Detection of Sitting Posture for Employees Using Microcontroller

Yulastri [a1], Era Madona [a2*], Aulia Novira [a3], Muhammad Rohfadli [a4], Anggara Nasution [a5], Fadhilah Zulfakhri [a6]

[a] Electronics Engineering Department, Politeknik Negeri Padang, Limau Manis, Padang, 25164, Indonesia
E-mail: eramadona@pnp.ac.id,
**Corresponding Author*

A B S T R A C T S

Sitting for prolonged periods with improper posture can cause serious health problems, including Low Back Pain (LBP) and other musculoskeletal disorders. Many employees spend long hours sitting at their desks without realizing the impact of their posture on their health. To address this issue, an employee sitting posture detector has been developed to monitor and analyze sitting posture and duration, helping to prevent long-term health risks. This device uses eight load cell sensors strategically placed to measure weight distribution and detect different sitting positions with high accuracy. It also incorporates an SD card module for data storage and a high-accuracy Real-Time Clock (RTC) timer to record sitting duration. The microcontroller processes the collected data and transmits it via a Bluetooth module to a dedicated smartphone application, allowing users to track their posture in real time. The tool is capable of detecting eight different sitting postures: ergonomic, overlap left back, overlap right back, overlap left, overlap right, sit all, sit front, and sit front back up. When the system detects prolonged improper sitting postures, it activates an alarm to remind employees to adjust their posture or take breaks. By utilizing this device, employees can develop better sitting habits, reducing the risk of health issues related to poor posture. This tool not only improves individual well-being but also enhances workplace ergonomics, ultimately leading to increased productivity and a healthier work environment.

K E Y W O R D S

Microcontroller, Bluetooth, RTC, SD Card Module, Smartphone.

1. Introduction

Sitting work position or sitting attitude is an attitude where sitting with a straight back, shoulders back, and buttocks touching the back of the chair because this can reduce the amount of static muscle load on the legs [1]. Spending a long time sitting in the same position can contribute to the appearance of Low Back Pain (LBP) [2]. Lack of rest during work can disrupt blood circulation and damage muscles in the body which can ultimately reduce body function and cause pain in some parts of the body [3].

Lower Back Pain (LBP) conditions can be caused by work positions that are less ergonomic and cause increased fatigue in the body[4]. Low back pain can be prevented by doing a good and correct sitting work posture according to ergonomics, namely sitting upright not tense better if there is a chair back, the head does not lean forward> 15º, thighs parallel to the floor, arms and hands supported and better feet have a foothold [5]. One example of a less ergonomic work position is when someone performs the same task repeatedly over a long period of time or holds a certain body position, such as a twisting motion position, working with a tilted body position, kneeling, squatting, holding, and clamping with hands for a long time [6].

Therefore, a tool is needed "Design of Sitting Posture Detection for Employees Using Microcontroller" which can provide warnings to employees to be more aware of body health due to sitting too long. This tool can detect 8 sitting postures, namely Ergonomically, Over Lap Right Back, Over Lap Left Back, Over Lap Right, Over Lap Left, Sit All, Sit Front, and Sit Front Back Up.

2. RESEARCH METHODOLOGY

This section describes the design and manufacturing procedures used in the design of a sitting posture detector for employees using a microcontroller.

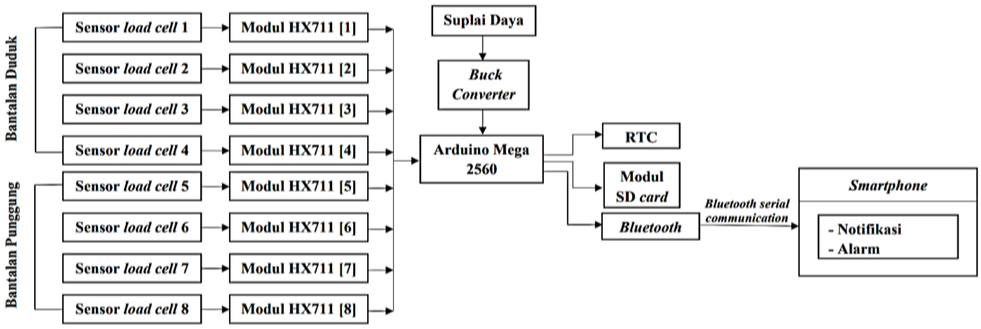


FIG 1. Block Diagram of The System

In Figure 1, it can be seen that this sitting posture detection system uses eight load cell sensors mounted on the chair. Four sensors are placed on the seat cushion, and the other four sensors on the back cushion. Load cells function to detect the load or pressure of the employee's body which shows the weight distribution during sitting. Because the signal generated by the load cell is very small, the HX711 module is used as an amplifier as well as a signal converter from analog to digital so that it can be processed by the microcontroller [7], [8], [9].

Arduino Mega 2560 microcontroller is used as a data processing center, with the support of Real-Time Clock (RTC) to record the time of each measurement. All posture detection data and time are stored on the SD card module, so that they can be accessed at any time for further analysis [10], [11], [12].

To facilitate real-time monitoring, data is sent to a smartphone application via a Bluetooth module. The app, developed using MIT App Inventor, displays information about sitting postures and notifies employees of any unergonomic sitting positions. Every 30 minutes, an alarm sounds as a reminder to take a break and will remain active for one minute if not turned off [13], [14], [15].

2.1 Mechanical Designing

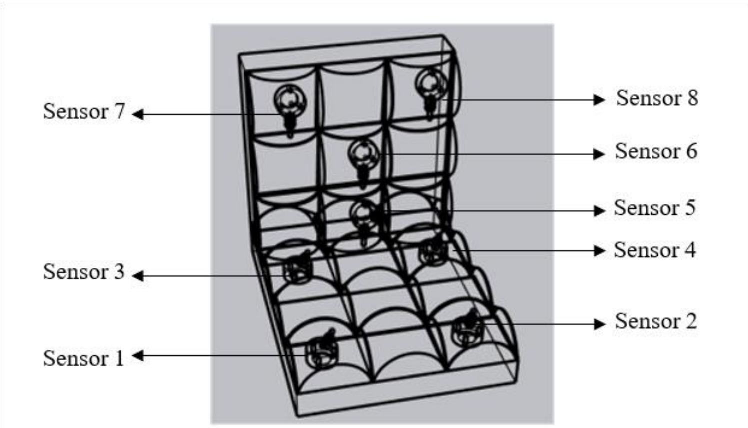


FIG 2. Sensor Positioning Plan

Figure 2 shows the layout of the eight load cell sensors mounted on the chair to detect the employee's sitting posture. These sensors are divided into two groups: four sensors are placed on the seat cushion (sensor 1 to sensor 4) and the other four sensors are installed on the back cushion (sensor 5 to sensor 8).

Sensors 1 to 4 detect the load distribution on the seat cushion, where the main body weight is usually focused when the employee is seated. Sensors 5 to 8 are mounted on the backrest to detect the pressure applied by the employee's back. The combination of these two groups of sensors allows the device to detect a more detailed weight distribution, both in the pelvis and legs and in the back.

This configuration aims to provide an accurate picture of the employee's sitting posture and detect uneven loads. A detected load imbalance may indicate an unergonomic sitting posture, potentially causing discomfort or health problems in the long run.

2.2 Software Designing

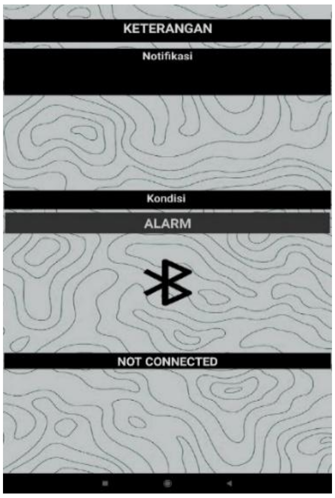


FIG 3. MIT APP Inventor Application System Design on Smartphone

The display of load cell sensor data on the smartphone can be seen in Figure 3. There is some information that will be displayed by the MIT App Inventor application, including:

TABLE 1. Explanation of the System Design of MIT APP Inventor Applications on Smartphones

Design	Description
Notification	Displays alerts to employees for each movement
Results	Shows sitting posture results during the use of the tool
Alarm	Reminds employees every 30 minutes
Bluetooth	Connects the system to the smartphone

The results will display symbols indicating the employee's sitting posture, which can be seen in Table 2 below.

TABLE 2. Seating Position Symbols

Symbol	Description
	*Ergonomically*
	*Overlap Right Back*
	*Overlap Left Back*
	*Overlap Right*
	*Overlap Left*
	*Sit All*

	*Sit Front*
	*Sit Front Back Up*

3. Results And Discussion

3.1 Bluetooth Module Testing Results

The Bluetooth module used in this test is the HC-06 Bluetooth module. The purpose of this test is to determine the range at which the connection between the HC-06 Bluetooth module and the smartphone remains stable, ensuring that the posture detection application using the MIT App Inventor functions optimally.

This test was conducted by measuring the maximum distance at which the Bluetooth connection remained stable before it was lost. Two testing conditions were evaluated: one without any obstructions and the other with physical obstructions.

Table 3. Results of Bluetooth Testing Without Obstruction

Distance	Condition
0 meters	Detected
1 meters	Detected
2 meters	Detected
3 meters	Detected
4 meters	Detected
5 meters	Detected
6 meters	Detected
7 meters	Detected
8 meters	Detected
9 meters	Detected
10 meters	Detected

This test aims to determine the maximum range of the HC-06 Bluetooth module in an open environment without physical interference. The HC-06 Bluetooth module and smartphone were placed in an open area. The test started at a distance of 0 meters and was gradually increased until the connection was lost. The stable connection range was recorded between 0 meters and 10 meters.

Table 4. Results of Bluetooth Testing With Obstruction

Distance	Condition
0 meters	Detected
1 meters	Detected
2 meters	Detected
3 meters	Detected
4 meters	Detected
5 meters	Detected
6 meters	Detected
7 meters	Detected
8 meters	Not Detected
9 meters	Not Detected
10 meters	Not Detected

The test with physical obstructions aims to assess the maximum range of the HC-06 Bluetooth module in an environment with physical barriers such as walls or partitions. The HC-06 Bluetooth module was placed in one room, and the smartphone in another, separated by a wall or other obstacles. The test started at a distance of 0 meters and was gradually increased until the connection was lost. The stable connection range was recorded between 0 meters and 7 meters.

These test results show that the maximum range of the HC-06 Bluetooth module is affected by the presence of physical obstructions. In an environment without obstructions, the range is wider compared to conditions with barriers.

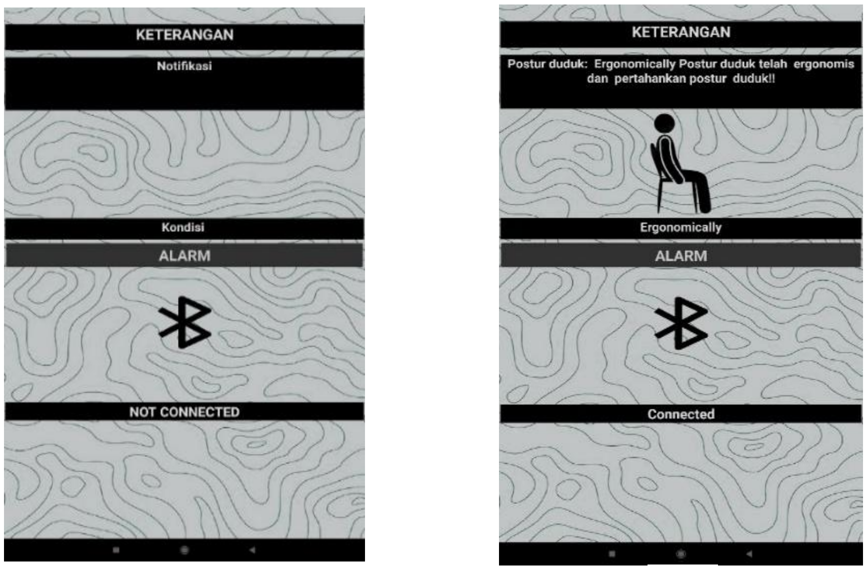
3.2 Sensor Reading Test Results on the Smartphone

In the load cell sensor readings, the weight measurement is converted into values of 0 and 1. The sensor reading will display a value of 0 if the weight detected by the sensor is less than 200 grams, and it will display a value of 1 if the weight is equal to or greater than 200 grams. This conversion helps determine the sitting posture of employees, as shown in Table 5 below.

TABLE 5. Seating Posture Specifications

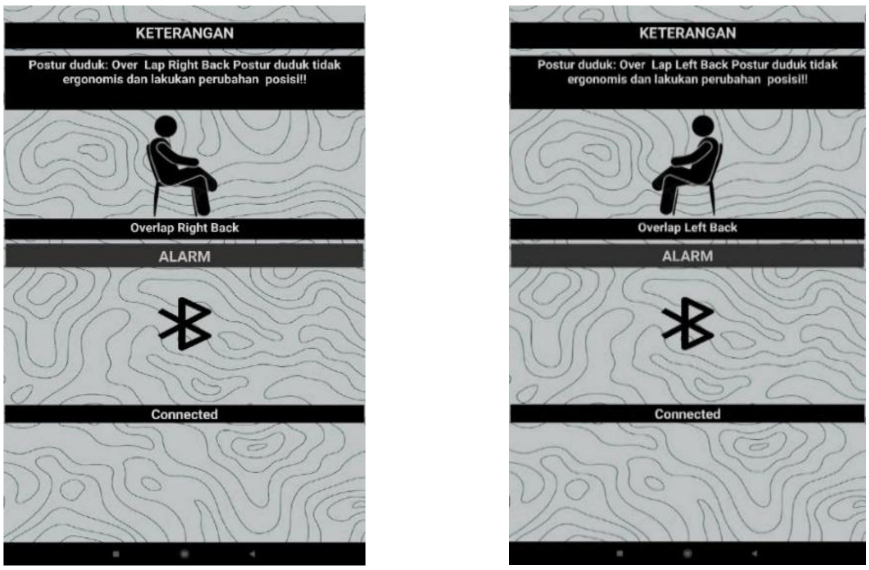
Posture	Position	Sensor								Description
		Seat Pad				Back Pad				
		S1	S2	S3	S4	S5	S6	S7	S8	
P1	*Ergonomically*	1	1	1	1	1	1	1	1	All seat sensors receive equal pressure.
P2	*Over Lap Right Back*	1	0	1	1	1	1	1	1	Right leg crossed, back pad sensors receive equal pressure.
P3	*Over Lap Left Back*	0	1	1	1	1	1	1	1	Left leg crossed, back pad sensors receive equal pressure.
P4	*Over Lap Right*	1	0	1	1	0	0	0	0	Right leg crossed, without using the back pad.
P5	*Over Lap Left*	0	1	1	1	0	0	0	0	Left leg crossed, without using the back pad.
P6	*Sit All*	1	1	1	1	0	0	0	0	Seat cushion sensors receive equal pressure, without using the back pad.
P7	*Sit Front*	1	1	0	0	0	0	0	0	Only the front part of the seat is used, without using the back pad.
P8	*Sit Front Back Up*	1	1	0	0	0	0	1	1	Only the front part of the seat and the upper back pad are used.

This test aims to assess how the system works as a whole using the MIT APP Inventor application. During the test, the sitting posture of employees is displayed on the smartphone. The system interface before activation can be seen in Figure 4 (a). The next test involves reading the sitting posture of employees. This test can be seen in Figure 4 (b), where the sitting posture of the employees is in an ergonomic position, with the recorded value being (1111 1111). In this case, the audio output on the smartphone is turned off. The display when the sitting posture of employees shows a postural error, which is non-ergonomic, can be seen in Figures 5 through 8.



(a) (b)

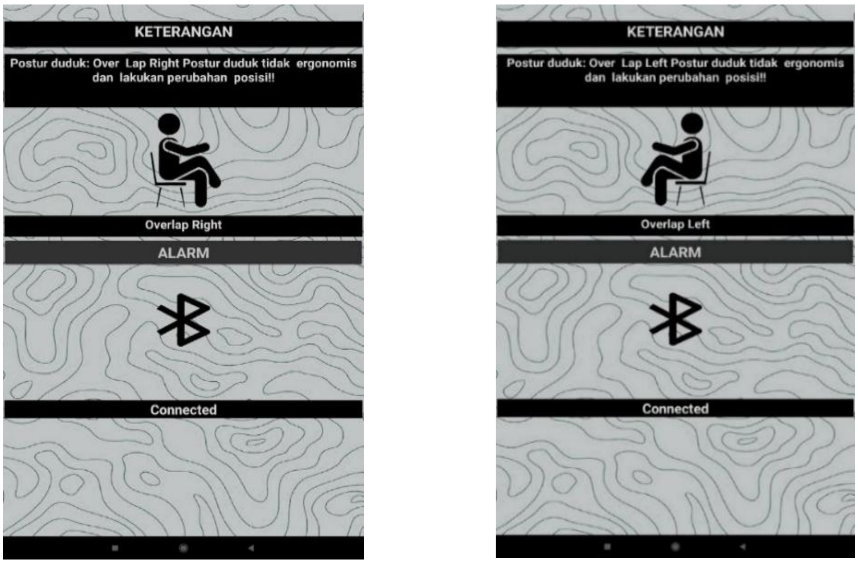
FIG 4. (a) Initial Display of Smartphone Application, (b) Ergonomic Seating Posture Display



(a) (b)

FIG 5. (a) Overlap Right Back Seating Posture Display, (b) Overlap Left Back Seating Posture

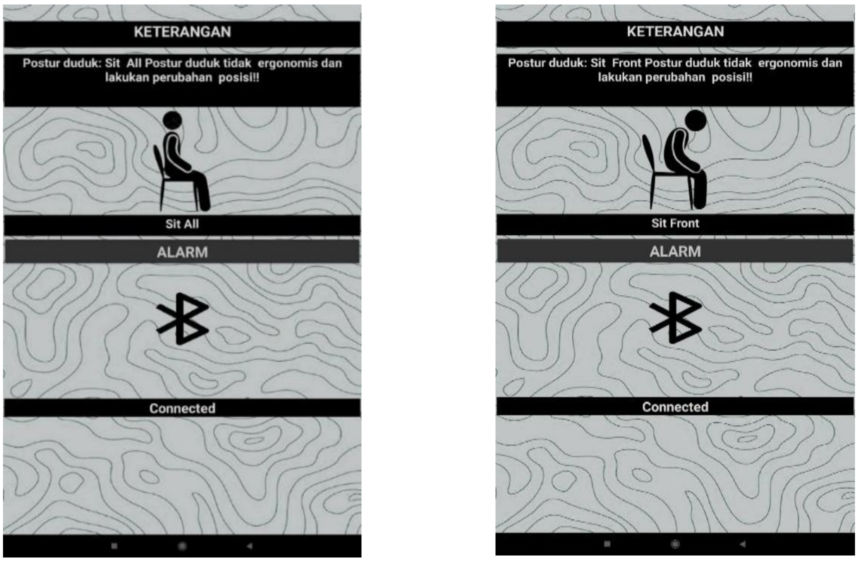
In Figure 5 (a), the sitting position of the employee is displayed as Overlap Right Back, with the recorded value being (1011 1111). The system will send the data and display the sitting position as Overlap Right Back. The audio output and notification on the smartphone will provide the warning: 'Sitting Posture: Overlap Right Back. This posture is non-ergonomic, please change your position!'. In Figure 5 (b), the sitting position of the employee is displayed as Overlap Left Back, with the recorded value being (0111 1111). The system will send the data and display the sitting position as Overlap Left Back. The audio output and notification on the smartphone will provide the warning: 'Sitting Posture: Overlap Left Back. This posture is non-ergonomic, please change your position!'



(a) (b)

FIG 6. (a) Overlap Right Seating Posture Display, (b) Overlap Left Seating Posture Display

In Figure 6 (a), the sitting position of the employee is displayed as Overlap Right, with the recorded value being (1011 000). The system will send the data and display the sitting position as Overlap Right. The audio output and notification on the smartphone will provide the warning: 'Sitting Posture: Overlap Right. This posture is non-ergonomic, please change your position!'. In Figure 6 (b), the sitting position of the employee is displayed as Overlap Left, with the recorded value being (0111 000). The system will send the data and display the sitting position as Overlap Left. The audio output and notification on the smartphone will provide the warning: 'Sitting Posture: Overlap Left. This posture is non-ergonomic, please change your position!'.



(a) (b)

FIG 7. (a) Sit All Seating Posture Display, (b) Sit Front Back Up Seating Posture Display

In Figure 7 (a), the sitting position of the employee is displayed as Seat All, with the recorded value being (1111 000). The system will send the data and display the sitting position as Seat All. The audio output and notification on the smartphone will provide the warning: 'Sitting Posture: Seat All. This posture is non-ergonomic, please change your position!'. In Figure 7 (b), the sitting position of the employee is displayed as Seat Front, with the recorded value being (1100 000). The system will send the data and display the sitting position as Seat Front. The audio output and notification on the smartphone will provide the warning: 'Sitting Posture: Seat Front. This posture is non-ergonomic, please change your position!'.

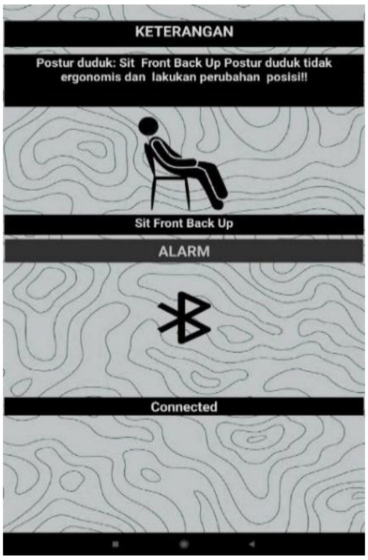


FIG 8. Sit Front Back Up Seating Posture Display

In Figure 8, the sitting position of the employee is displayed as Seat Front Back Up, with the recorded value being (1100 0011). The system will send the data and display the sitting position as Seat Front Back Up. The audio output and notification on the smartphone will provide the warning: 'Sitting Posture: Seat Front Back Up. This posture is non-ergonomic, please change your position!'.

3.3 Alarm Testing

The application also includes alarm settings. This alarm serves as a reminder for employees to stretch and take short breaks every 30 minutes. Short breaks can last about 1-2 minutes to reduce the risk of Lower Back Pain (LBP), Deep Vein Thrombosis (DVT), muscle atrophy, osteoporosis, and heart disease.

TABLE 6. Results of Alarm Testing Every 30 Minutes

Time	Description
30 minutes	Alarm On
60 minutes	Alarm On
90 minutes	Alarm On
120 minutes	Alarm On

This test aims to ensure that the alarm in the application functions according to the established settings. Based on Table 6, the test results indicate that the alarm works well, sounding every 30 minutes. Thus, the alarm feature in the application can be relied upon to help maintain employee health by reducing the risks associated with prolonged sitting.

4. CONCLUSIONS

This tool is designed to convert the measured weight values into binary values of 0 and 1, where if the weight detected by the load cell sensor is greater than 200 grams, the conversion result is 1, and it will be 0 if the weight detected by the load cell sensor is less than 200 grams. This tool can detect 8 sitting postures: Ergonomically, Overlap Right Back, Overlap Left Back, Overlap Right, Overlap Left, Sit All, Sit Front, and Sit Front Back Up. The readings will be displayed in the MIT APP Inventor application based on the specified posture values set in the Arduino IDE program.

REFERENCE

[1] R. Gupta, D. Saini, and S. Mishra, "Posture detection using Deep Learning for Time Series Data," in *2020 Third International Conference on Smart Systems and Inventive Technology (ICSSIT)*, IEEE, Aug. 2020, pp. 740–744. doi: 10.1109/ICSSIT48917.2020.9214223.

[2] J. Kulkarni, P. Durgule, K. Kale, and U. Deodhe, "Development Of Low-Cost Posture Detection System for Healthy Sitting," in *2023 International Conference on System, Computation, Automation and Networking (ICSCAN)*, IEEE, Nov. 2023, pp. 1–6. doi: 10.1109/ICSCAN58655.2023.10395344.

[3] A. Yıldız, P. Mişe, T. Çakar, A. M. Terzibaşıoğlu, and D. Öke, "Spine Posture Detection for Office Workers with Hybrid Machine Learning," in *2023 8th International Conference on Computer Science and Engineering (UBMK)*, IEEE, Sep. 2023, pp. 486–491. doi: 10.1109/UBMK59864.2023.10286584.

[4] M. Farnan, E. Dolezalek, and C.-H. Min, "Magnet Integrated Shirt for Upper Body Posture Detection Using Wearable Magnetic Sensors," in *2021 IEEE International IOT, Electronics and Mechatronics Conference (IEMTRONICS)*, IEEE, Apr. 2021, pp. 1–5. doi: 10.1109/IEMTRONICS52119.2021.9422488.

[5] T. Basmaji *et al.*, "Posture Detection Framework Using the Internet of Wearable Things," in *2022 2nd International Conference on Computing and Machine Intelligence (ICMI)*, IEEE, Apr. 2022, pp. 1–5. doi: 10.1109/ICMI55296.2022.9873656.

[6] M. Zaltieri *et al.*, "Assessment of a Multi-Sensor FBG-Based Wearable System in Sitting Postures Recognition and Respiratory Rate Evaluation of Office Workers," *IEEE Trans Biomed Eng*, vol. 70, no. 5, pp. 1673–1682, May 2023, doi: 10.1109/TBME.2022.3225065.

[7] H. Sun, G. Zhu, X. Cui, and J.-X. Wang, "Kinect-based intelligent monitoring and warning of students' sitting posture," in *2021 6th International Conference on Automation, Control and Robotics Engineering (CACRE)*, IEEE, Jul. 2021, pp. 338–342. doi: 10.1109/CACRE52464.2021.9501372.

[8] R. Laidi, L. Khelladi, M. Kessaissia, and L. Ouandjli, "Bad Sitting Posture Detection and Alerting System using EMG Sensors and Machine Learning," in *2023 International Conference on Artificial Intelligence in Information and Communication (ICAIIC)*, IEEE, Feb. 2023, pp. 324–329. doi: 10.1109/ICAIIC57133.2023.10067076.

[9] F. Ji-sheng, G. Li, and L. Xuan-xuan, "Sitting Posture Detection System Based on Stacking Ensemble Learning," in *2022 IEEE 2nd International Conference on Computer Systems (ICCS)*, IEEE, Sep. 2022, pp. 103–110. doi: 10.1109/ICCS56273.2022.9988350.

[10] L. C. K. Chin, K. S. Eu, T. T. Tay, C. Y. Teoh, and K. M. Yap, "A Posture Recognition Model Dedicated for Differentiating between Proper and Improper Sitting Posture with Kinect Sensor," in *2019 IEEE International Symposium on Haptic, Audio and Visual Environments and Games (HAVE)*, IEEE, Oct. 2019, pp. 1–5. doi: 10.1109/HAVE.2019.8920964.

[11] G. Liu, X. Li, C. Xu, L. Ma, and H. Li, "FMCW Radar-Based Human Sitting Posture Detection," *IEEE Access*, vol. 11, pp. 102746–102756, 2023, doi: 10.1109/ACCESS.2023.3312328.

[12] K. R. Kini, F. Harrou, M. Madakyaru, F. Kadri, and Y. Sun, "Automatic Detection of Unbalanced Sitting Postures in Wheelchairs Using Unlabeled Sensor Data," *IEEE Sens Lett*, vol. 6, no. 8, pp. 1–4, Aug. 2022, doi: 10.1109/LSENS.2022.3193114.

[13] M. Ramalingam, R. Puviarasi, E. Chinnavan, Q. C. Shern, and M. F. Zolkipli, "Alarming Assistive Technology: An IoT enabled Sitting Posture Monitoring System," in *2021 International Conference on Software Engineering & Computer Systems and 4th International Conference on Computational Science and Information Management (ICSECS-ICOCSIM)*, IEEE, Aug. 2021, pp. 592–597. doi: 10.1109/ICSECS52883.2021.00114.

[14] P. Yang, Z.-L. Peng, and W.-L. Wang, “Sitting Posture Detection System Based on Keras Framework,” in *2022 3rd International Conference on Computer Vision, Image and Deep Learning & International Conference on Computer Engineering and Applications (CVIDL & ICCEA)*, IEEE, May 2022, pp. 170–174. doi: 10.1109/CVIDLICCEA56201.2022.9824164.

[15] C. Xu and Y. Liu, “Frequency Modulated Continuous Wave Radar-Based Human Sitting Posture Detection In Bathroom Environment,” in *2023 3rd International Conference on Electronic Information Engineering and Computer Science (EIECS)*, IEEE, Sep. 2023, pp. 1230–1233. doi: 10.1109/EIECS59936.2023.10435510.