

# Influence of Probe Reaction Time during Rhythmic Stabilization on Standing Stability of Patients with Post-Stroke Hemiplegia

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**Abstract.** [Purpose] The purpose of this study was to examine the influence of the probe reaction time (P-RT) during rhythmic stabilization (RS) on standing stability of patients with post-stroke hemiplegia. [Subjects] The subjects were 29 patients with post-stroke hemiplegia (males, mean age  $56.2 \pm 11.9$  years), who had been receiving treatment at the Jilin Rehabilitation Medical Center in China. They were divided into two groups: the cerebral hemorrhage (CH) group and the cerebral infarction (CI) group. [Methods] We evaluated the simple reaction time (SRT), the P-RT during RS, the maximal resistance force of RS (Max. RF), the resistance force of RS during P-RT (RF during P-RT), and the timed up-and-go test (TUG). [Results] P-RT was significantly longer than SRT, and RF during P-RT was less than the Max. RF in both groups. P-RT of CH patients was significantly longer than that of CI patients. There were significant correlations between P-RT and SRT, P-RT and RF during P-RT, and Max. RF and RF during P-RT in both groups. [Conclusion] The results suggest that attention decreased more during the dual task in the CH group than in the CI group. Not only trunk muscle force but also attention maybe factors influencing the standing stability of patients with post-stroke hemiplegia.

**Key words:** Probe reaction time, Rhythmic stabilization, Post-stroke hemiplegia

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## INTRODUCTION

Improvement of the balance function is important to prevent falls by patients with post-stroke hemiplegia. The rhythmic stabilization (RS) of proprioceptive neuromuscular facilitation (PNF) is a technique which is used to improve the balance function. The RS technique uses isometric contraction of antagonistic patterns which result in co-contraction of the antagonists if the isometric contraction is not interrupted by the physical therapist<sup>1)</sup>. RS may be appropriate for improving short-term trunk muscle endurance and trunk mobility in people with chronic low back pain<sup>2,3)</sup>. RS is effective in the treatment of patients with impairment of motor coordination<sup>4)</sup>, and it is used as a clinical examination technique for slight cerebellar diseases<sup>5)</sup>.

Recently, dual tasks have been used to evaluate falls by many researchers<sup>6–8)</sup>. For instance, when a movement task is taking place, and another task is concurrently applied, it is known as a dual task. If the main task is comparatively simple, a comparatively large amount of attention can be allocated to the second task. This makes it possible to perform the second task comparative quickly, and it is interpreted that a lot of attention resources were allocated to

the second task. So, if a second task is demanded during movement task enforcement and the reaction time to the dual task is relatively short, it implies that the main task is performed automatically. This study method is called the probe reaction time (P-RT). Measuring phonatory reaction time is particularly recommended as in the probe reaction time method it sensitively recognizes a slight change in attention demand in voluntary movement<sup>9)</sup>. The purpose of this study was to examine the influence of the probe reaction time (P-RT) during rhythmic stabilization (RS) on standing stability of patients with post-stroke hemiplegia.

## SUBJECTS AND METHODS

The subjects were 29 patients with post-stroke hemiplegia (males, mean age  $56.2 \pm 11.9$  years), who had been receiving treatment at the Jilin Rehabilitation Medical Center in China. They were divided into two groups: the cerebral hemorrhage (CH) group and the cerebral infarction (CI) group (Table 1). All subjects gave their informed consent to participation in the study.

A physical therapist conducted the clinical examination, which included measurements of the simple reaction time (SRT), P-RT during RS, the maximal resistance force of RS

**Table 1.** Subject Characteristics<sup>a</sup>

		CH group (n=11)	CI group (n=18)
Age (y)		51.3 ± 11.9	59.3 ± 11.1
Weight (kg)		71.1 ± 11.2	65.3 ± 8.2
Height (cm)		170.0 ± 7.4	169.8 ± 4.4
Period of onset (months)		7.6 ± 3.4	8.3 ± 2.1
Hemiplegia	Left	7	11
	Right	4	7
Brunnstrom stage (lower limb)	II	1	2
	III	5	8
	IV	5	6
	V	0	2
Walking	Without a cane	4	7
	With a cane	7	11

Note: values are mean ± standard deviation. <sup>a</sup>CH group: the cerebral hemorrhage group. CI group: the cerebral infarction group.

(Max. RF), the resistance force of RS during P-RT (RF during P-RT), and the timed up-and-go test (TUG)<sup>(10)</sup>.

A digital audio player/recorder (Rio•Japan) was used as an auditory stimulator, and the recording device used was a digital voice recorder (Panasonic•Japan). An auditory stimulus file was prepared on a computer. The file was edited as a series of 16 warning signal and auditory stimulus (50 ms) sets using the personal computer overtone opinion processing software, DigionSound5 (Digion). The file was input to the digital audio player/recorder, and the digital audio player/recorder was connected both to the digital voice recorder and a headset used a two-socket adapter, so as to form an auditory cue box. The interval between the warning signal and auditory stimulus was completely randomized between 2–5 seconds.

The auditory cue box was attached to the abdominal region of the subjects to measure the probe reaction time. The subjects were required to respond to an auditory cue by loudly saying the word “Pa” as quickly as possible. The subjects wore the headset. The warning signal, the stimulus auditory and the response sound of the subject were recorded on the digital voice recorder.

The SRT was measured continuously five times in total with subjects in the standing position. One minute after a subject started RS, the P-RT was started and measured continuously for five times in total. Prior to the experiment, the subjects were informed what would be done in the experiment, and they made trial exercises to familiarize themselves with the procedure. Data was input into personal computer, and the DigionSound5 sound-processing software was used for the analysis. The difference in RT ( $\Delta RT = P-RT - SRT$ ) was calculated.

To measure Max. RF and RF during P-RT, manual pressure was alternately applied to both shoulders during RS. The RS was executed four directions on the diagonal line and ten seconds in unidirectional. To measure the resistance force of RS, two hand-held dynamometers (HDD, ANIMA MT-1) were held in both hands of the physical therapist, and the tester function of HDD was used to measure the maximum resistance force.

The resistance force was the maximum resistance force at which trunk shake of the subjects did not appear. The mean value of the maximum resistance force of both hands was used as the representative value. The difference in RF ( $\Delta RF = \text{Max. RF} - \text{RF during P-RT}$ ) was calculated.

To determine differences between the CH group and the CI group, the independent t-test was performed for each measure. To determine whether there were differences of SRT and P-RT, and Max. RF and RF during P-RT, two-way analyses of variance were performed. The task condition and the group were assumed to be factors. If a significant interaction between groups was found, the paired t-test was performed for each group. To determine correlations between items, Pearson's correlation coefficient was calculated. Data were analyzed using SPSS Ver. 12.0 for Windows.

## RESULTS

Table 2 shows the result of each measurement. The CH group had significantly longer P-RT and  $\Delta RT$  than the CI group ( $p < 0.01$ ). For two-way analyses of variance of RT, there was a significant interaction of group with task condition ( $F(1, 27) = 11.5, p < 0.01$ ); the change pattern of RT was different between the groups. The paired t-test

**Table 2.** Comparison of the CH group and the CI group<sup>a</sup> test results

	CH group (n= 11)	CI group (n= 18)
Timed up-and-go test (s)	33.0 ± 19.2	39.4 ± 25.9
Simple reaction time (ms)	644.9 ± 243.5	519.6 ± 192.7
Probe reaction time (ms)	1118.6 ± 559.0	629.6 ± 191.3
$\Delta RT$ (ms)	473.7 ± 447.3	110.1 ± 83.1
Max. RF (kg)	3.59 ± 0.67	3.99 ± 1.38
RF during P-RT (kg)	3.06 ± 0.61	3.21 ± 0.97
$\Delta RF$ (kg)	0.52 ± 0.43	0.78 ± 0.65

Note: values are mean ± standard deviation. \*\* $p < 0.01$ . <sup>a</sup>CH group: the cerebral hemorrhage group. CI group: the cerebral infarction group.  $\Delta RT$ : P-RT - SRT. Max. RF: the maximal resistance force of RS. RF during P-RT: the resistance force of RS during P-RT.  $\Delta RF$ : Max. RF - RF during P-RT.

**Table 3.** Pearson Correlation Coefficients between Measures <sup>a</sup> (n= 29)

	TUG	SRT	P-RT	ΔRT	Max. RF	RF during P-RT	ΔRF
TUG	–	–0.20	0.04	0.15	–0.03	0.06	–0.12
SRT	0.45	–	0.63*	0.24	–0.11	–0.35	0.33
P-RT	0.53*	0.91**	–	0.91**	–0.47	–0.78**	0.38
ΔRT	0.18	–0.23	0.20	–	–0.53	–0.78**	0.30
Max. RF	–0.42	–0.74**	–0.66**	0.13	–	0.78**	0.44
RF during P-RT	–0.45	–0.72**	–0.68**	0.16	0.91**	–	–0.21
ΔRF	–0.22	–0.48*	0.47	0.05	0.77**	0.43	–

\*:  $p < 0.05$ , \*\*:  $p < 0.01$ . The correlation coefficients of CI group (lower left portion) and CH group (upper right portion) are shown. <sup>a</sup> TUG: Timed up-and-go test, SRT: Simple Reaction Time, P-RT: Probe Reaction Time, ΔRT: P-RT - SRT. Max. RF: the maximal resistance force of RS. RF during P-RT: the resistance force of RS during P-RT. ΔRF: Max. RF - RF during P-RT.

showed a statistically significant difference between SRT and P-RT; P-RT was longer than SRT in both groups.

For two-way analyses of variance of RF, the main effects of the task condition ( $F(1, 27) = 35.1$ ,  $p < 0.01$ ) was statistically significant for Max. RF and RF during P-RT; RF during P-RT was less than Max. RF for each group. There were no main effects of group ( $F(1, 27) = 0.55$ ,  $p > 0.05$ ), and no significant interaction ( $F(1, 27) = 1.38$ ,  $p > 0.05$ ).

Pearson's correlation coefficient showed high correlations between P-RT and SRT, P-RT and RF during P-RT, and Max. RF and RF during P-RT in both groups. Compared with the CI group, correlations of single tasks (SRT or Max. RF) with dual tasks (P-RT or RF during P-RT) were lower in the CH group (Table 3).

## DISCUSSION

The result for the CH group showed that their P-RT and ΔRT were longer than those of the CI group. However, there were no differences in SRT or Max. RF between groups. Compared with the CI group, the correlations of single tasks (SRT or Max. RF) with dual tasks (P-RT or RF during P-RT) were lower in the CH group. In addition, there was significant interaction of group with task; the change pattern of RT was different between the groups. The results suggest that the attention during the dual task was decreased more in the CH group than in the CI group.

P-RT was longer than SRT in both groups; RF during P-RT was decreased in both groups, too. We think that the attention allocated to RS was decreased by the dual task. There was a significant negative correlation between P-RT and RF during P-RT in all subjects, which suggests that not only the trunk muscle force but also attention is factors influencing standing stability in all subjects.

The reproducibility of the measurement was examined for all the measurement items. To examine the reliability of P-RT, ten subjects were selected at random among the subjects. The retest was implemented on the next day. The interrater reliability interclass correlation coefficient (ICC) was calculated. The ICC (1, 1) of SRT was 0.98, that of P-RT was 0.95, that of RF during P-RT was 0.85, and that of Max. RF was 0.94, showing a high reproducibility.

A resistance force was applied by the therapist as a disturbance to facilitate the patient's righting reaction. P-RT of RS was longer than SRT, suggesting that attentional demand is associated with standing stability. Therefore, we think that RS exercise should improve attention as well muscle force. Moreover, we think that P-RT of RS can be used to judge the effect of intervention as a method for evaluating the standing stability.

TUG is a traditional assessment which is useful for estimating the risk of falls among the elderly. Shumway-Cook<sup>(11)</sup> reported the cut-off value of TUG as 13.5 seconds. In the present research, TUG times of the two groups were higher than the cut-off value, and there was no significant difference between the two groups. The subjects were convalescent patients with post-stroke hemiplegia, and the influence of poor walking ability was large. Except for P-RT in the CI group, significant relationships were not found for TUG with RT and RF. The RS task is static standing, but TUG is a dynamic task including a walking element. Therefore, a relationship was not found.

Recent studies have used P-RT to examine the risk of falls among the elderly and patients with post-stroke hemiplegia<sup>(12–14)</sup>. Our study did not examine falls. Further investigations will be needed with larger numbers of subjects, and also to examine the relationship between the P-RT during RF and falls in patients with post-stroke hemiplegia.

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