

Use of Tanner stages to estimate chronological age in alleged child pornography cases: a systematic review

Uso de las etapas de Tanner para estimar la edad cronológica en presuntos casos de pornografía infantil: revisión sistemática

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What do we know about the subject matter of this study?

For some time, the use of Tanner stages to estimate the chronological age of the victim from images in alleged child pornography cases has been the subject of discussion and conflicting opinions.

What does this study contribute to what is already known?

This method is ineffective when the alleged victim, for both sexes, shows sexual maturation at Tanner stages 3-5. In stages 1-2, it may be useful to indicate that the victim is under 18 years of age.

Abstract

The last two decades have seen an exponential growth in the distribution and availability of child pornographic material on the Internet and social networks. The medical community is involved in assisting the investigating authorities in relation to estimating the age and sexual maturity of the alleged victims. **Objective:** To determine the efficacy of using Tanner stages as a method for estimating chronological age in alleged child pornography cases based on published evidence. **Material and Method:** Systematic review study in PubMed and Scopus databases following PRISMA guidelines. Articles describing the outcome of using Tanner stages to estimate chronological age in alleged child pornography cases were identified. For screening, those written in English or Spanish published from January 1, 2000, to April 30, 2020, were considered. The following data were extracted from the articles included: type of study; material and methods used; Tanner items examined; evaluators' characteristics; results; estimated chronological age versus real age; observer-dependent variations (bias); and conclusions. **Results:** Seven studies were included. Three were literature reviews and four were case studies with expert testimony and observer bias. This method is ineffective when the alleged victim, in both sexes, shows sexual maturation in Tanner stages 3-5. In stages 1-2, it may be useful to

Keywords:

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state that the victim is under 18 years old, but not to determine their chronological age. **Conclusion:** Scientific evidence discourages the use of Tanner stages to estimate the chronological age of the victim from images in alleged child pornography cases. Pediatricians, and other medical professionals, should avoid making a testimony that is not scientifically based.

Introduction

Under the European Union Law, the Directive 2011/93/EU¹ is the main legal instrument regulating child pornography. Child pornography is defined as^{1,2} “any material that visually depicts a child participating in real or simulated sexually explicit conduct; any depiction of the sexual organs of a child for primarily sexual purposes; any material that visually depicts a person appearing to be a child participating in real or simulated sexually explicit conduct or any depiction of the sexual organs of a person appearing to be a child for primarily sexual purposes; or realistic images of a child participating in sexually explicit conduct or realistic images of the sexual organs of a child for primarily sexual purposes”.

Article 1 of the Convention on the Rights of the Child³ and Council framework Decision 2004/68/JHA⁴ on combating the sexual exploitation of children and child pornography together define a “child” as any person under the age of 18. Article 5 of the Directive 2011/93/EU¹ obliges the Member States of the European Union to take all necessary measures to ensure that the production, acquisition, possession, distribution, dissemination, transmission, offering, supplying, or making available of child pornography, as well as knowingly accessing such content, is punishable.

In the last two decades, there has been an exponential growth in the distribution and availability of child pornographic material on the Internet and social networks, making it a billion-dollar business⁵⁻⁸. Currently, the Covid-19 pandemic has led to a significant increase in the problem⁹⁻¹⁴. As an example, in March 2020, during the Covid-19 pandemic confinement, the National Center for Missing and Exploited Children (NCMEC), based in the U.S., received more than two million notifications of child pornography content, more than double the number reported the same month in 2019. NCMEC reports that 20% of Internet pornography involves children and estimates that 58% of children used are prepubescent and 6% infants, and that 1 in 5 girls and 1 in 10 boys will be victims before they reach the age of 18. The NCMEC has a service called CyberTipline through which electronic service providers and U.S.-based technology companies (Microsoft, Facebook, Twitter, Google, and TikTok, among others) are required by law to report if they detect child abuse

content anywhere in the world where they operate¹⁵.

The medical community is involved in the evaluation and treatment of persons who have been victimized in the production of child pornography, and in assisting the investigating authorities, specifically regarding estimating the age and sexual maturity of the alleged victims. Technically, the difficulty lies in verifying whether the material (photographs, videos) is pedo-pornographic, i.e. whether the subjects depicted are under 18 years of age. Therefore, it often happens that judges, magistrates, or the police call in specialists such as forensic pathologists, pediatricians, gynecologists, or forensic anthropologists as expert advisors to estimate the chronological age of the subjects, which can play a crucial role in determining whether or not a child pornography offense exists. In addition, an accurate age estimate could be essential for the identification of the victim depicted in the images and to establish the time intervals during which the abuse took place¹⁶⁻¹⁸.

The conventional method used for age estimation through images of individuals is based on the evaluation of Tanner stages. Tanner stages assess sexual maturation through the physical changes observed in genitalia, breasts, and pubic hair throughout puberty in both sexes. Their purpose is to estimate developmental or physiological age in individuals of known age who undergo a physical examination^{19,20}. Tanner stages have been used in chronological age estimation in different forensic contexts, such as criminal procedure, adoption cases, human trafficking, unaccompanied minor asylum seekers, sex workers, and child pornography^{18,21-24}. In particular, its use to estimate the chronological age of the victim from images in alleged child pornography cases has been discussed for some time because no scientific evidence had been found to support it^{18,24}. The objective of this research is to conduct a systematic review of the efficacy of the use of Tanner stages as a method for estimating chronological age in suspected child pornography cases.

Material and Method

Systematic review study in the PubMed and Scopus databases following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses)

guidelines²⁵. In the PubMed database, the search was performed using the following MeSH (Medical Subject Heading/subheadings) terms and subheadings: Child Abuse, Sexual/legislation and jurisprudence; Erotica/legislation and jurisprudence; Forensic Medicine; Adolescent; Puberty; Internet. The following search strategies were used to identify articles: (“Child Abuse, Sexual/legislation and jurisprudence” [Mesh] AND “Erotica/legislation and jurisprudence” [Mesh]); (“Erotica” [Mesh] AND “Forensic Medicine” [Mesh] AND “Adolescent” [Mesh]); (“Child Abuse, Sexual” [Mesh] AND “Internet” [Mesh] AND “Puberty” [Mesh]).

In the Scopus database, the search was performed using the following search terms: Child sexual abuse; Pornography; Erotica; Forensic medicine; Tanner staging; Adolescent; Puberty; Internet. The following search strategies were used to identify articles: (“Child sexual abuse” AND Erotica); (Erotica AND “Forensic medicine” AND Adolescent); (Pornography AND Puberty); (“Child sexual abuse” AND Internet AND Puberty); (“Tanner staging” AND Pornography).

Articles written in English or Spanish published from January 1, 2000, to April 30, 2020, were considered for screening.

After identifying and screening the studies that were the subject of this research, the eligibility and inclusion of these studies were carried out by two of the researchers of the team, excluding after reading those articles that were duplicated or that did not specifically address the objective of this work, which was to determine the effectiveness of using Tanner stages as a method for estimating chronological age in alleged cases of child pornography.

The following data were extracted from the articles finally included: type of study; material and methods used; Tanner items examined; evaluator characteristics; results; estimated chronological age versus actual age; observer-dependent variations (bias); conclusions.

Results

Figure 1 shows the flow diagram of the process of identification, screening, eligibility, and inclusion of the studies searched in the PubMed and Scopus databases. 88 articles were identified (36 in PubMed and 52 in Scopus). After screening, 54 articles were eligible (28 in PubMed and 26 in Scopus), of which 10 were excluded since they were duplicates and 38 because they did not specifically address the research objective. Finally, 6 articles were included for the study.

Of the six articles, three were case studies with expert testimony and observer bias²⁶⁻²⁸. The other three were literature reviews²⁹⁻³¹, one of which³⁰ provided additional data from a case study with expert testimony and observer bias previously conducted by the author and collaborators³² that was included for the review study. Table 1 shows the information obtained from the data extracted from the literature review studies²⁹⁻³¹.

The results of the study by Stathopulu et al²⁹ indicated that, if a Southeast Asian girl in Internet images does not show the initial breast buds, there is a 97.5% probability that she is younger than 13.7 years. They estimate that severe chronic malnutrition at preschool age is a causative factor for delayed pubertal development.

The results of Berkowitz’s study³⁰ indicated that Southeast Asian men in Tanner stage 3 pubic hair, in 97.7% of cases, are younger than 18 years of age. He emphasizes that there is great variability in sexual maturation, and therefore in establishing chronological age due to factors such as race, ethnicity, socioeconomic status, maternal nutrition during pregnancy, nutrition during childhood, and obesity.

The results of Cooper’s study³¹ indicated that pre-

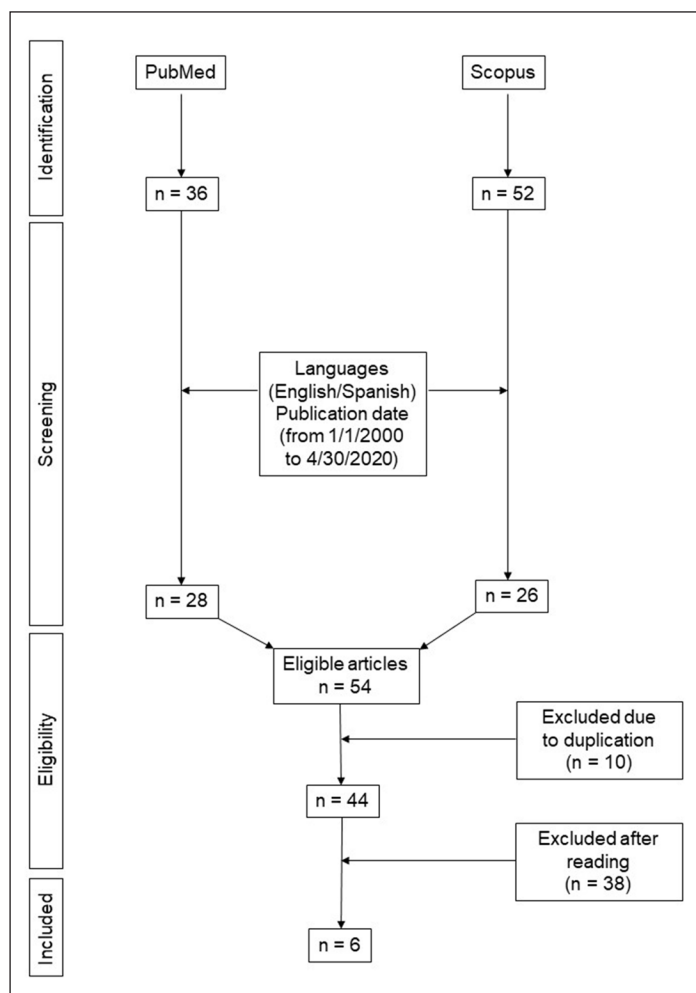


Figure 1. Flow chart of the study inclusion process.

Table 1. Literature review studies

Source	a) Material and methods b) Tanner items examined	Results and considerations
Stathopulu et al. ²⁹	a) The Medline database was searched from 1987 for studies of puberty in girls from the following countries and ethnic populations of Southeast Asia: Cambodia, Laos, Thailand, the Philippines, Sri Lanka, India, Hong-Kong, Singapore, Fiji, and China b) Breast development	97.5% of Southeast Asian girls will show in Tanner stage 2 by the age of 13.7 years 10% of Chinese girls will reach stage 2 before the age of 8 years Chronic malnutrition, severe enough to cause stunting in preschool years, is estimated to likely cause a delay in pubertal development of approximately 1.5 years
Berkowitz ³⁰	a) Manual search b) All Tanner items in females and males	97.7% of Southeast Asian males in Tanner stage 3 pubic hair are under the age of 18 years Establishing the age of an individual depends on information about the age of pubertal development in that individual's population or racial or ethnic group Factors such as socioeconomic status, maternal nutrition during pregnancy, and nutrition during childhood should be considered in assessing chronological age Earlier breast development may be related to childhood obesity, leading to an overestimation of chronological age
Cooper ³¹	a) Manual search b) All Tanner items in females and males	If there is no evidence of pubic hair or breast development (prepubescence), there is a reliable correlation with age younger than 12 years in American girls of non-Hispanic white, non-Hispanic black, and Mexican-American ethnic groups. This age determination also applies to children who do not have evidence of pubertal development. This is also generally true for almost all other foreign children, including Asian children The ages that correlated with the original Tanner stages were much higher than those currently observed

pubescence in girls and boys correlates reliably with an age younger than 12 years. He estimates that the ages that correlated with the original Tanner stages were much older than those observed today. Technically, he points out that the use of Tanner stages using photographs that may have been modified in light or color, or moving images, increases the possibility of inaccuracy in estimating the age of the victims.

Table 2 shows the information obtained from data extracted from case studies with expert testimony and observer bias^{26-28,32}.

The results of the study by Berkowitz et al.³² showed that there was a high degree of agreement among evaluators in estimating a chronological age of plus/minus 1-2 years for both sexes in sexually explicit photographs, but not for estimating the exact age. They observed a higher degree of agreement in estimating the chronological age of males.

The results of the study by Cattaneo et al.²⁶ showed that forensic pathologists were the professionals who best identified the real age of the females, while pediatricians had the lowest identification figures. In any case, the results as a whole showed the unreliability of

the Tanner stages for verifying the chronological age of post-pubertal women photographed in pornographic material.

The results of the study by Rosenbloom et al.²⁷ showed poor agreement in breast stage assessment between examiners, noting that an examiner could estimate a chronological age of less than 18 years in more than a quarter of the images of adult women.

The results of Rosenbloom's study²⁸ showed that the testimony of physicians with expertise in pubertal development may consider that images of adult women selected for their youthful appearance are younger than 18 years old in more than two-thirds of the cases.

Discussion

The use of Tanner stages to estimate the chronological age of the victim from images in alleged child pornography cases is controversial. It has been emphasized that there is great population and interindividual variability in sexual maturation due to individual bi-

Table 2. Case study with expert testimony and observer bias

Source	a) Material and methods b) Tanner items examined c) Evaluators	Estimated chronological age versus actual age Observer bias
Berkowitz et al. ³²	a) 33 confiscated sexually explicit photographs (some in color and others in black and white) involving 44 nude children and adolescents of both sexes b) All Tanner items in females and males c) 3 pediatricians (2 with expertise in adolescent medicine)	In 20%, all 3 evaluators agreed on the exact same chronological age, with a greater degree of agreement in males In 76%, all 3 evaluators agreed on the chronological age within 2 years, with a greater degree of agreement in males In 72%, the 2 evaluators with expertise in adolescent medicine agreed on the chronological age within 1 year in females
Cattaneo et al. ²⁶	a) 11 photos of 11 adult females, taken from official authorized pornographic websites b) Breast development and pubic hair c) Italy (n = 28): 15 expertise medical specialists (5 forensic pathologists, 5 pediatricians, 5 gynecologists) and 13 lay non-medical specialists (control group) c) Germany (n = 23): 10 expertise medical specialists (5 forensic pathologists, 3 pediatricians, 2 gynecologists) and 13 lay non-medical specialists (control group)	They estimate a chronological age as under 18 years: - Forensic pathologists: Italy 31% - Germany 49% - Pediatricians: Italy 73% - Germany 95% - Gynecologists: Italy 69% - Germany 91% - Laymen: Italy 50% - Germany 76%
Rosenbloom et al. ²⁷	a) 547 images of 547 adult females, taken from Playboy magazine b) Breast development (Tanner stage 4 or 5) c) 4 pediatric endocrinologists expert in pubertal development	There was agreement in the estimation of the breast stage: - In 4 examiners: 3.1% of the images - In 3 examiners: 6.6% of the images - In 2 examiners: 7.1% of the images 26.5% of the images could have been considered by a single examiner in Tanner stage 4 and estimate a chronological age under 18 years
Rosenbloom ²⁸	a) 10 images of 10 adult females, taken from legitimate pornographic internet sites promoting youthful images b) Breast development and pubic hair c) 16 pediatric endocrinologists expert in pubertal development	69% of the 160 estimates of chronological age were that the images represent females under 18 years of age

ology (genetics, race, ethnicity), socioeconomic status (developing vs. industrialized countries, rural vs. urban population), environmental factors (diet, geographic location, light, exposure to endocrine-disrupting chemicals, etc.), and pathological factors (obesity, chronic malnutrition, precocious puberty, infections, physical stress, etc.). On the other hand, one of the items of the Tanner scale, pubic hair, has a great variability according to race or ethnicity, as is the case of Chinese women who usually have less pubic hair. It is also known that sexual development in boys and girls begins at an increasingly earlier age than when this scale was made five decades ago, something that has been attributed to improvements in living conditions, especially in terms of nutrition and health. Technically, a major limitation would be the difficulty in compar-

ing photographic staging on two-dimensional images with a complete medical examination, including inspection and palpation. In addition, specific markers may be modified in the images, such as whether the pubic hair is shaved or not^{18,23,24,26,29-31}.

In 1998, Tanner³³ himself published a letter to the editor of the journal *Pediatrics* indicating that in cases of suspected child pornography, the use of videos and photographs of the victim to estimate probable chronological age, and not to stage sexual maturation (Tanner's stage), has no validity since there are no equations that estimate age from the stage, and even if they did, the degree of unreliability in staging (independent variable), would cause large errors in the estimation of age (dependent variable). Moreover, the unreliability of staging is increased to an unknown degree by stag-

ing performed incorrectly, i.e., not on clinical examination but through non-standardized and therefore inadequate imaging. Thus, he cautions pediatricians and other physicians to refrain from giving “expert testimony” regarding chronological age based on Tanner staging, which was designed to estimate developmental or physiological age for medical, educational, and sports purposes, in other words, to identify early and late maturation. He stresses that the method is appropriate for this as long as the chronological age is known. Also, he concludes that it is not designed to estimate chronological age and, therefore, is not properly used for this purpose.

However, in response to this warning, Kutz³⁴ indicated that one should not conclude that the use of Tanner stages is not useful in child pornography cases. According to child pornography legislation, the victim need only have the appearance of a minor, defined as an individual under 18 years of age. In assessing that a person has the appearance of a child, it is reasonable to use an assessment of the person’s general appearance, as well as Tanner’s stage of the breasts, genitalia, and pubic hair. He cautions that one needs to be very careful about making statements on individuals who appear to be Tanner stage 3 or higher, and recognizes the difficulty of distinguishing between stages 3 and 5 of the breasts in pornographic photos. He also understands that Tanner staging does not apply to populations not evaluated and described by Tanner. In addition to all the scientific evidence and technical criticisms mentioned above, we must add the conclusions of the studies reviewed.

The study by Stathopulu et al.²⁹ concluded that pediatricians could give a relatively accurate expert opinion only in cases of prepubertal girls involved in sex tourism. In cases of girls in early puberty, an accurate opinion cannot be given and detailed studies in the affected countries are required.

The Berkowitz study³⁰ concluded that in some cases, the assessment might be straightforward since the individuals are obviously prepubertal children, whereas assessing the age of peri- or pubertal individuals would be more difficult. Establishing the age of an individual would depend on information about the age of pubertal development in that individual’s population or racial or ethnic group, and the Tanner stages would allow the physician to give an opinion about the degree of sexual maturation and provide an approximation of the child’s age.

Cooper’s study³¹ concluded that the ages that correlated with the original Tanner stages were much older than those currently observed. Accordingly, it is imperative that the term “Tanner stage” be avoided if testifying about child pornography or producing a document for court. Consistent with this practice, the

more generic term “Sexual Maturity Classification” should also become a standard designation in child pornography analysis and medical evaluations of child sexual abuse so that there is terminological consistency in the evaluation of all forms of child sexual abuse.

The study by Berkowitz et al.³² concluded that for the estimation of the same chronological age there was a low agreement between examiners, which almost quadrupled when estimating a chronological age of plus/minus 2 years.

The study by Cattaneo et al.²⁶ highlights the difficulties and major uncertainties of assessing chronological age by visual observation of photographic material, especially when subjects have reached the stage of sexual maturation and, therefore, to verify whether the individual is older or younger than 18 years of age. The authors emphasize the need both to seek an alternative approach and to apply extreme caution in judicial evaluation. They conclude that it is almost impossible to say that adults who appear to be subadults are adults, which obviously can be applied to all those subadults who appear to be sexually mature. Therefore, forensic and medical experts should avoid such unscientific behavior that could have drastic consequences in a law court.

The study by Rosenbloom et al.²⁷ shows that a significant number of adult women have persistent breast development at stage 4. They emphasize that this observation, and the frequent difficulty in distinguishing stage 4 from stage 5, even by pubertal development specialists, particularly on nonclinical imaging, invalidates testimony based on this distinction. The authors emphasize that, without clinical relevance for distinguishing these advanced stages of breast development, both should be considered indicative of full maturation. They conclude that clinical experience does not support the notion of forensic testimony in alleged child pornography cases that commonly asserts that Tanner stage 4 breast development, characterized by a secondary mound in the areolar that is effaced by stage 5, is evidence of an age younger than 18 years. Therefore, court testimony based on this maturity test is inappropriate and should not be allowed.

Rosenbloom’s study²⁸ confirms that the testimony of physicians with expertise in pubertal development may consider images of adult women selected for their youthful appearance to be under the age of 18 in more than two-thirds of cases. The authors conclude that law courts should avoid testimony that has no scientific basis.

To our knowledge, this is the first systematic review to report on the efficacy of using Tanner stages as a method for estimating chronological age in alleged child pornography cases. A limitation of this review would be the lack and heterogeneity of the included

studies. One of the reasons was to limit the search to English and Spanish, as we are aware of three case studies with expert testimony written in Polish³⁵⁻³⁷.

Conclusion

Based on the available data, we conclude that the scientific evidence discourages the use of Tanner stages to estimate the chronological age of the victim from images in alleged child pornography cases. This method is ineffective when the alleged victim, for both sexes, shows sexual maturation in Tanner stages 3-5. When the alleged victim is in Tanner stages 1 (prepubertal) or

2 (females: mammary bud and small amount of long, velvety hair on labia majora; males: small penis, 3 cm. or less, and small amount of long, velvety hair at the base of the penis and scrotum), it may be useful for testifying that he is under 18 years of age, but not for determining her/his chronological age. Pediatricians and other medical professionals should avoid giving testimony that has no scientific basis.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

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