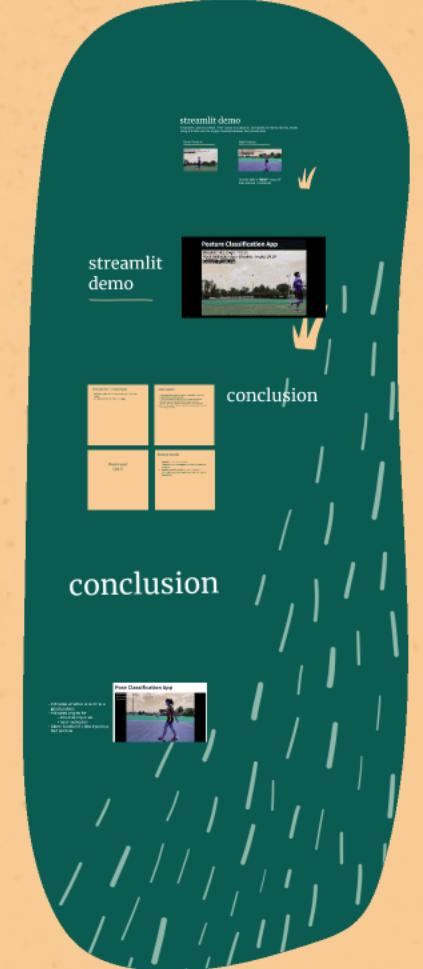
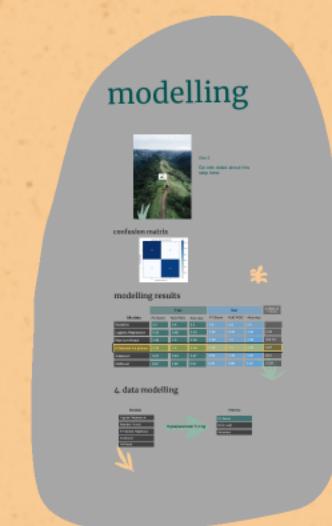


# posture analysis.

## capstone project

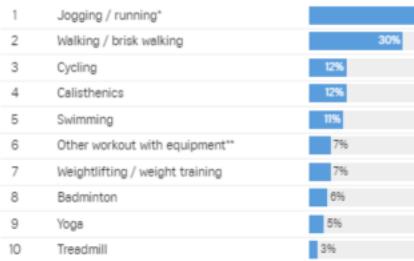


Raise your hand if you've walked or run today.

# walking & running are two of the most popular physical activities

The Straits Times, 2023

Top 10 activities for young adults (aged 20-39)



Sport participation in S'pore hits all-time high; walking, jogging and calisthenics top 3 activities



US National Health and Nutrition Examination Survey, 1999 - 2006

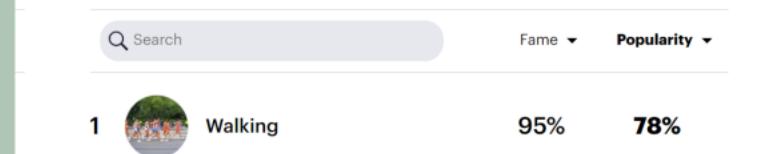
## Participation in Specific Types of Physical Activity

Overall Participation The percentage of adults who participated in each of the 33 activities varied from < 1% for hockey to 34% for walking (Table 3). Walking was the most frequently reported activity followed by bicycling (12%), yard work (11%), dance (8%), and treadmill (8%). Similar to

YouGov, 2023 (*international online research data group*)

## The Most Popular Physical Activities (Q3 2023)

Popularity is the % of people who have a positive opinion of a physical activity. [Find out more](#)



How often do  
you think about  
your posture  
though?



# Importance of a good posture when walking / running

---

- ④ Reduced stress and strain on the muscles, ligaments, and joints
- ④ Reduced fatigue
- ④ Reduced risk of injuries
- ④ Better balance
- ④ Better lung health

... and many more

# problem statement

In pursuit of a healthy lifestyle, many individuals turn to running or walking as a form of exercise.

However, poor running or walking posture can lead to unnecessary stress and strain on muscles and joints. **Poor posture can cause pain and injuries in up to 79% of adults, with low back pain affecting 25% of adults every year.**

**Existing methods:** Visiting a chiropractor for posture assessment - often costly and *inaccessible*.

**Gap in market:** no existing apps that track posture analysis.

# objective

This project aims to **empower individuals to improve their running / walking postures** by leveraging computer vision to develop a classification model app *that identifies good or bad postures.*

# target audience

casual runners / walkers

The background of the slide features a photograph of a person from behind, wearing a dark jacket and a cap, standing on a large, textured rock. They are looking out over a vast landscape with rolling hills and mountains under a blue sky with scattered white clouds.

# project workflow

1

Data Collection / Processing  
*using Mediapipe*

2

Exploratory Data Analysis

3

Feature Engineering

4

Data Modelling  
*Evaluating Classification Models +  
Hyperparameter Tuning*

5

Conclusion

# project workflow

## 1. data collection / processing

### Sourcing of Train Data

Collected photos and videos (self-timed / from Google) and defined their classes - Good or Bad posture

Good Posture:



Bad Posture:



### Data Processing using Mediapipe

Leveraged Mediapipe Pose Landmarker to identify key body locations from images / photos. It leverages existing trained machine learning (ML) models and outputs body pose landmarks in 3D coordinates.



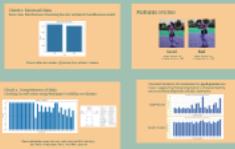
### Translation of Landmarks to Coordinates

Landmark coordinates from Mediapipe  
10 pairs (gesture pairs), 3 coordinates per point (x,y,z)

Output of Mediapipe Pose Landmarker:



## 2. EDA



## 3. feature engineering / selection

step 1 Create function to calculate angles between **3 body landmarks**

step 2

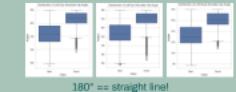
- Angles\* explored:
  - Eye-shoulder-hip
  - Ear-shoulder-hip
  - Nose-shoulder-hip

\*All our literature showing the "correct" upright posture

To analyse posture - we need to to calculate the angle between 3 body landmarks



Angles for "Good" posture are closer to 180°, while angles for bad postures tend to be lower than 180°



# 1. data collection / processing

## Sourcing of Train Data

Collected photos and videos (self-filmed / from Google) and defined their classes - Good or Bad posture

## **Good Posture:**



## *Bad Posture:*



## Data Processing using Mediapipe

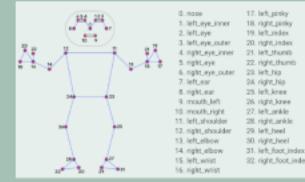
Leveraged Mediapipe Pose Landmarker to identify key body locations from videos / photos.

It leverages existing trained machine learning (ML) models and outputs body pose landmarks in 3D coordinates



## Translation of Landmarks to Coordinates

## Landmark coordinates from Mediapipe



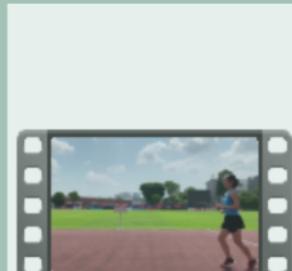
33 joints detection points,  
4 coordinates per point (x,y,z,v\*)

Output of Mediapipe Pose Landmarker

# Sourcing of Train Data

Collected photos and videos (self-filmed / from Google) and defined their classes - Good or Bad posture

*Good Posture:*



good-1

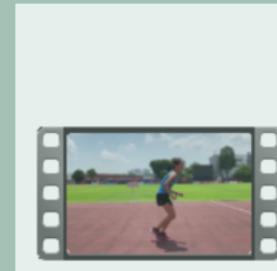


good-2



3-good

*Bad Posture:*



bad-1



bad-2



bad-3

# Data Processing using *Mediapipe*

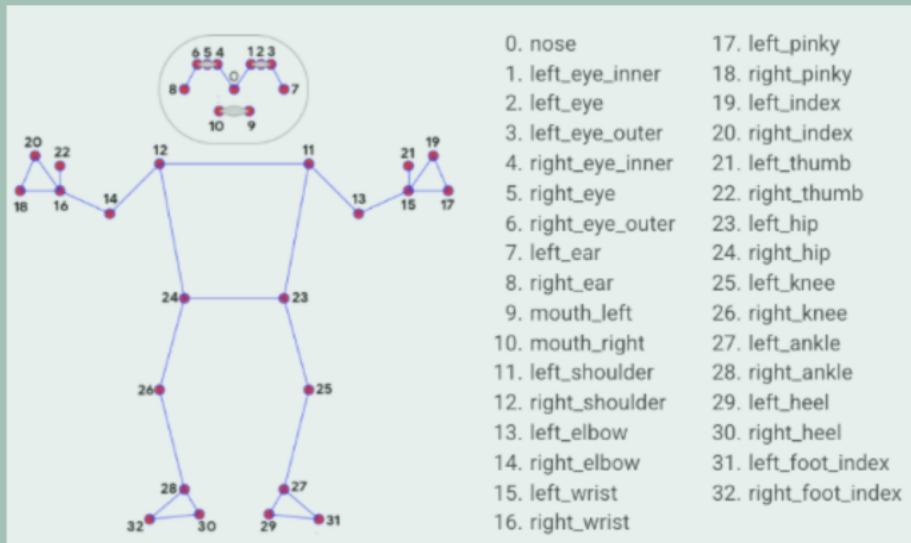
Leveraged **Mediapipe Pose Landmarker** to identify key body locations from videos / photos.

It leverages existing trained machine learning (ML) models and outputs body pose landmarks in 3D coordinates



# Translation of Landmarks to Coordinates

Landmark coordinates from Mediapipe

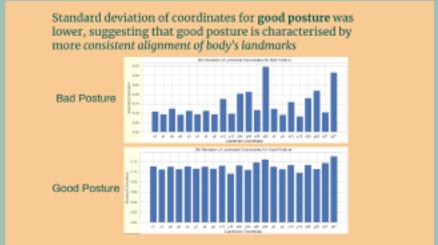
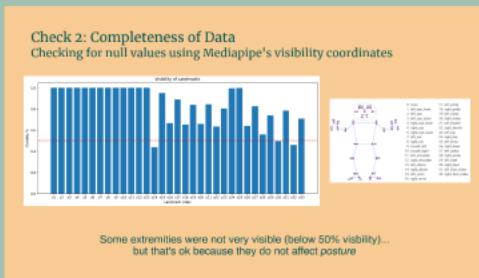


33 joints detection points,  
4 coordinates per point (x,y,z,v\*)

Output of Mediapipe Pose Landmarker:

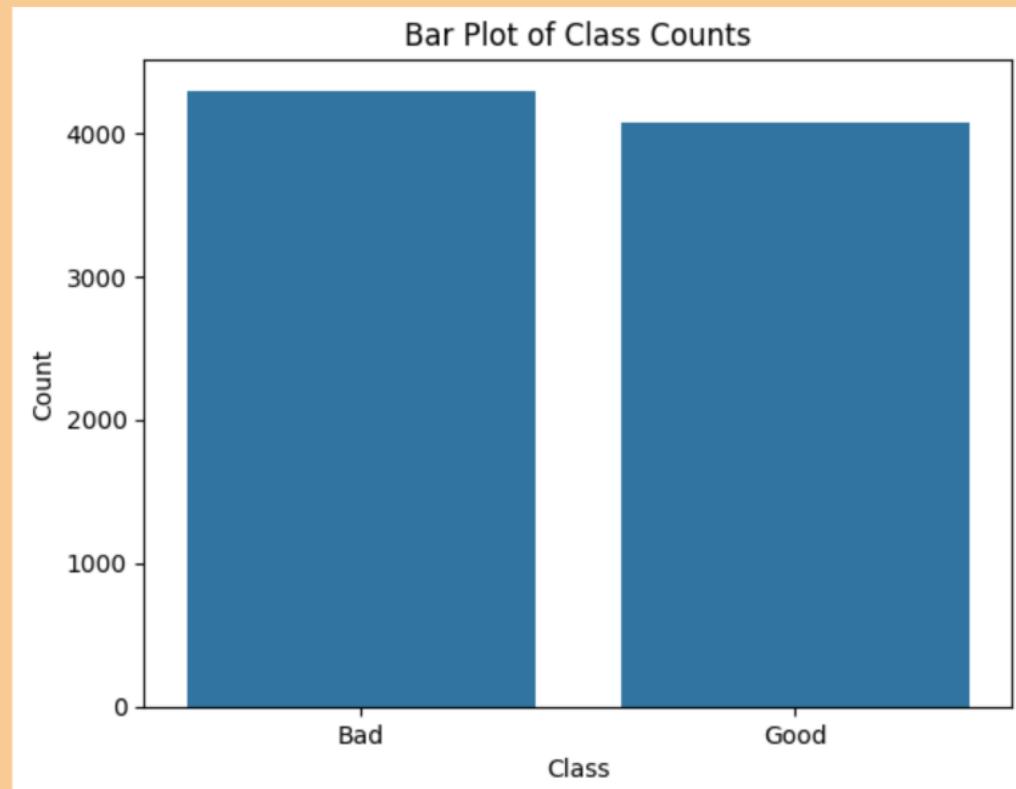
class	x1	y1	z1	v1	x2	y2	z2	v2	x3	...	z31	v31	x32	y32	z32	v32	x33	y33	z33	v33	
0	Bad	0.597514	0.330045	-0.046739	0.999786	0.595233	0.314657	-0.039935	0.999435	0.594381	...	-0.016369	0.986479	0.542886	0.811219	0.140850	0.936010	0.519139	0.821335	-0.042727	0.995285
1	Bad	0.603381	0.325570	-0.049170	0.999806	0.601188	0.310604	-0.040726	0.999489	0.600242	...	-0.024023	0.985957	0.541942	0.809034	0.138972	0.930692	0.536733	0.821338	-0.048026	0.994957
2	Bad	0.614878	0.315903	-0.031407	0.999825	0.613352	0.302009	-0.020730	0.999540	0.612598	...	-0.022843	0.986882	0.542489	0.811047	0.129956	0.932926	0.563722	0.822904	-0.049756	0.995270
3	Bad	0.624886	0.308227	-0.035477	0.999842	0.623481	0.295145	-0.026631	0.999585	0.622720	...	-0.008451	0.987635	0.539751	0.811104	0.098917	0.936107	0.592707	0.822877	-0.048756	0.995534
4	Bad	0.636889	0.295799	-0.043732	0.999856	0.634686	0.282637	-0.032385	0.999624	0.634024	...	-0.005093	0.988365	0.539935	0.810745	0.093304	0.938698	0.613125	0.822549	-0.048148	0.995753

## 2. EDA



# Check 1: Balanced class

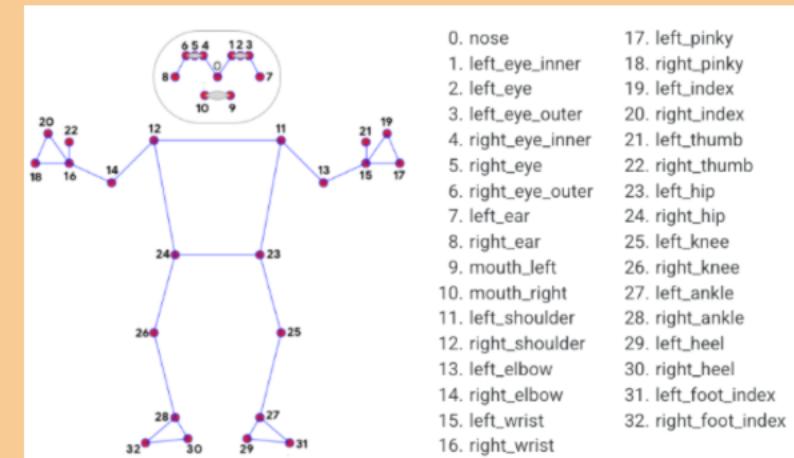
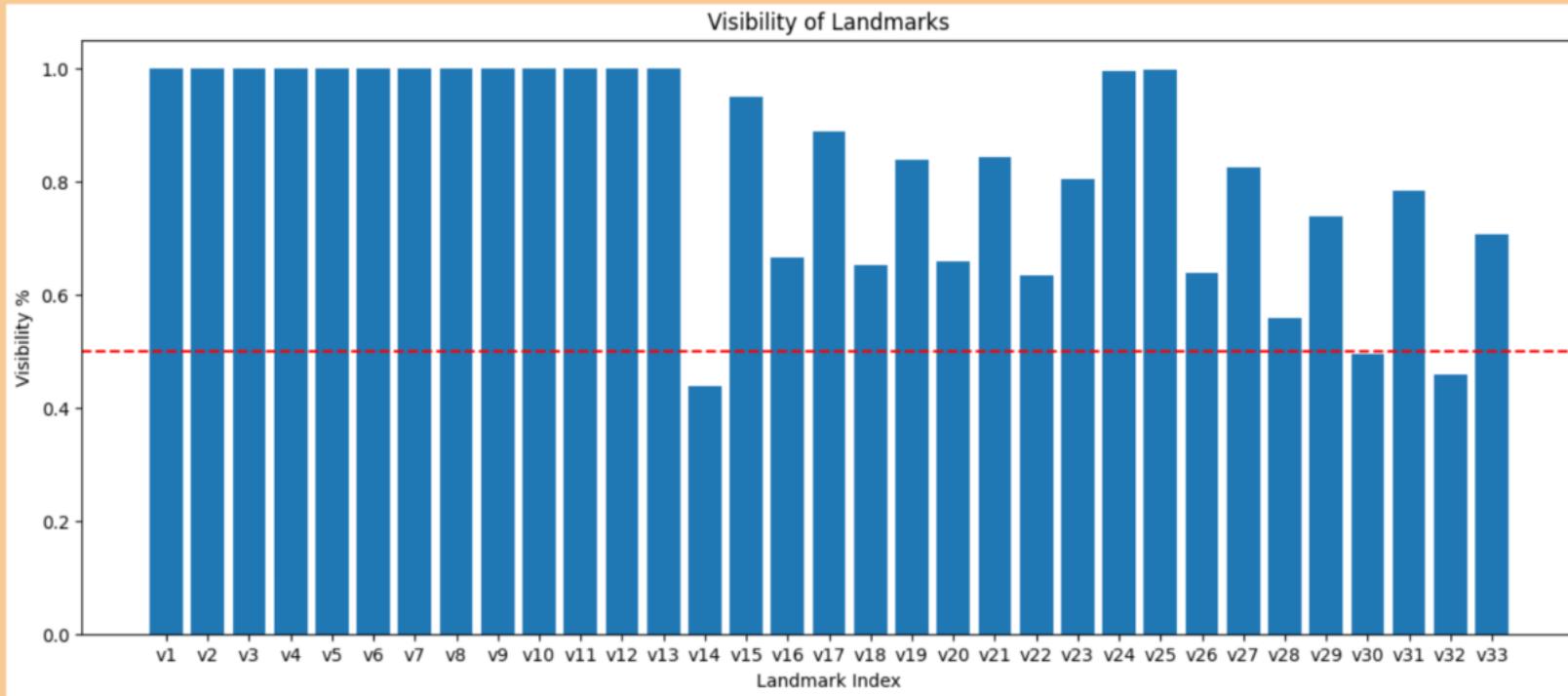
Even class distribution of training data for unbiased classification model



*Count refers to number of frames from photos / videos*

## Check 2: Completeness of Data

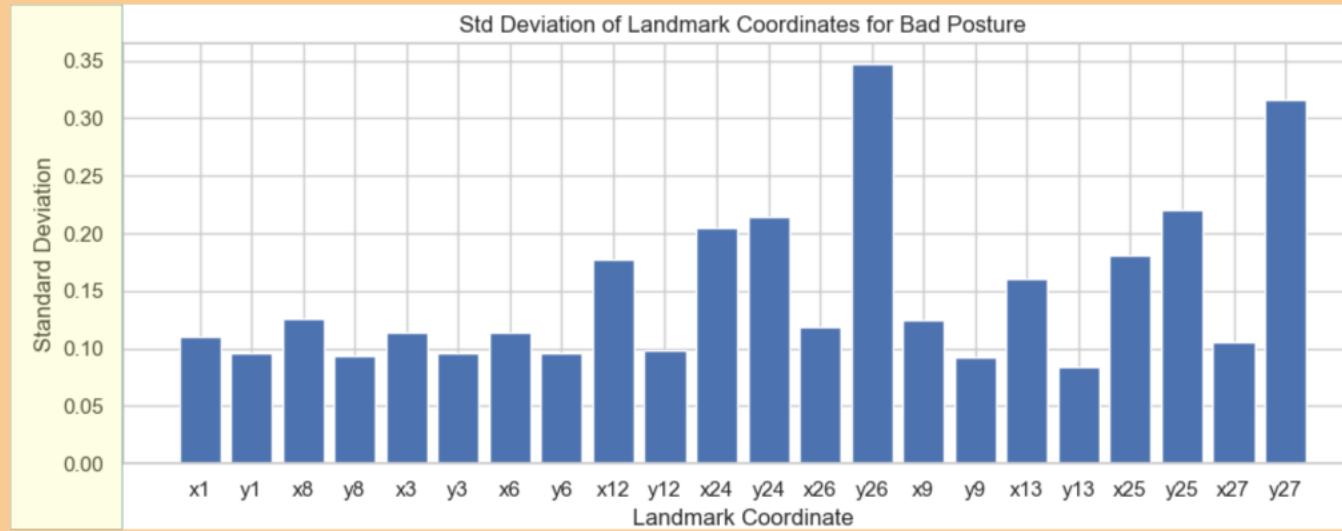
Checking for null values using Mediapipe's visibility coordinates



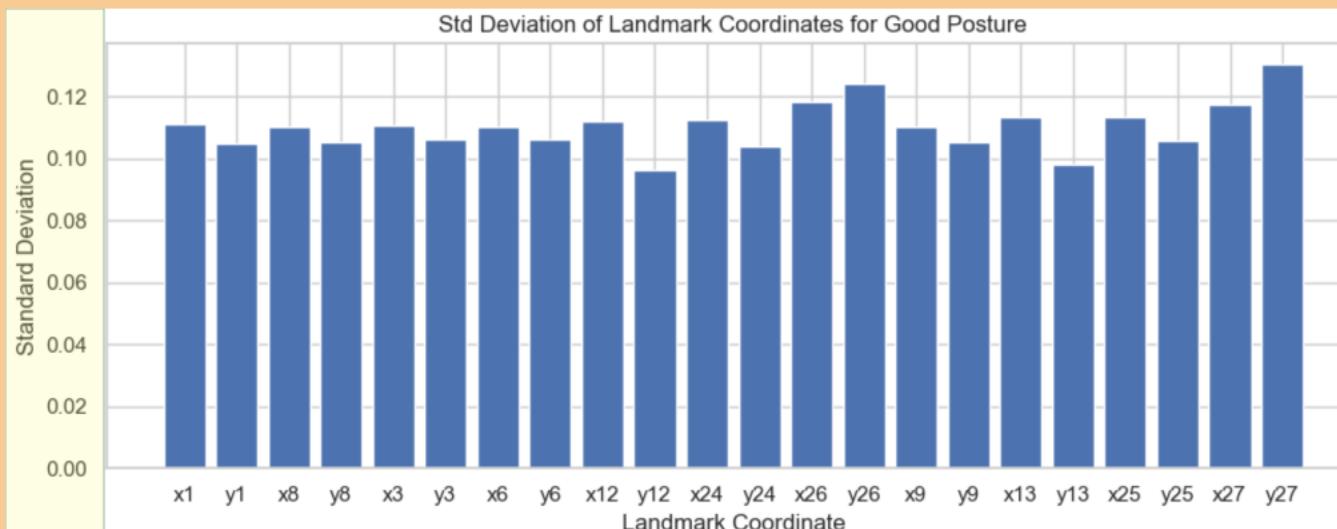
Some extremities were not very visible (below 50% visibility)...  
but that's ok because they do not affect posture

Standard deviation of coordinates for good posture was lower, suggesting that good posture is characterised by more *consistent alignment of body's landmarks*

Bad Posture



Good Posture



# Mediapipe overlays



Good

Angle between head,  
shoulder and hip  $\approx 180^\circ$



Bad

Angle between head,  
shoulder and hip  $\neq 180^\circ$



15

## 3. feature engineering / selection

---

step 1 Create function to calculate angles  
between **3 body landmarks**

step 2 Angles\* explored:

- Eye-shoulder-hip
- Ear-shoulder-hip
- Nose-shoulder-hip

---

\*As per literature showing the "correct" upright posture

# To analyse posture - we need to calculate the angle between 3 body landmarks

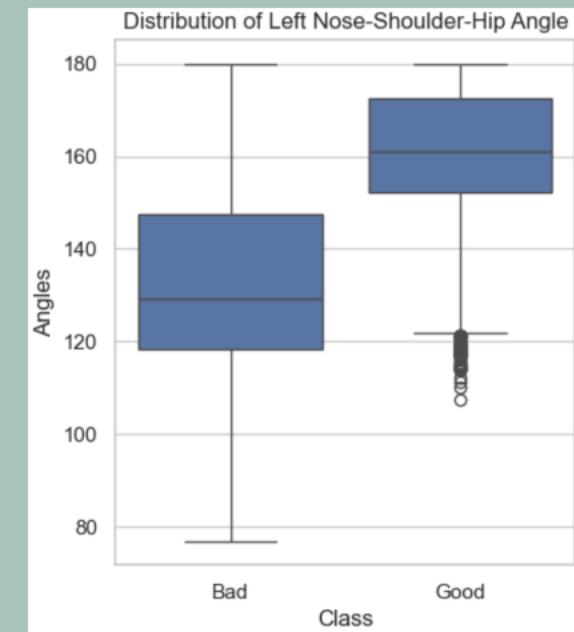
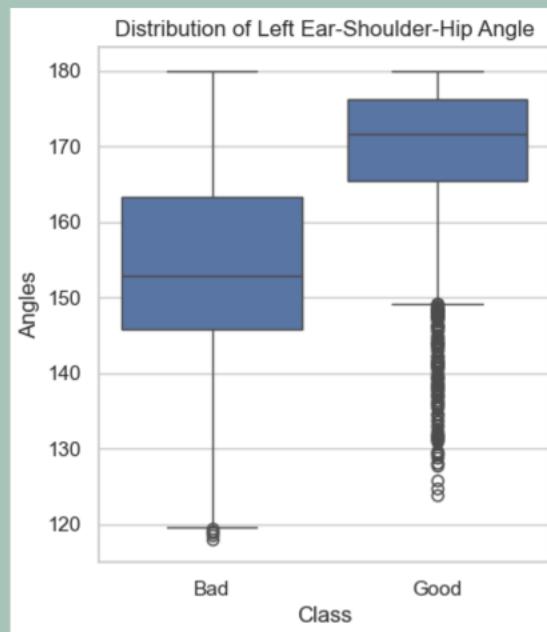
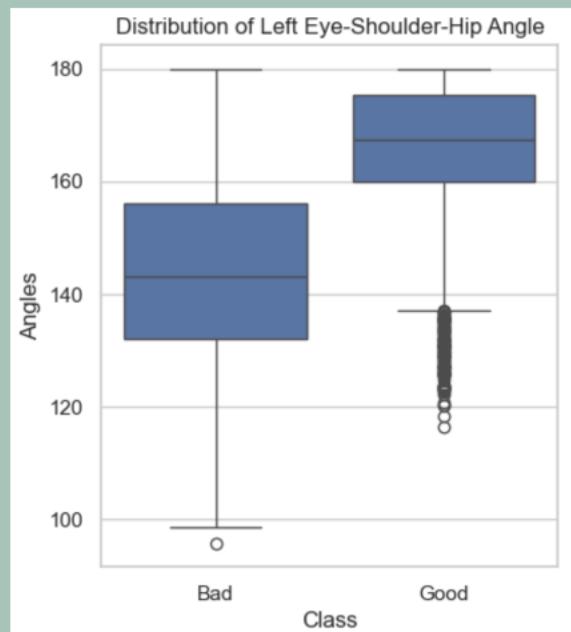
```
def calculate_angle(a,b,c):
    a = np.array(a) # First
    b = np.array(b) # Mid
    c = np.array(c) # End

    # Calculate angles for all rows using vector operations
    radians = np.arctan2(c[:, 1] - b[:, 1], c[:, 0] - b[:, 0]) - np.arctan2(a[:, 1] - b[:, 1], a[:, 0] - b[:, 0])
    angles = np.abs(radians * 180.0 / np.pi)

    # Ensure angles are within [0, 360) degrees
    angles = np.where(angles > 180.0, 360 - angles, angles)

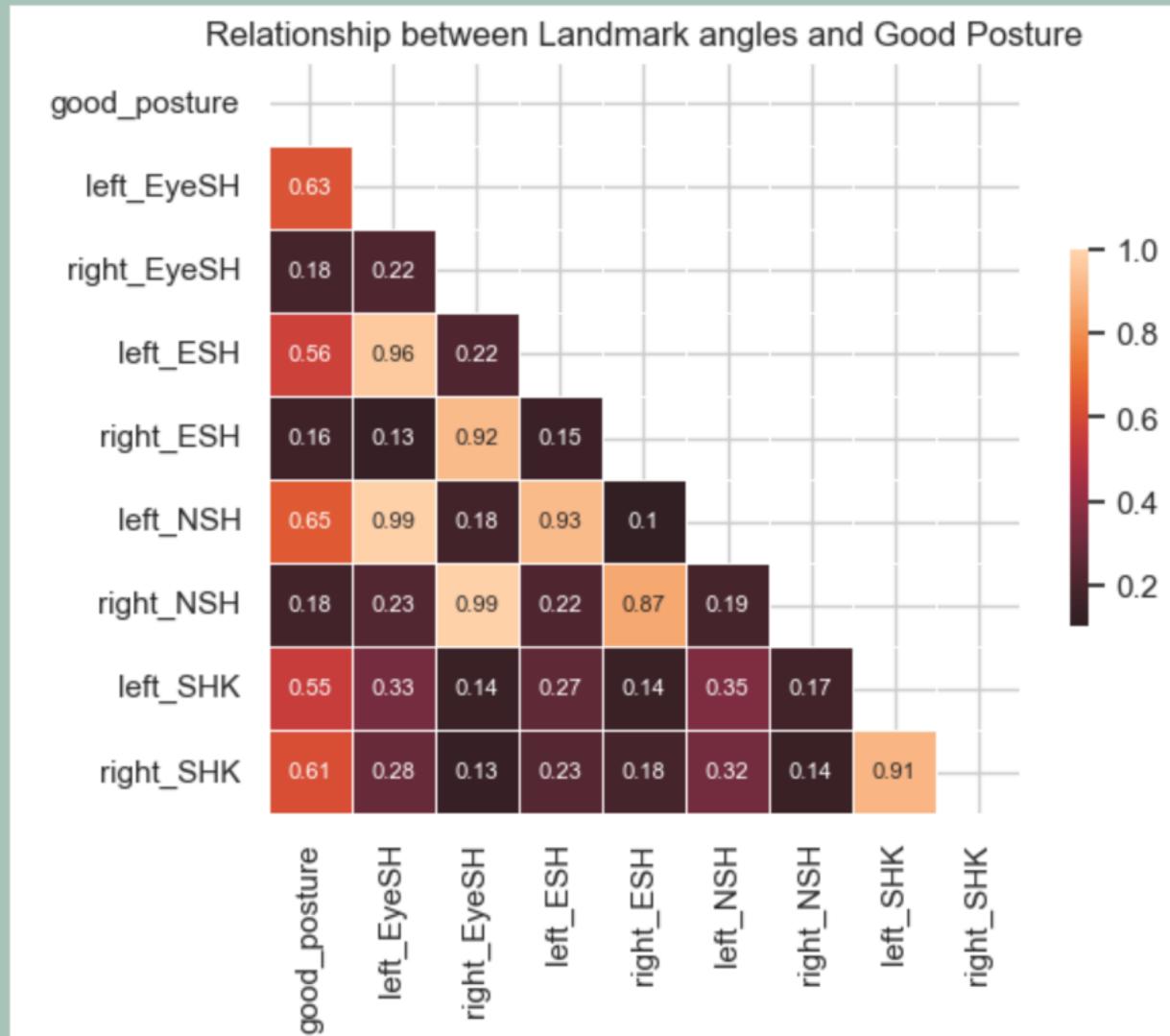
    return angles
```

Angles for "Good" posture are closer to  $180^\circ$ , while angles for bad postures tend to be lower than  $180^\circ$



$180^\circ$  == straight line!

# Eye-Shoulder-Hip and Ear-Shoulder-Hip angles were highly correlated with good postures



# 4. data modelling

## Models

Logistic Regression

Random Forest

K Nearest Neighbour

Adaboost

XGBoost

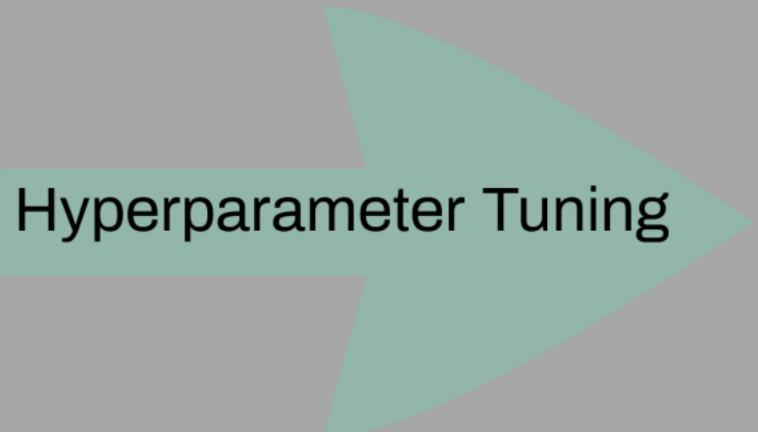
## Metrics

F1 Score

ROC-AUC

Accuracy

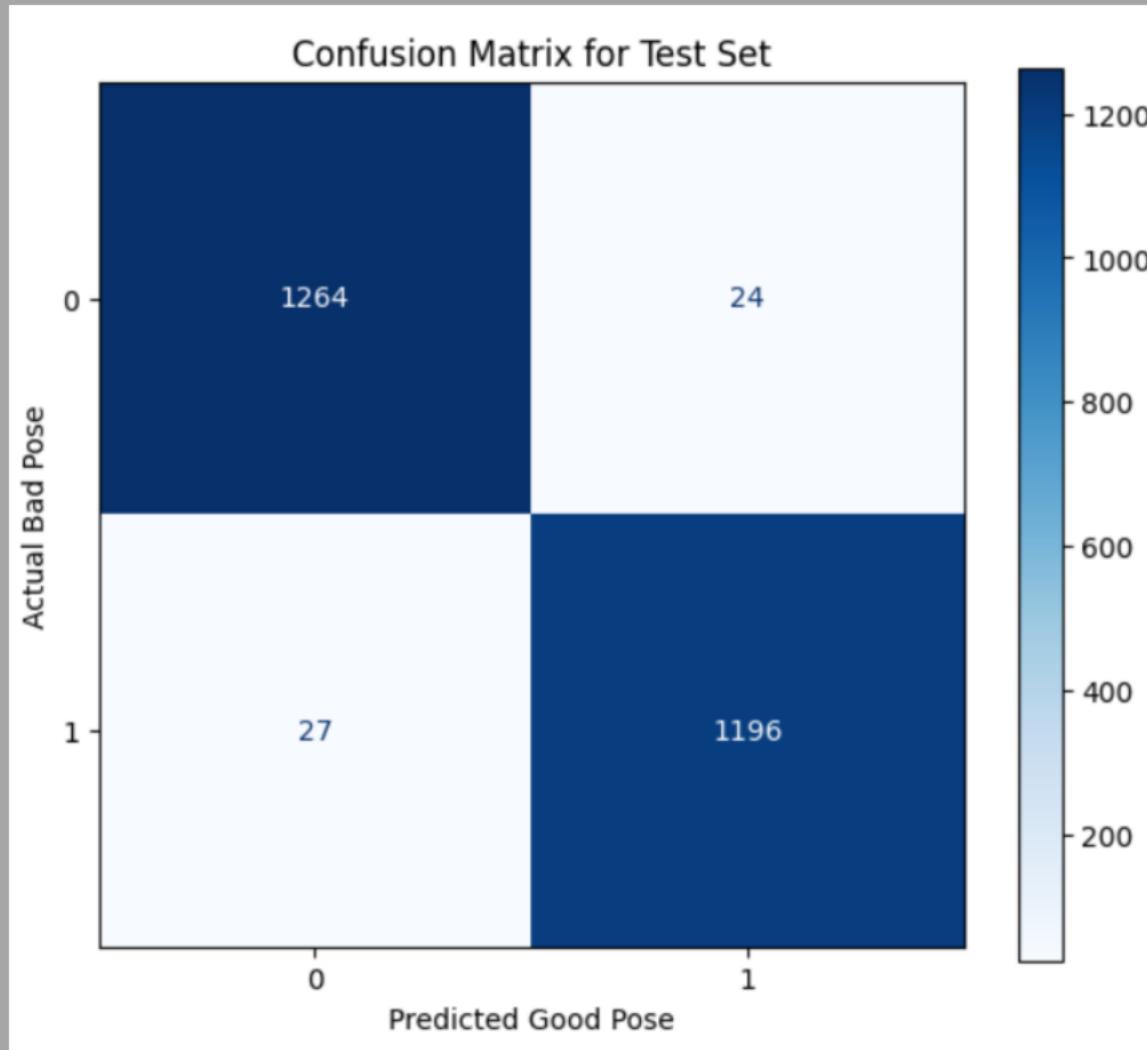
Hyperparameter Tuning



# modelling results

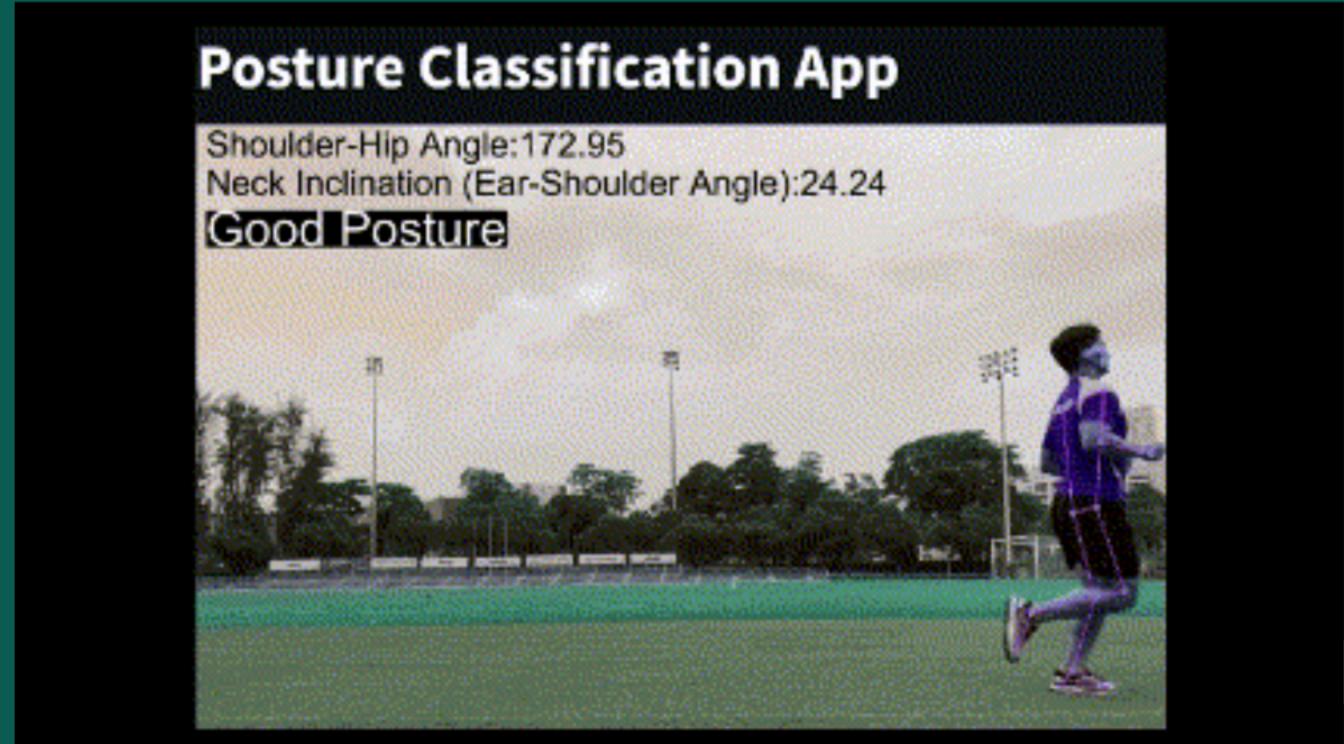
Models	Train			Test			GridSearch Time (s)
	F1-Score	AUC-ROC	Accuracy	F1-Score	AUC-ROC	Accuracy	
Baseline	0.5	0.5	0.5	0.5	0.5	0.5	-
Logistic Regression	0.93	0.96	0.93	0.92	0.95	0.92	2.65
Random Forest	0.99	1.0	0.99	0.98	1.0	0.98	105.28
K Nearest Neighbour	0.99	1.0	0.99	0.98	1.0	0.98	5.57
Adaboost	0.97	0.99	0.97	0.95	0.98	0.95	53.0
XGBoost	0.97	0.99	0.97	0.95	0.98	0.95	15.56

# confusion matrix



# streamlit demo

---



# streamlit demo

Empowers users to check if their posture is good or not based on the trained ML model, using the features like angles created between body landmarks

## Good Posture

---



## Bad Posture

---



Comes with a **\*BEEP\*** sound if  
bad posture is detected



# Conclusion

## Limitations / Challenges

- Multiple bodies in frame causes confusion for model
- App deployment to cloud is laggy

## Use Cases

- Public exercise areas like parks / stadiums to remind people to have good posture
- In schools, can be used during Physical Education classes to ensure students have good postures
- Assist in teleconsultation with doctors / chiropractors
- Can be deployed to phone app for individuals to monitor their own postures

thank you!  
Q & A

## Future Work

- Deploy it to a phone app
- Prescriptive messages on how to improve posture
- Detect specific types of bad posture / medical conditions such as overarching or slouching

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