Motor disturbances in autistic children: cross-sectional, controlled study

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Background
Children with autism have developmental motor profile that differ from other healthy children. This is evident since early childhood, sometimes noted by parents and neglected by clinicians. These motor deficits are related to other domains of dysfunction in children with autism as social and language skills. Improving motor deficits can help better prognosis for these children.

Objective
To detect and describe motor deficits in a sample of autistic children and correlate them with the severity of autistic symptoms.

Methods
We recruited 20 autistic children ranging from 3 to 6 years from the Institute of psychiatry outpatient child psychiatry and rehabilitation clinics of Ain-Shams university hospital. Patients with total intelligence less than 75 or having other neurodevelopment disorders were excluded. We matched healthy controls for age and sex and compared both motor development and self-help skills using Brigance scale. The diagnosis of childhood autism in each patient was confirmed by applying International Classification of Diseases-10 criteria of autism by a senior psychiatrist and by having a Childhood Autism Rating Scale score above 30. Relationship between autism severity and motor deficits was assessed by correlation coefficient test.

Results
Compared with controls, children with childhood autism showed low statistically significant Brigance test scores on gross movement, fine movement, and self-help skills subdomains. Motor delay was significantly correlated with autism severity.

Conclusion
Motor deficits were evident in this sample of autistic patients and were correlated with case severity. This can shed light onto potential targets for intervention early, as these deficits are detected by aware clinicians, especially in prelingual children.

Keywords:
childhood autism, children, essential feature, motor deficits

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Introduction

About 30 to 75% of autistic individuals have associated motor deficits [1]. They appear to be evident as early as infancy, manifesting as problems in sequencing movements to crawl or walk, absent reflexes when they should be, and persistence of other primitive reflexes [2,3]. In older children, manifestations of problems can be observed as poor coordination (both axial and limb), poor postural control, slow response speed, clumsy gait, hypotonia, fine movement deficits, tip toe movement, and hand flapping [4,5]. When a child presents with these kinds of motor difficulties and they are on the spectrum, the motor difficulties may be assumed to be part of the disorder and may be dismissed. Clearly then, they can serve as early detection markers for abnormal neurological development in autism [6].

Moreover, from a social deficits perspective, 'failure to cuddle' may be related to postural and tone abnormalities and 'indifference to affection' may be related to marked underactivity. Motor deficits in infancy and early childhood might contribute toward joint attention and imitation challenges. Similarly, from a language perspective, the impact of oral-motor abnormalities (e.g. dyspraxia and apraxia) on language development and expressive output should be considered significant. As such, it is possible that improvements in motor skills may influence not only motor ability and activities of daily living but also some of the core social and language symptoms of autism [4].

Rattue [7] and Muratori *et al.* [8] reported that motor impairments are a core characteristic of the diagnosis; they are considered one of the first signs that probably precede social or linguistic abnormalities 'since the first months' and may define specific subgroups of early autism spectrum disorder (ASD), related to different pathways to the syndrome. Delay in diagnosis because of the diagnostic criteria of the *Diagnostic and Statistical Manual of Mental Disorders*, 4th ed., Text Revision (DSM-IV-TR) manual

leads to considerable confusion and frustration for parents as they attempt to understand their child's unusual motor development and also seek appropriate services and treatment. They concluded that better understanding of motor incoordination signs could aid early identification and intervention in autistic children [7].

Considerable attention has been focused on other domains of autism and less attention has been focused on the motor in-coordination and motor delay encountered. We hypothesize that children with childhood autism have distinct motor deficits, incoordination, and poor motor development as core symptoms compared with their healthy peers. We aimed to detect and describe these motor signs and examine their possible relation to the severity of autism.

Participants and methods

Ethical approval

The study was approved by the Ethics and Research Committee of Ain Shams University; Cairo, Egypt. Parents signed an informed consent for their own and their children's participation after the aims and procedures of the study were explained to them and assuring confidentiality.

Participants

Children were recruited from the institute of psychiatry outpatient child psychiatry and rehabilitation clinics of Ain Shams University hospital (which serves urban and rural areas from different governments in Egypt, providing health services to different social classes) in the period from February 2011 to February 2012 to participate in this case–control study. The patients enrolled in our study were those diagnosed with only childhood autism according to the International Classification of Diseases-10 (ICD-10) research criteria, not less than 3 years old and up to 6 years old (3 years is the least age to ensure a valid diagnosis of childhood autism) and of both sexes. The diagnosis was confirmed by a senior psychiatrist and by a Childhood Autism Rating Scale (CARS) score above 30 by a trained researcher [9]. The severity of autistic symptoms was assessed by CARS, with the more severe form with a score of 36 and above. We excluded patients with a total intelligence score less than 75 and those with a history of medical or any other neurodevelopment or psychiatric disorders that can affect motor function and cause added disability, in addition to those who failed to complete the assessment required. Twenty autistic patients were enrolled and grouped as patient group (I) out of the initial 26 patients fulfilling the above-mentioned inclusion and exclusion criteria. We recruited age-matched and sex-matched healthy controls and grouped them in group II. The sample size was calculated using the Epi Info program (version 6.0; Centers for Disease Control and Prevention (CDC), Atlanta, Georgia, USA) at a 95% confidence interval; the power of the test is 80%. All participants were subjected to assessment of history, and medical, psychiatric, and neurological examinations mainly to exclude unfit patients. They were also screened for possible development motor difficulties and delay using the Brigance Inventory for Early Development, 2nd ed. (IED-II) administered by a psychiatrist and research assistant with extensive experience in this assessment and with high reliability. The selected items were selected based on the need for data; they included subdomains of gross motor skills, fine motor skills, and self-help skills. However, self-help skills did not depend only on motor coordination or motor deficits as it is the outcome of interlacing multiple skills, but they reflected motoric development. The fine motor skills subdomain included a drawing/visual motor composite and a writing skills composite. The gross motor skills subdomain included a nonlocomotor composite (jumping and hoping) and a locomotor composite (such as crawling, walking, running, and stair climbing). Self-help skills included two subdomains: self-help and prevocational (five assessments and 64 items).

Assessment tools for autism and motor development

Childhood Autism Rating Scale [9]

CARS is a diagnostic tool designed to evaluate children suspected to have autism. It is suitable for the evaluation of children 2 years old or older. CARS examines and scores a number of factors (15 items) to enable differentiation of children with autism from those with other developmental disabilities. CARS rates children on a scale from 1 to 4 for various criteria, ranging from normal to severely abnormal. This scale can be completed by a clinician or a teacher or parent, on the basis of subjective observations of the child's behavior. Total CARS scores range from 15 to 60, with a minimum score of 30 serving as the cutoff for a diagnosis of autism on the mild end of the autistic spectrum.

Brigance Inventory for Early Development – 2nd ed. [10]

The IED-II Standardized measures children's present level of performance, and diagnoses delay, disability, giftedness, and other exceptionalities. It can monitor children's progress and assess their strengths and weaknesses in basic skill areas such as physical development, language development, early numeracy and emergent literacy skills, socialemotional development, and self-care daily living skills. The IED-II Standardized is designed for use with children from birth to 7 years old and may be administered by teachers, school psychologists, developmental experts, and other early education professionals. It covers 46 skills across five domains: physical development domain (which assess fine motor skills and gross motor skills), language development (expressive and receptive), academic/cognitive (literacy and mathematical/general concepts), daily living (the two subdomains are self-help and prevocational), and social and emotional development. The IED-II takes 20–55 min to complete depending on the age of the child. Data for many items can be obtained through parent or teacher interview. Scores are calculated by assigning a point value to each skill assessed. Total points for skills (validated) can then be converted into quotients (with a mean of 100 and an SD of 15), percentiles, age equivalents, and/or instructional ranges, depending on the need for specific results. A total adaptive behavior score can be derived from the summation of the normed skill areas. This test has high inter-rater and test–retest reliability [10].

Statistical analysis

Analysis of data was carried out by an expert statistician by an IBM computer using statistical program for social science, version 12 IBM SPSS Statistics. Descriptive statistics were determined for numerical parametric data such as mean and SD (mean ± SD) minimum and maximum of the range, whereas they were determined for categorical data as number and percentage. Qualitative variables were described as frequency and percentage. Student's *t*-test of two independent samples was used to compare quantitative variables. The χ^2-test was used to compare qualitative independent variables. The correlation coefficient test (*r*-test) was used to rank variables against each other positively or inversely. The *P*-value for level of significance was expressed as follows: >0.05 = insignificant, < 0.05 = significant, and < 0.01 = highly significant.

Results

Characteristics of the sample

There were no statistically significant differences between group I and group II in terms of sex and age. The patient group (group I) included 20 children, six females (30%) and 14 males (70%), age range 3–6 years and mean (3.91 ± 1.19) years. The control group (group II) included nine females (45%) and 11 males (55%), age range 3–6 years and mean (4.30 ± 1.36) years (Table 1).

Variable parameters were assessed for the sample. The mean age of onset of autism in the patient group was 2.29 ± 0.68 years; the mean score of CARS was 36.18 ± 5.29. The mean score of the Brigance scale was 64.89 ± 18.03 for gross motor skills, 40.75 ± 17.66 for fine motor skills, 53.18 ± 16.46 for self-help, and 52.05 ± 15.08 for the total Brigance score (Table 2).

There were highly significant differences between the patient group and control group in Student's *t*-test for the maximum and minimum range as well as the mean scores of gross motor skills, fine motor skills, and self-help skills subdomains of Brigance scores in addition to the total score ($P = 0.000$) (Tables 3 and 4).

To determine the relation between the motor deficits detected in the patient group (i.e. self-help, gross motor, and fine motor skills) and the severity of autism, we used the correlation coefficient test (*r*-test) for both the CARS total score and the Brigance scale (tested subdomain and total scores). We found a statistically significant inverse correlation between the CARS score and the Brigance scale self-help subdomain and total scores. Moreover, there was a high significant inverse correlation with the gross motor score ($r = -0.643$**, $P = 0.003$), but an insignificant inverse correlation between the CARS score and the fine motor score (Table 5).

Discussion

Although the prevalence of ASD is 8.4 in 1000 and that of autism is 4.1 in 1000 according to DSM-IV-TR, scientists did not have knowledge of the mechanism of this serious developmental problem [11]. Difficulties with gross motor

Table 1 Demographics of both groups

	n (%)				
	Patient group	Control group	Total	χ^2	*P*-value
Sex					
Females	9 (45.00)	6 (30.00)	15 (37.50)	0.960	0.327
Males	11 (55.00)	14 (70.00)	25 (62.50)		
Total	20 (100.00)	20 (100.00)	40 (100.00)		
Age					
Mean ± SD	4.30 ± 1.36	3.91 ± 1.19	*t*-test		*P*-value
Range	2–6	2–6	0.950		0.348

There were no statistically significant differences in sex and age between the two groups studied.

Table 2 Clinical variables of the patient group

	Minimum	Maximum	Mean	SD
Age of onset (years)	8/12	4	2.29	0.68
CARS score	30	48	36.18	5.29
Brigance scale gross motor skills	28.5	84.1	64.89	18.03
Brigance scale fine motor skills	17	77.5	40.75	17.66
Brigance scale self-help	21	79.5	53.18	16.46
Brigance scale total score	21	72.6	52.05	15.08

This table shows the mean scores of the Brigance scale for the patient group.

Table 3 Brigance scale scores of the control group

Brigance scale	Minimum	Maximum	Mean	SD
Gross motor skills	57.1	100	90.03	9.74
Fine motor skills	50	100	86.40	10.28
Self-help	70.1	97.2	88.16	6.56
Total Brigance score	66.9	94.7	88.07	6.21

This table shows the mean scores of the Brigance scale for the control group.

Table 4 Group (I & II) mean scores of the Brigance scale

	Patient group (I)		Control group (II)			
Brigance scale	Mean	SD	Mean	SD	*t*	*P*-value
Gross motor skills	64.89	18.03	90.03	9.74	5.455	0.000**
Fine motor skills	40.75	17.66	86.40	10.28	9.788	0.000**
Self-help	53.18	16.46	88.16	6.56	8.829	0.000**
Total of Brigance score	52.05	15.08	88.07	6.21	9.878	0.000**

**$P < 0.01$: statistically highly significant difference between the mean score of the Brigance scale of the patients and the controls.

Table 5 Correlation between the CARS score and the total as well as differential subscales of Brigance for the patient group

	CARS	
Brigance scale	*r*	*P*
Gross motor skills	−0.643[b]	0.003
Fine motor skills	−0.389	0.123
Self-help	−0.452[a]	0.045
Total Brigance score	−0.491[a]	0.028

Pearson correlation coefficients.
CARS, Childhood Autism Rating Scale.
[a]Significant relation.
[b]Highly significant relation.

and fine movement, awkward gait, avoidance of sports, dyspraxia, or motor planning disabilities were all relevant to autism (60–80% of autistic individuals) [12,13].

Scarce research and little attention has been focused on these deficits despite their relevance, evidence, and importance [8,14]. Therefore, we designed this comparative study to assess motoric deficits in a sample of autistic patients versus healthy controls to investigate the possible relation of these deficits with the case severity.

In our study, the patient group had significantly low scores on the Brigance scale compared with the healthy controls as shown in (Table 4). They had evident delay in motor development and self-help skills. This was in agreement with Lloyd *et al.* [15], and other studies on gross motor development (supine, prone, rolling, sitting, crawling, and walking) and movement abnormalities in infants later diagnosed with autism, reporting delayed motor maturity compared with typical children [16], and also in agreement with Provost *et al.* [14] Smith [17], William *et al.* [18] Mostofsky *et al.* [19] and Minshew *et al.* [20] who reported motor delay, difficulties with coordination, imitation of body movement, motor planning, and postural control as frequently reported in children with ASD, and as often viewed as one symptom of the syndrome [14,17–20].

As early as 1996, researchers reported that difficulty in motor planning and coordination are often co-occurring conditions and perhaps 'soft neurological signs' of the disorder, but was not yet considered a diagnostic criterion [21]. Motor difficulties may have been neglected in the recent past because children with ASD, in general, start to walk at the same age as typically developing children [14].

For the majority, coordination, motor dysregulation, and fine motor difficulties using standardized assessment as well as dynamic analysis of movement have been identified in ASD groups [22]. Furthermore, the possibility of motor deficits as an early marker was reported in a retrospective study of infant videos long before a diagnosis of autism was made [5]. Some reported that motor deficits may be a characteristic of the pervasive neurological nature of autism [22].

Moreover, Muratori *et al.*'s [8] conclusions suggested that motor functioning may define specific subgroups of early ASD that could be related to different pathways, adding that motor deficits could be used as an early indicator of potential autism. A published case report by Dawson *et al.* [23] analyzing developmental data of an infant diagnosed later as autistic, reported that from the first 6 months and continuing throughout the first year, numerous disturbances in muscle tone, poorly integrated movements, toe walking, and absence of a coordinated stepping pattern were apparent before the social and communication defects of autism became obvious.

As autistic symptoms could be subtle and emerge with time to later form what was previously called the 'Triad of impairment' by Wing [24], Massie [25] described motor deficits in autistic as 'Core components', adding that they could be considered as 'Prodromal symptoms' for autism. Moreover, the results of Clifford *et al.* [26] suggested that those children later diagnosed with autism were clinically distinct from their peers before the age of 2, and that there were clearly observable distinct motor behaviors that were important 'predictors' of autistic disorder in preverbal children.

However, in contrast to this, Ozonoff *et al.* [5] carried out a study of gross movement development, analyzing home videos of autistic children compared with other normal and other developmentally delayed children, and reported that autistic children did not show different rates of movement abnormalities or lack of protective responses compared with healthy controls [5]. In fact, the exact pattern of motor deficits in autism has not been described clearly in the scientific literature. One elegant study reported postural stability problems in individuals with autism, whereas others suggested abnormalities in sensory integration as the main problem [20]. This may be because of the lack of distinction between motor skills and mobility and the use of different tools, which explains why the literature on motor skills/difficulties in ASD remains contradictory and is overlooked by many [27]. Also, this could explain why so few interventions have been designed to target motor skills in children with ASD [27,28].

In addition, our results showed that the scores of CARS were negatively or inversely correlated with those of the Brigance scale, indicating the possible use of developmental motor delay in autistic children as an indication of severity. Some researchers have reported the possibility that motor coordination and social responsiveness develop in the same area in the brain, adding that the lower the motor proficiency score in children with the disorder, the greater the severity of the disorder and the degree of social impairment [7]. In this study, motor dysfunction and delay can either indicate the biological nature, and structural pathology of the disorder or may be an indicator of comorbidity rather than etiology, which requires further verification.

Conclusion

To our knowledge, none or few, if available, Egyptian studies have assessed developmental motor deficits and incoordination in autistic children and their relation to case severity. Therefore, it is premature to conclude that delay in motor development is a core feature of autism as long as it is not included in the international guidelines or standard diagnostic systems.

Our results pointed to the significant delay in motor development of autistic children compared with healthy peers that was significantly correlated to the severity of autism. It may be impossible to generalize these findings as they should be seen in the light of the limitations and suggested recommendations. However, these results highlight facts that should not be overlooked.

Limitations and recommendations

The small sample size and the use of a cross-sectional design limited our findings. Also, inclusion of another matched control group with other neurodevelopmental

disorders such as attention deficit-hyperactivity disorder but without autism or with mental retardation could have strengthened and added to the results. Therefore, it is recommended to design more comprehensive research on this topic to obtain valuable results, exploring motor skills in relation to their neurological pathway and the interrelatedness between motor, social, and cognitive development [27]. In addition, researchers should use these findings and similar findings of other studies to develop screening and diagnostic instruments designed to assess children for the presence of ASD within the first 3 years of life and should tackle 'early motor prodromal signs' (which have been proved to be the earliest signs of all other prodromal signs) in infancy and early childhood periods. Furthermore, methods should be developed for promoting motor development that could help improve other related pervasive deficits in autism.

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Conflicts of interest

There are no conflicts of interest.

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