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Application and Effectiveness Evaluation of PBL Combined with Virtual Reality Technology in Teaching Geriatric Sarcopenia

Qing Ma

Shaanxi Provincial People's Hospital, Xi'an 710000, Shaanxi, China

Abstract: *Objective*: To investigate the impact of applying PBL combined with virtual reality (VR) technology in clinical teaching of geriatric sarcopenia on students' knowledge acquisition, attitudes, and behaviors, providing practical evidence for geriatric medicine teaching reform. *Methods*: Eighty clinical medicine undergraduate interns admitted to the geriatrics department of a hospital from January 2024 to June 2025 were randomly divided into an observation group (n = 40) and a control group (n = 40). The control group received traditional lecture-based instruction, while the observation group underwent PBL combined with VR technology. The two groups were compared on end-of-term theoretical knowledge assessment scores, clinical practice operation scores, teaching satisfaction, and clinical behavior observation scale scores. *Results*: Students in the observation group achieved significantly higher scores in basic theoretical knowledge (86.52 ± 5.31) and clinical practice skills (88.15 ± 4.26) compared to the control group (75.28 ± 6.15) and (72.33 ± 5.87), respectively ($p < 0.05$). The observation group and control group students' awareness of geriatric sarcopenia and satisfaction with teaching methods were 95.00% and 97.50%, and 77.50% and 72.50%, respectively, with statistically significant differences ($p < 0.05$); The observation group demonstrated significantly higher frequency of proactive sarcopenia screening, greater enthusiasm in participating in nutritional intervention plan development, and increased engagement in health education during clinical practice compared to the control group, with statistically significant differences ($p < 0.05$). *Conclusion*: The application of a PBL combined with virtual reality (VR) technology teaching model in clinical teaching on geriatric sarcopenia significantly enhances students' foundational theoretical knowledge, improves their attitudes toward geriatric sarcopenia, and enhances their clinical practice behaviors. This represents a scientifically effective teaching method in geriatric medicine.

Keywords: Problem-Based Learning (PBL) teaching model; Virtual Reality (VR) technology; Geriatric sarcopenia; Screening; Nutritional intervention

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1. Introduction

With the acceleration of global population aging, China's population aged 65 and above has surpassed 14%, marking the nation's full entry into a deeply aged society. Sarcopenia, a common degenerative disease among the elderly, is characterized by reduced muscle mass, diminished muscle strength, and impaired physical function. Its prevalence significantly increases with age, reaching 30% to 50% among individuals aged 80 and above [1]. Sarcopenia not only increases the risk of falls, fractures, and disability among the elderly but also exacerbates the healthcare burden. Therefore, cultivating clinical medical professionals with high-level expertise in screening, assessing, and intervening in sarcopenia is crucial for enhancing geriatric healthcare services [2]. However, under traditional lecture-based teaching models, the inability to authentically replicate early screening and nutritional intervention processes for geriatric sarcopenia often leaves students with only foundational theoretical knowledge. When confronted with real clinical scenarios, they frequently feel overwhelmed and unable to apply their learning. Problem-Based Learning (PBL) is an emerging student-centered teaching approach that guides students to actively explore through real clinical problems, effectively enhancing their clinical reasoning skills [3]. Wen Maowan observed that applying PBL significantly improved clinical interns' performance and self-directed learning abilities, while greatly benefiting the development of their clinical reasoning skills [4]. Virtual reality technology, also known as artificial reality or cyberspace technology, utilizes computers to construct immersive, interactive virtual clinical scenarios. This allows students to engage in repeated practice within simulated environments, enabling them not only to rapidly master clinical operational techniques but also to internalize foundational knowledge through continuous practice [5]. This holds significant importance for developing clinical reasoning, enhancing procedural compliance, and improving teamwork capabilities. Ling Lin et al. conducted an experimental study on applying VR technology in standardized residency training, confirming that VR enhances trainees' learning interest and improves their clinical skills [6]. This study will integrate PBL with VR technology, using sarcopenia screening and nutritional intervention in the elderly as its entry point, to construct a novel teaching model. It aims to explore the impact of this approach on medical interns' knowledge acquisition, attitudes, and behaviors, thereby providing new insights and methodologies for teaching sarcopenia in geriatrics.

2. Materials and methods

2.1. General data

The study enrolled 80 clinical medicine undergraduate interns admitted to the geriatrics department of a certain hospital from January 2024 to June 2025.

2.1.1. Inclusion criteria

(1) Completion of basic medical coursework and entry into the clinical internship phase
(2) Voluntary participation in the study with signed informed consent
(3) Absence of contraindications for VR device use

2.1.2. Exclusion criteria

(1) Failure to complete all teaching content during internship due to leave or department transfer
(2) Prior specialized training in geriatric medicine.

2.1.3. Participants

Participants were randomly assigned to an observation group (n = 40) and a control group (n = 40) using a random number table. Observation group: 22 males, 18 females; age 22–25 years, mean (23.45 ± 0.82) years; academic performance grades (based on undergraduate GPA): 12 excellent, 20 good, 8 satisfactory. The control group comprised 20 males and 20 females, aged 22–26 years (mean 23.62 ± 0.91 years). Academic performance levels were: 10 excellent, 21 good, and 9 satisfactory. Comparisons of general characteristics (gender, age, academic performance) between groups showed no statistically significant differences ($p > 0.05$ for all), indicating comparability.

2.2. Methods

Both groups were taught by faculty members holding the title of Associate Chief Physician or above in geriatrics. The practical training focused on geriatric sarcopenia, emphasizing

(1) Definition, epidemiological characteristics, and pathogenesis of sarcopenia in the elderly

(2) Screening methods for sarcopenia in older adults (grip strength measurement, 6-meter walk test, bioelectrical impedance analysis, etc.)

(3) Nutritional interventions for sarcopenia in the elderly (protein supplementation, vitamin D regulation, dietary pattern optimization, etc.)

(4) Comprehensive management and health guidance for sarcopenia patients.

The total teaching duration was 12 months.

2.2.1. Control group

Employed a traditional lecture-based teaching model, systematically presenting content in the conventional sequence of "definition-mechanism-clinical manifestations-diagnosis-treatment" using PPT slides, images, and videos. Post-class assignments included relevant literature readings. Following foundational theory instruction, students participated in bedside teaching sessions.

2.2.2. Observation group

Employed a PBL combined with VR technology teaching model, implemented as follows:

(1) PBL problem design

Using the core case "An 82-year-old male admitted for 'two recurrent falls,' with a 10-year history of hypertension and no history of diabetes. Physical examination: Height 165 cm, weight 52 kg, grip strength 21 kg, 6-meter walk speed 0.5 m/s. Laboratory tests: Serum albumin 32 g/L, vitamin D 15 ng/mL". A series of questions were designed around this core case: ① Does this patient have sarcopenia? What is the evidence? ② What additional tests are needed to confirm the diagnosis? ③ How should a nutritional intervention plan be developed for this patient? ④ How should fall prevention and health guidance be provided to the patient?

(2) VR scenario construction

Utilize a VR teaching system to construct virtual scenarios for sarcopenia screening and nutritional intervention in the elderly: ① Virtual clinic scenario: Includes standardized elderly patient models, grip strength meters, bioelectrical impedance analyzers, and other examination equipment; ② Nutritional assessment scenario: Provides virtual dietary survey tools, nutritional calculation software, and common food models; ③ Health guidance scenario: Simulates a home environment for one-on-one health education practice.

(3) Teaching implementation process

① Pre-class Preparation: Instructors distribute case materials. Students form groups (5 members per group) to review relevant literature and outline preliminary problem-solving approaches. ② Classroom Discussion: Each group presents case analysis findings. Instructors guide students in discussing core issues to clarify sarcopenia screening protocols and key nutritional intervention points. ③ VR Practical Application: Students wear VR equipment to enter virtual scenarios and sequentially complete: a. Grip strength measurement, gait speed testing, and bioelectrical impedance analysis on virtual patients to assess sarcopenia presence; b. Nutritional assessment based on virtual patients' dietary status, developing personalized protein and vitamin D supplementation plans; c. Fall prevention and nutritional education for virtual patients in home settings. Instructors provide real-time guidance to correct improper procedures. ④ Post-Session Summary: Group members share practical insights, and the instructor summarizes key teaching points to reinforce knowledge retention.

2.3. Observation indicators

2.3.1. Learning outcomes for the "geriatric sarcopenia prevention and management training program"

(1) Basic theoretical knowledge assessment

Following instruction, a closed-book exam evaluates both groups' mastery of geriatric sarcopenia knowledge, covering foundational theory (40 points), screening criteria (30 points), and nutritional intervention principles (30 points), with a total score of 100 points.

(2) Clinical practice assessment

Two senior geriatric physicians conducted blinded evaluations of students' proficiency in using dynamometers, conducting gait speed tests, developing nutritional plans, and providing health guidance. The maximum score was 100 points, with the final grade being the average of the two evaluators' scores.

2.3.2. Attitude change (pre- and post-training comparison)

Post-training questionnaires surveyed students' attitude shifts. Questionnaire items included:

(1) Attention to geriatric sarcopenia (rated as "Highly Concerned", "Concerned", "Neutral", or "Unconcerned")

(2) Satisfaction with teaching methods, rated on a 4-point scale: "Very satisfied", "Satisfied", "Neutral", "Dissatisfied".

A total of 80 questionnaires were distributed, with 80 valid responses collected, achieving a 100% valid response rate.

2.3.3. Behavioral change assessment

Within one month after the teaching session, supervising instructors assessed interns' performance in geriatric clinical practice using a clinical behavior observation scale. Key indicators included: frequency of proactive sarcopenia screening, initiative in participating in patient nutrition intervention plan development, and involvement in sarcopenia-related health education for elderly patients (rated as "frequently involved", "occasionally involved", or "not involved", with "frequently involved" counted as positive).

2.4. Statistical analysis

Data analysis was performed using SPSS 26.0 statistical software. Quantitative data are expressed as mean ± standard deviation ($\bar{x}$ ± s). Intergroup comparisons were conducted using independent samples *t*-tests. Qualitative data are presented as rates (%). Intergroup comparisons were performed using chi-square (χ^2) tests. A p value < 0.05 was considered statistically significant.

3. Results

3.1. Comparison of academic performance between groups

Students in the observation group demonstrated significantly higher scores in both theoretical knowledge assessments and practical skill evaluations compared to the control group, with statistically significant differences ($p < 0.05$). See **Table 1**.

Table 1. Comparison of basic theoretical knowledge and clinical practice scores between two student groups ($\bar{x}$ ± s, points)

Group	Basic theoretical knowledge assessment score	Practical skills assessment score (Points, $\bar{x}$ ± s)
Control group (n = 40)	75.28 ± 6.15	72.33 ± 5.87
Observation group (n = 40)	86.52 ± 5.31	88.15 ± 4.26
t	8.749	13.795
p	< 0.001	< 0.001

3.2. Comparison of attitude changes between the two groups

Students in the observation group demonstrated significantly higher levels of awareness regarding geriatric sarcopenia and greater satisfaction with teaching methods compared to the control group, with statistically significant differences ($p < 0.05$). See **Table 2**.

Table 2. Comparison of attention to geriatric sarcopenia and satisfaction with teaching methods between groups [(n), %]

Group	Attention to geriatric sarcopenia	Satisfaction with teaching methods
Control group (n = 40)	29 (72.50)	31 (77.50)
Observation group (n = 40)	38 (95.00)	39 (97.50)
χ^2	7.440	7.314
p	0.006	0.007

3.3. Comparison of behavioral changes between intern groups

The observation group demonstrated significantly higher frequency of proactive sarcopenia screening during clinical practice, greater enthusiasm in participating in nutrition intervention plan formulation, and higher engagement in health education compared to the control group, with statistically significant differences ($p < 0.05$). See **Table 3**.

Table 3. Comparison of proactive screening frequency, initiative in plan development, and health education participation between groups [(n), %]

Group	Frequency of proactive screening (≥ 3 times/week)	Plan development participation (active)	Health education participation (frequent participation)
Control group (n = 40)	18 (45.00)	22 (55.00)	25 (62.50)
Observation group (n = 40)	32 (80.00)	35 (87.50)	35(87.50)
χ^2	10.453	10.313	6.667
p	0.001	0.001	0.009

4. Discussion

Sarcopenia in the elderly is a syndrome characterized by reduced total body muscle mass, decreased muscle strength, and diminished physical function, representing an increasingly prominent public health issue in geriatric medicine. Currently, clinical awareness, screening rates, and diagnostic rates for sarcopenia remain generally low, posing significant challenges to its prevention and treatment. This necessitates higher competency standards for clinicians in geriatrics and general practice. However, traditional clinical teaching methods suffer from disconnects between theoretical instruction and clinical practice, as well as monotonous teaching formats, making it difficult to stimulate trainees' interest and ability to actively explore and solve complex clinical problems. Therefore, actively exploring and applying innovative educational models, such as Problem-Based Learning (PBL) combined with Virtual Reality (VR) technology, is of great significance for breaking through traditional teaching bottlenecks, deepening educational reform, and cultivating outstanding medical professionals capable of meeting the health needs of an aging society. The study findings indicate that students in the observation group achieved significantly higher scores in both theoretical knowledge assessments and practical skill evaluations compared to the control group. This demonstrates that PBL combined with VR technology effectively enhances interns' mastery of geriatric sarcopenia knowledge [7].

(1) PBL, guided by real clinical cases, motivates students to proactively review literature and organize knowledge frameworks. This approach integrates the fundamental theory of sarcopenia with screening and intervention practices, fostering a systematic knowledge system.

(2) VR technology creates immersive scenarios enabling students to directly observe physiological characteristics of elderly patients and repeatedly practice procedures like grip strength measurement and gait speed testing. This addresses the traditional teaching challenge of "much observation but little practice", enhancing proficiency and accuracy in clinical operations [8].

This study further revealed that students in the observation group demonstrated superior attention to geriatric sarcopenia, teaching satisfaction, and clinical behavior compared to the control group. This indicates that this teaching model effectively improves interns' learning attitudes and clinical practice behaviors. On one hand, the engaging and interactive nature of VR technology heightened students' learning interest, shifting their mindset from "I have to learn" to "I want to learn", thereby increasing their focus on sarcopenia, a critical geriatric medicine topic [9]. On the other hand, PBL group discussions cultivated students' teamwork and communication skills, while health guidance simulations in VR scenarios strengthened their confidence in communicating with elderly patients. This enabled them to participate more proactively in sarcopenia screening and health education during clinical practice [10].

5. Conclusion

In summary, the PBL-VR integrated teaching model combines problem-oriented learning with immersive practice, significantly improving medical interns' mastery of geriatric sarcopenia knowledge, enhancing their attitudes toward the condition, and modifying clinical behaviors. This approach warrants further promotion and refinement in medical education.

Disclosure statement

The author declares no conflict of interest.

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