Autism Spectrum Disorder: An Emerging Opportunity for Physical Therapy

Ana C. Mieres, PT, MSPT, PhD; Russell S. Kirby, PhD, MS, FACE; Kathleen H. Armstrong, PhD; Tanya K. Murphy, MD, MS; Lee Grossman, BA

School of Physical Therapy and Rehabilitation Sciences (Dr Mieres), Department of Community and Family Health College of Public Health (Dr Kirby), Department of Pediatrics (Drs Armstrong and Murphy), and Department of Psychiatry (Dr Murphy), University of South Florida, Tampa, Florida; Autism Society of America (Mr Grossman), Baltimore, Maryland.

Purpose: A growing body of evidence from research on autism spectrum disorder (ASD) confirms a substantial sensory motor component to ASD. Yet, policy and practice lag behind in recognizing the potential contributions of physical therapists in research, practice, and education related to ASD. The objective of this commentary is to inform and encourage reflection and formal dialogue among pediatric physical therapists regarding the assumption of vital roles in research, education, and clinical practice in ASD. **Key Points**: Selected studies representative of the type of work being carried out with respect to motor aspects of ASD is presented with selected older literature for those unfamiliar with the range of information available. **Conclusion:** Findings from research provide ample substantiation for physical therapists to join interdisciplinary efforts as researchers, scholars, educators, policy analysts, and advocates in ASD. Physical therapists have the potential and ability to play a much greater role in ASD. **(Pediatr Phys Ther 2012;24:31–37)**
***Key words:** autism spectrum disorder, interdisciplinary communication, motor skills disorders, physical therapy, professional practice, professional role*

INTRODUCTION

A growing body of evidence from research on autism spectrum disorder (ASD) confirms a substantial sensory motor component to ASD. Yet, policy and practice lag behind in recognizing the potential contributions of physical therapists in research, practice, and education related to ASD. We believe that physical therapists (PTs) have the potential and ability to play a much greater role in ASD. The objective of this article is to inform, while encouraging reflection, formal dialogue, and engagement among pediatric physical therapists in defining vital roles in education, clinical practice, and research in ASD. A variety of relevant findings from research is provided to aide in this process along with synthesis, insights, and recommendations from an interdisciplinary group of ASD researchers, scholars, educators, and advocates. Some older literature is brought forward, to assist in building a knowledge base for the reader who may not be familiar with the range of literature available.

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Correspondence: *Ana C. Mieres, PT, MSPT, PhD, eQHealth Solutions, 5802 Benjamin Center Drive, Suite 105, Tampa, FL 33634 (amieres@eqhs.org).*

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As important changes in the criteria for the diagnosis of ASD are in progress, our attention is necessary. The release of the fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-5), with extensive revisions, is expected in May 2013 and lively discussions at many scientific meetings have already begun. On the basis of comprehensive review of scientific advancements, targeted research analysis, and clinical expertise, new diagnostic criteria have begun to undergo field trials in selected locations in the United States. Field trials began in the summer of 2010 using draft criteria available for viewing at dsm5.org. Adjustments based on the field trial results generated a second field trial in the summer of 2011. Included in these new criteria undergoing field trials, ASDs will likely subsume autistic disorder, childhood disintegrative disorder, pervasive developmental disorder not otherwise specified, and Asperger disorder. [1,2] Rhett disorder will no longer be included.[3] Sensory and motor dimensions are minimally represented in the revised criteria for ASDs.[1,2]

The profession of physical therapy will be left out of this important document if discussion with the DSM-5 ASD work group does not occur. Physical therapists, active in the field of ASD, provided input in the early stages requesting inclusion of sensory and motor characteristics and the use of the term motor when discussing stereotypies. The importance was once again communicated in a national forum with representatives from the DSM-5 work group, where 2 PTs from the Pediatric Section ASD Committee provided input. From August 2011 through February 2012, the second phase of field trials testing will focus on those diagnostic criteria and dimensional measures that required modification based on the results of the phase I field trials. This time period will include data collection and analysis before finalizing the DSM-5. As the period for finalization is not yet over, input to the ASD work group is still a distinct possibility. Given the proposed changes in the DSM-5 and a growing body of relevant evidence in sensory and motor aspects of ASD, to be touched upon later in this commentary, the time is right to fully explore and consider the contributions PTs can make now and in the future.

ASD OVERVIEW

Autism spectrum disorders include a group of developmental disabilities that can cause significant social, communicative, and behavioral challenges. Individuals show a wide range of variation in both abilities and function. Currently, diagnosis is based on the diagnostic criteria in the fourth edition, text revision, of the DSM (DSM-IV-TR). As stated previously, DSM-5 criteria are not yet being used except in field studies. Criteria are documented through behavioral observations, history taking with the parents or caregivers, and assessment by health care providers using ASD-specific assessment instruments and tools. Autism spectrum disorders are marked by qualitative impairments in social interaction, communication, patterns of behavior, and symbolic play and are often complicated by comorbidity with other conditions.[3,4] Proposed revisions to the criteria and a new severity scale from the DSM-5 revision update dated January 26, 2011, can be found online at http://www.dsm5.org/.[1,2]

The clarification of comorbidities seen with ASD is also expected in the DSM-5.[1,2] Levy et al examined data documented in medical or educational evaluation records from a sample of 2568 eight-year-old children with ASD. They found that 85% of the children with ASD demonstrated comormidities. These findings support previous research indicating that ASD commonly occurs with other developmental, psychiatric, neurologic, chromosomal, and genetic diagnoses.[5-7]

The most recent report from the Centers for Disease Control's (CDC's) Autism and Developmental Disabilities Monitoring (ADDM) Network indicates that 1 in 110 children have ASD, with the average age of diagnosis at 48 months.[6,7] Sites that participated in the earlier 2002 study were observed to have an increase in ASD prevalence ranging from 27% to 95%, with an average increase of 57% from 2002 to 2006. [6–8] Prevalence of ASD is higher for boys, ranging from 3 to more than 6 boys for every 1 girl with ASD.[6] It is unclear exactly how much of this increase is due to a broader definition of ASD and better efforts in screening and diagnosis. However, a true increase in the number of people with an ASD cannot be ruled out. The CDC, along with other researchers, believes the increase in ASD diagnosis is likely due to a combination of a broader definition of ASD, better efforts in screening, and an in increase in prevalence.[6-11]

NEUROMOTOR FINDINGS IN ASD

Studies selected for this article, although not exhaustive nor selected by means of formal systematic review, are representative of the nature and depth of work being carried out with respect to motor aspects of ASD. Each study provides a different view or insight with the distinct potential to inform and shape prospective roles for PTs' research, education, and practice. As significant changes in health care policy are occurring, promising data on ASD may also shape policy at the local, state, or national level.

The South Carolina Autism and Developmental Disabilities Monitoring Program (ADDM) is one of 14 such programs that comprise the Center for Disease Control's ADDM Network. The program conducts active population-based surveillance of children who are 8 years old. The South Carolina study, resulting in a surveillance of 47 726 children, identified that 62% of children with ASD displayed delays in motor development.[12] In addition, these developmental concerns were seen before age 3 years in 85% of the children with ASD.[12]

Esposito et al[13] identified that motor skill deficits were found to have an effect on schooling and socialization. Using retrospective video analysis, Esposito et al performed the first evaluation of unsupported gait in toddlers with autism. Unsupported gait in this Italian study was defined as the "age of walking autonomy." Fifty-five toddlers, belonging to 3 groups were recruited from 2 separate institutions in Italy: toddlers with autistic disorder (AD, n = 20, age 14.2 months,), toddlers developing typically (n = 20, age 12.9 months), and toddlers with nonautistic developmental delays (DDs) of mixed etiology (n = 15, age 13.1 months). The Walking Observation Scale (WOS) and the Positional Pattern for Symmetry during Walking (PPSW) were used to gather data on the first unsupported gait. The WOS includes 11 items that analyze gait through 3 axes—foot movements, arm movements, and general movements—and the PPSW analyses static and dynamical symmetry during gait.

They identified statistically significant differences in gait patterns among the group of toddlers with AD as opposed to the control groups with respect to atypical foot movement, atypical arm movement, and atypical generalized movement. Significant differences between AD and the 2 control groups were found for both WOS ($P < .001$) and PPSW ($P < .001$). The specificity of motor disturbances in this study identified in autism (postural asymmetry) is consistent with previous findings that implicated cerebellar involvement in the motor symptoms of autism.[13]

Through imaging, Mostofsky et al[14] reported that children with an ASD show less activation in the cerebellum with relatively more activation in the fronto-striatal region. The findings provide information pivotal to understanding the neural basis of autism and were highlighted in a recent US Government summary of the 20 research articles that the Interagency Autism Coordinating Committee (IACC) felt made the most significant contributions to autism biomedical and services research in 2009.[14]

Mostofsky is currently working on (1) characterizing the motor deficits associated with autism, including differences in how children with autism learn motor skills; (2) determining through neuroimaging (anatomic magnetic resonance imaging [MRI] and functional MRI) the neural basis of those deficits; and (3) examining novel approaches for improving motor learning in children with autism. This type of impairment in motor learning may account for the significant and pervasive difficulties children with ASD demonstrate on motor assessment tools such as the Movement Assessment Battery for Children, where some of the tasks involve fast and automatic responses, which occur below the level of conscious awareness.[14] The cerebellum generates unconscious planned movements and the fronto-striatal region provides for conscious planned movement. In the absence of efficient cerebellar functions to achieve this less conscious motoric response, children with ASD may operate at a more conscious level that would place greater demands on the attentional and executive control centers of the brain, in particular the fronto-striatal regions, which themselves appear compromised, on the basis of the Mostofsky study.[14] Or could children with ASD have less awareness that their movements are uncoordinated due to sensory processing issues and therefore do not automatically compensate without cognitive strategies? In any event, limiting excessive demands of attention to enhance cognitive strategies, during physical therapy evaluation and intervention, may enhance learning of specific skills in the clinical setting.

Evidence now suggests that aspects of cerebral morphology are also different in people with ASD—including both volumetric (ie, cortical thickness, regional area) and geometric (ie, cortical shape) features[15,16]—and that different morphological features may have different neuropathological and genetic underpinnings.[17] For instance, cortical thickness is likely to reflect dendritic arborization,[18] while cortical surface area has been linked to the number of minicolumns in the cortical layer.[19] Thus, examining the relationship between such multiple cortical features could provide invaluable insights into the multifactorial etiology of ASD and ultimately the functional activities that these features represent.[20] Hence, functional challenges demonstrated by children with ASD may be linked to specific regions of the brain.

The neuroanatomy of autism is perplexing and inherently difficult to describe. Ecker et al[21] demonstrate how a multiparameter classification approach can be used to characterize the complex and subtle structural pattern of gray matter anatomy implicated in adults with ASD, and to reveal spatially distributed patterns of discriminating regions for a variety of parameters describing brain anatomy. Twenty control adults were recruited locally by advertisement and 20 adults with ASD were recruited through a clinical research program at the Maudsley Hospital/Institute of Psychiatry in London. A set of 5 morphological parameters including volumetric and geometric features at each spatial location on the cortical surface was used to discriminate between people with ASD and controls using a support vector machine analytic approach, and to find a spatially distributed pattern of regions with maximal classification weights. On the basis of these patterns, the support vector machine was able to identify individuals with ASD at a sensitivity and specificity of up to 90% and 80%, respectively.[21]

Ecker et al[21] identify that the "autistic brain" is not just bigger or smaller but is also abnormally shaped. Selected findings from this study may be of interest to PTs. Certain geometric features such as average convexity and metric distortion were noticed, particularly in the parietal, temporal, and frontal regions and in areas of the cingulum. Morphometric abnormalities in the middle temporal sulcus displayed increased thickness relative to controls. Morphometric abnormalities in the posterior cingulated gyrus demonstrated a combination of different cortical thickness and a folding pattern as compared with controls.[21] Physical therapists with training in applying imaging would find the availability of MRI in biomarker research of value. Perhaps motor characteristics will be a future biomarker for ASD, as it does not depend on social or linguistic development.

Continuing our extraction of relevant information from other disciplines, from the *Journal of Vision* from Australia, Crewther et al[22] identified left global visual hemi-neglect in ASD. This study explored the visual perceptual differences between individuals from a normal population (mean age, 25 years) showing high versus low autism-spectrum quotient (AQ). A perceptual rivalry stimulus, the diamond illusion, containing both global and local percepts was used to explore the effects of occluder contrast (that hide the vertices of the diamond) and peripheral viewing, in groups with high ($n = 23$) and low ($n = 15$) AQ. In addition, multifocal nonlinear visual evoked potentials, achromatic (24% and 96% contrast), were used to test for the presence of underlying physiological differences in function. Remarkably, the high AQ group showed a significant reduction in global perception when the stimulus was presented in the left hemifield, but not for presentation in the right hemifield. This global perceptual hemi-neglect suggests the possibility of abnormal parietal function in individuals with high AQ. Seven visual evoked potential parameters used in a discriminant analysis correctly classified high or low group membership in 95% of the participants.[22]

The prevalence of motor deficits in ASD was identified in a cohort of 154 children by Xue et al,[23] using retrospective chart review. Hypotonia was the most common motor symptom in the ASD cohort (51%) and appeared to improve over time, as suggested by the significant reduction in its prevalence in older children ($P = .002$). Likewise, motor apraxia (34%) showed a tendency to be more prevalent among younger children compared with older children ($P = .06$). Historical intermittent toe-walking was found in 19% of children, whereas reduced ankle mobility was a rare occurrence. Gross motor (GM) delay was reported in 9% of children. Except for GM delay, children on the autism spectrum with fine motor (FM) deficits were not more likely to receive services, compared with ASD children without the motor deficits. The results suggest that FM control and programming deficits are common co-occurrence of children with ASD in this cohort.[23]

A study examining mirror neuron developments in ASD may generate immediate clinical value for those presently seeing children with an ASD.[24] Theoret et al evaluated 10 high functioning individuals with ASD who met the clinical diagnosis through the DSM-IV-TR criteria with 10 gender-matched controls aged 21 to 60 years. Transcranial magnetic stimulation (TMS) induced motor evoked potentials, mirror neuron system (MNS) from the right first dorsal interosseus, and abductor pollicis brevis muscles were recorded, while subjects passively viewed 10-s movie clips of index or thumb movements on a computer screen at a distance of 1 m. In the group with ASD, muscle-specific facilitation was absent during observation of movements away from the observer (egocentric view). However, for conditions in which hand orientation and finger movements were toward the observer (allocentric view), motor-evoked potential facilitation was similar to that seen in controls. Individuals with autism display atypical patterns of motor cortex activation during simple finger movements.[24]

For the first time, the system matching action observation and execution in ASD is shown. Specifically, observation of a movement in control subjects selectively enhanced motor output to the muscles involved in the movement, whereas this modulation was weaker in ASD. The MNS seems to be intricately involved in imitation and might form a link between sender and receiver and thus be crucial to the adequate development of motor plans. Therefore, a dysfunction of the MNS in ASD could represent one neural underpinning for movement and provide insight on the faulty system effecting motor planning and effective motor production.[24]

The difference between the toward-away conditions in individuals with ASD may be explained by a self-consciousness deficit resulting in faulty self-other representation. Recent data suggest that individuals with ASD, contrary to controls, fail to display a memory advantage for self-referent material over semantic material and are impaired at recalling self-related events. Here, hand movement in the egocentric view failed to properly activate motor structures of the brain, whereas observation in the allocentric view was associated with normal activation of the motor cortex. As such, the self-directed movement (more primary in development) is correctly processed but the more complex "other-directed" movement is impaired. This might provide a useful strategy to identify and probe the mirror neuron level of other movements and perhaps inform clinical practice strategies.[24]

Forty-seven high-functioning children with an ASD, autism, or Asperger syndrome and 47 controls who were developing typically completed the Physical and Neurological Assessment of Subtle Signs, an examination of basic motor skills standardized for children, and a praxis examination that included gestures to command, to imitation, and with tool-use.[25] Hierarchical regression was used to examine the association between basic motor skill performance (ie, times to complete repetitive limb movements) and praxis performance (total praxis errors).[26] After controlling for age and IQ, basic motor skill was a significant predictor of performance on praxis examination. Nevertheless, the group with ASD continued to show significantly poorer praxis than controls. Furthermore, praxis performance was a strong predictor of the defining features of autism, measured by using the Autism Diagnostic Observation Schedule, and this correlation remained significant after accounting for basic motor skill. Thus dyspraxia in autism cannot be entirely accounted for by impairments in basic motor skills, suggesting the presence of additional contributory factors. Furthermore, praxis in children with autism is strongly correlated with the social, communicative, and behavioral impairments that define the disorder, suggesting that dyspraxia may be a core feature of autism or a marker of the neurological abnormalities underlying the disorder.[25,26]

Provost et al[27] assessed motor delay in young children aged 21 to 41months with ASD and compared motor scores in children with ASD to those of children without ASD. Fifty-six children (42 boys, 14 girls) were in 3 groups: children with ASD, children with DD, and children with developmental concerns without motor delay. Descriptive analysis showed all children with ASD had delays in GM skills, FM skills, or both. Children with ASD and children with DD showed significant impairments in motor development compared to children who had developmental concerns without motor delay. Motor scores of young children with ASD did not differ significantly on motor skill measures when compared to young children with DD.[27]

This study underscores the need to include GM metrics in the evaluation of children with ASD. In addition, it may be difficult to distinguish between children with DD and ASD.

Loh et al[28] examined motor behaviors in a longitudinal cohort of infant siblings of children with autism. Stereotypic motor behaviors and postures were coded from videotapes of participants during administration of the Autism Observation Scale for Infants, a brief standardized observational assessment that consists of 16 hypothesized risk markers for autism. Motor mannerisms were coded as they were observed, using continuous interval sampling. A timer sounded every 30 s to signal the coder to start a new time interval. Stereotypic movements and postures occurring during standardized observational assessments at 12 and 18 months were coded from videotapes. [28] Thelen's *1979* taxonomy of 47 repetitive behaviors, including stereotypies of the fingers, hands, arms, head, and trunk, provided the starting point for the coding system used by Loh et al.[28,29]

Participants included 8 infant siblings later diagnosed with ASD, a random sample of 9 siblings who were not diagnosed, and 15 controls.[28] Videos were coded blind to diagnostic group. At 12 and 18 months, the participants with ASD "arm waved" more frequently, and at 18 months, 1 posture ("hands to ears") was more frequently observed in the participants with ASD and those who were not diagnosed compared to the controls. Overall, the siblings subsequently diagnosed with ASD and the comparison groups had considerable overlap in their repertoires of stereotyped behaviors. However, findings from this small sample of 32 infants must be interpreted with caution. Within- and between-group variation in specific behaviors may be strongly influenced by atypical findings in a very small number of children, and as such, are not robust. [28]

Overall, a wide range of stereotyped motor movements and postures were observed and some evidence that certain motor behaviors were more frequent in infants who were subsequently diagnosed with ASD. Although these observations must be confirmed in a larger sample (and replicated by other groups), this study provides some of the first prospective observational data on this important but poorly understood domain of motor signs. Longitudinal analyses of stereotyped movements in high-risk infants may ultimately identify specific behavioral markers that assist with early detection and yield broader insights into the neurodevelopmental origins of atypical behaviors in ASD.[28]

In 2007, Provost et al[30] evaluated 38 children between the ages of 21 and 41 months, comparing levels of GM and FM development in young children with ASD, and comparing their levels of GM and FM development with children with DD without ASD. The Peabody Developmental Motor Scales, second edition, was used for this study. The findings suggested motor profiles of the young children with ASD were similar to the motor profiles of the young children with DD when the children were matched for chronological age, gender, and mental developmental age.[30]

The general implications of this exploratory research for pediatric physical therapists are that the majority of young children with ASD in this sample demonstrated comparable developmental levels to those with DD, including similar delays, in not only their overall GM and FM skills, but also in specific areas of locomotion, object manipulation, and visual-motor integration skills. If this sample is representative, therapists might consider planning interventions earlier and more effectively for young children with ASD by incorporating aspects of both GM and FM areas into their plans of care. A common misconception that most children with ASD have relative strengths in their GM skills is not supported by this study.[30]

IMPLICATIONS FOR PUBLIC HEALTH AND PHYSICAL THERAPY

The progressive increases in ASD prevalence recorded in the ADDM studies during 2002-2006 underscore the need to understand characteristics and comorbidities associated with ASD.[6] More children than ever before have been diagnosed with ASD and are receiving services. Even without fully understanding the complex causes of this increase in ASD prevalence, the effect on children, families, and communities is substantial. Prevalence estimates can be used to develop policy, and plan educational and intervention services needs for persons with ASD. In addition to continued evaluation of ASD prevalence, major collaborative efforts are needed to improve research into the factors that put certain people at risk and how to intervene to help reduce the debilitating symptoms of ASD. Concerted efforts in physical therapy to identify the many needs of affected families to improve daily functioning and long-term life outcomes would be of considerable value.

Research such as the Study to Explore Early Development, a CDC-funded study examining a wide array of risk factors for ASD, is being conducted.[31] In addition, the coordination of research priorities between public and private organizations through the IACC of the National Institutes of Health and Research on ASDs highlights the need for an urgent, coordinated, and multipronged approach to ASD research.[32] Physical therapists, as experts in movement and development, are poised to contribute with data collection, analysis, enhancement of developmental metrics and testing for longitudinal studies and participate as collaborators within the IACC to further inform and guide interagency initiatives.

Identification of ASD at earlier ages is essential to ensure that children in the United States receive optimal early intervention services. Screening tools for ASD could be evaluated for use within physical therapy and be available for clinical assessments. History taking regarding developmental concerns, a core requirement in the education and ongoing practice of PTs may be enhanced, as parents concerns are predictive of DDs in 70% to 80% of children with disabilities.[33]

The Netherlands has indicated significant increases in the ability to identify children with ASD earlier when a 2-tiered system was employed, using trained clinicians in the early screening of children, whether or not an ASD was suspected.[34] The 2-tiered system involves the comprehensive training of selected clinicians in many fields, which create a formal screening mechanism with clinical algorithms in place to guide further testing and referrals. Perhaps the time has drawn near for PTs to participate and even lead 2-tired early interventions. Screening is a separate function independent from evaluation and treatment as the training, infrastructure, and management differs from episodic, comprehensive rehabilitation services. However, screening can be provided through a community collaborative with other organizations. In addition, referral to early intervention and other community support services could occur simultaneously, supporting guidelines published by the American Association of Pediatricians (AAP) encouraging early intervention services when ASD is suspected.[35]

Orthopedic practice settings may be the last place to consider ASD, yet planning is of importance for effective patient care and limiting liability for the staff. In a study of 75 boys, Hediger suggests that bone composition may be altered in children with ASD.[36] At 5 or 6 years of age, the bones of the autistic boys were significantly thinner than the bones of boys without autism and the difference in bone thinness became even greater at ages 7 and 8.[36] Perhaps we will uncover that osteoporosis prevention education for individuals with ASD will become one part of home exercise programming.

Finally, the CDC believes that education concerning ASD is necessary to trigger early identification. The CDC is searching for partners to educate the public on childhood development. Materials have been developed and ready for downloading at no cost. Presentations ready for use, community outreach kits, posters formatted for the addition of organizations contact information, a media distribution kit, and the ability to add a milestone quiz widget to a Web site are all available for consideration. Some CDC partners in this campaign entitled "Act Early" are the American Academy of Pediatrics and the Association of University Centers on Disability.[37] This clear need could become an opportunity for PTs to be recognized as experts in childhood development. Through early screening, the PT could take on a more formative and vital role in the Early Intervention system.

RECOMMENDATIONS

The number of individuals being diagnosed with ASD is increasing, and implications for physical therapy require consideration. This initial consideration for physical therapy in ASD, written interdisciplinarily, has generated intriguing questions—unfortunately, more questions than answers.

Use of mutually agreed upon terms and definitions in ASD has not yet occurred, creating ambiguity. Consequently, analysis and comparison of movement, motor development, apraxia, coordination, and motor learning findings using similar vocabulary from all professional groups is needed to completely understand motor behavior findings to date. Randomized controlled trials are also needed to provide empirical basis for the provision of motor interventions, including the context, optimal timing, and intensity in addition to the sound use of terms and operational definitions. Well-designed prospective longitudinal studies over extended periods of time, preferably from large population-based samples, are needed. Such studies would further clarify the population-based prevalence, and extent of motor impairments, their developmental patterns and trajectories in those with ASD. Perhaps a group of policy makers could use this commentary as a guide for structuring a formal event such as a think tank, for focused reflection, research, and discourse.

A unique opportunity exists to consider our roles and responsibilities. Unfortunately, if we do not soon select our roles and responsibilities in education, clinical practice, research, or service, the decision will be made for us. It is our intent that this article becomes a prompt for rich dialogue and robust interactions between and among groups within physical therapy to further explore the literature and chart a formal role. The Autism Society and leaders in ASD from other disciplines involved in the writing of this article are interested in seeing PTs provide their unique skill sets to education, clinical practice, service, and research in ASD. We advocate building community-specific interprofessional alliances for education, research, and clinical practice. We urge conversation to occur at the state and national level, with task forces developed to explore the specific opportunities. We invite participation at Autism Society Interprofessional Conferences and recommend continued interprofessional education and capacity building for PTs, at professional meetings. We applaud the recent empowerment of a national APTA Pediatrics Task Force on ASD to identify roles and responsibilities. We further encourage this group to consider unique collaborations across disciplines with sustained vision for preservice education, continuing education, research, and clinical service.

CONCLUSIONS

A growing body of new evidence from research on ASD confirms a substantial sensory motor component to ASD, dispelling some previously thought misconceptions. Yet policy and practice lag behind in recognizing the potential contributions of PTs in research, practice, and education related to ASD. Changes in the DSM criteria for ASD are underway with formative input opportunity still available.

We believe that physical therapy has the potential and ability to play a much greater role in ASD. The assortment of relevant findings from evidence previously presented provides ample substantiation that PTs are needed to join interdisciplinary efforts as researchers, scholars, educators, policy analysts, and advocates in ASD.

REFERENCES

1. DSM-5: The Future of Psychiatric Diagnosis. http://www.dsm5.org/. Accessed February 10, 2011.
2. Center for Medicare and Medicaid Services. ICD-9-CM Coordination and Maintenance Committee. http://www.cdc.gov/nchs/icd/icd9cm_maintenance.htm. Accessed February 8, 2010.

3. Autism Spectrum Disorder. http://www.cdc.gov/ncbddd/autism/addm.html. Accessed August 8, 2010.
4. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders. fourth edition, Text Revision (DSM-IV-TR)*. Arlington, VA: American Psychiatric Association; 2000.
5. Gillberg C, Billstedt E. Autism and Asperger syndrome: coexistence with other clinical disorders. *Acta Psychiatr Scand*. 2000;102:321-330.
6. Centers for Disease Control and Prevention. Prevalence of autism spectrum disorders—Autism and Developmental Disabilities Monitoring Network, United States, 2006. *MMWR Surveill Summ*. 2009;58(SS10):1-20.
7. Gurney JG, McPheeters ML, Davis MM. Parental report of health conditions and health care use among children with and without autism. *Arch Pediatr Adolesc Med*. 2006;160:825-830.
8. Levy SE, Giarelli E, Lee LC, et al. Autism spectrum disorder and co-occurring developmental, psychiatric, and medical conditions among children in multiple populations of the United States, *Dev Behav Pediatr*. 2010;31:267-275.
9. Bertrand J, Mars A, Boyle C, Bove F, Yeargin-Allsopp M, Decoufle P. Prevalence of autism in a United States population: the Brick Township New Jersey investigation. *Pediatrics*. 2001;108:1155-1161.
10. Baird G, Charman T, Cox A, et al. Screening and surveillance for autism and pervasive developmental disorders. *Arch Dis Child*. 2001;84:468-475.
11. Centers for Disease Control and Prevention. Mental health in the United States: parental report of diagnosed autism in children aged 4-17 years—United States. *MMWR*. 2006;55:481-486.
12. Van Naarden Braun K, Pettygrove S, et al. Evaluation of a methodology for a collaborative multiple source surveillance network for autism spectrum disorders—Autism and Developmental Disabilities Monitoring Network, 14 Sites, 2002. *MMWR*. 2007;56(SS01):29-40.
13. Esposito G, Venuti P, Apicella F, Muratori F. **Analysis of unsupported gait in toddlers with autism**. *Brain Dev*. 2011;33(5):367-373.
14. Mostofsky SH, Powell SK, Simmonds DJ, Goldberg MC, Caffo B, Pekar JJ. Decreased connectivity and cerebellar activity in autism during motor task performance. *Brain*. 2009;132:2413-2425.
15. Levitt P. Structural and functional maturation of the developing primate brain. *J Pediatr*. 2003;143:35-45.
16. Wu Nordahl C, Dierker D, Mostafavi I, et al. Cortical folding abnormalities in autism revealed by surface-based morphometry. *J Neurosci*. 2007;27(43):11725-11735.
17. Panizzon MS, Eyler LT, Jernigan TL, et al. Distinct genetic influences on cortical surface area and cortical thickness. *Cereb Cortex*. 2009;19(11):2728-2735.
18. Huttenlocher PR. Morphometric study of human cerebral cortex development. *Neupsychologia*. 1990;28:517-527.
19. Rakic P. Defects of neuronal migration and the pathogenesis of cortical malformations. *Prog Brain Res*. 1988;73:15-37.
20. Van Essen DC. A tension-based theory of morphogenesis and compact wiring in the central nervous system. *Nature*. 1997;385:313-318.
21. Ecker C, Marquand A, Mourão-Miranda J, et al. Describing the brain in Autism in five dimensions—magnetic resonance imaging-assisted diagnosis of autism spectrum disorder using a multiparameter classification approach. *J Neurosci*. 2010;30(32):10612-10623.
22. Crewther Davis, Crewther Daniel, Ashton M, Kuang A. Left global visual hemineglect in high autism-spectrum quotient individuals. *J Vision*. 2010;10(7):358-361.
23. Xue M, Brimacombe M, Wagner GC. Prevalence of motor impairment in autism spectrum disorders. *Brain Dev*. 2007;29(9):565-570.
24. Théoret EH, Kobayashi M, Fregni F, Tager-Flusberg H, Pascual-Leone P. Impaired motor facilitation during action observation in individuals with autism spectrum disorder. *Curr Biol*. 2005;15(3):194-282.
25. Dziuk MA, Gidley Larson JC, Apostu A, Mahone EM, Denckla MB, Mostofsky SH. Dyspraxia in autism: association with motor, social, and communicative deficits. *Dev Med Child Neurol*. 2007;49(10):734-739.
26. Staples KL, Reid G. Fundamental movement skills and autism spectrum disorder. *J Autism Dev Discor*. 2010;40:209-217.
27. Provost B, Lopez BR, Heimerl S. A comparison of motor delays in young children: autism spectrum disorder, developmental delay, and developmental concerns. *J Autism Dev Disord*. 2007;37(2):321-328.
28. Loh A, Soman T, Brian J, et al. Stereotyped motor behaviors associated with Autism in high-risk infants: a pilot videotape analysis of a sibling sample. *J Autism Dev Disord*. 2007;37(1):25-36.
29. Thelen E. Rhythmical stereotypies in normal human infants. *Animal Behav*. 1979;27:699-715.
30. Provost B, Heimerl S, Lopez B. Levels of gross and fine motor development in young children with autism spectrum disorder. *Phys Occup Ther Pediatr*. 2007;27(3):21-36.
31. Autism Spectrum Disorders. http://www.cdc.gov/ncbddd/autism. Accessed April 11, 2010.
32. Interagency Autism Coordinating Committee. www.iacc.hhs.gov. Accessed April 11, 2010.
33. Autism and Developmental Disabilities Monitoring Network Surveillance Year 2002 Principal Investigators. Prevalence of autism spectrum disorders—Autism and Developmental Disabilities Monitoring Network, 14 Sites, United States, 2002. *MMWR*. 2007;56:1:12-28.
34. Oosterling IJ, Wensing M, Swinkels SH, et al. Advancing early detection of autism spectrum disorder by applying an integrated two-stage screening approach. *J Child Psychol Psychiatry*. 2009;51(3):250-258.
35. American Academy of Pediatrics. Technical report: the pediatrician's role in the diagnosis and management of autistic spectrum disorder in children [online article]. *Pediatrics*. 2001;107:e85. http://pediatrics.aappublications.org/cgi/content/full/107/5/e85.
36. Hediger ML, England LJ, Molloy CA, Yu KF, Manning-Courtney P, Mills JL. Reduced bone cortical thickness in boys with autism or autism spectrum disorder. *J Autism Dev Disord*. 38(5):848-856
37. Learn the Signs. Act Early. www.cdc.gov/actearly. Accessed April 11, 2010.