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Effects of Somatosensory Training on Dynamic Balance for the Cerebellar Ataxia

Jung-Woo Jeong[1], Sung-Ryong Ma[2], Byung-Il Yang[3], Ha-Na Kim[4], So-Young Han[5], Bo-Kyoung Song*[6]

[1]*Doctoral Course, Graduate School, Kangwon National University, 346 Hwangjo-gil, Dogye-eup, Samcheok-si, Gangwon-do, 24949, Republic of Korea, Department of Occupational Therapy, Bobath Memorial Hospital, Republic of Korea*

[2]*Professor, Department of Occupational Therapy, Shinsung University, Dangjin-si 31001, Republic of Korea*

[3]*Professor, Department of Physical Therapy, Sangji University, 83, Sangjidae-gil Wonju-si, Gangwon-do, 26339, Republic of Korea*

[4]*Doctoral Course, Graduate School, Kangwon National University, 346 Hwangjo-gil, Dogye-eup, Samcheok-si, Gangwon-do, 24949, Republic of Korea, Chung Dam Hospital, Republic of Korea*

[5]*Doctoral Course, Graduate School, Kangwon National University, 346 Hwangjo-gil, Dogye-eup, Samcheok-si, Gangwon-do, 24949, Republic of Korea, Department of Occupational Therapy, Bobath Memorial Hospital, Republic of Korea*

[*6]*Professor, Department of Occupational therapy, Kangwon National University 346 Hwangjo-gil, Dogye-eup, Samcheok-si, Gangwon-do, 24949, Republic of Korea*

Abstract

The purpose of this study was to investigate the effect of somatosensory training for cerebellar ataxia on dynamic balance through a single case report. This study was conducted in a 25-year-old male who was diagnosed with cerebellar ataxia for a total of 10 weeks over a period of 6 weeks from November to December 2019, using the ABA design. During the study period, a total of 18 sessions were applied to the subjects with 3 sessions of baseline A, 12 sessions of intervention period B, and 3 sessions of baseline A'. During the baseline period, BIORescue and functional reach test were measured by dynamic balance evaluation without somatosensory training, and the same evaluation was performed after applying somatosensory training for 40 minutes each session three times a week during the intervention period. As a result, it was confirmed that both were improved in the limited of stability and functional reach test compared to before the application of somatosensory training, and continued to be maintained even after the intervention was completed. This study showed that somatosensory training had a positive effect on dynamic balance with cerebellar ataxia.

Keywords: Stroke, Somatosensory, Balance, Cerebellar, Ataxia

* Corresponding author
Name: Bo-Kyoung Song
Email: bksong@kangwon.ac.kr
Contact: +82-10-6351-6517
Fax: -
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Introduction

In stroke, cerebellar stroke accounts for about 3-15%, and ataxia-related disorders occur more frequently than typical stroke symptoms such as hemiplegia and aphasia(Konczak., 2010). Ataxia refers to impaired control of walking, spontaneous upper and lower extremity movements, speech, and eye movements due to impairment of the brain's ability to harmoniously control balance and movement(Deluca C., 2011). This function is mainly performed by the cerebellum in our brain, and it is often referred to as cerebellar ataxia because it occurs mainly when cerebellar dysfunction occur(Ye B S et al., 2010).

The cerebellum is responsible for automatic coordination and regulation of motor learning, control of muscle tone and balance, and plays a very important role in postural control. (Earhart G M et al., 2001; Morton S M et al., 2003). In addition, the cerebellum is a sensory processing area through immediate feedback in balance and gait, and plays a role in motor control through a feedback method based on reactivation or sensory stimulation(Morton S M et al., 2006).

Typical symptoms in patients with cerebellar ataxia are hypotonia, in which resistance to passive limb movements is reduced, and motor distance dysregulation, which shows problems in starting limb movement and controlling the size and speed of movement, muscle coordination disorder in which joint coordination is difficult. In addition, there are hypermetria, an intentional tremor that is trembling while exercising spontaneously, as a

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limitation of motor control(Earhart G M et al., 2001; Morton S M et al., 2003). Balance disorder caused by such ataxia greatly degrades the subject's independence during the patient's gait and daily life movements, and has been considered to be impossible to treat for a long period of time, but it is gradually gaining attention that it can be overcome through rehabilitation(Marquer A et al., 2014).

However, even with continuous rehabilitation, as the disease progresses, weight movement is difficult and the ability to walk and balance gradually loses, such as dragging of the feet, leading to a risk of falls(Morton S M et al., 2010). Falls in patients with cerebellar ataxia are a very scary factor, and cause a negative effect on the independent life of patients, leading to psychological atrophy(Fonteyn E M et al., 2012). According to a previous study, about 84% of 113 cerebellar patients answered that they had a fall at least once within a year, and two-thirds of the patients who experienced a fall had a fall in the front and back direction instead of the left and right directions. They responded that they did(Fonteyn E M et al., 2012).

Postural control refers to the ability to maintain the center of mass at the support base of the body in the external environment in equilibrium, and can be said to be essential for the stability and independence of the body in everyday life. (Shumway Cook A et al., 2001). During balance control, the sensory processing process is largely processed through three types of information: somatosensory, visual, and courtyard systems. Information from the visual and courtyard system, including somatosensory sensation, goes through a process of integrating in the central nervous system, and based on this sensory processing process, appropriate exercise planning and execution are made(Shumway Cook A et al., 2001).

In particular, the somatosensory system is the most basic sense for providing information about balance in healthy adults(Shumway Cook A et al., 1990). and sensory receptors located at the periphery of the body have changes in muscle length, joint position, movement, and speed. It recognizes sensory information such as the back and transmits it to the upper segment of the spinal cord or the brain. This information plays an important role in planning and executing movements, maintaining posture throughout the central nervous system(Kandal E R et al., 2000; Lundy Ekman L., 2013). This sensory information plays an important role in planning and executing movements while maintaining posture throughout the central nervous system. In other words, the cerebellum functions to regulate motor responses through a feedback method using somatosensory sensation(Morton S M et al., 2004).

According to previous studies based on somatosensory sensation, it found that the Contactual

Hand-Orientating Response (CHOR) is the concept of the centerline of the torso, and the posture required to control wrist, elbow and shoulder movements(Raine S et al., 2013). It is said to promote stabilization. In a recent study, it was reported that the Contactual Hand-Orientating Response had a positive effect on the standing up behavior of chronic stroke patients(Seo T H et al., 2018).

However, this is a positive study on stroke patients with cerebral injury following the normal cerebellar sensory feedback pathway. On the contrary, patients with cerebellar ataxia have difficulty in balance and normal activities of daily life due to problems of the cerebellar sensory feedback pathway, unlike normal sensory pathways in the cerebral cortex. Therefore, in this study, the effect of the contact hand-position response on the balance and daily living activities of cerebellar ataxia patients is investigated, and the improvement of balance ability of these cerebellar ataxia patients is generalized to the performance of daily living activities

Materials and Methods

Subjects

This study targets patients with cerebellar injured stroke as a result of magnetic resonance imaging (MRI) as a recipient of comprehensive rehabilitation treatment after being admitted to the Department of Rehabilitation Medicine of B Hospital in Seongnam-si, Gyeonggi-do. The subjects who participated in this study were patients who could maintain posture without an assistive device, and those who had brain lesions other than the cerebellum or had orthopedic problems that could affect the examination were excluded.

The subject was a 24-year-old male who complained of a sudden severe headache while singing 3 years ago, and was diagnosed with a stroke due to bilateral cerebellar hemorrhage as a result of diagnosis after visiting the hospital. Initially, he had mild diplopia, but now he has improved and complained of difficulties in maintaining balance, moving, and walking. As a result of the Korean version of the simplified mental state test, there was no difficulty in the therapist's instruction and implementation with a perfect score of 30. The range of motion of the joint was normal and the overall strength was good grade. The result of the manual function test (MFT) was 25/32 on the left and 25/32 on the right in Table 1.

Subjects perform all physical and occupational therapy conducted in the hospital, and proceed with interventions and all evaluations for this study from 6 pm. Subjects receive sufficient explanation of the study in advance and fill out a consent form for participation, and data collection is conducted over a total of 6 weeks from November to December 2019.

Table 1. Characteristics of the subject

Characteristics	Subject
Gender	Male
Age	24
Duration of diseade	3 years 3 months
Range of motion	Full range
Manual muscle test	G
Manual function test(Rt./Lt.)	25/25
korean version of mini-mentel state exam(K-MMSE)	30/30

Materials

Dynamic balance

BIORescue(RM INGEINIERIE, Rodez, France)

This device is used to accurately determine the degree of static and dynamic ataxia, and measures the amount of body agitation when the eyes are closed or the eyes are open. This test is performed using a device consisting of a peripheral vision device, a computer device, and a platform, and it can be used as the most basic test method to discover the subjective balance problem of a patient who cannot maintain the balance of the body by itself.

In this study, climb barefoot and place both feet in the most comfortable position on the platform mark. On the monitor, voluntarily move the center of gravity as far as possible by following the arrows pointing forward, rear, left, and right, and a total of 8 directions in each diagonal direction. Measure in each direction for 10 seconds, and keep it by yourself while going to the maximum. Do not let your feet fall off the floor during measurement, and re-measure if your feet fall off the ground during measurement. The total limit of stability (LOS) is measured in four directions, front, rear, left and right, and in the four directions of each oblique line. Data collection is repeated three times and measured as the average of the result values. Give a 3 minute break for each measurement to minimize the effect on muscle fatigue.

Functional reach test; FRT

In this study, a functional reach test is used to check the dynamic balance of cerebellar ataxia patients. FRT measures the distance that can be reached by extending the arm horizontally while maintaining the support surface in a comfortable standing position. It was used to examine the change in balance ability during dynamic activity. FRT begins with the subject standing and bending the shoulder joint 90 degrees with the elbow extended. Measure at the end of the third metacarpophalangeal joint from

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the starting point while keeping one arm level on the ground, and measure the distance difference by remeasurement in the state extended to the maximum. At this time, the subject's hip joint and pelvis posterior inclination, and knee joint bending should not occur(Ducan P W et al., 1990).

Methods

The experimental design of this study uses the ABA inversion design among single-subject research design. The total number of experiments is 18 sessions; baseline phase A and baseline phase A'are periods without treatment, and basic data are collected three times each, and intervention phase B is A total of 12 treatment periods, once a day, 30 minutes per treatment period, and basic data are collected. After 3 baseline measurements without any initial intervention, the intervention period is conducted for 12 sessions. After the mediation period is over, baseline measurements are made three times.

Somatosensory training

Somatosensory training refers to contact made in the form of friction with the ground so that the hand can properly play a functional role based on the contactual hand-orientating response (CHOR). Intervention according to somatosensory training in this study revises and supplements the contents studied by them(Raine S et al., 2013).

First, the therapist allows the subject to support the treatment table behind the buttocks in an upright position. At this time, make sure that the outer sides of both feet are positioned within a range that does not cross the shoulder line, and then the left and right weight support is equalized. Next, place an auxiliary table on the left and right of the subject, and repeat so that the floors of both hands can be lightly placed on the table in the form of a balance auxiliary. The height of the left and right auxiliary tables is provided so that the subject's elbows can be sufficiently extended. Afterwards, support the weight with the elbows of both arms extended. Induces actively control the wrist, elbow and shoulder movements of the ipsilateral upper limb(provided with therapist's help). Finally, the task of moving an object or reaching for the opposite upper limb crossing the center line is repeated.

This study is assigned to occupational therapists with more than 5 years of experience and proceeds according to the study procedure. The specific procedure of intervention is as follows in Table 2, Fig 1.

Table 2. Intervention program

Stage	Minute	Intervention
I	5	Recognizing the concept of the mid line in a right standing posture

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II	5	Repeat so that the hand can be touched lightly as an auxiliary form of balance
III	5	Repeatedly supporting the weight while supporting the arm
IV	5	Repeated to actively control the wrist, elbow and shoulder movements of the ipsilateral upper limb (provided with therapist's help)
V	5	The opposite hand crosses the center line and repeats a simple task

Figure 1. Intervention Program

Process of study

Baseline phase A and baseline phase A'

During baseline A and A'period, two-hand-based somatosensory training was not conducted. Ataxia patients who participated in this study often complain of dizziness and fatigue, and after one program is over, a 3-minute break is given to minimize the effect on muscle fatigue. In order to prevent loss of concentration due to other external interference and noise, proceed in as much independent space as possible.

Intervention phase B

Intervention phase B is conducted three times a week for a total of 12 times. Each session was held for 30 minutes and consists of 5 stages. After treatment, LOS and FRT are evaluated each time.

Statistical analysis

In this study, LOS values are recorded during the baseline and the measured data are analyzed using a visual analysis method using a graph. Calculate the average value of each

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variable within the period and compare and present the rate of change of each step. If a value exceeding the mean ±2 standard deviation during the intervention period is measured twice consecutively, it is considered that there is a therapeutic effect(Ottenbacher K J., 1986), and the treatment persistence effect is at baseline according to the method suggested by Marklund and Klassbo. It is considered to have a sustained effect when it is above the average value(Marklund I et al., 2006).

Results and Discussion

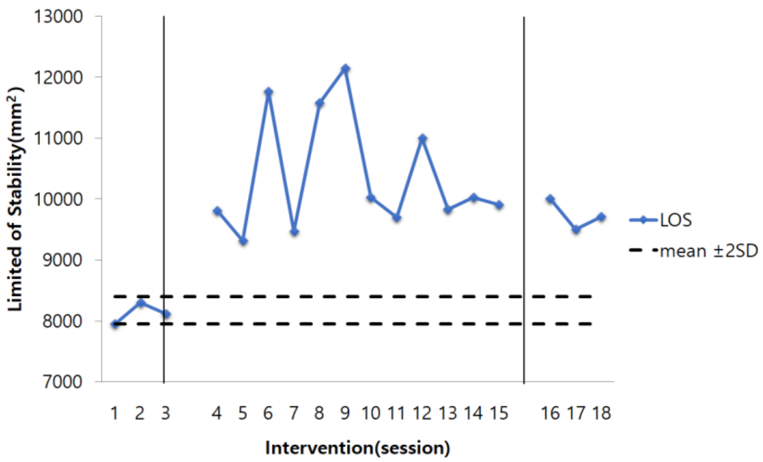
Results

Dynamic balance change

The results of evaluating dynamic balance after applying somatosensory training to patients with cerebellar ataxia are as follows. In LOS, on average, baseline A was 8123mm^2, mediator B was 10379mm^2, and baseline A' was 9737mm^2. In FRT, the average baseline A was 15.3cm, the mediator B was 19.25cm, and the baseline A' was 19.5cm in Table 3, Fig 2.

Table 3. The result of dynamic balance change

	Baseline(A)	Intervention(B)	Baseline(A’)
Limited of stability(mm^2)	8123±174	10379±971	9737±251
Functional reach test(cm)	15.3±0.2	19.25±1.65	19.5±0.5



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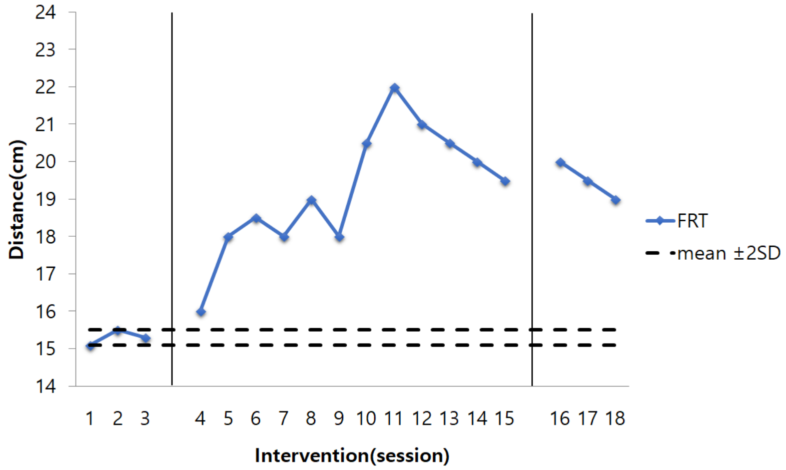

Figure 2. The result of dynamic balance change

Discussion

In this study, a dynamic balance evaluation was conducted to determine the improvement in balance ability after applying somatosensory training to patients with cerebellar ataxia. The cerebellum maintains equilibrium by combining the movements of each part of the body and functions to finely adjust the movements to occur smoothly.

According to previous studies, they found that various types of exercise program training had a positive effect on function recovery in patients with cerebellar ataxia(Ilg W et al., 2014; Miyai I et al., 2012).

In addition, exercise therapy such as gait and balance training, coordination training, posture control training, and static/dynamic balance training has been shown to help improve the symptoms of movement disorders in cerebellar patients(Keller J L et al., 2014).

In the LOS evaluation, the subjects showed significant results with baseline A 8123mm^2, mediator B 10379mm^2, and baseline A'9737mm^2. These results show the correlation of the center of gravity (COG) in the base of support (BOS), and are a result of improving stability. In order for us to perform our daily life effectively and efficiently, we need the ability to maintain body balance on the basal surface. The ability to maintain a stable posture and maintain balance integrates the performance of motor skills and is inseparable from the movement to be performed or the environment in which the movement occurs(Carr J H et al., 1998). In a recent study, it was reported that feedback through other sensory functions complements motor learning functions. However, such motor control does not occur only in the cerebellum, but also occurs in a deep relationship with the cerebrum.

Somatosensory training helps to maintain balance through the connection between cerebellum and cerebrum, and motor learning through somatosensory sense is thought to

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have an effect on improving balance ability of cerebellar ataxia patients. In previous studies, it was reported that learning through visual perception promotes the interconnection between the cerebral motor cortex and sensorimotor cortex, inducing neural reorganization, and improvement of motor function through rehabilitation treatment(Saleh S et al., 2011).

It is also reported that such motor learning is effective only when it is repeatedly performed in a task-oriented manner(Srivastava A et al., 2009). That is, it is thought that somatosensory training through repetitive and direct hand contact has a positive effect on balance ability of cerebellar ataxia patients.

In the FRT evaluation, the subjects showed significant results with baseline A 15.3cm, interventional phase B 19.25cm, and baseline A'19.5cm. This was found as a result of somatosensory training enabling central movement through the contact reaction of the upper limbs in a standing position, and also improving the balance ability within the body.

According to a previous study, it was reported that patients with cerebellar disease showed stronger trunk shaking than the general population, and that the change in the center of gravity and the variability of the speed during walking were very high(Hudcon C C et al., 2000). In addition, it was reported that movement disorders, irregular limb control, and limb tremor in cerebellar disease patients have difficulty in stabilizing movement during continuous tasks such as walking(Spencer R M et al., 2008). Somatosensory training improves the stability of these cerebellar patients, and it facilitates motor learning through sensory information. Since various tactile stimuli and physical activities provided by the therapist reorganize the cranial nerves and expand the sensory-receiving area in the cortex, the experience of various sensations using tactile sensation changes the neural map of the damaged cortical area(Carr J H et al., 1998). In other words, the repetitive stimulation of somatosensory nerves promotes the conjunctival efficiency in the primary motor area in acquiring new motor skills, thereby learning of motion(Asanuma H et al., 1997).

The limitation of this study is that this study is an individual experimental study, and although it is possible to find out in detail the characteristics and changes of subjects, it is difficult to generalize due to the small number of subjects.

In addition, there was no direct balance training, but repeated measurements of dynamic balance assessment may affect the results.

In future studies, it is necessary to establish a basis for the balance level and various senses of cerebellar ataxia patients, and to study a protocol for specific somatosensory training. In this study, after applying somatosensory training to patients with cerebellar ataxia, it was confirmed that there was a significant improvement in dynamic balance evaluation.

Conclusion

This study investigated changes in dynamic balance ability by applying somatosensory training through a single case study in cerebellar ataxia patients. The subject of the study was a 25-year-old male who complained of a sudden severe headache and was diagnosed with a stroke due to bilateral cerebellar hemorrhage after a visit to the hospital.

The experiment period was conducted over a total of 6 weeks from November to December 2019, and a total of 18 sessions were conducted with 3 sessions for baseline A and A'and 12 sessions for Intermediate Period B.

During the baseline period, somatosensory training was not conducted, and dynamic balance ability was measured through LOS and FRT evaluation. During the intervention period, somatosensory training was conducted, and changes in dynamic balance ability were confirmed through LOS and FRT evaluation. The results of this study are as follows.

First, after somatosensory training, the limited of stability of patients with cerebellar ataxia was significantly improved.

Second, after somatosensory training, there was an effect on the dynamic balance ability through functional stretching of cerebellar ataxia patients.

This study is meaningful in providing evidence that the application of somatosensory training to patients with cerebellar ataxia has an effect on dynamic balance ability.

References

1. Asanuma H., Pavlides C., 1997. Neurobiological basis of motor learning in mammals. Neuroreport, 8(4), pp.1-6.
2. Carr J. H., Shepherd R. B. Neurological Rehabilitation Optimizing Motor Performance. Butterworth-Heinemann: Oxford:1998, pp.25.
3. Deluca C., Moretto G., Di Matteo A., Cappellari M., Basile A., Bonifati M. D et al., 2011. Ataxia in posterior circulation stroke: clinical-MRI correlations. Journal of the Neurological Sciences, 300(1-2), pp.39-46.
4. Ducan P. W., Weiner D. K., Chandler J., et al., 1990. Functional reach: a new clinical measure of balance. J Gerontol, 45(6), pp.192-197.
5. Earhart, G. M., Bastian, A. J., 2001. Cerebellar gait ataxia: Selection and coordination of human locomotor forms following cerebellar damage. Journal of Neurophysiology, 85(2), pp.759-769.
6. Fonteyn, E. M., Schmitz-Hubsch, T., Verstappen, C. C., Baliko L., Bloem B. R., Boesch S

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 1757 - 1769
Received 15 December 2020; Accepted 05 January 2021.

et al., 2012. Prospective analysis of falls in dominant ataxias. European Neurology, 69(1), pp.53-57.

7. Hudson C. C., Krebs D. E., 2000. Frontal plane dynamic stability and coordination in subjects with cerebellar degeneration. Experimental Brain Research, 132(1), pp.103-113.
8. Ilg W., Bastian A. J., Boesch S., Burciu R. G., Celnik P., Claaßen, J et al., 2014. Consensus paper: management of degenerative cerebellar disorders. The Cerebellum, 13(2), pp.248-268.
9. Kandel, E. R., Schwartz, J. H., Jessell, T. M. Eds. Principles of neural science, New York: McGraw Hill: 2000, pp.44.
10. Keller J. L., Bastian A. J., 2014. A home balance exercise program improves walking in people with cerebellar ataxia. Neurorehabilitation and neural repair, 28, pp.770-778.
11. Konczak J., Pierscianek D., Hirsiger S., Bultmann U., Schoch B., Gizewski E. R et al., 2010. Recovery of upper limb function after cerebellar stroke: Lesion symptom mapping and arm kinematics. Stroke. 41(10), pp.2191-200.
12. Lundy Ekman, L. Neuroscience: fundamentals for rehabilitation. Elsevier Health Sciences: 2013. pp.191.
13. Marklund I, Klassbo M., 2006. Effects of lower limb intensive mass practice in poststroke patients: Single-subject experimental design with long-term follow-up. Clinical Rehabilitation. 20, pp.568-576.
14. Marquer A, Barbieri G, Perennou D., 2014. The assessment and treatment of postural disorders in cerebellar ataxia: A systematic review. Annals of Physical and Rehabilitation Medicine, 57(2), pp.67-78.
15. Miyai I., 2012. Challenge of neurorehabilitation for cerebellar degenerative diseases. The Cerebellum, 11(2), pp.436-437.
16. Morton S. M., Bastian A. J., 2003. Relative contributions of balance and voluntary leg coordination deficits to cerebellar gait ataxia. Journal of Neurophysiology, 89, pp.1844-1856.
17. Morton S. M., Tseng Y. M., Zackowski K. M., Daline J. R., Bastian A. J., 2010. Longitudinal tracking of gait and balance impairments in cerebellar disease. Movement Disorder, 25(12), pp.1944-1952.
18. Morton, S. M., & Bastian, A. J., 2004. Cerebellar control of balance and locomotion. The Neuroscientist, 10(3), pp.247-259.
19. Morton, S. M., Bastian, A. J., 2006. Cerebellar contributions to locomotor adaptations during splitbelt treadmill walking. The Journal of neuroscience, 26(36), pp.9107-9116.

Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 1, 2021, Pages. 1757 - 1769
Received 15 December 2020; Accepted 05 January 2021.

20. Ottenbacher K. J. Evaluating Clinical Change: Strategies for Occupational and Physical Therapists. Baltimore. MD: Williams & Wilkins:1986, pp.63.
21. Raine S, Mezdows L, LynchEllerington M. The Bobath Concept: Theory and clinical pratice in neurological rehabilitation. Wiley-Blackwell: 2013, pp.116.
22. Saleh S, Bagce H, Qiu Q et al., 2011. Mechanisms of neuralreorganization in chronic stroke subjects after virtual reality training. Conf Proc IEEE Eng Med Biol Soc. pp.8118-21.
23. Seo T. H., Yang S. E., Lee H. G., 2018. The Effects of Contact Hand-Orientation Response(CHOR) During Sit-to-stand(STS) in People with Stroke. The Journal of Korean Society for Neurotherapy, 22(3), pp.31-36
24. Shumway Cook, A., Horak, F. B., 1990. Rehabilitation strategies for patients with vestibular deficits. Neurologic clinics, 8(2), pp.441-457.
25. Shumway Cook, A., Woollacott, M. H. Motor control : Theory and practical applications (second edition), Baltimore : Williams & Wilkins: 2001, pp.25.
26. Spencer R. M. C., Ivry R. B., 2008. Sequence Learning is preserved in individuals with cerebellar degeneration when the movements are directly cued. Journal of cognitive Neuroscience, 21(7), pp.1302-1310.
27. Srivastava A, Taly A. B, Gupta A et al., 2009. Post-stroke balance training: role of force platform with visual feedback technique. J Neurol Sci, 287(1-2), pp.89-93.
28. Ye B. S., Kim Y. D., Nam H. S., Lee H. S, Nam C. M., Heo J. H., 2010. Clinical manifestations of cerebellar infarction according to specific lobular involvement. Cerebellum, 9(4), pp.571-9.