



EMORY
UNIVERSITY
SCHOOL OF
MEDICINE

Department of
Biomedical Informatics

Potential Sources of Biases in Cuff-based Blood Pressure Measurement Technologies

Alphanumerics Lab Meeting

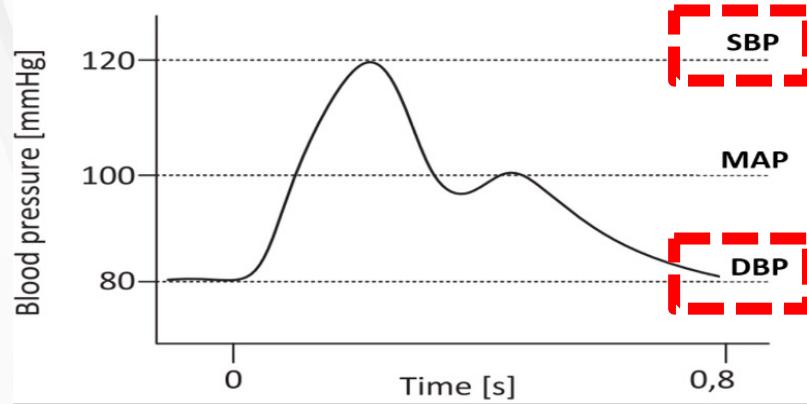
Seyedeh Somayyeh Mousavi

June 15th, 2023

Familiar Experience ...



Concept of Blood Pressure and its Measuring



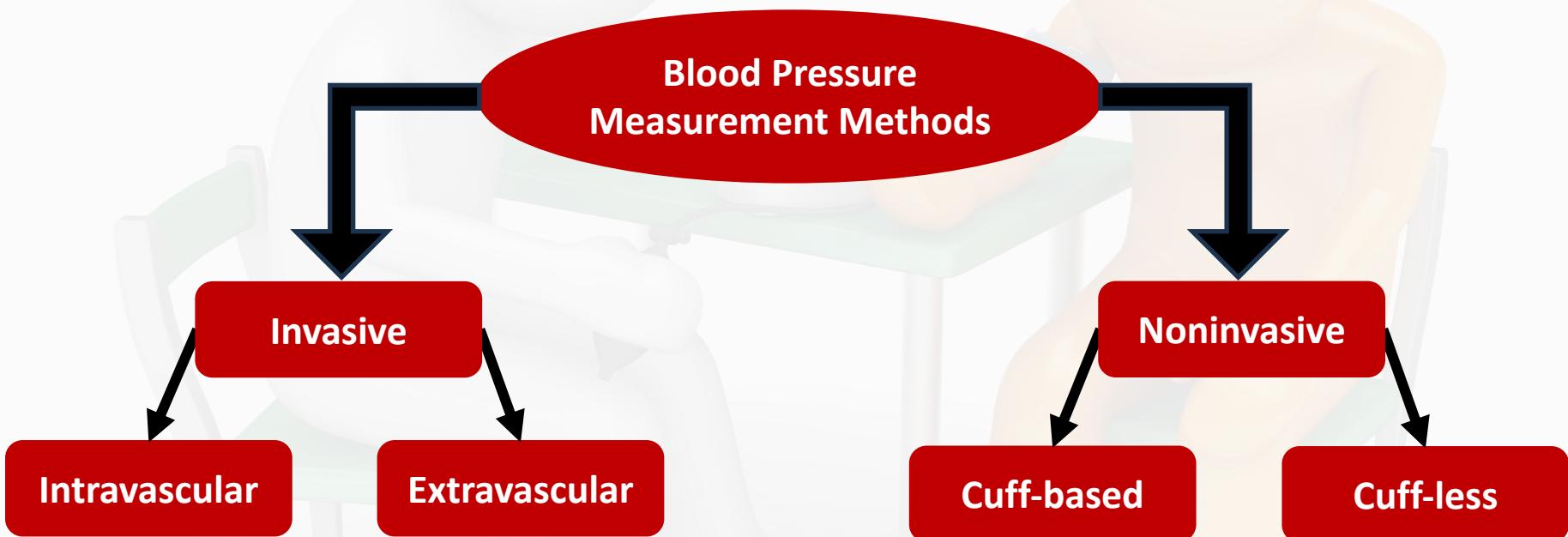
Systolic Blood Pressure

$$\text{MAP} = (2 \times \text{SBP} + \text{DBP}) / 3$$

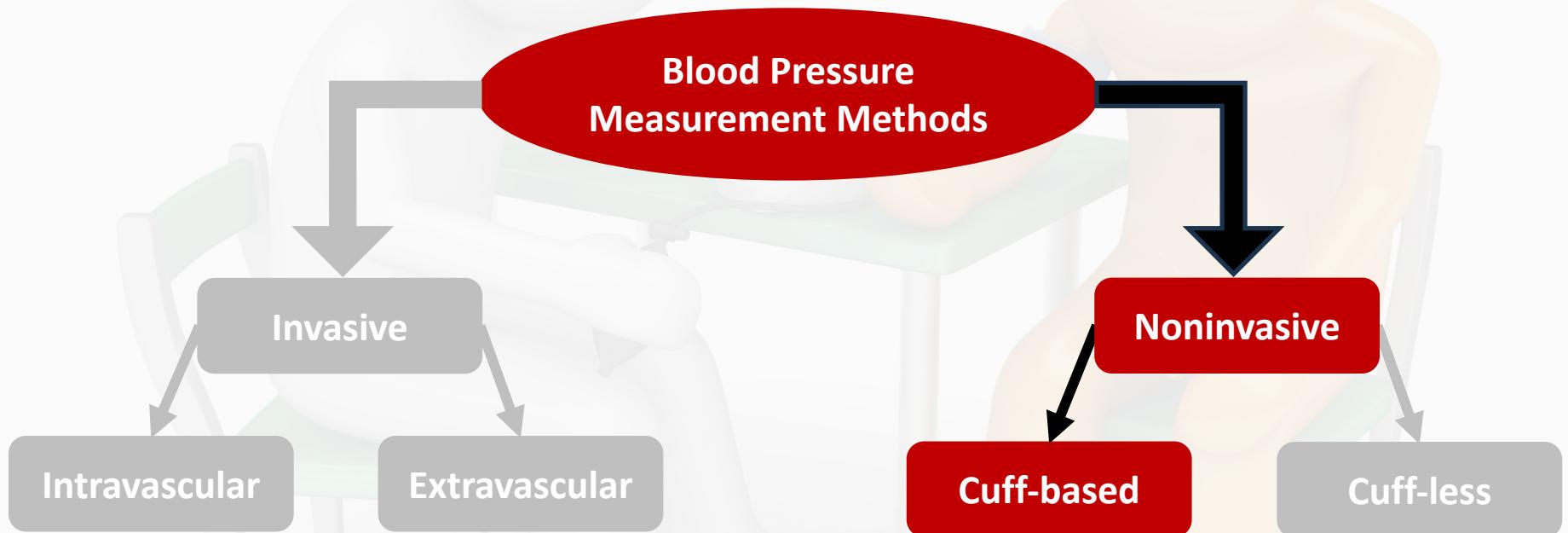
Diastolic Blood Pressure

Adopted from <https://www.ndtv.com/health/>

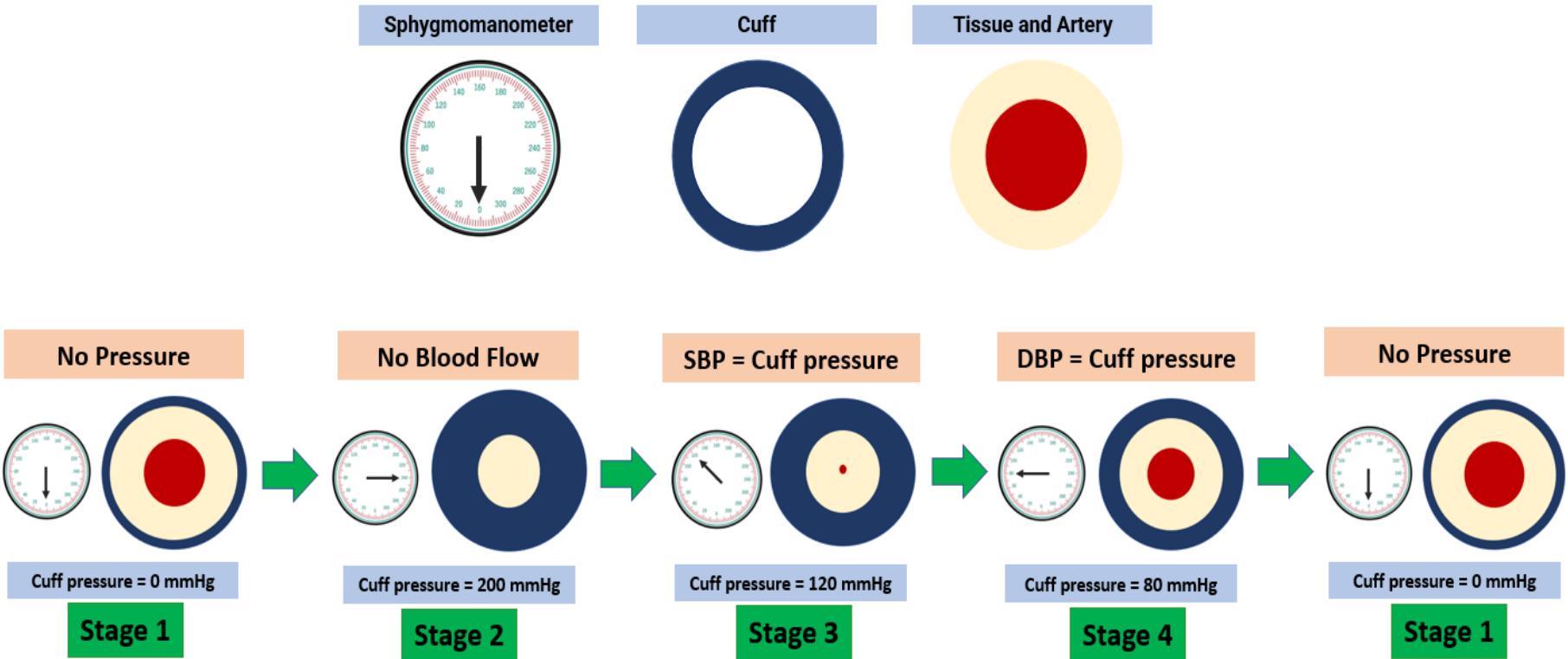
Methods of Blood Pressure Measuring



Methods of Blood Pressure Measuring



Steps of Measuring Blood Pressure: The Cuff-Based Method



Blood Pressure Categories



American
Heart
Association®

BLOOD PRESSURE CATEGORY	SYSTOLIC mm Hg (upper number)	and/or	DIASTOLIC mm Hg (lower number)
NORMAL	LESS THAN 120	and	LESS THAN 80
ELEVATED	120 – 129	and	LESS THAN 80
HIGH BLOOD PRESSURE (HYPERTENSION) STAGE 1	130 – 139	or	80 – 89
HIGH BLOOD PRESSURE (HYPERTENSION) STAGE 2	140 OR HIGHER	or	90 OR HIGHER
<u>HYPERTENSIVE CRISIS</u> (consult your doctor immediately)	HIGHER THAN 180	and/or	HIGHER THAN 120

Adopted from "<https://www.heart.org/>"

Hypertension

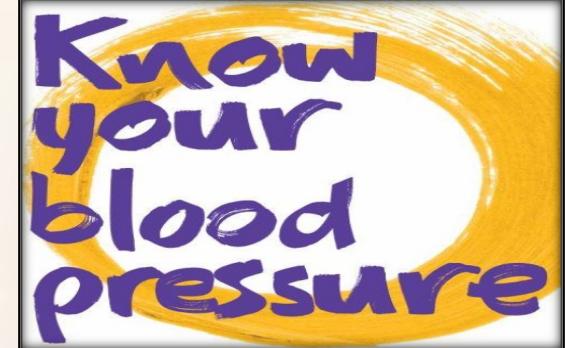


World Health Organization



A row of five stylized human figures (one red male, one grey female, one grey male, one grey female, and one grey male) representing adults with hypertension. Below them is a blue banner with white text.

1 in 3 adults with Hypertension does not know they have the disease



Adopted from <https://www3.paho.org/> & <https://www.thequint.com/> & <https://www.rotary-ribi.org/>

Significant Question of This Study

"Are the reported BP values close to their actual ones?"

$$y(t) = BP(t) + e(t)$$

$y(t)$: Reported BP

$BP(t)$: True BP (Invasive BP)

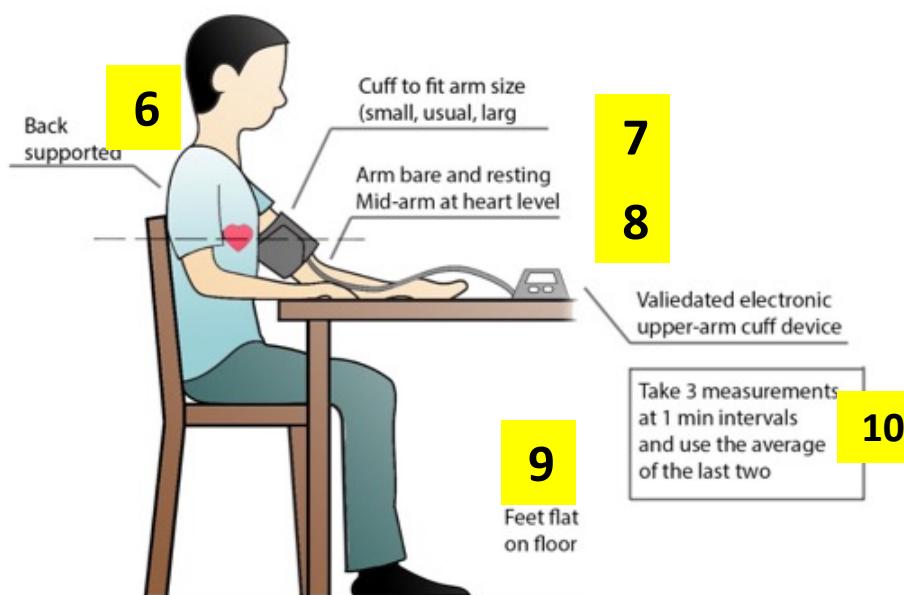
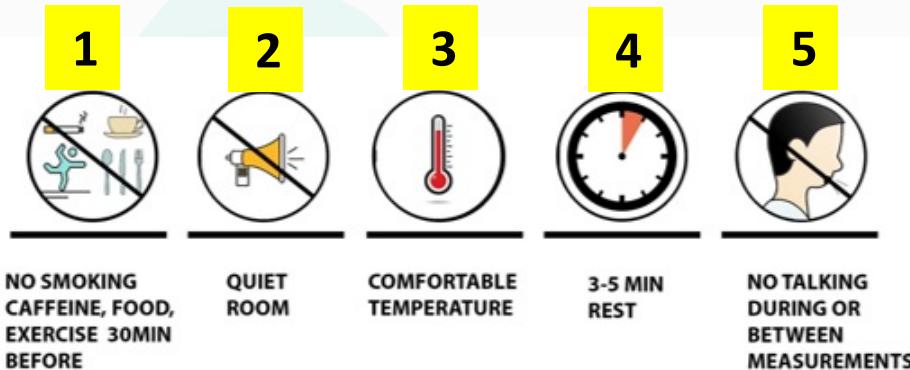
$e(t)$: Difference between $y(t)$ and $BP(t)$

Bias:

Difference between actual BP values and reported ones

Overview

- ✓ Standard Conditions of BP Measurement
- ✓ Potential Sources of Bias
- ✓ Discussion
- ✓ Future works
- ✓ Conclusion



Main Blood Pressure Measurement Devices



Consumables of Blood Pressure Measurement Devices



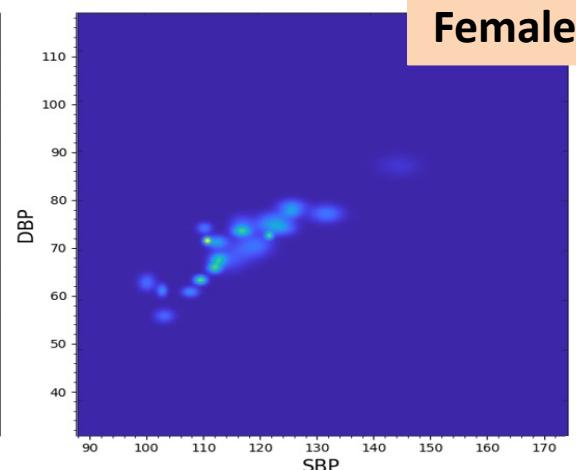
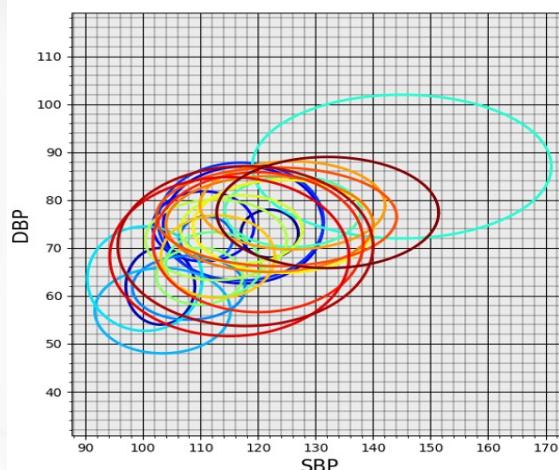
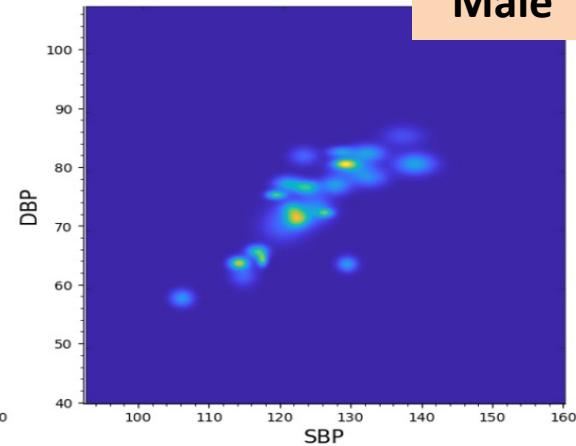
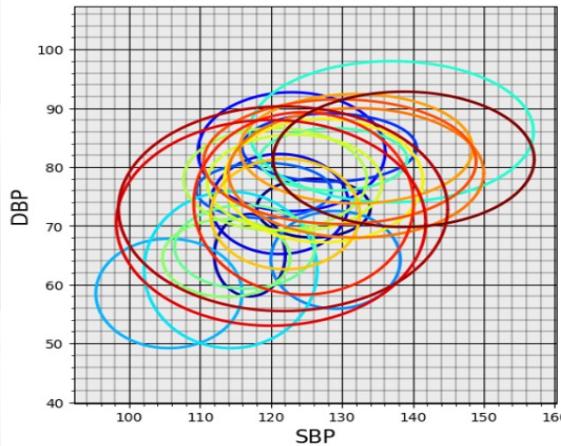
1. Blood Pressure Devices

2. Subject-Specific

3. Acquisition Session

✓ Demographic Features: Gender

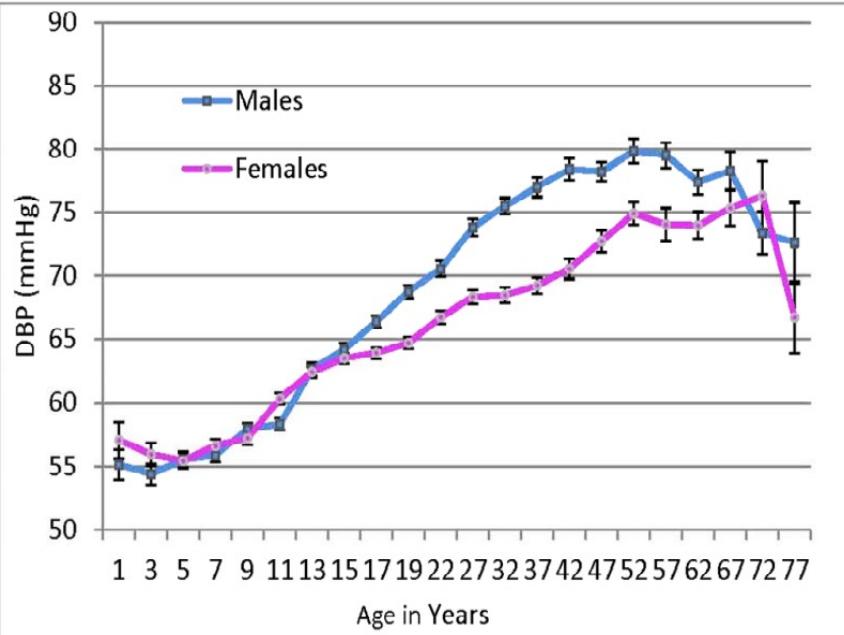
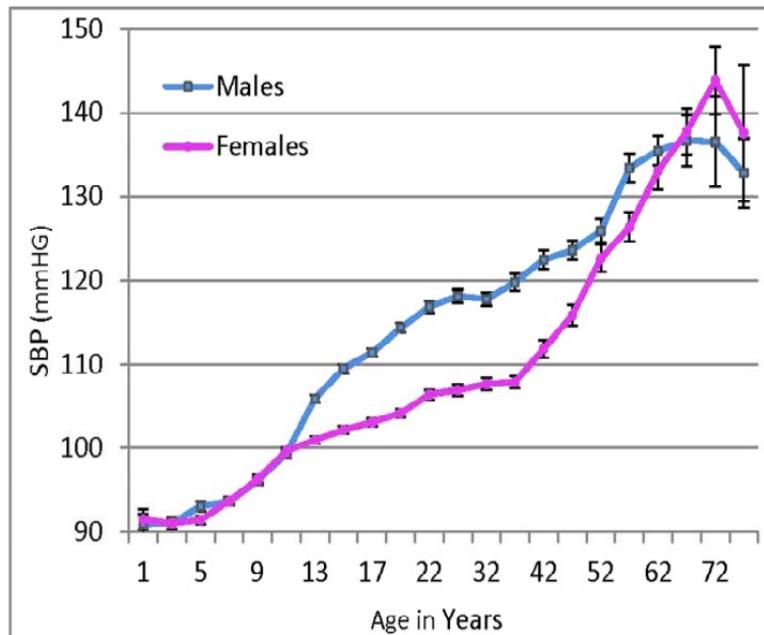
- The center of each ellipse is (mean SBP and mean DBP).
- Its radials are (std SBP and std DBP).



1. Blood Pressure Devices

2. Subject-Specific

3. Acquisition Session

✓ Demographic Features: Age


The relationship between blood pressure values, sex, and age (965 men and 1114 women)

(Adopted from "The predictive value of childhood blood pressure values for adult elevated blood pressure")

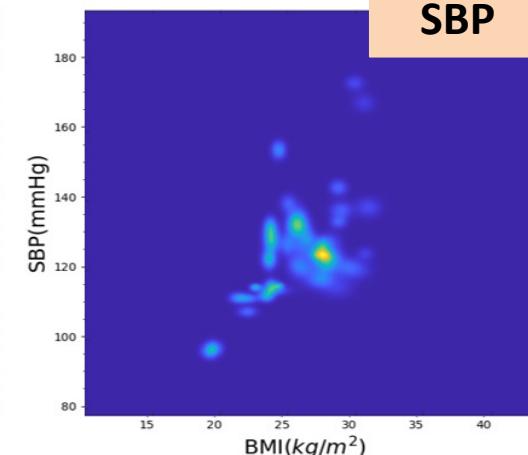
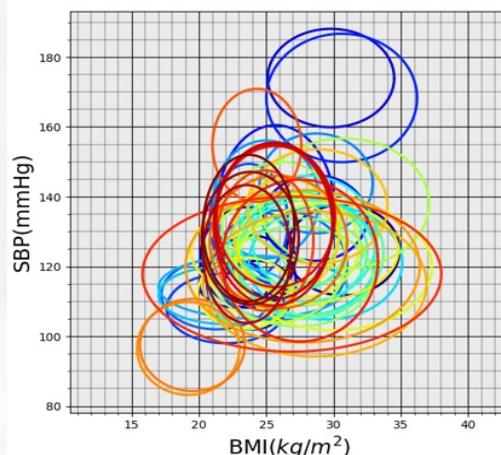
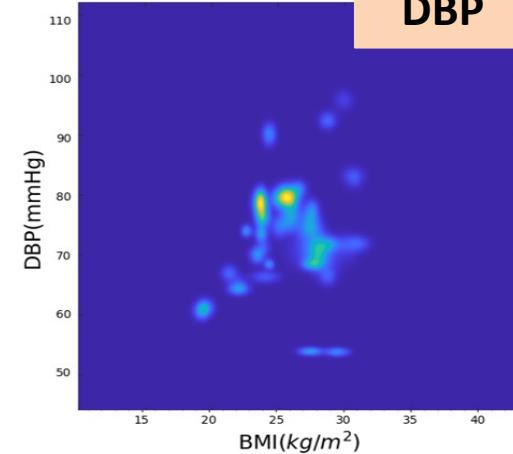
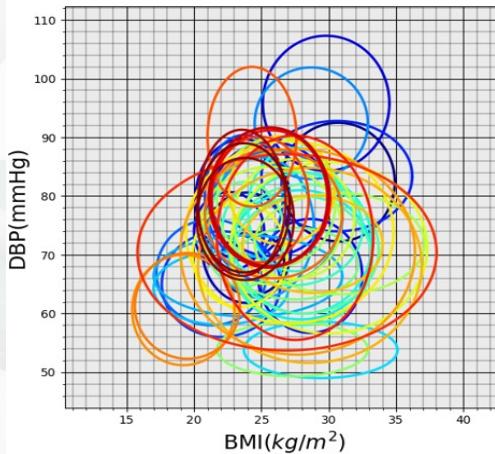
1. Blood Pressure Devices

2. Subject-Specific

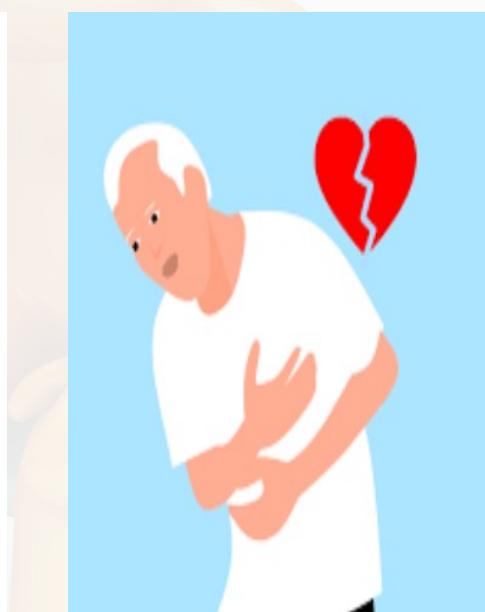
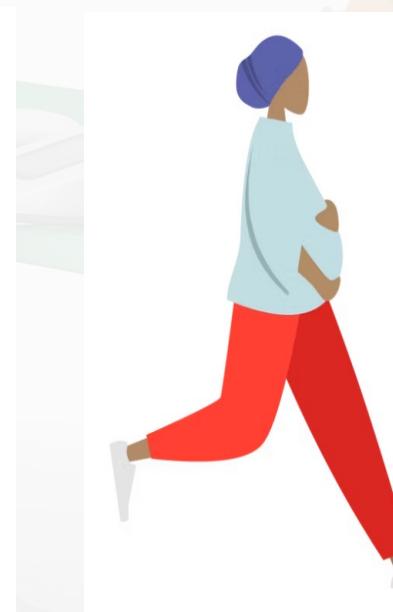
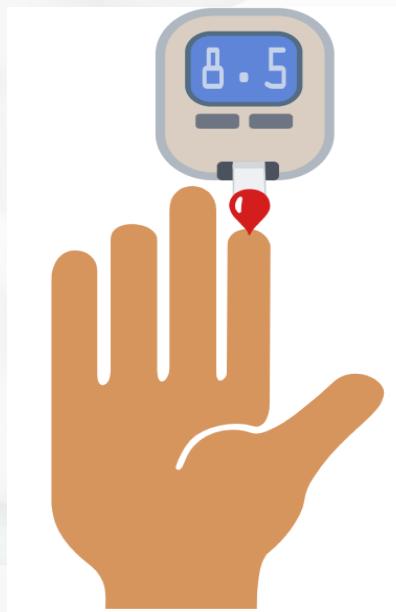
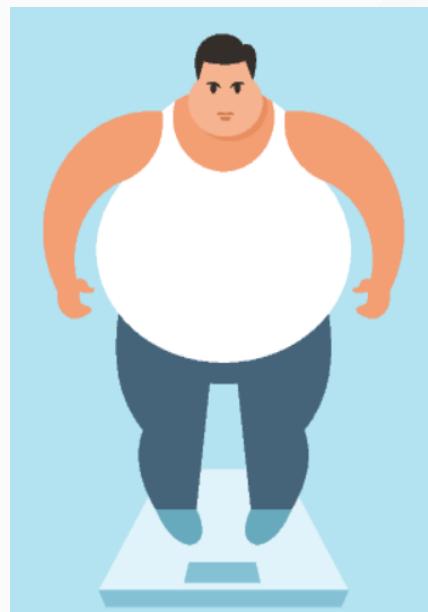
3. Acquisition Session

✓ Demographic Features: BMI

- The center of each ellipse is (BMI and mean BP).
- Its radials are (std BP and std BMI).



✓ Specific Patient Populations



Obesity

Diabetic

Pregnant Women

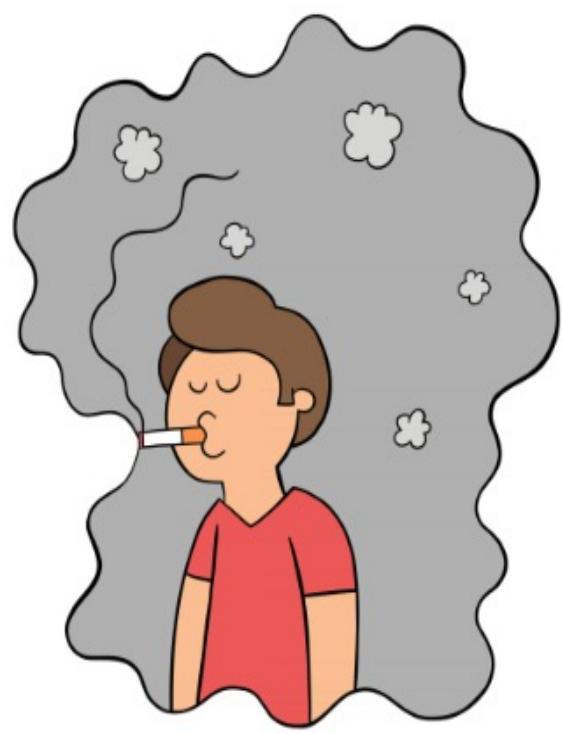
Hypertension

1. Blood Pressure Devices

2. Subject-Specific

3. Acquisition Session

✓ Smoking



✓ Drinking



✓ Eating



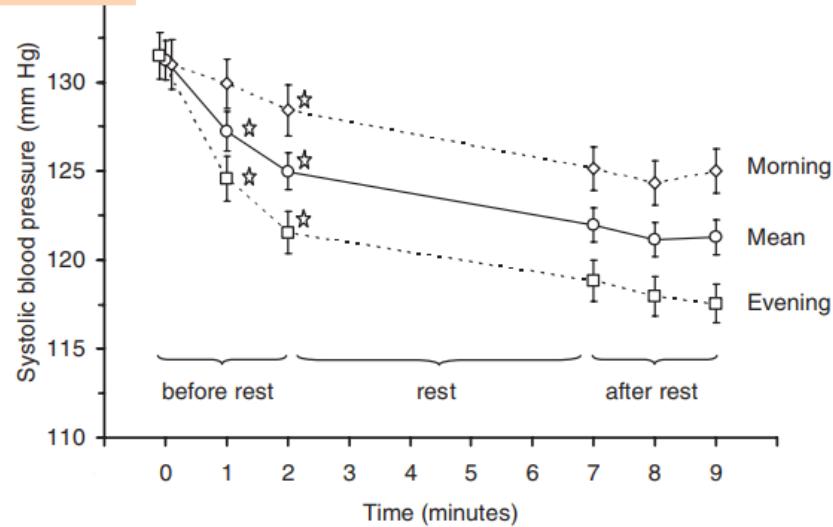
1. Blood Pressure Devices

2. Subject-Specific

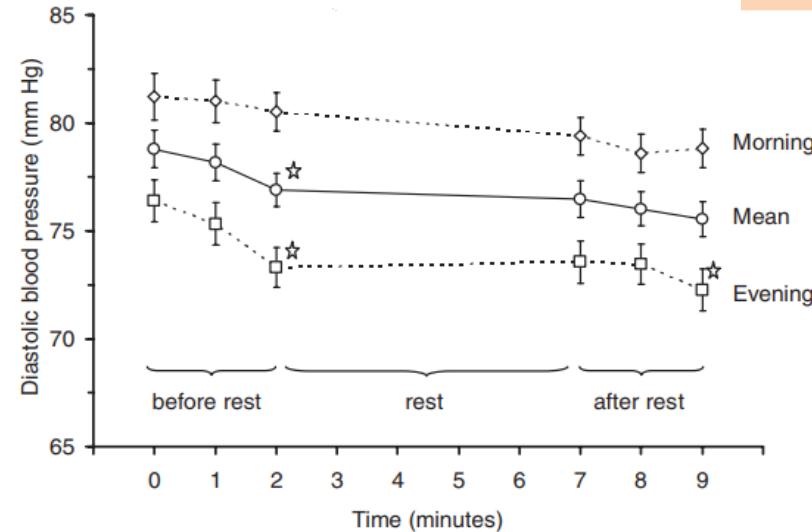
3. Acquisition Session

✓ Circadian Clock

SBP



DBP



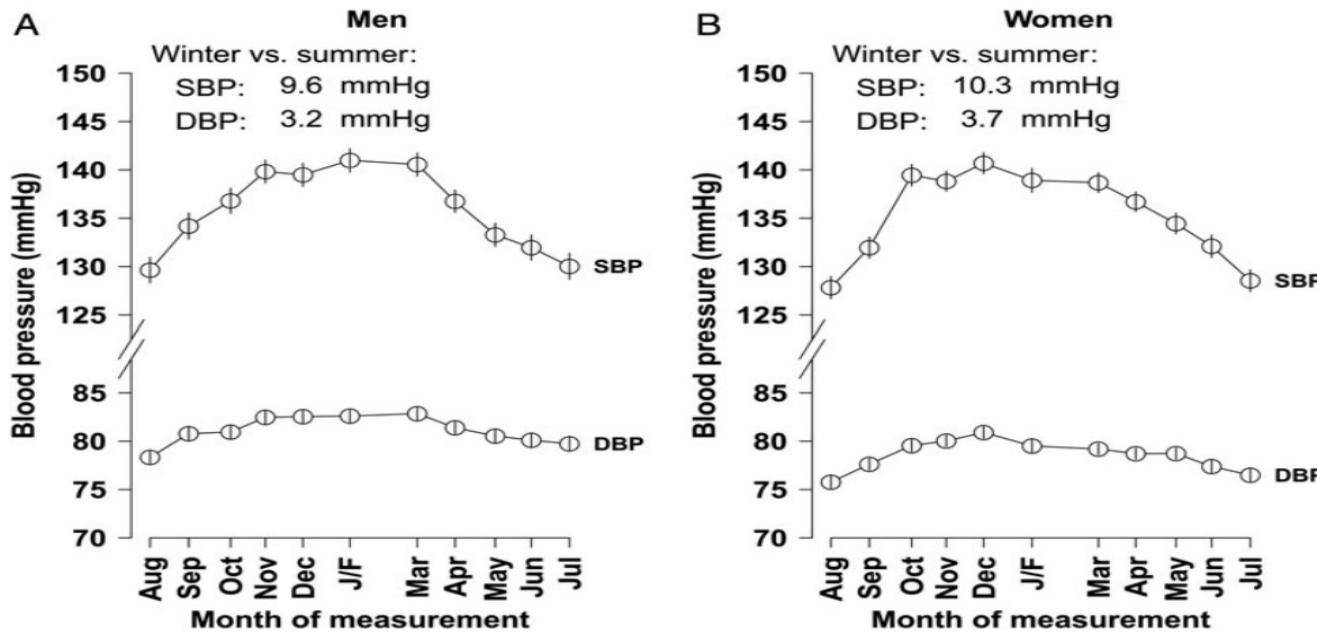
The results of a study that compares the BP values between 52 hypertensive-controlled patients based on time of the day (morning and evening)

(Adopted from home blood pressure monitoring: a few minutes of rest before measurement may not be appropriate paper)

1. Blood Pressure Devices

2. Subject-Specific

3. Acquisition Session

✓ Ambient Temperature


Fluctuating blood pressure values in different months and seasons of the year. The database is related to 23040 people with prior CVD in China between 2004 and 2008.

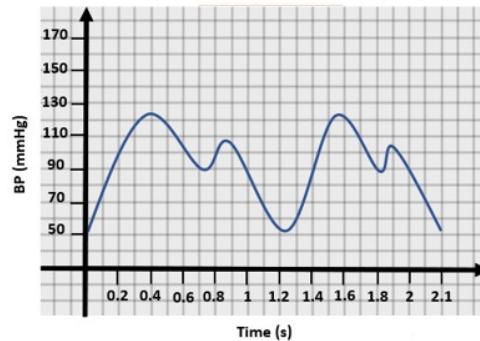
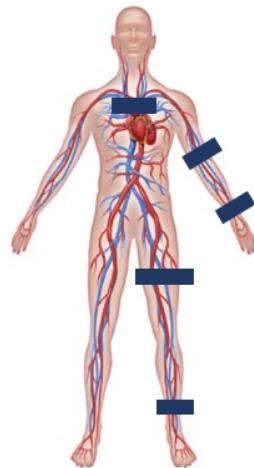
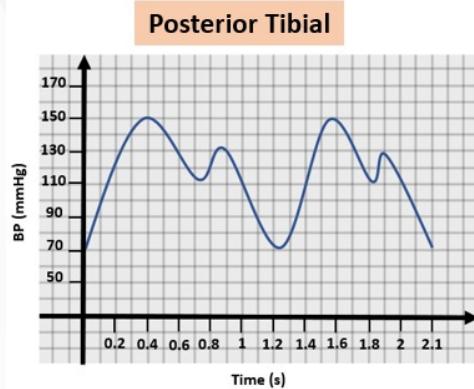
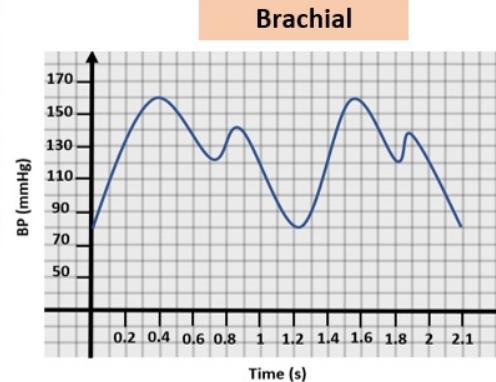
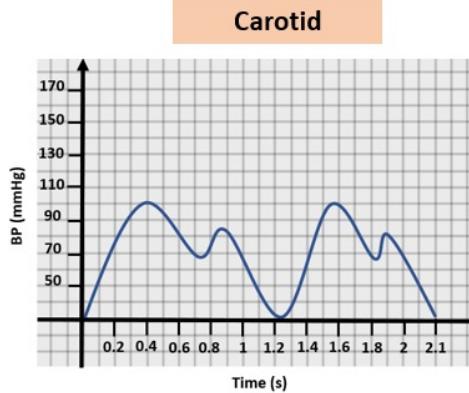
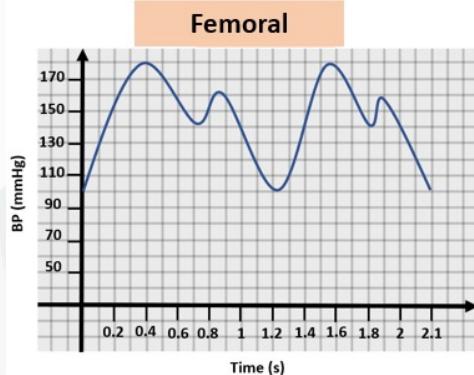
(Adopted from outdoor temperature, blood pressure, and cardiovascular disease mortality among 23000 individuals with diagnosed cardiovascular diseases from China paper)

1. Blood Pressure Devices

2. Subject-Specific

3. Acquisition Session

✓ Cuff Points



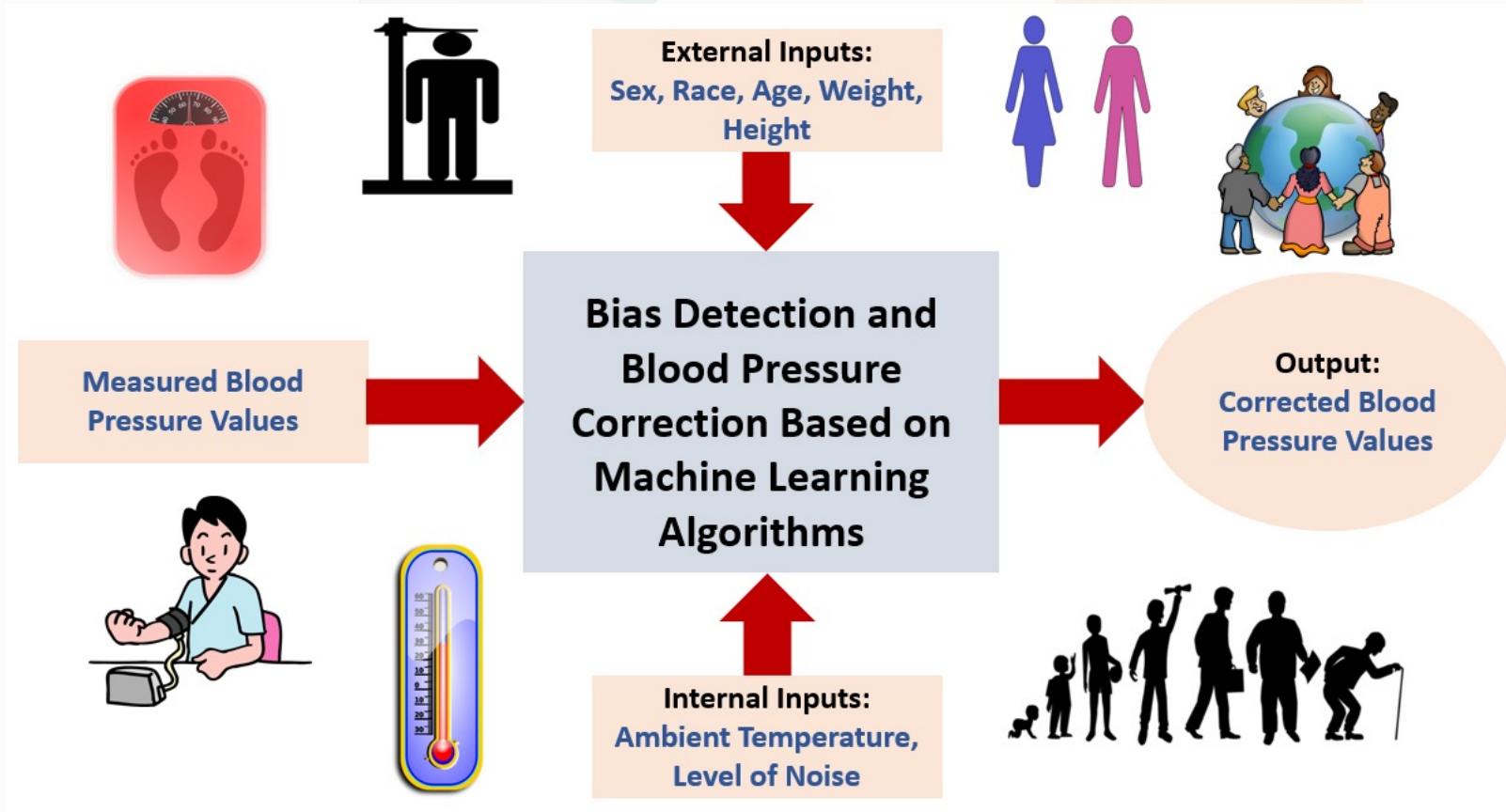
1. Blood Pressure Devices

2. Subject-Specific

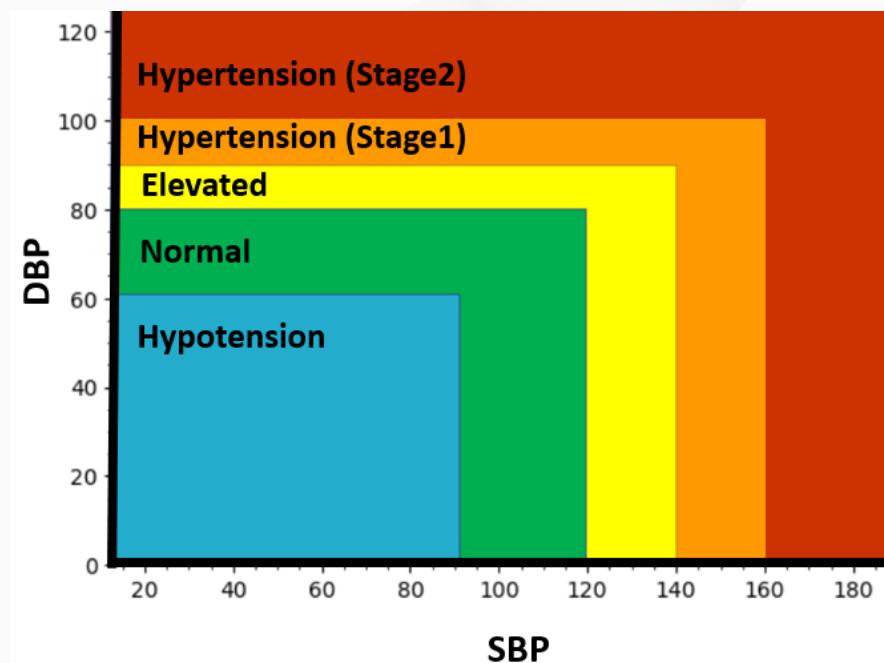
3. Acquisition Session

- ✓ **Body Position**
- ✓ **Arm Position**
- ✓ **Leg Position**
- ✓ **Left or Right Arm**
- ✓ **Cuff Size**
- ✓ **Cuff Tightness**
- ✓ **Rest Period Before Measuring**
- ✓ **Number of Measurements**
- ✓ **Clothing**

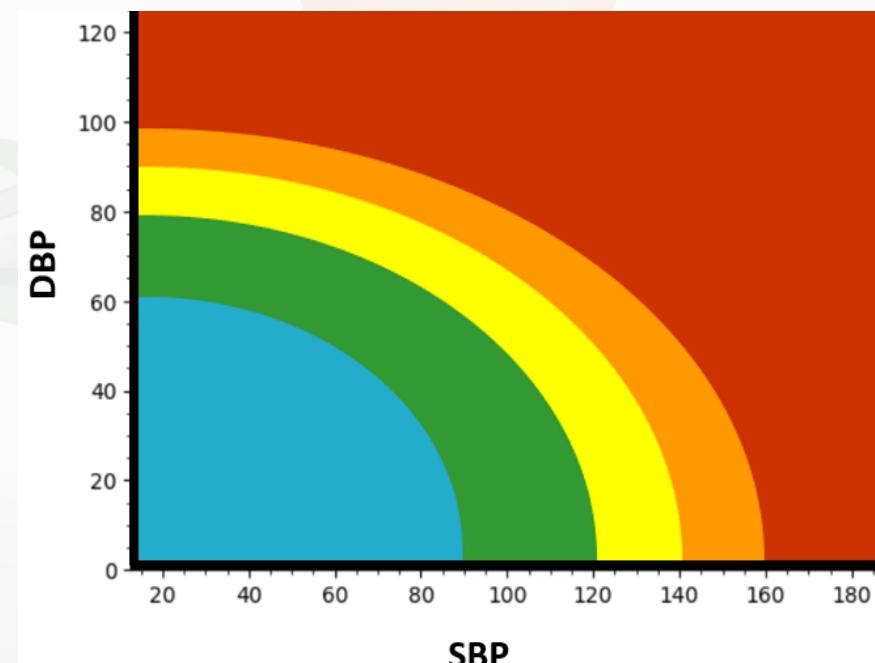
Blood Pressure Correction System



Schematic of the Blood Pressure Chart



Now



Future



- 1. Coverage of some potential sources of bias**
- 2. The impossibility of their independent investigation**

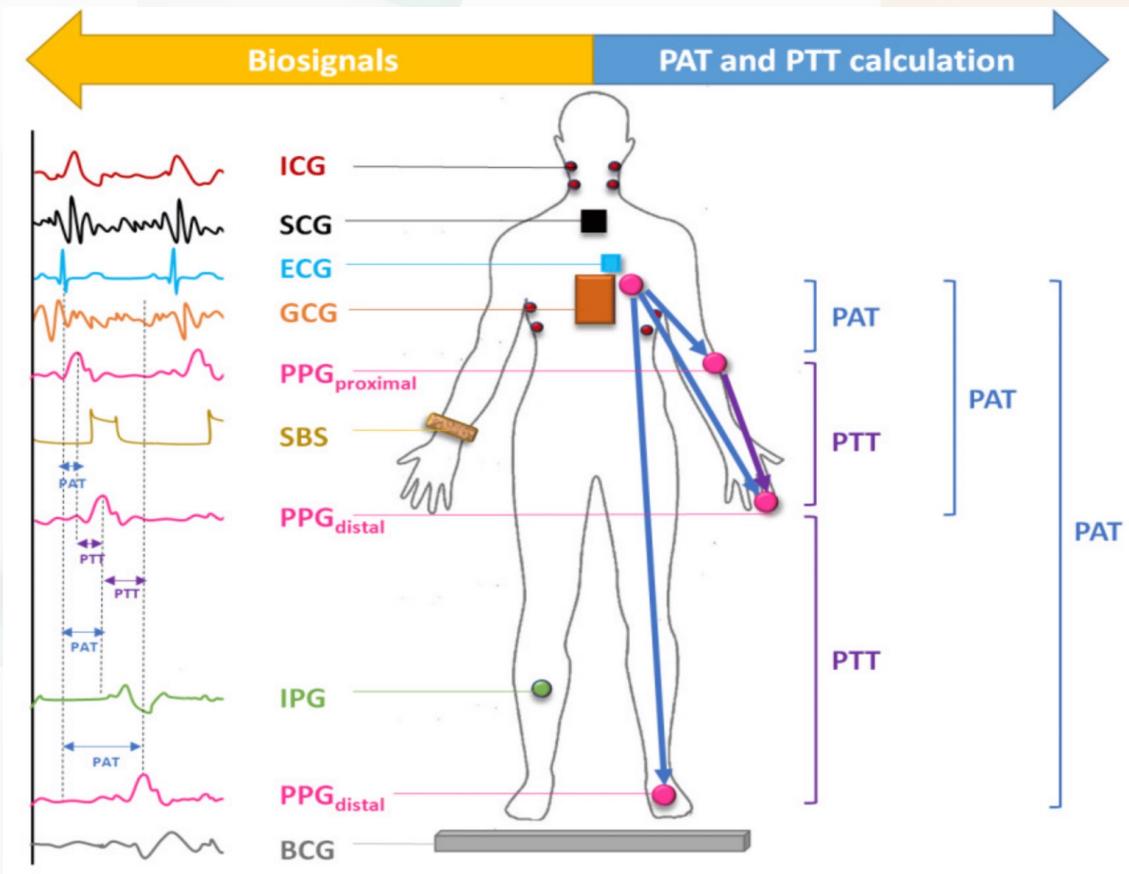
Developing Cuff-less BP Technologies Using the Cuff-based Ones



Adopted from “Comparing blood pressure measurements between a photoplethysmography-based and a standard cuff-based manometry device”

Adopted from <https://wt-obk.wearable-technologies.com/>

Developing Cuff-less BP Technologies Using the Cuff-based Ones



Adopted from "Multimodal Photoplethysmography-Based Approaches for Improved Detection of Hypertension"

- ✓ **Blood pressure is one of the critical vital signs.**
- ✓ **Physicians make decisions about patients using blood pressure values.**
- ✓ **The reported blood pressure values are incorrect**
- ✓ **The main reason for investigating bias is to prevent its distribution to the following stages.**
- ✓ **Developing new types of blood pressure devices is necessary.**



**Thank you for listening!
Any questions?**