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Hemiparetik Serebral Palsili Çocuklarda Eylem Gözlem Terapisinin Denge ve Alt Ekstremite Fonksiyonu Üzerine Etkisi

The Effect Of Action Observation Therapy On Balance And Lower Extremity Function In Children With Hemiparetic Cerebral Palsy

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Öz

Amaç: Eylem Gözlem Terapisi (AOT), ayna nöron sistemini kullanarak motor öğrenmeyi destekler ve serebral palsili çocuklarda üst ekstremite fonksiyonlarını geliştirmede umut verici sonuçlar göstermiştir. Ancak, hemiparetik serebral palsili çocuklarda denge ve alt ekstremite fonksiyonları üzerindeki etkileri yeterince araştırılmamıştır. Bu çalışmanın amacı, hemiparetik serebral palsili çocuklarda AOT'nin, konvansiyonel fizyoterapiye ek olarak uygulandığında dengeyi, alt ekstremite fonksiyonlarını ve yürüme performansını geliştirmedeki etkinliğini değerlendirmektir.
Yöntem: Hemiparetik serebral palsili (GMFCS seviye I–II) yirmi çocuk (ortalama yaş: 9,60 ± 2,19 yıl) rastgele olarak deney grubuna (konvansiyonel fizyoterapi + AOT) veya kontrol grubuna (yalnızca konvansiyonel fizyoterapi) ayrıldı. Müdahale 6 hafta sürdü; her iki grup da 12 fizyoterapi seansına katılırken, deney grubu ayrıca haftada iki kez 30 dakikalık AOT seansları aldı. Sonuç ölçütleri arasında Timed Up and Go (TUG) testi, Pediatrik Denge Ölçeği, Beş Basamak Merdiven Çıkma/İnme Testi ve 6 Dakika Yürüme Testi (6DYT) yer aldı.
Sonuçlar: Müdahale sonrası deney grubu, TUG performansında, dinamik dengede (özellikle 360° dönüş ve öne uzanma görevlerinde) ve merdiven çıkma becerisinde kontrol grubuna kıyasla anlamlı derecede daha fazla iyileşme gösterdi. Her iki grup 6DYT'de anlamlı gelişim gösterse de bu ölçütte gruplar arasında anlamlı bir fark bulunmadı. Ayrıca, fiziksel büyüme parametreleri ile motor performans sonuçları arasında orta ila güçlü düzeyde korelasyonlar görüldü.
Tartışma: Konvansiyonel fizyoterapi ile birlikte uygulanan AOT, hemiparetik serebral palsili çocuklarda dengeyi ve alt ekstremite fonksiyonlarını anlamlı şekilde artırmaktadır. Bu sonuçlar, dinamik denge ve fonksiyonel hareketliliği geliştirmek için AOT'nin rehabilitasyon programlarına entegre edilmesini desteklemektedir. Bulguların doğrulanması ve AOT'nin uzun dönem etkilerinin incelenmesi için daha geniş örneklemli ve uzun takip süreli çalışmalar önerilmektedir.
Anahtar Kelimeler: Çocuk, Fiziksel Aktivite, Fiziksel Okuryazarlık.

Abstract

Purpose: Action Observation Therapy (AOT) supports motor learning by engaging the mirror neuron system and has shown promising results in improving upper extremity functions in children with cerebral palsy. However, its effects on balance and lower extremity functions in children with hemiparetic cerebral palsy have not been sufficiently investigated. The aim of this study was to evaluate the effectiveness of AOT, when applied in addition to conventional physiotherapy, on improving balance, lower extremity functions, and gait performance in children with hemiparetic cerebral palsy.
Methods: Twenty children with hemiparetic cerebral palsy (GMFCS levels I–II) (mean age: 9.60 ± 2.19 years) were randomly assigned to either the experimental group (conventional physiotherapy + AOT) or the control group (conventional physiotherapy only). The intervention lasted 6 weeks; both groups participated in 12 physiotherapy sessions, while the experimental group additionally received AOT sessions twice weekly for 30 minutes. Outcome measures included the Timed Up and Go (TUG) test, the Pediatric Balance Scale, the Five Times Stair Ascending/Descending Test, and the 6-Minute Walk Test (6MWT).
Results: Following the intervention, the experimental group demonstrated significantly greater improvements in TUG performance, dynamic balance (particularly in the 360° turning and forward reach tasks), and stair climbing ability compared to the control group. Although both groups showed significant improvements in the 6MWT, no significant between-group difference was observed for this outcome. In addition, moderate to strong correlations were found between physical growth parameters and motor performance outcomes.
Conclusion: AOT combined with conventional physiotherapy significantly enhances balance and lower extremity functions in children with hemiparetic cerebral palsy. These findings support the integration of AOT into rehabilitation programs to improve dynamic balance and functional mobility. Further studies with larger sample sizes and longer follow-up periods are recommended to confirm these results and to investigate the long-term effects of AOT.
Keywords: Child, Physical Activity, Physical Literacy.

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1. INTRODUCTION

Cerebral palsy is a non-progressive condition caused by lesions occurring during fetal or early postnatal brain development, leading to permanent impairments in movement, posture, and motor function (1). In hemiparetic CP, one side of the body is predominantly affected, with greater involvement of the distal segments of the extremities. The affected lower limb often presents with an equinovarus deformity, frequently accompanied by secondary hip and knee contractures. Equinovarus is reported as the most common deformity in hemiparetic CP, with a prevalence of approximately 64% (2). Gait characteristics typically include toe-walking, increased pelvic rotation, and anterior pelvic tilt due to compensatory strategies (3). Additional deformities such as varus, dorsal bunion, and metatarsus adductus may also be observed, contributing to reduced walking speed, shorter step length, and a widened base of support. Structural limb shortening can further lead to pelvic asymmetry and balance impairments during standing (4,5).

The recognition of the mirror neuron system's role in motor learning has supported the development of Action Observation Therapy (AOT), a rehabilitation method in which patients observe specific movements—either through video or an instructor—and then imitate them. This approach aims to promote neural reorganization and restore motor function in individuals with central nervous system lesions (6). Although several studies have demonstrated that AOT improves upper extremity function and reaching performance in children with CP (7–9), evidence regarding its effects on lower extremity function remains limited. Furthermore, no studies from our country have examined the impact of AOT on balance or lower extremity performance in children with CP.

Therefore, the primary aim of this study is to evaluate the effects of AOT on balance and lower extremity function in children with hemiparetic cerebral palsy.

2. METHODS

2.1 Participants

Twenty children aged 5–12 years diagnosed with hemiparetic CP were recruited from the Special Empathy Counseling and Rehabilitation Center. All participants were classified as levels I or II on the Gross Motor Function Classification System. The study protocol was approved by the X University Non-Interventional Research Ethics Committee on January 10, 2023 (approval no. E-60116787020-316222).

2.2 Study Design and Intervention

Participants were randomly assigned to either the experimental or control group using a computer-generated simple randomization sequence. Allocation concealment was ensured by an independent researcher not involved in assessment or intervention procedures. Outcome assessors were blinded to group allocation.
Experimental Group: Received conventional physiotherapy and rehabilitation in addition to AOT.
Control Group: Received only conventional physiotherapy and rehabilitation.
Both groups participated in a 6-week program comprising a total of 12 sessions of conventional physiotherapy. The experimental group additionally underwent AOT for 6 weeks (2 days per week, 30 minutes per session). Pre- and post-treatment evaluations were performed.

2.3 Outcome Measures

Participant Information Form
Collected demographic data (name, sex, age, height, weight, birth date, education), duration of physiotherapy, affected side, and gross motor function level.

Timed Up and Go Test (TUG)
The TUG Test evaluates functional mobility, postural control, balance, and gait speed. Children were instructed to stand from a chair (with back support), walk a 3-meter distance at maximum speed without running, turn, and return to sit. Each test was repeated twice, and the mean time was recorded. A shorter duration indicates better functional mobility and balance (10,11).

Pediatric Balance Scale (PBS)
A modified version of the Berg Balance Scale for children, the PBS consists of 14 items (maximum score 56). It assesses functional balance through activities such as sitting-to-standing, standing, transfers, stepping, single-leg stance, turning, bending, and reaching. The scale has demonstrated strong correlations with other functional

measures in children with CP (12–14).

Five-Step Stair Climbing and Descending Test (FSS)
This test evaluates functional mobility parameters including walking speed, strength, active joint range, and balance. Children are instructed to ascend and descend a 5-step staircase without pausing. The better of two trials is recorded; a shorter completion time indicates superior functional performance (15,16).

6-Minute Walk Test (6MWT)
Originally developed by Balke (1963), the 6MWT measures the distance walked in 6 minutes, reflecting the child's functional capacity for daily activities. In children with CP, typical distances range from 334 to 455 meters, varying according to sex, age, height, weight, and step length (17,18).

AOT Protocol
The AOT video comprised four specific tasks designed to improve lower extremity function, balance, and gait (Figure 1):
1. Sitting Balance: Movements to enhance balance while seated (Figure 2).
2. Sit-to-Stand Transition: Exercises to facilitate the transition from sitting to standing.
3. Walking and Balance: Gait and balance training on a parallel bar or flat surface.
4. Single-Leg Balance: Activities focused on improving balance on one leg.

For each task, children observed the movement for 1 minute, then practiced the action for 5 minutes. A 1-minute rest period was allowed between tasks, with a total AOT session lasting 30 minutes. All sessions were conducted by the same physiotherapist.

2.4 Statistical Analysis
A power analysis was conducted using G*Power 3.1 based on the PBS results reported by Jung et al. (19), which indicated a strong effect size (d = 1.366). A minimum sample size of 20 participants (10 per group) was calculated to achieve 80% power at a 95% confidence level.

3. RESULTS

3.1 Participant Characteristics
Twenty children with hemiparetic cerebral palsy (mean age: 9.60 ± 2.19 years) participated in the study. The sample was evenly split by gender (50% female, 50% male). The participants had a mean height of 138.57 ± 17.64 cm, a mean weight of 37 ± 13.41 kg, and a mean body mass index (BMI) of 18.65 ± 4.46 kg/m². Demographic details are presented in Table 1. No statistically significant differences were found between the control and experimental groups in age, gender, height, weight, GMFCS level, or clinical subtype ($p > 0.05$) (Table 2). However, the BMI values were significantly higher in the experimental group compared to the control group ($p < 0.05$).
Participants did not use any orthoses and all demonstrated an independent gait pattern. The distribution of educational years varied (e.g., 10% in kindergarten, 40% with 5 years of education), and GMFCS levels were equally distributed (50% level I and 50% level II). Clinically, 55% were right hemiparetic and 45% were left hemiparetic.

3.2 Outcome Measures
TUG
Before treatment, there was no significant difference in TUG times between groups ($p = 0.776$). After treatment, the control group exhibited significantly higher (worse) TUG times than the experimental group. Both groups showed statistically significant improvements (control: $p = 0.05$; experimental: $p = 0.002$) with reduced completion times post-treatment. Moreover, the magnitude of change in the experimental group was significantly greater than in the control group (Table 3).

PBS
For most PBS items (items 1, 2, 3, 4, 5, 6, 7, 9, 11, 12, and 13), there were no statistically significant differences between groups either before or after treatment ($p > 0.05$), and no significant within-group changes were detected.
Item 8, which measures balance during single-leg stance while one foot is forward, did not differ significantly between groups before or after treatment. However, within the experimental group, post-treatment values significantly improved compared to baseline (Table 4).
Item 10, assessing the ability to perform a 360° turn (by turning one full circle clockwise and anticlockwise), showed no significant difference between groups at baseline. Post-treatment, the experimental group achieved

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Figure 1. AOT exercises video screenshots

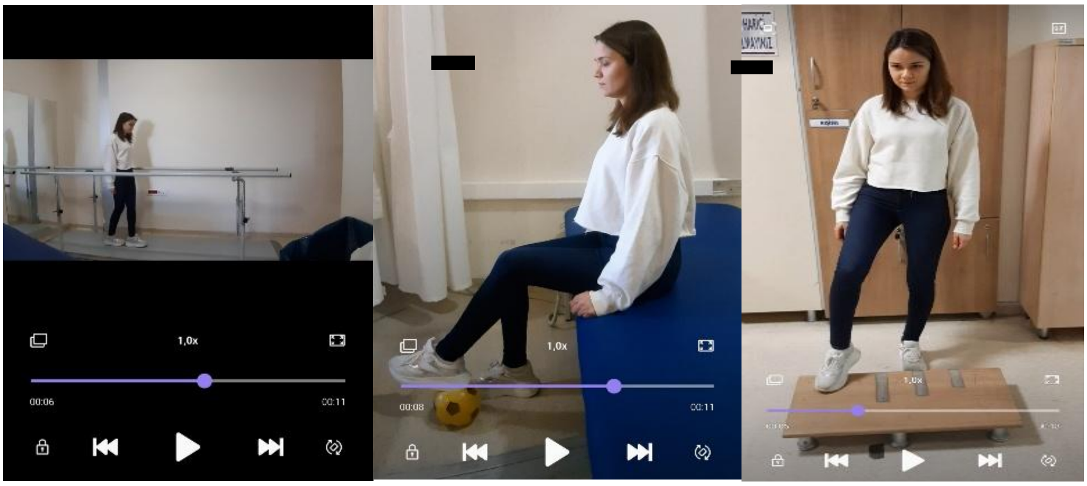

Figure 2. Activity to improve balance in a sitting position

significantly higher scores than the control group. In the experimental group, post-treatment values improved significantly relative to pre-treatment, and the difference between groups in the change scores was statistically significant (Table 4).

Item 14, which measures forward reach with an outstretched arm, did not show a significant between-group difference at baseline. After treatment, the experimental group's scores were significantly higher than those of the control group; within the experimental group, there was also a significant improvement compared to baseline (Table 4).

In terms of total PBS score (0–56 points), no significant between-group difference was noted at baseline. Post-treatment, the experimental group showed a significant increase compared to the control group. While the control group did not exhibit a significant change over time, the experimental group's overall score increased significantly

Table 1. Demographic data of participants

	Control Group X ± SD	Study Group X ± SD	p
Age (years)	9,30 ± 2,41	9,9 ± 2,02	0,554 (t=-0,603)
Height (cm)	136,35 ± 17,68	140,79 ± 18,26	0,587 (t=-0,552)
Weight (kg)	31,8 ± 12,52	42,2 ± 12,76	0,082 (t=-1,839)
BMI (kg/m²)	16,19 ± 2,88	21,1 ± 4,5	**0,019***(z=-2,307)

X: Mean; **SD:** Standard Deviation; **t:** Independent samples t test; **z:** Mann Whitney U test; *p<0,05

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Table 2. GMFCS and clinical types of participants

	Control Group n / %	Study Group n / %	p
GMFCS (I/II)	6 (%60) / 4 (%40)	4 (%40) / 6 (%60)	0,371 (kk=0,8)
Clinical Type (Right/Left)	6 (%60) / 4 (%40)	5 (%50) / 5 (%50)	1 γ

n: Number of participants; %: Percentage; p: significance level; kk: Chi-square test; γ: Fisher exact chi-square test

Table 3. Comparison of participants Timed Up and Go Test mean values before and after treatment

	Control Group		Study Group		p1 (intergroup)
	X ± SD	Median (min/max)	X ± SD	Median (min/max)	
TUG-BT	9,8 ± 1,79	9,86 (8,47 - 10,69)	9,53 ± 2,3	9,33 (7,93 - 10,27)	0,776 (t=0,288)
TUG-AT	9,23 ± 1,69	9,22 (7,79 - 10,61)	7,54 ± 1,01	7,31 (6,65 - 8,34)	**0,014*** (t=2,73)
p2 (intragroup)	**0,05*** (t=2,246)		**0,002*** (t=4,404)		
Mean Diff. TUG	0,56 ± 0,79	0,62 (-0,18 - 1,19)	2 ± 1,43	2,09 (0,81 - 2,55)	**0,013*** (t=-2,766)

TUG: Timed Up and Go Test; **X:** Mean; **SD:** Standard Deviation; **min:** minimum, **max:** maksimum; *p<0,05

p1: Independent samples t-test, **p2:** Paired samples t-test

from baseline, and the difference in change scores between the two groups was statistically significant (Table 5).

FSS

There were no significant between-group differences in the best performance values at baseline or after treatment (p > 0.05). Within-group analyses revealed no significant change in the control group, whereas the experimental group demonstrated a significant reduction in completion time post-treatment. The change in performance in the experimental group was significantly greater than that in the control group (Table 6).

Table 4. Analysis of PBS item 8, 10 and 14 result values

	Control		Study		
	X ± SD	Median (min/max)	X ± SD	Median (min/max)	Intergroup p
PBS-8-BT	3,3 ± 0,48	3 (3 - 4)	3,2 ± 0,63	3 (3 - 4)	0,796 (z=-0,316)
PBS-8-AT	3,4 ± 0,52	3 (3 - 4)	3,6 ± 0,52	4 (3 - 4)	0,481 (z=-0,872)
Intragroup p	0,317 (z=-1)		**0,046*** (z=-2)		
Mean Diff. PBS-8	-0,1 ± 0,32	0 (0 - 0)	-0,4 ± 0,52	0 (-1 - 0)	0,28 (z=-1,51)
PBS-10-BT	2 ± 0	2 (2 - 2)	2 ± 0	2 (2 - 2)	1 (z=0)

PBS-10-AT	2,5 ± 0,85	2 (2 - 3,25)	3,8 ± 0,63	4 (4 - 4)	**0,007*** (z=-2,969)
Intragroup p	0,102 (z=-1,633)		**0,003*** (z=-3)		
Mean Diff. PBS-10	-0,5 ± 0,85	0 (-1,25 - 0)	-1,8 ± 0,63	-2 (-2 - -2)	**0,007*** (z=-2,969)
PBS-14-BT	3 ± 0,47	3 (3 - 3)	3,4 ± 0,52	3 (3 - 4)	0,19 (z=-1,697)
PBS-14-AT	3,1 ± 0,32	3 (3 - 3)	3,8 ± 0,42	4 (3,75 - 4)	**0,007*** (z=-3,067)
Intragroup p	0,564 (z=-0,577)		**0,046*** (z=-2)		
Mean Diff. PBS-14	-0,1 ± 0,57	0 (-0,25 - 0)	-0,4 ± 0,52	0 (-1 - 0)	0,353 (z=-1,175)

PBS: Pediatric Balance Scale; **X:** Arithmetic mean; **SD:** Standard deviation; **min:** minimum, **max:** maximum; **z:** Mann Whitney U test; **z:** Wilcoxon paired two sample test; *p<0.05

Table 5. PBS total scale score result values review

	Control		**Study**		
	X±SD	**Median (min/max)**	**X ± SD**	**Median (min/max)**	**Intergroup p**
PBS-BT	51,8±0,92	52 (51 - 52,25)	51,8 ± 1,62	52 (50,75-53,25)	1 (z=0)
PBS-AT	52,6 ± 1,51	52,5 (51 - 53,5)	55,1 ± 0,88	55 (54 - 56)	**0,001*** (z=-3,151)
Intragroup p	0,169 (z=-1,376)		**0,005*** (z=-2,825)		
Mean Diff. PBS	-0,8 ± 1,23	-1 (-1,25 - 0,25)	-3,3 ± 1,25	-3 (-4 - -2)	**0,0001*** (z=-3,384)

PBS: Pediatric Balance Scale; **X:** Arithmetic mean; **SD:** Standard deviation; **min:** minimum, **max:** maximum; **z:** Mann Whitney U test; **z:** Wilcoxon paired two sample test; *p<0.05

Table 6. FSS results

	Control		**Study**		
	X ± SD	**Median (min/max)**	**X ± SD**	**Median (min/max)**	**Intergroup p**
FSS-BT	8,13 ± 2	7,51(6,46 - 9,68)	8,31 ± 1,88	8,23(6,7 - 10,57)	0,835(t=-0,212)
FSS-AT	8,33 ± 1,95	7,92(6,67 - 9,74)	6,64 ± 1,91	5,86(5,45 - 7,85)	0,066(t=1,958)
Intragroup p	0,528(t=-0,657)		**0,001***(t=4,789)		
Mean Diff. FSS	-0,21 ± 0,99	-0,06(-1,2 - 0,57)	1,67 ± 1,1	2,01(0,76 - 2,69)	**0,001***(t=-3,998)

FSS: Five-Step Stair Climbing and Descending Test; **X:** Arithmetic mean; **SD:** Standard deviation; **min:** minimum, **max:** maximum; In between-group analyses **t:** Independent groups t test; In within-group analyses **t:** Dependent groups t test; *p<0,05

6MWT

No significant between-group differences were found in the 6MWT at baseline or post-treatment. However, both groups improved significantly over time (control: p=0.034; experimental: p = 0.005) with increased walking distances post-treatment. The magnitude of change did not differ significantly between the groups (p > 0.05)(Table 7).

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Table 7. Comparison of 6MWT results

	Control Group		Study Group		Intergroup p
	X ± SD	**Median (min/max)**	**X ± SD**	**Median (min/max)**	
6MWT-BT	308,49±80,42	315,45 (238,13-378,46)	290,45±53,58	277,99 (259,28- 329,83)	0,562 (t=0,59)
6MWT-AT	334,74±77,11	316,48 (266,16 - 408)	368,09±57,28	364,31 (311,52- 414,41)	0,287 (t=-1,098)
Intragroup p	**0,034*** (t=-2,489)		**0,005*** (z=-2,803)		
Mean Diff. 6MWT	-26,25±33,35	-30,59 (-54,68 - -2,49)	-77,64 ± 78,04	-52,13 (-102,62- -33,13)	0,105 (z=-1,663)

6MWT: 6-Minute Walk Test; **X:** Arithmetic mean; **SD:** Standard deviation; **min:** minimum, **max:** maximum; In between-group analyses **t:** Independent groups t test; In within-group analyses **t:** Dependent groups t test; **z:** Mann Whitney U test; **z:** Wilcoxon paired two sample test; *p<0,05

4. DISCUSSION

The aim of this study was to compare conventional physiotherapy alone with conventional physiotherapy combined with AOT in children with hemiparetic CP, focusing on balance, lower extremity function, and gait-related motor skills. Hemiparetic CP is characterized by unilateral weakness that impairs motor function, balance, coordination, and the ability to perform activities of daily living. Improving these domains—particularly balance, gait, and functional mobility—is therefore a central goal in rehabilitation. AOT is a therapeutic approach that facilitates motor learning by having patients observe actions performed by others, with the underlying rationale that action observation activates neural networks involved in motor execution, thereby enhancing motor skill acquisition.

Our study demonstrated that adding AOT to conventional physiotherapy led to greater improvements in balance, gait performance, and lower extremity function compared to conventional physiotherapy alone. The experimental group showed larger pre–post gains on objective measures including the TUG test, Pediatric Balance Scale (PBS), and Functional Stair Scale (FSS). Both groups improved on the 6-Minute Walk Test (6MWT), but between-group differences were not significant, suggesting that short-term AOT primarily improves short-distance motor performance and task-specific functional mobility rather than endurance or cardiovascular capacity. This distinction is important for clinicians when setting treatment goals and selecting outcome measures.

Baseline characteristics—including age, sex, height, weight, and GMFCS level—were similar between groups, consistent with prior studies such as Jung et al. (4), which strengthens internal validity and ensures that observed effects are attributable to the intervention rather than demographic differences. The distribution of right versus left hemiparesis in our sample (11 right, 9 left) was comparable to prior reports, facilitating cross-study comparisons. Ensuring homogeneity between groups is critical for the reliability of rehabilitation trials and supports the generalizability of the intervention's short-term effects within this specific population.

Specifically, the experimental group showed significant post-treatment improvement in TUG, indicating faster gait speed and enhanced functional mobility. PBS total scores increased significantly only in the AOT group, reflecting better dynamic balance and postural control. FSS results indicated improved stair negotiation and task-specific functional gains. These findings are consistent with previous studies; Jung et al. (4) and Jeong & Lee (5) similarly reported that AOT improves motor skills, functional mobility, and balance in children with spastic CP subtypes. Tekin and Yarar (22) also emphasized that

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balance-targeted interventions reduce the risk of falls, suggesting that AOT may have both immediate and longer-term clinical benefits when integrated into therapy programs.

Despite the significant improvements observed in short-term motor performance, endurance outcomes as measured by 6MWT did not differ significantly between groups over the six-week intervention. This likely reflects the task-specific nature of AOT, which is primarily designed to enhance motor learning, coordination, and functional skill acquisition rather than aerobic capacity. Therefore, combining AOT with aerobic training or longer-duration interventions may be necessary to observe meaningful changes in endurance measures. Such integration could optimize both motor skill and cardiovascular adaptations in children with hemiparetic CP.

Correlational analyses revealed a moderate positive relationship between height and PBS total score and a strong correlation between TUG and stair-climbing performance. These associations align with findings from the WHO Multicenter Growth Reference Study (23) and other literature linking anthropometry and physical fitness with motor development (24). Recognizing these interrelationships helps clinicians interpret treatment responses and emphasizes the importance of individualized rehabilitation planning based on growth parameters and functional ability.

Strengths of this study include its comparative design, use of standardized, objective outcome measures (TUG, PBS, FSS), and focus on a specific hemiparetic CP population, increasing the clinical relevance of the findings. The six-week intervention period was sufficient to detect short-term functional gains attributable to AOT. Nevertheless, several limitations should be considered. The small sample size (n=20) limits generalizability and reduces statistical power. The short intervention period precludes assessment of long-term retention or the durability of functional gains. Additionally, the study evaluated AOT in isolation; combining AOT with other therapeutic modalities such as task-specific practice, strength, or aerobic training could potentially yield more comprehensive improvements.

Clinical implications are that AOT can be implemented as a low-cost adjunct to conventional physiotherapy to enhance motor learning, particularly for balance, gait initiation, and functional mobility tasks. Therapists may consider pairing brief action observation sessions immediately before active practice to maximize neural priming and motor acquisition. For goals related to endurance and cardiovascular performance, longer or higher-volume interventions may be necessary.

Future research should focus on larger randomized controlled trials with extended follow-up to evaluate the long-term effects of AOT, optimal dose and frequency, and the impact of combined therapeutic approaches. Subgroup analyses based on age, GMFCS level, or hemiparesis side may help identify patients who are most likely to benefit from AOT. Pragmatic trials and economic evaluations will facilitate translation of these findings into routine clinical practice.

In summary, adding AOT to conventional physiotherapy resulted in greater improvements in balance, lower extremity function, and short-distance gait-related motor skills in children with hemiparetic CP, as evidenced by larger gains on TUG, PBS, and FSS after six weeks. While endurance measured by 6MWT improved similarly in both groups, longer-duration or combined interventions may be needed to enhance cardiovascular performance. Overall, these findings suggest that AOT is a promising adjunct to physiotherapy for improving dynamic balance and functional mobility in children with hemiparetic CP, and further research is warranted to establish long-term outcomes, optimal treatment protocols, and integration with other therapeutic strategies.
This study indicate that AOT has a positive impact on balance and lower extremity function in children with hemiparetic CP. The experimental group showed significant improvements in dynamic balance tasks and functional mobility measures such as the TUG and FSS. These outcomes suggest that adding AOT to conventional physiotherapy enhances gait speed, balance performance, and stair negotiation abilities. Overall, the findings support the integration of AOT as an effective adjunct to physiotherapy for improving motor skills and functional independence in this population.

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