Improving Motor Proficiency in Children with Developmental Delays: A Meta-Analysis Evaluating the Impact of Motor Skills Interventions

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Abstract: This study investigated the impact of motor skill interventions in improving motor proficiency among children with developmental delays following Preferred Reporting Items for Systematic Reviews and Meta-analysis "PRISMA" recommendations. The included studies were searched on four databases: Google Scholar, PEDro, MEDLINE, and Cochrane Library. Studies published during the year 2012 to 2022 were selected. The data was extracted by defining the publication year, type of study design, targeted population, and type of physical therapy intervention. The outcome measures included four components of motor proficiency: bilateral coordination, balance, speed and agility, and strength. The results revealed statistically significant findings and a large effect size for bilateral coordination (SMD=1.003, CI=95%) and speed and agility (SMD=0.854, CI=95%). However, a smaller effect size with significant findings was observed in the balance domains (SMD=0.333, CI=95%) and strength (SMD=0.337, CI=95%). Despite the promising results of the analyzed interventions, some of the included studies observed a high risk of bias. However, it is evident from the analysis that protocols directed toward advanced approaches have shown more promising results than traditional physical exercise regimens.

Keywords: Children, developmental delay disorders, motor activity, physical therapy.

INTRODUCTION

World Health Organization (WHO) estimates that approximately 15% of the global population grapples with a diverse spectrum of physical and mental disabilities [1], of which around 2.4% are children [2]. Specifically, within the Asian population, 2.64% are affected, while Pakistan alone contributes to approximately 0.5% of this demographic [3]. The Centre for Disease Control and Prevention (CDC) emphasizes that developmental disorders, encompassing physical limitations, speech delays, and cognitive challenges, constitute a significant component of this population [4]. This inclusive category encompasses various conditions, including but not limited to Autism Spectrum Disorder, Attention-Deficit Hyperactivity Disorder, Down syndrome, Cerebral Palsy, and others [5]. Children with these disorders have numerous compromised areas, including motor proficiency [6]. A compromised motor skill makes it difficult for these children to perform day-to-day activities competently [7], including coordination, dexterity, balance, posture, gait, strength, speed, and agility [8]. However, it is a fact that these complications are not left unattended and have been addressed using numerous effective physical therapy techniques such as neurodevelopmental therapies [9], strength conditioning [10, 11], balance and vestibular training [12], goal-directed motor learning [13], and virtual reality [14].

Nonetheless, evidence surfacing on the efficacy of these evolving physical therapy approaches and their impact on developmental delays is scarce. Moreover, to the Author's knowledge, no previous meta-analysis has been published to identify the best-suited physical therapy approach for developmental delays. Therefore, this study aims to analyze the effectiveness of interventions designed to improve motor proficiency in children with developmental delays.

MATERIAL AND METHODS

Protocol

This study followed Preferred Reporting Items for Systematic Reviews and Meta-Analysis "PRISMA" recommendations.

Databases Sources and Search Strategies

Studies that evaluated the motor proficiency in children with developmental delays were searched on

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four databases, including Google Scholar, PEDro, MEDLINE, and Cochrane Library, from August to October 2022, considering MeSH terms “Motor Proficiency”, “Developmental Delays,” “BOT-2,” “Children” and “Randomized Controlled Trials”.

Eligible Criteria of Studies

Participants

Children aged ≦18 years diagnosed with Autism Spectrum Disorder, Down Syndrome, Cerebral Palsy, Intellectual Disability, and Attention Deficit Hyperactivity Disorder.

Inclusion

Randomized Controlled Trials based on physical therapy interventions, including ball therapy, balance, sports, motor and object control skills, and virtual reality versus control/conventional or any other form, administered on clinically diagnosed children with conditions like Autism Spectrum Disorder, Down Syndrome, Cerebral Palsy, Intellectual Disability, and Attention Deficit Hyperactivity Disorder.

Exclusion

Any trials lacking a control group or any condition of developmental delays and studies with children undergoing any other form of therapy except physical therapy were excluded from the analysis. Moreover, no filtration was done on the participants regarding the types or stages of their developmental delays. Furthermore, articles that were not available in full text were not included.

Outcome Measure

The most commonly used measure for motor proficiency, Bruininks-Oseretsky Test of Motor Proficiency-Second Edition (BOT-2), was selected. The tool comprises four gross motor composites, including bilateral coordination, balance, strength, and agility, measured by administering goal-directed activities. BOT-2 has excellent reliability (r=0.90) and evaluates motor proficiency from a maximum score of 34 [15].

Time Frame

Studies published during the year 2012 to 2022 were selected.

Data Extraction and Analysis

The data was extracted by defining the publication year, study design, targeted population, and type of physical therapy intervention.

Risk of Bias

The Cochrane Risk of Bias Tool was used to assess the risk of bias for random allocation, allocation concealment, blinding of participants and outcome assessment, incomplete outcome data, selective reporting, and other biases.

Synthesis of Results and Quantitative Analysis

The data was collected from RCTs that provided the composite scores for each subset of BOT-2, including coordination, balance, strength, speed, and agility. The studies that inducted a control or comparison group and recorded baseline and post-test values with measures of central tendency and distribution (Mean±S.D) were included in the analysis, which was conducted using MedCalc Statistical Software (Version 18.11.3). The standard mean difference was analyzed via a random effect model, keeping a confidence interval of 95% and a p-value of <0.05. The effect size was obtained using Cohen's rule of thumb and was classified as small, moderate, or large based on the respective values 0.2-0.5, 0.5-0.8, and >0.8, and for heterogeneity, I^2 statistics were considered.

RESULTS

The preliminary search strategy identified 1,638 citations. After the initial screening of the respective titles and abstracts, 1,518 articles were excluded, and 120 full-text articles were finally redeemed, of which only 8 fulfilled the inclusion criteria. The detailed extraction is illustrated in Figure **1**.

Study Characteristics

The studies included in the analysis were RCTs published between 2012 and 2022. All the selected studies comprised a physical therapy intervention protocol designed for children with developmental delays. The detailed study characteristics are listed in Table **1**.

Risk of Bias

The included studies were evaluated based on the Cochrane Risk of Bias Tool, where 7 out of 8 studies reported random allocation of the participants [16-23], in 3 studies the allocation was found to be concealed [17-19], 2 studies incorporated blinding of the participants [18, 20] whereas, in 4 studies outcome assessors were blind to the allocation [17-20]. A high risk of bias was observed in the description of random allocation, its concealment, and the blinding of

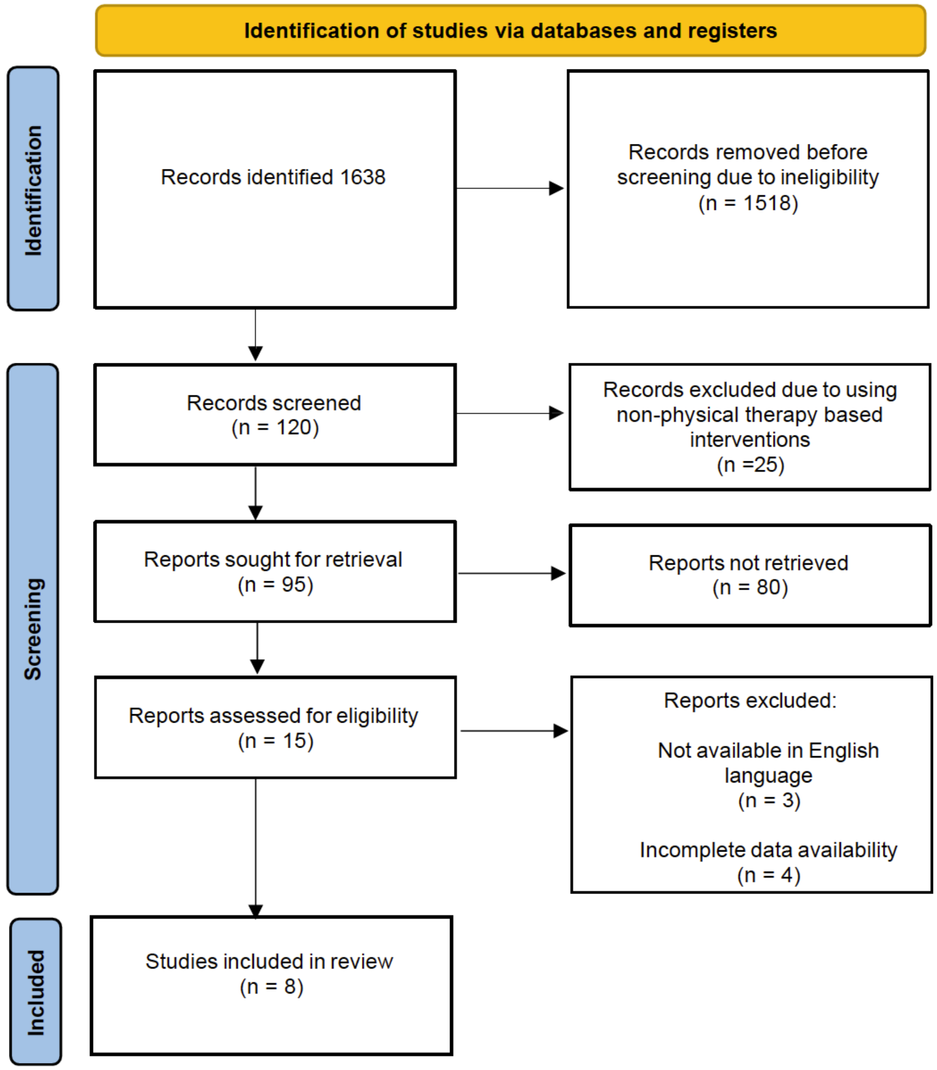


Figure 1: Represents the flow of studies following the PRISMA statement.

participants in 3 studies [20, 21, 23]. Moreover, inadequate data regarding concealment of allocation, blinding of participants, and outcome assessors were observed in 7 studies [16, 17, 19-23]. The details are shown in Table **2** and Figure **2**.

Physical Therapy Interventions

All the interventions were based on physical therapy protocols and administered by a trained physical therapist, physical education instructor, or physical therapy and physical education students under supervision. Following are the details or protocols applied in each study.

Home-Based Virtual Cycling Training [16]

This program included a home-based virtual reality cycling technique performed thrice weekly (40 min daily) for 12 weeks. The intervention included stationary cycling using a virtual reality device. The participants were also provided with guide videos for the workout. The participants were allowed to choose an exercise performed in an environment based on virtual reality by selecting one of the provided workout sample videos.

Virtual Reality Gaming Training Program [17]

A virtual reality-based structured program was administered for 12 weeks in this training program. The participants were provided with a structured program of games based on virtual reality that they practiced 3 days a week for 30 minutes at their homes, maintaining a diary for the record.

Virtual Reality Nintendo Game Training Program [18]

This training program included intervention based on virtual reality administered for 8 weeks (60 minutes

Table 1: Characteristics Features of the Included Studies

Author Year	Sample Size	Target Population	Study Design	Intervention Group	Control Group
Chen *et al*. 2012 [16]	27	Spastic CP aged 6-12 years with GMFCS level I and II	Randomized Controlled Trial	Home-based virtual cycling therapy program with 36 sessions of 40 minutes each for 12 weeks	Any general physical activity performed for 12 weeks at home under the supervision of parents
Farr *et al*. 2019 [17]	21	CP aged 5-16 years	Randomized Controlled Trial	VR games at home supported by a physiotherapist recommended structured games with 19 sessions for 12 weeks.	VR games unsupervised by a therapist with the freedom to choose games of choice with 24 sessions for 12 weeks
Ghazi *et al*. 2022 [18]	27	ADHD aged 8-11 years	Randomized Controlled Trial	VR Nintendo selected a gaming program with 24 sessions of 60 minutes each for 8 weeks.	No intervention given
Greco, 2020 [19]	24	ASD aged 8-11 years	Randomized Controlled Trial	Multilateral training physical activity program with 24 sessions of 70 minutes each for 12 weeks	No intervention given
Hassani *et al*. 2020 [20]	19	ASD aged 8-11 years	Randomized Controlled Trial	Spark motor training program with 16 sessions of 60 minutes each for 8 weeks	No intervention given
Mombarg, Jelsma and Hartman, 2013 [21]	30	Children with poor motor performance aged 7-12 years	Randomized Controlled Trial	Wii-balance board with the Wii-fit-plus1 software with 18 sessions of 30 minutes each for 6 weeks	No intervention given
Mondal, Yadav and Varghese, 2013 [22]	30	DS aged 10-18 years	Randomized Controlled Trial	Aerobic training program with 36 sessions of 55 minutes each for 12 weeks	No intervention given
Pan *et al*., 2016 [23]	22	ASD aged 6-12 years	Randomized Controlled Trial	Table tennis training with 26 sessions of 70 minutes each for 12 weeks	Table tennis without coach with 26 sessions of 70 minutes each for 12 weeks

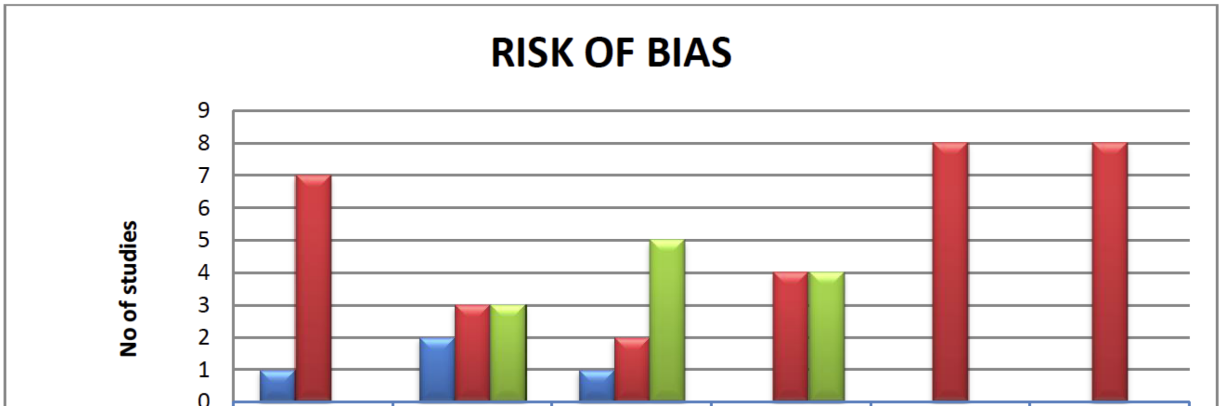
ASD: Autism Spectrum Disorder.
DS: Down Syndrome.
CP: Cerebral Palsy.
ADHD: Attention Deficit Hyperactivity Disorder.

Table 2: Assessment of Risk of Bias on Cochrane Risk of Bias Tool

Studies	Random Allocation	Allocation Concealment	Participants Blinding	Outcome Assessment Blinding	Incomplete Outcome Data	Selective Reporting
Chen *et al*. 2012 [16]	+	?	?	?	+	+
Farr *et al*. 2019 [17]	+	+	?	+	+	+
Ghazi *et al*. 2022 [18]	+	+	+	+	+	+
Greco, 2020 [19]	+	+	?	+	+	+
Hassani *et al*. 2020 [20]	-	?	+	+	+	+
Mombarg, Jelsma and Hartman, 2013 [21]	+	?	?	?	+	+
Mondal, Yadav and Varghese, 2013 [22]	+	-	-	?	+	+
Pan *et al*., 2016 [23]	+	-	?	?	+	+

−, denotes a high risk of bias.
+, represents a low risk of bias.

?, explains that the defined methodology cannot ensure the risk of bias.



	Random Allocation	Allocation Concealment	Participants Blinding	Outcome Assessors Blinding	Incomplete Data Outcome	Selective Reporting
High Risk	1	2	1	0	0	0
Low Rsk	7	3	2	4	8	8
Unknown Risk	0	3	5	4	0	0

Figure 2: Represents Risk of Bias.

per session). The participants performed selected games on the Nintendo Wii Console utilizing virtual reality as a treatment modality for improving motor proficiency.

Multilateral Training Program [19]

In this treatment program, a multilateral training protocol was applied to the participants for 12 weeks comprising 24 sessions (Two 70-minute sessions per week). Each intervention session consisted of four activities: warm-up, specific motor skill training, and cool down. The motor skill training was directed to improve the child's motor proficiency and performance, and it utilized object control skills using a ball.

Spark Motor Training Program [20]

This program administered the spark motor training bi-weekly (60 minutes each) for 8 weeks as treatment. Spark protocol comprised exercises like walking, balance, running, jumping, hopping, galloping, catching, throwing, and kicking that was specific to locomotion and ball control motor skills.

Wii-balance Board Training Program [21]

This program included a guided balance training program utilizing the Wii-fit-plus1 software for 6 weeks (Each session lasting 30 min per week). The children were given the liberty of choosing 3-5 games of choice out of any 18 games based on balance training available on the Wii computer, like obstacle course, skateboarding, and ski-jump for their training.

Aerobic Physical Training Program [22]

This bi-weekly training program included a customized physical training plan administered for 12 weeks. The children enrolled followed a set of given exercises like walking for 2 minutes, 5 repetitions of step-up and curl-up, and 2 minutes of the running relay, which they followed for two consecutive weeks that were altered in intensity and duration as the treatment progressed. Each session lasted for 55 minutes and included a set of 4 exercises.

Table Tennis Training Program [23]

This program included a game of table tennis as an intervention for 12 weeks (Two sessions per week, 70 minutes per session). This intervention included five activities: warm-up, motor skill training, individualized motor skill training, group game session, and cool down. Activities 2 and 3 focused on practicing table tennis strokes, which were the fundamental elements of the intervention.

Measurement of Motor Proficiency

Measurement of Motor Proficiency was carried out in each study using BOT-2. The tool comprises four gross motor composites: Bilateral Coordination, Balance, Strength, Speed, and Agility, each of which was analyzed separately. The interventions to improve bilateral coordination showed an impact of SMD=1.003 and CI=95%, which depicts a large effect size. In comparison, the observed values for balance (SMD=0.333, CI=95%) and strength (SMD=0.337,

Table 3: Analysis of Bilateral Coordination

Study	N1	N2	Total	SMD	SE	95% CI	T	P	Weight (%)	
									Fixed	Random
Hassani *et al*. 2020	10	9	19	1.909	0.537	0.776 to 3.042			12.36	17.08
Pan *et al*. 2016	11	11	22	0.880	0.431	-0.0189 to 1.780			19.18	20.11
Greco. 2020	12	12	24	1.888	0.479	0.894 to 2.882			15.52	18.69
Chen *et al*. 2012	13	14	27	0.236	0.375	-0.536 to 1.008			25.37	21.82
Ghazi *et al*. 2022	15	15	30	0.429	0.360	-0.307 to 1.166			27.57	22.29
Total (fixed effects)	61	61	122	0.876	0.189	0.502 to 1.250	4.640	< 0.001	100.00	100.00
Total (random effects)	61	61	122	1.003	0.341	0.328 to 1.678	2.943	0.004	100.00	100.00
Q	12.6152									
Significance level	P = 0.0133									
I^2 (inconsistency)	68.29%									
95% CI for I^2	18.26 to 87.70									

Table 4: Analysis of Balance

Study	N1	N2	Total	SMD	SE	95% CI	T	P	Weight (%)	
									Fixed	Random
Hassani *et al*. 2020	10	9	19	0.990	0.467	0.00376 to 1.976			14.57	16.77
Chen *et al*. 2012	13	14	27	0.472	0.379	-0.309 to 1.252			22.16	21.27
Farr *et al*., 2019	11	10	21	0.104	0.420	-0.774 to 0.983			18.06	19.04
Mombarg, Jelsma and Hartman,.2013	15	14	29	-0.384	0.365	-1.132 to 0.364			23.93	22.11
Ghazi *et al*, 2022	14	13	27	0.738	0.387	-0.0584 to 1.535			21.28	20.82
Total (fixed effects)	63	60	123	0.333	0.178	-0.0204 to 0.686	1.866	0.065	100.00	100.00
Total (random effects)	63	60	123	0.355	0.243	-0.127 to 0.837	1.458	0.147	100.00	100.00
Q	7.3682									
Significance level	P = 0.1177									
I^2 (inconsistency)	45.71%									
95% CI for I^2	0.00 to 80.10									

Table 5: Analysis of Strength

Study	N1	N2	Total	SMD	SE	95% CI	T	P	Weight (%)	
									Fixed	Random
Hassani *et al*. 2020	10	9	19	0.849	0.460	-0.121 to 1.820			13.65	14.99
Mombarg, Jelsma and Hartman, 2013	15	14	29	0.0883	0.361	-0.653 to 0.830			22.12	21.64
Mondal, Yadav and Varghese, 2013	15	15	30	-0.235	0.357	-0.966 to 0.495			22.72	22.05
Chen *et al*. 2012	13	14	27	0.562	0.381	-0.223 to 1.347			19.87	20.02
Ghazi *et al*. 2022	15	15	30	0.663	0.365	-0.0858 to 1.411			21.63	21.29
Total (fixed effects)	68	67	135	0.337	0.170	0.000980 to 0.673	1.984	0.049	100	100
Total (random effects)	68	67	135	0.348	0.199	-0.0450 to 0.741	1.752	0.082	100	100
Q	5.4319									
Significance level	P = 0.2458									
I^2 (inconsistency)	26.36%									
95% CI for I^2	0.00 to 70.72									

Table 6: Analysis of Speed and Agility

Study	N1	N2	Total	SMD	SE	95% CI	T	P	Weight (%)	
									Fixed	Random
Hassani *et al.* 2020	10	9	19	2.457	0.593	1.206 to 3.708			11.34	19.54
Chen *et al.* 2012	13	14	27	0.428	0.378	-0.351 to 1.206			27.89	26.46
Mondal, Yadav and Varghese, 2013	15	15	30	0.223	0.356	-0.507 to 0.953			31.36	27.20
Ghazi *et al.* 2022	15	15	30	0.746	0.368	-0.00783 to 1.500			29.41	26.80
Hassani *et al.* 2020	53	53	106	0.687	0.200	0.291 to 1.083			100	100
Total (fixed effects)	53	53	106	0.854	0.395	0.0712 to 1.637	3.443	0.001	100	100
Total (random effects)	10	9	19	2.457	0.593	1.206 to 3.708	2.164	0.033	11.34	19.54
Q	11.1050									
Significance level	P = 0.0112									
I^2 (inconsistency)	72.99%									
95% CI for I^2	23.89 to 90.41									

CI=95%) show a small, and speed and agility (SMD=0.854, CI=95%) exhibit a large effect size. Tables **3-6** show the analysis details, while Figures **3-6** illustrate the forest plot for each subset.

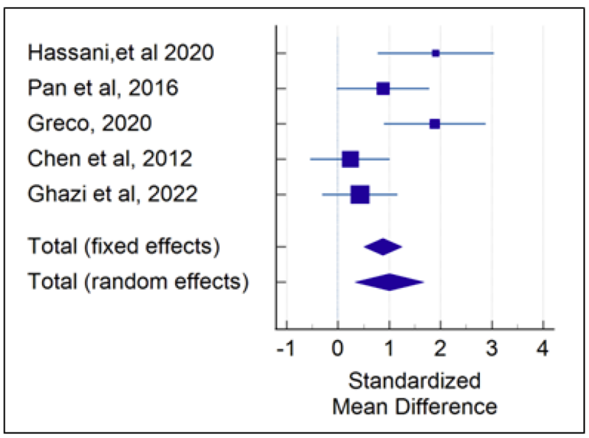


Figure 3: Illustrates the forest plot for Bilateral coordination.

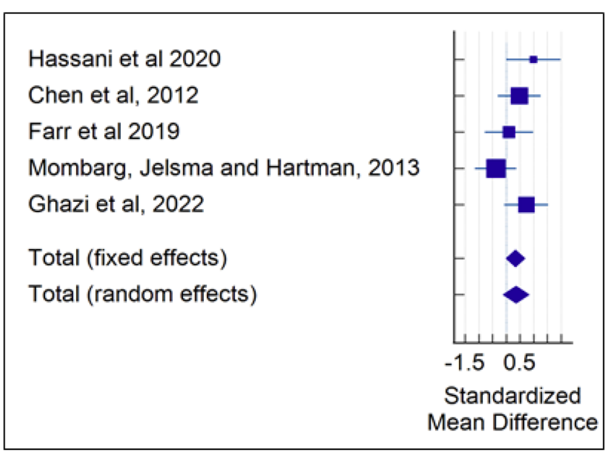


Figure 4: Illustrates the forest plot for Balance.

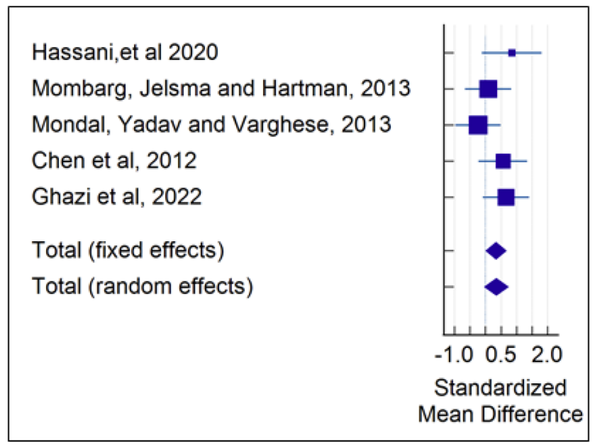


Figure 5: Illustrates the forest plot for Strength.

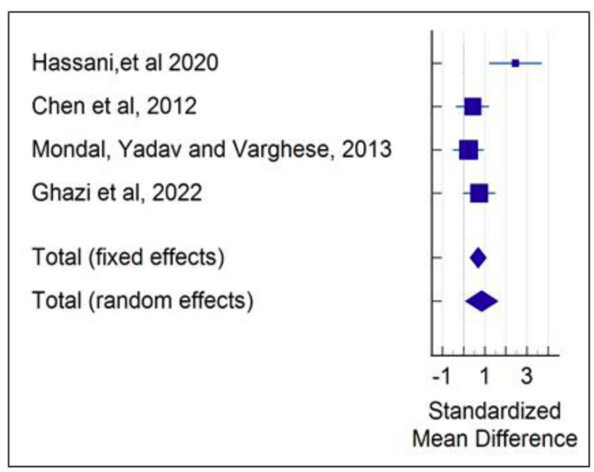


Figure 6: Illustrates the forest plot for Speed and Agility.

DISCUSSION

This meta-analysis aimed to integrate the evidence on the effectiveness of physical therapy interventions on the motor proficiency of children with developmental delays. The results revealed statistically significant findings and a large effect size for bilateral coordination, speed, and agility. However, a smaller effect size with significant findings was observed in the domains of balance and strength. Despite the promising results of the analyzed interventions, a high risk of bias was observed in some studies.

Bilateral Coordination

The results depicted a large effect size; however, variable SMD was obtained in all studies. Hassani *et al*., Pan *et al*., and Greco reported non-significant findings, respectively (SMD=1.909, CI=95%, SMD=0.880, CI=95%, and SMD=1.888, CI=95%). An SMD of 0.236 and 0.429, with a CI=95%, was obtained for the studies of Chen *et al*. and Ghazi *et al*. One probable reason for significant findings can be the utilization of virtual reality-based training, which has promising results on motor training as advocated by the studies of Chen *et al*. and Ghazi *et al*. On the other hand, the protocols administered by Hassani *et al*. and Greco utilized a combination of typical physical exercise patterns that have been followed for years as a treatment regimen. Furthermore, non-significant results analyzed for the protocol administered by Pan *et al*. can result from a specific game-based table tennis protocol that may have improved the game-based coordination of the participants rather than having a general effect on the parameter of bilateral coordination.

Balance

The analysis revealed a smaller effect size for balance with significant results, as observed in the protocols of Chen *et al*., Farr *et al*., and Mombarg, Jelsma, and Hartman, respectively (SMD=0.472, CI=95%, SMD=0.104, CI=95%, SMD=-0.384, CI=95%). On the contrary, the SMD scores of Hassani *et al*. (SMD=0.990, CI=95%) and Ghazi *et al*. (SMD=0.738, CI=95%) reported non-significant results. The success of the advanced protocols administered in the studies of Chen *et al*., Farr *et al*., and Mombarg, Jelsma, and Hartman that utilized virtual reality and Wii-fitt plus software-based training are an indicator of the need for advancement in physical therapy protocols targeted to enhance balance. However, this contrasts the SMD scores obtained for the virtual reality-based protocol of Ghazi *et al*., which, although enhanced bilateral coordination in participants, was non-significant in improving balance.

Strength

The statistical investigation proclaimed a smaller effect size for strength evident from the SMD values obtained from the analysis of Hassani *et al*. (SMD=0.849, CI=95%) and Ghazi *et al*. (SMD=0.663, CI=95%). On the contrary, the analysis of Mombarg, Jelsma, and Hartman (SMD=0.0883, CI=95%), Mondal, Yadav, and Varghese (MD= -0.235, CI=95%), and Chen *et al*. (SSMD=0.562, CI=95%) revealed significant findings. Where Chen *et al*. and Mombarg Jelsma and Hartman implied advanced training methods, Mondal utilized a structured exercise training protocol and advocated promising results that oppose the traditional protocols of Ghazi *et al*. and Hassani *et al*.

Speed and Agility

The results reported a large effect size for speed and agility, as observed from the findings of Chen *et al*. (SMD=0.428, CI=95%) and Mondal, Yadav, and Varghese (SMD=0.223, CI=95%), which is in contrast to the analysis of Hassani *et al*. (SMD=2.457, CI=95%) that utilized traditional physical exercise approaches. However, Ghazi *et al*. (SMD=0.746, CI=95%) showed a smaller deviation than Hassani *et al*. These findings indicate that non-traditional intervention methods better target speed and agility.

LIMITATIONS

This meta-analysis included only those studies that utilized BOT-2 as a mode of assessment. The analysis was not segregated based on the child's condition; instead, it was segregated based on parameters of motor proficiency. The included studies were not confined to a fixed period of protocol administration. Each study had its intervention timeframe, which can also be a potential reason for variation in SMD scores among studies. Moreover, few studies included in the review did not provide a comparative intervention to the control group, which can be the reason for more considerable differences obtained between groups.

RECOMMENDATIONS

Future studies are recommended with the inclusion of more protocols based on physical therapy that utilizes tools other than BOT-2. A meta-analysis based on studies having a follow-up period is also recommended.

CONCLUSION

It is difficult to identify and conclude which protocol is ideal for enhancing motor proficiency in children with developmental delays as each protocol is applied to different conditions and children of varying age groups. However, it is evident from the meta-analysis that protocols directed toward advanced approaches [16-18, 22] have shown more promising results than traditional physical exercise regimens. One reason for this can be enhanced engagement of children in exciting and new approaches. Another reason can be the utilization of a blended approach of traditional and advanced training, as observed in the studies of Chen *et al*. Moreover, protocols [21] that utilized a structured pattern of physical training with varying intensity and duration were also found to be more effective in enhancing the parameters of motor proficiency in children with developmental delays.

DISCLOSURE STATEMENT

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AUTHOR'S CONTRIBUTION

MS: Concept, Design, and Writing.

SIF: Design, Supervision, and critical review

JR: Interpretation of data, Writing.

BAH: Supervision and critical review.

BH: Interpretation of data and critical revision

ABBREVIATIONS

WHO = World Health Organization

CDC = Center for Disease Control and Prevention

MEDLINE = Medical Literature Analysis and Retrieval System Online

PEDro = Physiotherapy Evidence Database

PRISMA = Preferred Reporting Items for Systematic Reviews and Meta-Analysis

S.D = Standard Deviation

SMD = Standardized Mean Difference

ASD = Autism Spectrum Disorder

DS = Down Syndrome

CP = Cerebral Palsy

ADHD = Attention Deficit Hyperactivity Disorder

BOT = Bruininks-Oseretsky Test of Motor Proficiency

REFERENCES

[1] Disability World Health Organization. Available at: https://www.who.int/health-topics/disability.

[2] Disabilities UNICEF. Available at: https://www.unicef.org/topics/disabilities.

[3] Asia Pacific Forum Rights of people with disabilities | Asia Pacific Forum. Available at: https://asiapacificforum.net/support/human-rights/people-disabilities.

[4] Centers for Disease Control and Prevention USAGov. Available at: https://www.usa.gov/agencies/centers-for-disease-control-and-prevention.

[5] Rigby BR, Davis RW, Bittner MD, Harwell RW, Leek EJ, Johnson GA, Nichols DL. Changes in motor skill proficiency after equine-assisted activities and brain-building tasks in youth with neurodevelopmental disorders. Front Vet Sci 2020; 31: 7-22. https://doi.org/10.3389/fvets.2020.00022

[6] Hassani F, Shahrbanian S, Shahidi SH, Sheikh M. Playing games can improve physical performance in children with autism. Int J Dev Disabil 2022; 68(2): 219-26. https://doi.org/10.1080/20473869.2020.1752995

[7] Adaikina A. Comparing the effect of task-oriented intervention program vs. strength training program in improving motor proficiency in children aged 8-12 years with developmental coordination disorder (DCD): A randomized controlled pilot study.

[8] Sanglakh Goochan Atigh A, Akbarfahimi M, Alizadeh Zarei M. The effect of movement activities in synchronization with music on motor proficiency of children with autism. JAMSAT 2017; 3(2): 61-8. https://doi.org/10.18869/nrip.jamsat.3.2.61

[9] Tekin F, Kavlak E, Cavlak U, Altug F. Effectiveness of Neuro-Developmental Treatment (Bobath Concept) on postural control and balance in Cerebral Palsied children. J Back Musculoskelet Rehabil 2018; 31(2): 397-403. https://doi.org/10.3233/BMR-170813

[10] Ahmadi N, Peyk F, Hovanloo F, Hemati Garekani S. Effect of functional strength training on gait kinematics, muscle strength and static balance of young adults with Down syndrome. International Journal of Motor Control and Learning 2020; 2(1): 1-0. https://doi.org/10.29252/ijmcl.1.1.1

[11] Beerse M, Henderson G, Liang H, Ajisafe T, Wu J. Variability of spatiotemporal gait parameters in children with and without Down syndrome during treadmill walking. Gait Posture 2019; 68: 207-12. https://doi.org/10.1016/j.gaitpost.2018.11.032

[12] Topley D, McConnell K, Kerr C. A systematic review of vestibular stimulation in cerebral palsy. Disability and Rehabilitation 2021; 43(23): 3291-7. https://doi.org/10.1080/09638288.2020.1742802

[13] Au MK, Chan WM, Lee L, Chen TM, Chau RM, Pang MY. Core stability exercise is as effective as task-oriented motor training in improving motor proficiency in children with developmental coordination disorder: a randomized controlled pilot study. Clinical Rehabilitation 2014; 28(10): 992-1003. https://doi.org/10.1177/0269215514527596

[14] Stander J, du Preez JC, Kritzinger C, Obermeyer NM, Struwig S, van Wyk N, Zaayman J, Burger M. Effect of virtual reality therapy, combined with physiotherapy for improving motor proficiency in individuals with Down syndrome: A systematic review. S Afr J Physiothery 2021; 77(1). https://doi.org/10.4102/sajp.v77i1.1516

[15] Selves C, Renders A, Detrembleur C, Lejeune T, Stoquart G, Gilliaux M. Reliability and Concurrent Validity of the BruininksOseretsky Test in Children with Cerebral Palsy. Biomed J Sci Tech Res 2019; 18(5): 13961. https://doi.org/10.26717/BJSTR.2019.18.003226

[16] Ghazi A, Sohrabi M, Taheri HR, Ghahremani M. Effect of Nintendo Wii-Based Motor and Cognitive Training on Motor Proficiency and Cognitive Flexibility of Children with Attention-Deficit/Hyperactivity Disorder.

[17] Greco G. Multilateral training using physical activity and social games improves motor skills and executive function in children with autism spectrum disorder. European Journal of Special Education Research 2020.

[18] Farr WJ, Green D, Bremner S, Male I, Gage H, Bailey S, Speller S, Colville V, Jackson M, Memon A, Morris C. Feasibility of a randomised controlled trial to evaluate home-based virtual reality therapy in children with cerebral palsy. Disability and Rehabilitation 2021; 43(1): 85-97. https://doi.org/10.1080/09638288.2019.1618400

[19] Pan CY, Chu CH, Tsai CL, Sung MC, Huang CY, Ma WY. The impacts of physical activity intervention on physical and cognitive outcomes in children with autism spectrum disorder. Autism 2017; 21(2): 190-202. https://doi.org/10.1177/1362361316633562

[20] Mondal S, Yadav AK, Varghese J, LNIPE G, Pradesh M. Response of children with Down syndrome to physical activity programme on motor proficiency and functional abilities. Training 2013; 3(11).

[21] Mombarg R, Jelsma D, Hartman E. Effect of Wii-intervention on balance of children with poor motor performance. Research in Developmental Disabilities 2013; 34(9): 2996-3003. https://doi.org/10.1016/j.ridd.2013.06.008

[22] Chen CL, Hong WH, Cheng HY, Liaw MY, Chung CY, Chen CY. Muscle strength enhancement following home-based virtual cycling training in ambulatory children with cerebral palsy. Research in Developmental Disabilities 2012; 33(4): 1087-94. https://doi.org/10.1016/j.ridd.2012.01.017

[23] Hassani F, Shahrbanian S, Shahidi SH, Sheikh M. Playing games can improve physical performance in children with autism. Int J Dev Disabil 2022; 68(2): 219-26. https://doi.org/10.1080/20473869.2020.1752995

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