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Children with autism spectrum disorder and physical activity: A descriptive synthesis

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The purpose of this literature review was to describe research on strategies used in engaging children with Autism Spectrum Disorder (ASD) in physical activity. Keyword searches were used to identify articles from selected electronic databases over a 25-year period from 1990 through 2015. Thirty-five articles met all inclusion criteria. These studies were retrieved, reviewed, coded, analyzed thematically, and summarized. Five thematic categories emerged, which were: (a) comparison of physical activity (PA) levels between children with ASD and their typically functioning peers, (b) physical activity patterns of children with ASD, (c) barriers that impede children participation in physical activities, (d) benefits of participating in physical activities, and (e) strategies for engaging children with ASD in physical activities. Effective teaching strategies and the benefits of participating in physical activities for children with ASD are addressed in this review.

Key words: Autism spectrum disorder, physical activity, physical education, exercise.

INTRODUCTION

Physical activity has been described as any action where an individual is moving (Ortiz-Castillo, 2011) and defined by the Centers for Disease Control and Prevention (CDC, 2010) as "any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above a basal level. In these guidelines, physical activity generally refers to the subset of physical activity that enhances health" (Letter P para. 1). In this current review, physical activity is broadly defined as bodily movements or activities such as aerobic activities, sport and motor skill performances, play, and exercises as well as muscle and bone strengthening activities (CDC, 2003; United States Department of Health & Human Services, 2008). Some of the benefits of physical activity participation for children with ASD have been identified in past studies (Levinson and Reid, 1993; Todd and Reids, 2006). For example, research confirms that participating in physical activity allows children with ASD to gain positive experiences with their typically developing peers (Healy et al., 2013). ASD is a continuum of disabilities that is rapidly increasing[i] in the United States and elsewhere, yet the etiologies of ASD are still largely unknown (Doheny, 2008; Lerman et al., 2004). Children with ASD often exhibit stereotypic autistic behavioral tendencies that can be delineated into three categories, which are: (a) lack of social interaction, (b) poor communicative skills, and (c) repetitive and restricted behaviors. Children often exhibit these behavioral tendencies during physical education (PE) classes and this negatively affects their class participation

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(Obrusnikova and Dillon, 2011). For instance, Obrusnikova and Dillon (2011) indicated that physical education teachers and school staffs are challenged to engage children with ASD in physical activities during classes. In a preliminary experimental study in the adapted physical education (APE)/activity profession, Schleien et al. (1988) sought to determine the effects of a collaborative socio-motor, APE/therapeutic recreation curriculum on the social play and motor development of students with autism and their typically functioning peers in an integrated general physical education (GPE) program. The children with ASD participated in the intervention program called Special Friends, which focused on teaching social skills and fundamental motor skills with typically functioning peers. Based on the analyses of the data, Schleien et al. (1988) reported that the Special Friends program reduced inappropriate behaviors with simultaneous increases in appropriate behaviors of the children with ASD.

In addition to specially designed curriculum arrangements and other factors (e.g., facilities, supports from peer groups) linked to students' engagement in physical activity environments, parental influence is a salient factor in whether or not children with ASD are to become and remain physically active. Mindful of parental influence, An and Hodge (2013) explored the experiences and views of parents who had children with ASD and other developmental disabilities toward PE services. Based on the results, it was reported that parents took on the role of advocates for their children to have physical activity opportunities at school and within the community. The parents however were concerned about physical education programing due to a lack of communication between them and their children's general physical education (GPE) teachers. Parents value their children's education including physical education programming, but expectations of parents are suppressed where there is a lack of effective communication with GPE teachers (An and Hodge, 2013; Obrusnikova and Miccinello, 2012).

Similarly, Obrusnikova and Miccinello (2012) analyzed parents' views about factors that influence after school physical activity participation of children with ASD. They indicated that parents in their study realized the importance and the advantage of participating in physical activity for their children. Parents expected their children to improve social and communicative skills, while participating in physical activity. The parents nevertheless reported barriers that impede physical activity participation of their children, such as lack of self-motivation and lack of time. Children with ASD were more likely to engage in sedentary activities, such as playing computer games and watching television (TV) than they were in physical activity after school. It appears parents of children with disabilities value physical education. Parents are helpful when they encourage their children with ASD to be involved in physical activities (e.g., swimming, jogging, bicycling).

Over the years, researchers have analyzed variables associated with physical activity participation of children with ASD within schools and elsewhere. For example, Bandini et al. (2013) compared the physical activity (PA) levels between children with and without ASD. Their findings indicate that children with ASD had lower PA engagement levels compared to their aged group peers. In a systematic literature review, Lang et al. (2010) summarized studies about children with ASD in PA contexts, especially how physical exercise programs had influence on participants with ASD. They reported that most researchers commonly have reported that exercise and fitness programs can impact people with ASD in positive ways. For instance, studies show that participating in regular physical fitness and exercise programs provides opportunities for individuals with ASD to reach many benefits, such as increasing their socialization and experiencing inclusion. In addition, researchers had advocate for physical activity programming for students with ASD toward the acquisition and development of the mature motor skills (Schultheis et al., 2000).

To inform policy and practice, there is a need to describe the evidence based research to engage children with ASD in physical activities. Specifically, the purpose of this current literature review was to describe research on strategies used in engaging school-age children with ASD in PA. This review directly addresses the comparison of PA levels between children with ASD and their typically functioning peers. It identifies physical activities patterns of children with ASD and considerable barriers that impede children participation in PA. On the other hand, it identifies benefits of participating in PA. Lastly, strategies to engage children with ASD in physical activities are recommended. In short, the relevance and importance of the current review rests in describing empirically-tested strategies used in engaging children with ASD in physical activity.

METHODOLOGY

Procedures for searching articles

The following databases were searched for relevant studies: (a) Academic OneFile; (b) Academic Search Complete; (c) Education Full Text; (d) Education Research Complete; (e) ERIC; (f) Masterfile; (g) MEDline; (h) PE infor; (i) PsycINFO; (j) SocilNFO; and (k) Sportdiscus with Full Text. The following keywords were used for the electronic search: (a) autism spectrum disorder, children with ASD; (b) physical activity, exercise, teaching students with autism in physical education; and (c) evidence-based practice in physical education. All studies involving children with ASD were selected and reviewed to determine if the study: (a) focused on teaching children with ASD; (b) focused on engaging children with ASD in physical activities either in physical education or exercise,

health, sport, recreational, and/or leisure settings; (c) contained a physical activity intervention for children with ASD; and (d) was published in English in a peer-reviewed journal between 1990 and 2015.

Inclusion and exclusion criteria

The inclusion criteria for this literature review were studies: (a) published in the English language; (b) published in peer-reviewed journals from 1990 through 2015; (c) had full texts; (d) focused on children with ASD; and (e) designed to measure and/or improve the PA levels of children with ASD in PA or physical education settings. The exclusion criteria were studies: (a) involving adults with or without ASD, (b) published in non-English languages, and/or (c) published prior to 1990. Additional exclusion criteria included unpublished theses and dissertations.

The full search process produced a total of 198 articles about children with ASD in PA contexts. Of these, 162 were excluded due to failure of meeting some or all of the inclusion criteria. The most common reason for exclusion of studies was they were not focused on children with ASD in PA or physical education settings only. There were 35 articles that met all of the inclusion criteria (Figure 1).

Data analysis

The authors then reviewed 35 articles that met the inclusion criteria. Upon review of articles, the authors independently coded and later summarized key components of each study which included the purpose of the study, methodology used, participants, quality indicators, and outcomes. More explicitly, thematic analysis was used in analyzing the key components (Morse, 1994) of each study. The analysis entailed reading each article several times. Specifically, the authors followed three-steps to analyze the articles reviewed. In the first step, we read all 35 articles for familiarity with the contents while gleaning relevant data about the participants, sampling strategies, research paradigm/designs, measures/protocol, and outcomes/findings of studies. Next, each researcher read the articles over again and highlighted quality indicators that stood out, particularly those that were significant to the sampling strategies, research designs, and measures/protocol. In this step, we also added labels and structural descriptions to the highlighted quality indicators for further discussion. Finally, we again read each article carefully and independently to generate thematic statements or phrases. By way of reading each article repetitively, more thoughtful and richer descriptions of the thematic categories were identified. The authors then reviewed the thematic categories that allowed them to unpack (that is, explain and elaborate) the major themes. Afterward, an expert in conducting qualitative research and using thematic and content analysis procedures was invited to review the thematic categories and themes, and to confirm the accuracy of the authors' interpretations.

RESULTS

Included in this literature review were 35 peer-reviewed journal articles (Table 1), which were identified through the aforementioned search methods and met all of the inclusion criteria. Quality indicators of the studies (e.g., instrumentation validity and reliability and trustworthiness criteria, as applicable) are summarized in Table 2. The 35 articles included in the analysis covered a range of foci and approaches regarding children with autism spectrum disorders and physical activities. Overall, there were five major thematic areas of focus. These were studies focused on: (a) comparisons of PA levels between children with ASD and their typically functioning peers, (b) physical activities patterns of children with ASD, (c) barriers that impede participation of children with ASD in PA, (d) the benefits of participating in PA and exercise for children with ASD, and (e) strategies for engaging children with ASD in PA in such settings as physical education classes.

Comparison of PA levels

This literature review yielded studies focused on comparisons of PA levels between children with ASD and their typically functioning peers. Bandini et al. (2013) compared PA levels between children with ASD and their typically functioning peers. To which they hypothesized that children who were less physically active would have higher body mass index (BMI) scores than physically active children. The participants were children with ASD (n = 53) and their typically functioning peers (n = 58). The children with ASD and their typically functioning peers were recruited for this study to compare their PA levels. Bandini et al. (2013) examined daily PA including weekends moderate to vigorous physical activity (MVPA) levels of participants. In addition, they asked parents to complete a questionnaire which was designed for the study and provided to the parents to ascertain the types of physical activities their children were engaged. They also reported that children with ASD were less physically active than their typically functioning peers both during and after school. Based on the parents' responses, children with ASD spent less time in physical activities compared to their typically functioning peers.

Research studies also indicate that children with ASD have lower levels of social engagement and commonly demonstrate less motor skill efficiency compared to their typically functioning peers. For example, Pans (2008a) compared PA levels between students with ASD and their typically functioning peers. In addition, they examined the differences between PA levels when students with ASD were engaged in physical education classes versus recess settings. They also sought to identify factors that might compel children to participate in physical education classes and recess among students with and without disabilities. The participants were children with ASD (n = 24) and their typically functioning peers (n = 24). Students were asked to wear accelerometers to measure their PA levels. During 38 PA lessons, participants were observed and monitored. They reported that both students with and without disabilities were more active in physical education class than they

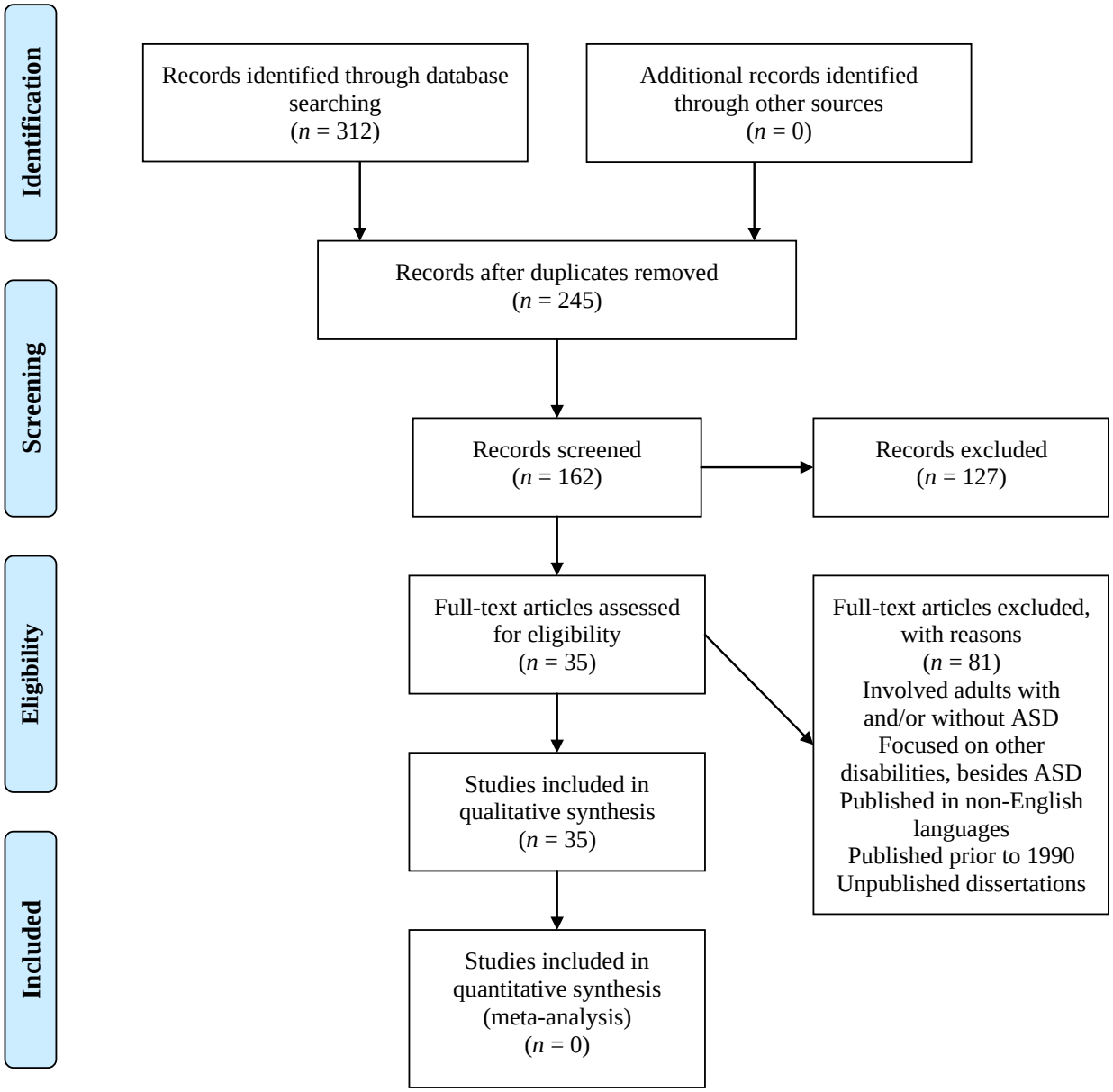

Figure 1. Inclusion and exclusion flow diagram.

were in recess. The levels of MVPA were similar between students with and without disabilities when they were in physical education classes. They also found that students with ASD tended to be more active in physical education (e.g., structured) than they were in recess (e.g., unstructured) settings. Pan (2008b) extended her previous work in the study of PA levels between students with ASD and their typically functioning peers in inclusive recess settings. The participants were students with ASD (n = 24) and their typically functioning peers (n = 24).

All participants with and without disabilities were monitored and asked to wear accelerometers for five consecutive school days to measure their PA levels during inclusive recess time. Noticeably, Pan (2008b) compared PA levels between students with ASD and their peers without disabilities in inclusive recess (e.g., non-structural) settings. The findings further confirmed that students with ASD tend to be much less physically active compared to their typically functioning peers in inclusive recess settings.

Pan (2009) examined the links between age, social engagement, and PA in children with ASD in both structured (e.g., physical education) and unstructured (e.g., recess) play contexts. Pan "hypothesized that age

Table 1. Summary of participants, measures/protocol, and outcomes of studies reviewed.

Study	Participants (*n*)	Measure/Protocol	Outcomes/Findings
Aksay and Güllü (2014)	Children with ASD (*n* = 33)	*Protocol*: Daily PA using visual stimuli. *Measures*: BPTF, M-ABC Video-taped performances.	Aksay and Güllü concluded "a 50-min daily exercise program with a delimited exercise field and display of cartoons can positively affect the physical performance and motor skills of children with ASD" (p. 34).
Ayvazoglu et al. (2015)	Families (*n* = 6) with children with ASD	*Measures*: Accelerometers, parent responses to Q-sort items and interviews, and follow-up interviews.	MVPA in children with high-functioning ASD varied. Parents were inactive. Three main themes exposed: (a) understanding PA in children with ASD, (b) living with a child with ASD, and (c) awareness of ASD at school and community settings.
Bandini et al. (2014)	Children with ASD (*n* = 53); Peers (*n* = 58)	*Measure*: Accelerometer.	Children with ASD were less physically active and spent less time in PA compared to typically functioning peers.
Beamer and Yun (2014)	GPE teachers (*n* = 142)	*Measures*: On-line rating scale (inclusion) ASD and the PESEISD-A instrument.	Results indicated that GPE teachers' experience, graduate APE coursework, and perceived quality of UG training in APE significantly predicted their self-reported behavior for including students with ASD.
Breslin and Rudisill (2011)	Children with ASD (*n* = 22)	*Protocol*: Performed the TGMD-2 under 3 protocols: (a) traditional, (b) picture task card, and (c) picture activity schedule.	GMQ scores measured and analyzed using a within-subjects repeated-measures ANOVA. Results indicated statistically significant differences between protocols, while post hoc tests indicated that the picture task card condition produced significantly higher GMQ scores than the traditional protocol and the picture activity schedule. (p. 342)
Breslin and Rudisill (2013)	Children with ASD (*n* = 22)	*Protocol*: Performed the TGMD-2 under 3 protocols: (a) traditional, (b) picture task card, and (c) picture activity schedule. *Measures*: BEST software	Breslin and Rudisill reported statistically significant differences emerged from across the duration of assessment time by assessment protocol, but no significant differences emerged for time on-task during the assessments by protocol used. (p. 338)
Duronjić and Válková (2010)	Children with ASD (*n* = 5)	*Protocol*: Exercise program; *Measures*: M-ABC, Direct observation.	Eight-week exercise program highly effective in increasing gross motor skills of students with ASD.
Hawkins et al. (2014)	Children with ASD (*n* = 2)	*Measures*: BOT-2, CARS	Equine-assisted therapy highly impacted children with ASD on increasing overall gross motor skills.
Healy et al. (2013)	Children with ASD (*n* = 12)	*Measure*: Interviews	Individual challenges were reported, such as, difficulty task, lack of supports from teachers, and peers.

Table 1. Cont'd.

Levinson and Reid (1993)	Children with ASD (*n* = 3)	*Measure*: Observation using interval-sampling protocol.	Exercise decreased stereotypic behaviors. Vigorous PA higher impact students with ASD than moderate PA.
Liu (2013)	Children with ASD (*n* = 32)	*Measures*: SSP | M-ABC-2	Direct relationship was found between sensory systems and gross motor skills among students with ASD.
Liu and Breslin (2013)	Children with ASD (*n* = 25)	*Protocol*: Performed M-ABC–2 under 2 protocols: (a) traditional and (b) picture activity schedule	Children with ASD received higher scores on M-ABC-2 when they performed with picture activity schedules.
Magnusson et al. (2012)	Children with ASD (*n* = 6)	*Measures*: Observations, questionnaires, interviews	Intensive exercise programs impacted children with ASD on increasing fitness levels and inappropriate behaviors.
Mechling and Swindle (2013)	Children with MOID (*n* = 3); Children with ASD (*n* = 3)	*Protocol*: Video modeling	Students with MOID performed better than students with ASD in PA. Importance of using video modeling in PA.
Memari et al. (2012)	Children with ASD (*n* = 80)	*Measures*: Accelerometer, exercise logs	Girls with ASD were less physically active than boys with ASD. They were more active in school than after school.
Memari et al. (2015)	Children with ASD (*n* = 83)	*Measures*: ATEC, GLTEQ, Daily activity logbook	Only 12% of the children were physically active. They mostly engaged in solitary play over social play. Low rates of PA participation were linked to sociodemographic variables.
Must et al. (2015)	Parents of children with ASD (*n* = 53) and parents of peers (*n* = 58)	*Measures*: Parent-completed questionnaires to assess each child's: (a) barriers to PA participation, (b) screen time, and (c) participation in organized and unstructured physical activities.	Parents of children with ASD reported significantly more barriers than parents of children without disabilities. The parents of children with ASD were also "more likely to report that adults lack skills needed to include their child (58%), that their child has few friends (45%), and that other children exclude their child (23%)" (p. 529). Must et al. also found that the "number of parent-reported barriers to PA was inversely correlated with the hours spent in PA per year…and positively related to total screen time…" (p. 529).
Obrusnikova and Cavalier (2011)	Children with ASD (*n* = 14)	*Measures*: Accelerometers, Photovoice methodology: (a) digital photography, (b) an online SRS questionnaire, and (c) a semi-structured interview.	These students were not physically active after school. There are many factors that impede and/or facilitate students' participation in PA after school.
Obrusnikova and Dillon (2011)	GPE teachers (*n* = 43)	*Measures*: Interview, Background and elicitation questionnaires.	Many challenges were reported among GPE teachers to include students with ASD, such as students' autistic behaviors and lack of supports.

Table 1. Cont'd.

Obrusnikova and Miccinello (2012)	Parents with ASD (*n* = 103)	*Measures*: Focused-group interview, Online questionnaires	Parental perspectives of children with ASD were still limited toward participation in PA.
Pan (2008a)	Children with ASD (*n* = 24); Peers (*n* = 24)	*Measures*: Accelerometer, Direct observation	Students with ASD were more active in PE (structured) than in recess (unstructured).
Pan (2008b)	Children with ASD (*n* = 24); Peers (*n* = 24)	*Measures*: Accelerometer, Direct observation	Students with ASD were less active compared to their typically developing peers in inclusive recess settings.
Pan (2009)	Children with ASD (*n* = 25)	*Measures*: Accelerometer, Engagement Check (an observational tool that uses momentary time sampling to assess social interactions).	Younger groups of students with ASD were more active than older students with ASD. Children with frequent social engagement with adults displayed higher levels of PA. No evidence was found to support the notion that children with ASD become more inactive and more isolate as they age. (p. 22)
Pan (2010)	Children with ASD (*n* =16)	*Intervention*: WESP; *Measures*: HAAR, SSBS–2	The water exercise swimming program (WESP) improved the aquatic and social skills of children with ASD.
Pan (2011)	Children with ASD (*n* = 15); Peers (*n* = 15)	*Protocol*: Aquatic program | *Measure(s)*: ACER test, TMEPFT, BIA, HAAR	The results provide empirical evidence that a 14-week aquatic program can promote motor skills and physical fitness components for children with ASD and their siblings.
Pan and Frey (2005)	Parents (*n* = 48); Children with ASD (*n* = 30)	*Measure(s)*: Accelerometer, CAALog, SPAS	Diverse factors contributed to PA levels of children with ASD, such as age and sedentary life styles.
Pan and Frey (2006)	Children with ASD (*n* = 30)	*Measure(s)*: Accelerometer, direct observation, CAALog	Elementary students with ASD were more active than students with ASD in middle and high school.
Pan et al. (2011a)	Children with ASD (*n* = 23); Peers (*n* = 75)	*Measure(s)*: Accelerometer, MPES	Adolescents with ASD were less physically active compared to their typically functioning peers.
Pan et al. (2011b)	Children with ASD (*n* =19); Peers (*n* = 76)	*Measure(s)*: Accelerometer, Direct observation	Diverse factors that might influence PA levels of adolescents with ASD in PE classes, such as relationships with peers and instructors, teaching environments, teacher's gender, and types of PE activities.

Table 1. Cont'd.

Pan et al. (2011c)	Boys with ASD (*n* = 35)	*Measures*: Accelerometer	Boys in the lower grades were more active both on weekdays and weekends compared to middle and upper grades; whereas, boys in upper grades had higher PA levels on weekdays than on weekends. Those in lower and middle grades demonstrated higher PA levels on weekends compared to weekdays.
Reid et al. (1991)	Children with ASD (*n* =19); Peers (*n* = 76)	*Measure(s)*: Accelerometer, Direct observation	Diverse factors influence PA levels of adolescents with ASD in PE classes (e.g., relationships with peers and instructors, the environment, teacher's gender, and types of PE activities).
Schenkelberg et al. (2015)	Six boys with ASD and six peers	*Measures*: Digital scale and stadiometer (weight and height measures); OSRAC-P scale used to assess PA and provide contextual information.	In free play, boys with ASD spent significantly less time in MVPA while with a peer, compared with a peer group or alone. They engaged in significantly more light-MVPA while in a solitary social context compared with alone with an adult or a peer, or with a peer group. No differences were indicated during organized activity. (p. 636)
Todd and Reid (2007)	Children with ASD (*n* = 3)	*Protocol*: Snowshoeing, walking, and jogging *Measures*: Self-monitoring board, direct observation	Students increased PA levels after the interventions.
Ward and Ayvazo (2006)	Children with ASD (*n* = 2); Peers (*n* = 2)	*Protocol*: Class wide peer tutoring | *Measure*: Direct observations	The importance of utilizing peer tutors for students with ASD in inclusive PE settings was affirmed.
Yanardag et al. (2015)	Boys with ASD (*n* = 3)	*Measures*: Digital camera, data collection forms, and a writing pad and pencil were used to collect data.	MLP was effective in teaching advance movement exploration skills in water, which were continued in maintenance and generalization probes. In addition, social validity results showed parents held positive opinions about their children's learning and participation in aquatic settings.

APE: Adapted physical education; ASD: autism spectrum disorder; Children = CA; GPE: general physical education; GMQ: gross motor quotient; MVPA: moderate to vigorous physical activity; PA: physical activity; Peers: participants without ASD; UG: Undergraduate. ATEC: Autism Treatment Evaluation Checklist; BEST: Behavior Evaluation Strategy and Taxonomy Software; BIA: Bioelectrical impedance analysis; BPTF: Brockport Physical Fitness Test; BOT-2: Bruininks-Oseretsky Test of Motor Proficiency, Second Edition; CAALog: Child and Adolescent Activity Log; CARS: Childhood Autism Rating Scale; GLTEQ: Godin-Shephard Leisure Time Questionnaire; HAAR: Humphries Assessment of Aquatic Readiness (Humphries, 2008); MPES: Motivation in Physical Education Scale; M-ABC: Movement Assessment Battery for Children; MLP: Most to Least Prompting; OSRAC-P: Observational System for Recording Activity of Children-Preschool Version; PACER: Progressive Aerobic Cardiovascular Endurance Run (PACER) multi-stage shuttle run; PESEISD-A: Physical Educators' Self-Efficacy Toward Including Students with Disabilities-Autism scale (Taliaferro, Block, Harris, and Krause, 2011); SSBS–2: School Social Behavior Scales (Merrell, 2002); SPAS: Social Support Toward Physical Activity Scale; SRS: Social Responsiveness Scale; TGMD-2: Test of Gross Motor Development-2; TMEPFT: Taiwan Ministry of Education Physical Fitness Test; WESP: Water exercise swimming program.

Table 2. Sampling strategies, research paradigm/designs, and quality indicators of the studies reviewed.

Study	Sampling	Paradigm/Design	Quality indicators
Aksay and Güllü (2014)	The sampling design was NI; however, it appears convenience sampling was used. Aksay and Güllü explained the participants were "chosen from 79 autistic children participating in the Rehabilitation Sports PA Program" (p. 36).	Quantitative | Pretest-Posttest Control Group Design.	Trained volunteers implemented the 20-week exercise program prepared by the researcher under the researcher's supervision. Social validity was indicated based on interviews family members and teachers of the participants.
Ayvazoglu et al. (2015)	Criterion-sampling approach	Mixed-method design	Content validity was established for the Q-sort items. The researchers used: (a) triangulation of methods -data from RT3 accelerometers and data from interviews of parent/caregiver and (b) triangulation of multiple analysts to establish trustworthiness and credibility. Member checks were also conducted.
Bandini et al. (2014)	The sampling design was NI; however, it appears convenience sampling was used. Bandini et al. explained the participants were recruited via outreach to local schools and community recreation programs, existing participant databases at a local medical school, ASO, and more.	The paradigm and design were NI; but, it appears Bandini et al. used a descriptive correlational design positioned in the quantitative paradigm.	Children's accelerometry-based PA measures on weekdays and weekends; and parent-completed survey, indicated the children's PA (that is, number of activities and hours of activities) behaviors. Bandini et al. (2014) explained the questionnaire used has not been tested for validity evidence with children, but they confirmed its reliability.
Beamer and Yun (2014)	Stratified national random sample.	Quantitative | On-line survey	According to Beamer and Yun, previous authors presented evidence for validity and reliability in the development of the PESEISD-A instrument. In the current study, Cronbach's alpha coefficient was 0.92.
Breslin and Rudisill (2011)	The sampling design was NI; yet, it appears convenience sampling was used to select children who were enrolled in a summer program designed for children with ASD.	The paradigm and design were NI; however, it was an experimental design (Latin Square or counterbalance) study| Quantitative paradigm.	The lead researcher and a research assistant…were trained to evaluate the criteria of test performance as mandated in the *TGMD-2 Examiner's Manual*. In all, aggregate interrater reliability for TGMD-2 criterion coding was calculated at 95.74%.
Breslin and Rudisill (2013)	The sampling design was NI; yet, it appears they used convenience sampling to select children who were enrolled in a summer program designed for children with ASD.	The paradigm and design were NI; but, it was an experimental design (Latin Square or counterbalance) situated in the quantitative paradigm.	Data coders were trained to code participant behavior (duration of time, percentage of time on-task, and motor performance) using the BEST software. IOA between the PI and the RA was 95.8% (p. 343)

Table 2. Cont'd.

Duronjić and Válková (2010)	The sampling design was not identified; it appears convenience sampling was used to select children who were enrolled in a special public kindergarten.	The paradigm and design were NI; but, it appears Duronjić and Válková used a mixed-method design.	M-ABC is a valid and reliable motor test. The intervention was comprised of 18 exercise sessions in total (each exercise session lasting for 60-minutes).
Hawkins et al. (2014)	The sampling design was NI; it appears they used convenience sampling. Hawkins et al. explained flyers were distributed within the local community to recruit children ages 4 to 14 diagnosed with ASD.	ABA paradigm using a multiple-baseline, single-subject treatment design.	All performance measures on the BOT-2 were recorded by two observers for every session across all phases of the study. IOA was higher than 98% for all sessions across all phases of the study (p. 141)
Healy et al. (2013)	Purposive sampling was used to recruit children who were enrolled in a summer camp for children with ASD.	The paradigm and design were NI; but, it seems they used an interviewing design situated in the qualitative paradigm.	They stated that researchers who had worked with individuals with ASD before were contacted for advice about creating an interview guide. Bracketing was used "to document the researcher's perceptions, attitudes and views with the intent of moving those to the periphery so that participants' views could be central to the analysis" (p. 223).
Levinson and Reid (1993)	The sampling design was NI; it appears convenience sampling was used. The participants were children who were enrolled in a special education school designed for the students with autism.	The paradigm and design were NI; but, it appears they used a single-subject multiple-treatment design in the ABA paradigm.	Percent agreement (M = 85%) was calculated separately for each session: baseline, intervention phases, and return to baseline. For the classification of observed stereotypic behavior into motor, vocal/oral, and other, IOA was 75% (p. 261)
Liu (2013)	The sampling design was NI; it appears Liu used convenience sampling. Liu stated the children were recruited through advertisements and personal contacts from local schools and organizations.	The paradigm and design were NI; but, it appears they used a descriptive correlational design positioned in the quantitative paradigm.	A trained RA administered and evaluated the children's performance on both the SSP and MABC-2. The PI and a RA evaluated the children's sensory profiles and motor-skill performances. Percentage of IOA between the PI and the RA was high at 98%.
Liu and Breslin (2013)	The sampling design was NI; it appears the researchers used convenience sampling. They used the same recruitment strategies as described in the Liu (2013) study.	Evidently, an experimental design (quantitative) was used. In that the "order of protocols was counterbalanced and randomly assigned to each child…" (p. 208).	The MABC-2 is "a valid and reliable standardized motor assessment that has been reported in the literature" (Liu and Breslin, 2013, p. 207) for use with children with ASD. Percentage of IOA between the PI and the RA was high at 96%.

Table 2. Cont'd.

Magnusson et al. (2012)	The sampling design was NI; it appears the sampling was convenience. The participants were recruited "through schools, a specialized hospital youth unit, an autism community group, and the University's Exercise Rehabilitation Clinic" (p. 73).	The paradigm and design were NI; but, it appears Magnusson and colleagues used a Pretest-Posttest Group quasi-experimental design situated in the quantitative paradigm.	They explained "the exercise programs… were designed by an Ex-Rehab Specialist familiar with ASD and individualized to each subject" (p. 77). Further, they asserted the study "used stringent measures to assess the physical changes from pre- to post-intervention thereby providing a guideline for how to optimize the benefits of an exercise program for ASD individuals" (p. 77).
Mechling and Swindle (2013)	The sampling design was NI; however, it appears convenience sampling was used. Mechling and Swindle explained that the students were enrolled in the same public school classroom.	ABA paradigm | A Multiple Probe Design across three sets of tasks (3 fine motor tasks and 3 gross motor tasks per set).	On average, IOA across all conditions and participants was 99% for Group 1 and 100% for Group 2. Procedural fidelity was estimated as well. Social validity was assessed with a 5-item survey administered to the students' teachers.
Memari et al. (2012)	Memari et al. explained they "visited all schools and used the probability proportional to size selection for sampling" (p. 152) to recruit children with ASD who attended special schools.	The paradigm and design were NI; but, it appears they used a descriptive correlational design positioned in the quantitative paradigm.	The Actigraph accelerometer is considered a reliable and valid tool for the assessment of different types of physical activities with children, including those with ASD.
Memari et al. (2015)	Sampling design was NI; it appears convenience sampling was used. Memari et al. stated the participants were "recruited from four autism specific schools" (p. 2).	Cross-sectional survey design positioned in the quantitative paradigm.	They reported validity and reliability scores for the instruments.
Must et al. (2015)	The sampling design was NI; however, it appears convenience sampling was used. Must et al. explained the participants were recruited via outreach to local schools and community programs, on-line postings, participant databases at a local medical school, ASO, and more.	The paradigm and design were NI; but, it appears this was a descriptive correlational study using a survey design positioned in the quantitative paradigm.	They asserted the study had many strengths. "We confirmed the ASD diagnosis through neurodevelopmental testing and our protocol included a comprehensive assessment of barriers across several domains" (p. 533). Further, they established reliability of the questionnaire for parent-reported measures of PA and screen time.
Obrusnikova and Cavalier (2011)	Convenience sample	Photovoice methodology was used. It is a community and participatory action research tool (mixed methods).	The researchers "communicated with the parents throughout the study to increase validity of the findings" (p. 199). They used: (a) triangulation of methods -data from accelerometers and data from interviews, and (b) triangulation of multiple analysts to establish trustworthiness and credibility.

Table 2. Cont'd.

Obrusnikova and Dillon (2011)	Convenience sample	Evidently, the researchers used survey method.	Both questionnaires were content validated. Further, CVI was calculated for each content validity rating.
Obrusnikova and Miccinello (2012)	Convenience sample	The paradigm and design were NI; but, it appears they used a mixed-method design.	Content validity was established by a panel of judges. Further to "offset potential interviewer bias and support the credibility of the interview data, peer review, debriefing, and member checking were used" (p. 69). Lastly, IOA for both the questionnaire and interview coding-yielded high reliability scores of 0.93 and 0.97, respectively.
Pan (2008a)	Convenience sample	Though Pan stated "the study [was] cross-sectional in design" (p. 1299), the paradigm and design were NI. It appears a correlational design (quantitative paradigm) was used.	He asserted a main strength of the study was "the assessment of PA using an objective measure because the accelerometer has been found to be a highly reliable and valid measure of PA in children" (p. 1299).
Pan (2008b)	Convenience sample	The paradigm and design were NI. It appears Pan used a descriptive correlational design positioned in the quantitative paradigm.	The Actigraph accelerometer is considered a reliable and valid tool for the assessment of different types of physical activities with children, including those with ASD.
Pan (2009)	Convenience sample	The paradigm and design were NI. It appears Pan used a descriptive correlational design positioned in the quantitative paradigm.	Each observer was trained in using the Engagement Check and suitable reliability and validity estimates have been reported previously on the instrument. Pan explained the "observers reached an overall agreement of at least 85% agreement for these data" (p. 26). Further, the accelerometer is a reliable and valid tool for assessing PA.
Pan (2010)	Sampling design was NI, but it appears convenience sampling was used. Pan explained the participants were attending "inclusive schools and were assigned to the resource room on a regularly scheduled basis to receive special education services while continuing their other studies…" (p. 12).	Experimental study (quantitative paradigm). Evidently, a Pretest-Posttest Control Group design was used. Pan stated the study used "a controlled, single-blind design" and stated further a "within-participant repeated-measures research design was adopted" (p. 12).	Results showed a high level of IOA (all >90%) between the PI and two RA in scoring using the HAAR checklist. The SSBS–2 is considered a highly reliable and valid instrument.
Pan (2011)	The sampling design was NI; but, it appears convenience sampling was used. Pan explained families were recruited using several strategies, including an ARC, local ASO, and media (direct contact, e-mail, autism listserves).	This study adopted a within-participant repeated-measures design with an experimental group and a control group.	Reliability was examined using IOA by two trained graduate students and the researcher, and the percentages of IOA were all above 0.90.

Table 2. Cont'd

Pan and Frey (2005)	The sampling design was NI; but, it appears convenience sampling was used. Pan and Frey noted all participants were recruited within a 200-mile radius of the research site.	The paradigm and design were NI; however, it appears a descriptive correlational design was used (quantitative paradigm).	CAALog exhibits moderate criterion validity and test-retest reliability. Pan and Frey also asserted the MTI accelerometer is considered a valid and reliable measure of PA in both youth and adults (p. 415).
Pan and Frey (2006)	The sampling design was NI; but, it appears convenience sampling was used. Pan and Frey noted all participants were recruited within a 130-mile radius of the research site, using various strategies (e.g., a university-based PA program).	The paradigm and design were NI; however, it appears a descriptive correlational design positioned in the quantitative paradigm was used.	CAALog is considered valid and reliable measure of daily PA. Likewise, the MTI accelerometer is a valid and reliable measure of PA in both youth and adults.
Pan et al. (2011a)	The participants were recruited from "mainstream classes at 15 regular schools in a large urban city in Taiwan, and volunteered to participate…" (p. 734). It appears convenience sampling was used.	Evidently, a correlational design (quantitative paradigm) was used.	The Cronbach's alpha coefficients for each subscale in the MPES ranged from 0.61 to 0.97, and the overall reliability score for the MPES instrument was .72, indicating that the measures had acceptable internal consistency in this population of middle school students (p. 735). Moreover, the accelerometer is a valid and reliable measure of PA in youth with ASD.
Pan et al. (2011b)	The sampling design was NI; yet, it appears a convenience sample was used. Pan and colleagues stated that boys with ASD and their typically developing peers from junior HS volunteered to participate. (p. 492)	The paradigm and design were NI; it appears they used a descriptive correlational design positioned in the quantitative paradigm.	The observers were trained to use systematic observation methods and the social engagement coding instrument. A periodic check of IOA was conducted throughout the data collection, and continuous training was provided to all observers during the study to maintain the 85% agreement rate (p. 493)
Pan et al. (2011c)	Convenience sample of boys with ASD from 23 primary schools volunteered to participate.	The paradigm and design were NI; however, it appears they used a descriptive correlational design (quantitative paradigm).	The accelerometer has been used extensively and reported as a valid objective measure of PA in youths.
Reid et al. (1991)	The sampling design was NI; it appears however the researchers used convenience sampling. They explained the participants were students who attended a special school for with multiple disabilities.	The paradigm and design were NI; but, it appears the researchers used a single-subject multiple-treatment design in the ABA paradigm.	On average, IOA between the three coders was 70% of the time across all trials.

Table 2. Cont'd.

Schenkelberg et al. (2015)	The sampling design was NI, but it appears a convenience sample was used. Schenkelberg et al. explained that children who were attending an inclusion-based summer camp were sampled.	Quantitative paradigm | Exploratory pilot study positioned in a factorial cross-sectional design.	They asserted quality indicators were: (a) they used a valid observational measure to explore the influence of the social environment on PA levels of children; (b) participants were matched on age and diagnosis, ensuring that children with and without ASD were observed simultaneously in the same setting; (c) the mixed model used in the analyses accounted for random effects including the observer, matched pair, session, and child; and (d) the RA were required to complete thorough training sessions before the study which resulted in high IOA across all variables (p. 641)
Todd and Reid (2006)	The sampling design was NI, but it appears a convenience sample was used. Todd and Reid stated the participants were recruited from a school designed for individuals with severe disabilities.	ABA paradigm using a changing conditions design.	They calculated IOA for classifying statements. This was done by having a second rater listen to 38% of the audio recordings. Reliability was 97% for verbal encouragement and 93% for verbal directives (p. 171)
Ward and Ayvazo (2006)	The sampling design was NI, but it appears a convenience sample was used. Ward and Ayvazo explained the study was conducted in a K-8 charter school…, specializing in inclusion placements for children with autism.	An A-B-A-C single-subject withdrawal design was used (ABA paradigm).	They employed various quality indicators: (a) the observers received training on coding the participants' behaviors and were required to meet a criterion level of 95% accuracy or better; (b) 50% of the intervention sessions were assessed for treatment integrity; (c) IOA was assessed on a randomly chosen sample of 37% of the observations. IOA was calculated and the mean was 92% for Holly, 95% for Ben, 93% for Sarah, and 99% for Peter (pp. 236-237)
Yanardag et al. (2015)	The sampling design was NI, but it appears a convenience sample was used.	A multiple probe design was used (ABA paradigm).	IOA data indicated that both researchers agreed 100% on all participants' performances during selected probe and training sessions.

ARC: Autism resource center; ASD: autism spectrum disorder; ASO: autism support organizations; Ex-Rehab: exercise rehabilitation; GPE: general physical education; HS: high schools; IAN: interactive autism network; NI: not identified; PA: physical activity; Peers: participants without ASD; PI: principal investigator. ABA: Applied behavior analysis; CAALog: child and adolescent activity log; CVI: content validity index; IOA: inter-observer agreement, inter-coder or interrater agreement; RA: research assistant; WESP: water exercise swimming program.

would show a significant influence on both PA and social engagement participation in both free play and organized settings in children with ASD" (p. 24). Moreover, she hypothesized that "more frequent social engagement behaviors would be observed in higher PA levels of children with ASD" (p. 24). It was expected that children with ASD who were socially active would show higher participation levels in physical education classes and recess than those children with ASD who were not socially active. The participants were children with ASD (n = 25) who were 7 to 12 years old. The children were asked to wear accelerometers to measure their levels of PA. The children were also observed to perceive the relationship between the levels of social involvement and PA during physical education classes and recess. They also reported the study's findings do not support the notion that age is an important variable in determining PA levels of children with ASD even though younger aged groups of children with ASD were more active than older aged groups of children with ASD. In addition, the findings did not indicate a significant relationship between the level of social engagement and PA among participants with ASD.

PA patterns of children with ASD

Several research studies were focused on determining potential factors that might contribute to physical activities levels of children with ASD. Pan and Frey (2005) analyzed the influence of parents' PA behaviors and supports, and sedentary pursuits on PA of youth with ASD. The authors hypothesized that there were various factors that might determine whether children with ASD become physically active. The participants were children with ASD (n = 30) and their parents (n = 48). Both parents and their children with ASD wore accelerometers for seven consecutive days to measure PA levels. In addition, parents were asked to complete the Social Support Toward Physical Activity Scale to identify possible factors that affect PA levels of children with ASD. The results showed that age and sedentary life styles, such as spending time watching TV and playing games, were significant factors in determining PA levels of children with ASD. In short, older children with ASD and those who were frequently engaged in sedentary activities were less likely to be physically active. Somewhat surprising, if not disappointing, Pan and Frey (2005) found that parents' involvement in physical activities and encouragement were not associated with PA levels of children with ASD.

Later, Pan and Frey (2006) examined age-related PA patterns in youth with ASD across different age groups. The participants were children with ASD (n = 30) and they were divided into three different age groups: elementary, middle, and high school. They were asked to wear accelerometers to measure their PA levels for seven consecutive days. Participants were also asked to respond to a 21-item survey questionnaire about PA. They reported that elementary-aged children with ASD were more active than students with ASD in middle and high school. Specific reasons to that result were not detected. Furthermore, the authors emphasized that students with ASD in every group did not meet the commonly accepted daily recommendations of PA. Conclusively, they affirmed the importance of promoting PA participation for older age groups of students with ASD.

Pan et al. (2011c) explained that the aim of their study was to "examine differences in patterns of objectively measured PA among weekdays and weekend days and among different time periods within a weekday and how these patterns are influenced by age in a sample of Taiwanese elementary school-aged children with ASD" (p. 1043). They expounded that "the relative importance of each time period to total daily MVPA accumulation during weekdays as well as the percentage of children meeting PA guidelines was also evaluated" (p. 1043). They hypothesized that older children with ASD would be less active than younger children both between days and within days. The participants were school-aged children with ASD (n = 35). These children were divided into lower (1-2), middle (3-4), and upper (5-6) elementary grades. PA levels were measured by Manufacturing Technology Inc. (MTI) accelerometers. Each participant was asked to wear an accelerometer for four weekdays and a weekend day. In addition to recess (typically 10 to 20 minutes) and lunch breaks (approximately 40 minutes) at school during the weekdays, the students had 40-minutes for physical education once or twice each week. The results of the study indicated that children with ASD in the lower grades were the most active both during weekdays and on weekends compared to those in middle and upper level grades. Additionally, children in the upper grade level had higher PA levels on weekdays compared to weekends. In contrast, children in both the lower and middle grades demonstrated higher PA levels on weekends compared to weekdays.

Schenkelberg et al. (2015) analyzed "setting (free play versus organized) and social group composition influences on PA of children with ASD during summer camp" (p. 636). They hypothesized that children with ASD would have lower MVPA than typically developing children in both settings. Moreover, boys with ASD and their peers would have greater LMVPA and MVPA when they are placed in free play settings compared to organized settings. The participants were six boys with ASD and six typically developing boys. The Observational System for Recording Activity of Children-Preschool Version (OSRAC-P) was used to examine PA and contextual information when the boys were engaged in PA settings. The results indicated that the levels of MVPA were not significantly different between boys with ASD and their peers. In addition, children with ASD were

not significantly more active when they were placed in free play settings compared to organized settings. While engaging in free play, children with ASD showed higher PA levels then they were with other social context and with a peers.

Continuing this line of research, Pan et al. (2011a) compared PA levels between adolescents with ASD and their typically functioning peers. The participants were adolescents with ASD (*n* = 23) and their typically functioning peers (*n* = 75). Children with and without disabilities were measured using ActiGraph accelerometers to inform their levels of PA. The Motivation in Physical Education Scale (MPES) was used to determine factors that might affect children motivation in physical education. The results showed that adolescents with ASD were less physically active compared to their typically functioning peers and they lacked self-motivation for participating in PA.

More recently, Memari et al. (2012) analyzed specific PA patterns among children with ASD. The participants were children with ASD (*n* = 80). These children wore accelerometers to measure their levels of PA and filled out daily exercise logs to identify patterns of PA. In addition, families were interviewed to investigate the reasons that might contribute to PA among children with ASD. Memari et al. (2012) found the girls with ASD were less physically active than the boys with ASD. These children were more likely to be active in school than they were after school. In addition, such factors as parents' and siblings' involvement in PA versus sedentary life styles were critical determinants in whether the children were active or not after school.

Liu (2013) assessed whether children with ASD would demonstrate sensory and motor delays compared to typically functioning children and analyzed the relationship between sensory processing and motor performance. He hypothesized that if children with ASD had dysfunctional sensory systems, they were likely to also exhibit delays in gross motor development. The participants were thirty-two children with ASD. The Short Sensory Profile (SSP) scale was used to examine the function of sensory systems of children with ASD. In addition, the Movement ABC-2 (MABC-2) instrument was used to examine gross motor skills. Results showed that if children with ASD have delayed or dysfunctional sensory systems[ii] they were more likely to also exhibit delays in gross motor skills. Consequently, the research hypothesis was confirmed that there exists a correlation between sensory systems and gross motor skills among children with ASD. Liu (2013) also confirmed that children with ASD tended to exhibit delays in both sensory and motor skills compared to their typically functioning peers.

Barriers that impede children's participation in PA

According to results in several studies, children with ASD are faced with multiple challenges that might interfere with them becoming involved in physical activities. Obrusnikova and Cavalier (2011) articulated the purpose of their study was "to assess barriers to and facilitators of after-school participation in MVPA as perceived by children with ASD and determine if PA patterns exist in relation to these barriers" (p. 197). They conjectured that "if something is perceived by the individual as a barrier, self-efficacy to perform a behavior in the face of this barrier becomes an important predictor of future behavior" (p. 197). The participants were children with ASD (*n* = 14). They were asked to wear accelerometers to measure their PA levels and participated in online questionnaires. In addition, parents participated in this study to share experiences with their children with ASD in PA by filling out exercise logs. Obrusnikova and Cavalier (2011) confirmed that most children with ASD were not physically active after school. There were various factors that impeded or facilitated children's participation. Interpersonal factors such as involvement of parents and siblings in PA and the relationship with peers without disabilities can be critical factors that impede and/or facilitate children's active participation after school. Lack of community facilities can also be associated with children's lower levels of participation in PA.

Ayvazoglu et al. (2015) examined how families of children with high functioning ASD perceive determinants and challenges to provide PA opportunities for their children with high functioning ASD. The participants were families of children with high functioning ASD (*n* = 6). Both quantitative and qualitative methodologies were used in the conduct of this inquiry. Children with high functioning ASD and their family members including siblings, parents, and caregivers were asked to wear RT3 accelerometers to measure MVPA levels. Further Q-sort methodology[iii] and semi-structured interviews were used to investigate, for example, each family's perspectives, focusing on findings determinants and challenges that impact on PA levels of children with high functioning ASD. Q-sorting was used to identify patterns of family's experiences about PA participation for their children. Findings revealed that levels of MVPA in children with high-functioning ASD varied between 85- and 405-minutes for seven days. Troubling, the parents of these children were mostly inactive. Their levels of MVPA varied between 6- and 53-minutes. Qualitative data analysis exposed three main themes, which were: (a) understanding PA in children with high-functioning ASD, (b) living with a child with high-functioning ASD, and (c) awareness (lack of) of ASD at school and community settings. In addition, the families reported that determinants such as lack of social skills, peer-related bulling, fear of injury, and issues with transitions adversely impacted PA participation of these children. Some additional challenges reported were limited time, lack of family support, exhaustion, and lack of financial

means that also negatively affect PA levels of children with high functioning ASD.

Memari et al. (2015) examined determinants and PA participation patterns of children with ASD. The participants were children with ASD (*n* = 83). Godin-Shephard Leisure Time Questionnaire (GLTEQ) was used to examine PA involvement. Because the participants were children with ASD, their parents were asked to complete the GLTEQ. Parents were also asked to complete a daily activity logbook to acquire more information about regular PA patterns. The Autism Treatment Evaluation Checklist was used to monitor autism symptoms during this investigation. Overall, only 12% of the children were physically active. They mostly engaged in solitary play over social play. Memari et al. (2015) reported that most participants in the study were hesitant to participate in regular PA by such factors as few positive experiences in contrast to failures experienced, emotional impairment, lack of motivation, fear of injury, and low-self-esteem. Moreover, low rates of PA participation were linked to sociodemographic variables. Specifically, they reported that low income families provided less PA opportunities to their children with ASD compared to high income families. Single parents of children with ASD also reported more barriers to PA participation compared to two parent families. Additionally, older children with ASD engaged in less PA compared to younger children with ASD. Boys with ASD were more likely to participate in PA compared to girls with ASD, although boys with ASD exhibited more stereotypic behaviors during the investigation. Girls with ASD were more likely to engage in solitary activities than boys with ASD.

Must et al. (2015) hypothesized that children with ASD had more family, social, and community barriers compared to children who were typically developing. This study was a part of the larger Children's Activity and Meal Patterns Study (CHAMPS). The participants were children with ASD (*n* = 53) and their peers without disabilities (*n* = 58). The Vineland Adaptive Behavior Scales (2nd edition) was used to characterize adaptive skills. In addition, the children's parents completed a questionnaire to identify family, social, and community barriers to PA participation for their children. The parents were asked to identify types and frequency of physical activities in which their children participate. Moreover, they completed questionnaires to identify the children's levels of screen time including watching TV and playing video/computer games. The parents of children with ASD reported significantly more barriers than parents of children without disabilities. The parents of children with ASD were also "more likely to report that adults lack skills needed to include their child (58%), that their child has few friends (45%), and that other children exclude their child (23%)" (p. 529). Must et al. (2015) also found that the "number of parent-reported barriers to PA was inversely correlated with the hours spent in PA per year and positively related to total screen time…" (p. 529). Family barriers including motor skills, behavior problem, and supervision were reported. Indeed, social barriers such as, lack of social skills, peer support, and lack of adult supports were identified. Meanwhile, lack of opportunities and low financial status were reported as community barriers. In addition, Must et al. (2015) indicated that PA participation was correlated with the level of screen time.

Pan et al. (2011b) study was to discern potential factors that might affect PA levels of adolescents with ASD in physical education classes. The participants were adolescents with ASD (*n* = 19) and their typically functioning peers (*n* = 76). All participants wore accelerometers to measure their PA levels in physical education classes. Moreover, the patterns of social integration of adolescents with ASD were observed during physical education classes.

According to Pan et al. (2011b), adolescents with ASD were obviously less active than their typically functioning peers in physical education classes. Importantly, they found that positive relationships with peers without disabilities and teachers can be significant determinants in increasing students' participation in physical education classes. The types of PA, physical environments, and instructors' attributes were also critical factors that contributed to whether adolescents with ASD were active or not in physical education classes. Critical factors were identified as types of physical activities (e.g., individualized or team activities), teachers' gender, class contexts, and teaching environments (e.g., outdoor or indoor).

Obrusnikova and Dillon (2011) sought to identify challenges experienced by teachers in involving students with ASD in inclusive GPE classes. The central research question guiding the study, as articulated by Obrusnikova and Dillon (2011) was: What are the instructional, managerial, and social challenges that physical education teachers encounter in teaching students with ASD in GPE classes? The 43 participants were teachers licensed to teach GPE in their respective states and/or licensed to teach APE in their respective states or held a national certification in APE. Participants were interviewed and participated in online questionnaires to share their perspectives toward working with students with ASD in inclusive physical education classes. Obrusnikova and Dillon (2011) reported that GPE teachers are faced with multiple challenges to engage students with ASD in physical education class activities because of their autistic behavioral tendencies. Children with ASD tend to socially isolate themselves from their peers without disabilities and refuse to participate in PA. Children with ASD show difficulty in understanding tasks and some GPE teachers consequently do not know how to adequately modify activities for their students who

need special and/or additional attention.

Obrusnikova and Miccinello (2012) analyzed parents' views about factors that influence after school PA participation of children with ASD. The participants were parents who had children with ASD (*n* = 103). Obrusnikova and Miccinello (2011) collected data from parents of children with ASD using an online open-ended questionnaire (e.g., quantitative data) and focus-group interviews (e.g., qualitative data) to determine parents' perceptions about their children in PA. They indicated that most parents in the study realized the importance and the advantages of participating in physical activities for their children.

The parents reported barriers that impede PA participation of their children, such as lack of self-motivation and lack of time. Further, the parents' main concerns for their children were they lacked social skills and communicative skills to be involved in PA. Children with ASD were more likely to engage in sedentary activities, such as playing games on a computer and watching TV compared to being physically activity after school. Lack of community facilities were identified as the considerable factor that impedes children after school participation in PA.

Healy et al. (2013) explored the experiences of students with ASD in physical education. The participants were children with ASD (*n* = 12) who were interviewed individually to share their experiences in physical education. It was challenging for them to participate in physical education classes. They felt this was because their skill levels were lower than their peers without disabilities in class. Further students with ASD were more likely to be excluded from physical activities.

In addition, peer acceptance and support from their physical education teachers were salient factors for students with ASD to increase or decrease participation in physical education. Participants also reported social isolation and bullying when they were in physical education.

Benefits of participating in physical activities and exercise

Importantly, several researchers report that participating in physical activities and exercises enables children with ASD to gain multiple benefits. For example, Levinson and Reid (1993) examined the effectiveness of movements on reducing stereotypic behaviors of children with ASD. The participants were children with ASD (*n* = 3) who participated both in a mild/moderate and a vigorous exercise program to examine the programs' effectiveness. The patterns of stereotypic behaviors with participants with ASD were videotaped to compare the differences between before and after the interventions. Levinson and Reid (2013) classified specific stereotypic behavioral patterns among participants, such as body rocking, biting, running away from tasks, and shaking of body, the observers coded stereotypic behavioral patterns during the interventions. They reported that exercise can have beneficial effects on stereotypic behaviors of student with ASD in terms of reducing inappropriate behaviors and increasing appropriate behaviors. Furthermore, they found that vigorous exercise had more impact on children with ASD than mild to moderate exercises.

Todd and Reid (2006) examined outcomes of participating in PA for children with ASD. The participants were children with ASD (*n* = 3) who participated in exercise programs consisting of snowshoeing and walking and/or jogging. During the interventions, frequency of providing verbal prompts and edible reinforcements were tallied. Children were encouraged to complete each session. The results indicated that children with ASD were able to stay on task for longer period of time after the interventions. Later in the study prompts and reinforcements to promote and reinforce participation were faded. Todd and Reid (2006) reported positive effects in using prompts and reinforcements to increase children's participation in PA. They also emphasized the importance of implementing appropriate exercise programs for children with ASD.

Recently, Hawkins et al. (2014) examined the effectiveness of the equine-assisted therapy for children with ASD on improving their gross motor skills. The participants were children with ASD (*n* = 2) and they were involved in 30 minutes of PA using horseback riding sessions. The Bruininks-Oseretsky Test of Motor Proficiency Second Edition (BOT-2) was used to assess overall gross motor competence of participants before and after the PA intervention. Each session was specifically designed based on each participants' goals and the baseline. Hawkins et al. (2014) found that children with ASD increased gross motor competence after the intervention. They were accordingly assured about positive effects of the equine-assisted therapy on increasing overall gross motor proficiency for children with ASD, which in-turn increases the likelihood of children engaging in leisure and recreational physical activities.

Magnusson et al. (2012) sought to determine whether "an individually-tailored, high-intensity exercise program would have a positive effect on the physical fitness and behaviors of children and adolescents with ASD" (p. 71). They focused on three measurable variables: autistic behaviors, physical fitness, and sleep. The participants (*n* = 6) were children and adolescents with ASD. Questionnaires and interviews were used to investigate the patterns of physical activities, autistic behaviors, and sleeping patterns among participants with ASD. Intensive exercise programs consisting of warm-up, interval training, aerobic exercise, resistance training and warm-

down were provided to participants with ASD for 12 weeks. The study's results indicated intensive exercise programs were highly impactful on children with ASD regarding the variables under the study. In that, the participants experienced increased appropriate behaviors and enhanced physical fitness levels after the intervention. In addition, sleeping patterns were much more stable after the interventions as stated by parents' reports.

Pan (2010) examined the effects of a 10-week water exercise swimming program on aquatic skills and social behaviors in children with ASD. He hypothesized that the water exercise swimming program would favorably impact children with ASD on improving aquatic skills and social behaviors. The participants were children with ASD (*n* = 16). Both aquatic skills and social behaviors were measured before and after the intervention to compare the differences. The School Social Behavior Scale (SSBS-2) was used by classroom teachers to assess social behaviors of the participants. Results indicated that children participating in a water exercise swimming program improved swimming skills and also there was improvement in appropriate social behaviors. Pan (2010) concluded that a water exercise swimming program is beneficial to the aquatic and social skill development of children with ASD.

In addition, Pan (2011) assessed the efficacy of a 14-week aquatic program on physical fitness and aquatic skills of children with ASD (*n* = 15) and their siblings (*n* = 15) without disabilities. For the treatment (e.g., aquatic program), the participants were divided into two groups. Group A received the treatment for the first 14-week period, but group B did not. After 14 weeks, the researcher reversed the direction in which group A continuously received the treatment and group B also received the treatments. The results indicated that participants increased swimming skills and fitness skills after the treatments. Pan explained that participants were able to reach goals after the treatment, because it was designed based upon goal oriented, structured, and intensive exercise programs.

Similarly, Duronjić and Válková (2010) examined the effectiveness of exercise treatments for preschoolers with ASD. The participants were preschoolers with ASD (*n* = 5), who participated in an eight-week PA exercise program. The Movement Assessment Battery for Children (M-ABC) instrument was used to assess the motor skills of the children before and after the treatment. Participants were observed for the purpose of qualitative analysis. The results revealed that children with ASD improved their motor skills after exercise treatments.

Strategies for engaging children with ASD in physical activities

Yanardag et al. (2015) sought to evaluate "the effectiveness of the 'most to least' prompting (MLP) procedure on the teaching of advance movement exploration skills in water to children with autism spectrum disorders…" (p. 121). The participants were boys with ASD (*n* = 3) who were selected if they were able to follow verbal prompts, to imitate motor skills, and had no physical dysfunction/health issues. Each session had a one-to-one arrangement (teacher to student) and the children were provided with physical to verbal prompts. A single-subject multiple probe across behaviors design was used to analyze the effectiveness of the most to least prompting strategy. Yanardag et al. (2015) found the most to least prompting approach was effective in teaching advance movement exploration skills in water to boys with ASD. Performing the exploration skills in water was continued after the training process during maintenance and generalization probes. In addition, social validity results reflected that parents' opinions were positive on the learning of skills in terms of functionality, beginning swimming and participation in other aquatic settings for their children.

Effectiveness

There were several studies that identified effective methods for engaging children with ASD in physical activities to improve motor skill proficiency. For example, Reid et al. (1991) examined the importance of using prompts for children with ASD during the process of acquiring motor skills. Visual, verbal, and physical prompts were separately provided to children with ASD when they were physically active learning new motor skills. The participants were children with ASD (*n* = 4). While learning each step of bowling, children with ASD were provided instructions with visual, verbal, and physical prompts to increase the levels of participation. Reid et al. (1991) found the effectiveness of using prompts to promote children engagement in exercise and they discerned that physical prompts were more effective for children with ASD than were visual and verbal prompts.

Beamer and Yun (2014) explored teachers' behaviors and beliefs toward including children with ASD in GPE classes. The participants were GPE teachers (*n* = 142) who responded to an on-line survey. Overall, Beamer and Yun (2014) found that teachers' experiences, graduate coursework in APE, and perceptions of the strength of their undergraduate training in APE predicted their self-reported behaviors for including students with ASD in classes. Further they reported that GPE teachers are generally supported by special education teachers when they have children with ASD in their classes. Teachers in this study had taken at least one course about teaching children with ASD which directly helped them to teach students with ASD. Lastly, Beamer and

Yun (2014) found the years of experience working with students with ASD was the strongest predictor to determine successful inclusion of students with ASD in physical education class.

Ward and Ayvazo (2006) analyzed the effectiveness of utilizing Class Wide Peer Tutoring in Physical Education (CWPT-PE) for including students with ASD in physical education class. The participants were children with ASD (n = 2) and their typically functioning peers without disabilities (n = 2). Prior to class lessons, participants without disabilities were educated about how to assist their friends with ASD during the interventions. Twenty-six modified PA lessons of catching were provided to students with and without ASD. Ward and Ayvazo (2006) reported the students' performance on catching were improved after utilizing CWPT-PE, which lends support to the notion that CWPT-PE has positive effects on children with ASD in inclusive physical education classes.

Mechling and Swindle (2013) analyzed "the effectiveness of video modeling to teach fine and gross motor tasks, and to determine if the effects would differ across disability groups (students with moderate intellectual disability and students with autism spectrum disorders)" (p. 136). The participants were children with moderate intellectual disabilities (n = 3) and children with ASD (n = 3). The video modeling protocol was designed whereby the gross motor tasks required movements of the entire body and the fine motor tasks required use of the hands and upper body only. All procedures carried out were videotaped before, during, and after the interventions. Mechling and Swindle (2013) reported that children with moderate intellectual disability performed better both on fine and gross motor tasks than children with ASD. Most participants were more proficient on performing gross motor tasks than fine motor tasks. Mechling and Swindle (2013) confirmed the effectiveness of utilizing video modeling when children with disabilities perform fine and gross motor tasks.

Likewise, Aksay and Güllü (2014) studied "the effects of physical activity with visual stimuli on the physical development, motor skills, and social skills of children with autism spectrum disorder" (p. 34). They implemented a 50-minute program of PA with visual stimuli with 33 children with ASD (experimental group n = 18; control group n = 15) aged 13-16 years. The modified 50-minutes PA program with visual stimuli was provided to children with ASD for 20 weeks. Participants were observed and recorded to measure the effectiveness of using visual stimuli for students' engagement in PA. Aksay and Güllü (2014) confirmed that using visual stimuli in a PA program assists children with ASD to perform motor tasks in term of understanding tasks. They concluded that "a 50-min daily exercise program with a delimited exercise field and display of cartoons can positively affect the physical performance and motor skills of children with ASD" (p. 34).

Breslin and Rudisill's (2011) investigated the effects of using visual supports for children with ASD as they performed locomotor and object control skills on the Test of Gross Motor Development (TGMD-2). The participants were children with ASD (n = 22) and they were evaluated on the TGMD-2 under three different protocols: (a) traditional, (b) picture task card, and (c) picture activity schedule protocols. All testing procedures were videotaped. Children with ASD were provided pictures of each motor task along with demonstrations and verbal instruction for analyzing picture activity protocol. The authors reported that picture card was an effective way to deliver instructions to children with ASD. Overall, the study indicated that using picture task cards and activity schedule protocols enabled children with ASD to perform better on the TGMD-2 compared to the traditional protocol.

Continuing this line of inquiry, Breslin and Rudisill (2013) articulated three purposes for their study. First, they "sought to explore if there were differences in the total amount of time it took children with ASD to complete the TGMD-2 assessments using the different administrative protocols" (p. 340). Second, they sought "to determine if there were differences in the percentage of time engaged in on-task behaviors across the three different administrative protocols" (p. 340). Third, they examined "the relationship between the amount of time it took to conduct the TGMD-2 assessments, the time on-task during the assessments, and the gross motor quotient scores on the TGMD-2 by children with ASD" (p. 340). They hypothesized that using picture activity schedules would enable children with ASD to complete TGMD-2 faster than traditional testing approaches. In addition, they anticipated that children with ASD were able to remain on tasks for longer periods of time if they perform TGMD-2 with visual supports. The participants were children with ASD (n = 22). All testing procedures were videotaped and interpreted by trained researchers. The results revealed using picture task card enables children with ASD to complete tasks faster than using a traditional protocol only. Actually, children with ASD needed the same amount of time to complete the TGMD-2 under picture task card as those with the traditional protocol. The authors explained the failure of their supposition that children with ASD might need more time to understand the picture task schedules in order to complete the TGMD-2 because of their lack of attention span.

Similarly, Liu and Breslin's (2013) study was to examine the effectiveness of utilizing picture activity schedules for children with ASD to perform skills assessed by the Movement Assessment Battery for Children Second Edition (MABC-2) scale. The participants were children with ASD (n = 25) and who were asked to demonstrate skills on the MABC-2 scale under traditional and picture activity schedule protocols.

During traditional protocol of MABC-2, children with ASD were required to demonstrate under verbal instructions and demonstrations of each skill. However, verbal instructions were minimized to emphasize visual supports for children with ASD during the procedures of picture activity schedule. The result showed that children with ASD received higher scores on the MABCS-2 when they were assessed with the MABCS-2 using picture activity schedules compared to under the traditional protocol.

DISCUSSION

The purpose of this literature review was to describe research on strategies used in engaging children with autism spectrum disorder in PA. Stated differently, the current synthesis of the literature was to describe the overarching characteristics of empirical studies published in peer-reviewed journal articles and to present their major findings with regards to children with ASD and PA. The selected studies provide ample information and perspectives about children with ASD in PA contexts. Researchers have found that children with ASD generally lack motor skill efficacy compared to their typically functioning peers (Bandini et al., 2013; Pan, 2008a, 2008b, 2009; Staples and Reid, 2010).

Children with ASD tend to spend less time being physically active than their peers without disabilities. It is obvious that children with ASD are less likely to be physically active compared to their typically developing peers. There are several reasons why children with ASD tend to show lower performance efficacy in PA behaviors than their typically functioning peers (Memari et al., 2012). Specific autistic behavioral tendencies were found in several studies that help explain children with ASD low engagement in moderate to vigorous PA, such as inattentiveness and hyperactive behaviors (Obrusnikova and Dillon, 2011). It is important to recognize these stereotypic behaviors because they often negatively affect children's participation in PA. Various factors also affect the PA levels and behaviors of children with ASD including age, gender, and parental support (Memari et al., 2012; Obrusnikova and Miccinello, 2012; Pan and Frey, 2006). These salient factors need to be considered in designing PA opportunities for children with ASD (Obrusnikova and Cavalier, 2011).

Participating in PA can be very meaningful for children with ASD to gain positive experiences in physical education (Healy et al., 2013). Lang et al. (2010) assert that participating in regular MVPA enables children with ASD to obtain multiple benefits, which include decreases in stereotypy, aggression, off-task, and elopement behaviors. In addition, the current review exposes that children with ASD show higher MVPA levels in physical education classes compared to levels during recess and other school activities. Pan (2008) articulates the importance of participating in structured physical education to give children with ASD opportunities to engage with their peers and to increase their PA levels.

The next step is to find what Evidence Based Practice (EBP) models can be accessible to physical education, especially in teaching children with ASD. A variety of interventional programs have been implemented for teaching children with ASD to succeed. In fact, some interventional strategies have persistently been used for teaching children with ASD in educational settings. Houston-Wilson and Lieberman (1999) provided examples of using EBP models in physical education, such as establishing well-structured environments and organizing tasks based on students' goals. They also emphasized practical teaching strategies, such as using picture boards, selecting appropriate verbal prompts, and providing clear task presentation.

Promptings can be great tools for teachers and parents to reinforce children active participation in PA and exercise (Reid and Cauchon, 1991). Using prompts can help children to understand tasks and to stay on tasks for long durations of time. Using video modeling can also be adoptable in PA contexts (Mechling and Swindle, 2013), because children with ASD can easily respond to visual stimuli (Aksay and Güllü, 2014). The method of peer assisted learning can be beneficial to include students with ASD in PE (Schleien et al., 1988; Ward and Ayvazo, 2006). Acceptance from their peers without disabilities can be very important factor for children with ASD to succeed in inclusive GPE because they often feel isolated from their peers and teachers (Healy et al., 2013).

In all, the major findings exposed in the current literature review indicate that children with ASD tend to have lower PA engagement levels compared to their aged group peers. In physical education, students with ASD consistently have lower PA levels compared to their typically functioning peers. On the other hand, specially designed curriculum arrangements (e.g., class-wide peer tutoring) as well as the level of parents' involvement, community facilities, and support from peer groups are salient determining factors in influencing whether students with ASD become and remain physically active.

Next, we summarize noteworthy strategies for engaging children with ASD in physical activity based on the aforementioned and other previous research findings. Researchers have found daily and programmatic exercise programs can positively affect the physical performance and motor skills of children with ASD. Further, intensive exercise programs increase fitness levels and reduce inappropriate and/or stereotypic behaviors of children with ASD. Students with ASD tend to be more active in structured environments such as physical education classes compared to less structured environments such as recess or free-play. Repeatedly, water exercise swimming programs have been effective

in improving the aquatic and social skills of children with ASD. Likewise, equine-assisted therapies as well as snowshoeing, walking, and jogging have been impactful on increasing the overall gross motor skills of children with ASD. Lastly, researchers have articulated the importance of using peer tutors for students with ASD in inclusive physical education settings.

However, some of the previous studies reviewed in this paper lack strong evidence of generalizability or transferability. In such cases, the reader is cautioned about generalizing or transferring the results to other contexts given the limitations of such works (Morse, 1999). The criterion of transferability is important to consider because it determines whether a qualitative inquiry can be replicated in other similar settings (Morse, 1994).

Quality indicators in both quantitative and qualitative research studies include such aspects as meticulous data collection strategies (e.g., multiple probing interviews with participants), detailed descriptions of research procedures, and systematic coding techniques (where applicable). Therefore, researchers need to include detailed and thorough descriptions of research procedures as much as possible including settings and participants in order to increase the possibility of generalizability or transferability (Table 2).

Conclusions

In conclusion, understanding autistic behaviors is the first step for teachers to modify their class structures and to practice effective teaching strategies. In working with students with ASD, empirically-based teaching strategies include structured class environments, clear direction, using visual cues, and scheduling. These teaching strategies should be accessible to increase children participation in physical activity.

Future research should be conducted to identify additional empirically-sound and accessible teaching strategies for children with ASD based on functional and analytic approaches.

Conflict of Interests

The authors have not declared any conflict of interests.

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Endnotes

[i] The rapid increases in reported cases of ASD has caused debate about why such a jump. Some authorities link the increases to an expanded definition of ASD to include such brain developmental disorders as Asperger's syndrome, for example. Whereas, other authorities argue the increases in reported ASD cases is because of "diagnostic substitution," which is the (re)classification of some children on the autism spectrum, who in previous times would likely have received a different diagnosis such as intellectual disabilities. Still, other authorities point to a combination of genetic and environmental factors as contributing to the increases in reported cases (Doheny, 2008).

[ii] Children and adults with autism, as well as those with other developmental disabilities, may have a dysfunctional [or delayed] sensory system. Sometimes one or more senses are either over- or under-reactive to stimulation. Such sensory problems may be the underlying reason for such behaviors as rocking, spinning, and hand-flapping. Although the receptors for the senses are located in the peripheral nervous system (which includes everything but the brain and spinal cord), it is believed that the problem stems from neurological dysfunction in the central nervous system—the brain. (Hatch-Rasmussen, 2016, para 1).

[iii] It is a mixed methodology, which refers to the analysis of individual participant's subjective expressions and views using "a by-person factor analysis in order to identify groups of participants who make sense of (and who hence Q 'sort') a pool of items in comparable ways" (Watts & Stenner, 2005). The basic tool of Q-methodology is Q-sorting procedure, which involves having participants rank and sort a series of statements or expressions from '*I agree*' to '*I disagree*' (Demir, 2016). The expressions and viewpoints are typically analyzed using a special software package (Demir, 2016).