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Tremor in a Population-Based Cohort of Children in New York City

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Abstract

Background—There have been virtually no surveys of the prevalence, clinical features or correlates of tremor in children, and none in the United States.

Methods—317 children (age 11.0 ± 1.1 years, range = 9.0 – 14.7) underwent an evaluation at one time point. Each drew Archimedes spirals, which were rated by a senior neurologist specializing in movement disorders.

Results—A spiral score of 1 (mild but consistent tremor) was present in either hand in 105 (33.1%) children; a higher score (1.5, mild to moderate tremor) was present in either hand in 7 (2.2%) children. Higher spiral scores were associated with poorer motor hand function as assessed using the Purdue Pegboard test. Spiral scores were higher in boys than girls, were inversely associated with age, and were higher in the non-dominant than dominant hand. Spiral scores were highest in children who were taking psychiatric medications and in children with psychiatric or neurological disorders.

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Conclusions—Mild tremor is common in children, and covaries significantly with several demographic and clinical factors as well as usage of certain medications. It also lessens with advancing age. Rather than an isolated finding, tremor was associated with other measures of poorer motor hand function.

Keywords

tremor; children; pediatric; clinical; epidemiology

Introduction

Tremor is a condition that is highly prevalent in human populations, particularly among the elderly.^{1–3} The focus of tremor research has almost exclusively been on adult populations. Curiously, there have been virtually no surveys of the prevalence, clinical features or correlates of tremor among children.⁴ In 2000, nearly 1 in 4 (i.e. 24.0%) people in the United States were under age 18 years;⁵ hence, the health of this age group, which also forms the core of the future adult population, is of considerable importance. A prospective population-based study of environmental exposures and neuro-cognitive development was conducted in New York City children.⁶ We used this opportunity to study tremor in more than 300 such children, all of whom drew spirals with each hand, from which tremor was systematically quantified by a senior movement disorders neurologist using a published clinical rating scale.⁴

Methods

Study and Study Sample

The subjects for this report were participants in an ongoing prospective cohort study (Columbia Center for Children's Environmental Health) of inner-city mothers and their newborn infants,⁶ and a follow-up study of neurodevelopment and brain function in the same cohort.⁷ The cohort study was initiated in 1997 to evaluate the effects of common ambient exposures on neuro-cognitive development in a cohort of newborns from low-income communities in New York City. The study was approved by the Institutional Review Board of Columbia University. Informed consent was obtained from all mothers, and informed assent, from all children (starting at age 7).

Of 725 pregnant women who consented to participate in the study and gave birth between 1997 and 2007, 535 mother-child dyads were retained in the full cohort at the time of this report. Of these children, 317 had: (1) reached at least nine years of age; (2) maternal and/or cord blood samples at delivery; (3) postnatal socio-demographic and biomedical covariates; (4) neurodevelopmental outcomes; (5) one set of handdrawn spirals (as described below).

Study Assessment

The in-home, yearly evaluation of mother-child dyads was conducted by a trained tester and included the collection of demographic data as well as data on medical diagnoses (e.g., epilepsy, attention deficit hyperactivity disorder [ADHD], depression, asthma), learning disorders, and medications. This included medications taken for any psychiatric or

neurological condition (e.g., depression, ADHD, epilepsy) or for any medical condition (e.g., asthma).

During their most recent yearly assessment, each child was also asked to draw five spirals: a practice Archimedes spiral with their dominant hand followed by four additional spirals (two with dominant hand followed by two with non-dominant hand). Spirals were drawn on a standard 8.5 × 11 inch sheet of paper using a pen or pencil while the participant was seated at a table. The paper was centered at right angles directly in front of them and held down by their other hand. The drawing hand was not allowed to rest or be supported when the spiral was being drawn. Participants started at the center of the page, without lifting their pen/pencil. The practice spiral was drawn in between the lines of a standardized, pre-drawn, photocopied, spiral. The remaining spirals were drawn free-hand on a blank sheet of paper.

Tremor in these five spiral drawings was later rated by a senior neurologist specializing in movement disorders (E.D.L.) who was blinded to all clinical information. Tremor ratings, published previously,⁴ for each spiral were: 0 (no tremor), 0.5 (subtle, low amplitude oscillations are present in a few spots but are not consistently present throughout the spiral), 1.0 (low amplitude oscillations are present in multiple places), 1.5 (low amplitude oscillations are present in multiple places and oscillations can at times reach moderate amplitude), 2 (moderate amplitude oscillations present throughout the spiral) (for examples of rated spirals, see Figures 2, 3 and 4 in⁴ as well as Figure 1 in this report). We have previously shown in a study in which 200 spirals were rated by four raters that the inter-rater agreement between the senior movement disorder and three other raters was high (interclass correlation coefficients = 0.67 – 0.74, $p < 0.001$).⁸ During spiral rating, the neurologist was careful to distinguish clear, regular, oscillations from sloppiness, spatial errors, and other irregularities or movement dysfluencies that were not strictly oscillatory. There were three spiral scores for each child: the spiral score of the practice spiral, the spiral score in the dominant hand (the average of the two ratings), and the spiral score in the non- dominant hand (the average of the two ratings).

To further evaluate the performance of hand motor function, each child performed the Purdue Pegboard test, which measured gross movements of hands, fingers and arms, and fingertip dexterity in assembly tasks. The child was asked to place small metal pegs in holes in a 30 second practice trial. This was followed by two 30 second trials with each hand separately and two 30 second trials with both hands simultaneously. A stopwatch was used for administration of the test, and the number of pegs placed was recorded. The Purdue pegboard test score was the average of the two trials that used both hands simultaneously.⁹

Statistical Analyses

The three spiral scores were not normally distributed (Kolmogorov-Smirnov tests < 0.05); therefore, non-parametric tests (e.g., Mann-Whitney test, Spearman's r) were used in analyses of these three variables. All analyses were performed in SPSS (version 21.0).

Results

There were 317 children (mean age = 11.0 ± 1.1 years, range = 9.0 – 14.7 years, Table 1). A spiral score of 1 (mild but consistent tremor) was present in either hand in 105 (33.1%) children, in the dominant hand in 40 (12.6%) children, in the non-dominant hand in 94 (29.7%) children, and in both hands in 29 (9.1%) children. A higher score (1.5, mild to moderate tremor) was present in the dominant hand in 0 (0.0%) children and in the non-dominant hand in 7 (2.2%) children. No children had scores of 2 or higher.

The mean spiral score was 0.56 ± 0.39 in the non-dominant hand and 0.41 ± 0.33 in the dominant hand (Table 1). In 117 (36.9%) of 317 children, the non-dominant spiral score was greater than the dominant spiral score, and in 170 (53.6%) they were equal. In only 30 (9.5%) was the dominant spiral score greater than the non-dominant spiral score.

Boys had higher spiral scores than girls; the difference in the spiral score on the practice spiral reached statistical significance (Table 2).

Age was inversely associated with the spiral score in the dominant arm (Spearman's $r = -0.20$, $p < 0.001$), the spiral score in the non-dominant arm (Spearman's $r = -0.12$, $p = 0.03$), and the score on the practice spiral (Spearman's $r = -0.19$, $p = 0.001$) (i.e., with older age, there was a significant reduction in spiral scores).

Approximately 15% of the children were taking medication. The spiral score in the non-dominant hand was highest in children who were taking a psychiatric medication (Table 3). Spiral scores did not vary by use of asthma medication (Table 3).

Slightly more than 6% of the children had symptoms of a psychiatric disorder, with the most common being ADHD, followed by depression, or a neurological disorder, with the most common being epilepsy, and their spiral test scores were higher than those of children without co-morbidity (Table 4, top rows). This difference was not due to the effects of medication; when we restricted the analysis to children who were not taking medication, the differences largely persisted, although the power of these analyses was reduced (Table 4, bottom rows). Children with learning disorders did not differ to a significant degree from those without comorbidity in terms of their spiral scores (Table 4).

The mean spiral score of the practice spiral was 0.48 ± 0.39 (Table 1). In 84 (27.6%) of 304 children who provided practice spirals, the mean practice spiral score was greater than the mean dominant spiral score, in 174 (57.2%) they were equal, and in only 46 (15.1%) was the mean dominant spiral score greater than the mean practice spiral score.

The score on the Purdue pegboard test score was inversely correlated with the score on the practice spiral (Spearman's $r = -0.14$, $p = 0.03$) and trended towards a similar inverse correlation with both the dominant and non-dominant spiral scores (for both, Spearman's $r = -0.11$, $p = 0.08$) (i.e., greater tremor was associated with fewer correct peg placements).

Discussion

There have been few studies of tremor in children. We studied more than 300 boys and girls (mean age = 11.0 years) living in New York City. Higher tremor scores (1.5, mild to moderate tremor) were present in few children (7, 2.2%).⁴ However, milder tremor (rating of 1) was present in both hands in approximately 1 in 10 children (i.e. 29 or 9.1%), indicating that there is some measureable tremor in this age group.⁴ The tremor was associated with poorer motor dexterity (i.e., poorer motor hand function) as assessed using the Purdue Pegboard test.

There have been few prior systematic studies of tremor in children and none in the United States. In a prior study we assessed tremor, using spirals, in more than 800 schoolchildren living in Spain.⁴ In that study, however, we were not able to assess in detail the effects of medications or medical comorbidity. In a study of 311 children aged 11 – 14 in Valcomonica Italy, tremor was measured by accelerometry¹⁰; however, tremor was not the focus of that study and its attendant analyses. An accelerometric study of tremor in 287 children aged 2–16 years was conducted in England in 1959.¹¹ However, the study focused on the effects of age on tremor frequency. Tremor amplitude was not assessed nor were gender differences or side to side differences.¹¹

Approximately 15% of the children in our cohort were taking medication. Spiral scores were highest in children who were taking psychiatric medications, with this effect most pronounced in the non-dominant hand. While numerous medications produce mild tremor, and some of the tremor we observed could have been due to medication, we also found that children with psychiatric or neurological disorders had higher spiral test scores than those without such comorbidities and this seemed to be independent of medication. These data suggest that these disorders might themselves be associated with subtle motor system manifestations.

Tremor was greater in the non-dominant hand than in the dominant hand. This side-side difference has been demonstrated in numerous studies of adults^{1, 12} as well as our prior study of children.⁴ Motor control, in general, is superior in the dominant than non-dominant arm, and this is one possible explanation. Motor ability in the non-dominant arm likely reflects more of a raw physiological state while motor output in the dominant arm also reflects a trained state. Of related interest is that tremor in our cohort lessened with advancing age. This might be the result of improving motor performance with age.

The tremor was associated with poorer motor hand function as assessed using the Purdue Pegboard test, indicating either that the tremor itself resulted in some reduction in dexterity or that both the tremor and the loss of dexterity were a result of an underlying perturbed motor state.

This study had limitations. We recognize that tremor was assessed using a clinical scale rather than accelerometry. Despite this, the method we used is very sensitive. Our data in other studies¹ has indicated that spiral drawings are a reasonably sensitive measure of tremor, as 97.0% of individuals with mild or greater tremor on a more detailed tremor examination exhibited ratings of 0.5 in one or more hands during spiral drawing. Second, the

current results reflect a sample of low-income children in New York City, and future studies should assess whether they may be generalized to other cohorts. Third, the spiral assessment was at one point in time rather than longitudinal; additional follow-up studies are needed. Finally, although the reliability of the rating scale has been demonstrated, the raters were not child neurologists, and it would be useful to conduct a reliability study among a group of pediatric neurologist. This study also had considerable strengths including the assessment of tremor in more than 300 children in a systematic way, the evaluation of spirals by a clinically-blinded senior neurologist specializing in movement disorders, and the ability to assess tremor in relation to a number of important clinical correlates including age, gender, medications and medical comorbidities.

Mild tremor is common in children. It covaries significantly with several demographic and clinical factors as well as usage of certain medications. It also lessens with advancing age. Rather than an isolated finding, tremor was associated with other measures of poorer motor hand function.

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Figure 1.

Examples of spirals given ratings of 0 – 1.5 (A – D). A. Rating = 0 (no tremor). B. Rating = 0.5 (subtle, low amplitude oscillations are present in a few spots [see arrows] but are not consistently present throughout the spiral). C. Rating = 1.0 (low amplitude oscillations are present in multiple places). D. Rating = 1.5 (low amplitude oscillations are present in multiple places and oscillations can at times reach moderate amplitude),

Table 1

Demographic and Clinical Characteristics of 317 Children

Age in years	11.0 ± 1.1 (9.0 – 14.7)
Girls	174 (54.9)
Right-handed	282 (89.0)
Current medication usage	
None	270 (85.2)
Asthma Medication	39 (12.3)
Psychiatric Medication ^a	8 (2.5)
Diagnoses	
None	278 (87.7)
Learning Disorder	18 (5.7)
Psychiatric or Neurologic Disorder ^b	21 (6.6)
Spiral score (dominant hand)	0.41 ± 0.33 (0 – 1.5)
Spiral score (non-dominant hand)	0.56 ± 0.39 (0 – 1.5)
Practice spiral score (dominant hand)	0.48 ± 0.39 (0 – 1.5)
Purdue pegboard test score	10.6 ± 2.2 (5.5 – 22.0)

All values represent mean ± standard deviation (range) or number (percentage).

^a Medications for ADHD, with the most common medication being methylphenidate (N = 8).

^b The most common disorder was ADHD (N = 12), followed by epilepsy (N = 3) and bipolar disorder (N = 2).

Table 2

Spiral Scores in Boys vs. Girls

	Boys	Girls	Significance ^a
Spiral score (dominant hand)	0.44 ± 0.35	0.38 ± 0.32	0.14
Spiral score (non-dominant hand)	0.61 ± 0.40	0.52 ± 0.37	0.077
Practice spiral score (dominant hand)	0.53 ± 0.42	0.43 ± 0.37	0.048

^a Mann-Whitney test.

Table 3

Spiral Scores by Medication Status

	No medication	Asthma medication	Psychiatric medication	Significance ^a
Spiral score (dominant hand)	0.41 ± 0.34	0.41 ± 0.25	0.50 ± 0.27	0.37
Spiral score (non-dominant hand)	0.56 ± 0.39	0.51 ± 0.35	0.88 ± 0.35	0.03
Practice spiral score (dominant hand)	0.49 ± 0.40	0.40 ± 0.35	0.56 ± 0.42	0.71

^aMann-Whitney test comparing children on psychiatric medications to children on no medication.

Table 4**Spiral Scores by Co-Morbid Disorder**

	No comorbidity	Learning disorder	Neurological or psychiatric disorder	Significance ^a
All Children				
Spiral score (dominant hand)	0.40 ± 0.34	0.44 ± 0.34	0.57 ± 0.36	0.02
Spiral score (non-dominant hand)	0.55 ± 0.39	0.53 ± 0.36	0.76 ± 0.38	0.01
Practice spiral score (dominant hand)	0.46 ± 0.39	0.56 ± 0.46	0.67 ± 0.37	0.025
Children not taking any medication				
Spiral score (dominant hand)	0.40 ± 0.34	0.43 ± 0.39	0.59 ± 0.44	0.096
Spiral score (non-dominant hand)	0.55 ± 0.39	0.57 ± 0.39	0.64 ± 0.39	0.43
Practice spiral score (dominant hand)	0.46 ± 0.39	0.64 ± 0.39	0.73 ± 0.34	0.036

^a Mann-Whitney test comparing children with a neurological or psychiatric disorder to those with no comorbidity.