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Original Research Article

Correlational Analysis of Metacognitive Awareness and Academic Performance among Phase-1 Medical Students

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ABSTRACT

Background: Metacognition, defined as "thinking about thinking," represents a fundamental cognitive process governing how individuals monitor and regulate their learning. While extensive research demonstrates positive correlations between metacognitive awareness and academic performance in various educational contexts, limited investigations have examined this relationship within medical education cohorts. This study investigated the correlation between metacognitive awareness and academic performance among first-year medical students in the subject of anatomy.

Methods: A quantitative, cross-sectional correlational study was conducted among 138 Phase-1 MBBS students at a medical college in central Andhra. Metacognitive awareness was assessed using the validated Metacognitive Awareness Inventory (MAI-52), comprising Knowledge of Cognition (17 items) and Regulation of Cognition (35 items) domains. Academic performance was measured using internal assessment scores in anatomy. Statistical analyses included descriptive statistics, Pearson and Spearman correlations, multiple linear regression, and one-way ANOVA. Students were stratified into tertile-based groups for comparative analysis.

Results: The sample demonstrated mean theory examination scores of 45.92 ± 12.67 and total MAI scores of 37.04 ± 6.06. All correlations between MAI subscales and academic performance were positive and statistically significant. Total MAI score showed the strongest correlation with academic performance ($r = 0.408$, $p < 0.001$), followed by Regulation of Cognition ($r = 0.378$), Conditional Knowledge ($r = 0.330$), and Knowledge of Cognition ($r = 0.323$). Multiple regression analysis revealed that approximately 17% of variance in theory marks was explained by metacognitive components, with Regulation of Cognition emerging as the sole significant predictor ($\beta = 0.80$, $p = 0.005$). Cross-tabulation analysis demonstrated that 57.5% of high MAI students were high achievers, while 53.1% of low MAI students were low achievers.

Conclusion: This study establishes a significant positive correlation between metacognitive awareness and academic performance in first-year medical students. Regulation of cognition emerged as the strongest predictor of academic success, suggesting that students' ability to monitor and adjust their learning strategies significantly contributes to academic achievement. These findings support the integration of metacognitive skill development into medical education curricula to enhance learning outcomes and foster self-directed learning capabilities essential for lifelong medical practice.

KEYWORDS: Metacognition, metacognitive awareness, medical education, academic performance, self-regulated learning, medical students, anatomy education, learning strategies.

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INTRODUCTION

Metacognition, defined as "thinking about thinking," represents a fundamental cognitive process that governs how individuals monitor and regulate their own learning. Flavell (1976) first introduced this construct, defining metacognition as "the active monitoring and consequent regulation and orchestration of cognitive processes concerning the cognitive objects or data on which they bear, usually in service of some concrete goal or objective"[1,2]. Building upon Flavell's foundational work, Ann Brown (1978) established a comprehensive framework comprising two primary components: knowledge of cognition and regulation of cognition. Knowledge of cognition encompasses three distinct elements: declarative knowledge (factual information about cognitive processes), procedural knowledge (understanding of how to execute cognitive strategies), and conditional knowledge (awareness of when and why to apply specific cognitive approaches). Regulation of cognition involves the executive control processes of planning, monitoring, and evaluation that govern cognitive activity [3].

Schraw and Dennison further refined the regulation component, identifying five critical elements: (a) planning, which involves goal setting and resource allocation before learning; (b) information management strategies, encompassing the systematic organization and elaboration of acquired information; (c) comprehension monitoring, involving continuous assessment of learning progress and strategy effectiveness; (d) debugging strategies, which address the correction of misunderstandings and performance errors; and (e) evaluation, comprising post-learning analysis of performance outcomes and strategy effectiveness [4].

Research consistently demonstrates that students with enhanced metacognitive awareness demonstrate superior academic performance across educational contexts [5]. Metacognition is a strong predictor of academic success and important for learning [6,7]. However, while extensive literature exists examining metacognitive awareness among secondary and undergraduate students in non-medical disciplines, limited research has investigated this relationship within medical education cohorts [1,8]. This gap is particularly significant given that metacognitive awareness represents a cornerstone of self-regulated learning theory, which is grounded in social cognitive theory and is fundamental to competency-based medical education [9,10]. The integration of metacognitive principles in medical education is essential for developing self-directed learning capabilities and fostering lifelong learning competencies—attributes that are critical for contemporary medical practice. Despite the established theoretical connections between metacognitive awareness and various educational learning theories applicable to medical training, empirical investigations within medical student populations remain scarce.

Therefore, this study aimed to investigate the correlation between metacognitive awareness and academic performance in Phase-1 MBBS students, specifically within the subject of anatomy, to develop evidence-based learning strategy recommendations for this population.

OBJECTIVES OF THE STUDY

1. To assess the level of metacognitive awareness among first-year MBBS students using the MAI-52 self-report questionnaire.

2. To determine the correlation between MAI scores and students' internal assessment scores as a measure of academic performance.

3. To identify metacognitive subdomains or subscales that most strongly relate to academic performance.

METHODS

Study Design: A quantitative, cross-sectional correlational study was conducted at the Department of Anatomy, Dr. Pinnamaneni Siddhartha Institute of Medical Sciences and Research Foundation, Andhra Pradesh, India, to investigate the relationship between metacognitive awareness and academic performance among first-year medical students.

Participants and Sampling: The study initially recruited 150 Phase-1 MBBS students who had completed internal assessments in anatomy and provided written informed consent to participate. Students were systematically approached following their internal assessment examinations. Twelve participants were excluded due to incomplete responses on the metacognitive inventory, yielding a final analytical sample of 138 students. All participants were enrolled in their first year of medical studies and had completed the anatomy curriculum as per the standard MBBS program.

Instruments and Data Collection

Metacognitive Assessment: Metacognitive awareness was assessed using the **Metacognitive Awareness Inventory (MAI-52)**, a well-established and psychometrically validated instrument developed by Schraw and Dennison. This freely available inventory comprises 52 items organized into two primary domains:

· **Knowledge of Cognition** (17 items): Assessing declarative, procedural, and conditional knowledge

· **Regulation of Cognition** (35 items): Evaluating planning, information management, comprehension monitoring, debugging, and evaluation strategies

Before administration, students received orientation sessions to familiarize them with the inventory format and ensure accurate responses. Participants provided binary responses (true/false) to all items, with scoring protocols assigning one point for each "true" response and zero points for "false" responses, resulting in a possible score range of 0-52. All participants provided written informed consent, and confidentiality of individual responses was maintained throughout the research process.

Academic Performance Measurement: Academic performance was quantified using students' internal assessment scores in anatomy, recorded as percentage scores out of 100 marks. These assessments were conducted according to standard institutional protocols and represented comprehensive evaluations of theoretical knowledge in anatomy.

Statistical Analysis: Data was systematically compiled and organized using Microsoft Excel, followed by comprehensive statistical analyses performed using appropriate software. Descriptive statistics in the form of mean, standard deviations, and distributional characteristics were calculated for the theory marks, MAI, and subscale scores. Pearson's correlation coefficient for normally distributed data and Spearman's coefficient were analysed for non-parametric data as part of correlational analysis. Both simple and multiple linear regression analyses were conducted to identify predictive relationships between MAI subscales and academic performance (regression analysis). Students were stratified into tertile-based groups (Low, Middle, High) according to both MAI total scores and academic achievement levels. Cross-tabulation analyses and percentage distribution were calculated to examine the overlap between metacognitive awareness categories and achievement groups, providing insights into the practical significance of these relationships.

Statistical Validation: One-way Analysis of Variance (ANOVA) was conducted to test for statistically significant differences between groups, confirming the reliability of observed relationships and supporting the validity of categorical distinctions. Post-hoc analyses were performed where appropriate to identify specific group differences.

Statistical significance was set at $p < 0.05$ for all analyses, and effect sizes were calculated to determine practical significance of findings.

RESULTS

Descriptive Statistics: The study sample (n = 138) demonstrated a mean theory examination score of 45.92 ± 12.67 out of 100 marks, with total MAI scores averaging 37.04 ± 6.06. Among the MAI subscales, Knowledge of Cognition achieved the highest mean score (11.59 ± 2.69), while Procedural Knowledge recorded the lowest mean score (2.73 ± 1.12) as shown in table-1.

All correlations were positive, indicating that students with higher metacognitive awareness consistently performed better on theory examinations. The MAI Total Score demonstrated the strongest correlation with academic performance (r = 0.408, moderate positive correlation), followed by Regulation of Cognition (r = 0.378, weak to moderate positive correlation), Conditional Knowledge (r = 0.330, weak to moderate positive correlation), and Knowledge of Cognition (r = 0.323, weak to moderate positive correlation) as presented in table 2.

Table 1: Descriptive Statistics for Theory Marks and MAI Subscales.

Variable	Mean	Standard Deviation
Theory marks	45.9	12.6
Procedural knowledge	2.73	1.12
Declarative knowledge	5.3	1.34
Conditional knowledge	3.55	1.06
Knowledge of cognition	11.59	2.68
Planning	4.41	1.37
Information management strategies	7.84	1.63
Comprehension Monitoring	4.6	1.19

Correlation Analysis

Table 2: Correlation Coefficients Between Theory Marks and MAI Subscales.

MAI Subscales	Correlation Coefficient
Procedural knowledge	0.246577
Declarative knowledge	0.178276
Conditional knowledge	0.329922
Knowledge of cognition	0.323319
Planning	0.29316
Information management strategies	0.223414
Comprehension management	0.292353
Debugging strategies	0.193939
Evaluation	0.258675
Regulation of knowledge	0.378084
Mai score	0.408195

These findings suggest that metacognitive awareness as a comprehensive construct is more predictive of academic performance than individual subscales. Among the specific components, students who excel at regulating their learning processes, understanding when and why to apply cognitive strategies, and maintaining awareness of their own thinking patterns tend to achieve higher examination scores.

Regression Analysis: Multiple linear regression analysis incorporating the three highest-correlating subscales (Regulation of Cognition, Conditional Knowledge, and Knowledge of Cognition) as predictors of theory marks yielded an R^2 value of 0.17, indicating that approximately 17% of the variance in theorymarks is explained by these metacognitive components.

Regulation of Cognition emerged as the sole statistically significant predictor ($\beta = 0.80$, $p = 0.005$), suggesting that each additional point in this subscale corresponds to an increase of approximately 0.8 points in theory marks, while controlling for other factors. Although Conditional Knowledge and Knowledge of Cognition demonstrated positive effects, their contributions were not statistically significant ($p > 0.05$) in the multivariate model.

Achievement-Based Group Analysis: Students were stratified into three achievement levels using tertile cutoffs based on theory marks: Low Achievement (≤ 40.66 marks, n = 46), Medium Achievement (40.67-51.00 marks, n = 49), and High Achievement (>51.00 marks, n = 43) as depicted in Table 3.

High-achieving students consistently demonstrated superior performance across all MAI subscales compared to their lower-performing peers. One-way ANOVA confirmed statistically significant differences in total MAI scores across achievement groups ($F = 12.47$, $p < 0.001$), validating the association between metacognitive awareness and academic performance.

MAI-Based Group Analysis: Students were similarly categorized into MAI groups using tertile cutoffs: Low MAI (≤ 35 points, n = 49), Middle MAI (36-40 points, n = 49), and High MAI (>40 points, n = 40) as shown in table 4.

A clear progressive relationship emerged, with higher MAI groups achieving superior academic performance and subscale scores. Spearman correlation analysis revealed strong, statistically significant positive relationships between MAI group classification and theory marks ($r = 0.42$, $p < 0.001$), as well as with all individual subscales (all $r > 0.70$, $p < 0.001$).

Cross-Tabulation Analysis

The cross-tabulation reveals (Table-5) a pronounced association between metacognitive awareness levels and academic achievement. Students in the High MAI group were predominantly represented among high achievers (57.5%) and minimally among low achievers (12.5%). Conversely, students with

Table 3: Achievement Groups - Mean Theory Scores and MAI Subscale Performance.

Achievement levels	Theory	*MAI	*ROC	*CK	*KOC	Number of students
High achievers	60.5 +/-5.9	40.04+/-5.84	27.4+/-3.89	3.98+/-1.01	12.67+/-2.76	43
Low achievers	31.87+/-6.17	34.13+/-5.5	23.61+/-4	3.15+/-0.94	10.5+/-2.13	46
Medium achievers	46.2+/-3.17	37.1+/-5.5	25.43+/-4.09	3.57+/-1.1	11.67+/-2.75	46

*MAI: metacognitive awareness inventory, *ROC: regulation of cognition, *CK: conditional knowledge, *KOC: knowledge of cognition

Table 4: Showing MAI Groups, mean theory marks, subscale scores and student distribution.

MAI group	Theory	ROC	CK	KOC	Number of students
High	54.075	29.92	4.5	13.95	40
Low	40.73	21.69	2.67	9.04	49
Middle	44.44	25.51	3.67	12.22	49

Table 5: Distribution of Students Across MAI Groups and Achievement Levels.

	High Achievers	Low Achievers	Medium Achievers
High MAI	23 (57.5 %)	5(12.4%)	12(30%)
Low MAI	9(18.4%)	26(53.1%)	14(28.6%)
Middle MAI	11(22.4%)	15(30.6%)	23(46.9%)

Low MAI scores were concentrated in the low achievement category (53.1%) and least represented among high achievers (18.4%). The Middle MAI group showed the most balanced distribution, with the highest proportion falling into the medium achievement category (46.9%).

This pattern demonstrates a clear positive association between metacognitive awareness and academic performance, with higher levels of metacognitive awareness strongly predicting superior academic outcomes.

DISCUSSION

Present study investigated the relationship between Metacognitive Awareness Inventory (MAI) scores and academic performance among phase-1 medical students, with comprehensive analysis of total MAI scores and subscale components. The strongest positive correlation was observed between theory examination scores and total MAI scores ($r = 0.408$, $p < 0.001$), indicating a statistically significant and practically meaningful association between overall metacognitive awareness and academic achievement.

A moderate positive correlation was identified between regulation of cognition subscale scores and academic performance, suggesting that students' ability to monitor and adjust their learning strategies contributes significantly to academic success. The conditional knowledge subscale demonstrated a weak-to-moderate positive correlation with theory marks, indicating that students' understanding of when and why to apply specific learning strategies has a modest but measurable impact on academic outcomes. Knowledge of cognition subscale scores also showed positive correlation with academic performance, reflecting the beneficial effect of cognitive self-awareness on learning outcomes.

These findings align with a comparable investigation by Shah et al who conducted a study among 64 students at Trinity Medical Sciences University, which similarly reported positive correlations between total MAI scores and final physiology course performance, as well as significant associations with knowledge of cognition and regulation of cognition subscales. The mean MAI score in Shah et al.'s study (38.3 ± 7.0) closely approximated the mean observed in the present investigation (37.03 ± 6.05), supporting the consistency of metacognitive awareness levels across similar populations. Weaker correlations were observed with declarative knowledge, implementation strategies, debugging strategies, and evaluation subscales in both studies. The present study demonstrated particularly weak associations with declarative knowledge, debugging strategies, and information management strategies, consistent with Shah et al.'s findings [11].

Analysis of MAI score distribution across academic achievement categories revealed that students with high MAI scores were predominantly represented in the high-achiever category, followed by medium achievers. Conversely, students with low MAI scores were disproportionately represented in the low-achiever category. This distribution pattern corroborates the findings reported by Shah et al., who conducted similar comparative analysis between academic performance categories and individual MAI subscale scores [11]. Tran and colleagues conducted a comprehensive investigation examining the relationship between metacognitive awareness and academic performance in 202 undergraduate students at Vietnam Military Medical University. Their findings demonstrated a total MAI median score of 0.8 (classified as high metacognitive awareness), with knowledge of cognition subscale scoring 0.7 and regulation of cognition subscale 0.8, respectively. A statistically significant difference was observed between the two subscales, with regulation of cognition scores exceeding knowledge of cognition scores (0.8 vs 0.7, respectively, $p < 0.05$). Students achieving total MAI scores above 0.8 demonstrated significantly superior academic performance compared to their lower-scoring counterparts, establishing a positive correlation between metacognitive awareness and academic achievement. The current investigation yielded a total MAI median score of 0.71, with knowledge and regulation of knowledge of 0.68 and 0.72. Both studies consistently demonstrated that regulation of cognition scores exceeded knowledge of cognition scores, suggesting a universal pattern where students possess stronger metacognitive regulatory skills than declarative metacognitive knowledge. The present study's findings align with Tran et al.'s conclusion that higher MAI scores correlate with improved academic performance, reinforcing the predictive validity of metacognitive awareness for educational outcomes but recorded lower overall metacognitive awareness levels (median total MAI: 0.71 vs 0.8) which can be attributed to population characteristics (different medical education systems),cultural factors influencing metacognitive development and methodological variations in MAI administration or scoring [12].

Pallavi and colleagues evaluated metacognitive awareness using the MAI in 86 first-year MBBS students. The overall metacognitive awareness was classified as average, with most participants (n=70, 81%) achieving scores in the 50-80% range. The mean total MAI score was 33.18. The two primary subscales knowledge and regulation of cognition demonstrated a mean score of 10.98 and 22.55 within average category. The participants distribution across MAI performance categories demonstrated 11(12.8%) students in low and only 5(5.8%) students in high categories [13].

The current investigation examined MAI scores in a comparable population and revealed notably different distribution patterns with Average MAI group of 49 students with mean total score of 37.1, Knowledge of Cognition with Mean of 12.22 and Regulation of Cognition with Mean of25.51. Out of 138 students 49 students were in low MAI group and 40 were in high MAI group. The subscale means scores between studies showed reasonable concordance, with both investigations yielding average-range metacognitive awareness scores for knowledge and regulation of cognition. The most notable divergence between studies lies in the distribution of high-performing students. While Pallavi et al. identified only 5.8% of students in the high MAI category, the present study found a substantially higher proportion of high achievers (40 students, representing a much larger percentage of the sample). This suggests that participants in the current study demonstrated superior metacognitive awareness and strategic learning approaches compared to the reference population. The increased proportion of high MAI scorers in the present study indicates that a greater number of students possessed well-developed metacognitive skills, suggesting enhanced self-awareness of their learning processes and more sophisticated regulatory strategies for academic performance optimization [13].

Hassan et al. conducted a significant investigation involving 84 undergraduate clinical-phase medical students, revealing important findings with strong positive correlation between total MAI scores and both knowledge and regulation of cognition subscales, a contrary finding of poor correlation between MAI scores and actual achievement score, the authors approached a novel method of comparing student self-estimated post-examination scores with corresponding MAI scores providing insights into metacognitive calibration accuracy. The poor MAI-achievement correlation in the above study in contrasts to present study highlights the complexity of metacognitive-performance relationships and suggests potential moderating variables like educational phase of the students, institutional culture, context, methods of assessment [14].

Hong et al conducted a study on correlation between metacognitive awareness and academic performance at the beginning and the end of academic year. They identified a strong correlation between the dimensions of metacognition but found a moderate correlation between the knowledge and regulation of metacognition with academic outcomes similar to the present study [15]. Sternberg referred to executive processes of the brain as meta components which include planning, evaluating and critical thinking and problem-solving activities in his triarchic theory of intelligence [16]. All these meta components are essential for learning process and emphasised on the ability to appropriately allocate cognitive resources which include deciding how and when a given task should be accomplished.

The Metacognitive Awareness Inventory (MAI) has been extensively validated and implemented across diverse educational contexts [17,18] with substantial research conducted at the secondary school level and various higher education disciplines. However, a notable research gap exists in medical education, where fewer investigations have examined the relationship between metacognitive awareness and academic performance in medical students.

The study's results support the integration of explicit metacognitive skill development into medical education curricula. Educational interventions focusing on enhancing students' regulatory capabilities—including planning, comprehension monitoring, and strategy evaluation—may significantly improve learning outcomes. These findings have important implications for medical educators seeking to foster self-directed learning competencies essential for lifelong professional development. Future research should explore longitudinal relationships between metacognitive awareness and clinical performance, while investigating the effectiveness of targeted interventions designed to enhance metacognitive skills in medical education contexts.

Contemporary research has adopted multidimensional assessment strategies, incorporating the MAI alongside complementary psychometric instruments to provide comprehensive evaluation of learning processes. Some of the Validated Concurrent Scales include Achievement Goals for Work Domain (AGWD) which assesses motivational orientations and learning drive [19,22], Self-Regulatory Learning Microanalytic Assessment Scale which evaluates specific self-regulation behaviour's [20], Self-Regulated Learning Perception Scale (SRLPS) that measures perceived self-regulatory competence [21], Goals Inventory Scale in Medical Education which emphasises on domain-specific assessment for medical learning contexts [22]. Saba et al administered the metacognitive awareness of reading strategies inventory (MARSI) to investigate the correlation between academic achievement and metacognitive awareness, which included three dimensions of metacognition (GLOB, SUB AND PROB) [23]. This multi-instrument approach underscores the recognized importance of metacognitive awareness as a foundational component of effective medical education and professional development.

CONCLUSION

This investigation establishes a significant positive correlation between metacognitive awareness and academic performance among first-year medical students, with total MAI scores demonstrating the strongest predictive relationship ($r = 0.408$, $p < 0.001$). The findings reveal that regulation of cognition emerges as the most critical component, serving as the sole statistically significant predictor of academic achievement in multivariate analysis. Students with higher metacognitive awareness, particularly those skilled in monitoring and adjusting their learning strategies, consistently demonstrate superior academic outcomes.

Author Contributions

Swathi Poornima Chandaka: Data collection, data analysis, statistical analysis, and part of the research writing.

Shivasakthy Manivasakan: Data interpretation and research writing.

Conflicts of Interests: None

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