The Relationship Between Seat Inclination Angles and Physical Strain When Using Sloped Stools

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Prolonged static postures during dental procedures, such as implant surgeries, often lead to significant physical fatigue, especially in the lumbar region of dental professionals. To address this, a dental operating stool (OS) with an adjustable seat tilt was developed and evaluated. The study aimed to determine the optimal seat tilt angle to reduce physical strain and improve work efficiency.

An experiment was conducted with four seat tilt angles: 0°, 3°, 5°, and 7°. Data on physical fatigue and postural stability were collected. Results showed that a 3° tilt significantly reduced physical strain, while a 5° tilt was preferred for usability and task visibility. These findings highlight the importance of seat tilt in reducing fatigue and enhancing operational efficiency. A 3° tilt is recommended for general fatigue reduction, while a 5° tilt is optimal for tasks requiring better visibility and precision during dental procedures.

***Keywords: Dental operating stool (OS); Seat tilt angle; Physical strain;***

1. Research Background

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AI 生成コンテンツは誤りを含む可能性があります。In recent years, dental procedures such as implant surgeries, which require prolonged periods of maintaining static postures, have increased, leading to significant physical fatigue among dental professionals. Surveys indicate that approximately 70% of dental professionals experience physical pain, with lumbar fatigue being particularly prominent (1). In response to this issue, we have been developing a dental operating stool (OS) equipped with a seat inclination mechanism. However, evidence regarding the effectiveness of seat inclination in reducing physical strain and the optimal inclination angle remains unclear. Figure 1 illustrates the seat inclination of the OS.

*Figure 1. Illustration of OS seat inclination*

1. Research Objectives

The objectives of this study are twofold: (1) to determine the optimal seat inclination angle for the dental operating stool (OS), and (2) to obtain evidence of the effectiveness of seat inclination in reducing physical strain during dental procedures. The inclination angles were set at 3 degrees, 5 degrees, and 7 degrees, and their usability was evaluated. Physical strain was assessed through simulated dental treatment tasks under conditions specified by seat inclination angles and directions, and the effectiveness of strain reduction due to changes in seat inclination angles was verified.

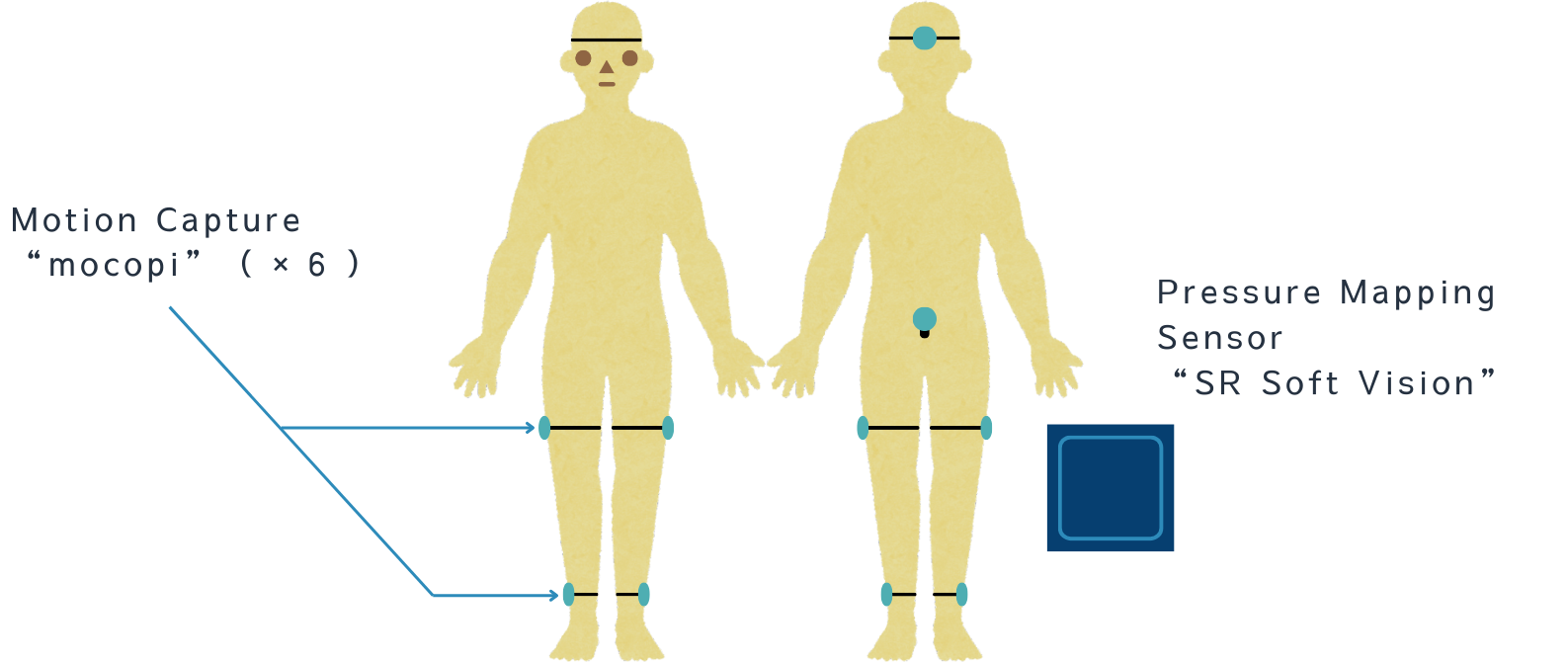
1. Research Methods
   1. **Experimental Equipment**

Table 1 shows the list of sensors used in this study.

*Table 1. List of Sensors*

|  |  |  |
| --- | --- | --- |
| Sensor Name | Manufacturer | Purpose |
| mocopi | Sony | Motion Capture |
| SR Soft Vision | Sumitomo Riko | Pressure Mapping Sensor |

The sensors were selected based on their ability to visualize the degree of lumbar fatigue and their efficiency in installation and analysis, considering their use in clinical experiments targeting dental professionals. Figure 2 shows the sensor attachment positions.



*Figure 2. Sensor attachment positions*

* 1. **Experimental Conditions**

In this experiment, a headrest currently used in dental clinics and a dental experimental head model previously created by the Tanaka Laboratory were utilized to simulate a dental treatment environment. The position of the experimental equipment was set following prior studies, with the height of the headrest set at 850 mm and the angle of the headrest adjusted to 40° (2). Additionally, an experimental OS capable of fixing the inclination angle was created and used for the experiment. The seat height of the experimental OS was set at 520 mm from the floor. Figure 3 shows the experimental OS, and the experimental setup.

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*Figure 3. The experimental OS, and the experimental setup.*

* 1. **Experimental Procedure and Patterns**

The participants performed simulated dental treatment tasks. The experiment was conducted a total of nine times: once without any seat inclination, followed by three patterns of inclination directions combined with three patterns of inclination angles. To minimize the influence of order effects on subjective evaluations, the inclination angles were not disclosed to the participants during the experiment.

1. Experimental Results

The experimental results were analysed using data collected during scaling tasks on the "lower anterior teeth to the lower right molars," which were frequently reported as causing high physical strain in the subjective evaluation questionnaire.

* 1. **Motion Capture**

Motion data were analysed by calculating the composite displacement of the rotational angles along the X, Y, and Z axes. The maximum, average, standard deviation, and RMS values of the composite displacement were computed and compared. If the rotational angle displacements along the X, Y, and Z axes are denoted as , , and , respectively, the composite displacement ,can be calculated using Equation (1).

Among these metrics, the RMS value represents the "magnitude of lumbar movement" during the task. Lower RMS values indicate smaller body movements, which can be interpreted as contributing to a reduction in dynamic physical strain. Figure 4 shows an example of the experimental results.

In many datasets, smaller inclination angles were associated with lower RMS values, suggesting that smaller angles may help reduce physical strain.

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AI 生成コンテンツは誤りを含む可能性があります。*Figure 4. Comparison of Composite Displacement of Lumbar Rotational Angles (During Forward Seat Inclination).*

* 1. **Pressure Mapping Sensor**

Pressure distribution data were analyzed by calculating the composite displacement of the center of pressure movement along the X and Y axes. The maximum, average, standard deviation, and RMS values of the composite displacement were computed and compared. Figure 5 shows an example of the experimental results.

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*Figure 5. Comparison of Composite Displacement of Center of Pressure Movement (During Forward Seat Inclination).*

However, in some cases, a 5-degree or 7-degree inclination showed favourable effects in reducing physical strain. One possible reason for the variability in data among participants is the differences in how everyone used the OS.

* 1. **Subjective Evaluation**

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AI 生成コンテンツは誤りを含む可能性があります。According to the results of the subjective evaluation questionnaire, most respondents indicated that a 5-degree inclination was the most optimal angle. This was based on a balance of factors such as perceived physical strain, ease of viewing inside the oral cavity, and body stability. Participants were asked to rank the angles based on their overall usability and suitability for dental procedures. Points were assigned using a scoring system: 3 points for the top-ranked angle, 2 points for the second, and 1 point for the third. Figure 6 shows the aggregated results.

*Figure 7. Survey Results for Optimal Inclination Angles of the OS.*

1. **Conclusion and Discussion**

From the results obtained in this study, it was concluded that the optimal inclination angle for the OS is 3 degrees from the perspective of reducing physical strain and 5 degrees from the perspective of usability. In dental treatment settings, it is considered appropriate to set the inclination angle to 5 degrees, particularly during tasks that require leaning forward, and to adjust it to 3 degrees during other tasks. This approach can help reduce the overall physical burden during treatment.

1. Prospects

In this study, experiments involving students were conducted to investigate the relationship between inclination angles and their effects on reducing physical strain. Moving forward, further validation of the OS’s utility will be pursued through experiments using the prototype OS and by analysing a larger dataset. Additionally, as the experimental methods were reviewed during the data analysis process, these improvements will be applied to future research.

1. **References**

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2) 山田航大,歯科医療従事者の診療中の姿勢に関する研究,pp.1-49,芝浦工業大学,修士論文,2019.

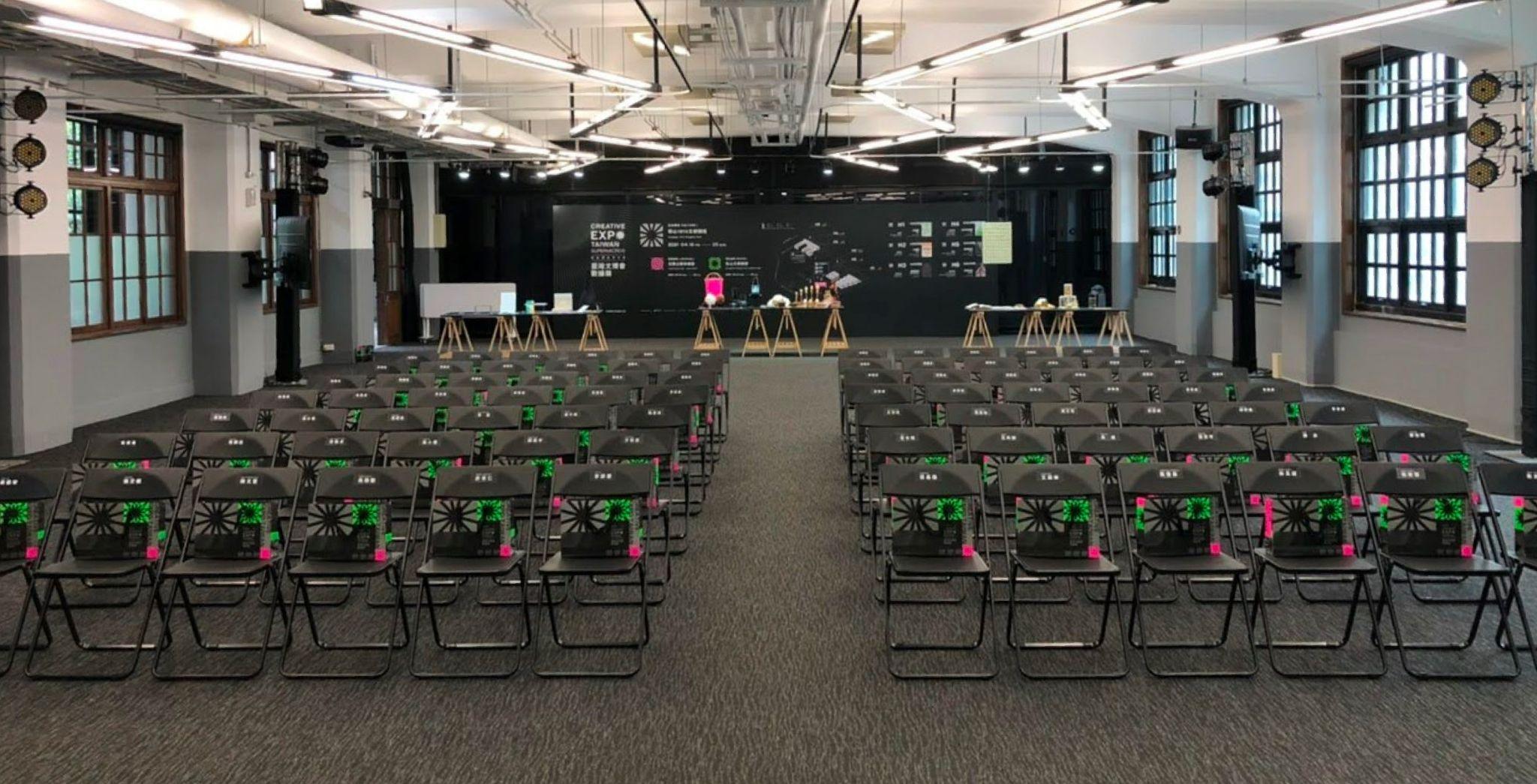
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*Figure 1. Songshan Cultural and Creative Park. Source: TDRI. (Caption: Calibri italic 9pt)*

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*Figure 2. Shared workspaces at TDRI office. Source: TDRI.*

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**Acknowledgements**

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