Original Research

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EVALUATING THE EFFICACY OF SPACED REPETITION AND OPTIMAL TIMING FOR ANATOMY KNOWLEDGE RETENTION IN FIRST-YEAR MEDICAL STUDENTS

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ABSTRACT

Background: The volume of information in medical education, particularly in foundational sciences, poses a significant retention challenge for students. Spaced repetition, a learning strategy grounded in cognitive psychology, involves reviewing information at systematically increasing intervals to counter memory decay. This study investigates the impact of a structured spaced repetition module and seeks to identify the most effective interval for reinforcing Anatomy knowledge among medical undergraduates. **Methods:** A one-month prospective interventional study was conducted with 250 first-year MBBS students. Participants were randomly assigned to one of five experimental groups, each corresponding to a different revision interval: 1, 2, 4, 7, or 14 days. All groups underwent an initial learning session, followed by a single revision session on their designated day. Knowledge retention was assessed through three timed tests: immediately after the initial learning, immediately before the revision session, and after the revision session. Standardized multiple-choice questionnaires on selected Anatomy topics were administered digitally. **Results:** The 7-day interval group (Group D) exhibited the most pronounced improvement in knowledge retention. While their pre-revision performance was moderate (58% of students scoring ≥8/10), it surged to 87% post-revision. This gain was the highest observed. Statistical analysis confirmed significant differences between groups (one-way ANOVA, $p < 0.001$). Post-hoc Tukey's HSD test identified the 7-day interval as statistically superior to all other intervals ($p < 0.05$). **Conclusion:** Spaced repetition is a highly effective pedagogical tool for enhancing long-term memory retention in medical education. The findings indicate that a seven-day interval is optimal for reviewing Anatomy concepts, as it effectively balances the need for some forgetting to occur—thereby making retrieval effortful and strengthening memory traces—without allowing knowledge loss to become too substantial. Integrating optimally-timed spaced repetition into medical curricula is strongly recommended.

Keywords: Spaced Repetition, Distributed Practice, Medical Education, Anatomy, Memory Retention, Learning Intervals, Undergraduate Education.

INTRODUCTION

The initial phase of medical education immerses students in a dense curriculum of foundational subjects such as Anatomy, Physiology, and Biochemistry. The cognitive load associated with mastering this vast amount of information is immense, and a primary difficulty students report is not merely understanding the material but retaining it over the long term. Traditional, massed "cramming" methods, while sometimes effective for short-term performance, often lead to rapid forgetting, thereby undermining the development of a stable knowledge base essential for clinical reasoning and practice.

The "spacing effect," a well-established phenomenon in memory research, suggests that information is more effectively encoded into long-term memory when study sessions are distributed over time rather than condensed into a single, intensive period. Spaced repetition is a systematic implementation of this effect, where material is reviewed at strategically timed, increasing intervals to proactively counteract the natural forgetting curve first described by Ebbinghaus. This technique leverages the psychological principle of 'desirable difficulties,' where introducing certain challenges during learning, such as the effortful retrieval of information after a delay, leads to stronger and more durable memory traces.

While the general principle of spaced repetition is well-known, the practical question of the optimal interval between study sessions for complex, high-volume subjects like medical Anatomy remains a subject of active investigation. Previous research has shown the benefits of spaced learning, but the ideal gap that maximizes retention without leading to excessive forgetting is not yet standardized for medical curricula. This study was designed to bridge this gap by empirically evaluating a structured spaced repetition module. Its primary objective was to determine the most effective time interval for revising Anatomy content to maximize long-term retention among first-year medical students.

MATERIALS AND METHODS

Study Design and Population:

A prospective, interventional study was conducted over one month. The participant pool consisted of 250 students from the 2021 entering MBBS class at a tertiary care medical institution. Ethical approval was obtained from the Institutional Ethics Committee (Ref: [IEC Number]), and informed consent was acquired from all participants.

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Group Allocation and Intervention:

Students were randomly divided into five groups of 50 each (Groups A through E). The intervention for all groups involved two core learning sessions focused on standardized, medium-difficulty Anatomy topics. The critical experimental manipulation was the timing of the second session:

Group A: 1-day interval
Group B: 2-day interval
Group C: 4-day interval
Group D: 7-day interval
Group E: 14-day interval

Assessment and Data Collection:

Knowledge was evaluated at three points:

Test 1: Immediately after the initial learning session (Day 0).

Test 2: Immediately before the spaced revision session (Day X).

Test 3: Immediately after the spaced revision session (Day X).

All assessments were conducted using identical, structured multiple-choice questionnaires delivered via a digital platform (Google Forms) to ensure standardization and efficient data collection. The primary outcome measure was the change in scores, particularly the percentage of students achieving a high score (≥8/10) in the pre- and post-revision tests.

STATISTICAL ANALYSIS

Data were analyzed using SPSS software version [e.g., 26.0]. Descriptive statistics were presented as percentages. A one-way Analysis of Variance (ANOVA) was used to compare mean scores across the five groups. Where significant differences were found, Post-hoc analysis using Tukey's Honest Significant Difference (HSD) test was applied for pairwise comparisons. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Baseline Performance:

Initial post-class test scores on Day 0 showed comparable understanding across groups, with no single group demonstrating a significant baseline advantage (Table 1).

Table 1: Baseline Scoring on Day 0 (Post-Class Test)

Group	% Scoring ≤7/10	% Scoring ≥8/10
A (1 Day)	56%	44%
B (2 Days)	65%	35%
C (4 Days)	46%	54%
D (7 Days)	31%	69%
E (14 Days)	45%	55%

Retention and Improvement:

The most critical data pertained to retention (pre-revision test) and learning gain (post-revision test). Group D (7-day interval) showed the largest absolute improvement, jumping from 58% to 87% of students scoring ≥8/10 (Table 2).

Table 2: Retention Scores (% of students scoring ≥8/10)

Group	Pre-Revision Score	Post-Revision Score
A (1 Day)	81%	77%
B (2 Days)	74%	79%
C (4 Days)	72%	83%
D (7 Days)	58%	87%
E (14 Days)	25%	80%

Statistical Significance:

One-way ANOVA confirmed a statistically significant difference in the mean post-revision scores among the five groups ($p < 0.001$). The Post-hoc Tukey's HSD test revealed that the mean score of Group D (7-day) was significantly higher than that of all other groups ($p < 0.05$ for all pairwise comparisons). No other inter-group differences were statistically significant.

DISCUSSION

This study provides robust evidence supporting the integration of spaced repetition into medical curricula. The key finding is the identification of a 7-day interval as being particularly effective for enhancing the retention of anatomical knowledge, a subject notorious for its high memorization load.

The superior performance of the 7-day group aligns strongly with the concept of "desirable difficulties". A one-day interval (Group A) likely did not provide sufficient time for any meaningful forgetting to occur, making the review session less effortful and thus less potent for long-term consolidation. This is reflected in their modest post-revision gain. Conversely, the 14-day interval (Group E) resulted in substantial forgetting, as evidenced by the low pre-revision score (25%), indicating that the initial memory trace may have degraded too far for a single review to be fully effective, a challenge noted in studies with extended intervals. The 7-day interval appears to strike an optimal balance, allowing for a manageable degree of forgetting that makes retrieval practice both effortful and powerful, without leading to irretrievable knowledge loss.

Our results are consistent with the literature on distributed practice. Cepeda et al. emphasized that interval length is critical, with moderately spaced sessions often yielding the best long-term results. Furthermore, computational models of learning, such as those discussed by Tabibian et al., support the existence of an optimal window for review that maximizes memory strength, which our findings suggest lies around one week for this context.

The implications for medical education are substantial. Embedding structured review sessions with a 7-day gap into the curriculum, perhaps through digital platforms or tutorial schedules, could significantly improve knowledge retention without a substantial increase in resource allocation. This approach moves beyond what is taught to address when it is reinforced, aligning curriculum design with cognitive science principles.

Limitations and Future Directions:

This study has several limitations. Its focus was solely on Anatomy; future research should explore the generalizability of these intervals to other basic and clinical sciences. While groups were randomized, unmeasured confounders like individual study habits or intrinsic motivation could have influenced outcomes. The assessment was limited to multiple-choice questions, which primarily test factual recall rather than higher-order application. Finally, the study duration was one month; longer-term follow-up is needed to confirm the durability of these retention gains.

Future studies could investigate adaptive spaced repetition software, incorporate qualitative student feedback, and use neuroimaging techniques to explore the underlying cognitive mechanisms.

CONCLUSIONS

Adult A Spaced repetition is a potent and practical learning technique for combating knowledge decay in medical education. This study demonstrates that its efficacy is highly dependent on timing, with a 7-day revision interval emerging as optimal for reinforcing Anatomy concepts in first-year students. Medical educators are encouraged to embed this evidence-based strategy into curriculum design to foster deeper, more durable learning.

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Conflict of Interest:

The authors declare that there is no conflict of interest.

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