Key stakeholders

- Urška Sršen: Bellabeat's cofounder and Chief Creative Officer;
- Sando Mur: Mathematician and Bellabeat's cofounder; key member of the Bellabeat executive team;
- Bellabeat marketing analytics team: A team of data analysts responsible for collecting, analyzing, and reporting data that helps guide Bellabeat's marketing strategy.

Questions to guide the analysis

1) What are some trends in smart device usage?

2) How could these trends apply to Bellabeat customers?

3) How could these trends help influence Bellabeat marketing strategy?

2. Prepare

Data Used

FitBit Fitness Tracker Data(CC0: Public Domain, dataset made available through Mobius): This Kaggle data set contains personal fitness tracker from thirty fitbit users. Thirty eligible Fitbit users consented to the submission of personal tracker data, including minute-level output for physical activity, heart rate, and sleep monitoring. It includes information about daily activity, steps, and heart rate that can be used to explore users' habits. Individual reports can be parsed by export session ID (column A) or timestamp (column B).

Problems with the data

These datasets were generated by respondents to a distributed survey via Amazon Mechanical Turk between 03.12.2016-05.12.2016. So it's relatively old and it is updated anually that also means data is not updated properly. These datasets only contain information from thirty eligible Fitbit users, which is a quiet small sample size. These datasets not include informations regarding users' age, gender, region, income level etc., which makes it not a perfect data source for BellaBeat, a women's focused company.

3. Process

I will be using R instead of the spreadsheet to analyze the data, since some reports are quite large in size.

Loading packages to set up the environment:

- tidyverse
- lubridate
- ggplot2

```
1 install.packages('tidyverse')
2 install.packages('lubridate')
3 install.packages('ggplot2')
```

```
Installing package into ‘/usr/local/lib/R/site-library’
(as ‘lib’ is unspecified)

Installing package into ‘/usr/local/lib/R/site-library’
(as ‘lib’ is unspecified)

Installing package into ‘/usr/local/lib/R/site-library’
(as ‘lib’ is unspecified)
```

```
1 library(tidyverse)
2 library(lubridate)
3 library(ggplot2)
```

```
── Attaching core tidyverse packages ──────────────────────── tidyverse 2.0.0 ──
✓ dplyr     1.1.2     ✓ readr     2.1.4
✓ forcats   1.0.0     ✓ stringr   1.5.0
✓ ggplot2   3.4.2     ✓ tibble    3.2.1
✓ lubridate 1.9.2     ✓ tidyr     1.3.0
✓ purrr     1.0.1
```

```
── Conflicts ─────────────────────────────────────── tidyverse_conflicts() ──
✖ dplyr::filter() masks stats::filter()
✖ dplyr::lag()    masks stats::lag()
ℹ Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

Importing Data

```
dailyActivity_merged = read_csv('/kaggle/input/bellabeat-datasets/dailyActivity_merged.csv')
sleepDay_merged = read_csv('/kaggle/input/bellabeat-datasets/sleepDay_merged.csv')
dailySteps_merged = read_csv('/kaggle/input/bellabeat-datasets/dailySteps_merged.csv')
hourlySteps_merged = read_csv('/kaggle/input/bellabeat-datasets/hourlySteps_merged.csv')
daily_Calories_merged = read_csv('/kaggle/input/bellabeat-datasets/dailyCalories_merged.csv')
weightLogInfo_merged = read_csv('/kaggle/input/bellabeat-datasets/weightLogInfo_merged.csv')
heatrate_seconds_merged = read_csv('/kaggle/input/bellabeat-datasets/heartrate_seconds_merged.csv')
```

```
Rows: 940 Columns: 15
── Column specification ────────────────────────────────────────────────────────
Delimiter: ","
chr  (1): ActivityDate
dbl (14): Id, TotalSteps, TotalDistance, TrackerDistance, LoggedActivitiesDi...

ℹ Use `spec()` to retrieve the full column specification for this data.
ℹ Specify the column types or set `show_col_types = FALSE` to quiet this message.
Rows: 413 Columns: 5
── Column specification ────────────────────────────────────────────────────────
Delimiter: ","
chr (1): SleepDay
dbl (4): Id, TotalSleepRecords, TotalMinutesAsleep, TotalTimeInBed

ℹ Use `spec()` to retrieve the full column specification for this data.
ℹ Specify the column types or set `show_col_types = FALSE` to quiet this message.
Rows: 940 Columns: 3
── Column specification ────────────────────────────────────────────────────────
Delimiter: ","
chr (1): ActivityDay
dbl (2): Id, StepTotal

ℹ Use `spec()` to retrieve the full column specification for this data.
ℹ Specify the column types or set `show_col_types = FALSE` to quiet this message.
Rows: 22099 Columns: 3
── Column specification ────────────────────────────────────────────────────────
Delimiter: ","
chr (1): ActivityHour
dbl (2): Id, StepTotal

ℹ Use `spec()` to retrieve the full column specification for this data.
ℹ Specify the column types or set `show_col_types = FALSE` to quiet this message.
Rows: 940 Columns: 3
── Column specification ────────────────────────────────────────────────────────
Delimiter: ","
chr (1): ActivityDay
dbl (2): Id, Calories

ℹ Use `spec()` to retrieve the full column specification for this data.
ℹ Specify the column types or set `show_col_types = FALSE` to quiet this message.
Rows: 67 Columns: 8
── Column specification ────────────────────────────────────────────────────────
Delimiter: ","
chr (1): Date
dbl (6): Id, WeightKg, WeightPounds, Fat, BMI, LogId
lgl (1): IsManualReport

ℹ Use `spec()` to retrieve the full column specification for this data.
ℹ Specify the column types or set `show_col_types = FALSE` to quiet this message.
Rows: 2483658 Columns: 3
── Column specification ────────────────────────────────────────────────────────
Delimiter: ","
chr (1): Time
dbl (2): Id, Value

ℹ Use `spec()` to retrieve the full column specification for this data.
ℹ Specify the column types or set `show_col_types = FALSE` to quiet this message.
```

Previewing the datasets

```
head(dailyActivity_merged)
head(sleepDay_merged)
head(dailySteps_merged)
head(hourlySteps_merged)
head(daily_Calories_merged)
head(weightLogInfo_merged)
head(heatrate_seconds_merged)
```

Id	ActivityDate	TotalSteps	TotalDistance	TrackerDistance	LoggedActivitiesDistance	VeryAct
<dbl>	<chr>	<dbl>	<dbl>	<dbl>	<dbl>	
1503960366	4/12/2016	13162	8.50	8.50	0	
1503960366	4/13/2016	10735	6.97	6.97	0	
1503960366	4/14/2016	10460	6.74	6.74	0	
1503960366	4/15/2016	9762	6.28	6.28	0	
1503960366	4/16/2016	12669	8.16	8.16	0	
1503960366	4/17/2016	9705	6.48	6.48	0	

A tibble: 6 × 5

Id	SleepDay	TotalSleepRecords	TotalMinutesAsleep	TotalTimeInBed
<dbl>	<chr>	<dbl>	<dbl>	<dbl>
1503960366	4/12/2016 12:00:00 AM	1	327	346
1503960366	4/13/2016 12:00:00 AM	2	384	407
1503960366	4/15/2016 12:00:00 AM	1	412	442
1503960366	4/16/2016 12:00:00 AM	2	340	367
1503960366	4/17/2016 12:00:00 AM	1	700	712
1503960366	4/19/2016 12:00:00 AM	1	304	320

A tibble: 6 × 3

Id	ActivityDay	StepTotal
<dbl>	<chr>	<dbl>
1503960366	4/12/2016	13162
1503960366	4/13/2016	10735
1503960366	4/14/2016	10460
1503960366	4/15/2016	9762
1503960366	4/16/2016	12669
1503960366	4/17/2016	9705

A tibble: 6 × 3

Id	ActivityHour	StepTotal
<dbl>	<chr>	<dbl>
1503960366	4/12/2016 12:00:00 AM	373
1503960366	4/12/2016 1:00:00 AM	160
1503960366	4/12/2016 2:00:00 AM	151
1503960366	4/12/2016 3:00:00 AM	0
1503960366	4/12/2016 4:00:00 AM	0
1503960366	4/12/2016 5:00:00 AM	0

A tibble: 6 × 3

Id	ActivityDay	Calories
<dbl>	<chr>	<dbl>
1503960366	4/12/2016	1985
1503960366	4/13/2016	1797
1503960366	4/14/2016	1776
1503960366	4/15/2016	1745
1503960366	4/16/2016	1863
1503960366	4/17/2016	1728

A tibble: 6 × 8

Id	Date	WeightKg	WeightPounds	Fat	BMI	IsManualReport	LogId
<dbl>	<chr>	<dbl>	<dbl>	<dbl>	<dbl>	<lgl>	<dbl>
1503960366	5/2/2016 11:59:59 PM	52.6	115.9631	22	22.65	TRUE	1.462234e+12
1503960366	5/3/2016 11:59:59 PM	52.6	115.9631	NA	22.65	TRUE	1.462320e+12
1927972279	4/13/2016 1:08:52 AM	133.5	294.3171	NA	47.54	FALSE	1.460510e+12
2873212765	4/21/2016 11:59:59 PM	56.7	125.0021	NA	21.45	TRUE	1.461283e+12
2873212765	5/12/2016 11:59:59 PM	57.3	126.3249	NA	21.69	TRUE	1.463098e+12
4319703577	4/17/2016 11:59:59 PM	72.4	159.6147	25	27.45	TRUE	1.460938e+12

A tibble: 6 × 3

Id	Time	Value
<dbl>	<chr>	<dbl>

Cleaning Data

```
num_record_activity  = nrow(dailyActivity_merged) #940 records
num_record_activity

num_record_sleep = nrow(sleepDay_merged) #413 records
num_record_sleep

num_record_steps = nrow(dailySteps_merged) #940 records
num_record_steps

num_record_hourly_steps = nrow(hourlySteps_merged) # 22099 records
num_record_hourly_steps

num_record_calories = nrow(daily_Calories_merged) # 940 records
num_record_calories

num_record_weight = nrow(weightLogInfo_merged) # 67 records
num_record_weight
```

```
940
413
940
22099
940
67
```

Found : We found that weight log record and sleep record are less than the other records.

```
## Removing duplicates to check the number of participants

dailyActivity = distinct(dailyActivity_merged, Id, ActivityDate, .keep_all = TRUE)
num_id_activity = nrow(distinct(dailyActivity, Id))
num_id_activity


dailySleep = distinct(sleepDay_merged, Id, SleepDay, .keep_all = TRUE)
num_id_sleep = nrow(distinct(dailySleep, Id))
num_id_sleep


dailyCalories = distinct(daily_Calories_merged, Id, ActivityDay, .keep_all = TRUE)
num_id_calories = nrow(distinct(dailyCalories, Id))
num_id_calories

dailySteps = distinct(dailySteps_merged, Id, ActivityDay, .keep_all = TRUE)
num_id_steps = nrow(distinct(dailySteps, Id)) ##33
num_id_steps

hourlySteps = distinct(hourlySteps_merged, Id, ActivityHour, .keep_all = TRUE)
num_id_hourly_steps = nrow(distinct(hourlySteps, Id)) ##33
num_id_hourly_steps

weightLogInfo = distinct(weightLogInfo_merged, Id, Date, .keep_all = TRUE)
num_id_weight = nrow(distinct(weightLogInfo, Id)) ##8
num_id_weight

heartrate_seconds = distinct(heatrate_seconds_merged, Id, Time, .keep_all = TRUE)
num_id_heartrate = nrow(distinct(heatrate_seconds_merged, Id))##14
num_id_heartrate

```

```
33
24
33
33
33
8
14
```

```
#Checking NA's and will identify data that we will not use due to NA's
colSums(is.na(dailyActivity))
colSums(is.na(dailySleep))
colSums(is.na(dailyCalories))
colSums(is.na(hourlySteps))
colSums(is.na(weightLogInfo))
colSums(is.na(heartrate_seconds))  # We found 65 NAs in column Fat, this column is not usable so far
```

```
Id:          0 ActivityDate:          0 TotalSteps:          0 TotalDistance:          0 TrackerDistance:          0
 LoggedActivitiesDistance:          0 VeryActiveDistance:          0 ModeratelyActiveDistance:          0 LightActiveDistance:
          0 SedentaryActiveDistance:          0 VeryActiveMinutes:          0 FairlyActiveMinutes:          0 LightlyActiveMinutes:
          0 SedentaryMinutes:          0 Calories:          0
Id:          0 SleepDay:          0 TotalSleepRecords:          0 TotalMinutesAsleep:          0 TotalTimeInBed:          0
Id:          0 ActivityDay:          0 Calories:          0
Id:          0 ActivityHour:          0 StepTotal:          0
Id:          0 Date:          0 WeightKg:          0 WeightPounds:          0 Fat:          65 BMI:          0 IsManualReport:          0
 LogId:          0
```

Found : Found out there are 65 NAs in column "Fat" in dataframe weightLogInfo, and totally there's only 67 records in this table, thus "Fat" column is not usable so far.

```
### Reformat, make sure the Date/Time all sharing the same format, the same column name; and adding column Day
daily_activity = dailyActivity %>%
```

```
    rename(Date = ActivityDate) %>%
    mutate(Date = as.Date(Date, format = "%m/%d/%Y" )) %>%
    mutate(Day = weekdays(Date)) #creating Day column for weekdays
head(daily_activity)


daily_sleep = dailySleep %>%
    rename(Date = SleepDay) %>%
    mutate(Date = as.Date(Date, format = "%m/%d/%Y")) %>%
    mutate(Day = weekdays(Date))
head(daily_sleep)


daily_calorie = dailyCalories %>%
    rename(Date = ActivityDay) %>%
    mutate(Date = as.Date(Date, format = "%m/%d/%Y")) %>%
    mutate(Day = weekdays(Date))
head(daily_calorie)


weight_log = weightLogInfo %>%
    mutate(Date = as.Date(Date, format = "%m/%d/%Y")) %>%
    mutate(Day = weekdays(Date))

head(weight_log)


daily_steps = dailySteps %>%
    rename(Date = ActivityDay) %>%
    rename(TotalSteps = StepTotal) %>%
    mutate(Date = as.Date(Date, format = "%m/%d/%Y" )) %>%
    mutate(Day = weekdays(Date))
head(daily_steps)

hourly_steps <- hourlySteps %>%
  rename(DateTime = ActivityHour) %>%
  rename(TotalSteps = StepTotal)%>%
  mutate(DateTime = format(as.POSIXct(DateTime,format='%m/%d/%Y %I:%M:%S %p'), format='%Y-%m-%d %H:%M:%S'))
head(hourly_steps)
```

Id	Date	TotalSteps	TotalDistance	TrackerDistance	LoggedActivitiesDistance	VeryActiveDi
<dbl>	<date>	<dbl>	<dbl>	<dbl>	<dbl>	
1503960366	2016-04-12	13162	8.50	8.50	0	
1503960366	2016-04-13	10735	6.97	6.97	0	
1503960366	2016-04-14	10460	6.74	6.74	0	
1503960366	2016-04-15	9762	6.28	6.28	0	
1503960366	2016-04-16	12669	8.16	8.16	0	
1503960366	2016-04-17	9705	6.48	6.48	0	

A tibble: 6 × 6

Id	Date	TotalSleepRecords	TotalMinutesAsleep	TotalTimeInBed	Day
<dbl>	<date>	<dbl>	<dbl>	<dbl>	<chr>
1503960366	2016-04-12	1	327	346	Tuesday
1503960366	2016-04-13	2	384	407	Wednesday
1503960366	2016-04-15	1	412	442	Friday
1503960366	2016-04-16	2	340	367	Saturday
1503960366	2016-04-17	1	700	712	Sunday
1503960366	2016-04-19	1	304	320	Tuesday

A tibble: 6 × 4

Id	Date	Calories	Day
<dbl>	<date>	<dbl>	<chr>

4. Analyze & Share

- Now we will analyze people's average activity level through out the whole tracking period

Based on paper "How many steps/day are enough? Preliminary pedometer indices for public health", classify individuals into different activity level:

- Sedentary
- Low Active
- Somewhat Active
- Active
- Highly Active

Paper's Link: https://pubmed.ncbi.nlm.nih.gov/14715035/

1927972279 2016-04-13 133.5 294.3171 NA 47.54 FALSE 1.460510e+12 Wednesday

```
daily_steps_summary<- daily_steps %>%
  group_by(Id) %>%
  summarise(avg_steps_daily = mean(TotalSteps))

daily_steps_summary <- daily_steps_summary %>%
  mutate(active_level = case_when(.$avg_steps_daily < 5000 ~ "Sedentary",
                                  .$avg_steps_daily < 7499 ~ "Low Active",
                                  .$avg_steps_daily < 9999 ~ "Somewhat Active",
                                  .$avg_steps_daily < 12500 ~ "Active",
                                  .$avg_steps_daily >= 12500 ~ "Highly Active"))

daily_steps_summary$active_level <- factor(daily_steps_summary$active_level, levels = c("Sedentary", "Low Active", "Somewhat Active", "Acti

daily_steps_summary

```

A tibble: 33 × 3

Id	avg_steps_daily	active_level
<dbl>	<dbl>	<fct>
1503960366	12116.742	Active
1624580081	5743.903	Low Active
1644430081	7282.967	Low Active
1844505072	2580.065	Sedentary
1927972279	916.129	Sedentary
2022484408	11370.645	Active
2026352035	5566.871	Low Active
2320127002	4716.871	Sedentary
2347167796	9519.667	Somewhat Active
2873212765	7555.774	Somewhat Active
3372868164	6861.650	Low Active
3977333714	10984.567	Active
4020332650	2267.226	Sedentary
4057192912	3838.000	Sedentary
4319703577	7268.839	Low Active
4388161847	10813.935	Active
4445114986	4796.548	Sedentary
4558609924	7685.129	Somewhat Active
4702921684	8572.065	Somewhat Active
5553957443	8612.581	Somewhat Active
5577150313	8304.433	Somewhat Active

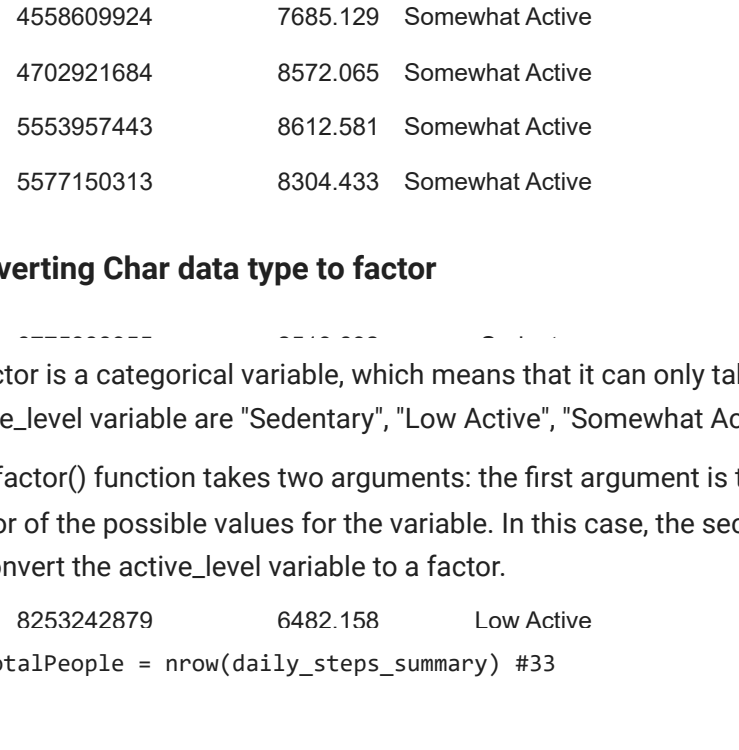
Converting Char data type to factor

A factor is a categorical variable, which means that it can only take on a limited number of values. In this case, the possible values for the active_level variable are "Sedentary", "Low Active", "Somewhat Active", "Active", and "Highly Active".

The factor() function takes two arguments: the first argument is the variable that you want to convert to a factor, and the second argument is a vector of the possible values for the variable. In this case, the second argument is a vector of strings, which is why the factor() function is able to convert the active_level variable to a factor.

8253242879	6482.158	Low Active

```
TotalPeople = nrow(daily_steps_summary) #33


daily_steps_summary %>%
    group_by(active_level) %>%
    summarise(people_each_active_level = n(),
              percentage = people_each_active_level/TotalPeople) %>%
ggplot(mapping = aes(x = active_level, y = percentage, fill = active_level)) +
geom_col() +
  geom_text(aes(label= round(percentage, digits = 4)*100, color = active_level), vjust= -0.5, size= 4.5) +
labs(title= "People's average activity level") +
  ylab("Percentage of people fall in different active level")

```

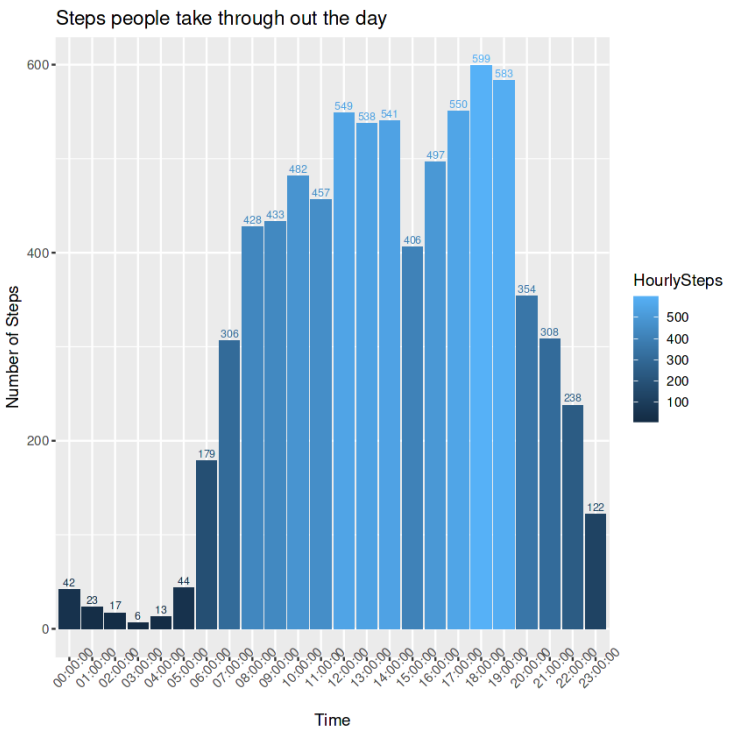


Found: There are less highly active peoples

Now we will analyze people's average steps taken through out a day, to see when they are most active and get the most excercise done.

```
hourly_steps = hourly_steps %>%
    separate(DateTime, c('Date', 'Time'), sep = ' ')
```

```
hourly_steps %>%
  group_by(Time) %>%
  summarise(HourlySteps = mean(TotalSteps)) %>%
  ggplot(mapping = aes(x = Time, y = HourlySteps, fill = HourlySteps)) +
  geom_col() +
  theme(axis.text.x = element_text(angle = 45))+
  geom_text(aes(label= round(HourlySteps, digits = 0), color = HourlySteps), vjust= -0.4, size= 2.5) +
  labs(title= "Steps people take through out the day") +
  ylab("Number of Steps")
```



Found: There are two peak active time period, one is 11:00 ~ 13:00, the other is 16:00 ~ 18:00.

- Now we will analyze whether there's a relationship between different week days and people's activity level by steps people take that day.

```
step_by_days = daily_steps %>%
    group_by(Day) %>%
    summarise(avg_step = mean(TotalSteps))
View(step_by_days)


#Converting chr to factor
step_by_days$Day = factor(step_by_days$Day, levels = c("Monday", "Tuesday", "Wednesday", "Thursday", "Friday", "Saturday", "Sunday"))
View(step_by_days)


#plot
ggplot(data = step_by_days, mapping = aes(x = Day, y = avg_step, fill = Day)) +
geom_col() +
geom_text(aes(label = round(avg_step, digit = 0), color = Day), vjust = -0.5, size = 5) +
theme(axis.text.x = element_text(angle = 45, size = 10))
```

A tibble: 7 × 2

Day	avg_step
<chr>	<dbl>
Friday	7448.230
Monday	7780.867
Saturday	8152.976
Sunday	6933.231
Thursday	7405.837
Tuesday	8125.007
Wednesday	7559.373

A tibble: 7 × 2

Day	avg_step
<fct>	<dbl>
Friday	7448.230
Monday	7780.867
Saturday	8152.976

Found: There is not much difference from Monday to Sunday, just people tends to relax bit more on sunday

Thursday 7405.837

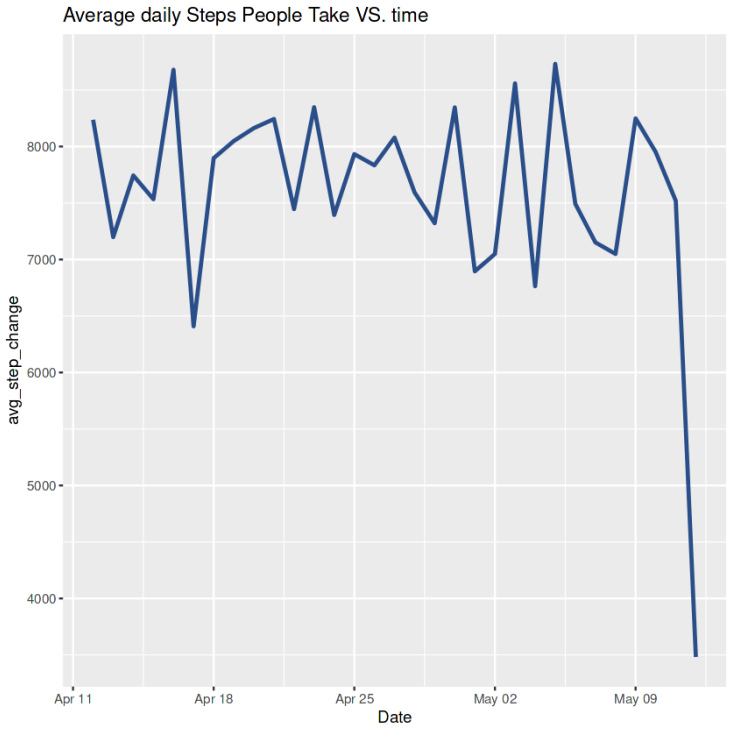
- Now we will analyze whether people's daily step changes along with wearing fitbit tracker

```
steps_change = daily_steps %>%
    group_by(Date) %>%
    summarise(avg_step_change = mean(TotalSteps))
head(steps_change)


#Plotting
ggplot(data = steps_change) + geom_line(mapping = aes(x = Date, y = avg_step_change), color="#143d80", size=1, alpha=0.9) +
labs(title= "Average daily Steps People Take VS. time ")
```

A tibble: 6 × 2

Date	avg_step_change
<date>	<dbl>
2016-04-12	8236.848
2016-04-13	7198.727
2016-04-14	7743.576
2016-04-15	7533.848
2016-04-16	8679.156
2016-04-17	6409.250

Warning message:
**“Using `size` aesthetic for lines was deprecated in ggplot2 3.4.0.
ℹ Please use `linewidth` instead.”**



Found: When people first start using a Fitbit tracker, they are excited about tracking their steps and becoming more active. This excitement often leads to an increase in the number of steps they take in the first few days or weeks of using the tracker. However, over time, this excitement can wear off and people may start to become less motivated to exercise. This is why the average daily steps of people who use Fitbit trackers often decreases over time.

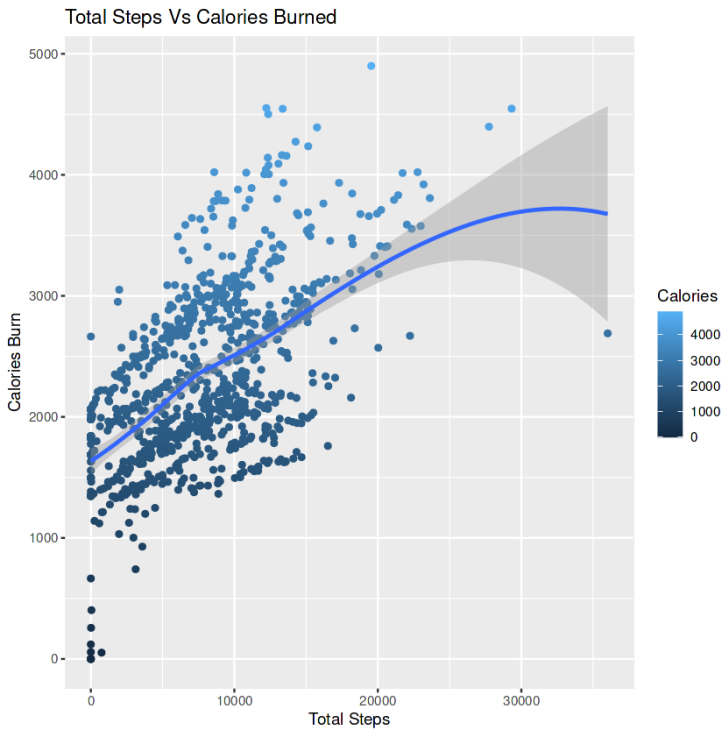
If Fitbit wants to keep people motivated to exercise, they need to find ways to keep their excitement levels high. One way to do this is to make the tracker more fun to use. For example, they could add new features that make it more challenging or rewarding to track steps. They could also offer incentives, such as discounts on products or services, for people who reach certain step goals.

Suggest: Do a suvey in users to understand if there's anything in product we can improve.

- Now we will analyze whether there is any relationship between daily steps and calories

```
ggplot(data = daily_activity, mapping = aes(x = TotalSteps, y = Calories, color = Calories)) +
       geom_point() +
       geom_smooth(method = 'loess') +
       labs(title = "Total Steps Vs Calories Burned", x = "Total Steps", y = "Calories Burn")
```

```
`geom_smooth()` using formula = 'y ~ x'
Warning message:
“The following aesthetics were dropped during statistical transformation: colour
ℹ This can happen when ggplot fails to infer the correct grouping structure in
  the data.
ℹ Did you forget to specify a `group` aesthetic or to convert a numerical
  variable into a factor?”
```



Found: We have found that there is a positive relationship between Total Steps and Calorie Burned and we have also found there are some people who has burned 0 calories which does not make sense to me. So we will search for this records

```
## There are some people literally burnt 0 calories a day, that doesn't make sense to me.
## So I searched for such records:

ppl_burn_zero_cal = filter(daily_activity, Calories == 0)
ppl_burn_zero_cal


## Found out while people have a sedentary time as long as the whole day, their calories burnt is 0
## So I made a wild assumption that people have 0 calories burnt, actually forget to wear their device.
## So to confirm my theory, I decide to check people's heart rate records and their sleep records


#First we will check if there is any record in sleep data for the people who has burned zero calories by joining ppl_burn_zero_cal datafram

ppl_burn_zero_vs_sleep = ppl_burn_zero_cal %>%
    left_join(daily_sleep, by = c("Id", "Date"))
head(ppl_burn_zero_vs_sleep)


# Found people burnt 0 calories a day also don't have sleep record that day.

### Second we will check: Heart rate dataframe and ppl_burn_zero_cal dataframe

people_list_heart_rate = distinct(heartrate_seconds, Id)
head(people_list_heart_rate)


ppl_burn_zero_cal$coincidence = ppl_burn_zero_cal$Id %in% people_list_heart_rate$Id
ppl_burn_zero_cal


```

Id	Date	TotalSteps	TotalDistance	TrackerDistance	LoggedActivitiesDistance	VeryActiveDis
<dbl>	<date>	<dbl>	<dbl>	<dbl>	<dbl>	
1503960366	2016-05-12	0	0	0	0	
6290855005	2016-05-10	0	0	0	0	
8253242879	2016-04-30	0	0	0	0	
8583815059	2016-05-12	0	0	0	0	

Id	Date	TotalSteps	TotalDistance	TrackerDistance	LoggedActivitiesDistance	VeryActiveDis
<dbl>	<date>	<dbl>	<dbl>	<dbl>	<dbl>	
1503960366	2016-05-12	0	0	0	0	
6290855005	2016-05-10	0	0	0	0	
8253242879	2016-04-30	0	0	0	0	
8583815059	2016-05-12	0	0	0	0	

A tibble: 6 × 1

Id
<dbl>
2022484408
2026352035
2347167796
4020332650
4388161847
4558609924

```
#Checking the relationship between active hours and calories burnt

daily_activity = daily_activity %>%  #Creating column for active hour
  mutate(active_hours = round(as.numeric(VeryActiveMinutes) / 60, 2))
head(daily_activity)

daily_activity %>%
  mutate(active_hours = round(as.numeric(VeryActiveMinutes) / 60, 2)) %>%
  ggplot(data = ., mapping = aes(x = active_hours, y = Calories, color = Calories)) +
  geom_point() +
  geom_smooth(method = 'loess') +
  labs(title = "Active Hours VS Calories Burned", x = "Active Hours", y = "Calories Burned")

```

Id	Date	TotalSteps	TotalDistance	TrackerDistance	LoggedActivitiesDistance	VeryActiveDi
<dbl>	<date>	<dbl>	<dbl>	<dbl>	<dbl>	
1503960366	2016-04-12	13162	8.50	8.50	0	
1503960366	2016-04-13	10735	6.97	6.97	0	
1503960366	2016-04-14	10460	6.74	6.74	0	
1503960366	2016-04-15	9762	6.28	6.28	0	

Found: People burnt 0 calories a day neither have heart rate record nor sleep record that day, which means they most likely not wearing the device. And some people burnt too little of caloriee, eg 400Cal , because they only were wearing it 10 or 20 miuntes a day. We also found one outlier that is at 4800 calories burnt arround 0.2 hours which might me due to some reason

Reason of Outlier

- The person may have been engaging in a very intense activity, such as sprinting or weightlifting.
- The person may have been overweight or obese, which would have increased the number of calories they burned.
- The person may have been wearing a fitness tracker that was not accurate.
- There may have been a measurement error in the data.

Suggest: We should develop device that people can wear comfortably during sleep, bath, etc.

Found: That the algorithm in tracker never considered the sleeping time. We only have 1440 mins in 24h, so if we wear the device while sleeping for 8 hours, this period of time shouldn't call as sedentary time. And such numbers on the tracker would give customer a bad impression that the tracker is not accurate.

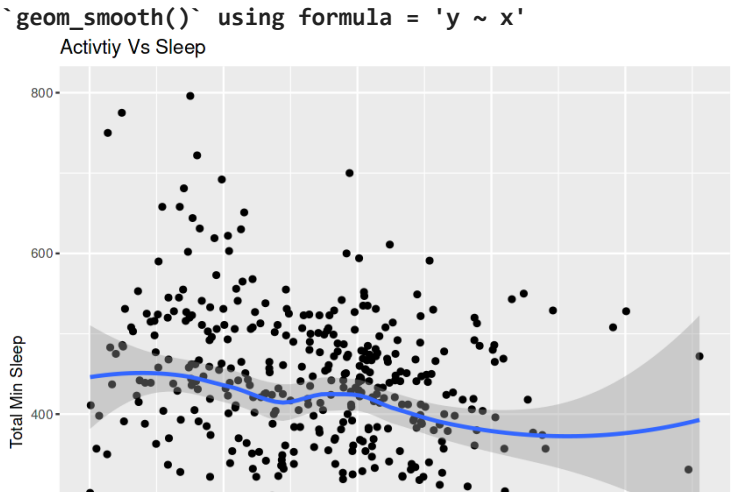
Suggest: Check BellaBeat's algorithm, to see if we made the same mistake and fix the problem.

- Now we will analyze whether there's a relationship between activity level and sleep quality .(whether enough sleep would lead to more activity/more activity would lead to better sleep)


```
## Check relationship between activity and sleep, calories and sleep
#Plotting Activity vs Sleep
activity_vs_sleep = merge(daily_activity, daily_sleep, by = c("Id", "Date"))
head(activity_vs_sleep)

ggplot(activity_vs_sleep, mapping = aes(x = TotalSteps, y = TotalMinutesAsleep)) +
geom_point() +
geom_smooth(method = 'loess') +
labs(title = "Activtiy Vs Sleep", x = 'Total Steps', y = 'Total Min Sleep')


#Plotting calories vs sleep

ggplot(data = activity_vs_sleep, mapping = aes(x = TotalMinutesAsleep, y = Calories)) +
geom_point() +
geom_smooth(method = 'loess') +
labs(title = 'Calories burnt Vs Sleep Time', x = 'Total Time Sleep', y = 'Calories Burnt')


```

	Id	Date	TotalSteps	TotalDistance	TrackerDistance	LoggedActivitiesDistance	VeryActive
	<dbl>	<date>	<dbl>	<dbl>	<dbl>	<dbl>	
1	1503960366	2016-04-12	13162	8.50	8.50	0	
2	1503960366	2016-04-13	10735	6.97	6.97	0	
3	1503960366	2016-04-15	9762	6.28	6.28	0	
4	1503960366	2016-04-16	12669	8.16	8.16	0	
5	1503960366	2016-04-17	9705	6.48	6.48	0	
6	1503960366	2016-04-19	15506	9.88	9.88	0	

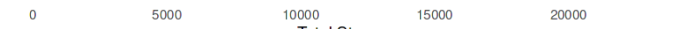
```
`geom_smooth()` using formula = 'y ~ x'
`geom_smooth()` using formula = 'y ~ x'
```



Found: No clear relationship between sleep and steps people take daily

Found: No clear relationship between sleep and calories people burnt daily

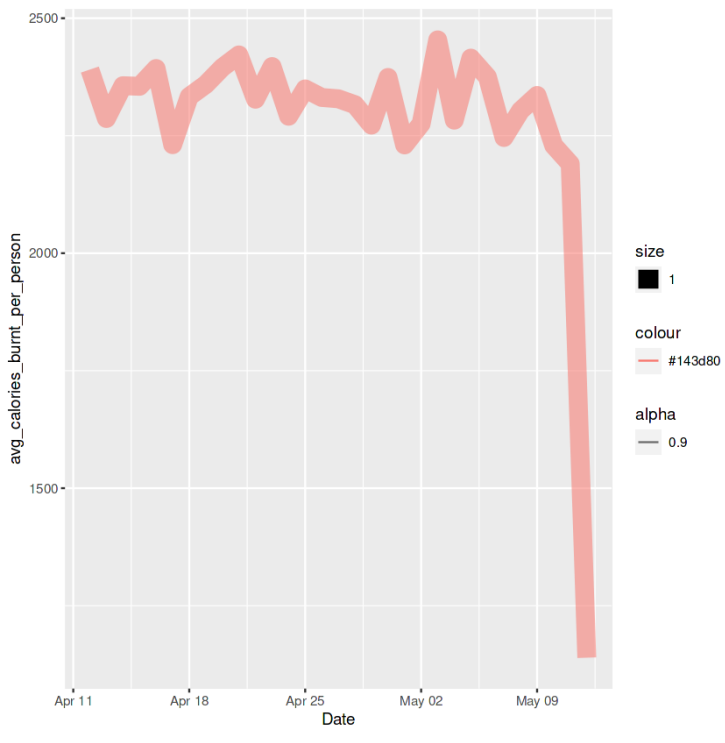
- Now we will analyze average calories burnt change with the time pass




```
calories_change = daily_calorie %>%
    group_by(Date) %>%
    summarise(avg_calories_burnt_per_person = mean(Calories))
head(calories_change)


ggplot(data = calories_change, mapping = aes(x = Date, y = avg_calories_burnt_per_person, color="#143d80", size=1, alpha=0.9)) +
  geom_line()

```

A tibble: 6 × 2

Date	avg_calories_burnt_per_person
<date>	<dbl>
2016-04-12	2390.697
2016-04-13	2286.636
2016-04-14	2356.394
2016-04-15	2355.182
2016-04-16	2392.938
2016-04-17	2230.969



Found: Not much of change, however people's average daily calories burnt jumps down by the end of the tracking period. So may be by the end of the tracking period, people just don't bother to wear the tracker. It also may indicate that after 2 month period, people still haven't built the habit of using the tracker.

```
1 weight_log %>%
2   group_by(Id) %>%
3   summarise(number_of_record = n(), manual = sum(IsManualReport), fat = mean(Fat, na.rm=TRUE))
```

A tibble: 8 × 4

Id	number_of_record	manual	fat
<dbl>	<int>	<int>	<dbl>
1503960366	2	2	22
1927972279	1	0	NaN
2873212765	2	2	NaN
4319703577	2	2	25
4558609924	5	5	NaN
5577150313	1	0	NaN
6962181067	30	30	NaN
8877689391	24	0	NaN

Found:

- Only 8 out of 33 users have logged their weight for at least 1 time
- Only 3 people have the habit to log their weight at least 1 time per week
- Only 1 people have the habit to log weight
- Only 2 people have record their body fat, which highly possible means most of people don't have smart scales at home
- Most users manually report their weight, this might be the reason why people don't like to log their weight

Suggest:

1. Develop smart scale which can measure people's body fat, skeletal muscle, bone mass, BMR, BMI, etc.
2. Connect that scale with our wearable device, automatically log people's weight, fat, BMI, etc.
3. Remind people to stand on the scale every week at the same time.

- Now we will analyze sleep data

```
1 head(daily_sleep)
```

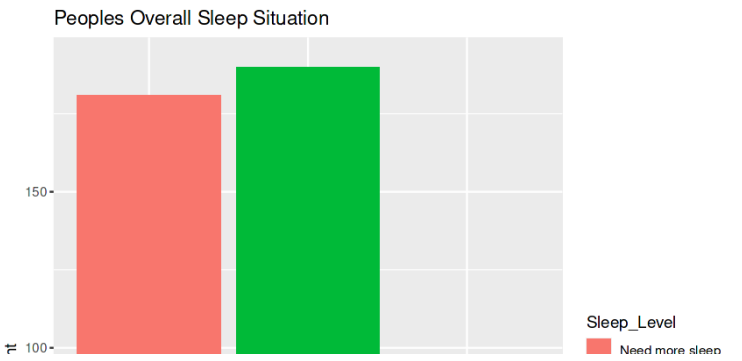
A tibble: 6 × 6

Id	Date	TotalSleepRecords	TotalMinutesAsleep	TotalTimeInBed	Day
<dbl>	<date>	<dbl>	<dbl>	<dbl>	<chr>
1503960366	2016-04-12	1	327	346	Tuesday
1503960366	2016-04-13	2	384	407	Wednesday
1503960366	2016-04-15	1	412	442	Friday
1503960366	2016-04-16	2	340	367	Saturday
1503960366	2016-04-17	1	700	712	Sunday
1503960366	2016-04-19	1	304	320	Tuesday

```
daily_sleep_v1 = daily_sleep %>%
    mutate(TimeAwake = TotalTimeInBed - TotalMinutesAsleep) %>%
    mutate(Sleep_Level = case_when(.$TotalMinutesAsleep < 420 ~ 'Need more sleep',
                                   .$TotalMinutesAsleep >= 420 & TotalMinutesAsleep < 540 ~ 'Enough Sleep',
                                   .$TotalMinutesAsleep >= 540 ~ 'Too much Sleep'))

daily_sleep_v1$Sleep_Level = factor(daily_sleep_v1$Sleep_Level, levels = c("Need more sleep", "Enough Sleep", "Too much Sleep"))

head(daily_sleep_v1)


ggplot(data = daily_sleep_v1, mapping = aes(x = Sleep_Level, fill = Sleep_Level)) +
geom_bar() +
labs(title = 'Peoples Overall Sleep Situation')
```

A tibble: 6 × 8

Id	Date	TotalSleepRecords	TotalMinutesAsleep	TotalTimeInBed	Day	TimeAwake	Sleep
<dbl>	<date>	<dbl>	<dbl>	<dbl>	<chr>	<dbl>	
1503960366	2016-04-12	1	327	346	Tuesday	19	Nee
1503960366	2016-04-13	2	384	407	Wednesday	23	Nee
1503960366	2016-04-15	1	412	442	Friday	30	Nee
1503960366	2016-04-16	2	340	367	Saturday	27	Nee
1503960366	2016-04-17	1	700	712	Sunday	12	To
1503960366	2016-04-19	1	304	320	Tuesday	16	Nee



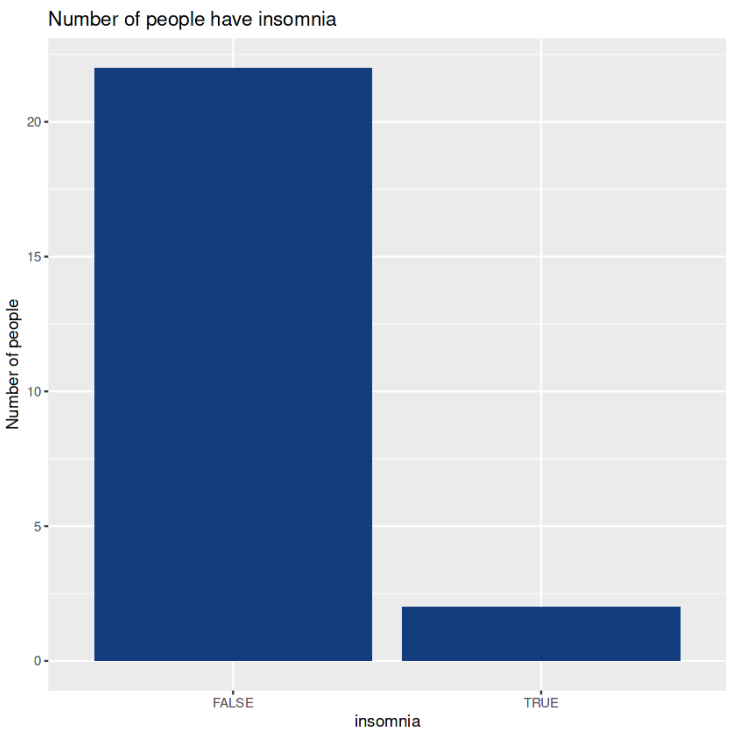

```
## Checking users' overall sleep quantity and quality

head(daily_sleep_v1)

sleep_summary <- daily_sleep_v1 %>%
  group_by(Id) %>%
  summarise(
            nights_of_insomnia = sum(TimeAwake >=90),
            nights_observed = n(),
            avg_asleep = mean(TotalMinutesAsleep),
            avg_inbed = mean(TotalTimeInBed),
            avg_time_awake = avg_inbed - avg_asleep,
            avg_sleep_percentage =(avg_asleep / avg_inbed)) %>%
  mutate(enough_sleep = ifelse( avg_asleep < 360, FALSE, TRUE)) %>%
  mutate(insomnia = ifelse(avg_sleep_percentage < 0.8 & nights_of_insomnia/nights_observed > 0.4, TRUE,FALSE))


head(sleep_summary)

ggplot(data = sleep_summary) +
  geom_bar(mapping = aes(x = insomnia),  fill="#143d80") +
  labs(title = "Number of people have insomnia" ) +
  ylab("Number of people")


ggplot(data = sleep_summary) +
geom_bar(mapping = aes(x = enough_sleep), fill = "#143d80") +
labs(title = "Number of people having enough sleep") +
xlab("Enough Sleep") +
ylab("Number of people")


sleep_summary

```

A tibble: 6 × 8

Id	Date	TotalSleepRecords	TotalMinutesAsleep	TotalTimeInBed	Day	TimeAwake	Sleep
<dbl>	<date>	<dbl>	<dbl>	<dbl>	<chr>	<dbl>	
1503960366	2016-04-12	1	327	346	Tuesday	19	Nee
1503960366	2016-04-13	2	384	407	Wednesday	23	Nee
1503960366	2016-04-15	1	412	442	Friday	30	Nee
1503960366	2016-04-16	2	340	367	Saturday	27	Nee
1503960366	2016-04-17	1	700	712	Sunday	12	To
1503960366	2016-04-19	1	304	320	Tuesday	16	Nee

A tibble: 6 × 9

Id	nights_of_insomnia	nights_observed	avg_asleep	avg_inbed	avg_time_awake	avg_sleep_perc
<dbl>	<int>	<int>	<dbl>	<dbl>	<dbl>	
1503960366	0	25	360.2800	383.2000	22.92000	0.9
1644430081	1	4	294.0000	346.0000	52.00000	0.8
1844505072	3	3	652.0000	961.0000	309.00000	0.6
1927972279	0	5	417.0000	437.8000	20.80000	0.9
2026352035	0	28	506.1786	537.6429	31.46429	0.9
2320127002	0	1	61.0000	69.0000	8.00000	0.8



A tibble: 24 × 9

Id	nights_of_insomnia	nights_observed	avg_asleep	avg_inbed	avg_time_awake	avg_sleep_perc
<dbl>	<int>	<int>	<dbl>	<dbl>	<dbl>	
1503960366	0	25	360.2800	383.2000	22.920000	0.9
1644430081	1	4	294.0000	346.0000	52.000000	0.8
1844505072	3	3	652.0000	961.0000	309.000000	0.6
1927972279	0	5	417.0000	437.8000	20.800000	0.9
2026352035	0	28	506.1786	537.6429	31.464286	0.9
2320127002	0	1	61.0000	69.0000	8.000000	0.8
2347167796	0	15	446.8000	491.3333	44.533333	0.9
3977333714	28	28	293.6429	461.1429	167.500000	0.6
4020332650	0	8	349.3750	379.7500	30.375000	0.9
4319703577	0	26	476.6538	501.9615	25.307692	0.9
4388161847	0	23	400.1739	423.2174	23.043478	0.9
4445114986	0	28	385.1786	416.8214	31.642857	0.9
4558609924	0	5	127.6000	140.0000	12.400000	0.9
4702921684	0	27	417.4815	438.2222	20.740741	0.9
5553957443	1	31	463.4839	505.8710	42.387097	0.9
5577150313	0	26	432.0000	460.6154	28.615385	0.9
6117666160	0	18	478.7778	510.1667	31.388889	0.9
6775888955	0	3	349.6667	369.0000	19.333333	0.9
6962181067	0	31	448.0000	466.1290	18.129032	0.9

Found:

- **24 people have used a Fitbit to track their sleep.** This is a small number of people, but it is a good start.
- **1/4 of people take their Fitbit off when they sleep.** This is a problem, because it means that the data from these people is not accurate.
- **6 out of 24 people sleep too little.** This means that they are not getting enough sleep, which can lead to health problems.
- **The number of sleep records is half the number of other records.** This means that people are not using their Fitbit to track their sleep as often as they could.
- **Only 2 people have 31 days of sleep record.** This means that most people are not tracking their sleep regularly.
- **Based on the assumption that people are in bed to sleep, and not to read or use their phone, I found out that 2 people have insomnia.** Insomnia is a sleep disorder that can cause people to have trouble falling asleep, staying asleep, or waking up too early.

Possible Cause:

- The tracker is not comfortable to wear.
- People don't know they need to wear it during sleep
- Tracker is not water proof, so people take it off during face washing or bath and forget to put it back on.
- The data recorded by tracker is not accurate and detailed enough, so people feel there's no need to wear it and track the sleep data.

Suggest:

- Do a suvey to see why people don't like to wear the fitbit tracker while sleep.
- Make our device comfortable and water-proof.
- Check to see if our tracker can provide accurate and detailed tracking records.
- Having doctor's consultation service options in our app, so it's much easier for user seeking help, and with the data we recorded, the doctor would give better solution.
- Implement functions into our wearable device to play white noise for people who haven't fall asleep in 30 mins

5. Act

1. Do a suvey to find out the reason why people purchased the product, why they forget to wear the fitbit tracker, and what are some defects the current fitbit tracker have would influence them to become a loyal customer.
2. Based on the suvey, improve our device, inicluding algorithm, function, and outside design (eg. comfortable to wear and water-proof)
3. Develop new product like smart scale to couple with our tracker.
4. Having doctor's consultation service options in our app for our users to seek for help from the professionals. It's a way to retain customers.
5. Implement functions into our wearable device: play white noise for people who haven't fall asleep in 30 mins; remind people to go to bed at a proper time.
6. Towards marketing, I would recommend company put more advertisement in Youtube/instagram/TV, since 1/3 of the days,people are living a sedentary life style, and towards the people who go to the gym, we can do campain there, add posters.
7. Towards content in advertisement, I would recommend company use the information we get from suvey, to highlight the defects of other tracker brand, and make the audience know that our products are different.