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EFFECTS OF PILATES ON STATIC AND DYNAMIC BALANCE IN CHILDREN WITH HEARING IMPAIRMENT

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Abstract
Children with hearing impairment often face challenges with their motor development and balance, as the auditory system has a significant role in balance and postural stability. Impaired equilibrium and restricted mobility can profoundly impact their holistic physical well-being and functional independence. Sensorineural hearing loss has a higher percentage of balance issues as more of the children suffer from this type of loss. Therefore, it becomes crucial to address balance issues in this population. The study was conducted to investigate the impact of Pilates on static and dynamic balance in children with hearing impairment. It was a Randomized Controlled Trial conducted for 6 months. Participants were recruited through non-probability convenience sampling. 38 children with hearing impairment who met the specified inclusion criteria were randomly placed utilizing the lottery method into experimental (Group A) and control (Group B) with 19 children in each group. Group A was given Pilates, while Group B was given conventional balance exercise 45 minutes per session, 3 days a week for 10 weeks. Balance evaluation was done on the Pediatric balance scale (PBS), Timed Up and Go test (TUG), and Pediatric Reach Test (PRT). Baseline measurement and post-treatment were measured on these tools and analyzed through the Shapiro-Wilk test, independent- t-test, and paired t-test on SPSS-26. The mean age of the population was 7.74±1. 639. Gender distribution was 22 females (58%) and 16(42%) males. PBS, TUG, and PRT were used to analyze the balance in children with hearing impairment. The mean difference for PBS was 29.68±0.268 for TUG was 19.52±0.561 and for PRT was 7.33±1.00. PRT, TUG, and PBS had $P<0.001$, which showed that Pilates affected balance improvement. The study concluded that both treatment techniques are effective in improving the symptoms however Pilates was more effective than conventional balance exercises on static and dynamic balance in children diagnosed with hearing impairment.

Keywords: Balance, Core, Hearing Impairment, Pilates

Introduction

It is impossible to overestimate the significance of hearing since it is necessary for the development of cognition, perception, behavior, and efficient communication. It is essential to the development of psychomotor skills in this setting. It is noteworthy that the receptor cells in the vestibular and auditory end organs are similar in terms of their phylogenetic and anatomical features, showing a similar organization and structure(1).

Conductive, sensorineural, and mixed hearing loss are the three main categories. The majority of conductive hearing loss cases result from issues with the middle or outer ear's ability to transmit sound. Conductive hearing impairment in children is primarily caused by otitis media with effusion, also known as "glue ear"(2). Sensorineural hearing loss is the result of blockages in the auditory pathway that runs from the brainstem to the cochlea in the inner ear. It appears to be the primary cause of childhood irreversible hearing loss, despite the fact that it is quite rare in general. When conductive and sensorineural components coexist, a condition known as mixed hearing loss results(3).

Concerningly, it is estimated that 440 million children globally experience hearing impairment at frequencies higher than 95 decibels. When frequencies of hearing loss are lowered to 50 decibels, the number of children increases to nearly 800 million. This data highlights the importance of early detection and efficacious therapeutic interventions to lessen the negative effects of hearing loss(4).

In order to support early intervention, it is critical to diagnose the development of speech, language, and hearing abilities in the kid at an early age. This approach will benefit a child's overall development. They can improve their capacity for contact and conversation with others as well as potentially overcome any barriers that may arise from their hearing loss in this way(5).

Key daily activities involving balance and movement are therefore particularly dependent on these localizations, monitoring, and, response abilities. Consequently, when defining the range of functional outcomes associated with “real-world hearing,” it is essential to look at how hearing and HL influence mobility-related outcomes. For complete sensorimotor skills, postural control must be correct, and for this purpose the development of static and dynamic balance is necessary(6). Because this is the body's requirement to fully explore the surrounding environment with as little risk of falling and injury as possible. The development of balance, although present from birth, is particularly notable between the ages of 6 and 10(7).This maturation phase is attributed to the emergence of adult-like postural control strategies, typically observed around 7 to 8 years of age. These strategies involve optimizing the coordination of head-trunk movements accompanied by a shift in how the brain regulates visual, somatosensory, and vestibular inputs through feedback mechanisms(8). At the same time, this period coincides with the development of other important maturational processes in the central nervous system and the acquisition of complex motor skills(9). This stage of development is marked by the appearance of adult-like postural control techniques, which usually appear between the ages of 7 and 8. These tactics entail improving head-trunk coordination along with a change in the way the brain uses feedback processes to control somatosensory, vestibular, and visual signals. Simultaneously, this phase is associated with the maturation of other significant processes in the central nervous system and the development of intricate motor abilities(10).

Two fundamental types of Pilates exercises are available: (a) Mat Pilates: This form of Pilates uses body weight and gravity as resistance while being performed fully on a yoga mat on the floor. (b) Pilates with apparatus: This method makes use of specific apparatus made for Pilates. The many advantages of Pilates include, but are not limited to, pain relief, increased joint stability and mobility, and enhanced body control and balance(11).

Pilates is done with children to help them with their balance. When it comes to keeping kids engaged and secure throughout physical activity, the Pilates approach offers many benefits. To begin with, Pilates provides a range of workouts that may be customized to target particular body areas or weak joints. Second, Pilates can assist persons with chronic diseases gain and keep strength in various body regions over time by providing an enjoyable, full-body workout(12).

Thirdly, using specialized Pilates equipment, like the reformer, which offers a safe way to build strength via body resistance and is especially good for body development, can also help older kids

and teens. Fourth, a lot of the Pilates exercises are closed-chain exercises that enhance joint proprioception (knowledge of one's own body position) and muscle control(13).
The functional reach test, the time up and go test, and pediatric balance are the most commonly used instruments for assessing children's balance. The BBS claims that the PBS scale listed items from simple to difficult in order of difficulty(14).
The guidelines have been made more straightforward. The time constraints for tasks requiring children to keep a still position was lowered. Children now only have 30 seconds to complete the unsupported, sitting, and standing periods. Furthermore, the test's components, such the bench, were made with kids in mind(15).

Materials and Methods

It was a Randomized controlled trial. Sample size was 44 by assuming 10% attrition rate that was calculated from G power with the help of "The Effects of Pilates training on Static and Dynamic balance of female deaf students"(16). Sampling technique was Convenience sampling technique. Study setting was Alam School of Speech and Learning Lahore and Hamza Foundation Study duration was August to December after the approval of synopsis. Inclusion Criteria was Children from both genders having age between 5 to10 years. Children who displayed balance difficulties during physical examination, despite their ability to independently stand and walk, scoring between 20 to 42 on PBS, with an average score of 37,Children who scored more than 24 on mini mental state examination (MMSE-C) for children, Pediatric individuals within the restricted age range who have were clinically diagnosed with congenital sensorineural hearing impairment (11), Children who have a hearing loss>75dB, Children who are capable of understanding and following instructions (17) Exclusion Criteria was the existence of any sort of visual, physical or mental disability concurrently with hearing deficits, or any orthopedic or neurological difficult that has the potential to impact balance(4), Participants and their parents or legal guardians decline participation and Participants who have simultaneously engaged on alternative therapy programs (17). Data Collection tools were Pediatric balance scale, Pediatric Reach Test (Pediatric Functional Reach Test) and Time Up and Go Test (TUG). Pilates were given to Group A, while Balance exercises for Group B. Ten sets of Pilate exercises were conducted with a 2-minute break between each set. The Pilate group received the intervention regimen consisting of 45-minute sessions, days a week for 10 weeks (18). It was a Randomized controlled trial. Sample size was 44 by assuming 10% attrition rate that was calculated from G power with the help of "The Effects of Pilates training on Static and Dynamic balance of female deaf students"(16). Sampling technique was Convenience sampling technique. Study setting was Alam School of Speech and Learning Lahore and Hamza Foundation Study duration was August to December after the approval of synopsis. Inclusion Criteria was Children from both genders having age between 5 to10 years. Children who displayed balance difficulties during physical examination, despite their ability to independently stand and walk, scoring between 20 to 42 on PBS, with an average score of 37,Children who scored more than 24 on mini mental state examination (MMSE-C) for children, Pediatric individuals within the restricted age range who have were clinically diagnosed with congenital sensorineural hearing impairment (11), Children who have a hearing loss>75dB, Children who are capable of understanding and following instructions (17) Exclusion Criteria was the existence of any sort of visual, physical or mental disability concurrently with hearing deficits, or any orthopedic or neurological difficult that has the potential to impact balance(4), Participants and their parents or legal guardians decline participation and Participants who have simultaneously engaged on alternative therapy programs (17). Data Collection tools were Pediatric balance scale, Pediatric Reach Test (Pediatric Functional Reach Test) and Time Up and Go Test (TUG). Pilates were given to Group A, while Balance exercises for Group B. Ten sets of Pilate exercises were conducted with a 2-minute break between each set. The Pilate group received the intervention regimen consisting of 45-minute sessions, days a week for 10 weeks (18). It was a Randomized controlled trial. Sample size was 44 by assuming 10% attrition rate that was calculated from G power with the help of "The Effects of Pilates training on Static and Dynamic balance of female deaf students"(16). Sampling technique was Convenience sampling technique. Study setting was Alam School of Speech and Learning Lahore

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Results

Age and gender descriptive data was analyzed on initial basis which showed mean value and standard deviation of the age was 7.74±1.639. Gender distribution was represented in the percentages that showed, there were 22 female (58%) and 16(42%) males. It was shown from the data analysis that it was evenly distributed as Shapiro-Wilk was $p>0.05$. Parametric test was used for further statistical analysis as independent t-test was utilized for between group analysis. Whereas, paired t-test was employed for within group analysis These analyses uncovered that there was no statistical difference between the groups that was $p>0.05$, and there was statistical difference within the groups that was $p<0.05$ respectively.

Figure 1: Histogram of Age

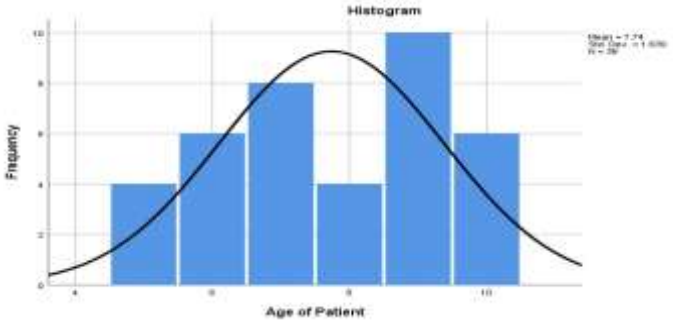

TABLE 1: BETWEEN GROUPS COMPARISON OF PRE-PRT, PRE-PBS AND PRE-TUG. (BASELINE MEASUREMENT)

Independent t-test				
Variable	**Group**	**No**	**Mean & Std. Deviation**	**P-Value**
Pre-Pediatric Balance Scale	Balance Exercises	19	15.42±3.043	0.721
	Pilates	19	17.21±2.417	
Pre-TUG	Balance Exercises	19	28.84±2.387	0.631
	Pilates	19	28.05±2.571	
Pre-Pediatric Reach Test	Balance Exercises	19	12.74±1.327	0.872
	Pilates	19	13.67±.866	

TABLE 2: BETWEEN GROUPS COMPARISON (PARAMETRIC) OF POST-PRT, POST - PBS AND POST -TUG (AT 10TH WEEK)

Independent t-test				
Variable	**Group**	**No**	**Mean & Std. Deviation**	**P-Value**
Post Pediatric Balance Scale	Balance Exercises	19	26.84±3.184	.001
	Pilates	19	46.89±2.685	
Post TUG	Balance Exercises	19	20.84±2.243	.002
	Pilates	19	8.53±2.010	
Post_ Pediatric Reach Test	Balance Exercises	19	14.00±.866	.004
	Pilates	19	20.00±1.886	

TABLE 3: WITHIN GROUP COMPARISON (PARAMETRIC) FOR GROUP A (BALANCE EXERCISES) OF PRT, PBS, AND TUG.

Paired t-test					
Variable	**No**	**Pre_ Mean & Std. Deviation**	**Post_ Mean & Std. Deviation**	**Mean Difference**	**P-value**
Pediatric Balance Scale	19	15.42±3.043	26.84±3.184	11.42±0.141	.001
Timed Up and Go Test	19	28.84±2.387	20.84±2.243	8.0±0.144	.001
Pediatric Reach Test	19	12.74±1.327	14.00±1.886	2.26±0.559	.001

TABLE 4: WITHIN GROUP COMPARISON (PARAMETRIC) FOR GROUP B (PILATES)OF PRT, PBS, AND TUG

Paired t-test					
Variable	**No**	**Pre_ Mean & Std. Deviation**	**Post_ Mean & Std. Deviation**	**Mean Difference**	**P-value**
Pediatric Balance Scale	19	17.21±2.417	46.89±2.685	29.68±0.268	.001
Timed Up and Go Test	19	28.05±2.571	8.53±2.010	19.52±0.561	.002
Pediatric Reach Test	19	13.67±.766	20.00±.866	7.33±1.00	.002

Discussions

Approximately 62 million people worldwide who are 15 years of age or younger suffer from lasting hearing loss. When compared to their age-matched, normally hearing peers of the same sex, children with SNHL exhibit more postural control instabilities as well as changes in the head and spine's mobility and postural alignment.(6). The current study demonstrated that when children with HI performed 45-minute Pilates exercises over a 10-week period, the mean±SD of PBS was (15.42±3.043,17.21±2.417) in the experimental and control groups, respectively, with (p=0.721); post-intervention, it was (26.84±3.184,46.89±2.68), with (p=001). When these kids' sitting and standing balance was assessed after a certain amount of time, there was a noticeable improvement. The results of this study showed that the children with HI who participated in Pilates exercises had improvements in their reaching capacity, posture, postural stability, and physical fitness. PRT mean±SD before and after the Pilates performance were, respectively, 12.74±1.327 and 14.00±1.886, after 10 weeks of the exercises.

Similar outcomes were seen in the 2023 study by Suharto S, in which 66 kids took part in 45-minute, 16-week periods of exercise during which Pilates activities were contrasted with Bobath exercises. Over the course of 16 weeks, this trial was conducted once daily, three times a week, for 45 minutes each time. Pilates workouts significantly improved sitting balance ($p = 0.002$) but had no discernible impact on standing balance ($p = 0.083$), according to a paired t-test. However, Bobath' s workouts resulted in a considerable improvement in balance while standing ($p = 0.023$) and sitting ($p = 0.001$). The results of the independent t-test for standing balance ($p = 0.034$) and sitting balance ($p = 0.039$) were obtained. Last but not least, there were noticeable differences in standing and sitting balance between the cerebral palsy children's Bobath exercises and the Pilates exercises group. The Pilates group demonstrated improved sitting and standing balance, as demonstrated by PBS measurements ($p<0.05$).(19)"

This study demonstrated that Pilates exercises improved static balance since they were effective in reducing imbalance as measured by the Functional Reach Test, Timed Up, and Go Test. The experimental group's pretreatment Functional Reach test scores were 12.74±1.327, whereas the control group's were 13.67±.866. Following the intervention, the values were 14..00±.866 and 20.00±1.886. This research project established the impact of Pilates ball workouts on preschoolers' motor skills, and it coincided with Obuz's 2022 study on kindergarten students' balance and dual-task performance. Two groups, an experimental group (EG) ($n = 30$) and a control group (CG) ($n = 32$), were randomly assigned to 62 participants. The findings showed that there were notable improvements in both the groups' dual-task and static balancing ability, with the IG showing larger improvements than the CG ($p < 0.05$). These results demonstrated how well preschoolers' static balance and dual-task performance can be enhanced by Pilates ball workouts. that demonstrated improvement in the intervention and control groups that shown improvements in the intervention and control groups' pre-FRT mean ±SD (17.06 ± 1.7, 16.99 ± 2.04) and post-FRT mean ±SD (17.26 ±

1.67, 17.04 ± 2) following ball Pilates sessions, with a P=0.057 conclusion that indicated improvements in children's static balance (17)"

According to the current study, when the HI children practiced Pilates exercises, their balance improved in both the static and dynamic domains. It has been demonstrated that the strength of the core muscles plays a key role in balance, and Pilates has contributed to this. This has also been shown to be significant for postural control, with p>0.05 for both static and dynamic balance parameters as evaluated by instruments. This is in contrast to a study by De Jesus from 2021 that looked at the effects on plantar arch stability and balance in 43 school-age children. It found that there were no differences in ALM and static and dynamic postural control between the Pilate group and the Control group, with a p-value of less than 0.05 for both. According to the statistically significant group differences in the PBS and PRT, the results of this RCT demonstrated that enrolling children with HI in a 10-week Pilate exercises group improved their functional balance and walking abilities. Cibinello's 2020 study, which involved 40 children, demonstrated comparable measuring results (20). Several limitations influenced the interpretation of this study findings were the duration of the intervention and follow-up period might not have captured long-term effects. The lack of comparison with alternative interventions might have limited the ability to attribute observed changes solely to Pilates and Finally, the study might not have encompassed the full spectrum of hearing impairment severity levels. The study's findings suggest several recommendations for integrating Pilates into the care of children with hearing impairment. Pilates exercises should be incorporated into rehabilitation programs, tailored to the unique needs of this population. Long-term monitoring should be established to assess the sustained impact of Pilates intervention. Further research is encouraged to explore variations in Pilates interventions, age-specific adaptations, and psychological/social impacts.

Conclusion

It was concluded from the study that 10 weeks of Pilates had significant effect on balance in the children with hearing impairment. Pilates exercises was more effective than balance exercises on static and dynamic balance in children with hearing impairment.

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