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Effects of Treadmill Training on Gross Motor Function, Spasticity and Gait Speed in Ambulatory Children with Spastic Cerebral Palsy

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Author`s Contribution

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A B S T R A C T

Background: Cerebral palsy is described as a permanent, non-progressive disorder related to neurodevelopmental abnormalities in an underdeveloped brain which leads to additional brain lesions resulting in secondary motor disturbances and postural abnormalities

Objective: To determine the effectiveness of treadmill training on gross motor function, spasticity and gait speed in ambulatory children with spastic cerebral palsy.

Methodology: It was a Randomized clinical trial, which was done in Bahria International Hospital, Lahore by convenient sampling technique. A sample size of 50 patients were divided into two groups. Patients in Group A underwent conventional physiotherapy, whereas those in Group B received a specialized treadmill training program tailored for children with spastic cerebral palsy, alongside their standard physical therapy sessions.

Result: Our data is normally distributed so wo applied Independent sample t test for between group analysis which shows that mean of group A at baseline is 5.40±0.49 and group B is 5.20±0.76, at 6th weeks group A is 4.80±0.48 and group B is 4.33±.0.88and at 12th weeks group A is 3.93±0.58 and group B is 2.13±0.68.p-value shows that there is no significant difference between two groups at baseline and at 6th weeks but at 12th weeks there is a significant differences as p-value is less than 0.00.Repeated measure ANOVA shows both groups shows significant results but mean difference of treadmill training group were more in all outcome.

Conclusion: - Our study concludes that treadmill training, along with physiotherapy, is beneficial for children with spastic cerebral palsy in improving gross motor function, spasticity, and gait speed.

Keywords: Treadmill exercise, Gait, Spasticity, cerebral palsy.

Introduction

Cerebral palsy, a non-progressive condition stemming from neurodevelopmental abnormalities in an immature brain, results in motor impairments and balance issues, hindering children in daily tasks and social interactions (Rajkumar, 2019). This condition encompasses diverse mobility and posture irregularities, limiting activities due to fetal and neonatal brain complications. Treadmill training offers promising prospects for children with cerebral palsy, allowing repetitive gait cycle practice and pattern enhancement.[1]

Spastic cerebral palsy, a specific type of cerebral palsy, manifests as impaired movement, coordination, and posture due to heightened muscular tone resulting from brain motor cortex or circuit injuries. Individuals with spastic cerebral palsy face challenges such as muscle weakness, involuntary contractions, aberrant posture, delayed developmental milestones, and difficulty controlling fine motor skills. Neurobiological advancements underscore the significance of early, task-specific, intensive motor training, with a primary focus on gait training.[2]

Physical therapy, tailored to individual needs, aids in enhancing motor skills, movement, and independence while mitigating future complications. Treadmill training serves as a pivotal tool, rhythmically improving postural control and skeletal muscle coordination during the gait

cycle. Although essential, physiotherapy remains fundamental in managing cerebral palsy, encompassing various exercises targeting specific muscle groups, mobility, balance, and coordination.[3]

Physical therapy, tailored to individual needs, aids in enhancing motor skills, movement, and independence while mitigating future complications. Physical therapists employ stretching, strengthening, and balancing exercises, gait training, and mobility-assistive equipment. Aqua therapy, orthotic devices, and posture management guidance further aid in improving muscle control and flexibility.[4]

For children with cerebral palsy, walking autonomously is a crucial objective. However, challenges such as muscle weakness and unstable posture hinder effective walking. Treadmill training, particularly when coupled with body weight support, has shown promise in enhancing gait patterns and mobility. Recent studies have examined treadmill training's impact on functioning assessments, walking speed, and endurance among children with cerebral palsy. Intensive, short-term locomotor training programs have demonstrated significant improvements in gross motor skills, walking speed, and endurance in young children with cerebral palsy, highlighting the efficacy of treadmill training in this population .[5 6]

This randomized clinical trial assesses the impact of treadmill training on gross motor activity and walking speed in spastic cerebral palsy children. It aims to determine treadmill training's effect on spasticity. Few studies have explored this in ambulatory spastic diplegic cerebral palsy children. This trial fills a crucial gap, enhancing rehabilitation interventions and mobility for these children.

Methodology

A randomized clinical trial was conducted on spastic CP child at Bahria International Hospital, Lahore. The sample size was calculated by using Modified Ashworth Scale (MAS) for spasticity as outcome measure is 25 in each group after adding 20% dropout the sample size was 25+5=30 in each group. Study was completed in 7 months (Feb 2023-Aug 2023) after the approval and registration of synopsis from the institutional review board (REC-UOL-347-04-2023) and data was collected by purposive sampling technique. Purposive sampling in an RCT is justified as it allows for the intentional selection of participants with specific characteristics or conditions relevant to the research question. This enhances the study's efficiency, relevance, and ethical considerations, increasing the likelihood of meaningful treatment effect detection. Children aged 13-19, of any gender, meeting inclusion criteria for spastic diplegic cerebral palsy (GMFCS I-II), whereas CP child having any of the cardiovascular diseases or surgery in past 12 months., any botulism injections in past 6 months and uncontrolled epilepsy were excluded from this study. Children randomly assigned to experimental and control groups through computerized method.[7]The study, single-blinded, involved baseline and 6-12 week assessments statistical analysis was done by using SPSS 25 version.

Both groups were given routine physical therapy which includes three sets of regular activities (Mat Training that includes stretching, strengthening, range of motion and rolling, balance exercises including side and backward stepping, one-foot balance, altering centerof gravity exercises, functional gross motor activities, gait Training)

Group B received the treadmill training program for the children with spastic cerebralpalsy in addition to regular physical therapy treatment. On motorized treadmill the participant has gone through three phases. The warm up, training and cool down phases. During the main training phase, participants would walk on the treadmill without any body weight supportto a comfortable speed for a maximum of 30 minutes per session. Finally, the 5-min cool- down phase will include of stretching. The speed would be set according to each participant's ability.[5]

Treatment duration was up to 45 minutes, three days per week for 12 consecutive weeks. Data was collected at baseline, 6th week and at 12th week. Outcome measures were calculated using Gross motor function measure , 10 min walk test. Modified Ashworth scale. The data was entered and analyzed using SPSS Version 24. The numerical data like age was presented in mean ±SD. Categorical Data like gender groups was presented in the form of frequency (Percentage). The data was normally distributed,

So parametric test was applied which was independent sample t -test to compare the mean difference between the two groups. Repeated measures ANOVA was used to assess the within group differences of the outcome variables at different time intervals. p-value ≤ 0.05 was considered significant.

Results

Kolmogorov Smirnov test for normality shows that our data was normally distributed because p-value was more than 0.05, which was expected to be normal. Percentage of male gender in A group is 36.7% and in B group is 40% and percentage of female gender in A group is 63.3% and in B group 60%.Mean and S.D of age were 16.53±2.25 years for group A and 16.16±2.35 for group B.BMI analysis showed

Table I: Independent samples t-test for Gross Motor Function Measure, 10-Meter Walk Test, and for Modified Ashworth Scale.			
GMFM			
GMFM	**Control**	**Experimental**	**P-value**
Baseline	21.93±3.55	20.00±3.65	0.94
At 6th week	32.03±4.16	45.96±.5.78	<0.001
At 12th week	53.83±2.56	75.30±7.13	<0.001
10 MWT			
10 MWT	**Control**	**Experimental**	**P-value**
Baseline	78.00±5.83	78.83±5.65	0.98
At 6th week	76.67±5.77	68.38±.3.51	<0.001
At 12th week	73.96±5.93	60.40±2.09	<0.001
MAW			
MAW	**Control**	**Experimental**	**P-value**
Baseline	5.40±0.49	5.20±0.76	0.23
At 6th week	4.80±0.48	4.33±.0.88	0.14
At 12th week	3.93±0.58	2.13±0.68	<0.001

minimum 16 and maximum 25 BMI with 20.38 mean and 2.25 standard deviation for group A whereas minimum 15 and maximum 23 BMI with 19.56 mean and 2.27 standard deviation for group B.

Experimental groups at baseline (p=0.94). However, at the 6th and 12th weeks, the experimental group showed significant improvement compared to the control group (p<0.001). For the 10 MWT, there was no significant difference between the groups at baseline (p=0.98). But at the 6th and 12th weeks, the experimental group exhibited a significantly greater improvement than the control group (p<0.001). In terms of MAW, there was no significant difference between the groups at baseline (p=0.23) and the 6th week (p=0.14). However, at the 12th week, the experimental group demonstrated a highly significant improvement in comparison to the control group (p<0.001).

Table II: Repeated measure Anova for gross motor function measure, 10-metre walk test and modified Ashworth scale Test of between subject's effects			
GMFM			
Mean difference of control group	Mean difference of experimental group	Green-house geisser	Sig
31.90	55.30	0.881	0.000
10-MWT			
Mean difference of control group	Mean difference of experimental group	Green-house geisser	Sig
-4.04	-18.43	0.659	0.000
MAS			
Mean difference of control group	Mean difference of experimental group	Green-house geisser	Sig
1.47	-3.07	0.884	0.000

The results for all measures (GMFM, 10-MWT, and MAS) were highly significant (p<0.001) for both the control and experimental groups, indicating substantial improvements in motor function, walking speed, and muscle tone, but mean differences show experimental group shows more significant results, respectively.

Discussion

The findings of this study provide valuable insights into the effectiveness of treadmill training in children with spastic cerebral palsy. Our results, consistent with previous research by Chrysagis et al., 2021; Peltoniemi, 2019, demonstrate significant improvements in gross motor function, walking speed, and muscle tone in the experimental group compared to the control group.[8,9]

In terms of gross motor function, the experimental group exhibited a remarkable mean difference of 55.30, significantly surpassing the control group's mean difference of 31.90 in the GMFM scores. These outcomes align with studies emphasizing the positive impact of treadmill training on motor skills in children with cerebral palsy. [8]

The 10-Meter Walk Test results further underscore the efficacy of treadmill training, revealing a substantial mean difference of -18.43 for the experimental group compared to -4.04 for the control group. This significant improvement in walking speed supports the findings of previous studies emphasizing the role of treadmill training in enhancing gait parameters.[9]

Moreover, the Modified Ashworth Scale results highlight the impact of treadmill training on muscle tone, with a mean difference of -3.07 for the experimental group compared to 1.47 for the control group. These findings corroborate studies

demonstrating the positive effects of treadmill training on muscle spasticity.[10]

The significant outcomes in our study underscore the importance of early intervention strategies, emphasizing task-specific, intensive, and motivated training for children with cerebral palsy.[11]Treadmill training, as demonstrated by our results, emerges as a promising approach to address the multifaceted challenges faced by these children, enhancing their motor function, walking speed, and muscle tone.

A large effect size was found for the Gait speed and this effect may be attributed to the repetitive leg movements throughout training, which is in accordance with the specific to a task approach that underpinned the current research. On the other hand, a small effect size was found for the Gross motor functions scores and this score represented the many essential characteristics, such as stamina and speed. The current findings of gait speed have been found to be accordance with and in contrast to recent Research findings. In particular, Elnaggar et al. observed kids treated on an electrical gait trainer significantly improved their gait speed compared to group undergoing traditional physiotherapy. The electrical gait trainer differs from the treadmill employed for the objectives of the current study in that it is an end-effector equipment.[12]

Despite cerebral palsy being a prevalent childhood motor disability, there is a relative scarcity of comprehensive research aimed at improving motor outcomes and social engagement in these young individuals. Many therapies, when tailored to address the unique needs of children with cerebral palsy, have been proven effective in enhancing their activities of daily living. These therapies not only contribute to the physical well-being of these children but also play a crucial role in improving their overall quality of life. Thus, the lack of substantial research in this area highlights the need for further studies to explore and establish therapies that can significantly benefit youngsters with cerebral palsy. Treadmill training, Cycling and gait training has recently been proven to enhance gross motor skills and mobility in these kids. The patterns of spasticity are reduced due to repetitive limb movements.[13]

There have been created and evaluated new therapeutic strategies for kids with moderate-to-severe bilateral CP, and now recommended cycling, and goal-directed training. Extremely efficient components of a training package, are used to achieve specific motor and leisure goals as well as broad motor and participation results.[14] 150 youngsters with bilateral cerebral palsy (5–15 years old) who were randomly assigned to receive treatment for eight weeks of Active Strides cerebral palsy for two times of the week for ninety minutes. The motor function capacity was measured overall using the GMFM-66. Gate endurance was measured by Test of a 6-minute walk Simple submaximal test that calculates distance Information about stamina during functional activities is provided by walking for more than 6 minutes.

One task-based intervention that has been utilized to enhance the gait cycle is treadmill training. Resistance, as well as balancing, and training for endurance are part of regular physical therapy. Many clinicians have explored therapies to help those with cerebral palsy walk more normally. The criteria for inclusion and exclusion for meta-analysis were met by Eleven papers. A minimal to moderate total effect size of twenty cents was found for treadmill training on the 6MWT, which measured gait endurance. The 10MWT results that favored standard PT and had an enormous total impact size of 0.94. In all studies, both treadmill training and conventional PT produced beneficial benefits. While regular physical therapy may be recommended for modifications to gait speed, exercising on a treadmill could be more suitable overall gains in gait endurance.[15]Within group analysis is done for 10 MWT in this study shows that at baseline and after 6th weeks of treatment there was no significant difference in control and experimental groups but, a little difference seen after 12th week of treatment in both groups. The table and graphical analysis shows that both groups show significant difference but experimental group shows more significant different which is corresponding to above mentioned meta -analysis thus treadmill training after twelve-week analysis give better results than routine physical therapy.

There were forty kids enlisted between two and five years, non–progressive neuron disability, and motor Grading System were the inclusion criteria by Haddon et al. Orthopedic surgery within the previous five months, hip subluxation, seizure, or treadmill exercises within the previous month were all considered exclusion criteria. Intervention. The 10MWT median difference was 2.3 and in GMFM-66 the mean difference was 2.5 both gave improvements.[16] Age of children 13 to 19 years, Modified Ashworth scale score of less than 2, Gait ability with or without any walking aids, Ability to follow the physical therapist instructions, GMFCS Level (I-II) is included in this study. Patients of spastic cerebral palsy. Any of the cardiovascular diseases or surgery in past twelve months, botulism injections in past six months and epilepsy were excluded. Within group analysis for GMF 66 shows that at baseline and after 6th weeks of treatment there was no significant difference but, a little difference seen after 12th week of treatment in both groups and treadmill training group shows more significant results.

The examination of muscle spasticity which is prevalent in Cerebral Palsy (CP), employs a variety of techniques. In the study by Duman et al, it was determined if children with cerebral palsy had bilateral upper-limb spasticity using the Modified Ash Worth Scale (MAS) and for surface electromyography measures. The study comprised thirty-two healthy participants and 34 patients with CP. Each side of the cases' upper-limb spasms were assessed. The MAS results on the impaired side were found to be better than those on the other side. Because it is simple to use and doesn't add any extra steps to the evaluation process, MAS is seen to be a better option for determining how much spasticity a person has.[17] Results of this research for modified ash worth scale shows a small difference seen after 12th week of treatment in both groups. The table and graphical analysis shows that both groups show significant difference but group receiving treadmill training shows more significant different.

The findings of this study might lend support to the idea that repetitive motions related to a task can help people learn motor skills. repetitive motions with a progressively accelerating speed on the Treadmill use may have increased speed by causing the central pattern generators to fire more frequently and it has been suggested in the past for people who have had strokes or spinal cord injuries.[18]

The study's limitations include incomplete blinding, omitting details on participant or healthcare provider blinding, potentially introducing bias and affecting internal validity. Furthermore, the short study duration hampers assessing the interventions' long-term efficacy, particularly in managing a chronic condition like cerebral palsy. Additionally, if the participant group was homogenous in terms of age, severity, or demographics, the study's findings might lack generalizability to a broader population, limiting its external validity. A more diverse participant spectrum would enhance the study's overall applicability and relevance.

Conclusion

In conclusion, both approaches to treatment were enforceable for cerebral palsy patients in terms of motor functions, gait speed and spasticity, but the treadmill training protocol combined with physical therapy produced a significantly greater result than the simple physical therapy plan. This rehabilitative training ought to be included in standard clinical practice in Pakistan to produce better and earlier outcomes, and it can also impact improved posture management and balance.

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