

Psychological Stress Induced by Prone Positioning among Adults with Severe Cerebral Palsy

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The purpose of this study was to investigate the psychological impact of various positionings in subjects with cerebral palsy (CP). The participants were 17 individuals with severe motor and intellectual disability due to CP. They began in a sitting position in their wheelchair, and were placed consecutively in prone or supine positions, with no intervals between placements. Physiological observations were made in each position, and included salivary α -amylase activity, pulse, percutaneous oxygen saturation, respiratory rate, clearance or not of airway secretions, and occurrence or not of adverse events. Salivary α -amylase activity values were higher in the prone position than in the baseline and supine positions ($p < 0.05$). Clearance of airway secretions was significantly more prevalent in the prone position than in the baseline and supine positions ($p < 0.05$). The participants' pulse was significantly lower in the supine and prone positions than in the baseline position ($p < 0.05$). Greater prevalence of airway secretion clearance and significantly higher stress levels as indicated by saliva amylase were observed in the prone position than in the other two positions. Therefore, when such patients are placed in a prone position, close attention to airway management and the potential for psychological stress may be necessary.

Key words: alpha-amylase, stress, positioning, cerebral palsy, severe motor and intellectual disability

Cerebral palsy (CP) is one of the most common causes of activity limitation in children. It has been defined as a non-progressive disorder of posture and movement [1] that occurs due to damage to or abnormalities inside the developing brain that disrupt the brain's ability to control movement and maintain posture and balance [2]. Children with spastic CP may have decreased strength, balance, and skill in activities of daily living as a result of their decreased postural stability. Their mobility may be impaired, and they are liable to develop contractures and deformities in their spine and extremities [3]. Most of the time, this motor

disability disorder leads to insufficient development of the postural reflex mechanism, which causes stereotypical movements to become tonic reflexes [4]. Positioning and postural management that promote motor-ability-enabling practical activities and reduce deformity have been considered important therapeutic measures in children with CP [5]. The use of positioning to improve respiratory function has been found to be effective among adolescents and adults with severe CP and scoliosis who have a history of respiratory illnesses and severe functional limitations, including the inability to sit without support, stand, or ambulate [6].

Alpha-amylase is one of the major salivary enzymes

in humans and is secreted by the salivary glands in response to stimuli from the sympathetic nervous system [7]. The measurement of this salivary enzyme is considered a useful tool for evaluating the activity of the sympatho-adrenomedullary system [8,9]. The stress response of salivary alpha-amylase has been posited as an index of sympathetic nervous system activation [10,11]. Stress-induced increases in amylase levels correlate with increases of amylase output [10].

Recent studies have demonstrated that salivary α -amylase activity (sAMY) is useful and valid as an objective measurement of psychological stress [12,13]. An instrument that utilizes this method has been marketed as a rapid and noninvasive way to assess objective stress levels [14,15].

When an individual has CP that is complicated not only by movement disorder but also by severe intellectual disability, their comprehension and expressiveness may be impaired. It may thus be difficult for them to express emotions such as comfort and discomfort. The purpose of this study was to investigate the psychological impact of different positions in adult subjects with severe motor and intellectual disability due to CP.

Methods

Participants and methods. The participants were 17 individuals who visited the Suita Municipal Disability Support Center to participate in daytime activities. The basic characteristics of the participants are presented in Table 1. All participants had been diagnosed with a neurological impairment that affected their central nervous system. They presented with severe motor and intellectual disabilities and displayed impaired communication abilities.

Subjects who met the following criteria were excluded: (1) those who did not perform prone positioning in their postural management program, and (2) those who were able to change their posture through spontaneous movement.

Ethical approval statement. An opt-out method of obtaining consent was used in this study. The participants' family was informed that they were free to opt-out of participation in the study by completing an opt-out form. All procedures in studies involving human participants are performed under an approved protocol and in accordance with the Ethics Review Committee of Kochi Professional University of Rehabilitation (R2-10)

Table 1 Basic information of subjects

| Variable | Score/Number |
|---------------------|--------------|
| Sex | |
| Male | 8 |
| Female | 9 |
| Age (year) | 34 (20–55) |
| Disease composition | |
| Cerebral palsy | 14 |
| Hereditary disease | 2 |
| Brain injury | 1 |
| Tracheostomy | |
| Presence | 6 |
| Absence | 11 |
| GMFCS (Score) | V |
| FIM (Score) | 19.6 (18–25) |

Median (range) or count.

GMFCS, Gross Motor Function Classification System; FIM, Functional Independence Measure.

and the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Methods. In this study, the participants were examined while in a sitting position, supine position, and prone position. Each position was maintained for about 20 minutes, all on the same day with no intervals between positions.

The initial baseline phase was a sitting position on a wheelchair. The same time each morning that was part of the subjects' daily routine was utilized as the start time of the wheelchair sitting posture. The supine position and prone position were randomly alternated after the sitting position.

The sAMY, pulse, percutaneous oxygen saturation and respiratory rate were measured and observations were made regarding clearance of airway secretions and occurrence of adverse events. The measurement of saliva amylase is intended to evaluate the effects of acute psychological stress. A stressor application time between 2.5 min and 15 min is considered to be acute [12,15]. Hence, the physiological survey items were measured after holding each position for 10 min.

The salivary α -amylase activity (sAMY). The sAMY level was measured using a Saliva Amylase Monitor[®] (Nipro Corporation, Osaka, Japan). In each position, a test strip for sampling was placed under the tongue for 30 seconds to collect the patient's saliva, and the sAMY level was subsequently measured. Since it has been reported that increased sympathetic nervous activity is a major stimulator of amylase secretion,

increases in sAMY were considered to indicate increased psychological stress [15,16]. The monitor includes an optical analyzer with an automatic saliva transcription device. A volume of about 30 μ L of saliva was collected using the test strip. After the saliva was collected from each participant, it took 30 sec to transfer and analyze the saliva using the handheld monitor. The validity of this device for measurement of sAMY has been confirmed in a previous study [15]. In this study, the saliva amylase test was conducted twice during each 20-min posture, and the average value (kIU/I) was calculated.

Baseline (Sitting position). The sitting position was considered the baseline. In the sitting position, participants were placed upright in custom wheelchair seating systems with the wheelchair back-to-seat angles set at an average of 119 degrees. These seating systems involved a tilt-in-space component, head support, custom molded back with lateral support, custom molded seat, pelvic positioning device, and foot supports.

Prone position. Since patients with CP find it difficult to lay in a prone position on a flat surface due to joint contractures and limb and trunk deformities, a custom-made device that accounts for their individual body structures was used to support the prone position (Fig. 1). The device, used to hold the front of the trunk, is essentially a styrofoam cube with a height of about 40 inches. The surface of the device in contact with the body is padded with a urethane cushion. In addition, a wooden stand with cushioning material is used to support the head.



Fig. 1 Device for prone position.

Owing to the danger of the participants' airways becoming obstructed, proximal monitoring was performed when patients were in the prone position. The proximal monitoring involved careful observation of their facial expression and respiratory condition, in addition to the monitoring of their oxygen saturation and heart rate with a pulse oximeter.

Supine position. In the supine position, participants were placed in their beds with pillows supporting their head/neck, trunk, and extremities to attain as comfortable a posture as possible, given their varying degrees of contractures.

Adverse events. Injuries during the saliva amylase test and accidents during transfer assistance and positioning were considered adverse events.

Statistical analysis. Repeated measures analysis of variance and the post hoc Tukey honestly significant difference test were used for parametric data, and the Friedman test followed by the Wilcoxon signed rank test and McNemar's test were used for nonparametric data. The level of significance was set at $p < 0.05$. For post hoc comparisons with the Wilcoxon signed rank test, the level of significance was corrected with a Bonferroni adjustment ($p < 0.017$).

Results

Table 2 shows the date on which each position was measured and the statistical results for each position. The sAMY and pulse data are shown in scatter plots (Figs. 2 and 3). The sAMY values were significantly higher in the prone position than in the baseline and supine positions ($p < 0.05$). Accumulation of airway secretions was significantly more frequent in the prone position than in the baseline and supine positions ($p < 0.05$). There was no significant relationship between airway secretions and sAMY in any position. The participants' pulses were significantly lower in the supine and prone position in comparison to the baseline position ($p < 0.05$). Their SpO₂ levels were significantly lower in the prone position than in the supine positions ($p < 0.05$).

No adverse events were observed during the investigation.

Discussion

The purpose of this study was to investigate the psy-

Table 2 Results of measurements

| Variable | Baseline | Prone | Supine | Baseline vs prone | Baseline vs Supine | Prone vs Supine |
|---------------------------------------------|-------------|---------------|-------------|-------------------|--------------------|-----------------|
| The salivary α -amylase ^a | 14 (3–112) | 44.5 (12–132) | 13.0 (3–58) | 0.005 | 0.196 | 0.001 |
| Pulse ^b | 84 (52–106) | 76 (43–114) | 78 (53–108) | 0.024 | 0.024 | 1.000 |
| Respiratory rate ^a | 17 (12–33) | 17 (10–32) | 15 (12–35) | 0.635 | 0.144 | 0.358 |
| SpO ₂ ^a | 98 (93–99) | 97 (91–99) | 97 (93–100) | 0.024 | 0.288 | 0.011 |
| Airway secretions (yes/no) ^a | 2/15 | 15/2 | 2/15 | $p < 0.0001$ | 1.000 | $p < 0.0001$ |

Median (range) or count

^a, multiple comparison test after Friedman's test, ^b, repeated measures analysis of variance.

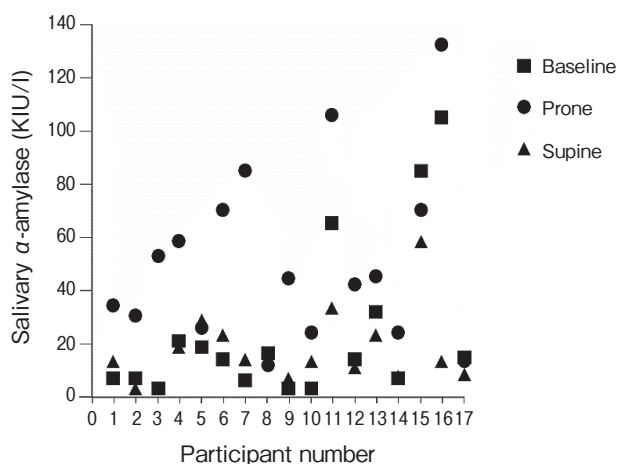


Fig. 2 Scatter plot of salivary α -amylase.

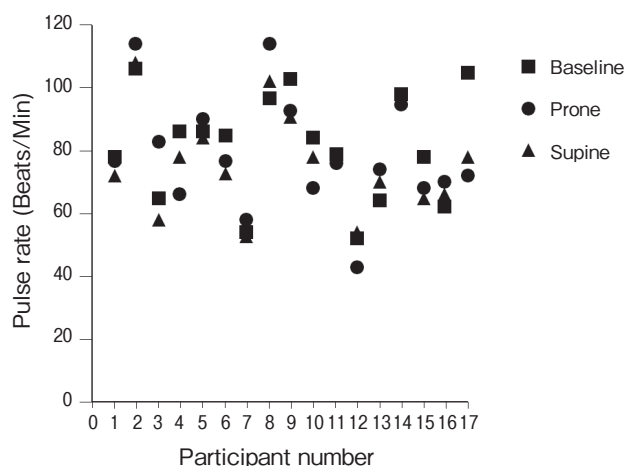


Fig. 3 Scatter plot of pulse rate.

chological impact of different positions in subjects with severe motor and intellectual disability due to CP. The participants' sAMY values were significantly higher in the prone position than in the baseline and supine positions. Clearance of airway secretions was significantly more prevalent in the prone position than in the baseline and supine positions. The participants' pulses were significantly lower in the supine and prone positions than in the baseline position. Their SpO₂ levels were significantly lower in the prone position than in the baseline and supine positions.

sAMY is known to be a useful indicator of sympathetic nervous system activity, and increases in sAMY have previously been reported in response to other conditions known to be psychologically stressful [11]. This study found that sAMY values were higher in the prone position than in the baseline and supine positions. Although the range of sAMY that can be measured ranges from 5–1140 kIU/l [15, 17], the criteria for indicating the degree of stress have not been clarified.

Although the degree of stress intensity cannot be specified, the prone position was presumed to induce higher stress than other postures because of its higher scores. Thus, our results suggest that prone positioning induces stress among subjects with severe motor and intellectual disability due to CP.

Previous studies have focused on prone positioning as a method of postural drainage to facilitate secretion clearance, particularly in those with CP and respiratory illnesses [18]. Using gravity, positioning assists the mucociliary transport system in removing excessive secretions from the tracheobronchial tree [19]. The results of the present study showed that the clearance of secretions was significantly more prevalent in the prone position than in the other positions. Therefore, we inferred that the movement and excretion of secretions were promoted in the prone position.

The increase in HR and contractility during physical exertion is in part due to the hormonal influence of the sympathetic nervous system [20]. HR has been shown

to be higher in the sitting and standing positions than in the lying postures [21]. The results of this study indicated that the participants' pulse was significantly lower in the supine and prone positions than in the baseline sitting position. It is speculated that this result, especially for the prone position, may suggest the greater influence of the hemodynamics of the lying positions than the activity of sympathetic hormones in response to stress.

Although there are no research reports on people with cerebral palsy, current evidence strongly supports the conclusion that lying prone has beneficial effects on gas exchange, respiratory mechanics, lung protection, and hemodynamics in healthy subjects, as it redistributes transpulmonary pressure, stress, and strain throughout the lungs and unloads the right ventricle [22]. Compared to a supine position, when a healthy person is in a prone position, lung aeration and strain distribution are more homogeneous, and the geometry favors a more equitable aeration distribution [23,24]. Interestingly, the results of this study showed that the participants' SpO₂ levels were significantly lower in the prone position than in the supine position. Psychological stress may have affected the findings of this study, or the physical disabilities accompanying severe CP may have made breathing in a prone position more difficult for our subjects than for healthy subjects. Indeed, this difficulty may be a cause for the stress.

This study had certain limitations. First, the sample size of this study was small. Thus, it is unknown whether examination of further cases would produce similar results. Second, although differences in psychological stress due to positioning were clarified, the mechanism for this stress was not, and no methods for reducing stress were examined. Third, this study only analyzed the short-term impact of positioning and could not examine long-term changes. Further consideration is required in the future.

In conclusion, in this study we compared the physiological measures of stress induced by sitting, supine and prone positioning in participants with severe motor and intellectual disability due to CP. Greater prevalence of airway secretion clearance and significantly higher stress levels as indicated by saliva amylase were observed in the prone position than in the other two positions. Therefore, when such patients are placed in a prone position, close attention to airway management and the potential for psychological stress may be necessary.

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