Relationship between reaction time for mandibular movement and the level of muscular discharge of the masticatory muscles in a reaction time task in patients with cerebral palsy

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Abstract We hypothesized that patients with Cerebral Palsy (CP) are affected by the preparatory process in the central nervous system for initiating a jaw movement. We tested this hypothesis on 13 in patients with CP (average: 36.9 years old) and 13 in healthy adults (average: 34.7 years old) as subjects. We recorded the muscular discharge of the masticatory muscles from the time a warning stimulus was presented to the time an instruction stimulus was presented during the reaction time (RT) with the open mouth movements in patients with CP. The following results were obtained. The RT for executing the open mouth movements is significantly longer in the CP subjects than in the healthy subjects. In the CP subjects during the movement task, the level of muscular discharge of the masticatory muscles in the 1-s period before presentation of a warning stimulus was significantly lower than that in the 1-s period or in the period from 1 s to 2 s after the presentation of the warning stimulus. The other side, In the healthy subjects, no change in the muscular discharge of the masticatory muscles was observed. However, In the CP subjects and in the healthy subjects during the nonmovement task, no change in the level of muscular discharge of the masticatory muscles in each period was observed. A significant correlation was observed between the percent change of the level of muscular discharge of the masseter muscle (or the digastric muscle) and RT for the open mouth movement. From the results of this study, as one of the reasons for the difficulty in executing smooth voluntary movements in the oromandibular region in individuals with CP, we consider that the movement is delayed because the period of preparation of the movement is significantly prolonged in individuals with CP although they started the preparation of the movement at an earlier period than in individuals who do not have CP.

Key words

Electromyogram (EMG) of the masticatory muscles,
EMG-reaction time,
Patients with cerebral palsy,
The open mouth movements

Introduction

Measurement of reaction time (RT) for limb movements using RT tasks is frequently performed in

order to evaluate the intellectual functions of patients with central dyskinesia and disorders of sensory motor functions^{1–3}. RT is defined as the latent period required from the presentation of an instruction stimulus to the execution of a quick movement as instructed^{4–6}. RT is considered to reflect the activity processes of the central nervous system that are

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represented by concepts such as motor preparation and motor program. Regarding patients with disorders in the central nervous system, examinations of RT using RT tasks are reported¹⁻³⁾. In recent years, it has been reported that during RT tasks requiring movements of the limbs, body trunk and jaw in humans, changes in the specific muscular discharge patterns such as frequency change, increase/decrease in amplitude and rhythmic movements are observed from the time a warning stimulus that notifies the start of a task is presented to the time an instruction stimulus is presented^{7,8)}. Such changes observed in an electromyogram are considered to be related to the initiation of the motor preparatory process in the central nervous system.

Cerebral palsy (CP) involves motor dysfunctions in the central nervous system due to a nonprogressive lesion of the brain which develops in the time between conception and the early postnatal period. CP is characterized by difficulty in performing smooth voluntary movements due to excessive tension or reflection of nonvoluntary muscles in the maxillofacial region or limbs, which leads to various motor dysfunctions in the entire body and/or oromandibular region⁹⁻¹¹⁾. In addition, individuals with CP have oversensitive muscles in their limbs and oromandibular region compared with healthy adults. As a reason for this, abnormalities in the information-processing mechanism which connects the central nervous system to the muscle spindles, which function as receptors, have been considered¹²⁻¹⁵⁾. Accordingly, individuals with CP are speculated to have difficulty in regulating muscular activities related not only to voluntary movements, but also before the start of the movements.

With this information as a background, we hypothesized that oromandibular dysfunctions in individuals with CP are influenced by the preparatory process for the start of the movement in the central nervous system. In order to test this hypothesis, we recorded the muscular discharge of the masticatory muscles from the time a warning stimulus was presented to the time an instruction stimulus was presented during the RT tasks using lower jaw movement as the specified movement in individuals with CP. The following items were examined: comparison of the RT between the CP group and the healthy group, comparison of the level of muscular discharge of the masticatory muscle before the presentation of an instruction stimulus between the two groups, and correlation between the

percent change of the level of muscular discharge of the masticatory muscles and the RT of the lower jaw movement.

Subject and Methods

Subjects

Subjects enrolled in the study are 13 outpatients of the Colony Ranzango Dental Clinic of the Social Welfare Service Corporation in Saitama Prefecture who have CP (nine males and four females, average age: 36.9 years old; CP group). The subjects had a mean Barthel index (BI) of 83.9 (minimum score: 65, maximum score: 100), which is an objective indicator of the individual's level of physical dysfunction in terms of carrying out daily life activities¹⁶⁾. Therefore, since the subjects showed fairly high BIs, their level of physical dysfunction is fairly mild.

Prior to the study, the details of this study were fully explained to the subjects themselves, guardians (parents) and caretakers, and their consent was obtained. Approval for the study was given by the President of Colony Ranzango, the Director of Ranzango Hospital and the Manager of the Dental Department.

The individuals with CP were selected based on the criteria established by Araki *et al.*¹⁷⁾

- 1) The position of head and jaw at rest can be maintained.
- 2) Absence of general complications other than CP.
- 3) Not ordinarily taking medications such as muscle relaxants.
- 4) The aim of this study can be understood and informed consent can be obtained.

As the control group, 13 healthy adults who do not have CP and oromandibular dysfunctions (eight males and five females, average age: 34.7, non-CP group) were selected.

Method of Study

Specified movements

According to the inquiry carried out prior to the experiments, all subjects use the right side of their jaws as the habitual masticating side.

Each subject was instructed to sit in a dentist's chair with their head slightly contacting the headrest, so that the Frankfort plane was parallel to the floor. They were also instructed to maintain a mandibular position at rest. Using a computer (NEC 98NOTE NS/R) placed approximately 1.5 m in front of the

subject, a warning sound used as an auditory stimulus (a 100-ms-duration beep sound; hereafter abbreviated as S1) was presented to the subjects. Then, a visual stimulus used as an instruction stimulus (300-ms duration; S2) was shown on the computer screen 2 s later. The subjects were instructed to quickly open their mouths to three-fingers' width starting from the lower-jaw stable condition. This movement was adopted as the specified movement. After completion of the RT task, the subjects in the CP group were subjected to another movement task (the nonmovement task) in which they were instructed not to open their mouths and to maintain their lower jaw in a stable condition even when S2 was shown. These movement and nonmovement tasks were performed 10 times each.

Recording and analytical conditions

Conditions of stimuli presentation in RT tasks

We used an α -DATE AK 110 (Microscience Company) as a device that controls the presentations of S1 and S2 in the RT tasks. The above-mentioned computer for presenting stimuli was connected to this device. To eliminate the effect of learning on the execution of specified movements by subjects, S1 was presented at a random interval between 8 and 20 s. In addition, a trigger stimulus was generated simultaneously with the presentation of S1 and S2, which was used as a time marker for the duration in the analysis of the lower jaw movement and electromyograms.

Recording of lower jaw movement and electromyography

We used a noncontact-type SAPHON visitrainer (C4-type, Tokyo Shizaisha) to record open mouth movements. The methods of usage and recording followed those of Ebihara¹⁸⁾ In the recording of the electromyograms of the masticatory muscles, a superficial part of the masseter muscle and digastric muscle on the side habitually used were used as the muscles to be tested (hereafter abbreviated as the masseter muscle and digastric muscle); recording electrodes were attached according to the electrode-placement method of Shiono¹⁹⁾ To record the waveforms of electromyograms, we used a neuropack (Nippon Kodan Co., Ltd.); the time constant was set at 0.03 s. With this recorder, signals of muscle activities were processed by the whole-wave rectified integration after amplification.

Analysis of RT and level of muscular discharge

Figure 1 shows the outline of the analysis of RT for the open mouth movements and the levels of muscular discharge on the electromyograms, and the relationship between the presentation of stimuli and periods during the RT tasks.

The open mouth movements recorded by the SAPHON visitrainer were input into the neuropack. RT was calculated as the time difference between the presentation of S2 and the signal indicating the start of an open mouth movement.

Fig. 1 RT for open mouth movement during the RT task, analysis of levels of muscular discharge based on the electromyogram and outline of the presentation of stimuli and division of periods

The analyses of levels of muscular discharge for the masticatory muscles were performed starting from prior to the presentation of S1 to the presentation of S2, which was divided into the following three periods: 1-s period before presentation of S1 (period B), 1-s period after presentation of S1 (period A1), and 1-s period following period A1 (period A2). The integral values of the amounts of activities in the masticatory muscles of each period were calculated as levels of muscular discharge. A mean value of muscular discharge for 10 trials was used as a representative value.

Calculation of the percent change of levels of muscular discharge

We calculated the percent change of levels of muscular discharge as an index of the change in the level of muscular discharge between before presentation of S1 and after presentation of S2. Namely, the difference between the level of muscular discharge in period A1 (or A2) and that in period B divided by the latter is designated as the percent change.

Percent change = $\{[(\text{level of muscular discharge in period A1 (or A2)}) - \text{that in period B}] / (\text{level of muscular discharge in period B})\} \times 100$

Items examined

We examined the following four items.

1. Comparison of RT during RT tasks between the CP group and the non-CP group.
2. Comparison of levels of muscular discharge between period A1 (or A2) and period B during RT tasks in the CP group and the non-CP group.
3. Comparison of levels of muscular discharge between period B and period A1 (or A2) for nonmovement tasks in the CP group.
4. Correlation between the percent change of the level of muscular discharge in period A1 (or A2) and RT in the CP group and the non-CP group.

Method of statistical analyses

Comparison of RT values between the two groups

was performed using Mann-Whitney's U-test. Comparison of the levels of muscular discharge between different periods was performed using Wilcoxon's signed ranks test. In addition, the correlation between the percent change of the levels of muscular discharge in each periods and RT for the open mouth movements was analyzed using Spearman's rank instruction correlation coefficient.

Results

Table 1 summarizes the results of the significance test of RT of the CP group and non-CP group during the RT task. The mean RT for open mouth movements during the RT task was 549.6 ± 171.7 ms for the CP group and 301.5 ± 55.4 ms for the non-CP group, showing a significant delay of RT in the CP group compared to the non-CP group ($P < 0.05$).

Figure 2 shows examples of typical recordings of a CP subject and a non-CP subject during the RT task. Figure 3 shows examples of typical recordings of a CP subject in the nonmovement task.

During the RT task, the amplitude of the muscular discharge of the masseter muscle and digastric muscle was more irregular in the CP group than in the non-CP group for all periods. In addition, in the CP group, the amplitude of the muscular discharge of the masseter muscle and digastric muscle decreased after the presentation of S1 compared to that before its presentation; in particular, a silent period (SP) of approximately 0.1 s was observed in the amplitude of the digastric muscle. In the non-CP group, no change in the muscular discharge of the masticatory muscles was observed between before and after the presentation of S1.

In the nonmovement task for the CP group, changes in the muscular discharge observed after the presentation of S1 during the RT task were not observed.

Table 2 summarizes the results of the significance test for the levels of muscular discharge for the three periods in the CP group and the non-CP group.

Table 1 RTs and the significance test of RTs between the CP group and the non-CP group during the RT task

The unit: msec			
	CP group	non-CP group	The significance test
RT	549.6 ± 171.7	301.5 ± 55.4	*

mean $\pm$ s.d. *: $P < 0.05$

In the CP group, the levels of muscular discharge of the masseter muscle were $5.2 \pm 1.8 \mu\text{Vs}$ for period B, $5.0 \pm 1.6 \mu\text{Vs}$ for period A1, and $4.5 \pm 1.5 \mu\text{Vs}$ for period A2; the levels of muscular discharge of

the digastric muscle were $10.1 \pm 5.6 \mu\text{Vs}$ for period B, $8.8 \pm 4.2 \mu\text{Vs}$ for period A1, and $8.3 \pm 4.0 \mu\text{Vs}$ for period A2. In the non-CP group, the levels of muscular discharge of the masseter muscle were

Fig. 2 Example of typical recordings during the RT task in a CP subject and a non-CP subject

Fig. 3 Example of typical recordings during the nonmovement task in the CP subject

Table 2 The significance test of levels of muscular discharge at each period and differences between each period for the CP group and the non-CP group

The unit: $\mu\text{V} \cdot \text{sec}$

The muscle	The period	CP group	The significance test		non-CP group	The significance test	
The masseter muscle	B	5.2 ± 1.8	] *	] *	3.9 ± 1.1	] —	] —
	A1	5.0 ± 1.6			3.8 ± 1.2		
	A2	4.5 ± 1.5			3.9 ± 1.3		
The digastric muscle	B	10.1 ± 5.6	] *	] *	4.8 ± 2.3	] —	] —
	A1	8.8 ± 4.2			4.8 ± 2.4		
	A2	8.3 ± 4.0			4.7 ± 2.1		

mean $\pm$ s.d. —: no significant difference *: $P < 0.05$

$3.9 \pm 1.1 \mu\text{Vs}$ for period B, $3.8 \pm 1.2 \mu\text{Vs}$ for period A1, and $3.9 \pm 1.3 \mu\text{Vs}$ for period A2; the levels of muscular discharge of the digastric muscle were $4.8 \pm 2.3 \mu\text{Vs}$ for period B, $4.8 \pm 2.4 \mu\text{Vs}$ for period A1, and $4.7 \pm 2.1 \mu\text{Vs}$ for period A2.

In the CP group, the levels of muscular discharge of both the masseter muscle and the digastric muscle in period A1 or A2 were significantly lower than those in period B ($P < 0.05$). However, in the non-CP group, no significant difference was observed ($P > 0.05$).

Table 3 The level of muscular discharge during the nonmovement task in the CP group

The unit: $\mu\text{V} \cdot \text{sec}$		
The muscle	The period	The level of muscular discharge
The masseter muscle	B	5.1 ± 2.1
	A1	5.4 ± 2.2
	A2	4.8 ± 2.6
The digastric muscle	B	6.5 ± 2.9
	A1	7.0 ± 3.3
	A2	6.4 ± 3.8

mean $\pm$ s.d.

Table 3 presents the levels of muscular discharge for the nonmovement task in the CP group. The levels of muscular discharge of the masseter muscle were $5.1 \pm 2.1 \mu\text{Vs}$ for period B, $5.4 \pm 2.2 \mu\text{Vs}$ for period A1, and $4.8 \pm 2.6 \mu\text{Vs}$ for period A2; the levels of muscular discharge of the digastric muscle were $6.5 \pm 2.9 \mu\text{Vs}$ for period B, $7.0 \pm 3.3 \mu\text{Vs}$ for period A1, and $6.4 \pm 3.8 \mu\text{Vs}$ for period A2. No significant differences in the level of muscular discharge of the masticatory muscles were observed among the three periods ($P > 0.05$).

Table 4 presents the percent change of the levels of muscular discharge of the muscle in each period for the CP group and non-CP group. In the CP group, the values of the percent change of the levels of muscular discharge of the masseter muscle were $96.7 \pm 8.5\%$ for period A1, and $88.5 \pm 18.7\%$ for period A2. Those of the digastric muscle were $91.8 \pm 14.6\%$ for period A1, and $88.7 \pm 22.1\%$ for period A2. In the non-CP group, the values of the percent change of the levels of muscular discharge of the masseter muscle were $98.7 \pm 9.4\%$ for period A1, and $101.0 \pm 12.9\%$ for period A2. Those of the digastric muscle were $98.3 \pm 9.3\%$ for period A1, and $98.3 \pm 11.2\%$ for period A2.

Table 5 lists the correlation coefficients between

Table 4 The percent change of levels of muscular discharge at each period for the CP group and the non-CP group

The unit: %			
The muscle	The period	CP group	non-CP group
The masseter muscle	A1	96.7 ± 8.5	98.7 ± 9.4
	A2	88.5 ± 18.7	101.1 ± 12.9
The digastric muscle	A1	91.8 ± 14.6	98.3 ± 9.3
	A2	88.7 ± 22.1	98.3 ± 11.2

mean $\pm$ s.d.

Table 5 In the CP subject and the non-CP subject, correlation coefficient between the percent change of the periods A1 (or A2) and RT, and the significance test results

The muscle	The period	CP group	non-CP group
The masseter muscle	A1	0.592*	0.143
	A2	0.071	0.065
The digastric muscle	A1	0.725*	0.225
	A2	0.099	0.052

*: $P < 0.05$

the percent change for both periods A1 and A2 and RT in the CP and non-CP groups, and the results of the significance test. In the CP group, the correlation coefficient between the percent change of muscular discharge in period A1 and RT for the masseter muscle was 0.592, showing a significant correlation ($P < 0.05$). For the digastric muscle, the correlation coefficient of those in period A1 was 0.725, also showing a significant correlation ($P < 0.05$). In the non-CP group, no significant correlation was observed between the percent change of the level of muscular discharge and RT in each period.

Discussion

In conventional research on RT using RT tasks, the living body is regarded as a mechanism for processing information provided from the outside environment, and the information detected by a sensory receptor is transmitted to the central nervous system, analyzed and integrated, following which, execution of a reaction movement is determined. During this process, the following activities are performed in the cerebral cortex: 1) willingness to perform a movement, 2) objective setting, 3) selection of the type and procedure of movement, 4) spatial and temporal structuring²⁰⁻²⁴.

During this process, impulses carried as output information descend to the motor nerves to be transmitted to a particular muscle to perform the movement. Thus, in RT tasks, several processing stages are considered to be present in the central nervous system from the presentation of a stimulus until the execution of the reaction movement. RT is interpreted as the total sum of the processing time at each stage²⁰⁻²⁴. That is, a long RT indicates slow processing, and a short RT indicates rapid processing.

In this study, we instructed individuals with CP to open their mouths as the specified movement in the RT task; this is because, in general, individuals with CP frequently exhibit abnormalities in dentition or occlusion due to oromandibular dyskinesia region⁹⁻¹¹). Accordingly, if we adopt mouth closing as the specified movement, then the subjects may be hindered by occlusal interference such as abnormalities in dentition and occlusion, resulting in low reproducibility due to the instability in occlusal positions.

In this study, we examined the waveforms of electromyograms not using original waveforms but

using those after whole-wave rectification, because the starting time of muscular discharge of the major muscles is not clear due to certain factors including involuntary movements that are characteristics of individuals with CP; therefore, the appearance of reaction movements is also unclear.

Botwinick *et al.*^{21,22}) and Drazin²⁵) already clarified that in individuals with CP, muscle contraction processes at the periphery following the instruction stimuli during an RT task for the limbs is prolonged compared to that in non-CP subjects. We also previously observed similar phenomena during RT tasks involving the oromandibular region¹⁵). In this study, we clarified that the duration in carrying out the open mouth movements during the RT task from the time S2 was presented is prolonged in the CP group compared to that in the non-CP group (Table 1).

In contrast, Oshima *et al.*⁷) and Nakajima⁸) showed that in RT tasks of finger and jaw movements in humans, a change in the amplitude patterns of muscular discharge in the major muscles was observed from the time of presentation of the warning stimulus that notifies the start of a task to the time when the instruction stimulus was presented. This change is considered to be related to the start of the preparatory process in the central nervous system for execution of movements.

Lippold²⁶), Bigland *et al.*²⁷), Vaughan *et al.*²⁸), Barrett *et al.*²⁹) recorded the brain potentials produced with arm extension movement, using CP and non-CP subjects, and found that the brain potential appeared at an earlier period in the CP subjects than in the non-CP subjects. They presumed that a preparatory process in the brain for movements in an individual with CP starts at an earlier period than that in a subject without CP. Therefore, we assumed that there may be muscular activity specific to individuals with CP that is related to the preparation of movements. This is observed in an electromyogram of the masticatory muscles in the period between presentation of S1 and S2 during the RT task in an individual with CP. We compared the waveforms of the electromyogram of the masticatory muscles between the CP group and the non-CP group. The results showed a decrease in the amplitude of muscular discharge as well as SP on the electromyogram of the masticatory muscles after the presentation of S1 during the RT task in the CP group (Fig. 2A). The level of muscular discharge was significantly lower after the presentation of S1 than before its

presentation of S1 (Table 2). On the other hand, in the non-CP group, no decrease in the amplitude of muscular discharge or SP was observed, as was the case of the CP group (Fig. 2B). These results suggest apparent variations in the muscular activities of the masticatory muscles in the CP group, in relation to the preparation of movements. It is well known that individuals with CP exhibit complex variations in muscle movements in the entire body due to the startle reflex induced by external stimuli such as sound and light^{30–32}. However, since variation in the muscular discharge of the masticatory muscles in the CP subjects was not observed in the nonmovement tasks (Fig. 3), we considered that this phenomenon did not occur in relation to the startle reflex, but is related to the appearance preparation of open mouth movement execution after the presentation of S2 in the CP group.

In general, in the case of the rapid execution of a voluntary movement in limbs from the state of maintaining a motor-preparation posture, temporary disappearance of muscular discharge in the major muscles is observed prior to the start of the movement³³. This phenomenon is called a premotion silent period (PMSP), and it is assumed that its physiological role is to accelerate the rising of a movement by synchronizing the muscular discharge that is subsequently induced, as confirmed by the observation of PMSP only in rapid voluntary movements²⁷. Namely, to rapidly execute a voluntary movement from the state of maintaining a posture, it is considered that starting from the state at which the posture is maintained by muscular activity based on the α - γ association, the activity of γ -motor neurons is suppressed and muscular activity via the α -motor neurons is induced²⁷. At this time, PMSP is said to be a temporary suppression of muscular activities which corresponds to the timing of “switching at the central nervous system²⁷”. Such a suppression of muscular discharge related to the preparation of voluntary movements appears not only immediately before the start of voluntary movements. Oshima *et al.*⁷ clarified that when the activity level in the major muscles is increased in advance during a RT task for the limbs, a decrease in the amplitude of muscular discharge and appearance of SP after the presentation of a warning stimulus are also observed in the waveforms of the electromyogram recorded during the period between the presentation of the warning and instruction stimuli. They explained that this is due to the adjustment of muscular tension

in the entire body via γ -motor neurons during the motor preparatory process in the central nervous system, as triggered by the presentation of a warning stimulus³⁴ clarified that during extension movement of the body trunk, frequency components in the electromyogram of the vertebral column muscles shift to the low-frequency region after the presentation of a warning stimulus. They assumed that this is due to the Renshaw suppression of α -motor neurons activities. Based on the findings, after the presentation of a warning stimulus during the RT tasks, we can assume that α -motor neurons are mainly involved in the preparation of movement in the central nervous system. In particular, the muscular sensory of our CP subjects is more sensitive than that in the non-CP subjects, not only in the limbs, but also in the masticatory muscles¹⁵. As a reason for this, γ -motor neurons which regulate the muscle spindle activity are excited to a higher level in the CP subjects than in the non-CP subjects, resulting in an increase in the emission frequency of centripetal impulses from the muscle spindle. Based on the results of these reports, the decrease in the muscular discharge of the masticatory muscles observed in this study is considered to be induced as follows. When a CP subject opens his mouth after the presentation of S2, the activity of γ -motor neurons is suppressed in the central nervous system, and the activity of α -motor neurons is involved in the preparation of the movement at its early stage; namely, there may be a relationship between the phenomenon of variations in muscular discharge in the masticatory muscles after the presentation of S1, in which the presence of the “switching mechanism in the central nervous system” is suggested, and the start of the open mouth movement after the presentation of S2. Therefore, we investigated the correlation coefficient between the percent change of the level of muscular discharge of the masticatory muscles after the presentation of S1 and the RT for open mouth movement in the CP group, and found a significant positive correlation between the percent change of A1 and RTs (Table 5). However, no positive correlation was observed between the percent change of A2 and RT. It is suggested that in the CP group, a preparatory process for the evaluation of the open mouth movement starts immediately after the presentation of S1.

In contrast, in the non-CP group, a decrease in the amplitude of muscular discharge and SP or a change in the level of muscular discharge is not

observed during the period between the presentation of S1 and S2 (Table 2). Moreover, no significant correlation between the percent change and RT was observed (Table 5). During RT tasks for the limbs, in general, when the amplitude of muscular discharge decreases, as indicated by the presence of SP during the period from the presentation of a warning stimulus to that of an instruction stimulus, the specified movement induces a voluntary tensile state in the major muscles of the subject prior to the presentation of the instruction stimulus⁷⁾. However, in this study, an open mouth movement starting from the position of a stable lower jaw is set as the specified movement, and this may eliminate changes in the amplitude of muscular discharge because tension is not present in the muscle.

From the results of this study, as one of the reasons for the difficulty in executing smooth voluntary movements in the oromandibular region in individuals with CP, we consider that the movement is delayed because the period of preparation of the movement is significantly prolonged in CP subjects although they started the preparation of the movement at an earlier period than in non-CP individuals.

Conclusions

We hypothesized that oromandibular movement dysfunctions in individuals with CP are affected by the preparatory process in the central nervous system for initiating a movement. We tested this hypothesis on 13 individuals with CP (average age: 36.9 years old) and 13 individuals who did not have CP (average age: 34.7 years old) as subjects. Using these subjects, we analyzed muscular discharges of the masticatory muscles during the period of presentation of warning and instruction stimuli with the open mouth movement as the specified movement during the RT tasks, compared RTs between the CP subjects and non-CP subjects, comparison of the level of muscular discharge of the masticatory muscle before the presentation of an instruction stimulus between the two groups and examined the correlation between the percent change of the levels of muscular discharge of the masticatory muscles and RT for the open mouth movements. We reached the following conclusions.

1. The RT for executing the open mouth movements is significantly longer in the CP subjects than in the non-CP subjects.
2. A decrease in the amplitude of muscular discharge

in the masticatory muscles after presentation of the warning stimulus was observed in the movement task for the CP subjects; in particular, when the magnitude of the decrease is strong, silent periods appeared.

3. In the CP subjects during the movement task, the level of muscular discharge of the masticatory muscles in the 1-s period before presentation of a warning stimulus was significantly lower than that in the 1-s period or in the period from 1 s to 2 s after the presentation of the warning stimulus.
4. In the CP subjects during the nonmovement task, no change in the levels of muscular discharge of the masticatory muscles in each period was observed.
5. In the CP subjects during the 1-s period after presentation of a warning stimulus, a significant correlation was observed between the percent change of the level of muscular discharge of the masseter muscle (or the digastric muscle) and RT for the open mouth movement.

From the results of this study, as one of the reasons for the difficulty in executing smooth voluntary movements in the oromandibular region in individuals with CP, we consider that the movement is delayed because the period of preparation of the movement is significantly prolonged in individuals with CP although they started the preparation of the movement at an earlier period than in individuals who do not have CP.

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