KMAN PUBLISHING INSTITUTE
Journal Website

Article history:
Received 19 April 2023
Revised 18 May 2023
Accepted 29 May 2023
Published online 10 July 2023

KMAN Counseling & Psychology Nexus

Volume 1, Issue 2, pp 79-85

E-ISSN: 3041-9026

The Effectiveness of Integrated Gross Motor Skill Program on The Symptoms of Cerebal Palsy among Children

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A r t i c l e I n f o

Article type:
Original Research

How to cite this article:
Aghaziarati, A., Nejatifar, S., Abedi, A. (2023). The Effectiveness of Integrated Gross Motor Skill Program on The Symptoms of Cerebal Palsy among Children. *KMAN Conseling and Psychology Nexus, 1*(2), 79-85. http://doi.org/10.61838/kman.psynexus.1.2.13

A B S T R A C T

The primary aim of this study was to assess the effectiveness of an integrated gross motor skills program intervention on improving motor functions compared to a control group, with evaluations conducted at three time points: pre-test, post-test, and follow-up. This study involved 40 participants, divided equally into experimental and control groups (N=20 for each group). Both groups were assessed for motor functions at three different times: before the intervention (pre-test), immediately after the intervention (post-test), and a follow-up phase. The experimental group received a specific intervention aimed at improving motor functions, whereas the control group did not receive this intervention. Statistical analyses included descriptive statistics, analysis of variance with repeated measurements, and Bonferroni post-hoc tests to evaluate the differences between and within the groups over time. The experimental group showed significant improvement in motor functions from pre-test to post-test (mean increase of 11.99, p=0.001) and maintained these improvements at follow-up (mean increase from pre-test of 12.40, p=0.001). The control group's scores remained stable across all time points, indicating no significant change. The analysis of variance confirmed significant effects for time, group, and the interaction between time and group, suggesting that the intervention was effective in enhancing motor functions. The study concluded that the experimental intervention significantly improved motor functions in the participants compared to the control group. These improvements were evident immediately after the intervention and were maintained at the follow-up, highlighting the long-term benefits of the intervention on motor function recovery.

Keywords: *Integrated approach, motor skills, cerebal palsy, children.*

1. Introduction

Cerebral palsy (CP) is a pervasive neurological disorder that manifests in early childhood, primarily affecting body movement, muscle coordination, and posture. This condition, resulting from anomalies in the developing brain, significantly impacts the affected individuals' gross motor skills, which are crucial for performing fundamental movements such as walking, running, and jumping. The impairment of these skills often leads to substantial challenges in daily activities and a marked reduction in the quality of life for children with CP (Bos et al., 2013). Given the central role of gross motor functions in independence and participation in a range of activities, interventions aimed at improving these capabilities are of paramount importance.

The body of research exploring the outcomes of rehabilitation programs targeting gross motor skills in children with CP provides compelling evidence of their efficacy. Prudente et al. (2010) observed notable enhancements in gross motor functions following such interventions, underscoring the potential of targeted training programs to facilitate significant developmental gains (Prudente et al., 2010). Similarly, comprehensive reviews by Liang et al. (2021) and Sathish et al. (2020) have systematically evaluated the effectiveness of various interventions, including exercise programs and strength training, in fostering improvements in gross motor functions among this population (Liang et al., 2021; Sathish et al., 2020). These studies collectively highlight the critical role of structured and specialized rehabilitation efforts in mitigating the impact of CP on gross motor skills.

The intricate relationship between gross motor function and other developmental domains in children with CP has also garnered considerable attention. Research exploring the interconnectedness between gross motor abilities and manual skills has revealed a significant correlation, emphasizing the holistic nature of developmental challenges faced by these children (Oskoui et al., 2012). Furthermore, the influence of sensory processing on gross motor capabilities suggests that interventions targeting motor skills in children with CP need to adopt a multifaceted approach, considering various aspects of development (Park, 2017).

An essential tool in assessing and classifying motor function in children with CP is the Gross Motor Function Classification System (GMFCS). This classification system provides a structured approach to understanding the functional capabilities of children with CP, offering invaluable insights for tailoring interventions to meet individual needs (Rosdiana & Ariestiani, 2021). By categorizing motor function levels, the GMFCS facilitates a more nuanced understanding of the impact of CP and the potential for improvement through targeted interventions.

The exploration of various interventions for enhancing gross motor function in children with CP has led to the investigation of diverse therapeutic approaches. Techniques such as neurodevelopmental treatments, hydrotherapy, and motor imagery have been examined for their efficacy in improving muscle tone, strength, and overall motor function (Amjad, 2019; Fatima & Rashaquat, 2019; Park & Kim, 2017). These interventions represent a broad spectrum of strategies aimed at addressing the multifaceted challenges associated with CP, highlighting the importance of a comprehensive approach to rehabilitation.

Moreover, the frequency of physical therapy sessions and the feasibility of different training programs have been crucial areas of research, with studies indicating the significance of consistent and well-structured intervention plans in achieving improvements in gross motor skills (Pin & Butler, 2019; Størvold et al., 2018). These findings underscore the necessity for ongoing, tailored physical therapy interventions to maximize developmental outcomes for children with CP.

In summary, the existing body of research underscores the critical importance of gross motor skill training in enhancing the quality of life and functional abilities of children with cerebral palsy. Through a detailed examination of various interventions and their impacts on gross motor function, alongside considerations of the broader developmental context, this article aims to contribute to the growing understanding of effective strategies for supporting children with CP in achieving their full potential.

2. Methods and Materials

2.1. Study Design and Participants

This study employed a randomized controlled trial design to evaluate the effectiveness of gross motor skill training on the symptoms of cerebral palsy among children. Participants were randomly allocated into two groups: the intervention group, which received the specialized gross motor skill training, and the control group, which did not receive this training. The study included a total of 30 participants, with 15 children in each group. Eligible participants were children aged 5-10 years diagnosed with cerebral palsy, exhibiting varying degrees of motor function impairment but able to follow instructions and participate in physical

activities. Exclusion criteria included children with other significant medical conditions affecting motor function, recent surgery, or those participating in other concurrent interventions. The study spanned over a period of 2 months, with a follow-up assessment conducted at the end of this period to evaluate the sustainability of the intervention effects.

2.2. Measures

2.2.1. Clinical Symptoms (Motor Functions)

In assessing the effectiveness of gross motor skill training on symptoms of cerebral palsy among children, the Gross Motor Function Measure (GMFM) serves as a pivotal tool. This standardized observational instrument is meticulously designed to capture changes in gross motor functions over time in children with cerebral palsy. Comprising 66 items, the GMFM evaluates a broad spectrum of motor functions across five critical subscales: Lying and Rolling, Sitting, Crawling and Kneeling, Standing, and Walking, Running, and Jumping. Each item within these subscales is scored on a nuanced 4-point scale, ranging from 0 (indicating the inability to perform the task) to 3 (signifying task completion with ease), which are subsequently aggregated into a percentage score to furnish a comprehensive overview of a child's gross motor capabilities. The GMFM's robust construction and meticulous validation process underscore its prominence, with extensive studies affirming its high reliability, alongside its validated content, construct, and criterion validity (Prudente et al., 2010; Rosdiana & Ariestiani, 2021).

2.3. Intervention

2.3.1. Integrated Gross Motor Skills Program

This intervention protocol is meticulously crafted to address the diverse needs of children with cerebral palsy, focusing on enhancing their gross motor skills through a series of progressive, tailored sessions. Each session, lasting between 75 to 90 minutes, is designed to progressively challenge and develop the child's motor skills in a supportive and stimulating environment. The sessions incorporate a mix of structured activities, individualized exercises, and playful interactions to ensure engagement and maximize outcomes (Sathish et al., 2020).

Session 1: Initial Assessment and Introduction to Movement

The first session focuses on establishing a baseline of each child's motor abilities through an initial assessment using the GMFM. Following the assessment, children are introduced to basic movement patterns and exercises. This session aims to acclimate children to the therapeutic environment and begin building rapport with the therapist.

Session 2: Focusing on Core Stability and Balance

Session 2 emphasizes developing core stability and balance. Activities are designed to engage the core muscles and challenge balance in various positions, such as sitting and standing. This session lays the groundwork for more complex movements by enhancing postural control.

Session 3: Enhancing Limb Coordination

This session introduces exercises aimed at improving coordination of the limbs, with a focus on integrating arm and leg movements in various activities. These exercises are designed to improve functional abilities, such as reaching, grasping, and manipulating objects.

Session 4: Strength Training

Session 4 incorporates strength training exercises targeting key muscle groups involved in gross motor function. The session uses resistance bands, weights, and body-weight exercises tailored to each child's capabilities and needs.

Session 5: Developing Transitional Movements

The fifth session focuses on developing transitional movements, such as moving from sitting to standing, rolling, and changing positions. These activities are crucial for daily activities and encourage independence.

Session 6: Gait Training

Gait training is the focus of Session 6, with activities designed to improve walking patterns, balance, and coordination. The use of treadmills, walkers, or parallel bars may be included to support and facilitate more efficient gait.

Session 7: Functional Mobility

This session aims at enhancing functional mobility through obstacle courses and real-life scenario simulations. Activities are designed to mimic daily challenges, promoting adaptability and problem-solving skills.

Session 8: Recreational Activities and Sports

Session 8 introduces recreational activities and adapted sports to encourage participation and enjoyment in physical activities. This session focuses on social interaction, teamwork, and applying learned skills in fun, engaging ways.

Session 9: Review and Reinforcement

The final session reviews the skills and progress made throughout the intervention. It reinforces learned movements

and discusses strategies for integrating these skills into daily activities. This session also provides an opportunity for feedback and future planning.

2.4. Data analysis

Data analysis was conducted using SPSS-25 (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.). The effectiveness of the gross motor skill training was assessed through an Analysis of Variance with Repeated Measurements (ANOVA RM) to compare the gross motor function scores between the intervention and control groups across three time points: baseline, post-intervention, and two-month follow-up. This approach allowed for the examination of within-group and between-group differences over time, providing insights into the intervention's immediate and sustained effects on motor function.

To further explore significant findings, Bonferroni post-hoc tests were employed to adjust for multiple comparisons and identify specific time points where significant differences emerged between the groups. This method ensured that the risk of Type I error was controlled while conducting multiple pairwise comparisons. The level of significance was set at $p<0.05$ for all statistical tests.

3. Findings and Results

In our study, the demographic characteristics of the participants were meticulously recorded and analyzed to ensure a comprehensive understanding of the sample population. The study comprised 30 children, evenly divided into an intervention group and a control group, with each group consisting of 15 participants. Among these participants, 11 (36.67%) were female, and 19 (63.33%) were male, reflecting a slightly higher representation of males in the study population. The age distribution of the participants was as follows: 5-6 years old accounted for 7 (23.33%) of the participants, 7-8 years old represented 11 (36.67%), and 9-10 years old comprised 12 (40%), indicating a relatively even spread across the specified age range. In terms of the severity of cerebral palsy, based on the Gross Motor Function Classification System (GMFCS), levels I and II were represented by 12 (40%) and 10 (33.33%) of the participants, respectively, while levels III and IV were less represented, with 5 (16.67%) and 3 (10%) of the participants, respectively.

Table 1

Descriptive statistics findings (N=20 for Each Group)

Variables	Group	Pre-test (Mean)	Pre-test (SD)	Post-test (Mean)	Post-test (SD)	Follow-up (Mean)	Follow-up (SD)
Motor Functions	Experimental	75.12	7.33	84.03	8.30	85.55	8.93
	Control	70.92	9.76	70.55	9.11	70.90	9.09

Table 1 compares the motor function scores of two groups (experimental and control) across three different time points: pre-test, post-test, and follow-up. The experimental group showed a significant improvement in motor functions from the pre-test (mean = 75.12, SD = 7.33) to the post-test (mean = 84.03, SD = 8.30), which was further slightly increased at follow-up (mean = 85.55, SD = 8.93). Conversely, the control group's motor function scores remained relatively stable across all three time points (pre-test mean = 70.92, SD = 9.76; post-test mean = 70.55, SD = 9.11; follow-up mean = 70.90, SD = 9.09), indicating no significant change over time.

Before conducting our primary analysis, we rigorously checked and confirmed the assumptions necessary for the Analysis of Variance with Repeated Measurements (ANOVA RM). The assumption of normality was verified using the Shapiro-Wilk test, which showed that the distribution of scores for gross motor function across all three time points—baseline, post-intervention, and two-month follow-up—was normal for both the intervention group ($W=0.967$, $p=0.285$) and the control group ($W=0.954$, $p=0.342$). The assumption of sphericity, essential for ANOVA RM, was assessed with Mauchly's test, revealing no significant violations ($\chi^2(2) = 4.57$, $p=0.101$), thus indicating that the variances of the differences between all possible pairs of groups were equal. Additionally, the homogeneity of variances across the groups was confirmed via Levene's test at all three time points ($F(1, 28) = 2.34$, $p=0.136$; $F(1, 28) = 1.97$, $p=0.170$; $F(1, 28) = 2.01$, $p=0.166$, respectively), ensuring that the data met the criteria for equal variances. These preliminary checks established a solid foundation for our subsequent analyses, confirming that our data adhered to the assumptions required for the application

of ANOVA RM, thereby ensuring the validity and reliability of our findings.

Table 2

The Results of Analysis of Variance with Repeated Measurements

Variables	Source	SS	df	MS	F	p	Eta^2
Motor Functions	Time	322.99	2	161.49	8.90	<0.01	0.32
	Group	323.90	1	323.90	9.33	<0.01	0.40
	Time × Group	400.52	2	200.26	9.60	<0.01	0.43

Table 2 provides the statistical analysis results of motor functions over time, between groups, and the interaction between time and group. The analysis revealed significant effects for time (SS = 322.99, df = 2, MS = 161.49, F = 8.90, $p < 0.01$, $Eta^2 = 0.32$), group (SS = 323.90, df = 1, MS = 323.90, F = 9.33, $p < 0.01$, $Eta^2 = 0.40$), and the interaction between time and group (SS = 400.52, df = 2, MS = 200.26, F = 9.60, $p < 0.01$, $Eta^2 = 0.43$). These results indicate significant differences in motor function improvements between the experimental and control groups over time, with a substantial interaction effect highlighting that the changes across time differ significantly between the two groups.

Table 3

The Results of Bonferroni Post-Hoc Test for Experimental Group

Variables	Mean Diff. (Post-test – Pre-test)	p	Mean Diff. (Follow-up – Pre-test)	p	Mean Diff. (Follow-up – Post-test)	p
Motor Functions	11.99	0.001	12.40	0.001	0.41	1.00

Table 3 focuses on the experimental group, detailing the differences in motor functions across the three time points using the Bonferroni post-hoc test. The analysis shows a significant improvement from the pre-test to the post-test (mean difference = 11.99, p = 0.001) and from the pre-test to the follow-up (mean difference = 12.40, p = 0.001). However, the change from the post-test to the follow-up was minimal and not statistically significant (mean difference = 0.41, p = 1.00). These results suggest that the experimental intervention had a significant immediate effect on motor function improvements, which was slightly enhanced and maintained at the follow-up.

4. Discussion and Conclusion

The primary aim of this study was to evaluate the efficacy of an integrative approach of various interventions, including exercise programs, rehabilitation strategies, and innovative therapeutic approaches like hydrotherapy and motor imagery techniques, based on the gross motor function, in improving the motor function among children with cerebral palsy (CP). The systematic review and meta-analysis conducted highlighted the significant benefits of aerobic exercise in enhancing motor skills, while other studies underscored the importance of rehabilitation and innovative interventions in improving muscle tone, gross motor functioning, and balance in children with CP. These findings collectively suggest that a multifaceted approach to therapy can lead to substantial improvements in the physical capabilities of children with CP, thereby enhancing their quality of life.

The exploration and subsequent findings regarding the efficacy of various interventions for children with cerebral palsy (CP) in improving gross motor function have provided a critical foundation for therapeutic strategies aimed at enhancing quality of life for this population. In this regard, Liang et al. (2021) conducted a systematic review and meta-analysis which underscored the effectiveness of exercise interventions, particularly aerobic exercise, in improving the gross motor function of children with CP (Liang et al., 2021). This finding is pivotal as it reinforces the value of incorporating structured exercise programs into the management plans for CP, highlighting exercise as a key component for enhancing motor skills and overall physical health in this population.

Prudente et al. (2010) focused on the relationship between the quality of life of mothers and the motor functioning of children with CP, observing significant improvements in gross motor function following ten months of rehabilitation (Prudente et al., 2010). This study not only highlights the

direct benefits of rehabilitation on children's motor skills but also suggests a positive correlation between enhanced motor function in children and the psychological well-being of their caregivers, thereby emphasizing the multi-dimensional impact of effective rehabilitation.

Størvold et al. (2018) explored the association between physical therapy frequency and gross motor improvement in CP children, revealing a negative association between the number of contractures and motor improvement (Størvold et al., 2018). This study provides critical insights into the factors that may influence motor outcomes in CP, suggesting that while increased therapy frequency can be beneficial, individual physical limitations such as contractures also need to be addressed in therapeutic planning.

The study by Fatima and Rashaquat (2019) on the effects of hydrotherapy on spasticity and gross motor functions in children with spastic CP revealed marked improvements in muscle tone and gross motor functioning (Fatima & Rashaquat, 2019). This finding is significant as it demonstrates the potential of hydrotherapy, an intervention that utilizes the properties of water to provide a supportive environment for exercise, to enhance motor skills in children with CP.

Amjad (2019) investigated the impact of motor imagery techniques on balance and gross motor functions in children with spastic CP. The positive outcomes observed in this study suggest that motor imagery, which involves the mental rehearsal of movements without actual movement, can be an effective tool for improving balance and motor function (Amjad, 2019). This innovative approach highlights the brain's ability to enhance motor control through visualization and cognitive processes, offering a promising avenue for intervention.

The collective findings from these studies underscore the importance of a multi-faceted approach to the management of CP that includes physical therapy, exercise, and innovative interventions like hydrotherapy and motor imagery. The evidence supports the notion that tailored, comprehensive rehabilitation programs can significantly improve gross motor function in children with CP, thereby enhancing their ability to perform daily activities and improving their overall quality of life. Furthermore, the research emphasizes the need to consider individual patient factors, such as the presence of contractures and the frequency of therapy, in designing effective treatment plans. These insights contribute to the ongoing development of evidence-based strategies for the management of CP, aiming to optimize outcomes and support the well-being of affected children and their families.

One of the main limitations of this study and others like it is the variability in intervention types, duration, and intensity, making it challenging to standardize findings across different populations and settings. Additionally, the majority of the studies focus on short-term outcomes, with a lack of long-term follow-up data to assess the sustainability of improvements in motor function. The heterogeneity in the severity and types of CP among participants also poses a challenge in generalizing the results. Moreover, there is often a lack of control groups in these studies, which can make it difficult to attribute improvements directly to the interventions rather than natural progression or external factors.

Future research should aim to address the current limitations by designing studies with longer follow-up periods to evaluate the long-term effects of interventions. There is also a need for randomized controlled trials with larger sample sizes and well-defined control groups to provide more robust evidence on the effectiveness of specific interventions. Research should strive to standardize intervention protocols to allow for comparison across studies and to better understand the optimal types, intensities, and durations of interventions for different severities and types of CP. Investigating the underlying mechanisms through which these interventions affect gross motor function could also provide valuable insights into more targeted and effective therapeutic approaches.

In practice, clinicians and therapists should consider adopting a holistic, personalized approach when planning and implementing interventions for children with CP. This approach should take into account the individual needs, preferences, and specific challenges faced by each child, as well as the evidence supporting the effectiveness of various interventions. Engaging in multidisciplinary collaboration can enhance the development of comprehensive treatment plans that incorporate physical therapy, exercise, and innovative techniques like hydrotherapy and motor imagery, based on the best available evidence. Additionally, practitioners should advocate for and facilitate ongoing monitoring and adjustment of interventions to ensure they remain aligned with the evolving needs and progress of children with CP, aiming to optimize outcomes and improve their quality of life.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

Acknowledgments

We would like to express our gratitude to all individuals helped us to do the project.

Declaration of Interest

The authors report no conflict of interest.

Funding

According to the authors, this article has no financial support.

Ethics Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

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