JPMHR Journal of Precision Medicine and Health Research

Volume 3, Issue 1, 2026
e-ISSN: 3106-9495
Open Access | CC BY 4.0
Article ID: 29

Original Article

Effects of Powerball on Grip Strength in Children With Developmental Delay

Huma Anjum[1], Laiba Arshad[1], Mudassar Nawaz[2], Hamaila Iqbal[3]

[1] Riphah International University, Lahore, Pakistan
[2] University of South Asia, Lahore, Pakistan
[3] University of Lahore, Lahore, Pakistan

Corresponding Author: Huma Anjum
Correspondence: huma.mzhar786@gmail.com

Received: 03 March 2026	Revised: 03 April 2026	Accepted: 07 April 2026	Published: 30 June 2026

ARTICLE INFORMATION

Article Type: **Original Article**

How to Cite: **Anjum H, Arshad L, Nawaz M, Iqbal H. Effects of Powerball on Grip Strength in Children With Developmental Delay. Journal of Precision Medicine and Health Research. 2026;3(1):1-9.**

Article ID: 29

Article Link: https://jpmhr.com/index.php/jpmhr/article/view/29

Declarations: See end of article.

ABSTRACT

Background: Developmental delay can impair motor coordination, fine motor performance, grip strength, and manual ability, thereby limiting independence in self-care, school-related tasks, play, and other activities of daily living. Conventional hand-strengthening exercises are frequently incorporated into pediatric rehabilitation, whereas Powerball training provides gyroscopic resistance through repeated wrist circumduction and may offer an engaging adjunct to conventional therapy. **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. Twenty-eight children aged 7-12 years with moderate developmental delay and affected fine motor skills were randomized equally to conventional hand-strengthening exercises or Powerball exercises combined with the same conventional therapy. One participant from each group discontinued after the first session, leaving 26 children for analysis. Both groups received 12 treatment sessions over one month. Grip strength was assessed using a hand-held dynamometer and manual ability using ABILHAND-Kids. **Results:** Thirteen participants in each group completed treatment. Post-treatment dynamometer scores were 0.8341 ± 0.22082 in the control group and 0.8831 ± 0.19084 in the experimental group; the between-group mean difference was 0.0490 (95% CI -0.1181 to 0.2161; p=0.550). Within-group dynamometer changes were also non-significant. ABILHAND-Kids median scores increased from 24.5 to 26.0 in the control group (p=0.048) and from 25.0 to 27.0 in the experimental group (p=0.007), while the post-treatment between-group difference remained non-significant (p=0.285). **Conclusion:** Both interventions were associated with improved manual functional ability, whereas measurable grip strength did not change significantly. The available between-group evidence does not demonstrate superiority of Powerball combined with conventional therapy over conventional hand therapy alone.

Keywords: Developmental Delay; Dynamometer; Grip Strength; Hand Function; Powerball; Rehabilitation.

Introduction

Developmental delay describes slower-than-expected acquisition of age-related developmental milestones and may involve motor, cognitive, communication, social, adaptive, or multiple functional domains. When significant delay occurs across two or more developmental domains, it is commonly characterized as global developmental delay. Early recognition is clinically important because developmental impairment can influence participation, educational performance, self-care, communication, and independence throughout childhood (1-3). Appropriate developmental assessment is particularly relevant in settings where delayed recognition or limited access to specialist services may postpone rehabilitation and supportive care (4). The occurrence and clinical expression of developmental delay are influenced by a range of prenatal, perinatal, postnatal, socioeconomic, environmental, and genetic factors, and affected children consequently represent a heterogeneous clinical population with varying functional needs (5-7).

Motor and fine motor impairments are especially relevant to rehabilitation because efficient hand function depends on the integrated performance of the intrinsic and extrinsic hand muscles, wrist and forearm musculature, proximal upper-limb stability, sensory feedback, motor planning, and postural control. The anatomical organization of the hand permits both forceful grasp and highly differentiated movements required for precision manipulation, pinch, opposition, object handling, handwriting, feeding, dressing, and play (8,9). In children, upper-limb strength and hand-grip performance vary with age, somatic development, neuromuscular maturation, and task demands (10-13). Children with developmental disorders may therefore encounter difficulty not only in generating adequate force but also in coordinating force with the timing and precision required for functional manual activities.

Grip strength is frequently used as an impairment-level indicator of hand and upper-limb function. Reliable measurement requires attention to testing position, device placement, participant understanding, effort, and consistency between repeated trials. Mechanical and positional factors can meaningfully alter measured force; wrist position influences grip-force estimation, and changes in elbow position can modify grip measurements even when the underlying muscular capacity remains unchanged (14,15). Standardized positioning and repeated measurements are consequently important when grip strength is used as an outcome in intervention research, particularly in children whose attention, motor planning, or ability to follow testing instructions may vary.

Strength alone, however, does not fully describe manual performance. Children may acquire better task strategies, coordination, confidence, and functional efficiency without demonstrating a parallel increase in maximal voluntary grip force. Studies involving children with motor impairments have demonstrated clinically meaningful relationships between hand strength, pinch performance, dexterity, and functional task execution (16,17). ABILHAND-Kids was developed to quantify manual ability in children with motor impairment and has been used to identify change following rehabilitation, providing an activity-oriented complement to impairment-level measurements of strength (18). Subsequent adaptation and validation work has further supported its use for evaluating manual activity limitations in pediatric rehabilitation populations (19). Combining a quantitative strength measure with a functional manual-ability measure can therefore provide a broader assessment of intervention response than either outcome alone.

Conventional pediatric hand rehabilitation commonly includes repetitive grip, pinch, finger-abduction, thumb-opposition, and isometric strengthening activities. Resistance-based exercise can improve muscular performance when the intervention provides sufficient repetition, intensity, and progression, although the magnitude and specificity of adaptation depend on training duration and participant characteristics. Resistance training has demonstrated upper-limb strength effects in adolescent populations, illustrating the trainability of developing musculoskeletal systems when exercise is appropriately prescribed (20). Interactive or device-assisted exercise may additionally improve engagement by combining muscular effort with feedback, novelty, and task-oriented participation; EMG-based exergaming has, for example, been investigated as a means of enhancing motivation and muscular performance during strengthening activities (21).

The Powerball is a hand-held gyroscopic device that generates resistance through rotational motion. Maintaining its rotation requires coordinated circumduction of the wrist together with activation of the hand, forearm, and supporting upper-limb musculature. Powerball exercise has previously been incorporated into rehabilitation research protocols as a resisted upper-limb activity, although much of this work has involved adult musculoskeletal conditions rather than pediatric developmental disorders (22). More broadly, active strength-oriented training in children and adolescents has also been investigated for effects extending beyond isolated force production, including motor and attentional performance (23). The combination of resistance, repetitive movement, sensorimotor demand, and an engaging device-based task therefore provides a plausible rationale for examining Powerball as an adjunct to conventional pediatric hand therapy.

Evidence regarding Powerball training specifically in children with developmental delay remains limited. It is therefore uncertain whether adding a brief gyroscopic-resistance exercise to conventional hand therapy produces measurable improvement in maximal grip performance or manual functional ability beyond that achieved through conventional exercises alone. The present randomized controlled trial was conducted to compare conventional physical therapy with Powerball exercises combined with conventional physical therapy in children aged 7-12 years with moderate developmental delay and impaired fine motor skills. The study evaluated changes in hand-held dynamometer performance and ABILHAND-Kids scores after 12 treatment sessions and examined whether the combined Powerball intervention produced superior post-treatment outcomes.

Materials and Methods

This randomized controlled trial was conducted over a six-month period at DHQ Hospital, Layyah, and Rising Sun Institute for Special Children, Lahore, Pakistan. The trial was registered under ClinicalTrials.gov identifier NCT05392296. Ethical approval was obtained from Riphah International University, Lahore, Pakistan, and permission for data collection was obtained from DHQ Hospital, Layyah, and Rising Sun Institute for Special Children, Lahore. Written informed consent was obtained from parents or guardians before participant enrollment.

Children aged 7-12 years of either sex were eligible when they had moderate developmental delay accompanied by affected fine motor skills. Children were excluded when another neurological condition or a diagnosed genetic disorder was present that could independently influence hand function, grip performance, participation, or response to the intervention. Following recruitment, participants underwent clinical history taking, physical examination, and regional assessment of upper-limb and hand function. Baseline manual ability was assessed using ABILHAND-Kids, and baseline grip performance was measured with a hand-held dynamometer before commencement of treatment.

Twenty-eight children meeting the eligibility criteria were randomized in a 1:1 ratio to two parallel intervention groups, with 14 participants initially allocated to conventional physical therapy and 14 to Powerball combined with conventional physical therapy. One child in each group discontinued participation after the first treatment session. Twenty-six participants therefore completed the 12-session intervention and post-treatment assessment, leaving 13 participants in each group for the final analysis.

Both groups received 12 supervised treatment sessions over one month at a frequency of three sessions per week. The control group received conventional physical therapy consisting of isometric and resisted hand-grip strengthening activities. Exercises included putty gripping and squeezing, thumb-pinch strengthening, isometric hook exercises, rubber-band finger abduction, and C-shaped thumb exercises. Exercises were performed separately for both hands. During putty gripping, the child held therapeutic putty in the palm and squeezed it until the fingers approached the palm. Grip and putty-based activities were performed for approximately 2-3 minutes. Thumb-pinch strengthening was performed by placing elongated putty on a table and asking the child to pinch the material using the thumb and index finger.

For the isometric hook exercise, the fingers of both hands were clasped together and the child was instructed to pull the hands outward against each other to produce a maximal voluntary isometric contraction. Each contraction was held for 5 seconds and repeated 10 times. Rubber-band finger abduction was performed by positioning a resistance band around the four fingers and asking the child to spread the fingers against resistance. For C-shaped thumb exercises, a rubber band was placed around the fingers and thumb, and the participant was asked to abduct the thumb and fingers to form a C-shaped position. These exercises were intended to activate intrinsic and extrinsic hand musculature while promoting repeated grasp, pinch, abduction, opposition, and isometric force production.

Participants in the experimental group received the identical conventional physical therapy program with the addition of Powerball exercise. Powerball training was performed for 3 minutes during each treatment session. The participant held the Powerball in the palm and maintained rotational movement through coordinated wrist circumduction. Gyroscopic resistance generated during continued rotation required active contribution from the hand, wrist, forearm, and supporting upper-limb musculature. Powerball use was supervised to facilitate safe performance, appropriate wrist movement, continued device rotation, and participant engagement. Apart from the additional Powerball activity, both groups received the same number and frequency of treatment sessions and were assessed at comparable baseline and post-treatment time points.

Grip strength was assessed using a hand-held dynamometer. Standardized positioning was used to reduce measurement variability associated with changes in body, elbow, and wrist position, which can materially influence force measurements (10,13-15). Hand-held dynamometry is widely applied for quantitative assessment of isometric muscular force, with acceptable clinical measurement properties reported across different muscle groups when testing procedures are standardized (24,25). Each child was seated comfortably with the back supported, shoulder in a neutral position, elbow flexed to approximately 90 degrees, and wrist maintained in a neutral position. The participant was instructed to grip the dynamometer and squeeze as strongly as possible for approximately 2-3 seconds without moving the arm. Three trials were completed with approximately 2 minutes of rest between trials, and the mean of the three measurements was recorded as the grip-strength score. The same procedure was used at baseline and after completion of the intervention.

Manual functional ability was evaluated using ABILHAND-Kids, a parent-reported measure designed to assess the difficulty children with motor impairment experience when performing manual activities in everyday life (18,19). Parents rated their child's functional ability on relevant manual tasks according to observed performance. The instrument complemented dynamometer testing by evaluating activity-level hand function rather than maximal isometric force alone. ABILHAND-Kids was completed before treatment and again after the twelfth treatment session.

Data were analysed using IBM SPSS Statistics version 25. Continuous variables were summarized as mean ± standard deviation when parametric presentation was appropriate, while ordinal outcome data were summarized using medians and rank-based methods. Categorical variables were reported as frequencies and percentages. Distributional assumptions were evaluated using the Shapiro-Wilk test. Hand-held dynamometer data were analysed using independent-samples t-tests for between-group comparisons and paired-samples t-tests for within-group pre-post comparisons. ABILHAND-Kids scores were analysed non-parametrically using the Mann-Whitney U test for independent between-group comparisons and the Wilcoxon signed-rank test for within-group comparisons. Statistical significance was defined as a two-sided p-value <0.05.

For enhanced estimation of the reported dynamometer findings, between-group mean differences and 95% confidence intervals at baseline and post-treatment were derived from the reported group means, standard deviations, and sample sizes using the independent-groups t distribution. Standardized between-group differences were additionally expressed as Hedges g to reduce small-sample bias. Positive mean differences indicated higher scores in the Powerball-plus-conventional-therapy group. No participant-level data were reconstructed, and rank-based effect estimates were not generated for ABILHAND-Kids because the reported aggregate information did not support their valid calculation.

Results

Twenty-eight children were randomized, with 14 initially assigned to each treatment group. One child from the conventional-therapy group and one from the Powerball-plus-conventional-therapy group discontinued after the first treatment session. Twenty-six participants completed all 12 sessions and the post-treatment assessment, corresponding to an overall completion rate of 92.9% and attrition of 7.1%. The final analysis included 13 children in each group.

The overall analysed sample had a mean age of 10.08 ± 1.495 years, with an age range of 7-12 years. Sixteen participants (61.5%) were male and 10 (38.5%) were female. The available aggregate results provided demographic characteristics for the complete analysed sample rather than separate age and sex distributions for each treatment group.

Table 1. Participant Flow and Overall Characteristics of the Analysed Sample

Characteristic	Value
Randomized, n	28
Initially allocated to control group, n	14
Initially allocated to experimental group, n	14
Discontinued from control group after first session, n	1
Discontinued from experimental group after first session, n	1
Completed treatment and post-treatment assessment, n	26
Final control group, n	13
Final experimental group, n	13
Overall completion rate, %	92.9
Overall attrition, %	7.1
Age, years, mean ± SD	10.08 ± 1.495
Age range, years	7-12
Male, n (%)	16 (61.5)
Female, n (%)	10 (38.5)

Distributional assessment supported different analytical approaches for the two principal outcomes. The reported Shapiro-Wilk p-value for hand-held dynamometer data was 0.470, and dynamometer comparisons were therefore conducted using parametric procedures. The corresponding p-value for ABILHAND-Kids was 0.013, and rank-based non-parametric procedures were used for that outcome.

Table 2. Distributional Assessment and Statistical Tests Used for Primary Outcomes

Outcome	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

At baseline, the mean hand-held dynamometer score was 0.8078 ± 0.19993 in the control group and 0.8557 ± 0.15024 in the experimental group. The experimental-minus-control mean difference was 0.0479 (95% CI -0.0953 to 0.1911), and the difference was not statistically significant (p=0.496). The corresponding standardized difference was small (Hedges g=0.26).

After the intervention, the control-group mean increased to 0.8341 ± 0.22082, whereas the experimental-group mean increased to 0.8831 ± 0.19084. The post-treatment experimental-minus-control mean difference was 0.0490 (95% CI -0.1181 to 0.2161), with no statistically significant between-group difference (p=0.550). The standardized post-treatment difference also remained small (Hedges g=0.23).

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

Assessment	Control, Mean ± SD	Experimental, Mean ± SD	Mean Difference*	95% CI	Hedges g	p-value
Pre-treatment	0.8078 ± 0.19993	0.8557 ± 0.15024	0.0479	-0.0953 to 0.1911	0.26	0.496
Post-treatment	0.8341 ± 0.22082	0.8831 ± 0.19084	0.0490	-0.1181 to 0.2161	0.23	0.550

*Mean difference calculated as experimental group minus control group. Confidence intervals and Hedges g were derived from the reported group means, standard deviations, and n=13 per group.

Within-group dynamometer analysis similarly showed only small numerical increases. The control-group mean increased by 0.0263 from baseline to post-treatment, while the experimental-group mean increased by 0.0274. The within-group change was not statistically significant in the control group (p=0.210) or experimental group (p=0.770). The absolute difference between the two observed mean changes was only 0.0011, indicating highly similar descriptive trajectories in the two groups over the intervention period.

Table 4. Within-Group Change in Hand-Held Dynamometer Scores

Group	Pre-treatment, Mean ± SD	Post-treatment, Mean ± SD	Mean Change	p-value
Control	0.8078 ± 0.19993	0.8341 ± 0.22082	+0.0263	0.210
Experimental	0.8557 ± 0.15024	0.8831 ± 0.19084	+0.0274	0.770

For manual functional ability, baseline ABILHAND-Kids median scores were 24.5 in the control group and 25.0 in the experimental group. The baseline between-group comparison was not statistically significant (p=0.701). After treatment, the median increased to 26.0 in the control group and 27.0 in the experimental group. Although the experimental group had the numerically higher post-treatment median, the between-group difference remained non-significant (p=0.285).

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

Assessment	Control, Median	Experimental, Median	Between-Group p-value
Pre-treatment	24.5	25.0	0.701
Post-treatment	26.0	27.0	0.285

*Between-group comparisons were performed using the Mann-Whitney U test.

Within-group ABILHAND-Kids analysis demonstrated statistically significant improvement in both treatment groups. The control-group median increased from 24.5 to 26.0, with a Wilcoxon signed-rank p-value of 0.048. The experimental-group median increased from 25.0 to 27.0, with a p-value of 0.007. These results indicate improvement in manual functional ability over the intervention period within both groups. However, the non-significant post-treatment between-group comparison indicates that the available evidence does not establish a statistically significant additional functional benefit of Powerball over conventional hand therapy.

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

Group	Pre-treatment Median	Post-treatment Median	p-value
Control	24.5	26.0	0.048
Experimental	25.0	27.0	0.007

*Within-group comparisons were performed using the Wilcoxon signed-rank test.

Taken together, grip-strength measurements and functional manual-ability scores demonstrated different response patterns. Maximal dynamometer performance changed minimally and did not reach statistical significance in either group. In contrast, ABILHAND-Kids scores improved significantly within both groups. The experimental group showed numerically higher post-treatment values for both outcomes, but neither between-group comparison demonstrated statistically significant superiority of Powerball combined with conventional therapy.

Discussion

The present randomized controlled trial compared conventional hand-focused physical therapy with the same conventional treatment supplemented by Powerball exercises in children with developmental delay. The principal finding was that both treatment groups demonstrated improvement in manual functional ability over 12 sessions, as reflected by statistically significant within-group changes in ABILHAND-Kids scores. In contrast, changes in hand-held dynamometer performance were small and statistically non-significant. Importantly, neither the post-treatment dynamometer comparison nor the post-treatment ABILHAND-Kids comparison showed a statistically significant difference between treatment groups. The findings therefore support improvement in manual activity during structured hand rehabilitation but do not demonstrate a comparative advantage of adding Powerball training over conventional therapy alone.

The distinction between maximal grip strength and manual ability is clinically relevant. Hand function requires more than force generation: coordinated grasp, pinch, finger individuation, object manipulation, timing, motor planning, proximal control, sensory integration, and task familiarity all contribute to functional performance. Pediatric studies have shown that grip and upper-limb strength vary considerably with age and physical development, and normative values must therefore be interpreted in the context of maturation and testing conditions (10-13). Similarly, work involving children with cerebral palsy and Down syndrome has demonstrated that manual dexterity and functional hand performance cannot be explained by maximal force alone (16,17). The present observation that ABILHAND-Kids improved while dynamometer scores remained relatively stable is consequently plausible and may indicate that repetitive hand therapy influenced task execution or functional hand use to a greater extent than maximal isometric force.

ABILHAND-Kids is specifically oriented toward manual activities rather than isolated muscular impairment and has demonstrated sensitivity to rehabilitation-related change in pediatric motor disorders (18). Its use in the current trial therefore complements dynamometry by capturing a different level of functioning. Cross-cultural adaptation and validation work has also reinforced its application as a structured measure of manual ability in children with motor impairment (19). The median improvement from 24.5 to 26.0 in the control group and from 25.0 to 27.0 in the Powerball group suggests that parents observed better manual performance after treatment. Nevertheless, the post-treatment between-group p-value of 0.285 indicates that the larger numerical median in the experimental group cannot be interpreted as evidence of statistically significant superiority.

Several factors may explain the absence of a significant grip-strength difference. First, the intervention consisted of only 12 sessions over approximately one month. Strength adaptation generally depends on sufficient training duration, intensity, repetition, and progressive overload. Resistance exercise can increase upper-limb strength in young populations, but training responses depend on the structure and duration of the intervention (20). In the present trial, the experimental component consisted of approximately 3 minutes of Powerball activity per session. Although the device provides gyroscopic resistance, the reported protocol did not include quantified progressive resistance or staged increases in duration. The resulting training dose may therefore have been more appropriate for sensorimotor engagement and repeated activation than for producing a large measurable change in maximal force within four weeks.

Second, the sample was small. Although 28 participants were randomized, one participant from each group discontinued after the first session, leaving 13 children per group for analysis. The post-treatment dynamometer mean difference was only 0.0490, with a 95% confidence interval extending from -0.1181 to 0.2161. The standardized difference was also small (Hedges g=0.23). These estimates indicate considerable uncertainty around a modest observed group difference and are consistent with the non-significant p-value. The near-identical descriptive mean changes of +0.0263 in the control group and +0.0274 in the experimental group further suggest that both groups followed very similar grip-strength trajectories during the study.

Third, developmental delay is clinically heterogeneous. Even among children categorized as having moderate developmental delay, differences in motor planning, muscle tone, attention, sensory processing, motivation, coordination, baseline strength, cognitive ability, and capacity to understand instructions may influence exercise performance and dynamometer testing. In children, strength measurement is particularly dependent on standardized positioning and participant cooperation (12,13). Experimental work has also shown that wrist and elbow positioning influence measured grip force (14,15). Although standardized testing positions were used in the present study, residual variability in effort and motor control could have contributed to the relatively broad standard deviations observed in both groups.

The improvement in both treatment groups may also reflect the substantial content of the conventional program itself. Putty squeezing, pinch activities, isometric hook exercises, finger abduction, and thumb opposition repeatedly challenge the intrinsic and extrinsic hand muscles and simultaneously practice movement patterns used in everyday manual tasks. Such exercises may enhance coordination, grasp strategy, and task confidence even when maximal force changes little. Research on pediatric manual performance emphasizes the interaction between strength and motor control, while broader work on exercise-based rehabilitation indicates that repeated task engagement can produce functional gains through mechanisms other than isolated hypertrophic strength adaptation (16-21).

Powerball training nevertheless remains an interesting adjunct because gyroscopic resistance combines hand gripping with continuous wrist circumduction and requires the participant to sustain coordinated motion. Device-assisted and interactive strengthening approaches have been explored as methods for enhancing motivation and muscular engagement, including exergaming systems that integrate biofeedback with repeated muscle activation (21). Powerball has also been incorporated into upper-limb rehabilitation research in other clinical contexts, although direct evidence in children with developmental delay is sparse (22). The novelty and continuous rotational feedback of the device may be attractive in pediatric rehabilitation, particularly when conventional repetitive hand exercises are difficult to sustain. The present results, however, indicate feasibility rather than established comparative efficacy.

Active movement may provide additional benefits through repeated sensorimotor practice. Research involving motor coordination and grip performance in neurological populations has demonstrated relationships between grip strength, limb position, and coordinated motor control (26). Similarly, proximal trunk and upper-limb stabilization can influence distal hand performance, emphasizing that grip function should not be regarded as an isolated property of the hand muscles alone (27). Although these studies were conducted in adult neurological populations and cannot be directly extrapolated to developmental delay, they support a broader biomechanical interpretation in which hand performance depends on coordinated activity throughout the upper kinetic chain. Powerball exercise recruits wrist and forearm movement within such an integrated system, which may explain its theoretical appeal despite the absence of a significant incremental effect in this trial.

The functional significance of grip strength has also been recognized beyond pediatric rehabilitation. Longitudinal research in older adults has identified multiple factors associated with change in grip strength over time (28), while grip strength has been examined as an indicator of broader health-related functional status and quality of life (29). These findings demonstrate the usefulness of grip measurement as a general marker of physical function but also illustrate that grip strength is influenced by age, health status, and population-specific characteristics. Pediatric developmental populations differ substantially from older adults in neuromuscular maturation, rehabilitation goals, environmental demands, and mechanisms of functional limitation. Accordingly, the clinical meaning of small dynamometer changes in children should be determined using pediatric-specific functional outcomes and developmentally appropriate reference values rather than adult benchmarks.

Another potentially important observation is that the experimental group achieved a more clearly significant within-group ABILHAND-Kids result (p=0.007) than the control group (p=0.048). This difference in p-values should not be interpreted as proof that the interventions differed from one another. Statistical significance within one group and a different level of significance within another group does not itself establish a treatment-by-group effect. The appropriate comparative evidence is the direct between-group analysis, which remained non-significant at post-treatment (p=0.285). The principal interpretation is therefore that manual ability improved in both groups, with no statistically confirmed additional benefit from Powerball in the available sample.

The study has several methodological characteristics that influence interpretation. Its randomized parallel-group design and use of both impairment-level and activity-level outcomes are strengths, as is the inclusion of the same conventional treatment in both groups, allowing the additional Powerball component to serve as the principal treatment contrast. Attrition was low and balanced, with one withdrawal from each group, and all remaining participants completed the intervention and post-treatment assessment. Standardized dynamometer positioning and repeated measurements also supported consistency of outcome assessment.

At the same time, the small final sample limited precision, and the intervention period was relatively short. The available study record did not provide sufficient detail to incorporate stratified randomization, allocation concealment procedures, or blinded assessor procedures into the methodological description. The final analysis was based on participants who completed treatment rather than all randomized participants. Group-specific baseline age and sex distributions were also unavailable in the aggregate results, limiting detailed assessment of demographic comparability. For the functional outcome, ABILHAND-Kids relied on parental reporting and could therefore reflect both actual changes in task performance and changes in parental perception of the child's ability. In addition, no longer-term follow-up was available to determine whether functional improvement persisted after completion of the supervised intervention.

The study nevertheless provides clinically relevant preliminary evidence regarding a simple, low-complexity adjunct for pediatric hand rehabilitation. Both groups completed a structured program incorporating repetitive hand use, and both demonstrated improved manual ability. The experimental group also tolerated the addition of Powerball exercise throughout the treatment period among participants who completed follow-up. For rehabilitation practice, these findings support Powerball as a potentially feasible activity that can be incorporated alongside conventional hand exercises when appropriate to the child's motor and cognitive abilities. Its comparative effect on grip strength or functional independence, however, remains uncertain and should be distinguished from the functional improvements observed in both treatment groups.

Future investigation of this intervention would benefit from a larger sample, longer treatment duration, quantified progression of Powerball resistance or exercise duration, predefined adherence measures, blinded outcome assessment, and follow-up beyond the immediate post-treatment period. Analysis based on change scores or baseline-adjusted regression models with confidence intervals would provide more direct estimation of the incremental treatment effect. Stratification or subgroup analysis according to age, developmental severity, baseline manual ability, hand dominance, and functional impairment may also help identify whether particular children are more likely to benefit from gyroscopic-resistance training.

Conclusion

Conventional hand-focused physical therapy and Powerball combined with conventional physical therapy were both associated with improvement in manual functional ability after 12 treatment sessions in children with developmental delay. Hand-held dynamometer scores showed only small numerical increases and did not demonstrate statistically significant within-group or between-group improvement. Although the Powerball group had descriptively higher post-treatment dynamometer and ABILHAND-Kids values, direct between-group comparisons did not establish statistically significant superiority of Powerball over conventional therapy alone. The findings therefore support structured hand rehabilitation for improving manual activity while the additional comparative effectiveness of Powerball remains unconfirmed.

DECLARATIONS

Author Contributions:	Concept: HA, LA; Design: HA, LA, MN; Data Collection: LA, HI; Analysis: HA, MN; Drafting: HA, LA, HI.
Ethical Approval:	Ethical approval was obtained from Riphah International University, Lahore, Pakistan. Permission for data collection was obtained from DHQ Hospital, Layyah, and Rising Sun Institute for Special Children, Lahore.
Informed Consent:	Written informed consent was obtained from parents or guardians before participant enrollment. Trial Registration: ClinicalTrials.gov registration: NCT05392296.
Conflict of Interest:	The authors declare no conflict of interest.
Funding:	No external funding was received for this study.
Data Availability:	Data are available from the corresponding author on reasonable request.
Acknowledgments:	None.
AI Declaration:	Generative AI tools were used solely for language and grammatical refinement. The authors verified the final manuscript and remain fully responsible for its accuracy, integrity, and scientific content.

REFERENCES

1. Choo YY, Agarwal P, How CH, Yeleswarapu SP. Developmental delay: identification and management at primary care level. Singapore Med J. 2019;60(3):119.
2. Bélanger SA, Caron J. Evaluation of the child with global developmental delay and intellectual disability. Paediatr Child Health. 2018;23(6):403-10.
3. Vasudevan P, Suri M. A clinical approach to developmental delay and intellectual disability. Clin Med. 2017;17(6):558-61.
4. Faruk T, King C, Muhit M, Islam MK, Jahan I, Baset KU, et al. Screening tools for early identification of children with developmental delay in low- and middle-income countries: a systematic review. BMJ Open. 2020;10(11):e038182.
5. Demirci A, Kartal M. Sociocultural risk factors for developmental delay in children aged 3-60 months: a nested case-control study. Eur J Pediatr. 2018;177(5):691-7. doi:10.1007/s00431-018-3109-y.
6. Zhang J, Guo S, Li Y, Wei Q, Zhang C, Wang X, et al. Factors influencing developmental delay among young children in poor rural China: a latent variable approach. BMJ Open. 2018;8(8):e021628.
7. Kato K, Mizuno S, Inaba M, Fukumura S, Kurahashi N, Maruyama K, et al. Distinctive facies, macrocephaly, and developmental delay are signs of a PTEN mutation in childhood. Brain Dev. 2018;40(8):678-84.
8. Pillemer R. Anatomy and function of the hand. In: Handbook of Upper Extremity Examination [Internet]. Cham: Springer International Publishing; 2022 [cited 2026 Apr 22]. p. 11-55. Available from: https://link.springer.com/10.1007/978-3-030-86095-0_2. doi:10.1007/978-3-030-86095-0_2.
9. Valenzuela M, Varacallo MA. Anatomy, shoulder and upper limb, hand interossei muscles. In: StatPearls [Internet]. Treasure Island: StatPearls Publishing; 2025 [cited 2026 Apr 22]. Available from: https://www.ncbi.nlm.nih.gov/sites/books/n/statpearls/article-23637/
10. Mendez-Rebolledo G, Ruiz-Gutierrez A, Salas-Villar S, Guzman-Muñoz E, Sazo-Rodriguez S, Urbina-Santibáñez E. Isometric strength of upper limb muscles in youth using hand-held and hand-grip dynamometry. J Exerc Rehabil. 2022;18(3):203.
11. Orsso CE, Tibaes JR, Oliveira CL, Rubin DA, Field CJ, Heymsfield SB, et al. Low muscle mass and strength in pediatric patients: why should we care? Clin Nutr. 2019;38(5):2002-15.
12. Rostamzadeh S, Saremi M, Abouhossein A, Vosoughi S, Molenbroek JFM. Normative data for handgrip strength in Iranian healthy children and adolescents aged 7-18 years: comparison with international norms. Ital J Pediatr. 2021;47(1):164. doi:10.1186/s13052-021-01113-5.
13. Gąsior JS, Pawłowski M, Williams CA, Dąbrowski MJ, Rameckers EA. Assessment of maximal isometric hand grip strength in school-aged children. Open Med. 2018;13(1):22-8. doi:10.1515/med-2018-0004.
14. Wang Y, Zheng L, Yang J, Wang S. A grip strength estimation method using a novel flexible sensor under different wrist angles. Sensors. 2022;22(5):2002.

15. Pitts G, Uhl TL, Day JM. Grip strength is more sensitive to changes in elbow position than isolated wrist extension strength in patients with lateral elbow tendinopathy. J Hand Ther. 2021;34(3):509-11.
16. Abd El-samad AA, El-Meniawy GH, Nour El-Din SM, Mohamed NE. Pinch grip strength and fine manual control in children with diplegic cerebral palsy: a cross-sectional study. Bull Fac Phys Ther. 2021;26(1):28. doi:10.1186/s43161-021-00048-6.
17. Priosti PA, Blascovi-Assis SM, Cymrot R, Vianna DL, Caromano FA. Fuerza de prensión y destreza manual en el niño con síndrome de Down. Fisioter Pesqui. 2013;20:278-85.
18. Bleyenheuft Y, Gordon AM, Rameckers E, Thonnard J, Arnould C. Measuring changes of manual ability with ABILHAND-Kids following intensive training for children with unilateral cerebral palsy. Dev Med Child Neurol. 2017;59(5):505-11. doi:10.1111/dmcn.13338.
19. Hansen AØ, Poulsen HS, Kristensen HK, Lauridsen HH. Danish translation, adaptation and validation of the ABILHAND-Kids questionnaire for children with cerebral palsy. Disabil Rehabil. 2022;44(5):807-16. doi:10.1080/09638288.2020.1780482.
20. Amara S, Barbosa TM, Negra Y, Hammami R, Khalifa R, Chortane SG. The effect of concurrent resistance training on upper body strength, sprint swimming performance and kinematics in competitive adolescent swimmers: a randomized controlled trial. Int J Environ Res Public Health. 2021;18(19):10261.
21. Garcia-Hernandez N, Garza-Martinez K, Parra-Vega V, Alvarez-Sanchez A, Conchas-Arteaga L. Development of an EMG-based exergaming system for isometric muscle training and its effectiveness to enhance motivation, performance and muscle strength. Int J Hum Comput Stud. 2019;124:44-55.
22. Uttamchandani S, Phansopkar P. A research protocol to evaluate the efficacy of Powerball versus Mulligan mobilization with movement on pain and function in patients with lateral epicondylitis. J Pharm Res Int. 2021;33(45B):491-500.
23. Polevoy G. The effect of speed and strength training on the indicators of attention stability of children aged 13-14 years with different typologies. J Pediatr Perspect. 2021;9(4):13343-8.
24. Hirano M, Katoh M, Gomi M, Arai S. Validity and reliability of isometric knee extension muscle strength measurements using a belt-stabilized hand-held dynamometer: a comparison with the measurement using an isokinetic dynamometer in a sitting posture. J Phys Ther Sci. 2020;32(2):120-4.
25. Karabay D, Yesilyaprak SS, Picak GS. Reliability and validity of eccentric strength measurement of the shoulder abductor muscles using a hand-held dynamometer. Phys Ther Sport. 2020;43:52-7.
26. Olczak A, Truszczyńska-Baszak A. Motor coordination and grip strength of the dominant and nondominant affected upper limb depending on the body position: an observational study of patients after ischemic stroke. Brain Sci. 2022;12(2):164.
27. Olczak A, Truszczyńska-Baszak A. Influence of the passive stabilization of the trunk and upper limb on selected parameters of the hand motor coordination, grip strength and muscle tension, in post-stroke patients. J Clin Med. 2021;10(11):2402.
28. Sternäng O, Reynolds CA, Finkel D, Ernsth-Bravell M, Pedersen NL, Dahl Aslan AK. Factors associated with grip strength decline in older adults. Age Ageing. 2015;44(2):269-74.
29. Musalek C, Kirchengast S. Grip strength as an indicator of health-related quality of life in old age: a pilot study. Int J Environ Res Public Health. 2017;14(12):1447.