Validity of Self-Assessed Sexual Maturation Against Physician Assessments and Hormone Levels

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Objective To compare self-report and physician assessments of sexual maturation against serum hormone markers to evaluate the hypothesis that the validity of self-assessed sexual maturation is underestimated in traditional validation studies.

Study design We adapted a self-assessment instrument that 248 Mexican children and adolescents, aged 8-13 years, completed. The participants were examined by a trained pediatrician and provided fasting blood samples for measurement of reproductive hormones (eg, testosterone, estradiol, sex hormone-binding globulin, inhibin B) and other hormones (eg, C-peptide, insulin-like growth factor 1, leptin, dehydroepiandrosterone sulfate) known to change during adolescence. Spearman correlations (r) were calculated among the average rank of all hormones and self-assessed and physician-assessed Tanner stage. The method of triads was used to assess the validity of self-reports by estimating correlations between self-assessments and true but unobservable sexual maturation based on all available data. Bootstrap sampling was used to construct 95% CIs.

Results The validity of self-reported genitalia staging for boys was modest ($r = 0.50$; 95% CI, 0.31-0.65) and inferior to physician assessment ($r = 0.75$; 95% CI, 0.56-0.93). Breast stage was well reported ($r = 0.89$; 95% CI, 0.79-0.97) and superior to physician assessment ($r = 0.80$; 95% CI, 0.70-0.89). Pubic hair stage reported by boys ($r = 0.91$; 95% CI, 0.79-0.99) and girls ($r = 0.99$; 95% CI, 0.96-1.00) was superior to physician assessment ($r = 0.79$; 95% CI, 0.57-0.97 and $r = 0.91$; 95% CI, 0.83-0.97, respectively).

Conclusion Self-assessment can be validly used in epidemiologic studies for evaluating sexual maturation in children; however, physician assessment may be necessary for accurate assessment of genitalia development in boys. *(J Pediatr 2017;186:172-8).*

The age at which girls and boys enter puberty has decreased over the past several decades, owing in part to changes in nutrition, hygiene, and improved health and socioeconomic status.[1,2] However, there is concern that environmental factors also may be contributing to earlier pubertal onset, with potential adverse effects.[1,3] For example, compared with their normally developing peers, children who enter puberty early are at greater risk for alcohol and substance use[4,5] and risk-taking behaviors during adolescence.[6] Earlier pubertal onset also has been associated with an increased risk of various disorders in adolescence[7-13] and adulthood.[14-30] For this reason, self-reported sexual maturation is used extensively in epidemiologic studies as a study outcome or as a critical covariate when evaluating other associations.

Validation studies have found reasonable agreement between self-reported and physician-observed Tanner stages of sexual maturation.[31-34] Sources of error in self-assessment include, for example, misidentification by obese adolescents of fat tissue as breast tissue.[35-37] Furthermore, although physician assessment has historically been the gold standard in validation studies, these assessments also may be subject to measurement error and thus reflect an apparently lower validity of self-reports. Specifically, Tanner staging is dependent on observer training and experience, and basing the validity of self-reports solely on correlations between self- and physician-assessed sexual maturation may underestimate children's ability to rate their own pubertal development.

BMI	Body mass index
DHEA-S	Dehydroepiandrosterone sulfate
IGF-1	Insulin-like growth factor 1
SHBG	Sex hormone-binding globulin

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In this study, we evaluated the hypothesis that the validity of self-assessed sexual maturation is underestimated in traditional validation studies. To address this question, we examined relationships among self-reported sexual maturation, physician-assessed sexual maturation, and a panel of serum hormone concentrations that serves as an objective marker of pubertal development. We then used the method of triads, a technique first proposed for validating dietary assessment tools,[38,39] to obtain an estimate of the relationship between self-reported and true, but unobservable, pubertal status.

Methods

The study participants were children enrolled in an ongoing longitudinal birth cohort study in which mothers were recruited from maternity hospitals in Mexico City, as described elsewhere.[40-43] Our analysis includes mothers who were recruited in their first trimester of pregnancy, between 1997 and 2004, into the second and third of 3 sequentially enrolled cohorts. Women were eligible to participate if they were >14 years, pregnant without a high-risk pregnancy, and had plans to reside in the area for at least 5 years. The children of enrolled mothers were followed from birth to age 5 years. In 2010, 250 child participants were selected based on the availability of archived maternal biological specimens and age 8-13 years (thus likely to be undergoing the pubertal transition), and were invited to participate in a follow-up study on growth and sexual maturation. Each participant completed a questionnaire on self-reported sexual maturation (described in detail below), underwent a physical examination, and provided a blood sample for hormone analysis. Of the 250 adolescents who completed the questionnaire, 131 girls and 117 boys had recorded information on physician and self-reported sexual maturation and serum hormone levels. The research protocols were approved by the Institutional Review Board at the University of Michigan and the Ethics Committee of the Mexican National Institute of Public Health. All child participants provided informed assent and were accompanied by a mother or other guardian, who signed a letter of informed consent before participation.

Self-Reported Sexual Maturation

We developed a questionnaire for self-reporting sexual maturation based on adaptations of the original Tanner stages of secondary sexual characteristics.[44] The questionnaire contained line drawings depicting the 5 Tanner stages and descriptions of each stage. Modifications to the layout of the line drawings were based on those made by Taylor et al[45] (**Figure 1**; available at www.jpeds.com). The questionnaire was translated into Spanish, reviewed by native speakers and field staff, and piloted among 12 participants aged 7-14 years before being administered to the study population. At the study visit, a member of the research team explained the objective of the questionnaire to the mother or guardian, showed her a sample of the figures, and explained that she would be given the option of discussing the questionnaire with her child before completion. The researcher reviewed the questionnaire with the child, explained that he or she had the option of having his or her mother present while completing the questionnaire, and then left the room.

The children was asked to select their self-perceived stage of development by choosing the drawings and descriptions closest to the current stage of sexual development, and girls were asked to report their attainment of menarche (yes/no; if yes, at what age). Both boys and girls were asked to report any practices of pubic hair shaving, which might bias their perceived Tanner staging. After completion, participants folded the questionnaire and returned it to the researcher.

Physical Exam and Standardization

A pediatrician trained according to standard methods assessed Tanner staging for breast and pubic hair development in girls and for genitalia and pubic hair development in boys. Testicular volume was assessed in boys using a Prader orchidometer. Trained nurses also measured height and weight at this visit. Before launching the study, one of the investigators conducted a standardization of anthropometry protocol with the research nurses and of Tanner staging with the pediatricians. The latter focused on defining rules to address key assessment issues, including differentiation of adipose and breast tissue in overweight girls, asymmetric breast stages, and pubic hair removal.

Hormone Analysis

During the study visit, a trained phlebotomist collected a fasting blood sample from the child for hormone analysis. Samples were centrifuged and separated into aliquots, and the serum was stored at -80 °C and shipped on dry ice to the University of Michigan School of Public Health. We measured total estradiol, total testosterone, inhibin B, and sex hormone-binding globulin (SHBG), dehydroepiandrosterone sulfate (DHEA-S), leptin, c-peptide, and insulin-like growth factor 1 (IGF-1) in serum as objective but unspecific biomarkers of sexual and somatic development during puberty. DHEA-S, total estradiol, SHBG, and testosterone were measured using an automated chemiluminescent immunoassay (ACS 180; Bayer Diagnostics, East Walpole, Massachusetts), and active inhibin B was assayed by enzyme-linked immunosorbent assay (Gen II ELISA; Beckman Coulter, Webster, Texas), all at the Clinical Ligand Assay Service Satellite Laboratory at the University of Michigan (Ann Arbor, Michigan). Leptin, c-peptide, and IGF-1 were measured at the Michigan Diabetes Research and Training Center Chemistry Laboratory by automated chemiluminescence immunoassay (c-peptide and IGF-1; Immulite 1000; Siemens, Erlangen, Germany) or radioimmunoassay (leptin; EMD Millipore, Billerica, Massachusetts).

Statistical Analyses

Because all of the sex hormones measured are known to change during adolescence[46-48] but none is a specific marker of the progression through puberty, we constructed a summary score of all hormones measured: total estradiol, testosterone, inhibin B, SHBG, DHEA-S, leptin, c-peptide, and IGF-1. Given that hormones are measured in different units, we ranked the