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Original Article

Effects of Powerball on Grip Strength in Children with Developmental Delay

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ABSTRACT

Background: Developmental delay may impair fine motor control, grip strength, and manual ability, limiting children's independence in daily and school-related activities. Conventional hand-strengthening exercises are commonly used in rehabilitation, while Powerball training may provide an engaging resisted wrist and hand activity through gyroscopic motion. Objective: To determine the effects of Powerball exercises combined with conventional physical therapy on grip strength and manual functional ability in children with developmental delay. Methods: This randomized controlled trial was conducted over six months at DHQ Hospital, Layyah, and Rising Sun Institute for Special Children, Lahore. Children aged 7–12 years with moderate developmental delay and affected fine motor skills were allocated to a control group receiving conventional hand-strengthening exercises or an experimental group receiving Powerball exercises in addition to conventional therapy. Both groups completed 12 sessions over one month. Grip strength was assessed using a hand-held dynamometer, and manual ability was assessed using ABILHAND-Kids. Results: Twenty-six children completed the study, with 13 participants in each group. Hand-held dynamometer scores increased slightly in both groups but showed no statistically significant within-group or between-group differences. ABILHAND-Kids scores improved significantly within the control group and experimental group, but the post-treatment between-group difference was not statistically significant. Conclusion: Both interventions were associated with improved manual ability over time, but the available data do not confirm statistically significant superiority of Powerball over conventional therapy. Larger adequately powered trials are required. Keywords: Developmental Delay; Dynamometer; Grip Strength; Hand Function; Powerball; Rehabilitation.

EDITORIAL INFORMATION

Author Contributions: HA and LA contributed to concept and design; MN contributed to supervision and methodology; HI contributed to data collection and drafting; all authors contributed to manuscript preparation and approved the final version.
Ethical Approval: Riphah International University, Lahore, Pakistan; Data Collection Approval: DHQ Hospital, Layyah, Rising Sun Institute for Special Children, Lahore
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INTRODUCTION

Developmental delay refers to delayed attainment of expected age-related developmental milestones and may involve motor, cognitive, speech, social, adaptive, or combined functional domains. When delay is present in two or more developmental domains, the condition is commonly described as global developmental delay and requires structured assessment because functional limitations may affect participation in daily, educational, and self-care activities during childhood (1). Children with developmental delay may present with impaired learning, delayed communication, reduced social interaction, difficulty with problem solving, and limitations in motor performance, including impaired fine motor control and reduced ability to perform hand-dependent activities (2). These impairments are clinically important because hand function contributes directly to independence in feeding, dressing, writing, grasping, object manipulation, play, and school-based tasks.

Grip strength is a key component of upper-limb function because it reflects the coordinated activity of the hand, wrist, forearm, elbow, shoulder, and postural control systems. In children with developmental delay, reduced muscle strength, poor motor coordination, impaired trunk stability, altered tone, and limited fine motor control may contribute to weak grasp patterns and reduced manual dexterity. Compromised grip strength can restrict activities such as holding pencils, drawing, eating with utensils, grasping objects, manipulating classroom materials, and performing age-appropriate activities of daily living. Pediatric evidence also indicates that hand strength varies with age, body development, positioning, and neuromotor control, making standardized assessment and targeted strengthening clinically relevant in children with functional motor limitations (3).

Manual ability and grip strength should be assessed using reliable tools that capture both body-function impairment and activity-level performance. Hand-held dynamometry provides a quantitative measure of maximal isometric grip force when standardized positioning, repeated trials, and consistent instructions are used (4). Functional questionnaires such as ABILHAND-Kids complement strength testing by estimating the child's perceived or parent-reported ability to perform daily manual tasks, particularly in children with neurodevelopmental or motor impairments (5). The combined use of impairment-level and activity-level outcomes is therefore appropriate when evaluating interventions intended to improve hand function in children with developmental delay. Conventional hand-strengthening exercises, including putty gripping, thumb pinch activities, isometric hook exercises, rubber-band abduction, and thumb opposition exercises, are commonly used to improve intrinsic and extrinsic hand muscle performance. However, children with developmental delay may have difficulty maintaining motivation and consistent performance during repetitive strengthening tasks. The Powerball is a gyroscopic hand-exercise device that requires circumduction of the wrist and coordinated activation of hand, wrist, and forearm musculature against self-generated resistance. This mechanism may provide an engaging adjunct to conventional therapy by promoting repeated resisted movement, grip activation, and sensorimotor participation during a short supervised training period (6).

Although grip-strength training has been studied in different pediatric and clinical populations, limited evidence is available regarding the additional effect of Powerball exercises on grip strength and manual ability in children with developmental delay. This creates a practical rehabilitation gap because therapists require feasible, child-friendly, and measurable interventions that can be integrated into routine physical therapy. Therefore, the present randomized controlled trial was designed to determine whether Powerball exercises combined with conventional physical therapy produce greater improvement in grip strength and manual functional ability than conventional physical therapy alone in children aged 7–12 years with developmental delay. The study hypothesized that children receiving Powerball exercises in addition to conventional therapy would show greater improvement in hand-held dynamometer scores and ABILHANDKids scores after 12 treatment sessions compared with children receiving conventional therapy alone.

MATERIAL AND METHODS

This study was conducted as a randomized controlled trial to compare the effects of Powerball exercises combined with conventional physical therapy versus conventional physical therapy alone on grip strength and manual functional ability in children with developmental delay. The study was carried out over a six-month period at DHQ Hospital, Layyah, and Rising Sun Institute for Special Children, Lahore. The trial was registered with the clinical trial registry under registration number NCT05392296. Children were recruited according to predefined eligibility criteria and were assigned to either the control group or the experimental group after parental informed consent was obtained.

Children aged 7–12 years of either sex with moderate developmental delay and affected fine motor skills were eligible for inclusion. Children were excluded if they had another neurological condition or a diagnosed genetic disorder that could independently influence hand function, grip performance, or participation in the intervention protocol. After recruitment, each child underwent detailed history taking, physical examination, and regional assessment of the upper limb and hand function. Parents completed the ABILHAND-Kids questionnaire according to their child's ability to perform daily manual activities, and grip strength was assessed using a hand-held dynamometer before starting the intervention.

A total of 28 children were initially enrolled according to the inclusion and exclusion criteria. Two children discontinued after the first treatment session, and 26 children completed the intervention and posttreatment assessment. The final analyzed sample therefore included 26 participants, allocated into two groups of 13 participants each. Both groups received 12 treatment sessions over one month, delivered at a frequency of three sessions per week. The control group received conventional physical therapy consisting of isometric hand-grip strengthening exercises, including putty grip and squeeze exercises, thumb pinch strengthening, isometric hook exercises, rubber-band finger abduction, and C-shaped thumb exercises. These exercises were performed separately for both hands. During putty gripping, the child held the putty in the palm and squeezed it until the fingers approached the palm, with each activity performed for approximately 2–3 minutes. Thumb pinch strengthening was performed by placing elongated putty on a table and asking the child to pinch it using the thumb and index finger. Isometric hook exercises were performed by clasping the fingers of both hands together and pulling outward to produce maximal voluntary contraction, holding for 5 seconds and repeating 10 times. Rubber-band abduction was performed by placing a rubber band around the four fingers and asking the child to spread the fingers against resistance. C-shaped thumb exercises were performed by placing a rubber band around the fingers and thumb and asking the child to abduct the thumb and fingers into a C-shaped position.

The experimental group received the same conventional physical therapy protocol in addition to Powerball exercises. The Powerball exercise was performed for 3 minutes during each session. During the activity, the child held the Powerball in the palm and generated rotational movement through coordinated wrist circumduction. The gyroscopic motion produced resistance requiring activation of the hand, wrist, forearm, and elbow musculature. The exercise was supervised during treatment sessions to encourage proper movement pattern, child engagement, and safe performance. Both groups received the same total number of treatment sessions and were assessed at baseline and after completion of the 12-session intervention period.

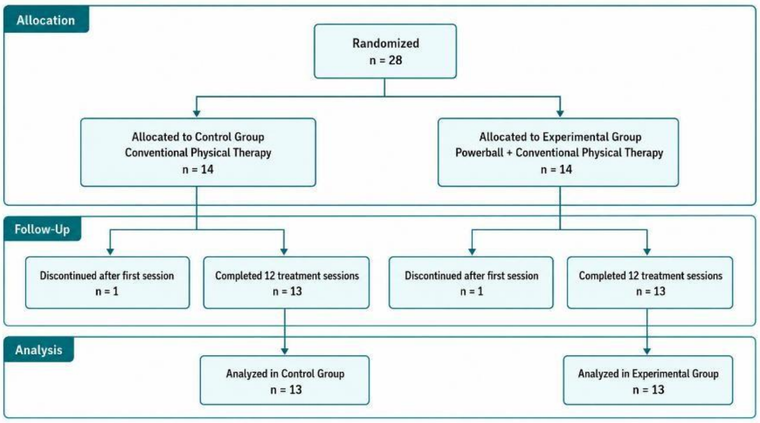

Figure 1 Consort flowchart

Grip strength was measured using a hand-held dynamometer. During testing, each participant sat comfortably on a chair with the back supported, shoulder positioned neutrally, elbow flexed to 90 degrees, and wrist maintained in a neutral position. The child was instructed to hold the dynamometer and squeeze as hard as possible for 2–3 seconds without moving the arm. The test was repeated three times with a twominute rest interval between trials, and the mean value of the three trials was used as the final grip-strength score. The same testing procedure was used at baseline and post-treatment assessment to maintain consistency in measurement conditions. Manual functional ability was assessed using the ABILHAND-Kids questionnaire, a parent-reported measure of manual ability in children with motor impairment. Parents rated their child's ability to perform daily manual activities according to observed functional performance. The tool was used to estimate the extent to which reduced hand function and fine motor impairment affected activities of daily living. The ABILHAND-Kids assessment was completed before the intervention and after the final treatment session.

Data were analyzed using IBM SPSS Statistics version 25. Continuous variables were summarized using mean and standard deviation when distributional assumptions were appropriate, while ordinal or nonnormally distributed data were summarized using median and rank-based statistics. Categorical variables were summarized using frequency and percentage. The Shapiro-Wilk test was used to assess normality of outcome data and to guide selection of parametric or non-parametric statistical tests. For normally distributed dynamometer data, independent-samples t-tests were used for between-group comparisons, and paired-samples t-tests were used for within-group pre-post comparisons. For

ABILHAND-Kids data, non-parametric testing was applied; Mann-Whitney U tests were used for between-group comparisons, and Wilcoxon signed-rank tests were used for within-group pre-post comparisons. The level of statistical significance was set at $\alpha = 0.05$. The primary comparison of clinical interest was the difference in posttreatment improvement between the experimental and control groups, while within-group analyses were interpreted as supportive rather than definitive evidence of treatment effectiveness.

RESULTS

A total of 28 children were initially enrolled according to the eligibility criteria. Two participants discontinued after the first treatment session, and 26 participants completed the intervention and posttreatment assessment. The final analysis included 26 children, with 13 participants in the control group and 13 participants in the experimental group.

The analyzed sample consisted of 26 children aged 7–12 years, with a mean age of 10.08 ± 1.495 years. Male participants represented 61.5% of the sample and female participants represented 38.5%. Although the manuscript states that demographic characteristics were similar at baseline, group-wise age and sex distributions were not provided; therefore, statistical comparison of baseline demographic equivalence could not be reproduced from the available data. Normality testing was performed to guide selection of parametric and non-parametric tests. The hand-held dynamometer outcome was analyzed using parametric tests, while ABILHAND-Kids data were analyzed using non-parametric tests.

The Shapiro-Wilk result for hand-held dynamometer data was 0.470, indicating that parametric testing was considered appropriate for this outcome. The ABILHAND-Kids result was reported as 0.013, indicating that non-parametric testing was appropriate. These p-values reflect distributional assessment only and do not represent treatment effectiveness. Between-group comparison of hand-held dynamometer scores showed no statistically significant difference between the control and experimental groups at baseline or after the intervention.

Table 1. Participant Flow and Overall Baseline Characteristics

Variable	Value
Initially enrolled, n	28
Discontinued after first session, n	2
Completed intervention and assessment, n	26
Control group, n	13
Experimental group, n	13
Age, years, Mean ± SD	10.08 ± 1.495
Age range, years	7–12
Male, n (%)	16 (61.5)
Female, n (%)	10 (38.5)

Table 2. Distributional Assessment and Statistical Test Selection

Outcome Measure	Shapiro-Wilk p-value	Between-Group Test	Within-Group Test
Hand-held dynamometer	0.470	Independent-samples t-test	Paired-samples t-test
ABILHAND-Kids	0.013	Mann-Whitney U test	Wilcoxon signed-rank test

Table 3. Between-Group Comparison of Hand-Held Dynamometer Scores

Outcome Time Point	Control Group, Mean ± SD	Experimental Group, Mean ± SD	p-value
Pre-treatment	0.8078 ± 0.19993	0.8557 ± 0.15024	0.496
Post-treatment	0.8341 ± 0.22082	0.8831 ± 0.19084	0.550

At baseline, mean hand-held dynamometer scores were 0.8078 ± 0.19993 in the control group and 0.8557 ± 0.15024 in the experimental group, with no statistically significant between-group difference. After treatment, the mean score was 0.8341 ± 0.22082 in the control group and 0.8831 ± 0.19084 in the experimental group. Although the experimental group had a descriptively higher post-treatment mean, the between-group difference was not statistically significant. Within-group comparison of hand-held dynamometer scores showed small numerical increases in both groups after treatment; however, neither within-group change reached statistical significance.

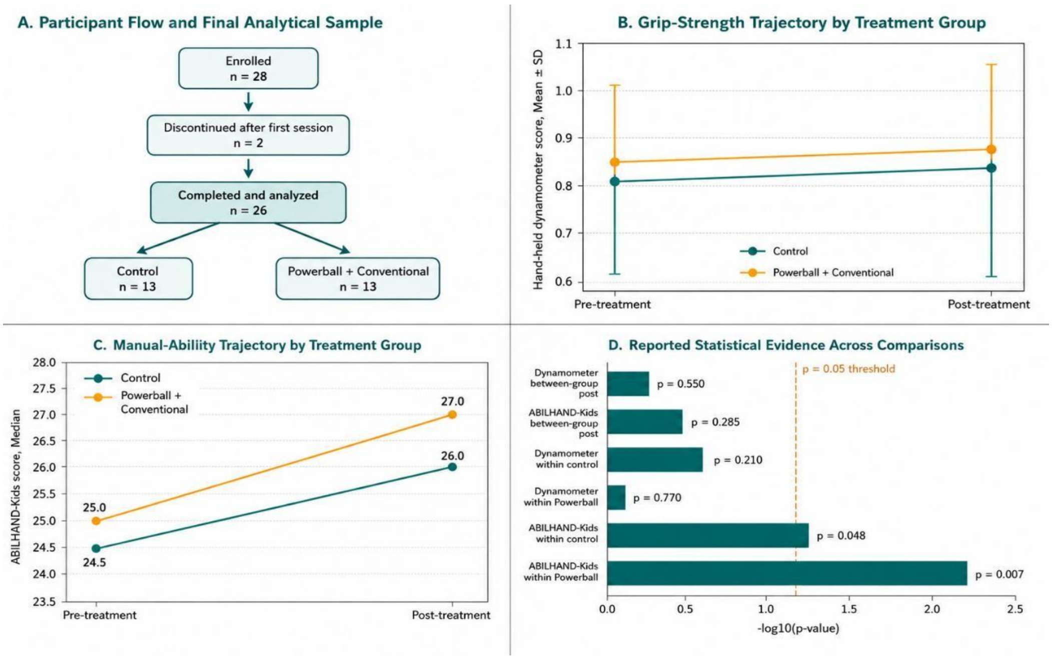

Figure 2 The multipanel figure summarizes the randomized trial evidence across participant flow, grip-strength trajectory, manual-ability trajectory, and reported statistical evidence. Of 28 enrolled children, 26 completed treatment and were analyzed equally across the control and Powerball plus conventional therapy groups. Hand-held dynamometer scores increased slightly from 0.8078 ± 0.19993 to 0.8341 ± 0.22082 in the control group and from 0.8557 ± 0.15024 to 0.8831 ± 0.19084 in the Powerball group, but neither within-group nor between-group dynamometer comparisons reached statistical significance. ABILHAND-Kids medians improved from 24.5 to 26.0 in the control group and from 25.0 to 27.0 in the Powerball group, with statistically significant within-group improvement in both groups. However, the post-treatment between-group ABILHAND-Kids comparison remained non-significant, indicating that the available aggregate data support functional improvement over time but do not confirm statistically significant superiority of Powerball over conventional therapy alone.

The control group increased from 0.8078 ± 0.19993 at baseline to 0.8341 ± 0.22082 after treatment, while the experimental group increased from 0.8557 ± 0.15024 to 0.8831 ± 0.19084. The within-group p-values were 0.210 for the control group and 0.770 for the experimental group, indicating that the observed numerical improvements in dynamometer scores were not statistically significant within either group.

Table 4. Within-Group Comparison of Hand-Held Dynamometer Scores

Group	Pre-treatment, Mean ± SD	Post-treatment, Mean ± SD	p-value
Control group	0.8078 ± 0.19993	0.8341 ± 0.22082	0.210
Experimental group	0.8557 ± 0.15024	0.8831 ± 0.19084	0.770

Between-group comparison of ABILHAND-Kids scores showed no statistically significant between the control and experimental groups at baseline or after treatment.

Table 5. Between-Group Comparison of ABILHAND-Kids Scores

Outcome Time Point	Control Group, Median	Experimental Group, Mean Rank	Control Group, Mean Rank	p-value
Pre-treatment	25.0000	13.54	12.42	0.701
Post-treatment	27.0000	15.08	11.92	0.285

Table 6. Within-Group Comparison of ABILHAND-Kids Scores

Group	Pre-treatment Median	Post-treatment Median	Pre-treatment Mean Rank	Post-treatment Mean Rank	p-value
Control group	24.5000	26.0000	3.67	6.88	0.048
Experimental group	25.0000	27.0000	0.00	5.00	0.007

The ABILHAND-Kids between-group comparison showed no statistically significant baseline difference between groups. Post-treatment median score was reported as 27.0000, and the experimental group had a higher mean rank than the control group at post-treatment assessment. However, the between-group pvalue was 0.285, indicating that the difference between groups was not statistically significant. Withingroup analysis of ABILHAND-Kids scores showed statistically significant improvement in both groups after treatment.

The control group improved from a median ABILHAND-Kids score of 24.5000 before treatment to 26.0000 after treatment, with a within-group p-value of 0.048. The experimental group improved from a median score of 25.0000 to 27.0000, with a within-group p-value of 0.007. These findings indicate statistically significant within-group improvement in manual functional ability in both groups, with a stronger withingroup p-value observed in the experimental group. However, because the post-treatment between-group comparison was not statistically significant, these findings should be interpreted as improvement over time within each group rather than definitive evidence of superiority of Powerball over conventional therapy.

DISCUSSION

The present randomized controlled trial evaluated whether adding Powerball exercises to conventional physical therapy improved grip strength and manual functional ability in children with developmental delay. The findings showed small numerical increases in hand-held dynamometer scores in both groups after 12 treatment sessions; however, these changes did not reach statistical significance within either group, and the post-treatment between-group comparison also remained non-significant. In contrast, ABILHANDKids scores improved significantly within both groups, indicating improvement in manual functional ability over time. The experimental group showed descriptively higher post-treatment values for both dynamometer and ABILHAND-Kids outcomes, but the available between-group analyses did not demonstrate statistically significant superiority of Powerball plus conventional therapy over conventional therapy alone.

These findings suggest that structured hand-focused rehabilitation may support functional manual improvement in children with developmental delay, but the additional effect of Powerball exercises remains uncertain in the current sample. The improvement in ABILHAND-Kids scores in both groups is clinically relevant because manual ability reflects the child's capacity to perform daily tasks such as grasping objects, holding pencils, drawing, feeding with utensils, and manipulating objects during play or school activities. This aligns with the rationale that grip strength and manual dexterity are important contributors to upper-limb function in children with neurodevelopmental or motor impairments. However, because ABILHAND-Kids improved in both groups and the between-group difference was not statistically significant, the improvement cannot be attributed exclusively to Powerball training.

The present findings are partially consistent with previous work reporting an association between grip strength and manual dexterity in children with Down syndrome, where hand function was influenced by developmental characteristics and required structured activity-based intervention rather than interpretation solely by sex-based differences (18). In the current study, both male and female children participated, and the intervention was delivered without gender-specific modification. The observed improvement in manual ability may therefore reflect the effect of repeated, supervised hand-use activities and task-related strengthening rather than a specific sex-related response. This interpretation is also consistent with pediatric evidence emphasizing that maximal hand-grip strength varies with age, physical development, and testing conditions, supporting the need for standardized assessment procedures when measuring grip performance in children (28).

The absence of statistically significant dynamometer improvement may be explained by several factors. First, the treatment duration was relatively short, with only 12 sessions delivered over one month. Grip strength adaptation may require a longer strengthening period, progressive resistance adjustment, and closer monitoring of exercise intensity. Second, the sample size was small, with only 13 participants per group, which limited statistical power to detect modest between-group differences. Third, developmental delay is heterogeneous, and variation in motor planning, attention, tone, coordination, motivation, and baseline functional ability may have influenced the response to exercise. Fourth, the dynamometer values showed relatively large variability compared with the small mean changes, reducing the likelihood of statistically significant results.

The improvement in ABILHAND-Kids scores despite non-significant dynamometer change may indicate that functional manual performance can improve through repeated practice, engagement, and task familiarity even when measurable maximal grip force does not substantially change. Conventional exercises such as putty gripping, thumb pinch strengthening, isometric hook exercises, rubber-band abduction, and C-shaped thumb exercises may improve coordination, grasp pattern, confidence, and task participation. Powerball exercises may offer additional engagement through active wrist circumduction and gyroscopic resistance, but the current data support this only as a possible adjunct rather than a proven superior intervention. Similar broader literature has described grip strength as a marker of function and health-related status in other populations, but extrapolation to children with developmental delay should be made cautiously because adult and elderly populations differ substantially in neuromuscular development, rehabilitation goals, and functional demands (27).

The study has several methodological limitations that should be considered when interpreting the findings. The manuscript does not provide sufficient details regarding random sequence generation, allocation concealment, assessor blinding, or intervention fidelity, which limits assessment of internal validity. The final analysis included only participants who completed the intervention, and no formal intention-to-treat analysis or missing-data strategy was reported. Group-wise baseline age and sex distributions were not provided, although baseline similarity was stated. The study also did not report change-score analysis, confidence intervals, effect sizes, or ANCOVA adjusted for baseline values, which would provide a stronger estimate of treatment effect in a randomized trial. In addition, the ABILHAND-Kids outcome was parentreported, and responses may have been influenced by parental perception, expectation, or awareness of treatment participation.

Despite these limitations, the study addresses a practical rehabilitation question and provides preliminary evidence that both conventional hand exercises and Powerball-assisted therapy may be feasible in children with developmental delay. The functional improvement observed on ABILHAND-Kids suggests that structured hand therapy may contribute to better manual task performance over a short intervention period. However, future studies should include larger sample sizes, concealed randomization, blinded outcome assessment, standardized Powerball progression, longer follow-up, adverse-event monitoring, and analysis of between-group change using confidence intervals and effect sizes. Future trials should also examine whether treatment response differs by age, baseline manual ability, developmental severity, dominant versus non-dominant hand involvement, and adherence to home-based practice.

CONCLUSION

The study found that both conventional physical therapy and Powerball combined with conventional physical therapy were associated with improvement in manual functional ability among children with developmental delay after 12 treatment sessions, as reflected by significant within-group improvement in ABILHAND-Kids scores. Hand-held dynamometer scores showed small numerical increases in both groups but did not demonstrate statistically significant within-group or between-group improvement. Although the Powerball group showed descriptively higher post-treatment values, the available betweengroup results do not confirm statistically significant superiority of Powerball over conventional therapy alone. Powerball may be considered a feasible adjunct to conventional hand therapy, but larger, adequately powered randomized controlled trials with clearer randomization, blinded assessment, change-score analysis, confidence intervals, and longer follow-up are required before firm conclusions can be made regarding its comparative effectiveness.

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