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Secondary Sexual Characteristics in Children With Cerebral Palsy and Moderate to Severe Motor Impairment: A Cross-Sectional Survey

Gordon Worley, MD*; Christine M. Houlihan, MD‡; Marcia E. Herman-Giddens, PA, DrPH§; Maureen E. O'Donnell, MD||; Mark Conaway, PhD¶; Virginia A. Stallings, MD#; W. Cameron Chumlea, PhD**; Richard C. Henderson, MD, PhD‡‡; Ellen B. Fung, PhD§§; Peter L. Rosenbaum, MD|||; Lisa Samson-Fang, MD¶¶; Gregory S. Liptak, MD###; Randy E. Calvert, MSc***; and Richard D. Stevenson, MD‡‡‡

ABSTRACT. *Objectives.* To compare the development of secondary sexual characteristics in children with cerebral palsy (CP) of moderate to severe motor impairment to children in the general population and to relate their sexual maturation to a measure of their body fat.

Methods. A multicenter, cross-sectional survey of 207 children who were 3 to 18 years of age and had CP of moderate to severe motor impairment (Gross Motor Functional Classification System [GMFCS] levels 3, 4, and 5) was conducted at 6 geographic sites; attempts were made to identify all eligible children through multiple methods and enroll them in the study. Trained research assistants performed anthropometric measurements, including subscapular skinfold thickness, determined GMFCS level, and assessed sexual maturation by Tanner stage. Secondary sexual characteristics were compared with the general population of children using cross-sectional surveys of the American Academy of Pediatrics Pediatric Research in Office Settings network and of the National Center for Health Statistics National Health and Nutrition Examination Survey (NHANES) III. Girls were classified as having begun puberty when they were at Tanner stage 2 or greater for pubic hair and breast development and to have completed puberty when they were at Tanner stage 4 or greater for pubic hair and breast development. Boys were classified as having begun puberty when they were at Tanner stage 2 or greater for pubic hair and genital development and to have com-

pleted puberty when they were at Tanner stage 4 or greater for pubic hair and genital development.

Results. The mean age (standard deviation) of subjects was 9.6 (4.6) years. Of the 207 subjects, 71% were white, 21% were black, and 8% were of other races; 59% were boys, and 41% were girls. Girls with CP ($n = 84$) entered puberty earlier than did boys with CP ($n = 123$). In contrast, girls with CP tended to complete puberty later than did boys with CP. Black boys and girls with CP ($n = 43$) entered puberty earlier than did white boys and girls with CP ($n = 147$). No difference between races was found in completion of puberty. Only for white children with CP were there a sufficient number of subjects for comparisons of sexual maturation to race-matched children in the general population, using data from the American Academy of Pediatrics Pediatric Research in Office Settings network and the NHANES III study. White girls with CP initiated pubic hair development (Tanner stage 2 or greater) earlier than in the general population, but the age of onset of breast development was similar to the general population, although the age distribution was different. A greater proportion of white girls with CP had early onset of breast development (Tanner stage 2 or greater), and a greater proportion had delayed onset of breast development than in the general population. White girls with CP completed breast development later than in the general population but not pubic hair development. For white boys ages 8 to 18 years with CP ($n = 75$), pubic hair and genital development both began earlier than in the general population, but genital development was completed later. The estimated median age of menarche for white girls with CP was 14.0 years, which was 1.3 years later (95% confidence interval: 0.7–2.3) than for the general population (estimated median age: 12.8 years; NHANES III). Relationships between sexual maturation and nutritional state, as assessed by subscapular skinfold thickness z score, were determined separately in white boys and in white girls with CP, between the ages of 8 and 18 years. For white girls with CP, more advanced sexual maturation was associated with more body fat, adjusting for age and GMFCS level (Spearman partial correlation: 0.41). In contrast, for white boys with CP, the opposite relationship pertained: more advanced sexual maturation was associated with less body fat (-0.29).

Conclusions. The pattern of sexual maturation in children with CP of moderate to severe motor impairment differs from that of children in the general population. Puberty begins earlier but ends later in white children with CP, compared with white children in the general population. In addition, menarche occurs later in white girls with CP. More advanced sexual maturation was

From the *Department of Pediatrics, Duke University Medical Center, Durham, North Carolina; †Department of Developmental Pediatrics, University of Virginia, Charlottesville, Virginia; ‡Department of Maternal and Child Health, Univ. of North Carolina School of Public Health, Chapel Hill, North Carolina; ||Department of Pediatrics, University of British Columbia, Vancouver, British Columbia, Canada; ¶Department of Health Evaluation Sciences, University of Virginia, Charlottesville, Virginia; #Department of Gastroenterology and Nutrition, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania; **Department of Community Health, Wright State University School of Medicine, Kettering, Ohio; ‡‡Department of Orthopaedics, University of North Carolina, Chapel Hill, North Carolina; §§School of Nursing, University of Pennsylvania, Philadelphia, Pennsylvania; |||Department of Pediatrics, McMaster University, Hamilton, Ontario, Canada; ¶¶Department of Pediatrics, University of Utah School of Medicine, Salt Lake City, Utah; ###Department of Pediatrics, University of Rochester Medical Center, Rochester, New York; ***Children's Exercise and Nutrition Centre, Hamilton Health Sciences Corporation, McMaster University, Hamilton, Ontario, Canada; and ‡‡‡Department of Pediatrics, University of Virginia School of Medicine, Charlottesville, Virginia.

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Reprint requests to (G.W.) Box 3120, Duke University Medical Center, Durham, NC 27710. E-mail: worle001@mc.duke.edu

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associated with more body fat in girls but less body fat in boys. *Pediatrics* 2002;110:897-902; cerebral palsy, puberty, precocious puberty, sexual maturation, secondary sexual characteristics, Tanner staging, nutritional status.

ABBREVIATIONS. CP, cerebral palsy; SSC, secondary sexual characteristics; NAGCPP, North American Growth in Cerebral Palsy Project; GMFCS, Gross Motor Functional Classification System; AAP PROS, American Academy of Pediatrics, Pediatric Research in Office Settings; SSFT, subscapular skinfold thickness; NHANES III, National Health and Nutrition Examination Survey III; CI, confidence interval.

Cerebral palsy (CP) is defined as a "group of nonprogressive but often changing motor impairment syndromes secondary to lesions or anomalies of the brain arising in the early stages of its development."¹ It is a common disability in childhood, occurring with a prevalence of 1 to 3 per 1000 live births.²⁻⁵ The concept that CP may be associated with abnormal sexual maturation has been suggested but has not been established. Children with CP have been included in case series of children with precocious puberty.^{6,7} In a cohort of children who had a history of neonatal encephalopathy and were followed until 8 years of age, 26 of 161 girls received a diagnosis of CP, 3 of whom (12%) began puberty before 8 years of age, compared with none of the 260 boys with neonatal encephalopathy.⁸ The epidemiology of the development of secondary sexual characteristics (SSC) in children with CP has not been investigated previously.

Sexual maturation in children with CP needs to be studied for several reasons. First, it has not been established that sexual maturation proceeds differently in children and adolescents with CP than in the general population. Second, possible relationships between nutritional state and sexual maturation have not been studied in children with CP, important because undernutrition is common in this population. Finally, parents of children with CP often raise concerns about progression through puberty.

The North American Growth in Cerebral Palsy Project (NAGCPP) is a research consortium organized to address scientifically the lack of data about relationships among nutritional state and growth, sexual maturation, and health status of children with CP. As part of a cross-sectional study, sexual maturation was assessed in children with CP for the following purposes: 1) to describe the development of SSC in children with CP; 2) to compare sexual maturation of children with CP to the general population; and 3) to relate the development of SSC in children with CP to nutritional state, as assessed by an anthropometric measure of body fat.

METHODS

Research Consortium

The NAGCPP was established in 1996, with the main, coordinating site at the University of Virginia (R.D.S., principal investigator). There are 5 other research sites: Duke University and the University of North Carolina (2 centers, functioning together as a single site), Children's Hospital of Philadelphia, the University of Rochester, McMaster University (Ontario), and the University of

British Columbia (Vancouver). The institutional review board of each participating center approved the study.

Subjects

Each of the 6 sites recruited subjects from a defined geographical area with a population of at least 500 000 people. Children were identified by multiple methods that included recruiting through clinics, parent-to-parent organizations, local CP associations, school systems, public service announcements, and service and therapy providers. Newspaper and radio advertisements were also used for recruitment. Once identified, parents were contacted by mail and asked whether they would allow their child to participate in the study. Parents who agreed were interviewed by telephone to determine the eligibility of their child. Medical records were not reviewed. Eligibility criteria were 1) confirmed clinical diagnosis of CP; 2) age 2 to 18 years; 3) no genetic, metabolic, or other disease that might impair growth; 4) no history of neurologic deterioration; and 5) motor impairment. The severity of motor impairment of subjects was classified at each site using the Gross Motor Functional Classification System [GMFCS]^{9,10} by research assistants who used an algorithm devised by a developer of the system (P.R.), who was also an NAGCPP investigator. Only a small portion of children who met eligibility criteria could be recruited for the study. Therefore, our study population must be considered to be a convenience sample.

The GMFCS was designed to classify motor function of children with CP from infancy through 12 years of age. There are 5 levels that are based on differences across ages in self-initiated movement, with particular emphasis on sitting and walking. For each level, functional abilities and limitations are presented by ages (expectations for before the second birthday, for between the second and fourth birthdays, for between the fourth and sixth birthdays, and for between the sixth and thirteenth birthdays). The levels are defined by the highest level of mobility that a child will reach between 6 and 12 years of age. Level 3 (moderate motor impairment) is "walks with assistive mobility devices; limitations walking outdoors and in the community." Level 4 (moderately severe motor impairment) is "self-mobility with limitations; children are transported or use power mobility outdoors or in the community." Level 5 (severe motor impairment) is "self-mobility is severely limited even with use of assistive technology." We decided to study only subjects with CP associated with moderate to severe motor impairment, as defined by the GMFCS (levels 3, 4, and 5) because undernutrition is more frequent in this group than in less severely impaired subjects.

Of the 669 children who were identified and their parents were contacted by telephone, 630 had CP. Of these, 479 met the motor inclusion criterion and 345 met the age criterion. After exclusions (based on the eligibility criteria), 329 children remained, 292 of whom lived within the boundaries of the defined geographical regions that made up the population base. Informed consent was obtained from parents or legal guardians. A total of 235 children were enrolled and measured and their parents interviewed. Of the 235 children enrolled, 207 had their sexual maturation assessed by Tanner stage; these children composed the study population.

Procedures

Research assistants were trained together in 1998 in the assessment of sexual maturation by one of the authors (M.E.H.G.), who was also a principal investigator of the American Academy of Pediatrics, Pediatric Research in Office Settings (AAP PROS) network study of sexual maturation in girls.¹¹ Pubertal staging criteria and definitions used were the 5 stages of pubic hair growth, breast development, and genital development described by Marshall and Tanner,^{12,13} known as Tanner staging. Training materials prepared for the study were composed of text, photographs, and visual aids for both girls and boys. After training, research assistants were required to stage accurately 12 photographs of SSC for both boys and girls with 100% accuracy, similarly to AAP PROS network study for girls.¹¹

Research assistants were also trained together to perform standard anthropometric measurements, using standard techniques.^{14,15} Intra- and interobserver reliability was established. Among the measurements obtained was subscapular skinfold thickness (SSFT). All measurements were obtained in duplicate with the average used for analyses. Subjects were measured in 1998.

Data Analyses

After data entry, discrepant or out-of-range measurements were identified by computer programs written for the purpose. For comparisons of the development of SSC of children with CP with the general population, 2 data sets were used: 1) for girls ages 3 to 12 years, the AAP PROS network study of sexual maturation was used¹¹; 2) for girls older than 12 years and for boys 8 to 18 years old, the National Health and Nutrition Examination Survey III (NHANES III) was used¹⁶; 3) for nutritional analyses for boys and girls 8 to 18 years, NHANES III was used.¹⁶

Comparisons of sexual maturation of children with CP with the general population were possible only for white children. There were too few children of other races enrolled for similar analyses. Because of differences in sexual maturation between white and Mexican American children (M.E.H.-G., personal communication, 2000), data from white Mexican American children were not used in comparison analyses of white children with CP with the general population.

Definitions

Girls were classified to have entered puberty when they were at Tanner stage 2 or greater for both pubic hair and breast development and to have completed puberty when they were at Tanner stage 4 or 5 for both pubic hair and breast development. Boys were classified to have entered puberty when they were at Tanner stage 2 or greater for both pubic hair and genital development and to have completed puberty when they were at Tanner stage 4 or 5 for both pubic hair and genital development.

Statistical Analyses

Logistic regression analyses were used to assess the effects of race and gender on the proportions of children who had CP and were entering and completing puberty. The statistical significance of the effects in these models was assessed with likelihood ratio tests.

Logistic regression models were used to compare the probabilities related to age of both entering and completing puberty of children with CP with the general population. The covariance matrix for the estimated parameters in the logistic regression models was calculated using 1000 bootstrap replications and was used in Wald tests to compare the CP group with the general population. For comparisons using the NHANES III data set, the weighted bootstrap method was used to compensate for the sampling design of NHANES III.¹⁷ The status quo method,¹⁸ based on the logistic regression estimates, was used to estimate the ages at which 25%, 50%, or 75% of children with CP had entered or completed puberty. These analyses were done primarily to permit comparisons of our results with published results for the general population and to illustrate the magnitude of the differences in sexual maturation between children with CP and in the general population.⁹ Confidence intervals (CIs) for these quantities were based on 1000 bootstrap replications, using the bias-corrected percentile method.¹⁹

The NHANES III reported age at menarche in years, whereas the NAGCPP collected the age in years and months. To adjust partially for the different ways of recording age at menarche, a random fraction of a year was added to the ages in the NHANES III data set. The weighted bootstrap distribution method was then used to obtain estimates and CIs for the differences in age at menarche between girls with CP and girls in the general population (NHANES III), taking into account this added random component. Methods that were appropriate for ordinal categorical outcomes, such as rank correlation and continuation ratio models, were used for the analyses of Tanner stages.²⁰

RESULTS

Demographic and physical characteristics of subjects are presented in Table 1. Girls with CP ($n = 84$) entered puberty earlier ($P = .02$) than did boys with CP ($n = 123$). For girls with CP, it was estimated that by 8.6 years (95% CI: 5.8–8.0), 50% were at Tanner stage 2 or greater for either breast or pubic hair development, whereas for boys, it was not until age 8.9 years (95% CI: 8.0–9.6) that 50% were at Tanner

TABLE 1. Description of Subjects ($n = 207$)

Age (y)	
Mean (SD)	9.6 (4.6)
Race*	
White	147 (69%)
Black	43 (21%)
Other races	16 (8%)
Gender	
Boys	123 (59%)
Girls	84 (41%)
Gross motor functional GMFCS	
Level 3	51 (25%)
Level 4	53 (26%)
Level 5	103 (53%)
Height estimate†‡	−2.7 (−2.9 to −2.5)
(mean z score [95% CI])	
Weight‡§ (mean z score [95% CI])	−2.0 (−2.3 to −1.7)
SSFT§ (mean z score [95% CI])	−0.84 (−1.00 to −0.68)

SD indicates standard deviation.

* Frequencies sum to 206 because 1 person refused to answer.

† Height estimate based on calculations from knee height.

‡ Reference data from NHANES III.¹⁶

§ Reference data from Frisancho.²¹

stage 2 or greater for either genital or pubic hair development. In contrast to their entering puberty earlier, girls with CP tended to complete puberty later ($P = .13$) than did boys with CP. It was estimated that by 14.4 years (95% CI: 13.7–15.0) 50% of boys with CP were at either Tanner stage 4 or 5 for both pubic hair and genital development; in contrast, it was estimated that it was not until 15.7 years (95% CI: 14.7–16.9), 1.3 years later than for boys with CP, that 50% of girls with CP were at either Tanner stage 4 or 5 for both pubic hair and breast development. Pooling data from boys and girls, it was found that black children with CP ($n = 43$) entered puberty earlier ($P < .01$) than did white children with CP ($n = 147$). By an estimated 5.6 years (95% CI: 3.9–6.7), 50% of black children with CP had at least 1 Tanner stage of 2 or greater, but it was not until an estimated 9 years (95% CI: 8.1–9.7) that 50% of white children with CP reached the same maturity. No difference was found in completing puberty.

Table 2 displays estimated means and standard deviations for the ages at which white girls with CP ($n = 59$) and in the general population began puberty (Tanner stage 2 for breast and pubic hair development) and completed puberty (Tanner stage 4 for breast and pubic hair development). Table 3 presents comparisons of patterns of sexual maturation of white girls for the 3 data sets (NAGCPP, NHANES III,¹⁶ and AAP PROS¹¹) by the ages at which white girls began and completed puberty. Although the mean age for initiation of breast development was similar in white girls with CP to the general population, the age distribution of breast development was different ($P < .001$). A greater proportion of white girls with CP had early onset of breast development (Tanner stage 2 or greater), and a greater proportion had delayed onset of breast development than in the general population. White girls with CP initiated pubic hair development (Tanner stage 2 or greater) earlier than in the general population ($P = .001$). White girls with CP completed breast development (Tanner stage 4 or 5) later than in the general popu-

TABLE 2. White Girls Ages 3 to 18 Years in the NAGCPP Study ($n = 59$), in the NHANES III Study ($n = 593$), and in the AAP PROS Study ($n = 15,439$): Estimates of Means and SDs of Distribution of Ages for Initiation and Completion of Puberty

	Mean* (95% CI)†	SD (95% CI)	$P‡$
Breast, Tanner stage ≥ 2			
NAGCPP	10.1 (8.8–11.2)	3.30 (2.3–5.0)	—
AAP PROS	10.07 (10.02–10.11)	1.70 (1.64–1.75)	.014
NHANES III	10.29 (10.09–10.45)	1.15 (0.91–1.35)	<.001
Breast, Tanner stage $\geq 4§$			
NAGCPP	15.6 (14.8–17.2)	2.20 (1.23–3.37)	—
NHANES III	13.16 (12.92–13.42)	1.58 (1.40–1.84)	.001
Pubic hair, Tanner stage ≥ 2			
NAGCPP	8.2 (6.7–9.2)	3.22 (2.25–4.88)	—
AAP PROS	10.59 (10.55–10.65)	1.59 (1.53–1.65)	<.001
NHANES III	10.46 (10.17–10.67)	1.35 (1.18–1.66)	<.001
Pubic hair, Tanner stage $\geq 4§$			
NAGCPP	13.2 (12.4–14.1)	1.90 (1.16–2.61)	—
NHANES III	12.88 (12.64–13.07)	1.27 (1.12–1.53)	.39

* Mean and SD estimates based on logistic regression model.

† 95% CIs based on 1000 bootstrap replications and bias-corrected percentile method.

‡ P values are based on Wald tests comparing means and SDs to the CP population (NAGCPP).

§ Data on completion of puberty not available from Hermann-Giddens et al.¹¹

TABLE 3. Comparisons of Patterns of Sexual Maturation of White Girls in the NAGCPP Study, in the NHANES III Study, and in the PROS Study

	NAGCPP (Ages 3–18)			NHANES III (Ages 8–18)			AAP PROS (Ages 3–12)		
	25th	50th	75th	25th	50th	75th	25th	50th	75th
Breast development									
Initiation (Tanner stage 2 or greater)	8.1 (6.0–9.3)	10.1 (8.6–11.0)	12.1 (10.9–13.3)	9.6 (9.3–9.8)	10.3 (10.10–10.5)	11.0 (10.8–11.2)	9.0 (9.0–9.1)	10.1 (10.0–10.1)	11.1 (11.0–11.1)
Completion (Tanner stage 4 or greater)	14.2 (13.4–15.3)	15.6 (14.5–16.5)	16.9 (15.7–18.3)	12.2 (12.0–12.5)	13.2 (12.9–13.4)	14.1 (13.8–14.4)	NA	NA	NA
Pubic hair development									
Initiation (Tanner stage 2 or greater)	6.2 (4.0, 7.5)	8.2 (6.6, 9.2)	10.1 (8.9, 11.6)	9.6 (9.2, 9.9)	10.5 (10.2, 10.7)	11.3 (11.1, 11.5)	9.6 (9.6, 9.7)	10.6 (10.5, 10.6)	11.6 (11.5, 11.6)
Completion (Tanner stage 4 or greater)	12.1 (11.2, 13.0)	13.2 (12.4, 14.0)	14.4 (13.3, 15.3)	12.1 (11.8, 12.3)	12.9 (12.6, 13.1)	13.6 (13.3, 13.9)	NA	NA	NA

NA indicates not applicable.

Estimates and 95% CIs (in parentheses) for the ages at which 25%, 50%, and 75% of white girls initiated puberty (Tanner stage 2 or greater for breast and pubic hair development) and completed puberty (Tanner stage 4 or greater for breast and pubic hair development), based on data from the NAGCPP ($n = 59$), the NHANES III study ($n = 593$),¹⁶ and the AAP PROS study ($n = 15,439$).¹¹ Estimates are based on the status quo method, using logistic regression.¹⁸ The 95% CI were based on 1000 bootstrap replications and the bias-corrected percentile method.¹⁹ Data for completion of puberty were not reported in Hermann-Giddens et al.¹¹

lation ($P = .001$) but not pubic hair development ($P = .39$).

Table 4 displays the estimated means and standard deviations for the ages at which white boys with CP and in the general population reached Tanner stage 2 and Tanner stage 4 for genital and pubic hair development. For white boys ages 8 to 18 years with CP ($n = 75$), pubic hair and genital development both began earlier than for white boys in the general population (NHANES III; $P = .014$ and $P = .017$), but genital development was completed later ($P = .034$). Table 5 present comparisons of sexual development of white boys with CP with the general population. Figure 1 compares the age of menarche for white girls with CP with the general population. The estimated median age of menarche for white girls with CP was 14.0 years, which is 1.3 years (95% CI: 0.7–2.3) later than for white girls in the general popula-

tion (estimated median age: 12.8 years; NHANES III; $P < .01$).

The relationship between Tanner stage and body fat, assessed by SSFT z score, was determined in white girls and boys with CP. For white girls, the Spearman partial correlation between Tanner stage and SSFT z score, adjusting for age and GMFCS level, was 0.41 ($P = .006$), suggesting that for girls, more advanced sexual maturation was associated with more body fat. In contrast, for white boys, the Spearman partial correlation was -0.29 ($P = .016$), suggesting that for boys, the opposite relationship pertained, that more advanced sexual maturation was associated with less body fat.

DISCUSSION

Up-to-date, relevant standards by age for development of SSC in girls and boys in the general popu-

TABLE 4. White Boys Ages 3 to 18 in the NAGCPP Study ($n = 75$) and in the NHANES III Study ($n = 536$): Estimates of Means and SDs of Distribution of Ages for Initiation and Completion of Puberty

	Mean* (95% CI)†	SD (95% CI)	P‡
Genital, Tanner stage ≥ 2			
NAGCPP	10.0 (9.0–11.3)	2.05 (1.80–2.46)	—
NHANES III	10.0 (9.7–10.3)	3.51 (2.58–4.56)	.017
Genital, Tanner stage ≥ 4			
NAGCPP	14.7 (14.0–15.5)	1.26 (0.78–1.91)	—
NHANES III	13.43 (13.19–13.67)	1.21 (1.01–1.50)	.034
Pubic Hair, Tanner stage ≥ 2			
NAGCPP	10.7 (9.6–11.6)	2.45 (1.66–3.41)	—
NHANES III	11.90 (11.69–12.14)	1.40 (1.19–1.55)	.004
Pubic hair, Tanner stage ≥ 4			
NAGCPP	14.2 (13.6–14.9)	1.06 (0.57–1.83)	—
NHANES III	13.45 (1.26–3.69)	1.11 (0.95–1.35)	.37

* Mean and SD estimates based on logistic regression model.

† 95% CI, based on 1000 bootstrap replications and bias-corrected percentile method.

‡ P values are based on Wald tests comparing means and SDs to the CP population (NAGCPP).

TABLE 5. Comparisons of Patterns of Sexual Development of White Boys With CP to the General Population

	NAGCPP (Ages 3–18)			NHANES III (Ages 8–18)		
	25th	50th	75th	25th	50th	75th
Genital development						
Initiation	7.8	9.9	12.1	8.8	10.0	11.3
(Tanner stage 2 or greater)	(6.6–9.1)	(8.9–11.2)	(10.8–13.5)	(8.3–9.1)	(9.7–10.3)	(11.0–11.6)
Completion	13.9	14.7	15.4	12.7	13.4	14.2
(Tanner stage 4 or greater)	(13.3–14.6)	(14.0–15.5)	(14.6–16.4)	(12.4–13.0)	(13.2–13.7)	(13.9–14.5)
Pubic hair development						
Initiation	9.3	10.7	12.2	11.1	11.9	12.7
(Tanner stage 2 or greater)	(8.3–10.5)	(9.8–11.8)	(11.2–13.6)	(10.8–11.3)	(11.7–12.1)	(12.5–13.0)
Completion	13.5	14.1	14.8	12.8	13.5	14.1
(Tanner stage 4 or greater)	(12.8–14.1)	(13.4–14.8)	(13.8–15.7)	(12.5–13.0)	(13.3–13.7)	(13.9–14.4)

Estimates and 95% CIs (in parentheses) for the age at which 25%, 50%, and 75% of white boys initiated puberty (Tanner stage 2 or greater for pubic hair and genital development) and completed puberty (Tanner stage 4 or greater for genital and pubic hair development), based on data from the NAGCPP study ($n = 75$) and the NHANES III study ($n = 536$).¹⁶ Estimates are based on the status quo method, using logistic regression.¹⁸ The 95% CIs were based on 1000 bootstrap replications and the bias-corrected percentile method.¹⁹

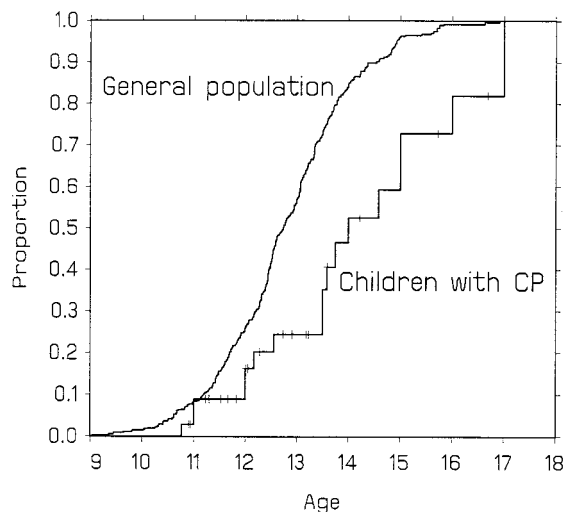


Fig 1. The estimated median age at menarche for white girls with CP was 14.0 years, compared with a median of 12.7 years for white children in the general population ($P < .001$).

lation in the United States are now available for statistical comparisons to special populations of children, such as those with CP. The AAP PROS network collected and analyzed data on the development of SSC in 17 077 girls aged 3 to 12 years in 1992 and 1993. NHANES III evaluated 5839 children between

the ages of 8 and 18 years between 1988 and 1994.¹⁶ The AAP PROS network study of girls extends downward the lower age limit for which normative data on sexual maturation in girls are available, complementing the NHANES III data set. The AAP PROS network study found that the onset of puberty in girls in the United States now begins 6 months to 1 year earlier than in previous studies.^{11,19} At 3 years of age, 3% of black girls and 1% of white girls showed breast and/or pubic hair development, with the proportions reaching 27.2% and 6.7%, respectively, at 7 years of age. Because early puberty is now so prevalent in the general population, to establish that a condition or disease is associated with precocious puberty, it is now necessary to compare the results of a cross-sectional survey of SSC by age of children with the condition or disease in question to appropriate controls in these large data sets. A case series of children with a developmental disability and early puberty is no longer adequate for the purpose.

The epidemiology of the development of SSC in children with CP previously has not been studied. Some conclusions can be drawn from our cross-sectional sample of children with CP. Girls with CP entered but tended to complete puberty later than did boys with CP. Black children with CP entered but did not complete puberty earlier than did white

children with CP. For white children with CP, puberty began earlier and was completed later than for white children in the general population. For white girls with CP, the estimated median age at menarche was 14.0 years, 1.3 years later than in the general population. There was a complex relationship between sexual maturation and body fat. For girls with CP, more advanced sexual maturation was associated with more body fat, but in boys with CP, more advanced sexual maturation was associated with less body fat.

There are some limitations to our study. First, the sample size was too small for all analyses to be conducted for all racial groups. Second, it is possible that the sample may not be representative of all children with CP of moderate to severe motor impairment. However, the distribution of subjects of GMFCS levels 3, 4, and 5 was similar to the distribution of >2000 children with CP studied in Ontario (P.R., personal communication, 2000). Therefore, we believe that our results are reflective of what would have been found had a random sample from a registry of children with CP been studied. Finally, only by a prospective longitudinal cohort study can early adrenarche be distinguished definitively from true precocious puberty.

We have demonstrated that sexual maturation in children who have CP with moderate to severe motor impairment from our study population differs from the general population. The clinical implications and pathophysiology of the earlier onset and delayed completion of puberty await clarification by additional investigation.

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We dedicate this article to the memory of Dr Edward B. Charney, who was a developmental pediatrician at the Children's Hospital of Philadelphia. His career was devoted to caring for

children with disabilities, and his studies of growth in children with CP helped lay the foundation for our work.

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Secondary Sexual Characteristics in Children With Cerebral Palsy and Moderate to Severe Motor Impairment: A Cross-Sectional Survey

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