Advances in Social Science, Education and Humanities Research, volume 388

3rd International Conference on Special Education (ICSE 2019)

A Review on the Efficacy of Physical Therapy Intervention on Motor Skills of Children with Autism Spectrum Disorder

Cindy Lee Chia Yin
Canaan Physiotherapy Enterprise
Kuching, Malaysia
canaanphysiotherapy@gmail.com

Teng Kie Yin
Jabatan Ilmu Pendidikan
Institut Pendidikan Guru Kampus Tun Abdul Razak
Samarahan, Malaysia
teng.kieyin@ipgmktar.edu.my

***Abstract*—Studies involving Physical Therapy (PT) intervention towards children with autism spectrum disorder (ASD) were reviewed. Systematic search procedures identified 3 studies meeting predetermined inclusion criteria. These studies were evaluated in terms of: (a) participant characteristics, (b) types of intervention, (c) procedures used (d) outcomes, and (e) research methodology. Across the corpus of studies, PT intervention was implemented on 67 participants with ASD aged five to twelve years. The PT intervention includes gait training with Rhythmic Auditory Stimulation (RAS), PT throwing intervention in conjunction with Applied Behavioural Analysis (ABA) approach, as well as motor skill training alongside with rhythm, robot and table-top activities. Results suggested that PT intervention for children with ASD may benefit in their motor skills in terms of bilateral coordination, balance, running speed, agility, strength, throwing accuracy, and reduction in imitation/ praxis error. Nonetheless, in view of limited numbers of studies reviewed, need of further research with larger number of articles are required.**

Keywords—physical therapy; motor skills; autism spectrum disorder

I. INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder with the characteristics of having impairments in communication and social interaction, along with restricted and repetitive behaviour since early childhood [1]. The diagnosis of ASD has been revised over the last 35 years, whereby the Diagnostic and Statistical Manual of Mental Disorders [DSM-IV-TR, 2000], DSM 5-2013 and the International Classification of Diseases [ICD-10] has been widely used to differentiate between childhood autism, Asperger's syndrome, atypical autism and pervasive developmental disorder (PDD) [1]. In the latest revised DSM-5, abnormalities in sensory reactivity were added to the restricted/repetitive behaviour domain as persistency of symptoms can cause functional impairments or motor deficits [2].

A comprehensive review of the evidence was conducted for motor activity limitations in children with ASD categorised the motor deficits in children with ASD into four aspects; namely early motor findings, gestures and motor imitation, postural control and lastly, dyspraxia [3]. They further commented that it is only with best understanding of the motor aspects of ASD that appropriate physical intervention could be administered towards the children with ASD deficits. Green et al. [4] found out that more than 50% of children diagnosed with ASD demonstrated with movement difficulties with the usage of Movement Assessment Battery for Children (M-ABC). These difficulties could be in the form of motor coordination and balance that limit the choice of activity engagement [5].

Prevalence of motor deficits in children with ASD was being looked into and hypotonia, motor apraxia, intermittent toe walking, reduced ankle mobility, gross and fine motor deficits in a cohort of 154 children has been identified [6]. To add to this, a meta-analysis study was being carried out on children with ASD, reported that they suffered from gross motor impairments and coordination problem [7]. There was also demonstration of atypical motor development and delay in the motor milestone achievement of children with ASD, of which happens to go in line with the study by Ozonoff et al. [8]. This is further supported by two studies of which indicated that the gross motor problems and delay in motor milestones of children with ASD is comparable to or greater than motor delays in infants with developmental delay [9, 10]. During the second and third year of life, this motor delay could be further observed in terms of delay onset of walking, lacking of heel-toe pattern, reciprocal arm movements and waddling gait in the gait analysis [10].

On the other hand, fine motor in infants later diagnosed with ASD includes delay in reaching, clapping, pointing and turning door knobs over the first and second year of life [11]. Not only that, motor delays found in infancy was in correlation with speech delay [11]. Motor impairments in children with ASD and motor delays in infants/toddlers at risk for ASD are lacking in gross and fine motor coordination, motor stereotypies, postural control as well as imitation/praxis [12]. Following through the second year of life, spontaneous movements such as motor stereotypies that is inclusive of rocking, arm flapping or finger flicking served as the "red flags" in children with ASD [12]. Interestingly, Ben-Sasson et al. [13] pointed out that children and adults with ASD suffered from Sensory Modulation Disorders (SMDs) of which is defined as difficulties in regulating and organising behaviour

Canaan Physiotherapy Enterprise, Kuching, Malaysia

in response to sensory input. The severity of SMDs appeared to be directly correlated with the severity of ASD, functioning level and social communication deficits [13]. In addition, two studies stated that children with ASD whose having atypical movement sensitivity are usually either overresponsive to sensory input, or having low energy and weak motor responses that could lead to poor fine and gross motor skills [14, 15].

Taken together from the discussion above, limitations in daily activities in individuals with ASD could be attributed by common motor impairments such as abnormal muscle tone, muscle weakness, incoordination during fine and motor gross motor activities, poor balance, involuntary movements or secondary impairments such as muscle contractures [16]. The relationship in between the motor and social communication in children with ASD do exist [17] and it is hopeful that by enhancing the motor performance may facilitate the development of social communication in children with ASD [12].

Yet, Physical Therapy (PT) being the professional experts of movement and development has not been involved in the Clinical Practice Guidelines (CPG) in the assessment of children with ASD [1]. Neither does a PT play a part in the screening nor in the intervention, as limitations in motor activity have always been considered not the core impairments of ASD [3]. The purpose of this review was to look into the recent evidence for the efficacy of PT intervention on motor skills improvement in children with ASD with the good intention in promoting PT role in the ASD discipline.

II. METHOD

This review involved studies that focused on PT intervention designed to increase the motor skills or performance of children with ASD. Each identified study that met predetermined inclusion criteria was analysed and summarised in terms of (a) participant characteristics (b) types of intervention; (c) procedures used (d) outcomes, and (e) research methodology.

A. Search Procedures

A literature search was carried out using PubMed, CENTRAL and PEDro as they are the most comprehensive databases indexing randomised controlled trials of PT intervention [18]. The publication year was from year 2010 to year 2019 and limited to studies written in English only. On all the three databases, three search terms were used addressing PT intervention on motor skills with children of ASD. This process identified 40 studies for possible inclusion. Secondly, the abstracts of these studies were reviewed to identify if the studies fulfilled the inclusion criteria. Thirdly, the reference list of studies meeting these criteria was then reviewed in order to identify any other additional articles for possible inclusion. Lastly, the surname of the first author of each of the included studies was then searched to identify of any additional work. This multi-step search procedure occurred in January 2019.

B. Inclusion Criteria

The studies reviewed had to meet three inclusion criteria; namely the participant need to be diagnosed with ASD (e.g., autism, Asperger's, or PDD-NOS). Second, the intervention had to be PT-based or administered by a PT. Thirdly, the outcome has to be targeted at motor skills or motor performance, regardless being gross or fine motor.

C. Data Extraction

Each identified study was first assessed for inclusion criteria. After which the included studies were summarised in terms of (a) participant characteristics (b) types of intervention, (c) procedures used (d) outcomes, and (e) research methodology (refer Appendix: Table 1). The effects of the intervention were also summarised with the terms used by the author of that study.

D. Reliability of Search Procedures and Inter-rater Agreement

In order to ensure the accuracy of the search, the first and the second authors both independently ran the multi-step search procedures and pre-identified the study that had met with the inclusion criteria. Due to limited number of articles available, the agreement reached 100% whereby both authors finalised with the three same articles. The resulting summaries were then developed by the first author of which was later agreed upon after the co-author had read through the study.

III. RESULTS

A. Participants

The three studies provided intervention to a total of 67 participants with ASD. Eighty-two (82%) of the participants were male and eighteen (18%) were female. The age ranged between five and twelve years old. All of the participants were diagnosed with ASD (n=67).

B. Intervention and Procedures Used

In the first identified study [19], 36 children with ASD were randomly allocated to rhythm group, robotic group and comparison group whereby triadic context consists of the child, an expert trainer and an adult model was applied. All trainers involved were pediatric PTs or PT/kinesiology graduate students who received training from their co-author who is a music educator and an Applied Behavior Analysis (ABA) expert. Both the rhythm and robotic group were engaged with movement-based activities that target the gross motor skills including balance, bilateral coordination, imitation, interpersonal synchrony and manual dexterity while the comparison group promoted fine motor skills such as gripping, pinches, coloring, drawing, cutting and gluing. All the three groups were trained for eight weeks with four sessions each week lasting for 45 minutes.

Second identified study did a case study report on a nine years old child with ASD who had fine motor, gross motor and communication delays on top of his repetitive movement behaviors such as self-stimulatory hand flapping and clapping [20]. The child participated in a 20-week gross motor

intervention designed to improve his overhand throwing ability in collaboration with ABA approaches. The whole training was divided into three phases; namely phase one: initial four weeks of motor planning practice; phase two: motor learning/target practice and phase three: participation. Altogether, the child underwent 13 times of PT sessions and 75 times of ABA sessions, each lasting for 30 minutes and 10 minutes respectively.

The third study intervened 30 children with ASD with gait training using rhythmic auditory stimulation (RAS), on top of a specially designed PT programme [21]. Children in control group underwent the training programme that included strengthening exercises for the trunk and extremities, balance training from different positions, stoop and recover from standing, facilitation of anticipatory mechanism, gait training using different obstacles, and ascending and descending stairs on alternate feet that lasted for one hour, three times each week for three months. Meanwhile, children in the study group underwent gait training with RAS stimulation for 30 minutes, three times each week for three months on top of the PT programme. The MIDI Cubase musical instrument digital interface programme along with a metronome was used to control the rhythmic tempo of the children's step pattern.

C. Outcomes of Reviewed Studies

Coincidentally, all three studies used Bruininks-Oseretsky Test of Motor Proficiency-2 (BOT-2) as assessment tool as it has been a valid and reliable test for gross and fine motor proficiency in children aged between 4 and 21 years of age [22]. All of the three studies showed improvements in either the gross motor domain that includes bilateral coordination, balance, running speed and agility, and strength or the fine motor domain which consists of fine manual control, manual coordination, body coordination, and strength and agility. The gains in the Test of Gross Motor Development-2 (TGMD-2) and the School Function Assessment (SFA) to above the criterion cut off during retention testing in [20] indicated that the child's motor learning has been maintained across a five months period of time.

D. Research Methodology

Out of the three studies, two studies randomly allocated their participants. All the three studies conducted pre-test and post-test within each group and between groups. The third study used Wilcoxon signed rank test to compare outcome measures within each group and Mann-Whitney U-test for between-group comparisons [21]. Meanwhile, the second study compared the baseline score prior to pre-test and a retention score at 5 months post-test [20]. In the first study, repeated measures ANCOVA was used to detect any within-group and between-group changes on body coordination composite and fine manual control composite [19]. Meanwhile, repeated measures ANOVA was used to reveal the effects of training session and synchrony type from early to late sessions of the children in the rhythm and robotic group.

IV. DISCUSSION

Our review which yielded only three studies revealed the limitation of existing research that focus on the PT intervention towards motor skills in children with ASD. With the existing corpus of studies, number of participants (n=67) were also relatively few. Nonetheless, the positive findings across all the three studies do suggest that PT intervention, being the base of intervention brought about improvements in both gross and motor skills.

Case report highlighted the gross motor programming during the throwing intervention [20]. The successful collaboration between the PT and ABA approach facilitated a more encouraging motor learning and behavioural shaping that led to the rewarding learning experience of the child. Not only does it reduce his other interfering behaviour, his participation level increased and was maintained across a period of five months post testing.

Emphasis has been put on the importance of including both gross and fine motor goals in the treatment plan for children with ASD [19]. The results showed that movement-based activities in both rhythm and robotic group helped the children with ASD to improve in their gross motor skills. Therefore, either music or robot therapy can be an adjunct therapy towards enhancing motor skills in children with ASD. As all the trainers in the study were either pediatric PT or PT/kinesiology graduate students who administered the training, the movement-based activities might be arguable to be designed more towards PT-manner.

Last but not least, the RAS intervention protocol on top of the specially designed PT programme reemphasised on the rhythmic stimulus that enhanced on the motor response [21]. However, it is still undeniable that the results for all the three studies might be the impact of selected PT programme or the movement-based activities related to PT intervention.

V. CONCLUSION

The main aim of this paper is to provide an evidence-based PT effect on motor skills for children with ASD. Due to the limited existing studies, there is a call for future research to further support PT intervention in improving both gross and motor skills of children with ASD. It would be beneficial to determine the effect of PT as a stand-alone intervention, with larger number of sample size used. Additionally, future research can also look into PT integration in the assessment and treatment plan of children with ASD.

ACKNOWLEDGEMENT

Fully funded by Canaan Physiotherapy Enterprise (Kuching, Malaysia).

REFERENCES

[1] Ministry of Health (MOH), Clinical practice guidelines: management of autism spectrum disorder in children and adolescents, Putrajaya: Malaysia Health Technology Assessment Section (MaHTAS), 2014.

[2] C.M. Murphy, C.E. Wilson, D.M. Robertson, C. Ecker, E.M. Daly, N. Hammond, A. Galanopoulos, I. Dud, D.G. Murphy, and G.M. McAlonan, Autism spectrum disorder in adults: diagnosis, management,

and health services development, Neuropsychiatric Disease and Treatment, vol. 12, pp. 1669-1686, 2016.

[3] R. Downey, and M.J. Rapport, Motor activity in children with autism: a review of current literature, Pediatric Physical Therapy, vol. 24(1), pp. 2-20, 2012.

[4] D. Green, T. Charman, A. Pickles, S. Chandler, T. Loucas, E. Simonoff, and G. Baird, Impairment in movement skills of children with autistic spectrum disorders, Developmental Medicine & Child Neurology, vol. 51, pp. 311-316, 2009.

[5] S. Reynolds, R.M. Bendixen, T. Lawrence, and S.J. Lane, A pilot study examining activity participation, sensory responsiveness, and competence in children with high functioning autism spectrum disorder, Journal of Autism and Developmental Disorders, vol. 41, pp. 1496-1506, 2011.

[6] M. Xue, M. Brimacombe, G.C. Wagner, Prevalence of motor impairment in autism spectrum disorders, Brain and Development, vol. 29(9), pp. 565-570, 2007.

[7] K.A. Fournier, C.J. Hass, S.K. Naik, N. Lodha, and J.H. Cauraugh, Motor coordination in autism spectrum disorders: a synthesis and meta-analysis, Journal of Autism and Developmental Disorder, vol. 40, pp. 1227-1240, 2010.

[8] S. Ozonoff, G.S. Young, S. Goldring, L. Greiss-Hess, A.M. Herrera, J. Steele, S. Macari, S. Hepburn, and S.J. Rogers, Gross motor development, movement abnormalities, and early identification of autism, Journal of Autism and Developmental Disorders, vol. 38, pp. 644-656, 2008.

[9] Esposito, G., Venuti, P., Maestro, S., and Muratori, F. (2009). An exploration of symmetry in early autism spectrum disorders: analysis of lying. Brain and Development, 31, 131-138.

[10] G. Esposito, and P. Venuti, Analysis of toddlers' gait after six months of independent walking to identify autism: a preliminary study, Perceptual and Motor Skills, vol. 106, pp. 259-269, 2008.

[11] M.A. Gernsbacher, E.A. Sauer, H.M. Geye, E.K. Schweigert, and H.H. Goldsmith, Infant and toddler oral-and manual-motor skills predict later speech fluency in autism, The Journal of Child Psychology and Psychiatry, vol. 49(1), pp. 43-50, 2008.

[12] A.N. Bhat, R.J. Landa, J.C. Cole-Galloway, Current perspectives on motor functioning in infants, children, and adults with autism spectrum disorders, Physical Therapy, vol. 91(7), pp. 1116-1129, 2011.

[13] A. Ben-Sasson, L. Hen, R. Fluss, S.A. Cermak, B. Engel-Yeger, and E. Gal, A meta-analysis of sensory modulation symptoms in individuals with autism spectrum disorders, Journal of Autism and Developmental Disorder, vol. 39, pp. 1-11, 2009.

[14] S.D. Tomcheck, and W. Dunn, Sensory processing in children with and without autism: a comparative study using the short sensory profile, American Journal of Occupational Therapy, vol. 61(2), pp. 190-200, 2007.

[15] A.E. Lane, R.L. Young, A.E. Baker, and M.T. Angley, Sensory processing subtypes in autism: association with adaptive behavior, Journal of Autism and Developmental Disorders, vol. 40, pp. 112-122, 2010.

[16] A. Shumway-Cook, and M. Woollacott, Normal reach, grasp, and manipulation. In: Shumway-Cook, A., and Woollacott, M., eds. Motor Control: Translating research into clinical practice, Baltimore, MD: Lippincott, Williams & Wilkins, pp. 443-467, 2008.

[17] J. Brian, S.E. Bryson, N. Garon, W. Roberts, I.M. Smith, P. Szatmari, and L. Zwaigenbaum, Clinical assessment of autism in high-risk 18-month-olds, Autism, vol. 12(5), pp. 433-456, 2008.

[18] Z.A. Michaleff, L.O. Costa, A.M. Moseley, C.G. Maher, M.R. Elkins, R.D. Herbert, and C. Sherrington, CENTRAL, PEDro, PubMed, and EMBASE are the most comprehensive databases indexing randomized controlled trials of physical therapy interventions, Physical therapy, vol. 91(2), pp. 190-197, 2011.

[19] S.M. Srinivasan, M. Kaur, I.K. Park, T.D. Gifford, K.L. Marsh, and A.N. Bhat, The effects of rhythm and robotic interventions on the imitation/praxis, interpersonal synchrony, and motor performance of children with autism spectrum disorder (ASD): A pilot randomized controlled trial, Autism Research and Treatment, 2015:736516, 2015.

[20] J.A. Colebourn, A.C. Golub-Victor, and A. Paez, Developing overhand throwing skills for a child with autism with a collaborative approach in school-based therapy, Pediatric Physical Therapy, vol. 29(3), pp. 262-269, 2017.

[21] S.A. El Shemy, and M.S. El-Sayed, The impact of auditory rhythmic cueing on gross motor skills in children with autism. Journal of Physical Therapy Science, vol. 30(8), pp. 1063-1068, 2018.

[22] R.H. Bruininks and B.D. Bruininks, The Bruininks-Oseretsky Test of Motor Proficiency Second Edition (BOT2), AGS Publishing, Circle Pines, Minn: USA, 2005.

Appendix

Table 1
Summarises the (a) participant characteristics, (b) type of intervention, (c) procedures used, (d) outcomes, and (e) research methodology for the included studies

Studies	Participant Characteristics	Type of intervention and procedures used	Outcomes	Research methodology
Srinivasan et al. (2015)	32 M and 4 F (5-12 years)	Randomly assigned to rhythm, robot and comparison group according to age and severity of ASD (ADOS-2). All 3 groups involved the child, expert trainer/robot and adult model. Rhythm group and robot group: movement-based games (gross motor) Comparison group: Table-top activities (fine motor) ABA, TEACCH and PECS were used in all groups. Training was provided for 8 weeks with 4 sessions each week, lasting 45 minutes. All trainers were PT or PT/kinesiology graduate students.	The rhythm and robot groups improved on the body coordination composite of BOT-2, whereas the comparison group improved on the fine manual control composite of BOT-2. Both the rhythm and robot groups showed improved interpersonal synchrony all three groups improved in imitation/praxis.	3 out of 36 children were excluded due to inability to perform pre and post test of BOT-2. Final analysis was based on 11 children per group. BOT-2 test was used to test for gross and fine motor performance. Repeated measures ANCOVA was used for composite type (body coordination and fine manual control) and test session (pretest and posttest). Repeated measures ANOVA was used for training-specific test of interpersonal synchrony.
Colebourn et al. (2017)	1 M (9 year)	20-week gross motor intervention designed to improve overhand throwing ability, which included weekly PT instruction and daily throwing trials using ABA approach.	Significant gains on BOT-2 TGMD-2 and the SFA.	BOT-2, TGMD-2 and SFA were used for test references. Baseline to retention scores was compared.
El Shemy and El-Sayed (2018)	22 M and 8 F (8-10 years)	Randomly allocated to control group special designed PT programme) or study group (PT programme with RAS). PT programme lasted for 3 months, 1 hour, 3 times/week. RAS lasted for 30 minutes each session.	Statistically significant improvement in bilateral coordination, balance, running speed and agility, and strength in both groups after treatment, with study group showing better improvement in all outcome measures.	BOT-2 was used to assess gross motor skills at baseline and after 3months of intervention. Wilcoxon signed rank test was used to compare the outcome measures within each group. Wilcoxon signed rank test was used to compare the outcome measures within each group.

Abbreviations: ADOS-2, Autism Diagnostic Observation Schedule 2nd Edition; ABA, Applied Behavioural Analysis; TEACCH, Teaching and Education of Autistic and Related communication Handicapped Children; PECS, Picture Exchange Communication System; BOT-2, Bruininks-Oseretsky Test of Motor Proficiency 2nd Edition; TGMD-2, Test of Gross Motor Development 2nd Edition; SFA, School of Function Assessment; PT, physical therapy; RAS, rhythmic auditory stimulation.