

Motor competence and social function in children with autism spectrum disorder

TING LIU¹, VINEELA KAARENGALA², LYN G. LITCHKE³

^{1,2}Department of Health and Human Performance, Texas State University, USA

Published online: March 31, 2019

(Accepted for publication February 14, 2019)

DOI:10.7752/jpes.2019.01076

Abstract:

Motor and social competence are delayed in children with autism spectrum disorder (ASD). Social interaction and functional physical capacity play an important role for developing peer relationships in school settings such as gym, playground, and classroom. Research on the delayed motor competence in relationship to poor social interaction in children with ASD is limited. The purpose of the study was to examine motor competence and social skills functioning in children with ASD. A sample of 23 children diagnosed with ASD participated in the study. Bruininks-Oseretsky Test of Motor Proficiency-II (BOT-2) was used to examine children's motor competence and Autism Social Skill Profile (ASSP) survey was given to parents to assess children's social skills functioning. The descriptive analysis revealed that 87% of the children with ASD were classified as below average or well below average category in BOT-2 suggesting the children with ASD were delayed in motor competence. In addition, 52% of the children were ranked at or below 50th percentile on the ASSP indicating that they had poor social skill functioning. A significant positive correlation was found between BOT-2 and ASSP revealed that children with ASD who performed poorly in BOT-2 also scored low in ASSP. These findings suggest that including fine and gross motor skills in the treatment interventions for children with ASD may improve their health-related wellbeing and maintain positive socialization.

Key words: autism; children; fine and gross motor competence; social skills.

Introduction

Autism Spectrum Disorder (ASD) is a neurological disorder in which a child exhibits delayed motor competence and deficits in social interaction (CDC, 2017). The occurrence of ASD in US was reported about 1 in 150 children in 2007 and the prevalence of ASD has increased to 1 in 68 children in 2012 (CDC, 2012). Many children diagnosed with ASD are delayed in fine and gross motor proficiency (Berkeley, Zittel, Pitney, & Nicholas, 2001; CDC, 2017; Liu, 2013; Manjiviona & Prior, 1995), demonstrate stereotypic behavioral patterns (APA, 2013; Liu, Fedak, & Hamilton, 2016; Pusponogoro et al., 2016), and show impaired social interaction (Liu et al., 2016; CDC, 2017). Most children with ASD also experience sensory abnormalities resulting in increased sensory seeking behavior so they tend to respond to the sensory input with repetitive movements like flapping arms, twirling, and rocking (APA, 2017; Ben-Sasson et al., 2009). Atypical sensory responses, specifically in tactile and auditory filtering, can affect a child's motivation to participate in physical activity and lead to delays in fine and gross motor competence. Few other symptoms of ASD include social functioning deficits of inability to understand facial expressions, difficulty in verbal expression of emotions, and understanding the concept of sharing the toys and taking turns in the classroom or playground (CDC, 2017).

While the research on diagnosing and managing ASD is still ongoing, few researchers argue that the relationship exists between the ASD symptoms. For example, children with ASD sensory impairments were related to their poor motor competence (Hilton et al., 2010; Liu, 2013) and poor motor competence was related to their social skill deficits (Berkeley et al., 2001; Fournier, Hass, Naik, Lodha, & Cauraugh, 2010; Lindsay, Hounsell, & Cassiani, 2017; MacDonald, Jaszewski, Esposito, & Ulrich, 2011; Pusponogoro et al., 2016). Hilton et al. (2010) examined the relationship of 36 high functioning children with ASD social response and their sensory profile. They reported that the sensory abnormalities were strongly related to the social deficits in children with ASD. Liu (2013) examined children with ASD's motor competence using movement assessment battery for children (MABC-2) and sensory profile using a short sensory profile (SSP). It was reported that the children with ASD were delayed on their fine and gross motor skill performance including manual dexterity, catching and throwing of ball, and balancing. It was also found that the children with low sensory processing scores also showed poor motor competence. Children with ASD with deficits in motor and social functioning may have limited physical functional capacity to participate in sports and less opportunity to be invited to participate in group activities on the playground as their typically developing peers.

Furthermore, Pusponogoro et al. (2016) conducted a cross-sectional study on children with ASD, aged 18 months to 6 years, using Vineland Adaptive Behavior Scales-2 to compare their motor competence with 40 typically developing children. The results showed that most of the children with ASD scored below average in

gross motor abilities of rolling a ball, object manipulation, hopping upward and forward on one foot, kicking a ball, and able to use alternate feet while using stairs. It was also found that the children who scored below-average in gross motor skills have scored low to moderately low in social skills. Research suggests that in addition to motor and sensory delays, children with ASD also found to have poor social skills such as difficulty in making eye contact, withdrawing from social situations, showing least interest in meeting other people (CDC, 2017; Puspnegoro et al., 2016; Rivard et al., 2016). Rivard et al. (2016) stated that children with ASD had hard time in voluntarily initiating conversation and showed less spontaneous minimal social initiation behaviors when compared to their peers. Children with ASD also tend to make inappropriate comments or dominate conversations with their personal interests that keeps them from engaging in positive social interaction (Bellini, 2006b; Kaale, Smith, & Sponheim, 2012). Many children with ASD also exhibit socially inappropriate behaviors like physical aggression, self-injury, property damage, and inappropriate refusal of screaming and pushing instead of saying “no” (Rivard et al., 2016).

Specifically related to conversation-social skills, children with ASD also tend to make inappropriate comments or dominate conversations with their personal interests that keeps them from engaging in positive social interaction (Bellini, 2006a; Kaale et al., 2012). For example, Hagopian, Kuhn, and Strother (2009) reported that as a therapist was talking about colors, the child interrupted and changed the topic by asking “Do you like horses?” This study also reported that the scores of the child’s frequency of inappropriate touching were high with a mean of 92% (Hagopian et al., 2009). The poor social skills functioning in children with ASD may lead to a larger effect of detrimental social behaviors that are disruptive to creating social relationships and eventually resulting in limiting peer relations.

Previous studies are available on existing social skill deficits, assessing social skills, and designing treatment programs in children with ASD (Bellini, 2006b; Kaale et al., 2012; Rivard et al. 2016). However, they are limited on how these social deficits are related to other existing symptoms in children with ASD like motor competence. Knowing this relationship is valuable and beneficial in helping educators and practitioners designing early intervention treatment programs to improve children’s motor competence and social skill functioning (MacDonald, Lord, & Ulrich, 2013). Furthermore, understanding this relationship may assist children with ASD to adjust in the school settings (Liu et al., 2016), improve academic performance (Nicholson, Kehle, Bray, & Heest, 2011), develop social relationships (Fuller et al., 2013; Legoff, 2004), and enhance quality of living (Tan, Cohen, & Pooley, 2013; Toscano, Carvalho, & Ferreira, 2018). Because low motor competence is related to poor social interaction in children with ASD, understanding how motor competence may affect their social skill functioning is important. Thus, the purpose of the study was to examine the relationship between motor competence and social function in children with ASD. It was hypothesized children with ASD’s social skill function were positively related to their motor skill competence.

Materials & Methods

Participants

Initially, a sample of 25 children with ASD (24 male and 1 female) aged 4-16 years were recruited for the study. Children were included in the study if (1) they were diagnosed with ASD by a physician or a school psychologist based on DSM-IV criteria (APA, 2000) and (2) they could follow instructions and communicate with the testing administrators to complete the fine and gross motor skill performance. Two participants were excluded from the study because they were unable to finish the required motor assessments. Therefore, a total of 23 children with ASD (all males) completed all assessments and were included in the study. This study was approved by the local University Institutional Review Board. The parents were informed about the protocol and signed the consent form prior to their child’s participation in the study.

Instrumentation

Bruininks-Oseretsky Test of Motor Proficiency-2(BOT-2; Bruininks & Bruininks, 2005)

The BOT-2 is an assessment tool to test motor competence of children with ASD. The short form with knee pushup test was used in this study to assess both fine and gross motor skills in children with ASD. The BOT-2 short form consists of eight subtests with a total of 14 tasks in which scores on four subtest measures fine motor competence: 1) fine motor precision (FMP), 2) fine motor integration (FMI), 3) manual dexterity (MD), and 4) bilateral coordination (BC), and four subtests assess gross motor competence: 1) balance, 2) running speed and agility (RSA), 3) upper-limb coordination (ULC), and 4) strength.

The raw scores were converted to a point score using the conversion table provided on the form. For example, if a child scored 12 in drawing lines through paths, the item score was converted as a 2-point score. Children performed two trials for each task and the better score of the two was selected. Total point scores were recorded by adding all point scores and using the norm tables to find percentile rank and standard scores. The range of percentile rank of each child’s scores for interpretation are as follows: 2 or less (well-below average), 3-17 (below-average), 18-83 (average), 84-97 (above average), and 98 or greater (well above average).

Autism Social Skills Profile (ASSP; Bellini & Hopf, 2007)

The ASSP is a caregiver survey that includes 49 items on a 4-point Likert scale. This assessment tool provides a comprehensive measure of social functioning in children with ASD with the age range of 6 to 17 years. The ASSP consists of three subscales, Social Reciprocity (SR), Social Participation/Avoidance (SPA), and

Detrimental Social Behaviors (DSB), and the overall social functioning. For example, the skill area of “recognizes the facial expressions of others” from the survey is related to SR. The social behaviors in children with ASD were rated as: 1 = never, 2 = sometimes, 3 = often, or 4 = very often. The point scores of all the questions were added together for analysis using ASSP summary form (Bellini, 2006a). The ASSP summary form includes the type of ASD in high-functioning or low-functioning and non-verbal or cognitive disability. Total raw scores were converted to percentile rank using ASSP summary form and the percentile scores were used to analyze children with ASD’s social functioning.

Procedures

Proper attire instructions were given to the parents prior to the testing administration. The research assistants and graduate students underwent an intensive training session to understand the concepts and instrumentation of BOT-2 prior to the testing by the principle investigator. Initially the research assistants received a lecture on how to implement, score, convert scores and minimize the testing errors. Later mock testing criteria were used to get familiarize with specific emphasizing on how to verbally instruct the child for each task. Research assistants were considered trained after they reach 90% agreement with the principal investigator.

Participants received verbal instructions and visual demonstration prior to each task. Each participant was given a practice trial until the skill was performed correctly as instructed on the manual of BOT-2. When a participant failed to meet the criteria on the BOT-2 manual, additional instruction and demonstration were given. The raw scores were recorded and later converted to point scores. Standard scores and percentile ranks were used to classify a child to a specific motor competence category. In addition, parents were asked to fill out the ASSP form assessing their child’s social functioning. The verbal instructions were given to parents prior to answering the questions on the survey.

Data Analysis

Descriptive analyses were used to assess children with ASD’s motor competence and social skill functioning. A Pearson correlation was run to analyze the relationship between percentile scores of BOT-2 and ASSP. The significance was set at a p value of 0.05. The effect sizes (ES) were also calculated to examine the practical significance (Cohen, 1988). ES can be identified as small ($d = .2$), medium ($d = .5$), or large ($d = .8$).

Results

The descriptive analysis showed that 87% of the children with ASD were in the below average or well below average category in BOT-2 suggesting that children with ASD had poor motor competence when compared to the norms (Table 1). The descriptive percentile ranks for ASSP revealed that 52% of the children were ranked at or below 50th percentile indicating that children with ASD had poor social skill functioning.

A Pearson correlation was performed to examine the relationship between the percentile ranks of BOT-2 (motor competence) and ASSP (social functioning). A significant positive correlation was found between BOT-2 and ASSP ($r = 0.36$, $p < 0.05$). This finding suggests that children with ASD who performed motor skills poorly in BOT-2 also scored low on their social function in ASSP.

Table 1. *BOT-2 performance classifications*

Classification	Percentile Rank	Participants
Well-Below Average	2 or less	6
Below-Average	3-17	14
Average	18-83	3
Above Average	84-97	0
Well Above Average	98 or greater	0

The effect size (Table 2) of the children with ASD’s BOT-2 scores in comparison to the norms were large for FMI (ES= -1.26), MD (ES= -1.05), BC (ES= -0.98), balance (ES= -1.27), and very large for strength with knee push-ups (ES= -2.06). The ES for ASSP (Table 3) describing various areas of social skill functioning were large for SPA (ES= -1.27), and very large for SR (ES= -3.21), DSB (ES= -6.4), and overall social functioning (ES= -8.59). The large ES values (>0.80) agreed with the statistically significant results that suggests the true effect of the delayed motor and social skills exist in the population.

Table 2. *Participants effect sizes in BOT-2 subtests*

BOT-2 Subtest	Effect Size
FMP	0.05
FMI	-1.26*
MD	-1.05*
ULC	-0.76
BC	-0.98*
Balance	-1.27*
RSA	-0.51
Strength (with Knee push-ups)	-2.06*

Note. FMP = fine motor precision; FMI = fine motor integration; MD = manual dexterity; ULC = upper limb coordination; BC = bilateral coordination; RSA = running speed and agility. * indicates large ES.

Table 3. *Participants Effect sizes in ASSP*

ASSP Subtest	Effect Size
SR	-3.21*
SPA	-1.27*
DSB	-6.4*
Overall Social Functioning	-8.59*

Note. SR=social reciprocity; SPA = social participation/avoidance; and DSB = detrimental social behaviors.
* indicates large ES.

Discussion

The results of this study supported the hypothesis that children with ASD showed low motor and social competence. In addition, the hypothesis of significant positive correlation between the motor competence in BOT-2 and social skill functioning in children with ASD was supported. These findings suggested that children with ASD who had poor motor competence also exhibited deficits in social functioning. In addition, there was a very large effect for fine motor integration, manual dexterity, bilateral coordination, balance, and strength indicating that children with ASD had low motor competence and the practical significance exists in this population. These findings were consistent with previous research that children with ASD were delayed in fine and gross motor competence (Berkeley et al., 2001; Downey & Rapport, 2012; Liu, 2013; Liu & Breslin, 2013; McPhillips et al., 2014; Provost, Lopez, & Heimerl, 2007). More specifically, the majority of children with ASD (87%) in this study demonstrated low motor competence was similar to the Provost et al. (2007)'s study that 84% of children with ASD were classified as significantly delayed in their motor proficiency and also in Liu and Breslin (2013)'s study that 80% of children with ASD showed significant fine and gross motor delays.

The results of 52% children with ASD showing significant social functioning difficulties was consistent with previous studies that reported 50% of children with ASD displayed social skill deficits (Bellini, 2006a; Kaale, et al., 2012; Mayes, & Calhoun, 1999; Puspnegoro et al., 2016; Rivard et al., 2016; VanMeter, Fein, Morris, Waterhouse, & Allen, 1997). The large ES were found in social reciprocity, detrimental social behaviors, and overall social functioning in children with ASD also suggested that the practical significance existed in children with ASD. Researchers have indicated several contributing factors to lack of reciprocal conversation skills with others (Bellini, 2006a; Kaale, et al., 2012). These included limited initiation of interaction (Mayes et al., 1999; VanMeter et al., 1997), difficulty understanding the concept relating to personal space (Parsons, Mitchell, & Leonard, 2004), and existing stereotypic behaviors such as repetitive hand movements and throwing objects that may result in injury (Watt, Wetherby, Barber, & Morgan, 2008).

In addition, the finding of children with ASD's fine and gross motor competence was significantly related to their social skills was in agreement with previous studies (MacDonald et al., 2013; Rivard et al., 2016; Watt et al., 2008). MacDonald et al. (2013) examined 35 children with high-functioning ASD on their motor competence and social communicative skills. It was found that children with greater motor competence showed better social communicative skills. As reported in our study, there were large effect sizes found on the ASSP for overall social performance in relation to motor competence in BOT-2. Furthermore, this study and others indicate a strong connection between motor competence and social functioning in children with ASD. Therefore, it seems reasonable to propose that motor skill interventions to be paired with social skills as the treatment programs to enhance children with ASD's quality of living. This study provides new valuable findings to researchers, educators, practitioners, and therapist that children with ASD are delayed in their fine and gross motor skills and social functioning as well as the fact that the motor competence and social skill functioning is correlated. Future researchers are recommended to focus on motor competence alongside social, sensory, behavior, and cognitive competencies when designing training, treatment, and intervention programs for children with ASD.

Moreover, the nature of the motor intervention was specific to the needs of children with ASD in structure and targeted physical modalities with social skills emphasis. For example, Gutman et al. (2010) studied children with high functioning ASD and found significant and sustained improvements in targeted social skills behaviors after a motor-based intervention. Similarly, Pan (2010) found that a very specific type of water exercise swimming program led to significant social improvements in children with ASD.

Overall, the findings of this study give rise to the implication of designing motor intervention programs that can best target the specific social skill behaviors (Bellini, 2006a). Structured and prolonged social skills intervention can have positive effects on anxiety and depression in children with ASD (Rumney, & MacMahon, 2017). Thus, it is important to investigate the most effective treatment program to ameliorate social skills to reduce more serious emotional outcomes. These findings also add important implications in examining and determining effective interventions for children with ASD to improve their health-related wellbeing and to maintain their positive socialization and enjoyment of motor activities.

One limitation of this study was the drop in sample size due to incompleteness of the motor assessments. Children could not complete or were not willing to finish the BOT-2 assessment were excluded from the study and their data were not included in the data analysis. Also, participants in this study were all males because ASD is about 4.5 times more likely to occur in males than in females. Future study may include more female participants. Furthermore, some of the scores from the ASSP survey was calculated as 0 when the parents

indicated the questions were not applicable to the child. Despite additional demonstrations given on the BOT-2 for children who did not appear to understand what was asked of them, there was no guarantee that the child completely comprehended how to perform the task. It is recommended that future research to use picture schedules to help children with ASD better understand the requested motor tasks in BOT-2.

Conclusions

In conclusion, this study indicates a low motor competence and poor social functioning in children with ASD. A relationship between motor and social skill competence in these children with ASD was found and the needs for designing intervention programs including both motor and social skills. More research is needed to better understand the impact of certain types of motor skills-based activities on successful social development. It is suggested for future interventions to incorporate small instructor to student ratio to enhance the opportunity for effective social practices with appropriate physical activities, which may strengthen the social skills outcomes for children with ASD. It is also recommended for teachers, therapists, parents, and practitioners to include motor and social skills in their practices when working with children with ASD so that they can then be more generalizable to other settings such as classroom, playground, home, and neighborhoods.

Conflicts of interests: the authors have no conflicts of interest to declare.

References

- American Psychiatric Association (APA; 2013). Autism spectrum disorders. Retrieved from <http://www.apa.org/pi/disability/resources/publications/newsletter/2016/09/autism-spectrum-disorder.aspx>
- American Psychiatric Association (APA, 2017). Diagnosing and managing autism spectrum disorder. Retrieved from <http://www.apa.org/helpcenter/autism.aspx>
- American Psychiatric Association (2000). Diagnostic and statistical manual of mental disorders (4th ed.). Washington, DC: Author.
- Bahrami, F., Movahedi, A., Marandi, S. M. & Sorensen, C. (2016). The effect of karate techniques training on communication deficit of children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 46, 978-986.
- Bellini, S. (2006a). *Building social relationships: A systematic approach to teaching social interaction skills to children and adolescents with autism spectrum disorders and other social difficulties*. Shawnee Mission, KS: Autism Asperger Publishing.
- Bellini, S. (2006b). The development of social anxiety in high functioning adolescents with autism spectrum disorders. *Focus on Autism and Other Developmental Disabilities*, 21, 138–145.
- Bellini, S. & Hopf, A. (2007). The development of the autism social skills profile. *Focus on Autism and Other Developmental Disabilities*, 22(2), 80-87.
- Ben-Sasson, A., Hen, L., Fluss, R., Cermak, S. A., Engel-Yeger, B., & Gal, E. (2009). A Meta-Analysis of sensory modulation symptoms in individuals with autism spectrum disorders. *Journal of Autism & Developmental Disorders*, 39(1), 1-11.
- Berkeley, L.S., Zittel, L. L., Pitney, L. V., & Nichols, (2001). Locomotor and object control skills of children diagnosed with autism. *Department of Kinesiology and Physical Education*, 18(4), 405-416.
- Bruininks, R. H., Litt, J., Taylor, H. G., Klein, N., & Hack, M. (2005). Bruininks-Oseretsky Test of Motor Proficiency. *Journal of Learning Disabilities*, 38(2), 130-141.
- Centers for Disease Control and prevention (CDC; 2017). Autism spectrum disorders. Retrieved from <https://www.cdc.gov/ncbddd/autism/facts.html>
- Center for Disease Control and Prevention (CDD, 2012). Reports of autism and developmental disorders monitoring (ADDM) 2007-2012. Retrieved from <https://www.cdc.gov/mmwr/volumes/65/ss/ss6503a1.htm>
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences (2nd ed.)*. New York: Academic Press.
- Downey, R., & Rapport, M. K. (2012). Motor activity in children with autism: a review of current literature. *Pediatric Physical Therapy*, 24(1), 2-20. doi:10.1097/PEP.0b013e31823db95f
- Gutman, S.A., Raphael, E.I., Ceder, L.M., Khan, A., Timp, K.M., & Salvant, S. (2010). The effect of a motor-based, social skills intervention for adolescents with high-functioning autism: two single-subject design cases. *Occupational Therapy International*, 17(4):188-97.
- Fournier, K. A., Hass, C. J., Naik, S. K., Lodha, N., & Cauraugh, J. H. (2010). Motor coordination in autism spectrum disorders: A Synthesis and meta-analysis. *Journal of Autism & Developmental Disorders*, 40(10), 1227-1240.
- Fuller, R. E., Kim, M., Seiple, D., Locke, J., Greenwell, R., & Levin, D., 2013. Social skills assessments for children with autism spectrum disorders. *Autism*, 3(122). DOI: 10.4172/2165-7890.1000122.
- Hagopian, L. P., Kuhn, D. E., & Strother, G. E. (2009). Targeting Social Skills Deficits in an Adolescent with Pervasive Developmental Disorder. *Journal of Applied Behavior Analysis*, 42(4), 907-911.

- Hilton, C. L., Harper, J. D., Kueker, R. H., Lang, A. R., Abbacchi, A. M., Todorov, A., & LaVesser, P. D. (2010). Sensory responsiveness as a predictor of social severity in children with high functioning autism spectrum disorders. *Journal of Autism & Developmental Disorders, 40*(8), 937-945.
- Kaale, A., Smith, L., & Sponheim, E. (2012). A randomized controlled trial of preschool-based joint attention intervention for children with autism. *Journal of Child Psychology and Psychiatry, 53*(1), 97-105.
- LeGoff, D. B. (2004). Use of LEGO® as a Therapeutic Medium for Improving Social Competence. *Journal of Autism & Developmental Disorders, 34*(5), 557-571.
- Liu, T. (2013). Sensory processing and motor skill performance in elementary school children with autism spectrum disorder. *Perceptual & Motor Skills, 116*(1), 197-209.
- Liu, T., Fedak, T., & Hamilton, M. (2016). Effect of physical activity on the stereotypic behaviors of children with autism spectrum disorder. *International Journal of School Health*. doi: 10.17795/intjsh-28674.
- Liu, T., & Breslin, C. (2013). Fine and gross motor performance of the MABC-2 by children with autism spectrum disorder and typically developing children. *Research in Autism Spectrum Disorders, 7*(10), 1244-1249.
- Lindsay, S., Hounsell, G. K., & Cassiani, C. (2017). A scoping review of the role of LEGO therapy for improving inclusion and social skills among children and youth with autism. *Disability and Health Journal, 10*(2), 173-182.
- MacDonald, M., Jaszewski, C., Esposito, P., & Ulrich, D. (2011). The effect of learning to ride a two-wheel bicycle on the social development of children with autism spectrum disorder: A qualitative study. *Palestra, 25*(4), 37-42.
- MacDonald, Lord, C., & Ulrich, D. (2013). The relationship of motor skills and social communicative skills in school-aged children with autism spectrum disorder. *Adapted Physical Activity Quarterly, 30*(3), 271-282.
- McPhillips, M., Finaly, J., Bejerot, S., & Hanley, M. (2014). Motor deficits in children with Autism Spectrum Disorder: a cross-syndrome study. *Autism Research, 7*(6), 664-676.
- Manjiviona, J. & Prior, M. (1995). Comparison of asperger syndrome and high-functioning autistic children on a test of motor impairment. *Journal of Autism and Developmental Disorders, 25*(1), 23-39.
- Mayes, S.D., & Calhoun, S. L. (1999) Symptoms of autism in young children and correspondence with the DSM. *Infants and Young Children, 12*, 90-97.
- Najafabadi, M.G., Sheikh, M., Hemayattalab, R., Amir, M., Rezaii, M., Hafizi S. (2018). The Effect of SPARK on Social and Motor Skills of Children with Autism. *Pediatrics and Neonatology* doi: 10.1016/j.pedneo.2017.12.005.
- Nicholson, H., Kehle, T. J., Bray, M. A., & Heest, J. V. (2011). The effects of antecedent physical activity on the academic engagement of children with autism spectrum disorder. *Psychology in The Schools, 48*(2), 198-213.
- Pan, C.Y. (2010). Effects of water exercise swimming program on aquatic skills and social behaviors in children with autism spectrum disorders. *Autism Speaks, 14*(1):9-28. doi: 10.1177/1362361309339496,
- Parsons, S., Mitchell P., Leonard, A. (2004) The use and understanding of virtual environments by adolescents with autistic spectrum disorders. *Journal of Autism Developmental Disorder, 34*, 449-466.
- Provost, B., Heimerl, S., & Lopez, B. R. (2007). Levels of gross and fine motor development in young children with autism spectrum disorder. *Physical & Occupational Therapy in Pediatrics, 27*(3), 21-36.
- Pusponegoro, H. D., Efar, P., Soedjatmiko, Soebadi, A., Firmansyah, A., Chen, H., & Hung, K., (2016). Gross motor profile and its association with socialization skills in children with autism spectrum disorders. *Pediatrics and Neonatology, 57*, 501-507.
- Rivard, M., Forget, J., Giroux, N., Mello, C., Kerr, K., & Regli, G. (2016). Observation of socially appropriate and inappropriate behaviours among children with autism spectrum disorder during an early behavioural intervention program. *Journal on Developmental Disabilities, 22*(1), 52-67.
- Rumney, H. L., & MacMahon, K. (2017). Do social skills interventions positively influence mood in children and young people with autism? A systemic review. *Mental Health and Prevention, 5*, 12-20.
- Tan, B. Z., Cohen, L., & Pooley, J. A. (2013). The implication of physical activity on attention span and quality of life in children with autism spectrum disorders: A pilot study. *Annual International Conference on Cognitive & Behavioral Psychology, 2*, 40-49.
- Toscano, C. A., Carvalho, H. M., & Ferreira, J. P. (2018). Exercise effects for children with autism spectrum disorder: Metabolic health, autistic traits, and quality of life. *Perceptual & Motor Skills, 125*(1), 126-146.
- VanMeter, L., Fein, D., Morris, R., Waterhouse, L., & Allen, D. (1997) Delay versus deviance in autistic social behavior. *Journal of Autism Developmental Disorder, 27*, 557-569.
- Watt, N., Wetherby, A.M., Barber, A., & Morgan, L. (2008) Repetitive and stereotyped behaviors in children with autism spectrum disorders in the second year of life. *Journal of Autism Developmental Disorder, 38*, 1518-1533.