**THE EFFECTS OF METRONOME AND CORE STRENGHTENING EXERCISE TO IMPROVE DYNAMIC BALANCE AND GAIT IN HEMIPARESIS PATIENTS**

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  **ABSTRACT**

BACKGROUND:

‘Hemiparesis is the third most common cause of death in the Western Hemisphere and the most common cause of adult disability; of the survivors, about 50% will have a significant long-term disability. Balance problems are thought to be common after Hemiparesis, and they have been implicated in the poor recovery of activities of daily living (ADL) and mobility and an increased risk of falls. For this reason, one of the primary goals of rehabilitation for Hemiparesis patients is to restore mobility through gait training. Where The use of an auditory rhythm, such as a metronome, has been investigated as a means to improve hemiparetic gait and also another term Core strengthening has been rediscovered in rehabilitation. Particular attention has been paid to the core because it serves as a muscular corset that works as a unit to stabilize the body and spine, with and without limb movement. In short, the core serves as the centre of the functional kinetic chain.

METHODOLOGY:

Study will conduct in two groups, in the group A (20 subjects) patients will perform core strengthening which improves dynamic balance and gait along with metronome balance and gait training and general dynamic balance and gait training exercises and in other group, this group B (20 subjects) patients will only perform all the core strengthening and general dynamic balance and gait training exercises at last we will compare the both groups and see in which group we get positive results. The duration of this study will be of 8 weeks and data will be collected on day 1, day 15, day 45 and day 60 (4 times) of the duration period. To test and to reach the conclusion we will take timed Up and Go test and Tinetti gait and balance score as an outcome measure

RESULTS:

Interpretation of results shows that patients with balance and gait problem due to Hemiparesis shown improvement in the metronome training and core strengthening exercise when put on both TUG and TINETTI with p value 0.00.

CONCLUSION:

The present study revealed both the techniques Metronome and Core strengthening are effective in improving balance and gait in Hemiparesis patients. But if we compare metronome with core strengthening and core strengthening alone, metronome with core strengthening is better technique to improve balance and gait in Hemiparesis patients.

Key Words: Hemiparesis, Metronome, Core strengthening, Tinetti, TUG.

**INTRODUCTION**

A Hemiparesis is the rapidly developing loss of brain function due to a disturbance in the blood supply to the brain. This can be due to ischemia caused by blockage or due to a hemorrhage. After a Hemiparesis, motor, sensory, perceptual, or cognitive deficits may occur, and these impairments can have various impacts on individual functioning through generation of disabilities and affect rehabilitation potential (1). Hemiparesis survivors have difficulty in balance and postural control for standing upright because they are impaired by asymmetric posture, abnormal body imbalance, and deficit of weight transfer .Previous studies have demonstrated the particular importance of trunk control in stable walking and decreasing falling risk in Hemiparesis patients. (2)

Hemiparesis is the third most common cause of death in the Western Hemisphere and the most common cause of adult disability; (3) of the survivors, about 50% will have a significant long-term disability. (4) Balance problems are thought to be common after Hemiparesis, and they have been implicated in the poor recovery of activities of daily living (ADL) and mobility and an increased risk of falls. (4,5) Despite these data, there is little detailed information about balance problems.

One factor that contributes to this lack of information is a lack of clarity in the language used to describe balance difficulties. The terms “balance,” “balance reactions,” “postural reactions,” “postural control,” “posture,” and “equilibrium” are used interchangeably, but there are neither commonly accepted definitions for these terms nor any consistency in the way in which they are used(6).

Recent data indicates that over 30 million people in the world have experienced and survived Hemiparesis. Despite recent advances in medical and rehabilitation sciences, many individuals have residual walking disability after Hemiparesis, which has long- lasting implications for quality of life and ability to participate in activities of daily living. Hemiparetic gait is characterised by several specific deficits, including decreased walking speed, increased variability, and asymmetrical stepping. Understanding and rehabilitating these features of hemiparetic gait are of paramount importance as walking affords a considerable level of independence and thus a better quality of life for many Hemiparesis survivors(7).

The study of the neurobiology of rhythm was also the first area in which new research insights helped to establish a new role for music in rehabilitation, moving from a more social science and cultural value driven approach that emphasized ‘well-being’ and ‘relationship to motor projections, finding rich connections between primary and secondary auditory cortices and motor cortex. In a MEG-study investigating motor synchronization (finger tapping) to tempo shifts in metronome cues above and below the level of conscious awareness (Tecchio, Salustri, Thaut, Pasqualetti, & Rossini, 2000(8). Other lines of research, especially from psychophysics, have shown that auditory (musical) rhythm may be a useful stimulus to cue motor function, due to the speed and high resolution of time processing in the auditory system. Taken together, conceptual understanding of these research findings has converged on an oscillatorentrainment model where rhythmic processes in neural motor networks become entrained to rhythmic timekeeper networks in the auditory system. The timekeeper networks are driven peripherally from rhythmic inputs, such as metronome or music.(16). For this reason, one of the primary goals of rehabilitation for Hemiparesis patients is to restore mobility through gait training.(10-11)

RAS is a training method that enhances motor skills by providing rhythmic stimulation to the motor center of the brain. The stride, gait speed, and symmetry of Hemiparesis patients trained with rhythmic auditory stimulation were found to increase. The effect of gait training with rhythmic auditory stimulation was proved through previous papers.’(10-11)

This notion is supported by cognitive neuro imaging findings; motor areas to be active when people—musicians or non-musicians—listen to musicalrhythms. Thus, rhythm perception, possibly also facilitated by rich connectivity between cerebral auditory and motor systems, has been described as a ‘backdoor’ into the motor system and a means to improve efficiency in movement (re-)learning. When considering how rhythm may impact movement, the relevant terms must first be specified. Generally, a ‘note’ or ‘event’ is a single sound, whereas a ‘rhythm’ or ‘rhythmic pattern’ is a combination of durations created by a group of notes. Such a pattern may explicitly or implicitly fit onto a temporal grid of equally spaced intervals, leading to an isochronous ‘beat’ or ‘pulse’, to which a listener can align their movement. The simplest example is an isochronous stimulus train, or metronome, presenting sound events at equally spaced time intervals, thus coinciding perfectly with the beat. However, in a rhythm with temporally unequally spaced notes, listeners will generally still infer an under lying is ochronous beat also called beat induction, allowing isochronous periodic movements to auditory rhythms.(12-15)

METHODOLOGY

It is a Randomized controlled trial in which data will be collected from Community dwellers which are eligible as per inclusion criteria. A total of 40 subjects both male and female were included for study. Simple random sampling technique was used for data collection.GBH General Hospital & GBH Memorial Cancer Hospital, Udaipur.

 Inclusion Criteria:

• Age group: - 45-60 years of age. (only right hemiplegic)

• 6months after Hemiparesis, walking disability but retained ability to stand and transfer.

• Grade of spasticity: - 2 (modified ashwarth scale)

• Synergy type: - Extension synergy.

Exclusion Criteria:

• Cognitive impairments preventing understanding of the task or hearing impairments reducing ability to hear the metronome.

• Cardiovascular or cardiopulmonary problems.

• Orthopedic conditions

• Use of walking aids.

Outcome Measures

 Timed up and go test

 Tinetti test

PROCEDURE

• 40 subjects were randomly assigned in 2 groups.

• Each group consisting of Male and Female subjects randomly.

• For Group A: metronome dynamic balance and gait training with core strengthening exercise with general dynamic balance and gait training.

• For Group B: core strengthening exercise with general dynamic balance and gait training.

Study were conduct in two groups, in the group A patients were performed core strengthening which improves dynamic balance and gait along with metronome balance and gait training and general dynamic balance and gait training exercises and in other group, this groupB patients will only perform all the core strengthening and general dynamic balance and gait training exercises at last we will compare the both groups and see in which group we get positive results.

The duration of this study was of 8 weeks and data collected on day 1, day 30, day 60 and day 90 (4 times) of the duration period.

To test and to reach the conclusion we took timed up and Go test and Tinetti gait and balance score as an outcome measure.

**Procedure:**

Group A: 20 (subjects) metronome training with core strengthening exercise and general dynamic balance and gait training exercises.

Core Strengthening Exercises:

1) Bridging: Bridging exercise, a closed chain weight baring exercise, is an exercise which increases muscular strength of the hip extensors and promotes trunk stability.The patient lies on its back witch the feet flat on the ground and with the flexion of the knees. Then the patient lifts his/her hip from the ground.

2) Knee Rolling: Lay on your back with your hands resting at your side. Bend your knees and place your feet flat on the floor. Roll your hips so that your knees push to the left, then to the right, then back to center. Repeat 10-20 times.

3) Single Leg Drop-Outs: Lay on the floor with the hips and feet flat with the knees bent. Keep the pelvis still, using the hands to keep it in place if needed. Inhale, and drop the left knee to the left, as far as possible without lifting the pelvis, keeping the knee bent. Exhale, and draw the knee back in. Repeat 5 times per side.

4) Single Leg Bridging: Lay on the exercise mat and place one leg flat on the floor with the knee bent. Place the other leg on an exercise ball. Using the core muscles, lift the pelvis off the mat and slowly lower back down. Repeat for 10 repetitions, then switch legs.

5) Four-Point Kneeling: Kneel on the ground and place your hands flat on the ground so you are in a crawling stance. Contract the pelvic floor and raise one leg while lifting the opposite arm. Hold for a few seconds, and return to the starting position, repeating with the opposite arm and leg. Repeat for two to three sets of 10 reps each.

**General Dynamic Balance A Gait Training Exercise: -**

6) Heel Raises (Holding On): Find a sturdy chair or countertop you can hold onto for support. Hold onto the chair or counter, and raise yourself up onto your tiptoes, keeping your knees straight and holding your upper body tall. Lower yourself back to the floor slowly and repeat.

7) Side Stepping (Holding On):Use a counter or ledge to hold on to or ask someone to give you a hand to hold for balance. Place tape on the floor in a straight line. Step sideways to cross the line, crossing one leg across the front of the other leg. Reverse the motion to return to the starting point, this time crossing a leg behind.

8) Single Leg Standing:Place both feet flat on the floor. Slowly lift one leg until you are balanced on the other leg. Hold for a count of 10, and slowly lower it back down. Alternate legs and repeat.

9) Backwards Walking: In a room that is free from obstacles, walk backwards slowly. Try to avoid looking where you are going but use your sense of balance and slow movements to avoid a fall. At first, perform this exercise with something close by to hold onto like a wall or countertop until you gain confidence in your abilities.

Timed up And go Test:- On the command of go patient 3 meters at comfortable and safe pace, turns and walk back to point where they have started.

DATA ANALYSIS

This study aimed to compare the analysis of Cupping therapy and MFR for management of chronic knee pain in badminton players. The researchers used statistical tools such as paired unpaired t-tests to analyze the data. Collected data on two different days: Days 0 and 60 day

By comparing the pre-test and post-test values, they found differences in the mean values of the VAS and KOOS between the two groups. The researcher analyzed and interpreted the significance of these differences using the t-values obtained from the tests. The statistical tools used for analysis were paired and unpaired "t" test.

## RESULTS

Data was analyzed using T test. A total of 40 subjects (Male and female) were recruited in our study. Descriptive analysis was done for functional effectiveness of pre and post treatment for chronic Hemiparesis patients. Significant increase was found in group A (metronome training with core strengthening exercise).

Table 6.1 : Descriptive Statistics of Mean, Std Deviation for Treatment of Tinetti Group Statistics

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| TINETTI | N | Mean | Std.Deviation | Std. Error Mean |
| Tinetti :A (metronome training with core strengthening)B (core strengthening) | 20 | 22.3000 | 1.04378 | .23340 |
| 20 | 18.3500 | 1.42672 | .31902 |

Table 6.2 : Descriptive Statistics of Mean, Std Deviation for Treatment of Tinetti Group Statistics

Tinetti -B

20.00

18.30

18.00

16.00

14.00

12.00

10.00

8.00

6.00

4.00

2.00

0.00

A- Meronome Training with Core strengthing

Axis Title

B- Core strengthing

A- Meronome Training with Core strengthing

B- Core strengthing

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| TINETTI | N | Mean | Std.Deviation | Std. Error Mean |
| Tinetti :A (metronome training with core strengthening)B (core strengthening) | 20 | 18.3000 | 1.04378 | .23340 |
| 20 | 14.3500 | 1.42672 | .31902 |

able 6.3 : Descriptive Statistics of Mean, Std Deviation for Treatment of Tug

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Group | N | Mean | Std.Deviation | Std. Error Mean |
| Tug test | B (core strengthening) | 20 | 12.3963 | .68807 | .15386 |
| A (metronome training with core strengthing) | 20 | 11.4462 | .81379 | .18197 |

Table 6.3 : Descriptive Statistics of Paired Differences, T-Test, Df & P Value of Tinetti Shows Significance.

Independent Samples Test

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Levene's Test for Equality ofVariances | t-test for Equality of Means |
| F | Sig. | T | df | Sig. (2-tailed) | Mean Differe- nce | Std. ErrorDiffer- ence | 95% Confidence Interval of theDifference |
| Lower | Upper |
| Tinetti | Equal variancesassumed | 1.863 | .180 | 9.993 | 38 | .000 | 3.95000 | .39528 | 3.14979 | 4.75021 |
| Equalvariances not assumed |  |  | 9.993 | 35 | .000 | 3.95000 | .39528 | 3.14737 | 4.75263 |

Table 6.4 : Descriptive Statistics of Paired Differences, T-Test, Df & P Value of Tug Shows Significance.

Independent Samples Test

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Levene's Test for Equality of Variances | t-test for Equality of Means |
| F | Sig. | t | Df | Sig. (2-tailed) | Mean Differ- ence | Std. Error Differ- ence | 95% Confidence Interval of the Difference |
| Lower | Upper |
|  | Equal |  |  |  |  |  |  |  |  |  |
|  | variances | .744 | .394 | 3.987 | 38 | .00015 | .95000 | .23830 | .46760 | 1.43240 |
| Tug | assumed |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |
| Test | Equal |  |  |  |  |  |  |  |
|  | variancesnot | 3.987 | 37 | .00015 | .95000 | .23830 | .46716 | 1.43284 |
|  | assumed |  |  |  |  |  |  |  |

## DISCUSSION

The result of the present study reported that the metronome gait training is useful for Hemiparesis. Though improvement was also seen in the other group receiving conventional physiotherapy (group B) but improvement in core strengthing & gait training was more in Group A.

The overall study proved that both core strengthening and metronome training is effective in improving balance and gait in Hemiparesis patients. Data from this study provided support for contention that both core strengthening as well as metronome training were beneficial for individuals with Hemiparesis. Furthermore, timed up and co test and tinetti test both support the contention that both core strengthening and metronome training can improve balance and gait in Hemiparesis patients. Present study showed significant changes in TUG and in both the intervention groups between pre-& post treatment. It was found that differences in mean for TUG & TINETTI for both the groups were statically significant (p < 0.05). t-test for group A showed statically significant results indicating improvement in TUG and TINETTI (that means improvement in balance & gait for Hemiparesis patients).

Janice J. Eng, Kelly S.Chu, (2002), Ratings of perceived exertion are generally believed to be valid and reliable markers of physiological intensity during exercise and are recommended to monitor exercise intensity. Severely impaired subjects perceive greater exertion. (67)

In the study conducted there were high levels of exertion and increased HR observed in older people as compared to the young population.

During high levels of exertion there is a decrease in spo2 level and increase in heart rate.

The variables chosen for monitoring were HR, SBP, DBP and SPO2 as indicators of hemodynamic response. Termination criteria was implemented according to the RPE scale for monitoring the exertion which helps to terminate the exercises and start relaxing the patient.

Elizabeth Inness, Anthony Aqui (2020), the use of termination criteria and appropriate monitoring of the patients’ responses for deciding that patients would be prescribed exercise intensities beyond the threshold of these changes. Therefore, in the absence of access to ECG, submaximal exercise testing may allow physical therapists to safely initiate AE early after stroke. (68)

Dr. Poojakumari Sah, Dr. Anjali Bhise, et al. (May-2020). The study has shown its effectiveness in improving cardiovascular endurance and reducing fatigue in elderly through chair based aerobic exercise. It provides a safe and accessible form of exercise for a vulnerable population who cannot participate safely in other forms of exercise because it is not too metabolically demanding so that it can be continued for a period of time long enough to stimulate aerobic adaptation. (25)

Soniya T. Lohana, Trupti Yadav, et al. (2020), Study shows that physical activity can boost self-esteem, mood, quality of sleep and energy, and reduce the risk of stress, anxiety and various other disorders because regular aerobic exercise appears to boost the size of the hippocampus, thereby improving verbal memory and learning along with numerous physiological effects seen in various systems of the body. (24)

There is an increase in cardiopulmonary responses. An increase in physical fitness will reduce the risk of premature death, while modest enhancements in physical fitness in previously sedentary people have been associated with large improvements in health status. (24)

Julie A. Rummel, et al. (1996), Seated aerobic exercise enhances body coordination, balance, postural correction and helping to reduce muscle spasticity in disabled individuals, because this increases total body circulation and promotes overall fitness, which assists in lower limb injury rehabilitation by providing a cross training effect in untrained limbs. And also, these exercises are convenient to do and most individuals have performed in their lives. (23)There is improvement in cardiopulmonary response & cardiovascular endurance, reducing fatigue and increase physical fitness. Healthy lifestyle can be seen with the help of slightest in physical fitness of the individual. It can augment or uplift self- esteem, mood, quality of sleep, quality of life. Seated aerobic exercise can improves body co-ordination, balance, postural correction, enhancement in the total systemic circulation and it also encourages overall fitness.Thus, Analysis from the results concluded that the Chairobic exercise was effective for hemiparesis patients.

## REFERENCE

1. Bamford J, Sandercock P, Dennis M, Warlow C. Classification and natural history of clinically identifiable subtypes of cerebral infarction. Lancet 1991, 337 1521-6
2. *St Thomas Hospitals School of Medicine, London, UK*
3. Sims NR, Muyderman H: Mitochondria, oxidative metabolism and cell death in Hemiparesis. Biochim Biophys Acta, 2010, 1802: 80–91.
4. Mercier L, Audet T, Hebert R, et al.: Impact of motor, cognitive and perceptual disorders on ability to perform activities of daily living after Hemiparesis. Hemiparesis, 2001, 32: 2602–2608. [Medline] [CrossRef]
5. Carr JH, Shepherd RB: Investigation of a new motor assessment scale for Hemiparesis patient. Phsy Ther, 1985, 65: 175–180.
6. Charness A: Hemiparesis /Head Injury. Rockville: Aspen, 1986.
7. Neckel ND, Blonien N, Nichols D, et al.: Abnormal joint torque patterns exhibited by chronic Hemiparesis subjects while walking with a prescribed physiological gait pattern. J Neuroeng Rehabil, 2008, 5: 19.
8. Hsieh CL, Sheu CF, Hsueh IP, et al.: Trunk control as an early predictor of comprehensive activities of daily living function in Hemiparesis patients. Hemiparesis, 2002, 33: 2626–2630. [Medline] [CrossRef]
9. Secretary of State for Health. *Saving Lives: Our Healthier Nation*. London, United Kingdom: The Stationery Office; 1999.
10. Wolfe CD. The impact of Hemiparesis. *Br Med Bull*. 2000;56:275–286.
11. Loewen SC, Anderson BA. Predictors of Hemiparesis outcome using objective measurement scales. *Hemiparesis*. 1990;21:78–81.
12. Kwakkel G, Wagenaar RC, Kollen BJ, Lankhorst GJ. Predicting disability in Hemiparesis : a critical review of the literature. *Age Ageing*. 1996; 25:476– 489.
13. Lamb SE, Ferrucci L, Volapto S, et al. Risk factors for falling in home- dwelling older women with Hemiparesis . *Hemiparesis*. 2003;34:494–501.
14. Lofgren B, Nyberg L, Osterlind O, Gustafson Y. In-patient rehabilitation after Hemiparesis : outcome and factors associated with improvement. *Disabil Rehabil*. 1998;20:55– 61.
15. Corriveau H, Hebert R, Raiche M, Prince F. Evaluation of postural stability in the elderly with Hemiparesis. *Arch Phys Med Rehabil*. 2004; 85: 1095–1101.
16. De Haart M, Geurts A, Huidekoper S, et al. Recovery of standing balance in post-acute Hemiparesis patients: a rehabilitation cohort study. *Arch Phys Med Rehabil*. 2004; 85: 886–895.
17. Lamontagne A, Paquet N, Fung J. Postural adjustments to voluntary head motions during standing are modified following Hemiparesis. *Clin Biomech*. 2003; 18: 832– 842.
18. Ikai T, Kamikubo T, Takehara I, et al. Dynamic postural control of patients with hemiparesis. *Am J Phys Med Rehabil*. 2003; 82:463–469.
19. Horstmann S., Koziol J.A., Martinez-Torres F, et al.: Sonographic monitoring of mass effect in Hemiparesis patients treated with hypothermia. Correlation with intracranial pressure and matrix metalloproteinase 2 and 9 expression. J Neurol Sci, 2009, 276: 75–78. [Medline] [CrossRef]
20. Thom T, Haase N, Rosamond W, et al. American Heart Association Statistics Committee and Hemiparesis Statistics Subcommittee: Heart disease and Hemiparesis statistics—2006 update: a report from the American Heart Association Statistics Committee and Hemiparesis Statistics Subcommittee. Circulation, 2006, 113: e85–e151.
21. Cho K, Yu J, Jung J: Effects of virtual reality-based rehabilitation on upper extremity function and visual perception in Hemiparesis patients: a randomized control trial. J Phys Ther Sci, 2012, 24: 1205–1208. [CrossRef]
22. Yoo HN, Chung E, Lee BH: The effects of augmented reality-based Otago exercise on balance, gait, and falls efficacy of elderly women. J Phys Ther Sci, 2013, 25: 797–801. [Medline] [CrossRef]
23. Roerdink M, Bank PJ, Peper CL, et al.: Walking to the beat of different drums: practical implications for the use of acoustic rhythms in gait rehabilitation. Gait Posture, 2011, 33: 690–694. [Medline] [CrossRef]
24. Thaut MH, McIntosh GC, Rice RR: Rhythmic facilitation of gait training in hemiparetic Hemiparesis rehabilitation. J Neurol Sci, 1997, 151: 207–212. [Medline] [CrossRef]
25. Schubotz RI, Friederici AD, Von Cramon DY. 2000 Time perception and motor timing: a common cortical and subcortical basis revealed by fMRI. Neuroimage 11, 1–12. (doi:10.1006/nimg.1999.0514
26. Ivry RB. 1996 The representation of temporal information in perception and motor control. Curr. Opin. Neurobiol. 6, 851–857. (doi:10.101 6/S0959-)
27. Grahn JA, Brett M. 2007 Rhythm and beat perception in motor areas of the brain. J. Cogn. Neurosci. 19, 893–906. (doi:10.1162/jocn. 2007.19.5.893)
28. 4. Chen JL, Penhune VB, Zatorre RJ. 2008 Listening to musical rhythms recruits motor regions of the brain. Cereb. Cortex 18, 2844–2854. (doi:10.1093/cercor/ bhn042)
29. 5. Thaut MH. 2005 Rhythm, music and the brain. New York, NY: Taylor & Francis.
30. 6. Honing H. 2012. Without it no music: beat induction as a fundamental musical trait. Ann. NY Acad. Sci. 1252, 85–91. (doi:10.1111/j.1749- 6632.2011.
31. Whitall J, Waller SM, Silver KHC, Macko RF. 2000 Repetitive bilateral arm training with rhythmic auditory cueing improves motor function in chronic hemiparetic Hemiparesis. Hemiparesis 31, 2390–2395.
32. Edlow JA, Newman-Toker DE, Savitz SI. Diagnosis and initial management of cerebellar infarction. *Lancet Neurol* (2008) 7(10):951–64. doi:10.1016
33. Kase CS, Norrving B, Levine SR, Babikian VL, Chodosh EH, Wolf PA, et al. Cerebellar infarction. Clinical and anatomic observations in 66 cases. *Hemiparesis* (1993) 24(1):76–83. doi:10.1161/01.STR.24.1.76
34. Ebersbach G, Sojer M, Valldeoriola F, Wissel J, Muller J, Tolosa E, et al. Comparative analysis of gait in Parkinson’s disease, cerebellar ataxia and subcortical arteriosclerotic encephalopathy. *Brain* (1999) 122:1349–55. doi:10.1093/brain/122.7.1349
35. Stolze H, Klebe S, Petersen G, Raethjen J, Wenzelburger R, Witt K, et al. Typical features of cerebellar ataxic gait. *J Neurol Neurosurg Psychiatry* (2002)
36. Ilg W, Timmann D. Gait ataxia – specific cerebellar influences and their rehabilitation. *Mov Disord*(2013) 28(11):1566–75. doi:10.1002/mds.25558
37. Hausdorff JM, Rios DA, Edelberg HK. Gait variability and fall risk in community-living older adults: a 1-year prospective study. *Arch Phys Med Rehabil*2001)
38. Hamacher D, Singh NB, Van Dieen JH, Heller MO, Taylor WR. Kinematic measures for assessing gait stability in elderly individuals: a systematic review. *J R Soc Interface* (2011) 8(65):1682–98. doi:10.1098/rsif.2011.0416
39. Brach JS, Studenski SA, Perera S, Van Swearingen JA, Newman AB. Gait variability and the risk of incident mobility disability in community-dwelling older adults. *J Gerontol A Biol Sci Med Sci* (2007) 62(9):983–8. doi:10.1093
40. Callisaya ML, Blizzard L, Schmidt MD, Martin KL, McGinley JL, Sanders LM, et al. Gait, gait variability and the risk of multiple incident falls in older

people: a population-based study. *Age Ageing* (2011) 40(4):481–7. doi:10.1093/ageing)

1. Schniepp R, Wuehr M, Schlick C, Huth S, Pradhan C, Dieterich M, et al. In crea-sedgait variability is associated with the history of falls in patients with cerebellar ataxia. *J Neurol* (2014) 261(1):213–23. doi:10.1007/s00415-013- 7189-3
2. Zijlstra GAR, van Haastregt JCM, van Eijk JTM, van Rossum E, Stalenhoef PA, Kempen GIJM. Prevalence and correlates of fear of falling, and associated avoidance of activity in the general population of community-living older people. *Age Ageing* (2007) 36:304–9. doi:10.1093/ageing/afm021
3. Delbaere K, Close JC, Brodaty H, Sachdev P, Lord SR. Determinants of disparities between perceived and physiological risk of falling among elderly people: cohort study. *BMJ* (2010)
4. Richardson C, Jull G, Hodges P, et al.: Therapeutic exercise for spinal segmental stabilization in low back pain: scientific basis and clinical approach. Edinburgh: Churchill Livingstone, 1999.
5. Akuthota V, Nadler SF: Core strengthening. Arch Phys Med Rehabil, 2004, 85: S86–S92. [Medline] [CrossRef]
6. Cholewicki J, Polzhofer GK, Radebold A: Postural control of trunk during unstable sitting. J Biomech, 2000, 33: 1733–1737. [Medline] [CrossRef]
7. Granata KP, Wilson SE: Trunk posture and spinal stability. Clin Biomech (Bristol, Avon), 2001, 16: 650–659. [Medline] [CrossRef]
8. Forster, A., Szabo, K., Hennerici, M.G.: Pathophysiological concepts of Hemiparesis in hemodynamic risk zones-do hypoperfusion and embolism interact? Nat Clin Pract Neurol. 4(4), 216--225 (2008)
9. Saunders, S.W., Rath, D., Hodges, P.W.: Postural and respiratory activation of the trunk muscles changes with mode and speed of locomotion. Gait Posture. 20(3), 280--290 (2004)
10. Ryerson, S., Byl, N.N., Brown, D.A., Wong, R.A., Hidler, J.M.: Altered trunk position sense and its relation to balance functions in people post-Hemiparesis. J Neurol Phys Ther. 32(1), 14--20 (2008)
11. Jung, W.M.: The effects of group occupational therapy program for improvement of cognitive abilities in mild case of dementia. Society of Occupational Therapy for the Agged and Dementia. 1(1), 46--55 (2007) Stevens, V.K., Coorevits, P.L., Bouche, K.G., Mahieu, N.N., Vanderstraeten, G.G., Danneels, L.A.: The influence of specific training on trunk muscle recruitment patterns in healthy subjects during stabilization exercise. Man Ther. 12(3), 271--279 (2007)
12. Bohannon, R.W.: Recovery and correlates of trunk muscle strength after stoke. Int J Rehabil Res. 18(2), 162--167 (1995)
13. Macko, R.F., Ivey, F.M., Forrester, L.W., Hanley, D.J., Sorkin, D., Katzel, L.I., Silver, K.H., Goldberg, A.P.: Treadmill exercise rehabilitation improves ambulatory function and cardiovascular fitness in patients with chronic Hemiparesis : a randomized, controlled trial. Hemiparesis. 36(10), 2206--2211 (2005)
14. De Almeida, I.C., Clementino, A.C., Rocha, E.H., Brandao, D.C., Dornelas de Andrade, A.: Effects of hemiplegic on pulmonary function and diaphragmatic dome displacement. Respir PhysiolNeurobiol. 178(2), 196--201 (2011)
15. Rhythmic Auditory Stimulation In Rehabilitation Of Movement Disorders: A Review Of Current Research (2009)
16. Rachel L. Wright, Afia Masood, Elinor S. MacCormac, David Pratt:- Metronome-Cued Stepping in Place after Hemiparetic Hemiparesis : Comparison of a One- and Two-Tone Beat(2013)
17. Eun-Jung Chung, PT, PhD1), Jung-Hee Kim, PT, MSc1), Byoung-HeeLee, PT, PhD1) The Effects of Core Stabilization Exercise on Dynamic Balance and Gait Function in Hemiparesis Patients (2013).
18. Jung-Hee Kim, PT, MSc1), Sung-Gook Park, PT1), Hyun-Jung Lim, PTEffects of the Combination of Rhythmic Auditory Stimulation and Task- oriented Training on Functional Recovery of Subacute Hemiparesis Patients(2012)
19. Gui-bin Song, PhD, PT1), Hyo Jeong Ryu, PhD, PT2)\* Effects of gait training with rhythmic auditory stimulation on gait ability in Hemiparesis patients (2016)
20. Pamela W. Duncan, PhD, FAPTA, Co-Chair; Richard Zorowitz, MD, Co- Chair; Barbara Bates, MD Management of Adult Hemiparesis Rehabilitation Care A Clinical Practice Guideline\*(2005)
21. GERBEN DEJONG, PH.D. \* AND LAURENCE G. BRANCH, PH.D. Predicting the Hemiparesis Patient's Ability to Live Independently(1982)
22. Kyung Yoon Kim1, Sung Pil Chun2, Tea Gyung Kang3, Gi Do Kim4Effects of Core Stability Training on Postural Control Ability and Respiratory Function in Chronic Hemiparesis Patients(2015)
23. Katherine J Sullivan, David A Brown, Tara Klassen, Sara Mulroy, Tingting Ge, Effects of Task-Specific Locomotor and Strength Training in Adults Who Were Ambulatory After Hemiparesis : Results of the STEPS Randomized Clinical Trial
24. Jin Soo Lee, MSc, PT1), Hong Gyun Lee, PhD, PT2)\* Effects of Sling Exercise Therapy on Trunk Muscle Activation and Balance in Chronic Hemiplegic Patients(2014)
25. Junsang Yoo, PT, Msc1), JuriJeong, PT, Msc1), Wanhee Lee, PT, PhD1)\* The Effect of Trunk Stabilization Exercise Using an Unstable Surface on the Abdominal Muscle Structure and Balance of Hemiparesis Patients(2014)
26. Charles D A Wolfe The impact of Hemiparesis (2000)
27. *Sarah F Tyson, Marie Hanley, Jay Chillala, Andrea Selley, Raymond C Tallis*

Balance Disability After Hemiparesis (2006)

1. *Mirjam de Haart, MD, Alexander C. Geurts, MD, PhD, Steven C. Huidekoper, PT, Luciano Fasotti, PhD* Recovery of Standing Balance in Postacute Hemiparesis Patients: A Rehabilitation Cohort Study(2004)
2. Melvyn Roerdink\*, Paulina J.M. Bank, C. (Lieke) E. Peper, Peter J. Beek Walking to the beat of different drums: Practical implications for the use of acoustic rhythms in gait rehabilitation(2011)
3. Rebecca S. Schaefer Auditory rhythmic cueing in movement rehabilitation: findings and possible mechanisms(2014)
4. Joyce L. Chen1,3, Virginia B. Penhune2,3 and Robert J. Zatorre1, Listening to Musical Rhythms Recruits Motor Regions of the Brain(2008)
5. *Rachel L. Wright1, 2\*, Joseph W. Bevins3, David Pratt4, Catherine M. Sackley5* Metronome Cueing of Walking Reduces Gait Variability after a Cerebellar Hemiparesis (2016)
6. Yuri Cha1), Young Kim1), Yijung Chung2) Immediate Effects of Rhythmic Auditory Stimulation with Tempo Changes on Gait in Hemiparesis Patients(2014)
7. Shanthi Mendis Hemiparesis disability and rehabilitation of Hemiparesis : World Health Organization perspective (2012)