Application of peer-assisted learning in respiratory physiology teaching

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Abstract

Background Physiology is an important basic subject of medical education. Its content is abstract and complex, which often leads to students ' learning difficulties. In order to better grasp the knowledge of physiology, this study adopts the innovative teaching mode of Peer-assisted learning (PAL), namely " teacher intensive teaching-test feedback-student mutual teaching-personalized counseling, " combined with traditional teaching, applied to the chapter of respiratory physiology, to solve the problems in students ' learning, improve the teaching quality and students ' learning initiative, and provide new practical methods for improving the teaching effect of medical physiology. Objective To enhance students' learning initiative and improve the teaching quality of physiology, this study explores the application of Peer-Assisted Learning (PAL) in teaching practice, using respiratory physiology as an example. Method This study involved 240 clinical undergraduate students, who were divided into a control group (CN, n=120) and an experimental group (EP, n=120). The experimental group was further subdivided into 10 teams with 12 students each. A team-based teaching approach was adopted, where the learning content was modularized. Before class, the instructor provided study materials and posed questions. During class (8 credit hours), students presented, summarized, and discussed key concepts in respiratory physiology. Result The data showed that the

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total score of the experimental group was 7.8% higher than the control group's ($P<0.05$), and the number of correct answers was significantly higher than the control group ($P<0.05$). There was no difference in the number of wrong answers, but the number of non-answer questions was significantly reduced. The satisfaction of learning methods was significantly improved ($P<0.01$), and the satisfaction of students ' communication ability and teaching effect was also significantly improved ($P<0.01$). The application of PAL students won the third place in the Chinese mainland group of the international physiology competition. Conclusion PAL effectively enhances students' self-directed learning ability and stimulates their interest in physiology, demonstrating significant value in physiology education.

Keywords：Peer-assisted learning; Respiratory physiology; Autonomous learning; Team collaborative learning; Teaching reform

Introduction

Physiology is a fundamental discipline that studies the normal functional activities of organisms at the system, organ, tissue, and cellular levels. It intersects with multiple disciplines such as biochemistry, anatomy, and pathophysiology, providing an important theoretical foundation for clinical medicine. In the process of clinical practice and disease treatment, medical staff can gain an in-depth understanding of the causes of diseases, providing theoretical support for diagnosis, treatment, and prevention. Therefore, learning physiology holds significant importance for the future career development of medical students.However, the content of physiology is often considered abstract and difficult to comprehend. Factors such as a lack of relevant background knowledge, the abundance of detailed information, and the high level of abstraction of physiological processes and concepts contribute to students' perception that physiology is challenging to learn. As a result, educators have been exploring effective approaches to make learning physiology easier for students (Yang Huidi et al., 2019; Yang Huidi & Xue Mingming, 2017; Yang Juan et al., 2025).Respiratory physiology is an essential component of the discipline. While the basic process of respiration seems simple, students often encounter significant challenges when delving deeper into its mechanisms (Paganini & Rubini, 2015). In recent years, educational reforms emphasizing active learner engagement have gained attention in undergraduate medical education, particularly with the growing application of the Peer-Assisted Learning (PAL) method. PAL refers to an instructional strategy that uses specially designed conceptual test questions aimed at identifying learners' misconceptions and guiding them toward deeper exploration. Through interactive feedback systems, instructors obtain feedback on learners' levels of understanding and adjust instructional activities accordingly (Herrmann-Werner et al., 2017; Afshar et al., 2024).This method typically follows a structured approach that includes focused teaching by instructors, assessment and feedback, student-led teaching, and one-on-one peer tutoring (Dong Jun et al., 2020). Therefore, this study applies the PAL method in teaching the concepts and processes of respiration, using the sequence

of instructor-led lectures, testing, student presentations, and peer tutoring to enhance conceptual understanding and improve learning outcomes in physiology.

1. Materials and Methods

1.1 Research Subjects

The study subjects were students from the clinical undergraduate programs of the classes of 2019, 2020, and 2021 at our university, with two classes per year (40 students per class), totaling six classes and 240 students. All students had completed basic medical courses in their first year, including human anatomy, histology and embryology, and medical biology. The physiology course was taught in the first semester of the second year by the same instructor.For the study, students in each year were randomly divided into two groups based on their academic performance:Control Group (CN): Traditional teaching method, n = 120.Experimental Group (EP): Peer-Assisted Learning (PAL) method, n = 120.The experimental group was further divided into 10 study groups, each consisting of 12 students. Following the principle of within-group heterogeneity, factors such as gender, interests, and academic performance were balanced. This ensured that each student could leverage their strengths and have the opportunity to serve as a peer tutor. The roles were not fixed and could be adjusted at any time to guarantee that every learner experienced different roles.

1.2 Pre-Class Preparation

This intervention was implemented in the chapter on respiratory physiology, which consisted of 8 class hours.Experimental Group:Students were required to preview the material before class. The instructor distributed preparatory materials (e.g., principles and influencing factors of pulmonary ventilation and gas exchange) and information on respiratory-related diseases (e.g., chronic obstructive pulmonary disease, bronchial asthma, pulmonary emphysema, and pulmonary fibrosis). Students were instructed to summarize relevant respiratory physiology concepts according to the matrix in Table 1 and perform a self-evaluation, identifying areas of difficulty and content that was easier to understand. Preparatory assignments had to be completed and submitted online by the day before class to earn preview credit. The instructor reviewed these submissions online to assess the students' self-study status and prepare for the lecture.Control Group:Students were only required to preview the content before class, without additional structured assignments.

Table 1. Matrix for Student Preparation in Peer-Assisted Learning

Parameters	Ventilation	Gas Exchange	Restrictive (Pulmonary Fibrosis)	Obstructive (Asthma)	Obstructive (Emphysema)

Parameters	Ventilation	Gas Exchange	Restrictive (Pulmonary Fibrosis)	Obstructive (Asthma)	Obstructive (Emphysema)
Airway diameter			/		
Lung compliance			/		
Elastic recoil			/		
Respiratory membrane area			/		
Respiratory membrane thickness			/		
Lung volumes: VC (or FVC)			/		
FEV1/FVC			/		
RV			/		
/ indicates not applicable					

1.3 Peer-Assisted Learning (PAL) Implementation

In-Class Activities：At the start of each class, students answered 3–5 test questions using QR code scanning or a learning platform app (e.g., Chaoxing Learning). This provided immediate feedback on their preview performance, helping the instructor gauge students' prior understanding and set appropriate teaching starting points.The respiratory physiology content was divided into six subunits, each focusing on a core topic. For each unit:The instructor delivered a short lecture (5–10 minutes).Students answered 3–5 test questions via the app, with results displayed on the screen for immediate feedback.eaching strategies were adapted based on response accuracy:<30% accuracy: Detailed explanation by the instructor.30–70% accuracy: Group-based peer discussion and mutual teaching. Students worked in small groups of four to explain answers, clarify misunderstandings, and reach consensus. Those with better understanding used various methods—such as games or diagrams—to explain concepts.>80% accuracy: Transition to the next topic.After group discussions, a representative from each group presented their conclusions to the class, and the instructor summarized or clarified as needed. Notably, students were not graded on their answers during these activities, but participation was required to foster intrinsic motivation for learning.

1.4 Course Effect Evaluation

1.4.1 Academic Performance Assessment

After completing the respiratory physiology unit, 40 students were randomly selected from both the experimental and control groups for a written test. The test included 50 multiple-choice questions (total score: 50 points), scored as follows:Correct answer: +1 point.Wrong answer: –2 points.No answer: –1 point.Additionally, students completed a worksheet on the principles of pulmonary ventilation and gas exchange.

1.4.2 Student Satisfaction Survey

A structured questionnaire assessed satisfaction in three areas:Satisfaction with learning methods.Satisfaction with communication and interaction.Satisfaction with overall teaching effectiveness.Scoring was based on five levels:Very satisfied (90–100).Satisfied (70–89).Uncertain (50–60).Dissatisfied (30–49).Very dissatisfied (0–10).The survey also included an open-ended question: “What benefits did you gain from the application of the PAL method?” Data from the surveys were collected and statistically analyzed.

1.4.3 Practical Validation – Physiology Competition

To further evaluate the teaching effectiveness and enhance skills such as self-learning, oral expression, logical thinking, and adaptability, the university annually organizes teams of outstanding students, led by instructors, to participate in the “International Physiology Competition (China Mainland Division).” The competition outcomes were used as an auxiliary indicator to evaluate the impact of PAL-based instruction.

1.5 Statistical Analysis

Data were analyzed using SPSS 17.0 software (SPSS Inc., Chicago, IL, USA). Results are expressed as mean ± standard deviation ($\bar{x} \pm s$). Comparisons between the experimental and control groups were performed using independent samples t-tests, with $P<0.05$ indicating statistical significance.

2. Results

2.1 Student Performance

Table 2 presents several questions based on the general gas flow model, which effectively revealed which students understood the principles of pulmonary ventilation and gas exchange and which did not.The results indicated that students in the Peer-Assisted Learning (PAL) group performed significantly better than those in the traditional teaching group. The total score of the PAL group was 7.8% higher than that of the control group ($P<0.05$).The number of correctly answered questions was significantly higher in the PAL group ($P<0.05$).The number of incorrectly answered questions showed no significant difference between the two groups.The number of unanswered questions in the PAL group was significantly lower than that in the

control group (P<0.01), suggesting that students in the PAL group had a clearer understanding of respiratory physiology concepts (Figure 1).

Table 2. Examples of Difficult Questions in the Respiratory Physiology Section

Challenging Concept	Correct Answer	Common Incorrect Answer
Explaining causal relationships in pulmonary ventilation	When the volume of the lungs cannot increase, the intrapulmonary pressure cannot decrease, so the pressure gradient from the atmosphere to the alveoli is reduced.	The amount of inhaled air decreases, but intrapulmonary pressure remains higher.
Understanding that different gases behave independently in the same space (Dalton's law)	Not applicable	The partial pressure of gases in the alveoli decreases.
Relationship between lung elastic recoil and compliance	Lung scarring affects both lung compliance (reduced inspiratory ability) and elastic recoil.	Elastic recoil increases to compensate for reduced compliance.
Influence of airway resistance on ventilation	The only known factor affecting airway resistance is the airway diameter.	Increased resistance allows more air to be expelled into the atmosphere.

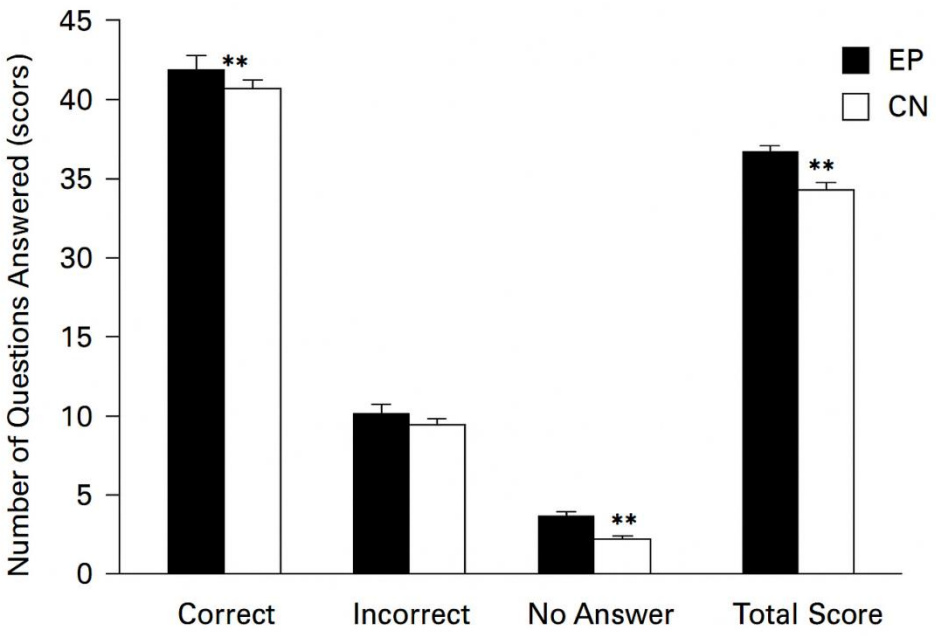

Figure 1. Scores for student responses to test questions (**P**<0.01).

2.2 Student Satisfaction Survey

Analysis of all collected teaching-related questionnaires revealed that, in terms of learning method satisfaction, the Peer-Assisted Learning (PAL) group scored significantly higher than the traditional teaching group (P<0.01). Students in the PAL group also reported that this method significantly improved their communication skills and their satisfaction with teaching outcomes compared to the control group (P<0.01, Table 4).Many students indicated that PAL deepened their logical understanding of difficult concepts, stimulated their motivation to study physiology actively, and cultivated independent inquiry and innovation. Moreover, PAL notably improved students' organizational and verbal communication skills, building their confidence.Over the past three years, students under this approach, with instructor guidance, have successfully undertaken:2 projects under the Inner Mongolia Medical University Laboratory Open Fund.6 projects under the university's "Elite Talent Training Program".2 university-level innovation and entrepreneurship projects funded by the Inner Mongolia Autonomous Region

Table 4. Comparison of Student Satisfaction Survey Results (100-point scale)

Group (n)	Learning Method Satisfaction	Communication Satisfaction	Teaching Effect Satisfaction
PAL Group (n=40)	85.45 ± 1.21 **	87.67 ± 1.23 **	88.01 ± 1.78 *
Control Group (n=40)	64.89 ± 1.10	63.75 ± 1.13	67.48 ± 2.23

Note: P<0.05, ***P****<0.01*

2.3 Practical Evaluation — Physiology Competition

To further validate the effectiveness of the PAL approach and assess students' abilities in self-learning, oral expression, logical reasoning, and real-time problem solving, the university organizes teams of outstanding students annually, led by instructors, to participate in the International Physiology Competition (China Mainland Division).Over the past three years, participants have achieved:1 national second prize.2 national third prizes.

3. Discussion

The results from the respiratory physiology knowledge tests clearly show that PAL enhances students' comprehension of the subject. Survey data also demonstrated that students in the PAL group expressed greater satisfaction with learning methods and

teaching effectiveness, and they perceived notable improvements in communication and collaboration skills.Feedback from students validated that PAL fosters autonomous learning, innovative thinking, and personalized knowledge integration. Students could design and analyze experiments, interpret data, and complete reports, thereby mastering fundamental physiological principles and experimental skills. This process strengthened their research thinking and hands-on abilities, providing a solid foundation for future research projects, competitions, and professional development.

PAL is a form of active learning that improves conceptual understanding and problem-solving skills, and its effectiveness has been verified across multiple disciplines and academic levels (Hull, 2018). For medical students, who often need to teach patients, families, or peers about health-related information, PAL provides a valuable training experience. Pre-class preparation and peer teaching deepen their conceptual understanding and encourage exploration of relevant clinical literature, broadening both the depth and scope of their knowledge (Evans & Cuffe, 2009; Swallow, Wride & Donroe, 2023).Student feedback in this study strongly supported PAL as a necessary component of medical education, echoing findings from previous research (Bardach, Vedanthan, & Haber, 2003; Brierley, Ellis, & Reid, 2022). Acting as a "student-teacher" requires learners to explain complex physiological processes, clarify misconceptions, and field peer questions, reinforcing their own learning through self-explanation.Moreover, PAL created a collaborative learning environment that mitigated several issues typical in teacher-centered classes, such as limited student expression, poor interaction, and passive knowledge transfer (Khan et al., 2021).However, implementing PAL is not without challenges (Fu Shuai et al., 2021; Srivastava et al., 2015). Some discussions may stray off-topic, requiring instructors to actively guide focus. Others may struggle with verbal expression, in which case teachers need to assist by summarizing contributions and encouraging participation (Yuan Tangbo et al., 2022; Li Qingyu, Zhang Xuan & Yang Chunli, 2022; Naren Gaowa & Yang Huidi, 2022).

The scoring system used in this study—+1 for correct, –2 for incorrect, and –1 for unanswered—provided a more accurate assessment of students' understanding. Results showed that although error rates were similar between groups, the PAL group left significantly fewer questions unanswered, indicating reduced uncertainty and greater conceptual clarity.Over three years of applying PAL in physiology, students reported increased confidence and better preparation for advanced courses such as pathophysiology and pathology (Khan et al., 2021). This approach encouraged self-reflection, active learning, and accountability, while cultivating critical, divergent, and innovative thinking (Srivastava et al., 2015; Kamble et al., 2019; Liang Dalong et al., 2022; Yuan Tangbo et al., 2022).Practical outcomes also highlight the long-term benefits of PAL: students have successfully secured multiple innovation and research projects, including 2 regional-level entrepreneurship projects, 1 laboratory open project, and 4 elite talent training projects at the university level, demonstrating PAL's growing positive impact on academic and professional development.

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