

**Overview: Our study investigates whether a poor neck posture can be improved through real-time nudging using a IMU wearable device, positioned around the neck, that detects poor posture.**

## Introduction

With their ability to store vast amounts of data and enable long-distance communication, mobile devices such as smartphones and laptops have become indispensable in modern society. However, prolonged use of mobile devices has contributed to poor posture habits, including forward head posture (FHP), which increases the risk of musculoskeletal and other health issues. Students and office workers, who spend extended hours at their desks, are especially vulnerable to this problem. To address this problem, our research team developed Turtle Track, a wearable device designed to detect FHP and provide real-time feedback to encourage healthier posture.

Our pre-study online survey, which received 54 responses—primarily from students and office workers—aimed to assess the severity of postural problems, identify existing solutions, and characterize the typical desk-based environment targeted by our intervention.

In the study, we developed a neck-worn IMU-based wearable device to detect FHP and deliver real-time corrective nudges. The effectiveness of the intervention was evaluated by comparing postural imbalance rates among groups that received different interventions.

In our short-term experiment, an educational video significantly improved FHP, while the wearable's nudges showed noticeable effects mainly in a severe case, likely overshadowed by the educational intervention. These findings suggest the need for further long-term evaluation of the device's benefits over long periods.

## Results

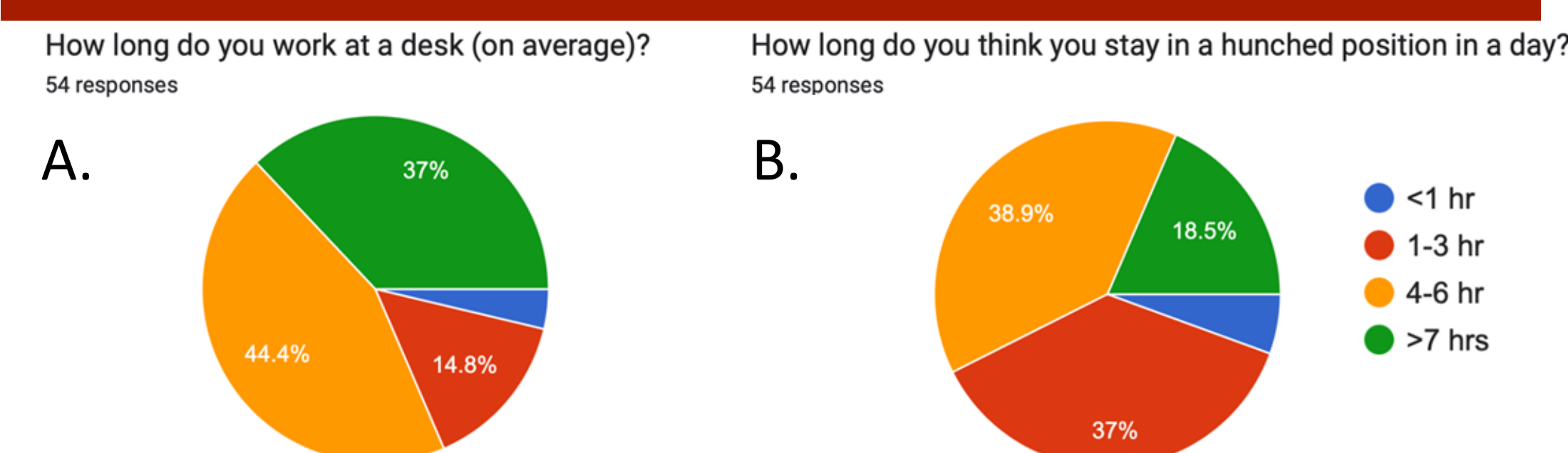


Figure 1. (A) Time spent at a desk. (B) Time spent in a hunched position based on their awareness.

In our survey, 81.4% of respondents spent over four hours a day at a desk, and 57.4% maintained a hunched posture for the same duration, highlighting the prevalence of prolonged poor seated posture. Additionally, 98% had no prior experience with orthotic devices for this issue, yet showed strong interest in TurtleTrack after hearing its description.

Table 1. Mean proportion of time (%) spent in poor posture during a 20-minute session.

	Session 1 before education	Session 2 after education
Group 1 (Education-Only)	29.8 %	0.5 %
Group 2 (Nudging + Education)	61.65 %	6.25 %

Table 1 compares the average poor-posture time (%) between Session 1 (before education) and Session 2 (after education). Group 1 (Education-Only) reduced poor posture by an average of 99.39% and Group 2 (Nudging + Education) by 93.26%, both showing marked improvement. Percentages differ from Table 1 because each participant's reduction was calculated individually before averaging.

In Group 2, Participants 2 and 3 received only one or two nudges, suggesting that education could be the main factor in their improvement. In contrast, Participant 1, who exhibited severe FHP, received frequent nudges during Session 2, resulting in a marked reduction in poor posture, highlighting the potential of sensor-based nudging to improve seated posture. Figures 2 and 3 show the improvement in Participant 1's posture across sessions following the continuous nudging intervention. A pitch angle above the red line indicates good posture, while values below indicate poor posture.

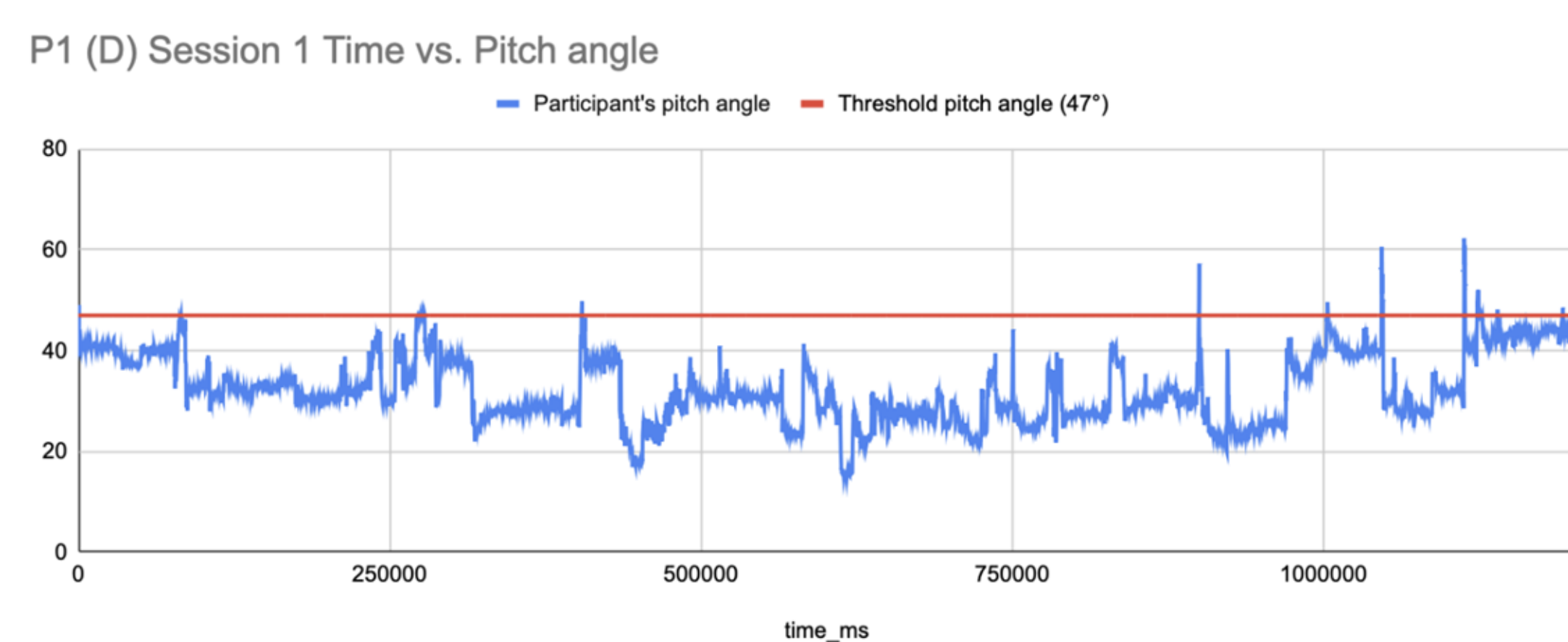


Figure 2. Pitch angle over time during Session 1 for Participant 1 in Group 2.

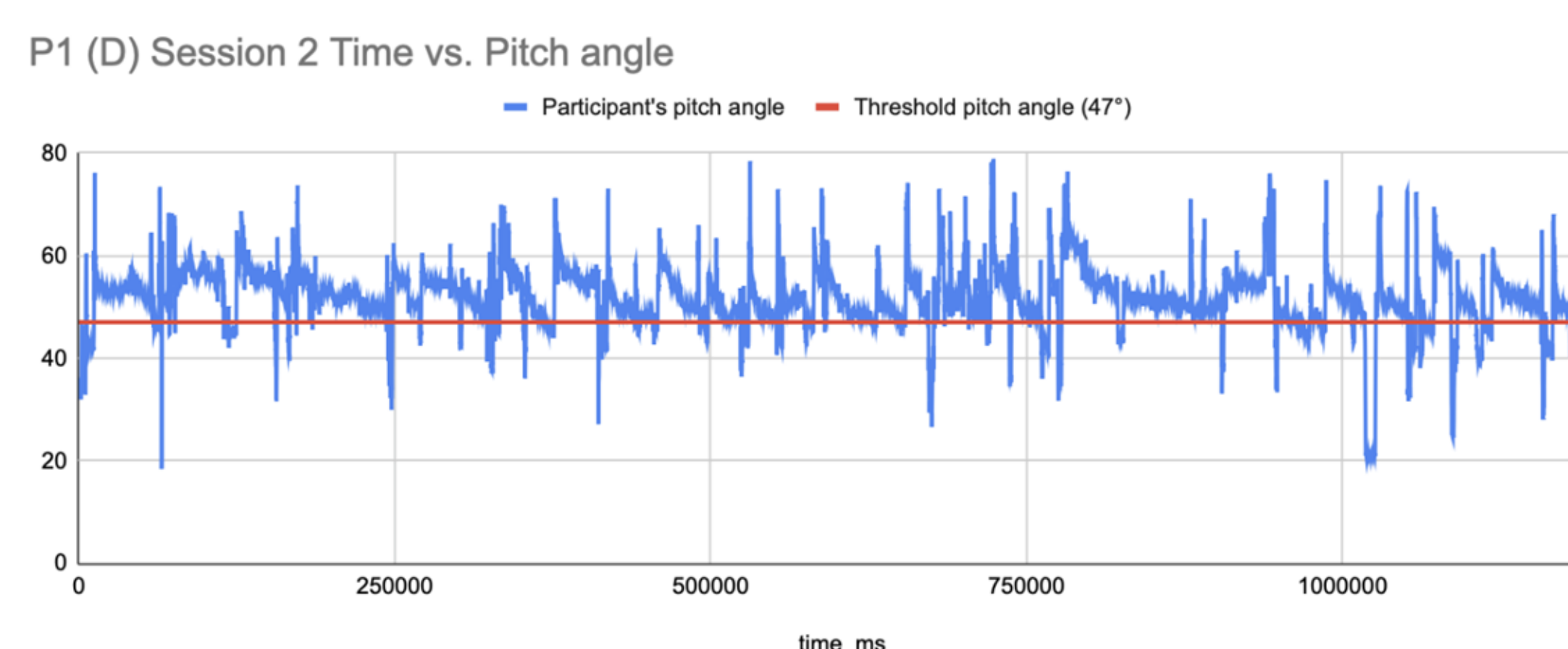


Figure 3. Pitch angle over time during Session 2 for Participant 1 in Group 2.

## Methods

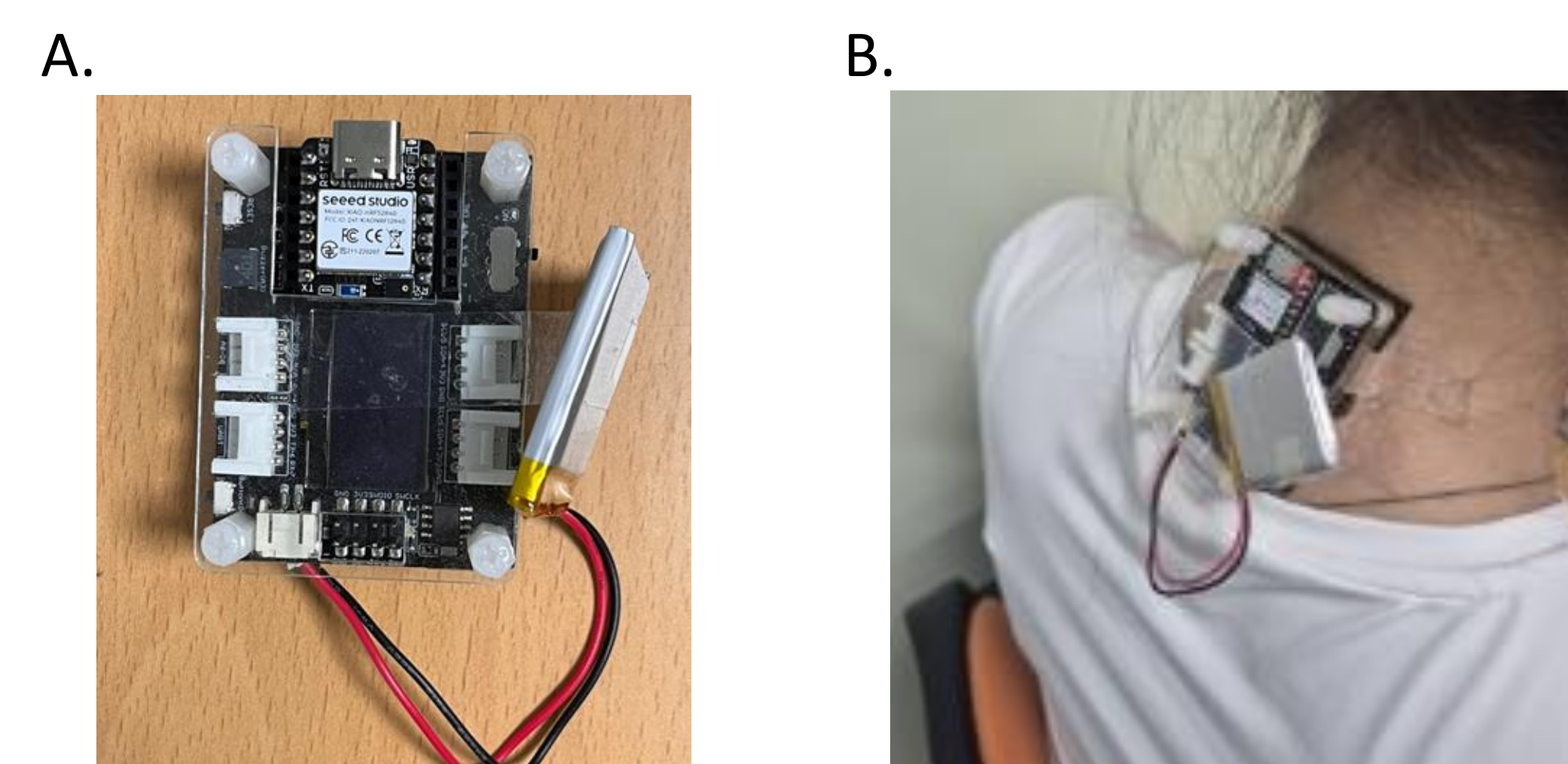


Figure 4. (A) Top view of the IMU wearable device. (B) A participant wearing the device on the back of the neck.

$$\text{Pitch} = \arctan\left(\frac{-a_x}{\sqrt{a_y^2 + a_z^2}}\right) \times \frac{180}{\pi}$$

Equation 1. Equation used to calculate pitch angle in real-time

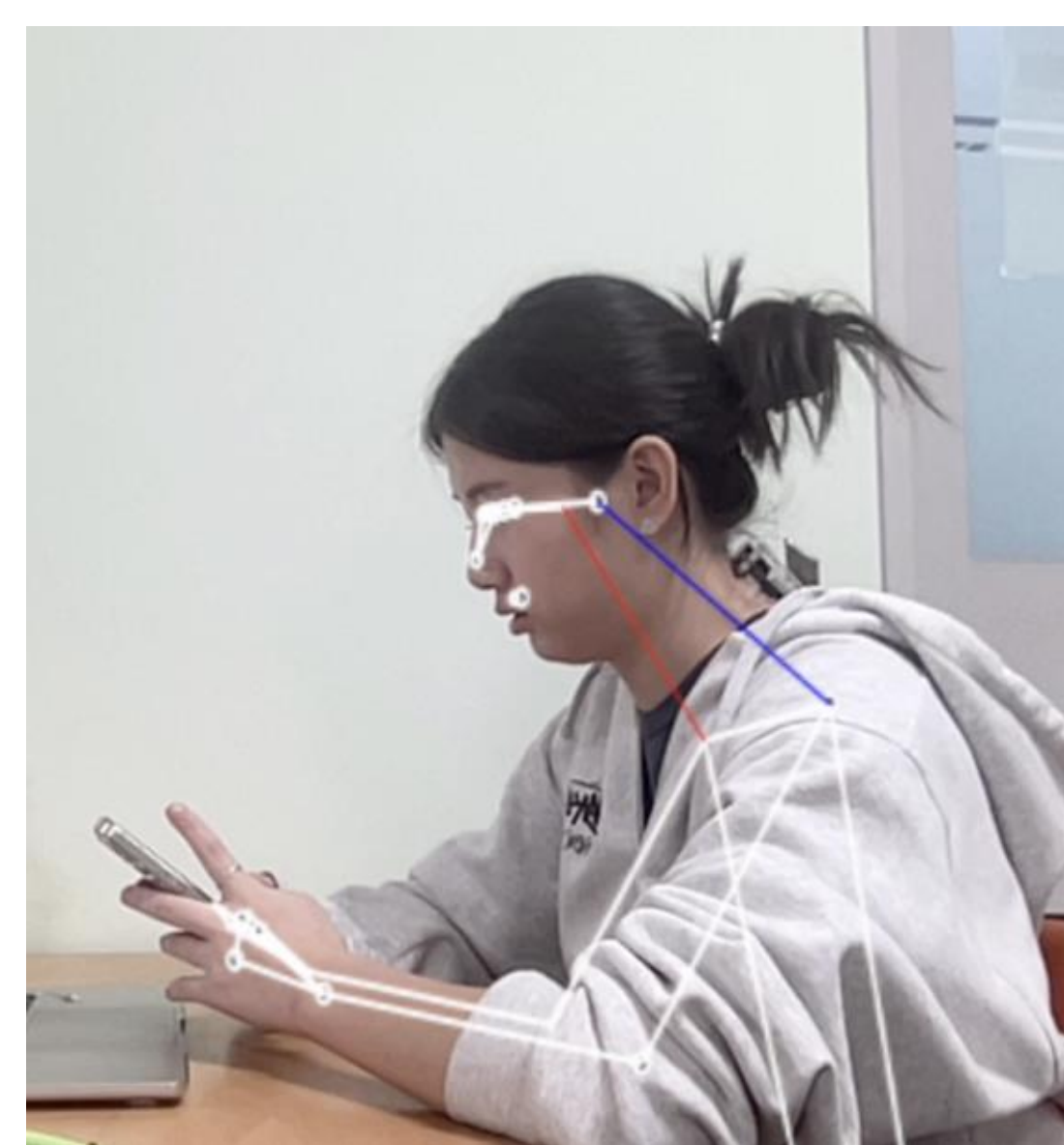


Figure 5. Screen capture showing skeletal tracking of a participant wearing the IMU device.

### Experimental design

This study involved six participants, evenly divided into two groups: Group 1 (Education-Only) and Group 2 (Nudging + Education). Conducted over two sessions on the same day, the experiment evaluated the effects of real-time monitoring and educational intervention on forward head posture (FHP). Each session was designed to resemble a casual environment, with participants engaging in technology-based activities to replicate real-world posture and habits, ensuring natural data collection. Posture was monitored using two sensors: an inertial measurement unit (IMU) wearable for tracking head and neck orientation, and a camera-based skeletal tracking system as a backup for validating questionable data.

In Session 1, all participants' posture was recorded passively for 20 minutes while they used mobile devices such as smartphones, laptops, and tablets. Afterward, all participants viewed an educational video on the health risks of poor posture and how to correct it. In session 2, Group 2 (Nudging + Education) received real-time posture feedback, with a supervisor clapping whenever the device's LED signaled poor posture, while Group 1 (Education-Only) received no feedback. Comparison of posture data between sessions and groups allowed an assessment of the impact of education alone against education with real-time sensor feedback.

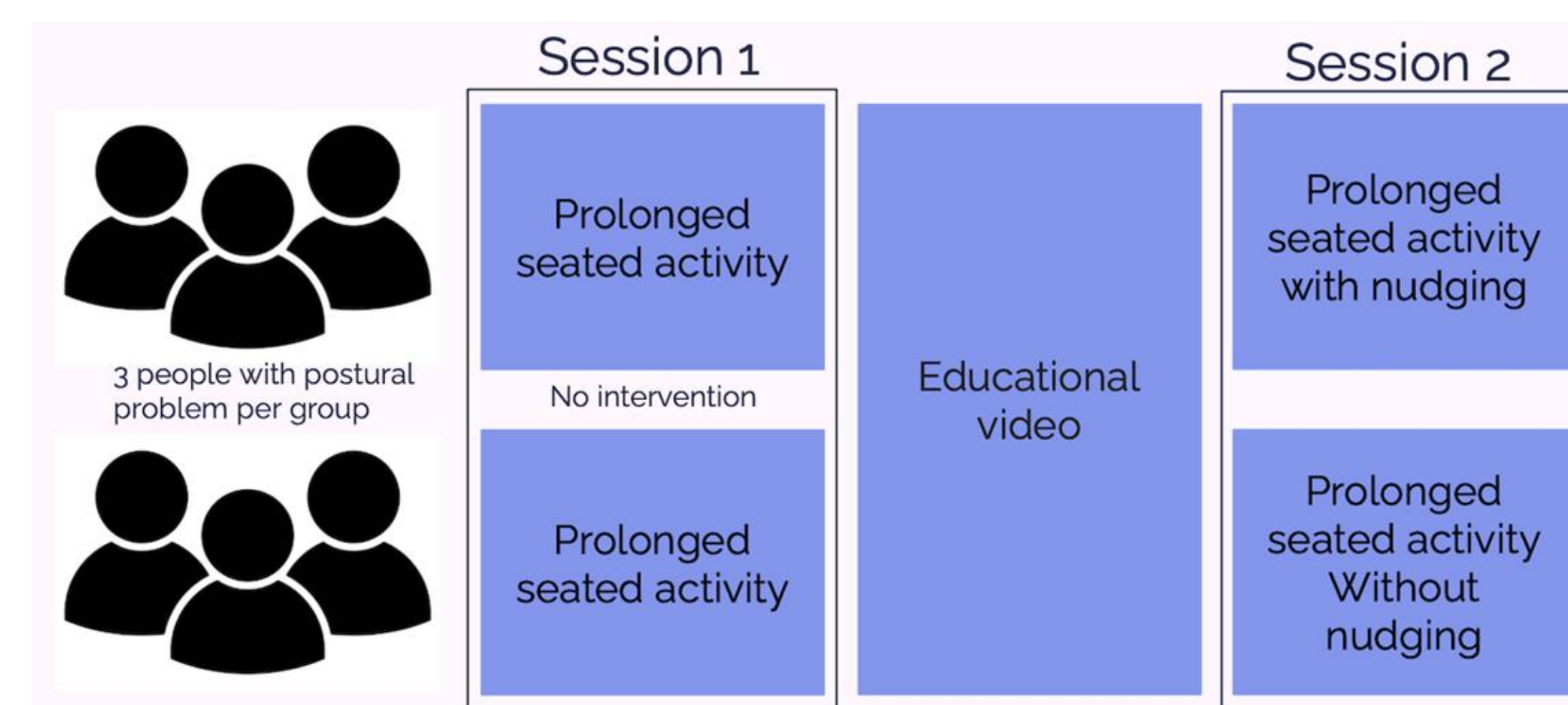


Figure 6. Visualization of the experimental design.

## Conclusion & Future Work

In our study, real-time sensor-based nudging showed promise mainly for individuals with severe FHP. Nevertheless, its impact was likely limited by the small sample size (six participants) and short duration (20 minutes), which may have been overshadowed by the influence of the educational intervention. Notably, substantial differences between groups were observed in the mean proportion of time (%) spent in poor posture during Session 1. In future studies, participant numbers, selection criteria, and experimental duration should be carefully defined to ensure comparable baselines and to better assess the benefits of nudging.

Despite efforts to improve comfort—such as reducing the device's weight, securing TurtleTrack with medical tape, and adding soft materials at points of skin contact—participant feedback indicated that its design remained somewhat obtrusive due to its size and attachment method. This subtly restricted natural neck movement and caused minor discomfort, inadvertently increasing participants' awareness of their posture even without nudging. Future iterations should focus on making the device unobtrusive when the wearer maintains proper posture, both for experimental accuracy and real-world use, by reducing its size or designing it as an accessory, such as a necklace.

Another limitation of this study was the reliance on human supervision for nudging. To provide real-time feedback, a supervisor physically stood behind the participant, monitored LED signals, and clapped to signal poor posture. The presence of another person during the task may have influenced natural behavior, potentially affecting data collection. This issue could be mitigated in future work by incorporating automated nudging methods, such as a vibration motor or buzzer.

## References & Acknowledgements

[1] Naz, Arfa, Muhammad Salman Bashir, and Rabiya Noor. "Prevalence of Forward Head Posture Among University Students." *Rawal Medical Journal*, vol. 43, no. 2, 2018, pp. 260–262. DOI: 10.25259/RMJ.43.2.260-262.

[2] Titcomb, David A et al. "The Effects of Postural Education or Corrective Exercise on the Craniovertebral Angle in Young Adults with Forward Head Posture: A Randomized Controlled Trial." *International journal of exercise science* vol. 16,1 954-973. 1 Aug. 2023, doi:10.70252/PYPQ8483

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