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Effectiveness of vestibular stimulation exercise and neuromuscular exercise on balance and lower extremity functional activities in subject with down syndrome-single case study

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Abstract

Background: Down syndrome is the genetic condition characterized by chromosomal abnormality where there is an extra copy of chromosome 21.

Objective: The study's primary objective is to find out the effectiveness of the vestibular stimulation exercise and neuromuscular exercise on balance and lower extremity functional activities in subject with Down syndrome.

Subject and Methodology: The single subject with Down syndrome was taken in this study. The subject received vestibular stimulation exercise and neuromuscular exercise as a treatment. The subject received the intervention for 1 hour per sessions, 5 days in a week for 8 weeks. The pre and post score values of balance was measured by using Berg balance scale, the lower extremity functional activities is measured using Lower Extremity Functional Scale. The data was recorded for statistical analysis.

Result: The pre and post-test was taken with in between test at the end of every two weeks. The pre-test and post-test values of Berg Balance Scale is 27 and 41, Lower Extremity Functional Scale is 40 & 65. Statistical analysis shows significant improvement in balance after 8 weeks of vestibular stimulation exercise and neuromuscular exercise program.

Conclusion: The study concluded that there was statistically significant improvement in the effectiveness of vestibular stimulation exercise and neuromuscular exercise on balance and lower extremity functional activities in subject with Down syndrome.

Clinical implications: Vestibular apparatus stimulation is combined with the neuromuscular exercise shows significant effect on balance and lower extremity functional activities in Down syndrome subject.

Keywords: Down syndrome (DS), vestibular stimulation exercise, neuromuscular exercise, balance, lower extremity functional activities

Introduction

Down syndrome is the most common type of genetic disorder ^[1]. It is a condition in which an individual has an extra chromosome. Chromosomes are small "packages" of genes in the body. The chromosomes determine the baby's body structures and their function as it grow during pregnancy and after birth. Typically, a child is born with a 46 chromosomes. Babies with Down syndrome have an extra copy of one of these chromosomes, i.e., chromosome 21. Down syndrome is also referred to as trisomy 21. Children with this condition will have a small sized brainstem and delayed cerebral maturation ^[2]. This extra copy changes the child's body structure and brain develop, which can cause both mental and physical challenges for the child.

This condition is characterized primarily by variable intellectual disability and peculiar physical features like distinct facial phenotype, short neck and generalized joint laxity and hypo-tonic, etc., ^[3]. Hypo-tonicity causes flaccidity of muscles and hyper-mobility in joints, compromising the joints and muscles function and delay in developing gross motor skills, poor balance, and co-ordination ^[4, 5].

Down syndrome is characterized by several clinical symptoms which include orthopedic, cardiovascular, neuromuscular, visual, cognitive and perceptual impairments. It is the most common genetic cause of developmental disability and affects both the gross motor and fine motor skills of children.

Several studies have demonstrated that individual's with Down syndrome have deficits in eye-hand coordination, visual motor control, strength, balance and co-ordination, motor learning [6-13].

World Health Organization (WHO) documents the global incidence of children with Down syndrome to be 1 out of 600 - 1000 live births. In UK alone, there are approximately 40,000 people living with Down syndrome and 750 new born with Down syndrome each year [14].

Balance disorder is the common for children with Down syndrome to be delayed in reaching common milestones such as sitting independently, standing and walking. One of the contributing factors to the delay of these specific milestones is poor balance.

It is well known that persons with Down syndrome are often considered floppy, clumsy, uncoordinated and have awkward movement patterns due to balance issues. These balance challenges often follow the child into the teen years and sometimes into adulthood [15].

While impaired balance is difficult on its own, it may also impact the development of other motor abilities and cognitive development. Being able to maintain balance allows for exploration, social interaction and overall freedom [16].

Lower extremity functional activity is the main function of the lower limb is to support the weight of the body and acts as a lever to propel the body forward [17]. Lower extremity strength and coordination are areas of development needed for many functional tasks that children complete throughout the day. By developing the gross motor coordination by building strength in the legs and the core of the body so that lower extremity coordination and mobility are used in daily tasks such as self-care, mobility, etc. The flaccidity of the muscles and joints make the lower extremity weaken which increases the fall of risk in child with Down syndrome. By increasing the strength of the lower limb there will a low or no risk of fall of child with Down syndrome [18].

In recent studies, some investigators in physical medicine and rehabilitation demonstrate the exercise which strengthens the lower extremity is used to improve the subject's balance [19].

The vestibular (apparatus) system is the part of labyrinth or inner ear, plays a major role in maintaining posture and equilibrium through stato-kinetic reflexes, the others parts are considered for hearing [20]. The vestibular stimulation is to improve the central or brain compensation for abnormalities within the vestibular or balance system which is to correct

Functional performance, postural (or) balance, strength of lower extremity, functional stability for knee and trunk. Vestibular exercise merely stimulate the vestibular system to train movements of eyes independent of the head, to practice the balance, head movements that cause dizziness, encourage re-building of confidence in making easy, relaxed, spontaneous movements [21].

Neuromuscular exercise program is aimed at improving sensorimotor control and attaining functional joint stabilisation by addressing the quality of movement in all three dimensional planes [22]. Neuromuscular exercises seeks to improve the unconscious response of muscles to signals related to dynamic joint stability, which is the ability of joint to remain stability during movement execution.

To achieve this neuromuscular exercise improves variables such as muscle strength, flexibility and balance.

Neuromuscular exercise activates neuro-physiological processes of intermuscular coordination that together with increased muscle strength and postural responses, contribute to stability in the execution of motor patterns within the functional repertoire of subject with Down syndrome [23].

Methodology

Study design: A pre test and post test single case study was used with two different interventions to assess the effectiveness of vestibular stimulation exercise and neuromuscular exercise on balance and lower extremity functional activities in subject with Down syndrome.

Subjects: The patient came with the complaints of reduced balance and increased fall of risk in Ashwin multispeciality hospital, Coimbatore. The patient was confirmed to have an Down syndrome and assessed by using Berg Balance Scale and Lower Extremity Functional Scale.

Methods: Vestibular stimulation exercise and the neuromuscular exercise was given for 3 days in a week with 1 hour session for 8 weeks with pre and post test and also with in-between test followed by a home program.

The vestibular stimulation exercise was given for 30 minutes and the neuromuscular exercise was given for 30 minutes which includes totally a 1 hour session per day. The static balance was tested by the Berg Balance Scale, dynamic balance by Star Excursion Balance Test, functional activities of lower extremity by the Lower Extremity Functional Scale, followed by home program with the some functional activities.

Description of experimental technique

Vestibular stimulation exercise

Vestibular exercise merely stimulate the vestibular system to train movements of eyes independent of the head, to practice the balance, head movements that cause dizziness, encourage re-building of confidence in making easy, relaxed, spontaneous movements.

Vestibular stimulation exercise works on the principle of central or brains compensation for injuries or abnormalities within vestibular or balance system. Typically developed individual has an vestibular receptors in inner ear which provides accurate representation of head motion in three dimensions. The information received from the vestibular receptors used by central vestibular pathway to control reflexes and perceptions that are mediated by vestibular system. Brain interprets information gains from the vestibular or balance system. If, it is injured or any abnormality in the development, it leads to sensations that reflect abnormal information about motions from vestibular receptors to brain. Then the brain must be retrained or taught to interpret correctly the information it receives. The vestibular stimulation exercise provides continuous and repetitive proper information about the motion which stimulates vestibular system or receptors. This will merely stimulate vestibular apparatus or system. This stimulation produces information to be processed by the brain. The goal is for the brain to learn to tolerate and accurately interpret by vestibular stimulation.

Neuromuscular exercise

The neuromuscular exercise (NEMEX) program is aimed at improving sensorimotor control and attaining functional joint stabilization by addressing the quality of movement in all three movement planes. Neuromuscular exercise works

on the mechanism of muscular and neural adaptations. Neuromuscular exercise can cause muscle adaptations by increased myofibrillar protein synthesis which results in enlargement of muscle fibers, this leads to increase in muscle size, strength and power through muscular contraction. Neuromuscular exercise cause neural adaptations by increased central drive from higher centers of brain to increase the strength by increase in motor unit synchronization, increase in force threshold and decrease in co activation of antagonist muscles.

Statistical analysis

Data were analysed using Berg Balance Scale [BBS] and Lower Extremity Functional Scale[LEFS] to compare pre and post test scores. The pre-test and post-test values of Berg Balance Scale is 27 and 41, Lower Extremity Functional Scale is 40 & 65.

Results

The pre and post-test was taken with in between test at the end every two weeks. The pre-test and post-test values of Berg Balance Scale is 27 and 41, Star Excursion Balance Test is 0.5 feet and 4 feet, Lower Extremity Functional Scale is 40 & 65. Statistical analysis shows significant improvement in balance after 8 weeks of vestibular stimulation exercise and neuromuscular exercise program.

Table 1: Data analysis of Berg Balance Scale

Berg balance scale	Pre test	End of 2 nd week	End of 4 th week	End of 6 th week	Post test
Score out of 50	27	32	35	39	41

Table 2: Data analysis of lower extremity functional scale

Lower extremity functional scale	Pre test	End of 2 nd week	End of 4 th week	End of 6 th Week	Post test
Score out of 80(20 questions)	40	47	52	59	65

Discussion

Down syndrome (DS) is a genetic disorder attributed to chromosomal abnormality and small sized brainstem, delayed cerebellar maturation. In India, Neuro epidemiological studies demonstrate that the prevalence of Down syndrome was approximately 23,000 – 29,000 children born every year. The majority of children with developed progressive functional disability in balance, which can start early in the diseases and worsens over a lifetime. Vestibular stimulation is one of the key to maintain the body balance.

Sarah Sunderman March 22, 2016 [1] Children with Down Syndrome (DS) are delayed in motor development and coordination which contributes to poor balance. Purpose: The aim of this study was to investigate whether the utilization of vestibular stimulation exercises would influence balance in children with Down syndrome. Eighteen participants completed the study. Group one consisted of 10 (6 male, 4 female) participants with Down syndrome and ranged in age from 5-14 years. Group two consisted of eight (4 male, 4 female) participants with Down syndrome and ranged in age from 15-20 years. Eight subtests of the Bruininks-Oseretsky Test of Motor Proficiency were used for pre and post-testing focusing on

bilateral coordination, balance, running speed and agility, upper limb coordination, and strength. The intervention, the vestibular stimulation exercises, consisted of 15 exercise stations performed 2 times per week for 6 weeks. A trained instructor accompanied each subject during participation to reduce risk of injury. Results indicated that group one had significant improvements in upper limb coordination and speed and agility. Group two showed significant improvements in balance, upper limb coordination, and speed and agility. An early intervention that utilizes vestibular stimulation exercises may improve balance in children with Down syndrome.

Vestibular stimulation exercise works on the principle of central or brain’s compensation for injuries or abnormalities within vestibular or balance system. Typically developed individual has vestibular receptors in inner ear which provides accurate representation of head motion in three dimensions. The information received from the vestibular receptors used by central vestibular pathway to control reflexes and perceptions that are mediated by vestibular system. Brain interprets information gains from the vestibular or balance system.

If it is injured or any abnormality in development, it leads to sensations that reflect abnormal informations about motions from vestibular receptors to brain. Then the brain must be retrained or taught to interpret correctly the information it receives. The vestibular stimulation exercise provides continuous and repetitive proper information about the motion which stimulates vestibular system or receptors. This will merely stimulate vestibular apparatus or system. This stimulation produces information to be processed by the brain. The goal is for the brain to learn to tolerate and accurately interpret by vestibular stimulation.

Neuromuscular exercise works on the mechanism of muscular and neural adaptations. Neuromuscular exercise can cause muscle adaptations by increased myofibrillar protein synthesis which results in enlargement of muscle fibers, this leads to increase in muscle size, strength and power through muscular contraction. Neuromuscular exercise cause neural adaptations by increased central drive from higher centers of brain to increase the strength by increase in motor unit synchronization, increase in force threshold and decrease in co activation of antagonist muscles.

In the present study, the training focuses on the vestibular apparatus or system. The data analysis obtained has significant difference between pre-test and post-test values and found better result in balance and lower extremity functional activities. There was a statistical significant improvement in balance and lower extremity functional activities, hence null hypothesis is rejected and the alternate hypothesis is accepted.

Limitations

1. The study has been conducted as a single case study.
2. The study was a short duration study.
3. Follow up was not done.
4. Long term effects have not been evaluated.
5. Further directions of this study:
6. Further study may be extended with larger samples.
7. Further study can be conducted with quasi experimental study and comparative study.
8. Further studies can be recommended that long term benefits are needed to be evaluated.

9. To make results more reliable long term study can be employed.

Conclusion

There was a significant difference between pre-test and post test values. The data analysis shows significant improvement in balance and improvement in lower extremity functional activities. The statistical result shows significant difference between the pre-test and post-test. Finally, the study concludes that there is statistical improvement in Effectiveness of vestibular stimulation exercise and neuromuscular exercise on balance and lower extremity functional activities in subject with Down syndrome.

Conflicts of interest: No potential conflict of interest was reported by the authors.

Finding: Nothing to report

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Authors contribution

Sarah sunderman *et al.*, have conducted this study using Bruininks-Oseretsky Test of Motor Proficiency.

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