Early Motor Skills in Children with Autism Spectrum Disorders Are Marked by Less Frequent Hand and Knees Crawling

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Abstract

Our aim in this study was to affirm or negate (quantitatively) our subjective impression of altered hands and knees crawling (H&K crawling) among children with Autism Spectrum Disorder (ASD). Through parental questionnaires and children's health records, we retrospectively compared early motor skills, including the frequency of H&K crawling in 79 children with Autistic Disorder or Asperger Syndrome versus 100 children with typical development (TD). We found H&K crawling to be significantly less frequent among children with ASD (44.2%) versus children with TD (69%). Children with ASD also showed a decreased frequency of acquiring a seating position without help and a later mean walking age compared to the TD children. These data suggest that early motor development delays may be a useful sign for detecting ASD at early ages.

Keywords: hands and knees crawling; crawling on all fours; autism spectrum disorders; motor development; early diagnosis

Introduction

Autism spectrum disorder (ASD) is lifelong developmental disorder characterized by impaired social interaction and communication as well as by repetitive behaviors and restricted interests, with a large range of varying severity (American Psychiatric Association, 2013). Its prevalence has increased strongly in recent decades, with high variability across the world, and a mean national prevalence about 0.7 - 1% (Chiarotti & Veneros, 2020). Thus, ASD is a serious public health challenge, involving individuals with ASD, their families and society generally.

Early diagnosis of ASD can lead to a substantial improvement in quality of life for children with ASD, thanks to early and intensive interventions (e.g. Rogers, 1996). While ASD is often diagnosed after age three (Goin-Kochel et al., 2006), some symptoms are present earlier. Identifying them and developing methods to facilitate early diagnosis are urgently needed (e.g. King & Bearman, 2009). To date, researchers and clinicians look for various warning signs, such as characteristic brain functioning (e.g. Bosl et al., 2011), eye movements (e.g. Jones & Klin, 2013), gene expression profiles (e.g. Scherer & Dawson, 2011), and even head circumference at birth (e.g. Grandgeorge et al., 2013) or symptom trajectory (e.g. Elder et al., 2008).

Among possible warning signs, motor abnormalities have received much recent attention (for a review, see Esposito & Venuti, 2008; Wilson et al, 2018). Some authors have speculated that movement disturbances may be directly related to the ASD core symptoms and should be considered as a first sign of the disorder, even one that may precede characteristic social or linguistic abnormalities (Leary & Hill, 1996). To explore these early motor abnormalities, researchers have retrospectively examined earlier studies of ASD children (e.g., through family home movies) and conducted prospective longitudinal studies of high-risk children (e.g., siblings of children with ASD). These methods have provided opportunities to observe the child's development prior to a formal ASD diagnosis (e.g. Adrien et al., 1993;

Bryson et al., 2007; Flanagan et al., 2012; Kanner, 1943). Teitelbaum et al. (1998) studied 17 infants aged 4-6 months who were later diagnosed with ASD and found that all of these infants displayed both some abnormal movement patterns (e.g., atypical organization of body segments when rolling from prone to supine, inability to maintain balance while sitting independently) and delayed motor skills during the first year of life. Others have confirmed these symptoms through reports of numerous examples of motor difficulties among children with ASD during their first two years of life (e.g., Dawson et al, 2000; Landa & Garrett-Mayer, 2006). These studies clearly highlighted the importance of examining motor skills for early identification of ASD and the resultant need for more research focused on early motor development in infants at high risk for ASD (Bhat et al., 2011).

According to the World Health Organization's (WHO) Motor Development Study (WHO Group & De Onis, 2006), six gross motor development skills have been identified for study (sitting without support, hands and knees [H&K] crawling, standing with assistance, walking with assistance, standing alone and then walking alone), since approximately 90% of typically developing children achieved these skills at predictable ages. Among these six gross motor skills, H&K crawling has been used by most children as an intermediate way of moving before starting to walk, and the timing of its acquisition has been integrated into various standardized developmental assessment scales (Bayle, 1993; Zdanska-Bricken & Wolanski, 1969). Although this locomotor skill is typically present in infants, it is well documented that some infants skip this stage with no negative consequences (Esposito et al., 2009). Most infants start H&K crawling when they begin to sit, the median age for which is approximately 8.3 months (WHO Group & De Onis, 2006).

H&K crawling is described as, "... the child alternately moves forward or backward on hand and knees, the stomach does not touch the supporting surface, and there are continuous and consecutive movements, at least three in a row." (Wijnhoven et al., 2004, S38). In ASD,

deviations from the normal pattern of H&K crawling have been reported. Teitelbaum et al. (1998) observed asymmetrical lack of support in the arms and asymmetry in the legs; and, according to these authors, similar patterns of movement disorders exist in children with sub-diagnoses of both Asperger Syndrome (AS) and Autistic Disorder (Teitelbaum et al., 2004). Kim (2008) focused on both babbling and H&K crawling symptoms that were displayed through parental reports among a sample of 32 children with ASD aged 35- to 65-months old. Five of these children did not use H&K crawling, though typically developing children began to display H&K crawling at an average age of 8.5 months. Another study, based on 54 children with ASD (Ozonoff et al., 2008) found that two subgroups of 48 children in this sample whose parents reported that the children used H&K crawling at either a mean age of 8.3 months (ASD without regression) or 7.3 months (ASD with regression). Thus, H&K crawling may be an interesting behavior to consider for distinguishing typical and atypical motor skill development. Indeed, children with dyslexia also displayed numerous motor skill delays, including H&K crawling (e.g., Fawcett & Nicolson, 1992) as did developmentally delayed infants, who were at high risk of cerebral palsy (Xiong et al, 2018).

While investigators have often studied qualitative abnormalities among children with ASD, there has been limited preliminary quantitative data on H&K crawling frequency in this population. To fill this research gap, our goal for this study was to evaluate the frequency of H&K crawling in children with ASD compared to a cohort of children with typical development. Our hypotheses were that (a) fewer children with ASD, compared to children with typical development, would display H&K crawling before walking and (b) absence of H&K crawling might be associated with absence of other motor skills.

Method

Participants

Participants in this research were children and adolescents aged between 18 months and 15 years of age in two groups: (a) a clinical group of 79 children with ASD; and (b) a control group of 100 children with typical development. Further details regarding each group are presented below. As data collection for this study preceded 2014 when there was no French requirement for protocol approval from a formal ethics committee of our University. Rather, researchers engaged in non-invasive investigations with no medical/pharmacological interventions, and we were expected to follow the principles expressed in the Helsinki Declaration. We adhered to those principles and obtained informed verbal consent from parents of all participants in this study to access the children's health records without disclosing their identity in any fashion, with data gathered shared only in a denominated, aggregate form. Parents also agreed to respond to a questionnaire about their children. We received retrospective approval for this process from the chair of our institutional review board.

ASD Group

We first recruited French children and adolescents in the ASD group from within the full database of the [...] (a clinic specializing in the diagnosis and assessment of ASD) between 2011 and 2014 ($n = 300$). Inclusion criteria for these children were (a) a diagnosis of Autistic Disorder (F84.0) or Asperger syndrome (F84.5) according to the ICD-10 (*International Classification of Diseases, 10th Edition*, World Health Organization, 1994) and DSM IV (*Diagnostic and Statistical Manual for Mental Disorders, Fourth Edition*, American Psychiatric Association, 1994) criteria (see below for further details on the diagnostic process) and (b) aged less than 15 years of age at the time of the first evaluation. We excluded individuals with (a) other known congenital, genetic or neurological abnormalities, (b) premature birth (gestational age less than 37 weeks), or (c) epilepsy. These inclusion/exclusion criteria narrowed the sample size to 129 children and adolescents.

Next, parents were called to give their consent to our extracting data from their children's health records and to personally answering a short questionnaire (see below). This written questionnaire was completed directly by parents the with a professional's help as needed. From this survey, we eliminated an additional 50 families from further study, mainly because their parents did not respond to the researchers' requests (e.g., could not be contacted due to an outdated address or email) or had no time. Thus, the ASD group was then comprised of 79 children whose parents responded positively to research participation, consisting of 64 males and 15 females (M age= 103.2, SD = 20.7 months); there were 43 participants with Autistic disorder (F84.0; 34 males, 9 females) and 36 participants with Asperger syndrome (F84.5; 30 males, 6 females). As noted, all of these children were diagnosed by a child psychiatrist, based on criteria from the DSM IV and ICD-10, with the diagnosis confirmed, at least, by Autism Diagnostic Interview – Revised (ADI-R) ratings (Lord et al., 1994).

Typical Development Group

Participants in our control group were also recruited in France, through different adverts (e.g., school), and their inclusion was based on the informed voluntary participation of their parents. To be eligible, these children and adolescents (a) were also between 18 months and 15 years old, (b) had parent-completed questionnaires (see below), and (c) had never presented any developmental delay (based on information in the children's health records and parental reports). We excluded individuals with (a) congenital, genetic or neurological abnormalities (or suspicion of such conditions), (b) siblings diagnosed with ASD or related disorders, (c) premature births (gestational age less than 37 weeks), and (d) epilepsy. These inclusion/exclusion criteria led to a control group of 100 individuals (46 males, 54 females; (M age = 53.1, SD =16.3 months). Table 1 summarizes all participant characteristics.

[Insert Table 1]

Procedure

Data Collection

As noted, we collected developmental data from the children's health records and from the parental questionnaire created for this study. This questionnaire included questions about six motor developmental skills, the importance of which has been shown in the literature as reported above:

- Holding up their own head at four months of age (yes/no)
- Leaning on their own forearms at four months of age (yes/no)
- Sitting without support at nine months of age (yes/no)
- Moving at nine months of age (e.g., crawling, rolling) (yes/no)
- Age of walking at least 10 steps without help
- Hands and Knees (H&K) crawling: presence (yes/no); and age of first appearance. If yes, presence of any peculiarity in this motor skill; if no, presence of other ways to move
- Motor rehabilitation before walking (e.g., physiotherapy) (yes/no)

Parents were given a precise definition of each motor developmental skill. Concerning our main interest in H&K crawling, our precise description, to assist parental recall, was as follows: "...child alternately moves forward or backward on hands and knees, the stomach doesn't touch the supporting surface, and there are continuous and consecutive movements, at least three in a row". If parents had trouble recalling or identifying the skill, we would show them a drawing board representing different moments of the hand and knees crawling (Fig. 1). Furthermore, the several motor developmental skills included were investigated following a chronological and developmental way to help the parental recall, that is, we began by the first skills acquired (e.g. holding up their own head) and finished by walking.

Figure 1: Drawing board representing hand and knees crawling

Moreover, in France, all children are routinely examined by a trained physician during the first year of life, and personal information is compiled in their health records (i.e., a medical document completed by the primary care physician at each childhood life stage). These records were used in this study to confirm parental reports for:

- Holding up their own head at 4 months of age
- Leaning on their own forearms at 4 months of age
- Sitting without support at 9 months of age
- Moving at 9 months of age (e.g., crawling, rolling)
- Age of walking at least 10 steps without help

If differences appeared between the parental report and the childhood health records for a given child/adolescent, we used data from health records.

Data analysis

Because our data were not normally distributed, we used nonparametric statistical tests to compare groups. Data were analyzed using SPSS 19 software (IBM software, USA). The statistical significance threshold was set at $p < 0.05$. We used Chi-square tests to compare groups on categorical variables (e.g., presence or absence of H&K crawling), with the average age for onset of walking compared between groups using Mann–Whitney U-tests.

Results

H&K Crawling before Walking

There was some missing data in both groups regarding some of the developmental milestones. However, from available data, 41 participants with ASD (51.9%) and 69 (69%) participants in the control group crawled on their hands and knees before walking. The control group and the collective ASD group were significantly different with regard to the presence of H&K crawling before walking ($X^2 = 8.02$, $p = .005$; $\Phi^2 = .045$). H&K crawling before walking was reported in 19 (44.2%) of the participants with Autistic Disorder, which was significantly lower than the rate (69%) found in the control group ($X^2 = 7.82$; $p = .0052$; $\Phi^2 = .055$). Nineteen (52.8%) of participants with Asperger Syndrome engaged in H&K crawling before walking, but this difference from the control group did not reach statistical significance ($X^2 = 3.05$, $p = .08$; $\Phi^2 = .022$). See Figure 2.

Figure 2: Percentage Rate of H&K Crawling in the ASD Group (separated here into the two sub-groups) as Compared to the Percentage Rate in the Control Group

Note: Chi-square tests: $**p < .01$.

Only 49 parents of ASD group gave data regarding their children's motor rehabilitation for these participants with ASD, H&K crawling before walking was reported more frequently for participants with ASD who did not undergo motor rehabilitation (96.2%; $X^2 = 4.08$, $p = .043$) than among those who did. The four participants with a diagnosis of Autistic Disorder who underwent a rehabilitation program did not crawl on their hands and knees before walking ($X^2 = 4.36$, $p = .037$).

Within the ASD group, the rate of H&K crawling before walking did not differ significantly by gender ($X^2 = 0.49$, $p = .485$), age for onset of walking ($U = 775.5$ $p = .561$), the presence of other ways to move before walking ($X^2 = 2.31$, $p = .129$), holding up their own head at four months of age ($X^2 = 0.35$ $p = .555$), leaning on their own forearms at four months of age ($X^2 = 0.06$ $p = .80$), sitting without support at nine months ($X^2 = 0.01$, $p = .908$) or moving at nine months ($X^2 = 1.29$, $p = .255$). There were no significant differences between ASD subgroups of Asperger Syndrome and Autistic Disorder ($X^2 = 0.58$ $p = .557$) on these variables. Notably, some individuals with ASD used other ways to move before walking. Ten participants with ASD (two males with Asperger syndrome and six males and two females with Autism) were reported to have moved on their buttocks, and twelve (four with Asperger syndrome and eight with Autism; all were males) were reported to have crawled. Eleven participants (four males) in the control group were also reported as having moved on their buttocks (four males) and fifteen (11 males) crawled.

Other Motor Development Skills

Examining available data for the participants' motor skill development generally, among participants with ASD, the average age of onset for walking was 15.3 ($SD = 2.1$) months for individuals with ASD, and this age was significantly older than the average age of 13.1 ($SD =$

1.2) months for this achievement among participants in the control group ($U = 2420.5$, $p < 0.001$). Considering ASD subgroups separately, the mean age for walking was 15.9 ($SD = 2.3$) months for individuals with Autistic Disorder and 14.5 ($SD = 1.9$) months for those with Asperger Syndrome; both were significantly older, compared to individuals in the control group ($U = 1082$, $p < .001$; and $U = 1338.5$, $p = .037$, respectively).

From available data, Table 2 shows the percentage of individuals who achieved the four motor development skills at time threshold, presented as percentages. The majority of individuals in both groups were reported as having held up their heads at four months of age. The percentage in the control group (95.4%) did not differ significantly from that of participants with ASD (97%), nor were rates of this achievement significantly different between control group participants and participants in the separate ASD subgroups of Autistic Disorder and Asperger Syndrome (all Chi-square tests, $p > .05$). Similarly, most individuals in both groups were reported as having leaned on their own forearms at four months of age. The rates of the control (88%) and ASD (85%) groups at achieving this milestone on time did not differ significantly, nor did the rates between the control group and either of the two separate ASD subgroups (all Chi-square tests, $p > .05$).

Sitting without support at nine months of age was reported for 98% of individuals in the control group, and this rate was significantly higher than the rate of 81.8% found for participants in the collective ASD group ($X^2 = 13.48$, $p < .001$), or the rates of the two subgroups of Autistic Disorder or Asperger Syndrome (both Chi-square tests, $p < .05$). Moving at nine months of age was reported for 84% of individuals in the control group, and this rate was significantly higher than the rate of 66.1% found among participants in the ASD group ($X^2 = 7.08$, $p < .001$) and when compared to those with Autistic Disorder ($X^2 = 9.26$, $p = .002$). There was no difference in this rate between the control group and participants Asperger's Syndrome ($X^2 = 1.52$, $p = .218$).

[Insert Table 2 about here.]

Discussion

Our aim in this study was to compare the incidence of omitting or delaying hands and knees or H&K crawling during early development among children with ASD compared to typically developing children. Secondly, we sought to examine possible links between the comparative delays in this locomotor skill and other motor skills in these two groups. Our retrospective data of samples of children and adolescents from parent report and health records confirmed our initial hypothesis that fewer children with ASD (vs. typically developing children) displayed H&K crawling before walking than children with typical development. We also identified significant differences between these two groups of children in their development of other motor skills, such that, at nine months, fewer children with ASD than typically developing children sat still without support and children with ASD walked later, compared to typically developing children. There was no difference for holding up their heads or leaning on their forearms at four months. These findings are consistent with results from Teitelbaum et al. (1998) showing that children with ASD at six months of age were unable to maintain sitting stability, whereas typically developing children were. In our study, among those with ASD, H&K crawling before walking was more frequent for those who did not have motor rehabilitation, relative to those who did have motor rehabilitation. Among children with ASD, neither participant gender nor ASD sub-diagnosis (i.e., of Autistic Disorder or Asperger Syndrome) was associated with differences in H&K crawling.

About half of the children with ASD in this study crawled on their hands and knees before walking while significantly more (69%) typically developing children did so, even though the percentage of typically developing children who crawled before walking in this

study was quite low, compared to 90% from other prior reports (WHO, 2006). These differences may derive from either or both (a) different definitions of H&K crawling and (b) cultural differences in this developmental milestone. In this study, tracked H&K crawling before walking while the WHO Study group (2006) did not attend to the order of crawling and walking). Among children with ASD, other researchers also reported higher percentages of crawling than we did (e.g., 84% by Kim, 2008; and 88% by Ozonoff et al., 2008), but both of these other studies studied a smaller and/or younger sample, and relied on different inclusion criteria and/or criteria for defining crawling onset. Furthermore, the average onset for age of walking among children with ASD was later (15 months old) in our study relative to age of walking for typically developing children (13 months old). Regarding the specific ASD subgroup of children with Asperger's Syndrome, unlike Tetelbaum's (2004) qualitative findings, our quantitative data did not show the incidence of H&K crawling before walking for this subgroup to be less frequent than that of typically developing children.

Several hypotheses may explain the lower frequency of crawling in children with ASD compared with typical developing children. First, a sensory-motor explanation, based on physiotherapist works (Bullinger, 1998), suggests that H&K crawling requires the development of specific flexion and extension patterns to prevent rotations of the bust that, in association with a loss of visual-motor coordination, represent altered motor skills in children with ASD children (Bullinger, 1998). Second, given atypical visual processing (Simmons et al., 2009 for a review), especially for motion coherence and motion perception (Dakin & Frith, 2005; Gepner et al., 1995), as well as unusual responses to optic information flow and/or abnormal postural control (Milne et al., 2005) among children with ASD, H&K crawling may be a complicated way to for children with ASD to move. Third, related to sensory difficulties observed in the majority of people with ASD (Ben Sasson et al, 2009), especially the sense of touch, hyper-sensitivity to different textures and associated anxiety may impede crawling for early aged

children with ASD relative to other children without these sensory integration difficulties (Ayres, 1972; Royeen & Lane, 1991). Tactile stimulation reactions among children with ASD may vary but usually take the form of an avoidance-withdrawal response (e.g., rubbing and scratching, negative emotional reaction, avoidance of a specific texture). One could argue that different floor textures and sensations (e.g., carpet may be itchy, tiles may be too cold; Grandin & Scariano, 1996) may produce aversive reactions to H&K crawling, that lead some children with ASD to walk directly, without a prior reliance on crawling for locomotion. Fourth, and perhaps related to this sensory integration hypothesis, there appears to be a general reduction in exploratory behaviors among children with ASD (DSM-IV; APA, 2013). For most infants, H&K crawling is the first way to get independent mobility and to explore their environment. Crawling may be an early means of exploration and experimentation with new coordinated movement patterns for typically developing children who find this more satisfying than do children with ASD who engage in more avoidant behaviors. Thus, the relatively lower frequency of crawling among children with ASD may be due to their reduced ability or willingness to experiment and explore (Kawa & Pisula, 2013). This reluctance could link as well a possible association between ASD and the presence of that muscular diseases, highlighting the importance of considering a variety of etiological factors in assessment procedures. Finally, for some children with ASD, a coexisting intellectual disability or associated cognitive dysfunction may impact motor development (Thelen, 2004). For example, a study comparing motor abilities of children diagnosed with fragile X syndrome with and without ASD (Zingerevich et al, 2008), showed that intellectual level contributed to reduced motor abilities of children with both ASD and fragile X syndrome. Indeed, this link between motor and cognitive abilities is not ASD specific as it is well known in typical development (Iverson, 2010) and in other developmental disorders as well. For example, children with Developmental Coordination Disorder (World Health Organization, 1994) have encountered

motor deficits often followed by other cognitive problems, such as disorders of attention or speech/language (Deng et al, 2014). These various hypothetical explanations for a reduced frequency of H&K crawling among children with ASD relative to children with typical development may not be mutually exclusive, as they may be combined in some or all children with ASD.

Additionally, previous studies have shown that motor delays associated with ASD are difficult to differentiate from motor delays associated with other, possibly comorbid, developmental disorders (Miyahara et al., 1997; Noterdaeme et al., 2002). Thus, early signs of motor delay may simply be a consequence of a general developmental disorder that is not specific to ASD. However, even if delays in the achievement of major motor skills are not specific to ASD, they are indicative of a general risk for these children; and, given the importance of skilled movement for perception, action and cognition (Thelen, 2004), it is critical to identify such delays and to provide appropriate interventions for them at an early age.

Limitations and Directions for Future Research

The main limitations of this study were our dependence on retrospective parent reporting and our samples of children who varied widely in age in each of our two groups. As parent recall may become less accurate over time, our findings may reflect some systematic variation in parent recall, referred to as forward telescoping (Loftus & Marburger, 1983) in which people report events as having occurred more recently (closer to the time of recollection) than they actually took place and recall distant events with less accuracy over time. This tendency may even have differentially affected the recall of children in the ASD versus the control group, since the children in the ASD group tended to be older. But, this phenomenon depends on the nature of the behavior being recalled (Loftus & Marburger, 1983). We believe that our data should have suffered only minimally from this phenomenon because hands and knees crawling is a clearly defined and memorable separate event, much like independent

walking. Hus et al. (2011) showed that age of onset for independent walking is a fundamental and reliable parent-reported skill as it is a clear defined and separate event (compared to language onset for example). This was confirmed by other recent research (Ozonoff et al, 2018). Furthermore, our study did not require parents to provide an age for their child's first H&K crawling, but, rather asked them to recall its order in relation to walking. We propose that this binary criterion for a clearly defined and separate event should have afforded good reliability of parental recall. Indeed, dramatic changes occur when a child moves from prone to upright postures or from immobility to independent locomotion, and these dramatic changes improve accuracy of parental recall. It is also true that H&K crawling usually has many concrete consequences for parents' daily lives (in terms of home security, domestic accident prevention) when a child shifts from sitting in one place to moving alone for the first time, all of which should assist parental recall, even over long timespans. Moreover, starting to walk alone prior to H&K crawling is a very rare developmental trajectory (WHO Group & De Onis, 2006). Therefore, we can assume that recall of this atypical sequence could be all the more reliable that it might be considered by parents as a developmental regression and loss of skills in motor development. At last, since age of onset for independent walking is a highly salient event accurately dated without telescoping effect, it may also have served as temporal marker and chronological landmark event to improve the accuracy of recall whether H&K crawling occurred before or after by reference to that date. Another possibility for further research in this area would be to use landmark-based interviewing (Gernsbacher et al., 2008) to support the accuracy of parent recall. Additionally, our choice to use data from children's health records when there were differences between health records and parental reports further minimized a effect of relying on parent recall.

Another study limitation was related to our recruitment of control group participants. This recruitment was based on a convenient sample of voluntary parent participants rather than

a random subset of typically developing children. Thus, this missing of matching of important attributes such as age, sex or socioeconomic status was clearly a limitation that should be further explored. Moreover, these children were not submitted to full diagnostic screening with its objective data. Here too, we relied upon developmental information from volunteer parents and data from each child's health record to help exclude any developmental delay, any suspicion of congenital, genetic or neurological abnormalities, children with siblings diagnosed with ASD or related disorders, prematurity, or epilepsy. Thus, there was a possibility of including a participant with some type of developmental impairment in the control group. We took steps to minimize this risk, and we believe it unlikely that this would have affected our overall results. Future studies of this kind might ideally include cognitive/neuropsychological assessments as well as socioeconomic status of the family to help measure underlying factors of relevance to these motor deviations, not the least of which might include variance in executive functioning known to affect motor performance. Finally, our findings need to be confirmed or replicated with a larger sample and/or complementary studies.

Conclusion

This study of H&K crawling and other early motor skills in children with ASD highlights the importance of monitoring early motor functioning as potential signs of intervention needs, especially for at-risk populations. Further studies should systematically assess both quantitative and qualitative aspects of early motor behaviors in very young children with known or suspected ASD and our results suggest a potential benefit to attending specifically to H&K crawling. Identifying motor delays and abnormalities in infants' motor skills, especially in populations at-risk for ASD populations, should lead to earlier interventions to facilitate these children's better outcomes in motor, social and communication development.

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	Typical Development	Autistic disorder	Asperger syndrome
Sample size	n =100	n = 43	n =36
Age in months - <i>M</i> (<i>SD</i>)	53.1 (16.3)	86.7 (19.7)	122.9 (17.5)
Gender – males/females	46/54	34/9	30/6

Table 1. Participants' Ages and Gender by Group at Time of Data Collection

	At 4 months				At 9 months			
	Holding own head		Leaning on own forearms		Sitting without support		Moving	
	Percentage of individuals	X ² (p-value)	Percentage of individuals	X ² (p-value)	Percentage of individuals	X ² (p-value)	Percentage of individuals	X ² (p-value)
Control	97%		88%		98%		84%	
ASD	95.4%	0.26 (0.610)	85%	0.3 (0.586)	81.8%	13.48 (<0.001)	66.1%	7.08 (0.008)
Autistic disorder	91.4%	1.86 (0.173)	81.3%	0.94 (0.333)	76.5%	17.03 (<0.001)	58.8%	9.26 (0.002)
Asperger syndrom	100%	0.96 (0.327)	89.3%	0.03 (0.852)	87.5%	6.16 (0.013)	74.2%	1.52 (0.218)

Table 2. Comparisons of Motor Development Skills for Participants in ASD and Control Groups

Notes: Motor development skills are expressed as the percentage of participants who acquired this skill at the expected age threshold shown. Chi-square tests level of significance: $p < .05$.

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