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REVIEW

Effectiveness of Simulation-Based Gynecologic Endoscopy Training: A Systematic Review Comparing Objective Technical Skill Performance

Ichnandy Arief Rachman[1], Togas Tulandi[2], Heru Pradjatmo[3], Sunarno Sunarno[4], Muhammad Yurizar Yudhistira[5], Ronny Wijaya[4], Memory Motivanisman Waruwu[4]

[1]Doctoral Program of Faculty of Medicine, Public Health, and Nursing; Gadjah Mada University, Yogyakarta, Indonesia; [2]Department of Obstetrics and Gynecology; McGill University, Montreal, Canada; [3]Department Obstetrics and Gynecology; Sardjito National Referral Hospital/Gadjah Mada University, Yogyakarta, Indonesia; [4]Department of Nuclear Engineering and Physical Engineering; Gadjah Mada University, Yogyakarta, Indonesia; [5]Faculty of Medicine; Sebelas Maret University, Surakarta, Indonesia

Correspondence: Ichnandy Arief Rachman, Doctoral Program of Faculty of Medicine, Public Health, and Nursing; Gadjah Mada University, Jalan Farmako; Sleman, Yogyakarta, 55281, Indonesia, Email ichnandy@gmail.com; ichnandy@mail.ugm.ac.id

Purpose: Simulation-based training may accelerate the learning curve in a controlled environment, with potential benefits including improved technical performance, procedural efficiency, and patient safety. This systematic review evaluated the effectiveness of simulation-based training, using standardized assessment measures, in gynecologic endoscopy.

Methods: We conducted an electronic database search of PubMed, Scopus and ScienceDirect from inception to November 2024. The study was designed, conducted, and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. Eligible studies provided data on participant characteristics, simulation modality, training duration, intervention, and standardized assessment measures for simulation-based gynecologic endoscopy training. Risk of bias was assessed using the Joanna Briggs Institute tool.

Results: Nine studies involving 342 participants were included, comprising 206 trainees in intervention–control comparisons and 136 participants in proficiency-level comparisons. Simulation modalities included box trainers, virtual reality simulators, and high-fidelity models, with training durations ranging from 90 minutes to 12 months. Overall, simulation-based training and higher proficiency levels were associated with superior objective technical performance in gynecologic endoscopy.

Conclusion: This systematic review demonstrates that simulation-based training is associated with improved objective technical performance as measured by standardized assessment tools in gynecologic endoscopy.

Keywords: endoscopy, gynecologic, global rating scales, laparoscopy, simulation training

Introduction

Minimally invasive gynecologic surgery (MIGS) has expanded globally, driven largely by high-income countries (HICs), with its development well established before 2014 and contributions from 1888 institutions across 97 countries over the past decade.[1] As procedural volumes increase, large-scale studies from HICs continue to report persistent perioperative complication rates, including 3.1% in Japan based on a two-year nationwide study and 11.2% in gynecologic laparoscopic procedures in the United States over a six-year period.[2,3] The risk of complications depends on patient characteristics, comorbidities, and surgeon expertise.[2,4,5] In contrast, despite these advances, FIGO reports that adoption in low- and middle-income countries (LMICs) remains limited, with only 0.2–14.7% of gynecologic surgeries performed minimally invasively, largely due to constraints in training opportunities, mentorship, and safe skill acquisition.[6]

Consequently, an increasing priority in surgical education is the ability to accurately monitor the technical progression and to provide reliable certification for independent practice.[7,8] Traditionally, surgical skills were taught using an apprenticeship-based model; however, increasing procedural complexity and concerns regarding patient safety have

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highlighted the limitations of this approach.[9,10] Expanding simulation-based training, strengthening faculty development, and allocating protected operating room time have therefore emerged as key strategies to address current barriers in MIGS training. These approaches align with FIGO and ACOG recommendations emphasizing equitable access to safe surgical care, sustainable capacity-building, and long-term skill development, particularly in low-resource settings.[11,12]

Comprehensive gynecologic endoscopy training programs worldwide are built upon three core modalities: dry box simulation, animal-based workshops, and supervised live patient surgery.[13] Simulation-based training offers several advantages, including portability, learner autonomy, and opportunities for targeted practice through focused repetition, goal setting, immediate feedback, and objective performance evaluation.[14,15]

Over the past five years, seven systematic reviews and meta-analyses have examined laparoscopic training, primarily focusing on simulation curriculum frameworks and types of simulation modalities.[16–22] Recent reviews by Vitale et al and Orejuela et al further demonstrated that simulation-based training improves hysteroscopic and gynecologic surgical skill acquisition, operative performance, and technical competence.[23,24] However, evidence remains limited regarding whether simulation-based training translates into objectively measurable improvements in technical competence using standardized assessment tools.

None have evaluated simulation-based training using standardized outcome measures such as the Objective Structured Assessment of Technical Skills (OSATS) and the Global Operative Assessment of Laparoscopic Skills (GOALS) across different proficiency levels or intervention groups. Therefore, this systematic review aimed to evaluate the effectiveness of simulation-based training in gynecologic endoscopy using standardized assessment measures.

Materials and Methods

The study was designed, performed, and analyzed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020[25] and it was registered on the International Prospective Register of Systematic Reviews (PROSPERO) (CRD42024559372).

Search Strategy and Selection Process

We conducted an electronic literature search in PubMed, ScienceDirect, and Scopus from January 2000 to November 2024 using free-text terms, Boolean operators, and Medical Subject Headings (MeSH) terms (Table 1). Only original research articles published in English were included. Literature screening was conducted independently by five reviewers (IAJ, TT, S, HP, and MYY), and any disagreements related to study inclusion or exclusion were resolved through discussion among all authors based on the predefined eligibility criteria.

Study Eligibility

The initial screening and study selection were performed based on article titles and abstracts, followed by full-text assessment of potentially eligible studies. Eligibility criteria were defined according to the PICOS framework. Population (P): medical students, obstetrics and gynecology residents, obstetricians and gynecologists, and trainees undergoing

Table 1 Search Strategy

	AND	AND	AND	AND
	Concept 1	**Concept 2**	**Concept 3**	**Concept 4**
OR	Gynecologic Endoscopy	Training Methods	Pelvic Box Trainer	Skills Assessment
OR	Gynecologic Surgical Procedures	Educational Training	Pelvic Manikins	Capability Assessment
OR	Minimally Invasive Surgery	Curriculum	Pelvic Simulators	Proficiency Testing
OR	Hysteroscopy	Instructional Support	Anatomical Pelvic Models	Competency Evaluation
OR	Laparoscopy	Continuing Education	Pelvic Training Devices	Competency-Based Assessment

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minimally invasive gynecologic surgery training. Intervention (I): simulation-based gynecologic endoscopy training using box trainers or other physical simulators designed to replicate gynecologic endoscopic procedures and techniques. Comparison (C): comparison between different simulation-based training approaches, intervention groups, or baseline and post-training assessments when applicable. Outcomes (O): technical skill performance evaluated using standardized assessment tools,[26,27] including the OSATS[28] and GOALS.[29] As this review was designed as a qualitative systematic review, no pooled aggregate effect size analysis was planned. Studies (S): original research articles including prospective studies, randomized controlled trials, non-randomized controlled trials, multicenter studies, single-center studies, and descriptive observational studies published in English. Studies involving healthcare professionals unrelated to minimally invasive gynecologic surgery training, as well as opinion articles, abstracts, editorials, case reports, case series, reviews, correspondence, and commentaries, were excluded. Studies with incomplete data or duplicate records were also excluded.

GOALS and OSATS both use structured scoring systems to assess technical skills in minimally invasive surgery. For GOALS, each of the five domains—depth perception, bimanual dexterity, efficiency, tissue handling, and autonomy—is typically scored on a Likert scale from 1 to 5. The minimum total score is 5 (if all domains score 1), and the maximum is 25 (if all domains score 5). Similarly, OSATS combines two components: a task-specific checklist and a global rating scale (GRS). The checklist evaluates essential steps in a procedure, with each step typically scored as 0 (not performed) or 1 (performed correctly), and the total possible score depends on the number of steps in the task. The GRS evaluates broader aspects such as tissue handling, time efficiency, and procedural flow, with each domain usually scored from 1 to 5. With seven domains, the GRS minimum score is 7, and the maximum is 35. When the checklist and GRS are combined, the total score reflects both the procedural accuracy and overall performance, with maximum scores varying based on the complexity of the task.[26–29]

Study Risk of Bias Assessment

Quality of studies was evaluated using the Joanna Briggs Institute (JBI) Critical Appraisal tools.[30–33] According to the JBI methodology, studies are not automatically excluded solely based on a high risk of bias assessment. In this review, studies with predominantly "No" or "Unclear" responses across key JBI critical appraisal domains were considered to have a high risk of bias.

Data Collection

Five reviewers (IAJ, TT, S, HP, and MYY) independently screened all titles and abstracts based on the predefined eligibility criteria. Studies unrelated to simulation-based gynecologic endoscopy training or those not reporting standardized technical skill assessment outcomes were excluded during the initial screening process. Data extraction was performed using the PICOS framework. Extracted study characteristics included the first author's name, publication year, study location, sample size, and study design. Population data included participant characteristics and baseline surgical proficiency. Intervention data included the type of gynecologic endoscopy simulator or box trainer, training duration, and simulation tasks performed. Comparison data included intervention and control groups or pre- and post-training assessments when applicable. Outcome measures included technical skill performance assessed using standardized scoring systems, particularly the OSATS and the GOALS. Outcome data were extracted as percentages or mean ± standard deviation, when available.

Results

The PRISMA flow diagram (Figure 1) outlines the study selection process. The initial search across three databases yielded 2771 articles (PubMed: 115, Scopus: 2166, and ScienceDirect: 490). After duplicate removal using Rayyan.ai®, 644 articles remained for title and abstract screening. Following full-text assessment based on the predefined eligibility criteria, 9 studies were included in the qualitative synthesis. A total of five studies fulfilled all criteria (Table 2), while the remaining studies had minor methodological limitations, including unclear follow-up duration, confounding factors, or assessor blinding. However, no studies demonstrated critical methodological deficiencies requiring exclusion.[4,34–41]

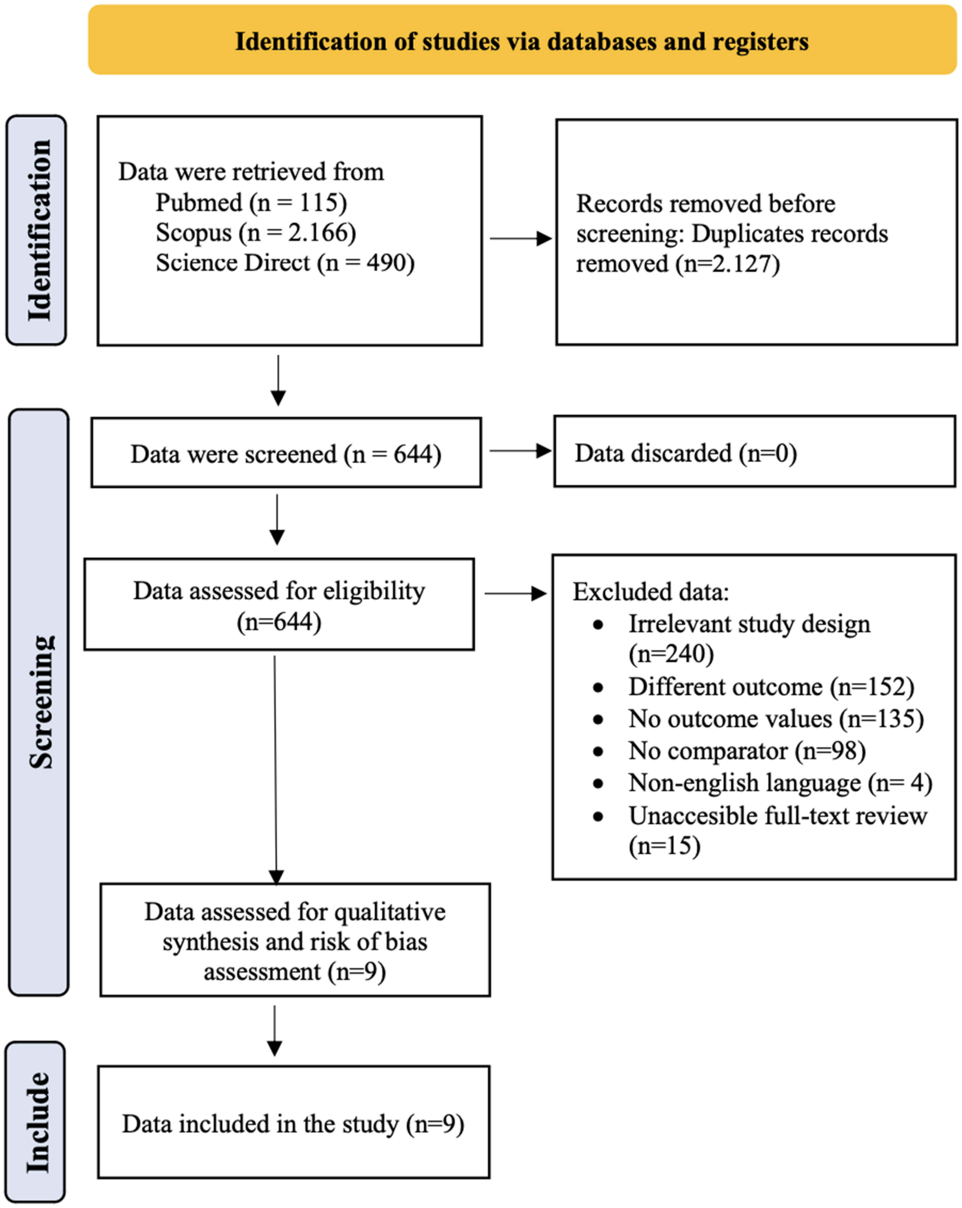

Figure 1 PRISMA flowchart.

This study classified participants using two complementary approaches. Classification A divided participants into a control group (no simulator training) and an intervention group (received simulator training) across all proficiency levels. Classification B stratified participants by baseline proficiency, categorizing them as novice (medical students or obstetrics and gynecology residents) or competent/proficient (minimally invasive gynecologic surgery fellowship trainees or attending obstetrician–gynecologists). The two classification approaches were designed to address different analytical objectives and were applied as mutually exclusive categories within this review, with no overlap between groups. As this review was conducted as a qualitative systematic review rather than a quantitative meta-analysis, no formal subgroup analysis or pooled comparative framework was planned. The classification system was intended to facilitate structured descriptive synthesis and improve interpretation of participant heterogeneity across the included studies.

The characteristics of the included studies are summarized in Table 3. The studies consisted of five cohort studies, one cross-sectional study, and four randomized controlled trials conducted across Asia (Hong Kong and Taiwan), Europe (Finland and Italy), and the United States. A total of 342 participants were included. Based on intervention exposure, 106

Table 2 JBI Critical Appraisal

Cohort studies	**Were the two groups similar and recruited from the same population?**	**Were the exposures measured similarly to assign people to both exposed and unexposed groups?**	**Was the exposure measured in a valid and reliable way?**	**Were confounding factors identified**	**Were strategies to deal with confounding factors stated?**	**Were the groups/ participants free of the outcome at the start of the study (or at the moments of exposure)?**	**Were the outcomes measured in a valid and reliable way?**	**Was the followup time reported and sufficient to be long enough for outcomes to occur?**	**Was the follow up complete, and if not, were the reasons to loss to followup described and explored?**	**Were strategies to address incomplete followup utilized**	**Was appropriate statistical analysis used?**		
Antosh et al, 2023[34]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
Arora et al, 2020[39]	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y		
Miles et al, 2022[40]	Y	Y	U	U	Y	Y	N	Y	Y	Y	Y		
Raffel et al, 2022[4]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y		
Cross sectional	**Were the criteria for inclusion in the sample clearly defined?**	**Were the study subjects and the setting described in detail?**	**Was the exposure measured in a valid and reliable way?**	**Were objective, standard criteria used for measurement of the condition?**	**Were confounding factors identified?**	**Were strategies to deal with confounding factors stated?**	**Were the outcomes measured in a valid and reliable way?**	**Was appropriate statistical analysis used?**					
Mannella et al, 2019[38]	Y	Y	Y	Y	Y	Y	Y	Y					

(*Continued*)

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Table 2 (Continued).

Randomized Controlled Trial	Was true randomization used for assignment of participants to treatment groups?	Was allocation to treatment groups concealed?	Were treatment groups similar at the baseline?	Were participants blind to treatment assignment?	Were those delivering the treatment blind to treatment assignment?	Were treatment groups treated identically other than the intervention of interest?	Were outcome assessors blind to treatment assignment?	Were outcomes measured in the same way for treatment groups?	Were outcomes measured in a reliable way	Was follow up complete and if not, were differences between groups in terms of their follow up adequately described and analysed?	Were participants analysed in the groups to which they were randomized?	Was appropriate statistical analysis used?	Was the trial design appropriate and any deviations from the standard RCT design (individual randomization, parallel groups) accounted for in the conduct and analysis of the trial?
Gala et al, 2013[35]	Y	Y	Y	Y	Y	Y	U	Y	Y	N	Y	Y	Y
Ko et al, 2017[36]	Y	Y	Y	Y	Y	Y	U	Y	Y	Y	Y	Y	Y
Jokinen et al, 2020[37]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Kuo et al, 2023[41]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Abbreviations: Y, yes; N, no; U, unclear; N/A, not applicable.

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Table 3 Characteristic of Study

Study	Population	Study Design	Location	Period of Study	Subject (N)
Classification A					
Antosh et al, 2013[34]	PGY-4 Obstetrics and Gynecology	Observational Analytics (Cohort Prospective)	Multicentric (United States of America)	August 2011 - January 2012	29
Gala et al, 2013[35]	PGY-4 Obstetrics and Gynecology	Randomized controlled trial	Multicentric (United States of America)	July 2006 - March 2010	102
Ko et al, 2017[36]	Junior residents, interns, and elective students who had no laparoscopic experience or early experience with no laparoscopic suturing	Randomized controlled trial	Monocentric (Hong Kong)	February 2015 - August 2015	24
Jokinen et al, 2020[37]	All residents in gynecological surgery rotation with experience in laparoscopic diagnostic and adnexal surgery as a first surgeon (assisting in more advanced laparoscopic procedures)	Randomized controlled trial	Monocentric (Finland)	June 2013 - March 2016.	19
Raffel et al, 2022[4]	PGY-4 Obstetrics and Gynecology	Observational Analytics (Cohort Retrospective)	Monocentric (United States of America)	January 2019 - April 2021	32
Classification B					
Mannella et al, 2019[38]	• PGY 1–3 Obstetrics and Gynecology • PGY 4–5 Obstetrics and Gynecology	Observational Analytics (Cross Sectional)	Multicentric (Italy)	N/A	33
Arora et al, 2020[39]	• Obstetrics and gynecology residents within 3 months before or after graduation • Fellows of AAGL-accredited fellowships in minimally invasive gynecologic surgery programs within 6 months before or after graduation	Observational Analytics (Cohort Prospective)	Multicentric (United States of America)	April 2018 - May 2019	34
Miles et al, 2022[40]	• Obstetrics and gynecology residents • Attendings who regularly perform hysteroscopy.	Observational Analytics (Cohort Prospective)	Monocentric (United States of America)	N/A	30
Kuo et al, 2023[41]	• Gynecologic doctor • 4th year medical student	Randomized controlled trial	Monocentric (Taiwan)	2019 - 2020	39

participants were categorized into the control group (without simulator training), whereas 100 participants underwent simulator-based training. Based on baseline proficiency, 74 participants were classified as novice and 62 as competent or proficient.

Simulation Training Modalities

The simulators utilized in these studies ranged from laparoscopic box trainers to virtual reality (VR) systems and biological models. For example, Antosh et al (2013) employed the TASKit laparoscopic box trainer (Ethicon Endo-

Surgery, Inc).,[34] while Jokinen et al (2020) used the LAP Mentor VR simulator (Simbionix Corporation).[37] Some studies incorporated innovative models, such as the high-fidelity biological Gynesim model[39] or the Origami Box Folding Exercise (OBFE).[41] Other simulators included the Zoe Gynecologic Skills Trainer (Gaumard, Miami, FL) for hysteroscopy simulation[40] and FLS box trainers from institutions like the Hong Kong Jockey Club Innovative Learning Centre for Medicine[41] and Limbs and Things (Savannah, Georgia)[4] (Table 4).

Table 4 Characteristic of Training Simulation

Study	Simulator	Duration of Training	Intervention	Assessment
Classification A				
Antosh et al, 2013[34]	FLS web-based curriculum and to TASKit laparoscopic box trainers (Ethicon Endo-Surgery, Inc., Cincinnati, OH)	6 months of web-based training with self-practice and monthly simulation skill labs, with testing conducted after 6 months.	• A 5 task manual skills section (peg transfer, pattern cut, ENDOLOOP ligation (Ethicon, Inc., Somerville, NJ), and laparoscopic suturing with both intracorporeal and extracorporeal knot tying)	• OSATS • GOALS
Gala et al, 2013[35]	FLS web-based curriculum and box trainer (BT)	N/A	• Traditional Teaching: Standard teaching methods without simulation. • Faculty-Directed Simulation: 30-minute simulation sessions on five basic laparoscopic tasks (peg transfer, pattern cutting, ligating loop, intracorporeal knot suturing, and extracorporeal knot suturing) with open lab access for additional practice within duty hour regulations.	• OSATS
Ko et al, 2017[36]	FLS web-based curriculum and box trainer (BT) from Hong Kong Jockey Club Innovative Learning Centre for Medicine	10-days-training (a maximum of 4 hours of training (2 sessions of 2 hours each) per day)	• Intracorporeal knot (positioning a needle in the needle holder, running the needle across two pre-marked circles on a surgical glove, a double throw knot, and then two single throw knots)	• GOALS
Jokinen et al, 2020[37]	Web-based theoretical course 'Basics in gyneco- logical laparoscopy' and virtual reality simulator (LAP Mentor, Simbionix Corporation, Cleve- land, Ohio, USA).	A 1-month training (web-based and self-practiced)	• Laparoscopic hysterectomy (expo- sure, division of adnexa, division of round ligaments, opening of vesico-uterine and vesico-vaginal space, division of utero-sacral ligaments and posterior leaflets of board ligaments, division of uterine pedicles, and hemostasis and final inspection)	• OSATS • GOALS
Raffel et al, 2022[4]	FLS simulator box trainer (Limbs and Things, Savannah, Georgia, 2015)	A 12 months training (unlimited access to the FLS box training with 3x testing period (interval 6 months)	• A 5 task manual skills section (peg transfer, precision cutting, loop ligation, suture with extracorporeal knot, and suture with intracorporeal knot)	• OSATS

(*Continued*)

Table 4 (Continued).

Study	Simulator	Duration of Training	Intervention	Assessment
Classification B				
Mannella et al, 2019[38]	Fundamentals of Laparoscopic Surgery (FLS) box trainer (BT)	A 2-hour training (self-practice, demo from the expert and repetition) of the same task.	• Peg board transfer, pattern cutting, intracorporeal knot, and miscellaneous creating pneumoperitoneum and positioning trocar under vision, and changing the shape of a rubber band on a platform with spikes using dominant and non-dominant hand)	• OSATS
Arora et al, 2020[39]	A high-fidelity, biological model developed by Gynesim	N/A	• A standardized TLH-BSO (five standardized segments to enable more granular comparisons in skill across participants: 1) adnexa; 2) broad ligament, bladder flap, vascular pedicles (dissection and pedicles); 3) colpotomy; 4) cuff closure; and 5) tissue extraction)	• OSATS
Miles et al, 2022[40]	The vaginoscopy model was created with an inanimate female pelvis simulator with an exam glove placed within the vagina (Zoe Gynecologic Skills Trainer (Gaumard, Miami, FL)	N/A	• Hysteroscopy simulation with a vaginoscopic approach	• OSATS
Kuo et al, 2023[41]	Origami Box Folding Exercise (OBFE)	A 90-minute OBFE course to enhance psychomotor skills and a 120-minute suture cycle course focusing on key suturing techniques, both involving pre/post-tests and video assessments.	• Pre-folding process and re-folding process	• OSATS

Training Duration and Intervention

Training durations varied significantly across studies. Long-term regimens, such as the 12-month unlimited access program described by Raffel et al (2022), were contrasted with shorter courses, including the 90-minute OBFE session reported by Kuo et al (2023) and the 2-hour task-specific training by Mannella et al (2019). Interventions included specific laparoscopic tasks such as peg transfers, pattern cutting, ligating loops, and intracorporeal and extracorporeal suturing.[34,35] More advanced simulations, like total laparoscopic hysterectomy (TLH-BSO), were standardized into segments for granular skill assessment.[39] Other tasks focused on psychomotor skill refinement[41] or comprehensive laparoscopic hysterectomy training[37] (Table 4).

Training Outcome

Outcomes were typically assessed using standardized evaluation tools such as the OSATS and GOALS. In Classification A, studies focused on PGY-4 OB-GYN residents. Antosh et al (2013) showed higher OSATS (29 ± 9 vs 23 ± 6) and GOALS (16 ± 5 vs 13 ± 3) scores for the simulation group. Similarly, Gala et al (2013) reported improved GOALS (30.5 ± 2.69 vs 28 ± 4.84), and Jokinen et al (2020) found significant gains in OSATS (20 ± 3.3 vs 16 ± 2.8) and GOALS (17 ±

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3.1 vs 11.2 ± 2.4). Ko et al (2017) noted modest OSATS improvements (8.2 ± 2.1 vs 7.6 ± 1.7), while Raffel et al (2022) reported slight GOALS differences (12.2 vs 11). In Classification B, studies included participants with varying experience. Mannella et al (2019) reported higher OSATS for senior residents (12.7 vs 10.34), while Arora et al (2020) showed fellows outperformed residents (27 ± 4.52 vs 24 ± 4.39). Miles et al (2022) found attending surgeons scored better than residents (26.1 ± 2.4 vs 22.5 ± 3.7), and Kuo et al (2023) highlighted significant psychomotor skill gains for attending surgeons (16.38 ± 7.63 vs 5.93 ± 6.35) (Table 5).

Table 5 Training Outcome

Study	**Group**	**OSATS (Mean ± SD)**		**GOALS (Mean±SD)**	
Classification A					
Antosh et al, 2013[34]	• Group 1: 15 PGY-4 Obgyn Resident without simulation (Control) • Group 2: 14 PGY-4 Obgyn Resident underwent simulation (Cases)	Group 1: 23±6	Group 2: 29±9	Group 1: 13±3	Group 2: 16±5
Gala et al, 2013[35]	• Group 1: 54 PGY-4 Obgyn Resident without simulation (Control) • Group 2: 48 PGY-4 Obgyn Resident underwent simulation (Cases)	N/A	N/A	Group 1: 28±4.84	Group 2: 30.5±2.69
Ko et al, 2017[36]	• Group 1: 12 included subject without simulation (Control) • Group 2: 12 included underwent simulation (Cases)	Group 1: 7.6±1.7	Group 2: 8.2±2.1	N/A	N/A
Jokinen et al, 2020[37]	• Group 1: 9 PGY-4 Obgyn Resident without simulation (Control) • Group 2: 10 PGY-4 Obgyn Resident without simulation (Control)	Group 1: 16.0±2.8	Group 2: 20±3.3	Group 1: 11.2±2.4	Group 2: 17±3.1
Raffel et al, 2022[4]	• Group 1: 16 PGY-4 Obgyn Resident without simulation (Control) • Group 2: 16 PGY-4 Obgyn Resident underwent simulation (Cases)	N/A	N/A	Group 1: 11	Group 2: 12.2
Classification B					
Mannella et al, 2019[38]	• Group 1: 16 PGY 1–3 Obgyn Resident (Novice) • Group 2: 17 PGY3-5 Obgyn Resident (Competent/Proficient)	Group 1: 10.34	Group 2: 12.7	N/A	N/A
Arora et al, 2020[39]	• Group 1: 18 PGY 4 Obgyn Resident (Novice) • Group 2: 16 Fellowship AAGL-Accredited (Competent/Proficient)	Group 1: 24±4.39	Group 2: 27±4.52	N/A	N/A
Miles et al, 2022[40]	• Group 1: 20 PGY 4 Obgyn Resident (Novice) • Group 2: 10 Attending Surgeon Obgyn (Competent/Proficient)	Group 1: 22.5±3.7	Group 2: 26.1±2.4	N/A	N/A

(Continued)

Table 5 (Continued).

Study	Group	OSATS (Mean ± SD)		GOALS (Mean±SD)	
Kuo et al, 2023[41]	• Group 1: 20 Fourth-year medical students (Novice) • Group 2: 19 Attending Surgeon Obgyn (Competent/Proficient)	Group 1: 5.93 ±6.35	Group 2: 16.38 ±7.63	N/A	N/A

Discussion

Simulation-based training (SBT) is a cornerstone of contemporary medical education, providing realistic learning environments that enable the safe acquisition of technical and non-technical skills through deliberate, repetitive practice supported by direct observation and feedback.[42,43] In line with Asia Pacific Association for Gynecologic Endoscopy (APAGE) recommendations, gynecologic endoscopy training is commonly structured around a progressive triad comprising dry box simulation, animal workshop simulation, and live patient surgery. Within this framework, fundamental laparoscopic skills are initially developed in a simulated environment, refined using anatomically realistic animal models, and ultimately translated into supervised clinical practice with strict adherence to ethical principles and patient safety.[13] The present review primarily focuses on the effectiveness of dry box simulation as the foundational component of this training continuum.

Simulation Training Modalities

This study includes wide range of simulators such as laparoscopic box trainers, virtual reality and biological models. Both box trainers and VR simulators were superior to no training in improving psychomotor skills such as camera navigation, hand–eye coordination, depth perception, and instrument handling.[4,34–41] Recent systematic review report no significant differences between VR simulators and box trainers.[16,18,21] Nevertheless, box trainers are generally favored for mastering foundational skills such as suturing and knot tying, whereas VR simulators appear more effective for procedure-specific training and early-stage skill acquisition.[19] Despite the immersive advantages of VR simulation, high costs remain a major barrier to widespread implementation, particularly in resource-limited settings. In contrast, box trainers are more cost-effective and have been shown to better enhance depth perception and hand–eye coordination.[44–46] Feenstra further indicate that digital tools outperform no training but yield outcomes comparable to conventional laboratory-based training, while also revealing persistent gaps in the assessment of non-technical skills and methodological rigor.[17] Emerging evidence on ergonomics and haptic feedback suggests that both VR and box trainers reduce physical workload; however, box trainers may offer more natural tactile feedback and steeper learning curves for core psychomotor skills.[22]

Training Duration and Intervention

Training duration and structure varied substantially across the included studies, ranging from long-term, unrestricted access programs to short, task-focused interventions. Extended regimens, such as a 12-month unlimited access simulation program, were contrasted with brief courses including a 90-minute structured exercise session and 2-hour task-specific training modules. Despite this heterogeneity, improvements in laparoscopic performance were consistently observed across different training durations.[4,34–41]

Interventions commonly incorporated core laparoscopic tasks, including peg transfer, pattern cutting, loop ligation, and intracorporeal and extracorporeal suturing, which are fundamental for psychomotor skill acquisition.[8] More advanced simulations standardized complex procedures—such as total laparoscopic hysterectomy—into discrete components, allowing granular assessment of technical performance.[47] Other interventions emphasized targeted psychomotor refinement or comprehensive procedural training, supporting the effectiveness of both basic and advanced simulation tasks when embedded within a structured curriculum.[4,34–41]

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Curriculum-oriented reviews consistently emphasize the importance of deliberate practice, characterized by clearly defined goals, focused and repetitive training, structured feedback, and sustained learner motivation.[45] Compared with the traditional Halstedian apprenticeship model—which is increasingly constrained by work-hour limitations and patient safety concerns—simulation-based training provides a safer, more standardized approach, particularly suited to minimally invasive surgery where video-based feedback facilitates reflective learning and objective skill assessment.[20]

Training Outcome

This study demonstrated that simulation-based training consistently improved technical performance when evaluated using standardized assessment tools, particularly OSATS and GOALS, across different study classifications and proficiency levels.[4,34–41] In Classification A, simulation-trained participants achieved higher OSATS and GOALS scores compared with controls, indicating superior operative performance following structured simulator exposure.[4,34–37] In Classification B, where participants were stratified by baseline experience, simulation-based training benefited both novice and experienced surgeons. Senior residents, fellows, and attending surgeons consistently outperformed less experienced counterparts on objective assessments, reflecting the role of simulation not only in foundational skill acquisition but also in skill refinement at advanced proficiency levels. Importantly, improvements in psychomotor performance among experienced surgeons highlight the utility of simulation beyond early training, supporting its role as a longitudinal educational tool within competency-based surgical curricula.[38,39,41]

Our study has several limitations, including heterogeneity in training duration, simulation modalities, participant classifications, and follow-up periods across the included studies. These variations limited direct comparison between studies and prevented identification of the most effective simulator or training approach, particularly for implementation in low-resource settings. In addition, observer bias may have influenced performance assessments despite the use of standardized evaluation tools. The strengths of this review include the use of validated assessment instruments, such as OSATS and GOALS, and the inclusion of studies evaluating participants across different proficiency levels and training interventions. Furthermore, the review provides a comprehensive overview of simulation-based gynecologic endoscopy training and its impact on technical skill acquisition.

Conclusion

This systematic review demonstrates that simulation-based training is an effective educational strategy for improving laparoscopic performance in gynecologic endoscopy when evaluated using standardized assessment tools such as OSATS and GOALS. Dry box simulators would appear to enhance fundamental psychomotor skills, task efficiency, and objective technical performance across different levels of surgical proficiency. These findings support the role of structured, curriculum-based simulation as a scalable approach to skill acquisition and progression, especially in settings with limited operative exposure. Incorporating standardized outcome measures into simulation training frameworks may facilitate more objective benchmarking of competence and contribute to safer translation of skills into clinical practice.

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