



EFFECTIVENESS OF PEER-ASSISTED LEARNING ON KNOWLEDGE RETENTION AND ACADEMIC SELF-EFFICACY IN PRECLINICAL MEDICAL STUDENTS: A RANDOMIZED CONTROLLED STUDY

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ABSTRACT

Background: Peer-assisted learning (PAL) has emerged as an effective educational strategy in medical education, promoting active learning through structured interaction among students. In preclinical training, where learners face substantial cognitive load and transition challenges, PAL may enhance knowledge retention and foster academic self-efficacy by encouraging collaboration, feedback, and self-regulated learning. However, evidence from randomized controlled studies in preclinical medical students remains limited, necessitating systematic evaluation of PAL's educational impact.

Objectives: To compare the effectiveness of PAL and traditional didactic lectures on knowledge retention, procedural skills, and academic self-efficacy among first-year preclinical medical students, with primary emphasis on Physiology teaching.

Methods: A prospective randomized controlled study was conducted among 150 first-year medical students, allocated using a computer-generated random sequence to either a PAL group (n = 75) or a traditional lecture group (n = 75). The intervention was implemented during selected core modules of Cardiovascular Physiology, with supportive integration of related gross anatomical concepts where required for physiological understanding. Outcomes included pre- and post-intervention theory assessments, Objective Structured Practical Examination (OSPE) scores focusing on physiology practical skills, and academic self-efficacy measured using the validated Medical Achievement Self-Efficacy Scale (MASS). Long-term knowledge retention was assessed using a surprise re-test conducted six months after the intervention.

Results: Post-intervention theoretical scores improved significantly in the PAL group compared to controls (Mean percentage improvement from baseline: 18.9% vs. 6.8%; $p < 0.001$). OSPE performance related to physiology practical competencies was higher in the PAL group (mean score: 50.2 vs. 33.5; $p < 0.001$). At six months, the PAL group retained a greater proportion of post-test knowledge (76%) compared to the control group (52%). Academic self-efficacy scores were significantly higher among PAL participants ($p < 0.001$; effect size = 0.95).

Conclusion: Peer-assisted learning demonstrated significant advantages over traditional lectures in improving knowledge retention, physiology practical skills, and academic self-efficacy among preclinical medical students and may serve as an effective adjunct to conventional physiology teaching.

Keywords: Academic Self-Efficacy, Knowledge Retention, Medical Education, Peer-Assisted Learning, Preclinical Medical Students.

INTRODUCTION

The first year of the Bachelor of Medicine, Bachelor of Surgery (MBBS) program marks a critical



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transition in medical education, during which students are introduced to foundational preclinical subjects, particularly Physiology. As a core discipline, Physiology provides the functional basis for understanding normal body processes and underpins subsequent learning in pathology, pharmacology, and clinical medicine. However, the extensive scope and conceptual complexity of physiological principles place substantial cognitive

demands on novice learners, often resulting in surface learning strategies and poor long-term knowledge retention.^{1,2}

Traditional didactic lectures remain the predominant instructional approach in preclinical Physiology. Although lectures are effective for content delivery to large groups, they frequently promote passive learning, limited student engagement, and minimal opportunities for active recall or application. Educational psychology research has demonstrated that information acquired through passive exposure is prone to rapid decay, as described by the Ebbinghaus forgetting curve, with significant loss occurring within weeks to months in the absence of reinforcement.^{3,4} In Physiology, where integration and application of concepts are essential, such decay can negatively affect academic performance and future clinical reasoning.⁵

Peer-Assisted Learning (PAL) has emerged as an instructional strategy that emphasizes active participation and collaborative learning. PAL involves structured teaching–learning interactions among students of similar academic levels and is grounded in the principles of cognitive and social congruence. Peer tutors often communicate complex concepts using language, analogies, and reasoning approaches that closely align with the learner’s current understanding.⁶⁻⁸ This alignment is particularly beneficial in Physiology, where abstract concepts such as homeostasis, feedback mechanisms, and cardiovascular regulation are commonly challenging for first-year students.

Reciprocal peer teaching, a structured form of PAL in which students alternate between tutor and learner roles, further strengthens learning through the “protégé effect.” Preparing to teach requires learners to organize information, identify gaps in understanding, and engage in deeper cognitive processing. Such generative learning strategies have been shown to enhance conceptual clarity, promote durable memory formation, and improve transfer of knowledge.^{9,10} These processes are especially relevant in Physiology education, which requires integration of theoretical knowledge with practical application.¹¹

In addition to cognitive outcomes, academic self-efficacy is a key determinant of student learning. First-year medical students frequently experience academic stress, reduced confidence, and anxiety when confronted with complex physiological content and practical exercises. Lower self-efficacy has been associated with avoidance of active learning strategies and poorer academic outcomes.¹² Peer-based instructional models may mitigate these challenges by fostering a supportive learning environment that encourages discussion, questioning, and repeated practice without fear of negative evaluation.¹³

Although PAL has been widely studied in clinical

skills training and senior undergraduate education, evidence regarding its effectiveness in improving long-term knowledge retention, practical competency, and academic self-efficacy in first-year Physiology remains limited. Addressing this gap is essential for optimizing early medical education. Therefore, the present study aims to evaluate the effectiveness of Peer-Assisted Learning compared with traditional didactic lectures among first-year MBBS students.

MATERIALS AND METHODS

Study Design and Setting

This study was a prospective, randomized controlled, parallel-group educational intervention conducted over a six-month academic semester in the Department of Physiology at a tertiary-care medical college. The study design and reporting were informed by established methodological standards for educational intervention research in medical education.

Participants

The study population consisted of 150 first-year MBBS students enrolled in the preclinical Physiology curriculum during the study period.

Inclusion Criteria: All first-year MBBS students who provided written informed consent and were regularly attending Physiology theory and practical classes.

Exclusion Criteria: Students with less than 80% attendance in Physiology classes, students repeating the academic year, and those who did not complete all assessments were excluded from the final analysis.

Randomization and Group Allocation:

Baseline academic performance was assessed using National Eligibility cum Entrance Test (NEET) percentile scores to ensure equivalence between groups. Students were stratified according to baseline performance and subsequently randomized into two groups using a computer-generated random sequence.

- **Group A (Control Group):** Traditional didactic lecture method (n = 75)
- **Group B (Experimental Group):** Peer-Assisted Learning (PAL) method (n = 75)

Allocation concealment was maintained by assigning group codes prior to the commencement of the intervention. The randomization approach was consistent with previously published randomized studies in medical education.

Interventions

Control Group (Traditional Lecture Method): Students in the control group received conventional

faculty-led didactic lectures in Physiology, followed by routine practical demonstrations conducted in the Physiology laboratory. Teaching was delivered in accordance with the institutional undergraduate curriculum, without additional structured peer-learning activities.

Experimental Group (Peer-Assisted Learning Method): Students allocated to the PAL group participated in structured Reciprocal Peer Teaching sessions, an established model of peer-assisted learning in medical education.

The intervention was implemented during selected core modules of Cardiovascular Physiology, including the cardiac cycle, regulation of blood pressure, and electrocardiography. Students were subdivided into small groups of five. For each session, one student was designated as the peer tutor on a rotational basis.

Peer tutors prepared assigned topics using standard Physiology textbooks and faculty-recommended resources. Sessions emphasized explanation of physiological mechanisms, diagrammatic representation, and interactive discussion. Faculty members were present only as facilitators to ensure accuracy and to correct major conceptual errors, without direct instructional involvement. This structure was designed to promote cognitive congruence, active engagement, and deep learning.

Outcome Measures

Theoretical knowledge was assessed using a combination of multiple-choice questions (MCQs) and structured essay questions (SEQs) designed to evaluate conceptual understanding and application of physiological principles. Pre-tests were administered prior to the intervention, and post-tests were conducted immediately after completion of the module. This assessment format has been widely used in undergraduate medical education research. Practical competency was assessed using an Objective Structured Practical Examination (OSPE), focusing exclusively on Physiology practical skills. OSPE stations evaluated

competencies such as blood pressure recording, interpretation of physiological tracings, identification of laboratory instruments, and performance of basic experimental procedures. OSPE has been validated as an objective and reliable method for assessing practical skills in Physiology education.

Academic self-efficacy was measured using the Medical Achievement Self-Efficacy Scale (MASS), a validated instrument developed for medical students. The scale assesses confidence in understanding, applying, and retaining academic content. Responses were recorded on a 5-point Likert scale ranging from 1 (not confident) to 5 (very confident).

Long-term retention of physiological knowledge was evaluated using a surprise re-test administered six months after completion of the intervention. Retention was calculated as the proportion of post-test knowledge preserved at follow-up, a method consistent with prior studies on knowledge decay and retention in medical education.

Statistical Analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 25.0. Continuous variables were expressed as mean \pm standard deviation. Between-group comparisons were performed using independent-sample t-tests, while categorical variables were analyzed using the chi-square test. Effect size was calculated where appropriate. Normality of continuous variables was assumed based on sample size and distribution characteristics. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 150 first-year MBBS students participated in the study, with 75 students allocated to each group. There were no statistically significant differences between the Peer-Assisted Learning (PAL) group and the control group with respect to age, gender distribution, or baseline academic performance, indicating comparability between groups at study entry (Table 1).

Table 1: Baseline Characteristics of Participants

Characteristic	PAL Group (n=75)	Control Group (n=75)	p-value
Age (Mean \pm SD)	18.4 \pm 0.8	18.5 \pm 0.7	0.65
Gender (M/F)	35 / 40	32 / 43	0.82
Baseline Entrance Score (%)	88.5%	89.1%	0.55

Pre-intervention theoretical scores did not differ significantly between the two groups (PAL: 45.2 \pm 5.1; Control: 46.0 \pm 4.8; $p = 0.62$). Following the intervention, students in the PAL group demonstrated a significantly higher post-test score compared to the control group (73.8 \pm 9.0 vs. 52.8 \pm 7.2; $p < 0.001$).

The mean percentage improvement in theoretical scores was markedly greater in the PAL group (28.6%) compared to the control group (6.8%), indicating superior knowledge acquisition associated with peer-assisted learning (Table 2).

Table 2: Comparison of Pre- and Post-Test Theoretical Scores (Max: 100)

Metric	PAL Group (Mean ± SD)	Control Group (Mean ± SD)	Mean Difference	p-value
Pre-Test Score	45.2 ± 5.1	46.0 ± 4.8	-0.8	0.62
Post-Test Score	73.8 ± 9.0	52.8 ± 7.2	+21.0	< 0.001
Improvement (%)	28.6%	6.8%	-	0.001

Performance in the Objective Structured Practical Examination (OSPE) was significantly higher in the PAL group across all assessed domains. Students exposed to peer-assisted learning demonstrated better identification of physiological instruments, more accurate recording of blood pressure, improved interpretation of physiological tracings,

and superior procedural execution compared to controls.

The mean total OSPE score was significantly higher in the PAL group than in the control group (50.2 ± 2.3 vs. 33.5 ± 4.1 ; $p < 0.001$), reflecting enhanced practical competency among students trained through reciprocal peer teaching (Table 3).

Table 3: OSPE Scores for Physiology Practical Skills (Max: 60)

Domain	PAL Group	Control Group	p-value
Gross Physiology Spotters	24.5 ± 2.1	18.2 ± 3.4	< 0.01
Practical Technique	25.7 ± 1.8	15.3 ± 2.2	< 0.001
Total OSPE Score	50.2 ± 2.3	33.5 ± 4.1	< 0.001

Long-term retention was assessed using a surprise re-test conducted six months after completion of the intervention. Students in the PAL group retained a significantly greater proportion of post-intervention theoretical knowledge compared to the control group. Retention rates were 76% in the PAL group and 52% in the control group, indicating a slower rate of knowledge decay among students exposed to peer-assisted learning.

Post-intervention assessment using the Medical Achievement Self-Efficacy Scale (MASS) revealed significantly higher self-efficacy scores among students in the PAL group compared to the control group (4.2 ± 0.4 vs. 3.1 ± 0.6 ; $p < 0.001$). The calculated effect size (Cohen's $d = 0.95$) indicated a large and educationally meaningful difference in academic self-efficacy between the two groups.

DISCUSSION

The present study demonstrates that PAL was an effective educational strategy for first-year MBBS students in Physiology, leading to significant improvements in theoretical knowledge acquisition, practical skills, long-term knowledge retention, and academic self-efficacy when compared with traditional didactic lectures.

The superior performance of the PAL group in post-intervention theory assessments highlights the value of active learning approaches in Physiology education. Physiological concepts such as cardiovascular regulation, feedback mechanisms, and electrocardiographic interpretation require integration of multiple processes rather than rote memorization. Peer-assisted learning facilitates this integration by encouraging discussion, questioning, and repeated explanation, which promote deeper cognitive processing and conceptual clarity. These findings are consistent with earlier studies

demonstrating enhanced learning outcomes with peer-based instructional models in medical education.^{3,4}

Long-term retention of knowledge was significantly higher among students exposed to PAL, as evidenced by the six-month surprise re-test. This finding supports the educational psychology principle of the "protégé effect," whereby learners who prepare to teach engage in generative learning processes that strengthen memory consolidation and retrieval pathways.^{9,10} The reduced rate of knowledge decay observed in the PAL group aligns with prior evidence that active recall and elaborative rehearsal attenuate the forgetting curve, particularly for complex basic science content.^{3,4} In the context of Physiology, improved retention is of particular importance, as foundational concepts are repeatedly revisited and applied throughout the clinical years.

The marked improvement in OSPE performance among PAL participants indicates that peer-assisted learning is especially beneficial for developing practical competencies in Physiology. Practical skills such as accurate blood pressure measurement, interpretation of physiological tracings, and handling of laboratory instruments require repeated practice and immediate feedback. Small-group peer teaching allows for frequent hands-on engagement and real-time correction, which may not be feasible in large, faculty-led practical sessions. Similar benefits of peer-assisted learning on practical skill acquisition have been reported in anatomy and clinical skills training, supporting its applicability to Physiology laboratories.

Academic self-efficacy scores were significantly higher in the PAL group, with a large effect size, underscoring the psychosocial benefits of peer-assisted learning. First-year medical students often experience anxiety and reduced confidence when

confronted with complex physiological concepts and assessments. PAL creates a supportive learning environment that reduces fear of judgment, encourages active participation, and fosters a sense of shared responsibility for learning. Enhanced self-efficacy has been shown to positively influence motivation, persistence, and academic performance, suggesting that the benefits of PAL may extend beyond immediate academic outcomes.

Li Z et al.¹⁴ analyzed 81 randomized controlled trials and demonstrated that Peer-Assisted Learning (PAL) was superior to traditional teaching methods in facilitating transfer of theoretical knowledge and acquisition of practical skills. The benefits of PAL were particularly evident in learner satisfaction and acceptance. However, the authors noted that the magnitude of benefit may be limited in disciplines requiring highly specialized or advanced knowledge, suggesting that PAL is most effective as a complementary rather than standalone instructional approach.

Similarly, Noor S et al.¹⁵ reported a statistically significant improvement in academic performance among students exposed to PAL. Mean OSCE scores were higher in the PAL group compared with controls ($79.1 \pm 5.0\%$ vs. $72.4 \pm 6.4\%$; $p < 0.001$). In addition to cognitive gains, PAL was associated with a marked reduction in anxiety, as evidenced by a mean decrease of 4 points in GAD-7 scores, compared with a minimal reduction in the control group ($p < 0.01$). Qualitative findings further highlighted improved peer cohesion, increased leadership confidence among peer tutors, and positive professional identity formation, despite minor logistical challenges. These findings are consistent with existing literature supporting the role of PAL in reducing learner anxiety, enhancing skill acquisition, and fostering leadership development in health professions education.

Brierley C et al.¹⁶ also reported comparable outcomes, reinforcing the effectiveness of PAL in improving both learning outcomes and student engagement across health science curricula.

Further supporting this evidence, Guraya SY et al.¹⁷ conducted a meta-analysis demonstrating a significant overall effect of PAL, with a standardized mean difference of 1.26 (95% CI: 0.58–1.94). Statistical heterogeneity was high ($I^2 = 98\%$), reflecting variability across study designs and educational settings; nevertheless, the pooled effect remained significant, with a z-value of 3.65 confirming the robustness of PAL's educational impact. Collectively, these findings substantiate the effectiveness of PAL as an active learning strategy that enhances academic performance, learner confidence, and engagement when appropriately integrated into medical education.

Despite its strengths, this study has certain limitations. The intervention was conducted within

a single institution and focused primarily on selected modules of Cardiovascular Physiology, which may limit generalizability to other institutions or physiological systems. Additionally, long-term retention was assessed using a single follow-up assessment at six months; future studies incorporating multiple follow-up points may provide a more detailed understanding of retention trajectories. Finally, although faculty oversight was maintained, variability in peer tutor effectiveness may have influenced learning outcomes.

CONCLUSIONS

Peer-Assisted Learning is an effective educational strategy for preclinical Physiology teaching, demonstrating clear advantages over traditional didactic lectures in improving theoretical knowledge acquisition, practical skills, long-term knowledge retention, and academic self-efficacy among first-year MBBS students. By promoting active engagement, peer interaction, and deeper cognitive processing, PAL addresses key limitations of passive learning approaches commonly employed in preclinical medical education.

The integration of structured peer-assisted learning sessions into the Physiology curriculum may enhance both academic performance and learner confidence, thereby supporting foundational learning essential for subsequent clinical training. Incorporating PAL as a complementary teaching modality may represent a pragmatic and scalable approach to strengthening competency-based medical education in the preclinical phase

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Conflicts of Interest

The authors declare no conflicts of interest.

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Informed Consent Statement

Written informed consent was obtained from all participants involved in the study.

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