Archives of Surgical Research | Meta-Analysis

Proficiency-Based Progression Training: Key To Effective Clinical Procedural Teaching?

Hamza Azhar, Ehtisham Sohail Khan, Talat Waseem

IMPORTANCE Proficiency-Based Progression (PBP) training is a form of training in which the trainee has to achieve a benchmark that has been quantitatively defined. This is contrary to conventional training where progression benchmarks are arbitrary, This form of training may find its place in surgery and procedural medicine with some studies finding it to be effective while others claim to have seen no impact on trainees.

METHODS A systematic literature search was conducted on PubMed and Cochrane library and 15 eligible RCTs were extracted in which proficiency-based progression (PBP) training was compared with traditional surgical training methods.

RESULT 15 RCTs were included (412 participants from all RCTs). The PBP group demonstrated a reduced number of procedural errors as compared to the non-PBP group (Weighted Mean Difference: —6.14 errors, 95% Confidence Interval (CI) —8.63 to —3.65, $p < 0.00001$), as well as a reduction in procedural time in the PBP group as compared to the non-PBP group (Weighted Mean Difference: —5.46, 95% Confidence Interval (CI) —8.56 to —2.37, $p = 0.0005$) but the non-PBP group performed more procedural steps than the PBP group (Weighted Mean Difference: 2.18, 95% Confidence Interval (CI) —1.31 to 5.66, $p < 0.00001$).

CONCLUSION Our meta-analysis shows that PBP-trained groups outperform their traditional counterparts by completing procedures quicker and making fewer errors. This model of training may be an effective training tool of the future.

KEYWORDS PB; Traditional Surgical training; Simulation training; Proficiency based progression; Meta-analysis.

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Meta-Analysis

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Proficiency-Based Progression (PBP) training is a form of training in which the trainee has to achieve a benchmark that has been quantitatively defined, this is contrary to conventional training where progression benchmarks are arbitrary, this form of training has found its place in surgery and procedural medicine[1]. A study by Satava et al was the first to propose the use of this method of simulation training in surgery and demonstrated favorable results[2]. One of the pioneer studies carried out in 2002 by Seymour et al showed that trainees taught through PBP methods outperformed their traditionally trained counterparts[3]. Proficiency-based simulation has proved to not only improve skill acquisition but also maintenance of skills over an extended period of time[4], such form of simulation training has especially had a positive impact on and is widely used in laparoscopic training[5]. With advancements in technology and the introduction of robotic surgery this form of proficiency-based simulation training may have an even more integral role in training[6,7]. Previous review studies on the matter make an attempt at highlighting the significance of such a form of training but are mostly focused on laparoscopic procedures[8,9] but these studies showed limitations in which they focus more on process measures, and do not adequately assess the quality of the studies and focus minimally on patient outcome. Many studies and trials, as of now, have concluded that PBP training has shown to be a more effective and efficient method of training compared to conventional methods of training, while some studies show no significant impact on the trainees. Our meta-analysis attempts to compare and analyze the outcomes of a number of high-quality studies which compare and contrast PBP training and traditional training.

METHODOLOGY

We used PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) guidelines to do the literature search for our meta-analysis.

Literature search: PubMed and Cochrane library was used to carry out our literature search. Only Randomized controlled trials were included in the search. We conducted our search from 1st March 2020 to 1st July 2022 according to the PRISMA devised guidelines. We used these search terms for our literature review: (Proficiency-based AND progression AND training) OR (Proficiency AND based AND progression) OR (Proficiency-based AND training). Only randomized controlled trials (RCTs) published between 1st March 2020 and 1st July 2022 were selected. We also searched the reference lists of the relevant articles to include RCTs in our study.

Inclusion of studies: A literature search according to PRISMA guidelines was done and 16 articles were found in PubMed's database, 64 articles were found in the Cochrane Library database and 12 studies were identified through other sources. Duplicates were removed and a total of 88 studies were screened after the exclusion of 63 articles. 25 articles were selected after reading their titles and abstracts. Full-text assessment of these 25 articles was done and out of these 25 studies, 10 studies were excluded because they did not meet our inclusion criterion i.e. studies other than randomized controlled trials (RCTs), unavailability of full text, poor MERSQI scores and studies which did not compare the outcomes of our interest. After exclusion of these 10 studies, we were left with 15 randomized control trials which were then included in our final analysis.

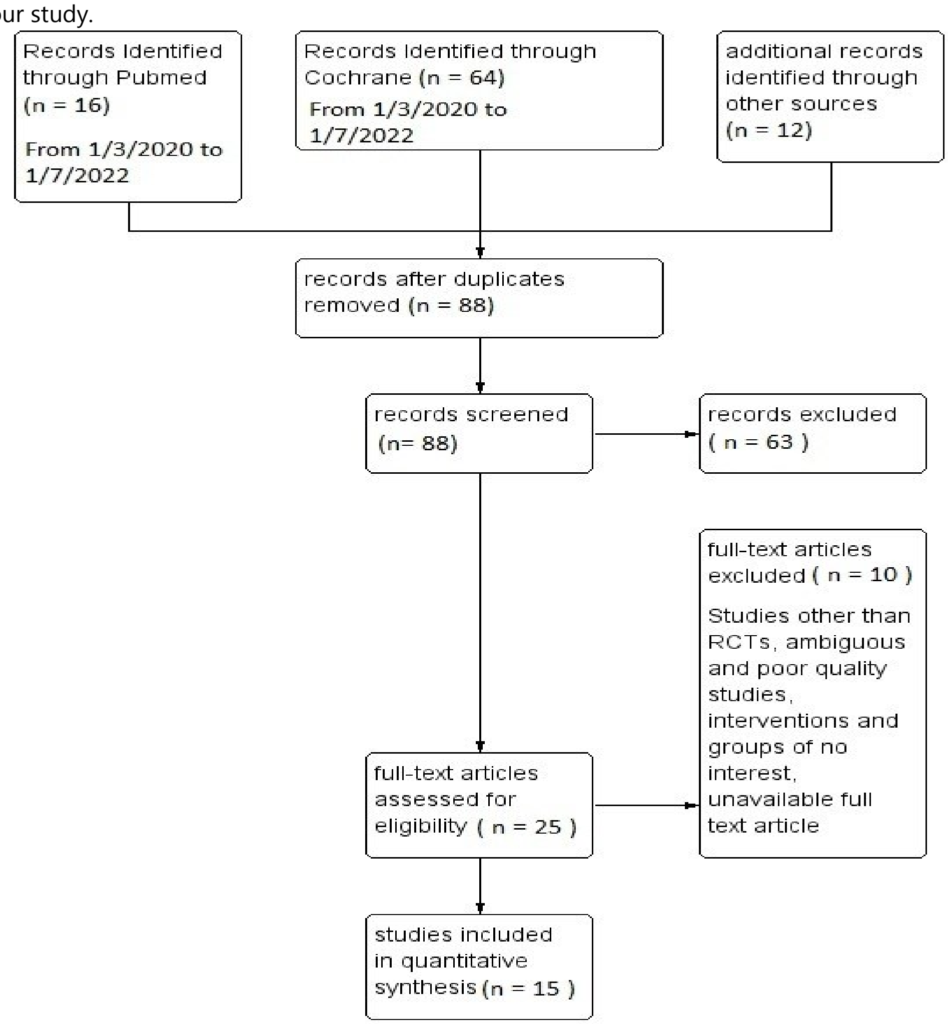

Figure 1: Showing PRISMA Flow diagram

Quality assessment and Risk of Bias: The quality of trials was assessed using the Medical Education Research Study Quality Instrument (MERSQI) scoring system, which contains the following judgment criteria: study design, institutions studied, response rate, type of data, internal structure, content, relationship to other variables, appropriateness of analysis complexity of analysis and outcome. Only high-quality studies were included in the quantitative analysis.

Study	Study design (1-3)	Institutions studied (0.5-1.5)	Response rate, %: (0.5-1.5)	Type of data (1 or 3)	Internal structure: (0 or 1)	Content (0 or1)	Relationships to other variables: (0 or 1)	Appropriateness of analysis: (0 or 1)	Complexity of analysis: (1 or 2)	Outcome (1-3)	Final score
Ahlberg et al. 2007	3	1.5	1.5	3	1	1	0	1	2	2	16
Ahmed et al. 2018	3	0.5	1.5	3	1	1	0	1	2	2	15
Angelo et al. 2015	3	1.5	1.5	3	1	1	0	1	2	2	16
Breen et al. 2019	3	0.5	1.5	3	1	1	0	1	2	2	15
Cates et al. 2016	3	0.5	1.5	3	1	1	0	1	2	2	15
Jensen et al. 2015	3	1.5	1.5	3	1	1	1	1	2	2	17
Palter 2012	3	0.5	1.5	3	1	1	0	1	2	2	15
Pedowitz et al. 2015	3	1.5	1.5	3	1	1	0	1	2	1.5	15.5
Peeters et al 2015	3	1.5	1	3	1	1	0	1	2	2	16.5
Seymour 2002	3	0.5	1.5	3	1	1	0	1	2	2	15
Srinivasan et al. 2017	3	0.5	1.5	3	1	1	1	1	2	3	17
Van Sickle et al. 2008	3	0.5	1.5	3	1	1	0	1	2	1.5	14.5
Gurung PMS et al 2019	3	0.5	1.5	3	1	1	0	1	2	2	15
Puliatti S et al 2021	3	0.5	1.5	3	1	1	0	1	2	2	15
Cassidy DJ et al 2021	3	1.5	1.5	3	1	1	0	1	2	2	16

TABLE1: MERSQI scores of the 15 studies included in the final quantitative synthesis

Data extraction and Statistical analysis: The relevant data was collected and sorted in a structured way. Three outcomes were used for analysis i.e. procedural errors, number of procedural steps and procedural time. The outcomes of The Proficiency Based Progression (PBP) group and Non Proficiency based progression (Non PBP) group were compared. We used continuous and dichotomous variables to compare the outcomes. In cases of continuous variables, we used mean difference with inverse variance while odd's ration with Mantel-Haenszel method with 95% confidence interval was used for the calculation of dichotomous variables. Heterogeneity of the data was calculated and random effect was used when the heterogeneity of the data was more than 50% while fixed effect was used when it was less than 50%. 2x2 chi-squared test was applied to carry out our meta-analysis in Review manager 5.4.

RESULTS

A PRISMA compliant literature search was done on databases of PubMed and Cochrane library and 15 Randomized controlled trials (RCTs) were selected and included in the final quantitative synthesis[3,10-23]. A thorough summary of each study has been given in the table. Each study was an RCT and they gave a comparison of different outcomes for PBP and non PBP group. The participants of these studies included surgical residents, surgical attending, medical students and nursing students. A total of 412 participants from all RCTs were included in the analysis. The table 2 shows the comparison arm, procedure/ task trained, intraoperative patient performance, compared outcomes and MERSQI score of each study.

Study	Subjects(N); Type	Comparison Arm	Task/Procedure Trained	Intraoperative Patient Performance	Outcomes Compared	Other Scale Used	MERSQI
Ahlberg et al	13;Residents	Swedish National Surgical Residency Training Program	Laparoscopic Cholecystectomies	Yes	Errors	—	16
Ahmed et al	18;Medicine Students	Self-Guided Ultrasound-Guided Peripheral Nerve Block Simulation Practice	Ultrasound-Guided Peripheral Nerve Block	No	Errors, Steps	—	15
Angelo et al	44;Residents	ACGME approved Orthopedic Residency & Arthroscopy Association of North America Shoulder Course	Arthroscopic Bankart Procedure	Yes	Errors, Steps, Time	—	16
Breen et al	90;Medicine and nursing students	National and certified ISBAR training Program	Clinical Communication	No	Errors, Steps	—	15
Cates et al	12;Attendings	Industry sponsored CASES education and training system	Carotid Artery Angiography	Yes	Errors, Time	—	15
Jensen et al	16;Residents	ESC Core Curriculum for the General Cardiologist	Coronary Angiography	No	Errors, Steps, Time	—	17
Palter, et al	25;Residents	ACGME approved General Surgery Residency Training Program	Laparoscopic Right Colectomy	Yes	Steps	OSATS	16
Pedowitz et al	44;Residents	ACGME approved Orthopedic Residency & Arthroscopy Association of North America Shoulder Course	Knot-Tying	No	Errors	—	14.5
Peeters, et al	10;Residents	National Obstetrics and Gynecology Residency Program	Fetoscopy Laser Surgery	No	Steps, Time	—	16.5
Seymour et al	16;Residents	ACGME approved General Surgery Residency Training Program	Laparoscopic Cholecystectomy	Yes	Errors, Time	—	15
Srinivasan et al	17;Residents	Irish National Anesthesia Training Program	Epidural Analgesia	Yes	Errors	GRS, TSCL	17
Van Sickle et al	22;Residents	ACGME approved General Surgery Residency Training Program	Nissen Fundoplication	Yes	Errors, Time	—	14.
Gurung PMS et al 2019	16; MS3 Medical students	conventional proficiency-based training protocol (CTP)	Robotic surgical simulation training	No	Steps	—	15
Puliatti S et al 2021	47; Medical students	Quality assured online learning for robotic suturing and knot tying in ORSI academy	Robotic vesico-urethral anastomosis	No	Steps, Errors	—	15
Cassidy DJ et al 2021	22; Residents	Repetition based VR training program for Fundamentals of Endoscopic Surgery (FES) program	Porcine endoscopy and colonoscopy	No	Time	—	16

TABLE 2: Summary of Studies

Procedural Errors: A total of 9 RCTs gave the comparison of procedural errors between the PBP and non PBP group. 89 participants were included in the PBP group while 85 participants were included in the Non PBP group. The lesser statistical analysis revealed that the PBP group committed a Number of procedural errors in comparison to non PBP group (Weighted Mean Difference: —6.14 errors, 95% Confidence Interval (CI) —8.63 to —3.65, p < 0.00001). A high heterogeneity of 97% was observed so random effect model was used.

Study or Subgroup	PBP Mean	PBP SD	PBP Total	Non PBP Mean	Non PBP SD	Non PBP Total	Weight	Mean Difference IV, Random, 95% CI
Ahlberg et al	28.4	2.9	6	86.2	17	7	3.0%	-57.80 [-70.61, -44.99]
Ahmed et al	1.5	0.9	10	4	1.5	8	13.4%	-2.50 [-3.68, -1.32]
Angelo et al	2.6	0.7	12	6.1	1.5	12	13.5%	-3.50 [-4.44, -2.56]
Cates et al	7.7	1.6	6	15.1	2	6	12.6%	-7.40 [-9.45, -5.35]
Jensen et al	15	2.7	8	27	3	8	11.7%	-12.00 [-14.80, -9.20]
Pedowitz et al	0.6	0.3	16	1.5	0.3	14	13.8%	-0.90 [-1.12, -0.68]
Seymour et al	1.2	0.3	8	7.4	1.8	8	13.3%	-6.20 [-7.46, -4.94]
Stefano et al	13.5	1.33	12	11.36	1.74	11	13.3%	2.14 [0.87, 3.41]
Van Sickle et al	25.9	9.3	11	37.1	10.2	11	5.5%	-11.20 [-19.36, -3.04]
Total (95% CI)			**89**			**85**	**100.0%**	**-6.14 [-8.63, -3.65]**

Heterogeneity: Tau² = 11.69; Chi² = 294.67, df = 8 (P < 0.00001); I² = 97%
Test for overall effect: Z = 4.84 (P < 0.00001)

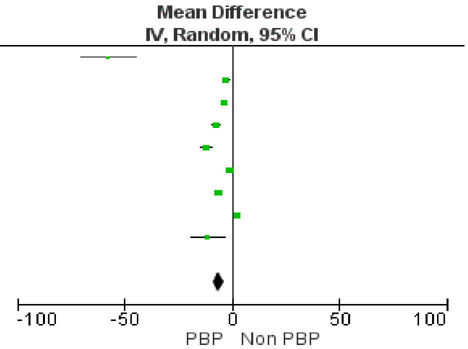

Figure 2: Showing forest plot of comparison of Procedural Errors between PBP and Non PBP group

Procedural Steps: 7 RCTs reported this outcome. 80 participants were included in the PBP group and 77 participants were included in the Non PBP group. The analysis showed that Non PBP group performed more Procedural steps than the PBP group (Weighted Mean Difference: 2.18, 95% Confidence Interval (CI) —1.31 to 5.66, p < 0.00001). 99% heterogeneity was observed therefore random effect model was used.

Study or Subgroup	PBP Mean	PBP SD	PBP Total	Non PBP Mean	Non PBP SD	Non PBP Total	Weight	Mean Difference IV, Random, 95% CI
Ahmed et al	15	1.2	10	4	3.6	8	11.2%	11.00 [8.40, 13.60]
Angelo et al	42.6	0.6	12	38.6	0.9	12	11.9%	4.00 [3.39, 4.61]
Jensen et al	70.5	5.8	8	45.5	3.3	8	9.9%	25.00 [20.38, 29.62]
Palter et al	15.7	1.3	9	10.4	2.1	9	11.7%	5.30 [3.69, 6.91]
Peeters et al	47.7	2.9	5	36.2	4.1	5	10.1%	11.50 [7.10, 15.90]
Pratik (Task 1)	7.88	1.25	8	21.63	3.34	8	11.3%	-13.75 [-16.22, -11.28]
Pratik (Task 2)	10.38	2.67	8	23.5	3.29	8	11.0%	-13.12 [-16.06, -10.18]
Pratik (Task 3)	12.75	2.82	8	20.5	3.38	8	11.0%	-7.75 [-10.80, -4.70]
Stefano et al	2.75	0.41	12	2.18	0.515	11	12.0%	0.57 [0.19, 0.95]
Total (95% CI)			**80**			**77**	**100.0%**	**2.18 [-1.31, 5.66]**

Heterogeneity: Tau² = 26.46; Chi² = 555.10, df = 8 (P < 0.00001); I² = 99%
Test for overall effect: Z = 1.22 (P = 0.22)

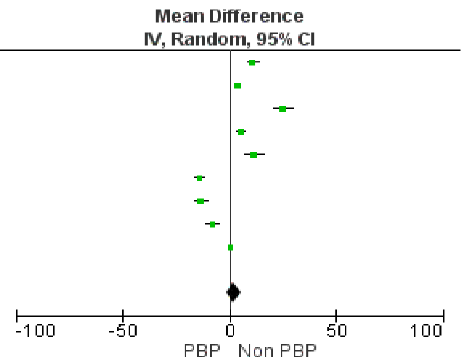

Figure 3: Showing forest plot of comparison of Procedural Steps between PBP and Non PBP group

Procedural Time: A total of 7 RCTs provided the comparison of procedural time between PBP and Non PBP group. PBP group contained 83 participants while Non PBP group also contained the same number of participants. The analysis showed a reduction in procedural time in the PBP Group in comparison to the non PBP group (Weighted Mean Difference: —5.46, 95% Confidence Interval (CI) —8.56 to —2.37, p = 0.0005). Heterogeneity of 62% was observed and random effect model was used for analysis.

Study or Subgroup	PBP Mean	PBP SD	PBP Total	Non PBP Mean	Non PBP SD	Non PBP Total	Weight	Mean Difference IV, Random, 95% CI
Angelo et al	80.4	5	12	81	8	12	14.8%	-0.60 [-5.94, 4.74]
Cates et al	26.9	5.3	6	32.3	4.8	6	13.9%	-5.40 [-11.12, 0.32]
Douglas (Advanced Mucosal Evaluation 1)	43.5	20.9	11	68.5	22.4	11	2.6%	-25.00 [-43.10, -6.90]
Douglas (Endoscopic Navigation)	43.1	25	11	70.6	17	11	2.7%	-27.50 [-45.37, -9.63]
Douglas (FES)	170	66.3	11	242.2	48.6	11	0.4%	-72.20 [-120.78, -23.62]
Jensen et al	22.6	2.2	8	27.1	2.5	8	23.1%	-4.50 [-6.81, -2.19]
Peeters et al	36.2	5.6	5	39.1	8.1	5	8.7%	-2.90 [-11.53, 5.73]
Seymour et al	14.5	5.5	8	20.5	10	8	9.7%	-6.00 [-13.91, 1.91]
Van Sickle et al	8.7	3.2	11	13.1	0.3	11	24.1%	-4.40 [-6.30, -2.50]
Total (95% CI)			**83**			**83**	**100.0%**	**-5.46 [-8.56, -2.37]**

Heterogeneity: Tau² = 9.42; Chi² = 21.17, df = 8 (P = 0.007); I² = 62%
Test for overall effect: Z = 3.46 (P = 0.0005)

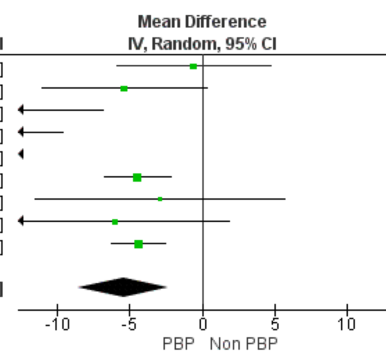

Figure 4: Showing forest plot of comparison of Procedural Time between PBP and Non PBP group

DISCUSSION

In this meta-analysis, we attempted to draw out the differences in training outcomes of proficiency-based progression simulation training as opposed to more classical or traditional methods of training. This analysis included only prospective, randomized, and blinded clinical studies, after scouring for literature on 2 main search platforms (PubMed, and Cochrane) while also searching through additional sources, the results of 15 studies were included. The quality of studies analyzed was high, based on the MERSQI scoring instrument, no study scored below a score of 14.5.

Proficiency-Based-Progression training is effective, as it sets performance metrics that are developed by experienced surgeons and clinicians and an accumulation of validated evidence derived from them[24,22] the method is based on strict performance metrics such as procedural steps, time, and errors or deviation from optimum performance. These set objectives allow trainees to have more deliberate practice instead of undirected repetitions[25] such deliberate practice is vital to achieving proficiency[4]. And these are the exact metrics explored in this study.

In the past few meta-analyses have been taken up on the topic. Mazzone et al[26] in 2020 compare similar outcomes of procedural error, steps, and duration but feature fewer studies than in this paper. While other meta-analyses present focus more on specific fields such as laparoscopy[27] or dental procedures[28] and do not focus on the implications of such methods as a whole on surgical training.

Our analysis shows that PBP groups have outperformed Non-PBP groups making fewer procedural errors and requiring less time to complete procedures, which is validated in other such analysis[26]. But our study differs in its finding of PBPs effect on procedural steps completed as we found Non-PBP groups completed more steps, however, this metric isn't an appropriate measure of quality, for example, a procedure with all its steps completed but done inadequately or a procedure may be completed swiftly but not done safely or steps skipped to achieve faster times[12,29,30]. Hence the number of procedural errors in the PBP methodology gives the most reliable and quantitatively measurable index of the quality of the procedure.

Even with the results of the study favoring PBP training and the inclusion of high-quality trials the study was not free of limitations. Despite this inclusion of more RCTs than previous such studies (15 RCTs), the number is still insufficient and more additions are still required, as a limited number reduces the general application of the findings and elevates the risk of residual biases. Furthermore, despite the use of a random-effect model, which accounts for within-study as well as between-study variations, there is residual heterogeneity between studies due to differences in population, study protocols, and tasks/procedures which may have remained unaccounted for. However, it is important to note that only high-quality RCTs were used, a factor that supports our strong findings.

CONCLUSION

Our meta-analysis found that PBP trained groups outperform their traditionally trained counter parts, by not only completing procedures quicker but also making fewer errors, our study did however show that traditional (Non PBP) groups complete more number of steps but having said that there is significant evidence based on the results of this review to consider the integration of the PBP training method into current surgical training.

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