



Teaching Clinical Assessment of Puberty in Iranian Pediatric Practice: Educational Barriers, Cultural-Ethical Considerations, and Strategies to Enhance Clinical Competence

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Abstract

Background: Accurate pubertal assessment and Tanner staging are essential for diagnosing precocious or delayed puberty, monitoring growth, and preventing psychosocial harm. However, limited trainee competence may result in misclassification and inappropriate referrals. This study examined educational, structural, and cultural barriers to pubertal-assessment training and identified feasible, evidence-informed strategies for Iran.

Materials and Methods: In this structured critical narrative review, guided by SANRA and the Thomas and Harden thematic synthesis framework, we searched international (PubMed/MEDLINE, Scopus, Web of Science, and ERIC) and Iranian (SID, Magiran, and CIVILICA) databases, plus grey literature, from inception to March 15, 2026. English- and Persian-language studies addressing pubertal-assessment education, Tanner-staging accuracy, examination barriers, or educational interventions were included. Data were synthesized thematically across skill-related, structural, ethical/cultural, and educational domains.

Results: Three themes emerged: (1) Clinical and technical deficits, including overreliance on visual inspection, difficulty distinguishing glandular thelarche from lipomastia in girls with overweight or obesity, and high error rates and poor reliability in Prader orchidometer use; (2) Structural constraints, including high patient volume, limited consultation time, scarce private examination space, and inadequate opportunities for direct observation and feedback; and (3) Ethical and cultural complexities, including adolescent embarrassment, modesty norms, preferences for gender-concordant clinicians, ambiguity regarding adolescent assent and parental consent, and limited use of professional chaperones. Tactile and three-dimensional breast and scrotal simulators, standardized patients, case-based learning, and workplace-based assessments (DOPS, Mini-CEX, and OSCE) improved diagnostic accuracy, tactile discrimination, communication, and clinical decision-making.

Conclusion: Improving pubertal-assessment training in Iran requires staged, simulation-based practice before real-patient contact, culturally congruent chaperone policies, institutionalized adolescent-assent protocols, and structured workplace-based assessments to develop comprehensive, patient-centered clinical competence among pediatric residents.

Key Words: Adolescent Assent, Iran, Pediatric Residency Education, Pubertal Assessment, Tanner Staging.

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1- INTRODUCTION

Puberty is one of the most dynamic and sensitive developmental stages encountered in pediatric practice. It encompasses somatic growth, maturation of the hypothalamic–pituitary–gonadal axis, development of secondary sexual characteristics, and important psychological and social transitions. Deviations in the timing or progression of puberty, particularly precocious puberty and delayed puberty, may have substantial diagnostic, physical, and psychosocial consequences. Progressive precocious puberty may be associated with accelerated growth, advancement of bone age, and reduced adult height potential. In selected patients, it may also warrant evaluation for underlying causes, including central nervous system disorders, gonadal or adrenal tumors, and exposure to exogenous sex steroids (1, 2). Conversely, delayed puberty may be associated with psychological distress, reduced self-esteem, social difficulties, impaired bone health, chronic disease, undernutrition, gonadal insufficiency, or genetic disorders (3). Furthermore, the mental health and psychological well-being of pediatric populations may be affected by various stressors and health-related anxieties, potentially complicating the clinical management of developmental transitions (4).

Timely, standardized, and accurate pubertal assessment is therefore essential in primary care, pediatric outpatient clinics, and clinical training settings. Such assessment extends beyond chronological age or laboratory testing and requires focused history-taking, evaluation of growth trajectory and growth velocity, systematic physical examination, assessment of sexual maturity, and interpretation of findings within the individual child's clinical context. Tanner staging remains a widely used approach for documenting the development of

secondary sexual characteristics; however, its accurate application requires familiarity with its limitations, proficiency in clinical examination, and the ability to distinguish normal variation from findings that require further assessment (5).

An important component of pubertal evaluation is differentiating normal or relatively benign developmental variants from true pubertal disorders. For example, distinguishing isolated premature thelarche, premature adrenarche, adipose tissue in the breast area of children with overweight or obesity, and genuine activation of the hypothalamic–pituitary–gonadal axis requires careful examination and appropriate longitudinal follow-up (2, 5). In girls, differentiating glandular breast tissue from adipose tissue depends largely on appropriate inspection and palpation of the subareolar region. In boys, assessment of testicular volume—particularly through use of a Prader orchidometer—plays an important role in identifying early pubertal onset and differentiating true puberty from superficial or non-gonadal changes. Nevertheless, trainees require standardized instruction in both the technique and interpretation of orchidometric assessment (5, 6).

Inadequate proficiency in physical examination and interpretation of pubertal stages may lead to unnecessary or poorly targeted hormonal tests, bone-age studies, imaging investigations, or subspecialty referrals. Conversely, insufficient clinical assessment may contribute to delayed identification of children who require timely specialist evaluation. Therefore, teaching pubertal assessment should not be limited to memorization of Tanner stages or age-based diagnostic thresholds. Instead, it should develop trainees' competencies in professional communication, respectful and safe examination, accurate documentation, contextual clinical interpretation, and

appropriate follow-up or referral decisions (5, 7).

Despite the importance of these competencies, teaching pubertal examination in pediatrics is often affected by educational and environmental barriers. Time constraints in busy clinical settings, large numbers of trainees, limited opportunities for direct observation and feedback, variability in teaching practices, and reliance on didactic or image-based instruction may hinder acquisition of sensitive clinical examination skills. Literature on clinical medical education in Iran has highlighted the effects of workload, limited bedside teaching opportunities, inadequate supervision and feedback, and a potential gap between curriculum expectations and the realities of clinical practice (8). In pediatric endocrinology education, training and assessment strategies have also been reported to be heterogeneous, underscoring the need for more structured and competency-based approaches (7).

Breast and genital examinations in children and adolescents are particularly sensitive clinical encounters. They may cause anxiety for patients, concerns among parents or caregivers, discomfort among trainees, and uncertainty regarding consent procedures. In these circumstances, clinicians should clearly explain the purpose of the examination using age-appropriate language, protect privacy, allow the patient an opportunity to ask questions or decline the examination, and ensure the availability of an appropriately trained chaperone. The American Academy of Pediatrics emphasizes the importance of chaperone use during sensitive examinations of pediatric and adolescent patients, consideration of patient and family preferences, and appropriate documentation in the medical record (9).

In Iran, these issues are further shaped by cultural, religious, and family values

related to modesty, privacy, gender, and preferences for gender concordance between the examiner and adolescent patient. Such considerations may reduce opportunities for medical students, interns, and pediatric residents—particularly those whose gender differs from that of the patient—to participate directly in pubertal examinations. Nevertheless, restricted exposure to real patients should not result in omission of practical training. Rather, it highlights the need for clear communication protocols, private examination settings, age-appropriate consent processes, chaperone use, and complementary educational modalities that preserve the dignity, rights, comfort, and autonomy of children and adolescents while supporting clinical learning (8, 9).

Furthermore, pubertal timing and the clinical presentation of pubertal disorders may be influenced by population characteristics, nutritional status, social factors, and underlying chronic diseases. Studies conducted in Iran have described patterns of pubertal development among Iranian girls and emphasize the importance of considering local population data when interpreting pubertal findings (10). Clinical observations among Iranian adolescents with chronic pediatric diseases also suggest that delayed puberty may present additional diagnostic and interpretive challenges in the context of chronic illness (11). These considerations reinforce the importance of designing pubertal-assessment education that is informed by both international standards and the local clinical context.

In recent years, several innovative approaches have been proposed to strengthen the teaching of pubertal assessment. These include hands-on simulation using three-dimensional breast models for teaching breast Tanner staging, instructional use of orchidometers, case-based learning, standardized patients for practicing communication and consent,

multimedia e-learning, workplace-based assessment, and structured feedback. Such approaches may help move learning beyond theoretical knowledge toward observable clinical performance (7, 12).

For example, a hands-on synthetic three-dimensional breast model has been developed to help medical students and pediatric residents identify and distinguish stages of breast development according to the Tanner classification (12). Such models may offer repeated, low-stakes opportunities to compare palpable features of breast development and practice Tanner staging in a setting that protects patient privacy and minimizes discomfort. When integrated with supervised clinical exposure and feedback, simulation-based activities may contribute to trainees' confidence and competence in the clinical assessment of children with pubertal concerns.

1-1. Objectives

The overall objective of this review is to examine the challenges associated with teaching clinical pubertal assessment in Iranian pediatrics and to identify feasible educational, ethical, and culturally responsive strategies for improving the competence of pediatric trainees and practitioners.

Specifically, this review aims to:

- Identify educational, skill-related, environmental, and cultural barriers affecting the teaching and learning of pubertal examination and Tanner staging in pediatric training.
- Examine ethical, communication-related, and cultural considerations in sensitive pubertal examinations of children and adolescents, with particular attention to consent, privacy, and chaperone use.
- Review innovative and potentially adaptable educational strategies—including simulation, teaching models,

case-based learning, standardized patients, workplace-based learning, and structured feedback—to improve the assessment, follow-up, and referral of children with pubertal disorders.

2- MATERIALS AND METHODS

2-1. Study Design

This study was conducted as a structured critical narrative review to examine educational barriers; ethical, cultural, and communication-related considerations; and contemporary teaching strategies relevant to the clinical assessment of pubertal development and pubertal disorders in pediatric practice. The review aimed to integrate evidence on clinical examination skills, Tanner staging, sensitive physical examinations in adolescents, and educational approaches potentially applicable to pediatric training in Iran.

To enhance transparency, reporting consistency, and rigor in the selection and interpretation of evidence, the review was designed and reported with reference to the Scale for the Assessment of Narrative Review Articles (SANRA) and the principles of thematic synthesis described by Thomas and Harden (13, 14).

2-2. Search Strategy and Information Sources

A structured literature search was conducted from the inception of each database through March 15, 2026, in English and Persian. International databases included PubMed/MEDLINE, Scopus, Web of Science Core Collection, and ERIC. To identify evidence relevant to the Iranian health-care and medical-education context, national sources, including the Scientific Information Database (SID), Magiran, CIVILICA, and accessible Iranian medical-journal databases and portals, were also searched.

In addition to electronic database searching, the reference lists of key articles, clinical guidelines, consensus statements, policy documents, and relevant educational resources were manually searched. Grey-literature searches were also undertaken to identify potentially relevant guidelines, educational materials, professional recommendations, and policy documents not indexed in conventional bibliographic databases. Websites of professional organizations and scientific societies, including the American Academy of Pediatrics, the Pediatric Endocrine Society, and other credible resources related to adolescent health and medical education, were reviewed.

The search strategy combined Medical Subject Headings (MeSH) with free-text terms searched in title and abstract fields. Search concepts covered pubertal assessment, pubertal disorders, Tanner staging, orchidometry, medical education, clinical competence, simulation, standardized patients, sensitive examinations, consent, chaperones, and cultural considerations. Boolean operators (AND and OR) were used to combine search terms, and the search syntax was adapted to the indexing structure and technical requirements of each database.

An illustrative PubMed search strategy was as follows:

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("Puberty"[Mesh] OR "Precocious Puberty"[Mesh]
OR "Delayed Puberty"[Mesh]

OR "pubertal assessment" OR "Tanner staging" OR
"sexual maturity rating"

OR orchidometry OR "Prader orchidometer" OR
thelarche OR pubarche)

AND

("Education, Medical"[Mesh] OR "Pediatric
Residency" OR "Clinical Competence"[Mesh]

OR "Simulation Training" OR "Standardized
Patients" OR "Objective Structured Clinical
Examination"

OR "Workplace-Based Assessment" OR
curriculum OR "clinical teaching")
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AND

(Iran OR "Middle East" OR "cultural barriers" OR chaperone

OR "Ethics, Medical"[Mesh] OR confidentiality OR gender)

For Persian-language databases, equivalent Persian free-text terms were used, including «بلوغ»، «بلوغ زودرس»، «بلوغ دیررس»، «ارزیابی بلوغ»، «مراحل تانر»، «ارکیدومتر پرادر»، «آموزش پزشکی کودکان»، «شبیه‌سازی بالینی»، «بیمار استاندارد»، «معاینه فیزیکی»، «رضایت آگاهانه»، «حریم خصوصی»، «همراه بالینی»، «ملاحظات فرهنگی» و «ایران». The complete search strategies for all databases can be provided as supplementary material.

2-3. Inclusion Criteria

Publications available in English or Persian through March 2026 were included if they addressed at least one of the following areas:

- Clinical assessment of pubertal development, Tanner staging, breast or genital examination, testicular-volume assessment, precocious puberty, delayed puberty, or associated diagnostic and referral challenges.
- Training of medical students, interns, pediatric residents, general practitioners, family physicians, pediatricians, or pediatric endocrinology trainees in pubertal assessment.
- Educational strategies, including simulation, three-dimensional or tactile teaching models, orchidometer training, standardized patients, case-based learning, e-learning, workplace-based learning, objective structured clinical examinations, direct observation of performance, and structured feedback.
- Ethical, cultural, communication-related, and gender-related considerations in sensitive examinations of children and

adolescents, including consent, adolescent assent, confidentiality, privacy, and chaperone use.

- Studies conducted in Iran or international evidence with potential relevance and transferability to Iranian medical-education settings.

Quantitative, qualitative, mixed-methods, interventional, quasi-experimental, cross-sectional, survey-based, and review studies were considered. Clinical guidelines, consensus statements, policy documents, and professional position papers were also included when directly relevant to the objectives of the review.

2-4. Exclusion Criteria

The following sources were excluded:

- Basic science, molecular, genetic, pharmacological, or pharmacokinetic studies without direct implications for clinical assessment, education, diagnostic decision-making, referral, or ethical considerations.
- Conference abstracts without accessible full texts or adequate methodological details.
- Non-educational single case reports, letters to the editor, editorials, and commentaries that did not provide relevant data, analysis, or professional recommendations.
- Publications in languages other than English or Persian.

2-5. Study Selection and Reference Management

All identified records were imported into EndNote 20, and duplicate records were removed. Titles and abstracts were initially screened for relevance to the review objectives. Full texts of potentially relevant publications were subsequently retrieved and reviewed. Final selection was based on direct relevance to the study topic, credibility of the journal or issuing

organization, reporting quality, methodological transparency, relevance to pediatric education, and potential applicability or adaptability to the Iranian medical-education context.

2-6. Critical Appraisal of Sources

Given the structured critical narrative nature of this review and the heterogeneity of included sources, evidence was critically appraised according to publication type. Considerations included source credibility, methodological transparency, quality and completeness of reporting, relevance to the objectives of the review, reported limitations, transferability of findings, and applicability to the cultural, educational, and organizational context of Iran.

For clinical guidelines, consensus statements, policy documents, and professional recommendations, appraisal focused on the credibility of the issuing organization, recency of publication, transparency of the development process, and relevance to pediatric care and medical education. This appraisal was intended to support cautious interpretation and contextual weighting of the evidence rather than mechanical exclusion of sources.

2-7. Data Extraction

Data from eligible sources were recorded using a standardized data-extraction form. Extracted information included author, year of publication, country, study design or source type, study aim and setting, target learner or clinical population, educational intervention or teaching strategy, assessment tools, reported educational, skill-related, environmental, cultural, and ethical barriers, educational and clinical outcomes, study limitations, and potential applicability to Iranian medical-education settings.

Educational and clinical outcomes of interest included knowledge acquisition,

learner confidence, examination performance, communication skills, clinical decision-making, diagnostic accuracy, follow-up practices, and appropriate referral of children and adolescents with pubertal concerns.

2-8. Data Synthesis

Findings were analyzed using a narrative thematic synthesis approach. Initial organization of the evidence was informed by the three-stage framework proposed by Thomas and Harden, including coding of key concepts, development of descriptive themes, and generation of analytical themes (14). This framework entails line-by-line coding, development of descriptive themes, and generation of higher-order analytical themes (14).

Because the review included qualitative, quantitative, educational, and policy-oriented sources, this approach was not used as a purely qualitative synthesis method. Rather, it served as an organizing framework to systematically compare, interpret, and integrate heterogeneous evidence.

The final synthesis was organized into four interrelated domains:

1. Cognitive and skill-related challenges in physical examination, breast palpation, testicular-volume assessment, and Tanner staging.
2. Structural and environmental barriers, including workload, time constraints, limited opportunities for bedside teaching, insufficient direct supervision, and inadequate structured feedback.
3. Cultural, ethical, gender-related, and communication considerations in sensitive examinations of children and adolescents, with particular emphasis on consent, privacy, confidentiality, and chaperone use.

4. Contemporary educational strategies, including simulation, three-dimensional teaching models, orchidometer training, standardized patients, case-based learning, workplace-based learning, digital educational tools, and their potential for contextual adaptation in Iran.

2-9. Ethical Considerations

This review was based exclusively on publicly available published literature and did not involve human participants, biological sampling, access to identifiable patient information, or review of medical records. Therefore, informed consent from participants was not required. Throughout the study, principles of academic integrity, transparent reporting, accurate citation, avoidance of selective interpretation or misrepresentation of evidence, and respect for intellectual property were observed. Ethical principles related to publication integrity and transparent reporting were considered in accordance with the recommendations of the Committee on Publication Ethics (COPE) (15).

3- RESULTS

The critical synthesis of the included evidence indicated that teaching the clinical assessment of pubertal development and pubertal disorders in pediatric practice is affected by a set of interrelated challenges. These challenges can be grouped into three main domains: first, cognitive and skill-related limitations in performing pubertal examinations and interpreting pubertal stages; second, structural and curricular constraints, including high patient volume, time limitations, inadequate opportunities for direct supervision, and limited structured feedback; and third, ethical, cultural, and communication-related considerations associated with sensitive breast and genital examinations in children and adolescents.

At the clinical skill level, difficulties in distinguishing glandular breast tissue from adipose tissue in children with overweight or obesity, inaccurate estimation of testicular volume, and overreliance on visual inspection rather than systematic examination and palpation were prominent concerns. These limitations may contribute to unnecessary diagnostic investigations, inappropriate referral decisions, or delayed recognition of children requiring specialist evaluation (5, 6, 16–19).

Conversely, the evidence suggests that combining didactic teaching with hands-on practice, tactile or three-dimensional models, simulation-based education, case-based scenarios, standardized patients, workplace-based learning, and structured feedback may improve learner confidence, examination accuracy, communication skills, and readiness for clinical decision-making. However, the effectiveness of each approach depends on the learner population, quality of instructional design, opportunities for repeated practice, faculty supervision, clinical setting, and the feasibility of contextual adaptation in Iran (7, 12, 20–23).

The findings are presented in three main themes and two analytical tables: educational, skill-related, structural, and cultural barriers to pubertal assessment; ethical and communication considerations in sensitive examinations; and contemporary teaching and assessment strategies.

3-1. Educational, Skill-Related, Structural, and Cultural Barriers

3-1-1. Skill-Related and Diagnostic Challenges

One of the principal challenges in pubertal assessment is reliance on visual inspection rather than complete examination and systematic palpation. In girls, differentiating early glandular breast development from adipose tissue in the context of overweight or obesity,

particularly in the subareolar region, requires appropriate examination skills and accurate interpretation of Tanner stages. Reliance on breast appearance alone may lead to incorrect pubertal staging and unnecessary concern or evaluation for precocious puberty (2, 5, 16).

In boys, testicular-volume assessment using a Prader orchidometer is clinically valuable for identifying pubertal onset; however, accurate use of this tool requires practical training. In a simulation study, participants correctly estimated testicular volume in only approximately one-third of assessments, and interobserver reliability was low. Accuracy in estimating a 4-mL testis, a clinically important volume indicating pubertal onset, was also limited, emphasizing the need for hands-on teaching and structured feedback (17). Another study reported that a simulation-based workshop improved the accuracy, reliability, and retention of testicular-volume estimation skills among medical students (20).

3-1-2. Gap Between Knowledge and Practice

Although pediatric trainees generally recognize the importance of pubertal assessment, awareness does not necessarily translate into consistent clinical practice. In a national survey of pediatric trainees in the United States, 96% of respondents acknowledged the importance of pubertal assessment, 62% reported confidence in performing it, and only 33% reported performing external genital examinations at all routine health visits. More advanced training and completion of a pediatric endocrinology rotation were associated with greater knowledge, comfort, and use of pubertal assessment in practice (19).

Although these findings cannot be directly generalized to Iran, they illustrate a persistent gap between theoretical knowledge and clinical performance. In

the Iranian context, time constraints in outpatient clinics, large trainee numbers, heavy clinical workloads, and limited access to simulation resources may further widen this gap (7, 8).

3-1-3. Structural and Environmental Barriers

High patient volume, restricted consultation time, and lack of adequate private examination space may limit the thorough performance of sensitive

examinations in teaching clinics. In addition, inadequate opportunities for faculty members to directly observe trainees and provide immediate feedback may impede the development of clinical competence. Reviews of pediatric endocrinology education and clinical medical education in Iran have highlighted the need for more structured educational approaches, strengthened bedside teaching, and effective feedback mechanisms (7, 8).

Table-1: Summary of Educational, Clinical, Structural, and Cultural Barriers to Pubertal Assessment in Pediatric Training.

Challenge domain	Common manifestations and errors	Potential educational and clinical consequences	References
Clinical and technical	Reliance on visual inspection without breast palpation; difficulty differentiating glandular from adipose breast tissue; inaccurate testicular-volume estimation; insufficient or incorrect use of the Prader orchidometer; misinterpretation of Tanner stages	Incorrect pubertal classification; unnecessary concern or investigations; inappropriate follow-up or referral; reduced learner confidence	(2, 5, 6, 16–18)
Educational and curricular	Predominantly didactic or atlas-based teaching; limited tactile-skills practice; insufficient access to models and simulators; lack of performance-based assessment	Gap between theoretical knowledge and clinical performance; variability in trainee competence; limited readiness for independent decision-making	(7, 12, 19, 20)
Structural and environmental	High patient volume; limited time; inadequate private examination areas; insufficient direct observation and faculty feedback	Omission or shortening of sensitive examinations; inadequate clinical documentation; reduced quality of workplace-based learning	(7, 8, 19, 23)
Ethical and cultural	Adolescent embarrassment or anxiety; family concerns; preference for examiner–patient gender concordance; absence of a chaperone; uncertainty regarding consent and adolescent assent	Limited patient cooperation; trainee anxiety; reduced family trust; risk of privacy violations or professional misunderstanding	(9, 24–26)

Note: The categories presented are interrelated and may coexist in clinical teaching settings. Their relative impact may vary according to trainee level, faculty supervision, institutional resources, clinical workload, and local cultural context.

3-2. Ethical, Communication, and Cultural Considerations

3-2-1. Privacy and Professional Communication

Breast and genital examinations in children and adolescents should be performed in a private setting and with full respect for patient dignity. The clinician should provide a clear, age-appropriate explanation of the purpose and steps of the examination, allow the adolescent to ask questions, and respect the patient's wish to pause or defer the examination, where appropriate.

Nonjudgmental communication, adequate draping, limiting the examination to clinically necessary components, and providing reassurance may improve patient comfort and cooperation (24, 25).

In settings where modesty, family involvement, and gender concordance between the examiner and patient are particularly important, these considerations should be incorporated into clinical teaching as elements of professional competence. The objective is not to eliminate practical training but to provide a staged, ethically appropriate educational process. Such a process may begin with simulation-based practice and proceed to supervised encounters with real patients only when clinically indicated and conducted with full respect for patient rights and privacy.

3-2-2. Consent, Assent, and Chaperone Use

Before a sensitive examination is performed, its purpose, necessity, procedures, and boundaries should be explained to the parent or guardian and to the adolescent in age-appropriate language. Parental consent should not replace the adolescent's involvement in decision-making. Seeking the adolescent's assent, respecting their preferences, and addressing their concerns are therefore

essential components of ethically appropriate pubertal assessment (24, 25).

The presence of an appropriately trained chaperone during sensitive examinations is an important component of professional pediatric care and supports both the patient and the clinical team. A chaperone should be a trained member of the health-care team who understands the responsibilities of this role, rather than simply a family member. Parental presence may be helpful according to the preferences of the adolescent, family, and institutional policy; however, it does not necessarily substitute for a professional chaperone. The American Academy of Pediatrics policy statement and the American Medical Association ethical guidance emphasize the importance of chaperone use, consideration of patient and family preferences, and appropriate documentation (9, 26).

3-3. Contemporary Teaching and Assessment Strategies

3.3.1. Simulation and Teaching Models

Three-dimensional and tactile models can provide a safe, repeatable, and low-stress environment for practicing Tanner staging and palpation skills. Synthetic breast models, particularly those representing different stages of breast development and subareolar glandular tissue, may help learners connect visual knowledge with tactile examination skills. Three-dimensional breast models have been designed and validated for teaching Tanner staging and breast palpation; however, their effects on real-world clinical outcomes require further evaluation across diverse educational settings (12, 21).

Simulated scrotal models used with orchidometers may similarly support practice in testicular-volume estimation. Available evidence indicates that initial errors in estimating testicular volume can be substantial and that simulation-based workshops may improve accuracy,

reliability, and skill retention (17, 20). However, broad claims that these interventions reduce errors “by more than half” should be avoided unless supported by comparable quantitative results across studies.

3-3-2. Standardized Patients and Case-Based Learning

Standardized patients and role-play are useful for teaching the non-palpation, yet essential, components of pubertal assessment. These include history-taking, explaining the need for examination, responding to adolescent and parental concerns, obtaining consent and assent, managing anxiety, and using professional language. These approaches provide opportunities for deliberate practice and feedback before learners encounter real patients and can be tailored to culturally sensitive communication scenarios (7, 22).

Case-based learning may also strengthen clinical reasoning in situations involving precocious puberty, delayed puberty, premature thelarche, premature adrenarche, breast appearance in the context of obesity, and chronic disease. Integrating growth charts, growth velocity, Tanner-staging findings, bone-age data, and relevant clinical history into case scenarios can help trainees avoid making

decisions based on a single isolated sign (2, 3, 7).

3-3-3. Workplace-Based Learning and Assessment

Workplace-based assessment methods, including Direct Observation of Procedural Skills (DOPS) and the Mini-Clinical Evaluation Exercise (Mini-CEX), enable faculty members to assess physical examination skills, professional communication, consent and privacy practices, chaperone use, and interpretation of findings in real or simulated clinical settings. These methods are most useful when accompanied by clear checklists, direct observation, timely feedback, and opportunities for repeated practice (7, 23).

Objective Structured Clinical Examinations (OSCEs) can also assess trainees’ ability to interpret Tanner stages, estimate testicular volume, explain the examination, obtain consent and assent, make follow-up or referral decisions, and demonstrate professional behavior. Combining OSCEs with simulation and workplace-based assessment may be more appropriate than relying on a single assessment method, as this allows simultaneous evaluation of knowledge, technical skill, communication, clinical reasoning, and professionalism.

Table-2: Educational and Assessment Strategies for Teaching Pubertal Assessment.

Strategy	Suggested educational activity	Target competency	Appropriate assessment method	Implementation considerations	Sources
Structured module	Teaching growth indicators, anthropometry, chart selection, and interpretation	Conceptual knowledge and readiness for clinical application	Knowledge test, case assignment, and post-teaching quiz	Content should be revisited across curriculum stages	(3, 4, 10)
Skills workshop	Practice of weight, height/length, head circumference, data recording, and chart plotting	Accuracy of anthropometry and data recording	Direct observation checklist and DOPS	Should include repetition, feedback, and standard tools	(8–10, 22)

Strategy	Suggested educational activity	Target competency	Appropriate assessment method	Implementation considerations	Sources
Case-based learning	Analysis of real or simulated cases with serial growth charts	Trajectory interpretation and clinical reasoning	Case-based test, group discussion, or analytical report	Scenarios should include risk factors and longitudinal data	(4, 21, 24, 26, 30)
Simulation	Practice of anthropometry, chart plotting, and counselling with standardized parents	Practical skills, communication, and decision-making	OSCE and structured checklist	Suitable for safe, repeated practice before real clinical exposure	(12, 22, 32)
Outpatient training	Active participation in well-child clinics and primary care centers	Application of skills in real settings and family-centered care	Mini-CEX, DOPS, and direct feedback	Requires clear objectives, clinical supervisor, and sufficient participation opportunities	(1, 5, 8, 10, 29)
Longitudinal record or portfolio	Recording, plotting, and analyzing child growth over multiple visits	Understanding the dynamic nature of growth and professional reflection	Portfolio assessment, faculty feedback, and self-assessment	Assessment criteria and follow-up schedule must be clear	(11, 21, 29, 36)
Multi-method assessment	Combination of knowledge test, OSCE, and workplace assessment	Comprehensive assessment of knowledge, skills, reasoning, and communication	Written test, OSCE, DOPS, mini-CEX, and portfolio	Tools should align with learning objectives and learner level	(11, 12, 31, 36–39)

Note: Selection and implementation of educational strategies should be tailored to learning objectives, trainee level, faculty capacity, institutional resources, availability of simulation facilities, and the ethical and cultural requirements of sensitive examinations. DOPS: Direct Observation of Procedural Skills; Mini-CEX: Mini-Clinical Evaluation Exercise; OSCE: Objective Structured Clinical Examination.

4- DISCUSSION

4-1. Evidence Synthesis and the Knowledge–Practice Gap

Clinical assessment of pubertal development and accurate determination of sexual maturity rating using Tanner staging are essential components of growth and developmental surveillance in pediatric and adolescent care (1–3, 16). However, the findings of this review suggest that a substantial gap may exist

between trainees' theoretical awareness of the importance of pubertal assessment and their confidence, competence, and consistent performance of this skill in clinical practice (5, 7).

This gap has also been identified in surveys of pediatric trainees. In a national survey conducted in the United States, most pediatric residents acknowledged the importance of pubertal assessment; however, confidence in performing the

examination and routine use of external genital examinations during health-maintenance visits were limited (19). In a study by Ens and colleagues involving pediatric residency programs in Canada, 52% of residents reported discomfort when introducing pubertal examinations, 50% reported insufficient confidence, and 56% indicated that they had avoided at least one clinically indicated pubertal examination. During the intervention phase, an online case-based learning module improved residents' knowledge and confidence compared with a control group, and 95% of participants considered the module useful (27).

Although these findings cannot be directly generalized to Iranian medical-education settings, they highlight an important and potentially transferable concern. Trainee discomfort, limited practical experience, uncertainty regarding consent and chaperone procedures, and inadequate opportunities for supervised practice may contribute to incomplete assessment or reluctance to perform clinically indicated sensitive examinations. In Iranian training settings, high patient volume, limited consultation time, large numbers of trainees, restricted access to clinical-skills laboratories, and inadequate opportunities for direct faculty observation may further widen the gap between knowledge and performance (7, 8).

Accordingly, education in pubertal assessment should extend beyond teaching age thresholds, Tanner stages, or laboratory algorithms. Training programs should enable learners to perform systematic examinations, communicate professionally with adolescents and families, obtain consent and age-appropriate assent, use chaperones appropriately, document findings accurately, and make informed decisions regarding follow-up and referral.

4-2. Diagnostic Challenges and Clinical Examination

The findings of this review indicate that overreliance on visual inspection, without systematic assessment and gentle palpation of subareolar breast tissue, is an important potential source of error in pubertal staging (5). In children with overweight or obesity, differentiating adipose breast tissue from true glandular breast development, particularly Tanner stage B2, requires careful clinical examination and longitudinal assessment in the context of growth patterns and other clinical findings (2, 5, 10, 16).

In girls, misinterpretation of breast appearance may increase concern about precocious puberty and lead to diagnostic investigations such as hormonal testing, bone-age radiography, and, in selected cases, gonadotropin-releasing hormone stimulation testing (1, 2, 5). However, decisions regarding further investigation or referral should not be based on a single physical sign. They should take into account the child's age, growth velocity, progression of pubertal signs, family history, complete physical examination, and the presence of clinical warning features.

In the Iranian context, interpretation of early pubertal signs and decisions regarding further assessment should also consider locally relevant determinants of pubertal timing and clinical presentation. A recent review of precocious puberty in Iranian children highlighted the potential contribution of genetic, nutritional, environmental, socioeconomic, and sociocultural factors. These considerations reinforce the need for context-sensitive clinical education and locally adapted approaches to the assessment, follow-up, and referral of children with pubertal concerns (28).

In boys, testicular-volume estimation using a Prader orchidometer is an important

component of identifying the onset and progression of puberty. Nevertheless, this skill requires hands-on instruction, repeated practice, and feedback. In a simulation study, overall accuracy in estimating testicular volume was low, and interobserver agreement was limited. Estimation of a 4-mL testis, a clinically important threshold for pubertal onset, was also associated with substantial error (17). A subsequent study showed that a simulation-based workshop improved the accuracy, reliability, and retention of testicular-volume estimation skills among medical learners (20).

Errors in estimating testicular volume, whether through overestimation or underestimation, may affect the recognition, follow-up, and timing of referral for children with delayed puberty, hypogonadism, gonadal disorders, or pubertal delay associated with chronic disease (3, 6, 11, 17, 18). Therefore, orchidometry should not be regarded as a peripheral skill; rather, it should be incorporated into structured training on pubertal assessment in pediatric residency programs.

The ability to distinguish relatively benign variants, such as premature thelarche, premature adrenarche, and obesity-related breast changes, from central or peripheral precocious puberty is also important. Case-based learning, interpretation of growth charts and growth velocity, practice in Tanner staging, review of bone-age findings, and discussion of referral scenarios may help reduce decisions based on isolated findings and strengthen trainees' clinical reasoning (1–3, 7).

4-3. Simulation and Experiential Learning

To reduce skill-related gaps, simulation-based medical education may complement traditional observation- and lecture-based approaches. Kolb's experiential learning theory proposes that durable learning

occurs through a cycle of concrete experience, reflective observation, abstract conceptualization, and active experimentation (29).

Three-dimensional and tactile breast models can be used to practice inspection and palpation across different stages of breast development, particularly to identify subareolar glandular tissue during early puberty. These models provide opportunities for repeated deliberate practice without compromising the comfort or privacy of real patients (12, 21). Similarly, simulated scrotal models used with Prader orchidometers can facilitate practice in estimating different testicular volumes and receiving structured feedback (17, 20).

Despite promising findings, simulation alone should not be assumed to ensure complete transfer of skills to real clinical practice. The effectiveness of simulation depends on instructional design, clarity of learning objectives, model quality, repeated practice, faculty feedback, learner reflection, and integration with supervised clinical experience. A systematic review of pediatric endocrinology education also emphasized the heterogeneity of educational and assessment approaches in this field and the need for more structured, competency-based educational strategies (7).

Online and case-based education may provide an accessible complementary method for teaching clinical decision-making, Tanner staging, scenarios of precocious and delayed puberty, consent, and communication with adolescents. The online learning module developed for pediatric residents in Canada improved knowledge and confidence related to pubertal examination; therefore, development of culturally adapted Persian-language modules may be a feasible option for medical universities in Iran (27).

4-4. Ethical, Communication, and Adolescent-Centered Considerations

Pubertal assessment lies at the intersection of technical competence, professional communication, and medical ethics. Breast and genital examinations, particularly in adolescents, may be associated with embarrassment, anxiety, concerns about privacy, sensitivity to examiner gender, and parental concerns. Examinations conducted without adequate explanation, psychological preparation, appropriate draping, and privacy protection may increase adolescent discomfort. Conversely, trainee uncertainty or discomfort in these situations may contribute to incomplete assessment or avoidance of clinically indicated examinations (8, 25, 27).

Ethically appropriate pubertal assessment requires an age-appropriate explanation of the purpose and steps of the examination, protection of dignity and privacy, appropriate draping, limitation of the examination to clinically necessary components, opportunities for questions, and meaningful involvement of the adolescent in decision-making. Parental consent is important in pediatric care but should not replace the adolescent's participation in decisions that affect them. When adolescents have appropriate developmental capacity, their assent should be sought and their objections should be respected, particularly when the examination is primarily educational rather than clinically necessary (24, 25, 30).

Ethical guidance regarding the participation of children and adolescents in medical education emphasizes that trainees should clearly disclose their role and level of supervision to the patient and family. When educational activities extend beyond clinically necessary care, parental permission and age-appropriate assent should be obtained, while refusals or limitations expressed by the child, adolescent, or family should be respected.

Sensitive examinations performed by junior trainees should also occur under appropriate supervision by experienced clinicians (30).

The availability of a trained clinical chaperone during sensitive examinations is another important element of professional care and protection for both the patient and the clinical team. A chaperone should be a health-care professional who understands the responsibilities of the role, rather than a passive observer. Professional policies emphasize the need to consider adolescent and family preferences, institutional policy, the clinical context, and appropriate documentation (9, 26, 31).

In the study by Wilson and colleagues, adolescent and caregiver preferences regarding the presence of others during physical examinations varied according to patient sex, examiner sex, and the type of examination. Female adolescents, particularly during breast, genital, or rectal examinations and when examined by a male clinician, more frequently preferred the presence of a same-sex parent. However, many patients and caregivers did not necessarily prefer a professional chaperone over parental presence (32). Although this study was not conducted in Iran, it indicates that locally adapted protocols should consider patient choice, comfort, privacy, and family preferences rather than relying on inflexible, uniform policies. From adolescents' perspectives, eight domains—accessibility, staff attitudes, communication, medical competence, guideline-based care, including confidentiality and autonomy, an age-appropriate environment, adolescent involvement in care, and health outcomes—shape positive care experiences. This framework can inform the design of locally adapted protocols for sensitive examinations in Iran (33).

Standardized patients and role-play can offer a safe environment for practicing communication skills in these sensitive

encounters. Learners can rehearse introducing themselves, explaining the need for examination, obtaining consent and assent, responding to parental concerns, explaining the role of a chaperone, using nonjudgmental language, and managing adolescent anxiety. Standardized patients have a long history in clinical-skills teaching and assessment and may be adapted for pediatric and adolescent education, provided that ethical principles, the welfare of child or adolescent actors, and opportunities for feedback are adequately considered (23, 30).

4-5. Structural Challenges and Workplace-Based Assessment

In Iranian teaching hospitals and outpatient clinics, high patient volume, short consultation times, clinical workload, limited private examination areas, large numbers of trainees, and a predominant emphasis on written assessments may restrict the teaching and assessment of practical pubertal examination skills (8, 10, 11). In such circumstances, breast and genital examinations may be omitted, abbreviated, or performed without sufficient direct supervision and feedback.

Workplace-based assessment can provide a practical means of linking instruction, performance observation, and feedback. Tools such as Direct Observation of Procedural Skills (DOPS) and the Mini-Clinical Evaluation Exercise (Mini-CEX) can be adapted, using specific checklists, to assess components of pubertal assessment. These may include history-taking, communication with adolescents and parents, explanation of the need for examination, privacy practices, consent and assent, appropriate chaperone use, examination technique, documentation, and decisions regarding follow-up or referral (23). Workplace-based assessment should primarily serve a formative purpose and should be accompanied by timely, specific, and constructive feedback rather

than functioning solely as a summative grading tool.

Objective Structured Clinical Examinations (OSCEs) may complement workplace-based assessment. OSCE stations using breast models, orchidometers, scenarios of precocious or delayed puberty, and standardized patients can assess knowledge, technical examination skills, professional communication, clinical reasoning, and ethical practice concurrently. This approach may be particularly useful when equal opportunities for observing trainees during real patient encounters are limited.

Entrustable Professional Activities (EPAs) may also provide a competency-based framework for defining the expected level of trainee independence in authentic professional tasks. EPAs are units of professional practice that trainees may be trusted to perform with a specified level of supervision, or without direct supervision, after demonstrating adequate competence (34). In Iranian pediatric training, a future EPA could be developed for the “initial assessment of a child or adolescent presenting with pubertal concerns.” Such an EPA could encompass history-taking, ethical examination, Tanner staging, growth assessment, recognition of warning signs, documentation, and follow-up or referral decisions. However, development and implementation of such an EPA would require expert consensus, content validation, faculty development, and feasibility testing in Iranian training settings.

4-6. Strengths, Limitations, and Future Directions

This structured critical narrative review was developed with reference to SANRA principles and a narrative thematic synthesis approach (13–15). Its strengths include the integration of clinical, educational, ethical, and cultural evidence; attention to the needs of pediatric medical

education in Iran; and identification of potentially adaptable educational strategies.

Nevertheless, the findings should be interpreted cautiously. The included studies were heterogeneous in terms of learner populations, educational settings, simulation tools, assessment approaches, and measured outcomes. A substantial proportion of directly relevant evidence was derived from countries outside Iran; therefore, its transferability should be assessed in light of cultural, organizational, legal, economic, and educational differences. This is particularly important because pubertal timing and the presentation of precocious puberty in Iranian children may be influenced by locally relevant genetic, nutritional, environmental, socioeconomic, and sociocultural factors (28).

In addition, evidence remains limited regarding long-term retention of simulation-acquired skills, transfer of these skills to authentic clinical practice, the effects of educational interventions on diagnostic accuracy and referral quality, and the experiences of patients and families in Iranian settings. Future research in Iran should therefore focus on the design, cultural adaptation, and validation of educational tools. Potential priorities include development of tactile and three-dimensional breast models, simulated testicular-volume models for clinical-skills laboratories, Persian-language case-based modules on Tanner staging and pubertal disorders, and standardized-patient scenarios for practicing consent, assent, privacy, chaperone use, and communication with adolescents.

Qualitative and mixed-methods studies are also needed to explore the perspectives of adolescents, parents, trainees, and faculty members regarding examiner gender, parental presence, chaperone use, confidentiality, consent, and assent in sensitive examinations. Finally,

multicenter studies should evaluate the feasibility, acceptability, and effectiveness of multimodal educational programs—including simulation, case-based learning, standardized patients, OSCEs, workplace-based assessment, and structured feedback—in improving learner competence and clinically relevant outcomes.

5- CONCLUSION

This structured narrative review indicates that teaching the clinical assessment of pubertal development and pubertal disorders in pediatric practice is influenced by interconnected skill-related, educational, structural, ethical, and cultural factors. A considerable gap may exist between trainees' theoretical knowledge and their ability to perform pubertal examinations confidently, consistently, and appropriately in clinical settings. Skills such as differentiating glandular breast tissue from adipose tissue, accurately determining Tanner stages, and estimating testicular volume using a Prader orchidometer require hands-on practice, direct observation, repetition, and structured feedback. Deficiencies in these skills may contribute to inaccurate pubertal classification, unnecessary or inappropriate diagnostic investigations and referrals, and delayed identification of children who require specialist assessment.

The findings further indicate that education in pubertal assessment cannot be considered separately from the clinical environment or from ethical and cultural considerations. High patient volume, limited consultation time, inadequate private examination spaces, insufficient opportunities for direct faculty supervision, and restricted access to clinical-skills training resources represent important barriers in educational settings. In addition, breast and genital examinations in children and adolescents should be performed using age-appropriate

communication, with respect for patient privacy and dignity, parental permission and adolescent assent, consideration of patient and family preferences, and appropriate use of a trained clinical chaperone.

Accordingly, pediatric training programs in Iran may benefit from a multimodal, staged, and competency-based educational model that integrates theoretical instruction with three-dimensional and tactile models, orchidometry training, case-based and online learning, standardized patients, workplace-based assessment, and structured feedback. Adaptation of these strategies should take into account institutional resources, outpatient workflow, ethical and cultural considerations, and the preferences of adolescents and their families. Local research is needed to evaluate the feasibility, acceptability, educational effectiveness, and clinical implications of these interventions in Iran. Such an approach may strengthen trainee competence, support more appropriate follow-up and referral decisions, and promote adolescent-centered, ethically responsive pediatric care.

6- AUTHORS' CONTRIBUTIONS

Study conception and design: HK and SP. Data analysis and initial manuscript drafting: SP and HK. Critical revision of the manuscript: SP. Supervision of the research: HK and SP. Final approval of the version to be published: HK and SP.

7- CONFLICT OF INTEREST: None.

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