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Original Research Article

EFFECTIVENESS OF CASE-BASED LEARNING VERSUS TRADITIONAL LECTURE IN TEACHING PHYSIOLOGY AMONG MBBS STUDENTS

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ABSTRACT

Background: Physiology forms the foundation of medical education, yet traditional lecture-based teaching often limits active learning and clinical application. Case-Based Learning (CBL), a learner-centered approach, has been increasingly advocated under competency-based medical education to enhance understanding and clinical reasoning. The aim is to compare the effectiveness of CBL with traditional lecture (TL) methods in teaching physiology among MBBS students.

Materials and Methods: A prospective randomized interventional study was conducted among 100 First-year MBBS students, divided into CBL (n=47) and TL (n=48) groups. The topic of cardiovascular physiology (regulation of blood pressure and hypertension) was taught using respective methods. Pre-test and post-test assessments were conducted using validated questionnaires. Student perception regarding CBL was evaluated using a Likert-scale feedback tool. Statistical analysis was performed using paired and independent t-tests, with $p<0.05$ considered significant.

Results: Both groups showed significant improvement in post-test scores ($p<0.001$). However, the CBL group demonstrated significantly higher post-test scores (19.6 ± 2.1 vs 16.8 ± 2.5, $p<0.001$) and greater mean score improvement (7.8 ± 2.3 vs 4.7 ± 2.4). A higher proportion of students in the CBL group achieved good to excellent performance (65.9% vs 33.3%, $p=0.012$). Students reported high satisfaction with CBL, particularly in terms of engagement and clinical relevance.

Conclusion: Case-Based Learning is a more effective teaching strategy than traditional lectures in physiology education, promoting deeper understanding, improved academic performance, and better clinical integration. Its incorporation into undergraduate teaching may enhance competency development in medical students.

Keywords: Case-Based Learning; Traditional Lecture; Physiology; MBBS Students; Competency-Based Medical Education.

INTRODUCTION

Physiology constitutes a core component of undergraduate medical education, forming the scientific basis for understanding normal human body functions and their alterations in disease.[1] Conventionally, physiology has been delivered through didactic lectures, which facilitate structured content dissemination to large groups.[2] However, this traditional teacher-centered approach often results in passive learning, limited student engagement, and suboptimal development of higher-order cognitive skills such as analysis, application, and clinical reasoning.[3] In response to evolving healthcare needs and educational reforms, there has been a global shift toward competency-based medical education (CBME), emphasizing learner-centered approaches and outcome-driven training.[4] In India,

the implementation of CBME by the National Medical Commission underscores the need to train Indian Medical Graduates (IMGs) who are not only knowledgeable but also competent in clinical reasoning, problem-solving, communication, and lifelong learning.[5] The CBME framework specifically highlights domains such as "knows," "knows how," "shows how," and "does," thereby necessitating teaching-learning methods that go beyond rote memorization to application and integration of knowledge.[6] Case-Based Learning (CBL) has emerged as an effective pedagogical strategy aligned with CBME principles.[7] It involves the use of structured clinical scenarios to facilitate active learning, encouraging students to apply physiological concepts to real-life clinical situations.[7] This approach directly supports key CBME competencies, including early clinical exposure, integration of basic and clinical sciences, critical thinking, and self-directed learning.[8] Furthermore, CBL promotes collaborative learning and enhances communication skills, aligning with the IMG roles of clinician, communicator, and lifelong learner as envisaged by the NMC.[9] Evidence suggests that active learning methods such as CBL improve knowledge retention, conceptual understanding, and student satisfaction.[10,11] Studies have reported that students exposed to case-based or problem-oriented teaching demonstrate significantly better academic performance and retention rates (approximately 20–30% higher) compared to those taught via traditional lectures.[10,11] Additionally, CBL enhances the ability to contextualize physiological principles in clinical settings, which is essential for achieving competency milestones defined in CBME curricula.[12] Despite these advantages, the integration of CBL into routine teaching remains inconsistent, particularly in resource-constrained settings, due to challenges such as large class sizes, limited faculty training, and time constraints. Moreover, there is a need for context-specific evidence evaluating the effectiveness of CBL within the framework of CBME in Indian medical colleges. Therefore, in alignment with the CBME mandate of the National Medical Commission, the present study aims to evaluate the effectiveness of Case-Based Learning compared to traditional lecture methods in teaching physiology among MBBS students.

MATERIALS AND METHODS

Study Design and Setting: This prospective, parallel-group, randomized controlled educational intervention study was conducted in the Department of Physiology at a tertiary care teaching institution in India over a period of four months (August–November 2025). The study was designed and reported in accordance with CONSORT guidelines adapted for educational interventions to ensure methodological rigor and transparency. Prior approval was obtained from the Institutional Ethics Committee, and the study adhered to the ethical principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants, and confidentiality of data was strictly maintained.

Study Participants and Sampling: The study included second-year MBBS students undergoing training under the Competency-Based Medical Education (CBME) curriculum prescribed by the National Medical Commission. A total of 100 students were assessed for eligibility, of whom 100 students fulfilling inclusion criteria were enrolled. Students who were absent during intervention sessions or failed to complete either pre-test or post-test assessments were excluded from final analysis. The sample size was calculated assuming a moderate effect size (Cohen's d = 0.6), 80% power, and 5% level of significance, yielding a minimum of 45 participants per group; this was increased to 50 per group to account for potential attrition.

Randomization, Allocation Concealment, and Blinding: Participants were randomly allocated into two groups—Case-Based Learning (CBL) group and Traditional Lecture (TL) group—in a 1:1 ratio using computer-generated random numbers. Allocation concealment was ensured using sequentially numbered, opaque, sealed envelopes prepared by an independent faculty member not involved in the study. Due to the nature of the educational intervention, blinding of participants and instructors was not feasible; however, outcome assessment was blinded. The evaluators responsible for scoring pre-test and post-test responses were unaware of group allocation, thereby minimizing assessment bias [Figure 1].

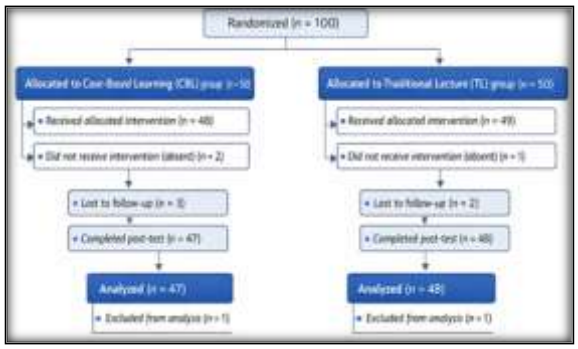

Figure 1: CONSORT Flow Diagram Showing Participant Enrollment, Randomization, Allocation, Follow-up, and Analysis.

Intervention and Teaching Methods: The selected teaching module focused on cardiovascular physiology, specifically regulation of blood pressure and pathophysiology of hypertension, chosen for its high clinical relevance and comprehensive alignment with CBME competencies (PY 5.1–PY 5.3), Indian Medical Graduate roles, and Miller's pyramid of clinical competence [Table 1].

Table 1: Mapping of Study Intervention with CBME Competencies

Domain	Competency Code	Competency Description	Teaching Method Alignment
Knowledge	PY 5.1	Describe regulation of blood pressure	Covered in both TL & CBL
Application	PY 5.2	Explain pathophysiology of hypertension	Strongly addressed in CBL
Integration	PY 5.3	Correlate physiological mechanisms with clinical conditions	Emphasized in CBL
Clinical Reasoning	IMG Role: Clinician	Apply knowledge to patient scenarios	Core strength of CBL
Communication	IMG Role: Communicator	Discuss and present case findings	Achieved in CBL group discussions
Lifelong Learning	IMG Role: Lifelong learner	Self-directed learning and inquiry	Promoted in CBL
Skill Level	Miller's Pyramid	Knows → Knows How → Shows How	TL (Knows), CBL (Knows How/Shows How)

In the Traditional Lecture (TL) group, students received a structured didactic lecture of 60 minutes delivered by experienced faculty using PowerPoint presentations. The session focused on core theoretical concepts, emphasizing knowledge acquisition at the "knows" and "knows how" levels of competency.

In the Case-Based Learning (CBL) group, students were divided into smaller subgroups of 10–12 participants to facilitate interaction. Each session lasted 90 minutes and was conducted using a structured clinical case scenario (e.g., a patient presenting with hypertension and its complications). The session began with case presentation, followed by guided discussion wherein students identified key clinical problems, applied physiological principles, and integrated concepts to explain disease mechanisms. Faculty acted as facilitators, using probing questions mapped to CBME competencies and encouraging self-directed learning, peer discussion, and clinical reasoning. This approach targeted higher domains of Miller's pyramid, particularly "knows how" and "shows how," while also fostering roles of Indian Medical Graduate (IMG) such as clinician, communicator, and lifelong learner.

Outcome Measures and Assessment Tools: The primary outcome measure was improvement in knowledge acquisition, assessed using pre-test and post-test scores. A validated questionnaire comprising 25 items (15 multiple-choice questions and 10 short answer questions) was used, covering both recall and application-based domains aligned with CBME competencies. The same questionnaire was administered before and immediately after the intervention for both groups to ensure comparability. Content validity was established through expert review by three senior physiology faculty members, and reliability was confirmed with a Cronbach's alpha of 0.82.

Secondary outcomes included student perception and satisfaction, assessed using a structured feedback questionnaire based on a 5-point Likert scale. The tool evaluated parameters such as clarity of concepts, engagement, understanding of clinical relevance, promotion of self-directed learning, and overall effectiveness of the teaching method.

Data Collection Procedure: Baseline demographic details of participants were recorded prior to intervention. Pre-test assessment was conducted simultaneously for both groups under standardized conditions. Following their respective teaching sessions, post-test assessment was administered immediately to evaluate short-term learning gain. Feedback questionnaires were distributed to students in the CBL group after completion of sessions to capture their perception of the learning experience.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS version 20.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Within-group comparisons of pre-test and post-test scores were performed using paired t-test, and between-group comparisons were analyzed using independent t-test. Effect size (Cohen's d) was calculated to determine the magnitude of difference between groups. A p-value of <0.05 was considered statistically significant.

RESULTS

The baseline characteristics of participants in the CBL (n=47) and TL (n=48) groups were comparable. The mean age of students was 20.3 ± 0.8 years in the CBL group and 20.5 ± 0.9 years in the TL group (p=0.218). Gender distribution was similar, with males comprising 55.3% and 56.3% in the CBL and TL groups, respectively (p=0.934). The mean previous physiology scores were also comparable (64.8 ± 6.5% vs 65.2 ± 7.1%, p=0.781). Additionally, the distribution of medium of schooling did not differ significantly between groups (p=0.972), indicating baseline homogeneity [Table 2].

Table 2: Baseline Characteristics of Study Participants

Variable	CBL Group (n=47)	TL Group (n=48)	p-value
	Frequency (%)/mean ± SD		
Age (years)	20.3 ± 0.8	20.5 ± 0.9	0.218
Gender			
Male	26 (55.3%)	27 (56.3%)	0.934

Female	21 (44.7%)	21 (43.7%)	
Previous Physiology Score (%)	64.8 ± 6.5	65.2 ± 7.1	0.781
Medium of Schooling			
English	30 (63.8%)	32 (66.7%)	0.972
Hindi	12 (25.5%)	11 (22.9%)	
Other	5 (10.6%)	5 (10.4%)	

CBL: Case-Based Learning; TL: Traditional Lecture.

Both groups demonstrated a statistically significant improvement in knowledge following the intervention. In the CBL group, mean scores increased from 11.8 ± 2.4 in the pre-test to 19.6 ± 2.1 in the post-test, with a mean difference of 7.8 ± 2.3 ($p<0.001$). Similarly, in the TL group, scores improved from 12.1 ± 2.6 to 16.8 ± 2.5, with a mean difference of 4.7 ± 2.4 ($p<0.001$). However, the magnitude of improvement was notably greater in the CBL group [Table 3].

Table 3: Within-Group Comparison of Pre-test and Post-test Scores

Group	Pre-test Score	Post-test Score	Difference	p-value
	mean ± SD			
CBL (n=47)	11.8 ± 2.4	19.6 ± 2.1	7.8 ± 2.3	<0.001
TL (n=48)	12.1 ± 2.6	16.8 ± 2.5	4.7 ± 2.4	<0.001

CBL: Case-Based Learning; TL: Traditional Lecture.

There was no significant difference in pre-test scores between the CBL and TL groups (11.8 ± 2.4 vs 12.1 ± 2.6, $p=0.542$), confirming comparable baseline knowledge. However, post-test scores were significantly higher in the CBL group (19.6 ± 2.1) compared to the TL group (16.8 ± 2.5), with a statistically significant difference ($p<0.001$), indicating superior effectiveness of the CBL method [Table 4]

Table 4: Between-Group Comparison of Pre-test and Post-test Scores

Parameter	CBL (n=47)	TL (n=48)	p-value
	mean ± SD		
Pre-test Score	11.8 ± 2.4	12.1 ± 2.6	0.542
Post-test Score	19.6 ± 2.1	16.8 ± 2.5	<0.001

CBL: Case-Based Learning; TL: Traditional Lecture.

A significantly higher proportion of students in the CBL group achieved better performance categories compared to the TL group ($p=0.012$). The proportion of students in the "good" (44.7% vs 25.0%) and "excellent" (21.2% vs 8.3%) categories was higher in the CBL group, whereas a greater proportion of TL students fell into the "average" (50.0% vs 29.8%) and "poor" (16.7% vs 4.3%) categories. This indicates enhanced academic performance with case-based learning [Table 5].

Table 5: Distribution of Students According to Performance Categories

Performance Category	CBL (n=47)	TL (n=48)	p-value
	Frequency (%)		
Poor (<50%)	2 (4.3%)	8 (16.7%)	0.012
Average (50–70%)	14 (29.8%)	24 (50.0%)	
Good (71–85%)	21 (44.7%)	12 (25.0%)	
Excellent (>85%)	10 (21.2%)	4 (8.3%)	

CBL: Case-Based Learning; TL: Traditional Lecture.

Students in the CBL group reported highly positive perceptions toward the learning method. The highest ratings were observed for increased engagement (4.7 ± 0.5) and better clinical correlation (4.6 ± 0.5), followed by overall satisfaction (4.6 ± 0.5) and improved understanding of concepts (4.5 ± 0.6). Promotion of self-directed learning also received favorable responses (4.4 ± 0.7), reflecting strong acceptance of CBL as an effective teaching modality [Table 6].

Table 6: Student Perception of Case-Based Learning

Parameter	Mean ± SD
Improved understanding of concepts	4.5 ± 0.6
Better clinical correlation	4.6 ± 0.5
Increased engagement	4.7 ± 0.5
Promoted self-directed learning	4.4 ± 0.7
Overall satisfaction	4.6 ± 0.5

5-point Likert scale (1 = strongly disagree, 5 = strongly agree).

A statistically significant positive correlation was observed between previous physiology scores and gain in test scores (r=0.28, p=0.006), indicating that students with better baseline academic performance tended to achieve greater learning gains. In contrast, age did not show a significant correlation with score improvement (r=0.09, p=0.382), suggesting that learning outcomes were independent of age [Table 7].

Table 7: Correlation of Gain in Scores with Baseline Variables

Variable	Correlation Coefficient (r)	p-value
Previous Physiology Score	0.28	0.006
Age	0.09	0.382

Pearson's correlation coefficient (r).

DISCUSSION

The present study demonstrates that Case-Based Learning (CBL) is significantly more effective than Traditional Lecture (TL) in improving knowledge acquisition, performance outcomes, and learner engagement among MBBS students studying physiology. The baseline comparability between the two groups, with no significant differences in age, gender distribution, prior academic performance, or educational background ($p>0.05$), strengthens the internal validity of the study and ensures that the observed differences in outcomes can be attributed to the teaching intervention rather than confounding factors.

Both teaching methods resulted in significant improvement in post-test scores ($p<0.001$), indicating that structured teaching, irrespective of modality, enhances learning. However, the magnitude of improvement was substantially greater in the CBL group (mean gain: 7.8 ± 2.3) compared to the TL group (4.7 ± 2.4), with a highly significant between-group difference ($p<0.001$). This large effect size suggests that CBL not only facilitates knowledge acquisition but also enhances deeper understanding and application of concepts.[13] These findings are consistent with previous studies by Tiwale et al., Bansal et al., and Bansal et al., in medical education by , which have reported superior learning gains with active learning strategies, often demonstrating 20–30% higher retention rates compared to passive lecture-based methods.[13-15]

The significantly higher post-test scores in the CBL group (19.6 ± 2.1 vs 16.8 ± 2.5, $p<0.001$) further support the effectiveness of case-based pedagogy. From a cognitive perspective, CBL promotes elaborative encoding and contextual learning, where knowledge is processed in relation to clinically relevant scenarios.[16] This aligns with constructivist learning theory, which posits that learners actively construct knowledge through interaction and application rather than passive reception.[17] Moreover, the use of clinical cases in topics such as regulation of blood pressure and hypertension enables integration of basic physiology with clinical reasoning, thereby reinforcing CBME competencies (PY 5.1–PY 5.3) and advancing learners along Miller's pyramid from "knows" to "knows how" and "shows how".[18]

The distribution of performance categories further highlights the pedagogical advantage of CBL. A significantly higher proportion of students in the CBL group achieved "good" and "excellent" grades (65.9% combined) compared to the TL group (33.3%), while fewer students remained in the "poor" category (4.3% vs 16.7%, p=0.012). This suggests that CBL not only improves average performance but also shifts the overall achievement spectrum toward higher competency levels.[19] Similar trends have been reported in studies by Shireesha et al., Dave et al., and Aristotle et al., where case-based and problem-based approaches resulted in improved academic performance and clinical reasoning skills among medical students.[20-22]

Student perception findings in the present study strongly favor CBL, with high ratings for engagement (4.7 ± 0.5), clinical correlation (4.6 ± 0.5), and overall satisfaction (4.6 ± 0.5). These results indicate that CBL creates a more stimulating and interactive learning environment, which is known to enhance intrinsic motivation and promote self-directed learning.[23] The relatively high score for self-directed learning (4.4 ± 0.7) reflects the alignment of CBL with adult learning principles, particularly Knowles' theory of andragogy, where learners take responsibility for their own learning. Comparable findings have been reported in Indian and international studies by Alamoudi et al., and Garg et al., where students consistently expressed preference for case-based or problem-based learning over traditional lectures due to improved understanding and relevance to clinical practice.[24,25]

The correlation analysis revealed a modest but significant positive relationship between prior academic performance and learning gain (r=0.28, p=0.006), suggesting that students with stronger baseline knowledge may derive slightly greater benefit from CBL. This could be explained by the fact that CBL requires active participation, prior knowledge activation, and higher-order thinking, which may be more readily utilized by academically stronger students.[26] However, the lack of significant correlation with age indicates that the effectiveness of CBL is independent of demographic factors, reinforcing its broad applicability.

From a CBME perspective, the findings of this study are particularly relevant. The National Medical Commission emphasizes integration, early clinical exposure, and development of competencies across

cognitive, affective, and psychomotor domains.[27] CBL inherently supports these objectives by integrating basic science with clinical scenarios, fostering communication and teamwork, and encouraging lifelong learning.[28] In contrast, traditional lectures primarily address lower levels of cognition and may be insufficient in achieving higher competency outcomes required for the Indian Medical Graduate.[29]

Limitations

This study was conducted in a single institution with a relatively small sample size, which may limit generalizability. Blinding of participants and instructors was not feasible due to the nature of the intervention. The study assessed short-term knowledge gain without evaluating long-term retention or clinical performance. Additionally, student perception was assessed only in the CBL group, which may introduce response bias.

CONCLUSION

The present study demonstrates that Case-Based Learning is significantly more effective than traditional lecture-based teaching in enhancing knowledge acquisition, academic performance, and student engagement among MBBS students in physiology. CBL not only resulted in greater improvement in test scores but also facilitated better clinical correlation, active participation, and self-directed learning. These findings highlight the superiority of learner-centered approaches in achieving higher-order cognitive outcomes and align well with competency-based medical education requirements. Incorporating CBL into routine physiology teaching may bridge the gap between theoretical knowledge and clinical application, thereby contributing to the development of competent, analytically oriented, and clinically proficient Indian Medical Graduates.

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