ORIGINAL ARTICLE

Biochemistry as a predictor of academic performance in Digestive Physiology in medical students

La bioquímica como predictor del rendimiento académico en Fisiología Digestiva en estudiantes de Medicina

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ABSTRACT

Background: Basic biomedical sciences integrate molecular mechanisms with organic functioning in medical education.

Objective: to determine the value of biochemistry knowledge as a predictor of academic performance in Digestive Physiology in medical students.

Methods: a prospective longitudinal study with an analytical-correlational approach was carried out at the Puerto Padre Medical Sciences Branch, Las Tunas, during the 2024-2025 academic year. The population included the 42 second-year medical students. Theoretical methods (analytical-synthetic, historical-logical, inductive-deductive) and empirical methods (diagnostic test, questionnaire, and documentary analysis) were used. Data were processed with descriptive and inferential statistics (Student's t-test, Spearman's correlation, Kruskal Wallis, multiple linear regression).

Results: significant correlations were identified between liking for biochemistry (p=0.959; p<0.001), mastery of Molecular Biology (p=0.696; p<0.001), mastery of Metabolism and Nutrition (p=0.760; p<0.001) and academic performance. Linear regression showed that mastery of Metabolism and Nutrition had a strong predictive effect (β=0.566; *p*<0.001) and mastery of Molecular Biology had a moderate but relevant effect (β=0.332; *p*<0.006).

Conclusions: mastery of basic biochemistry specifically in Molecular Biology, and Metabolism and Nutrition directly influenced learning in Digestive Physiology, thus validating its predictive role.

MeSH: forecasting; education, medical, undergraduate; educational measurement; learning; education, medical

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RESUMEN

Fundamento: las ciencias básicas biomédicas integran mecanismos moleculares con el funcionamiento orgánico en la formación médica.

Objetivo: determinar el valor de los conocimientos sobre bioquímica como predictor del rendimiento académico en Fisiología Digestiva en estudiantes de Medicina.

Métodos: se realizó un estudio longitudinal prospectivo con enfoque analítico-correlacional en la Filial de Ciencias Médicas de Puerto Padre, Las Tunas, durante el curso 2024-2025. La población incluyó a los 42 estudiantes de segundo año de Medicina. Se emplearon métodos teóricos (analítico-sintético, histórico-lógico, inductivo-deductivo) y empíricos (examen diagnóstico, cuestionario, análisis documental). Los datos se procesaron con estadística descriptiva e inferencial (t de Student, correlación de Spearman, Kruskal Wallis, regresión lineal múltiple).

Resultados: se identificaron correlaciones significativas entre agrado por la bioquímica (*p*=0,959; p<0,001), dominio de Biología Molecular (*p*=0,696; p<0,001), dominio de Metabolismo y Nutrición (*p*=0,760; p<0,001) y rendimiento académico. La regresión lineal mostró que el dominio de Metabolismo y Nutrición tuvo un efecto predictor fuerte (β=0,566; *p*<0,001) y el de Biología Molecular un efecto moderado pero relevante (β =0,332; *p*<0,006).

Conclusiones: el dominio de la bioquímica básica específicamente en Biología Molecular, y Metabolismo y Nutrición influyó directamente en el aprendizaje de Fisiología Digestiva, por lo cual valida su rol predictivo.

DeCS: predicción; educación de pregrado en Medicina; evaluación educacional; aprendizaje; educación médica

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INTRODUCTION

Higher education must train highly qualified human resources, endowed with ethical principles and values that enable them to assume a real and consistent social commitment to face the global problems of their time, in response to prevailing social demands.[1]

Universities have historically evolved by modifying their roles, functions, and characteristics in continuous adaptation to different societal circumstances, not exempt from conflicts and resistance. Over time, their functions and tasks have increased and diversified, as referred to by De Armas, cited by Agüero Figueredo *et al.*[2]

In Cuban medical sciences universities, professional training requires educational guidance that ensures a contextualized character, a systemic and dynamic approach as a curricular prioritization of the professional problems to be solved by the graduate.[3]

Since the early years of the Revolution, academic curricula in the Medicine degree have been reformed with the aim of training a highly qualified medical professional capable of solving health problems in Cuba and the rest of the world.

The "Plan de estudios E" (Study Plan E) promotes developmental learning with active student participation and a high workload of education in the workplace; at the same time, it maintains the broad-profile model. The main integrating discipline does not respond to a specific science, but to the object of work of the profession; it requires a transition from the disciplinary to the interdisciplinary paradigm, both in its vertical and horizontal coordination with other disciplines and subjects of the aforementioned plan.

Among its disciplines, the Biological Bases of Medicine stands out, responsible for laying the methodological and content foundations so that in later years the student can update, expand, and deepen their knowledge of basic biomedical sciences under teacher guidance. This responds to the demands of the main integrating discipline for learning clinical practice, in a process of basic-clinical and epidemiological integration that progressively shapes professional modes of action.

The subject Cardiovascular, Respiratory, Digestive and Renal Systems, belonging to the Biological Bases of Medicine discipline, studies these systems in an interrelated manner. It builds upon previous subjects covering the molecular, cellular, tissue, and regulatory systems (nervous and endocrine system) levels. This stepwise approach guarantees a gradual acquisition of knowledge and skills, which will allow applying these bases in content analysis and orientation towards individual study.[4] However, this subject, within that discipline, has the lowest pass rate at the Puerto Padre Medical Sciences Branch, Las Tunas.

Various research conducted by the teaching staff has analyzed this situation, identifying influential variables and proposing strategies to improve results.

A recurring pattern is the low pass rate in the digestive system topic, especially in content related to its microscopic and macroscopic characteristics. Although performance in the

Digestive Physiology subject has shown an upward trend, difficulties persist in the section on Digestion and absorption of nutrients.

During teaching activities, particularly workshops and seminars, professors have detected deficiencies in students regarding the molecular knowledge acquired in Molecular Biology, and Metabolism and Nutrition, which is essential for understanding these processes. Therefore, this research aims to determine the value of biochemistry knowledge as a predictor of academic performance in Digestive Physiology in medical students.

METHODS

A prospective longitudinal study with an analytical-correlational approach was carried out at the Puerto Padre Medical Sciences Branch, Las Tunas, during the 2024-2025 academic year. The population consisted of the 42 students enrolled in the second year of the Medicine degree.

Theoretical methods were used:

- Analytical-synthetic: to break down the predictor variables of academic performance and synthesize their relationship with learning in Digestive Physiology.
- Historical-logical: to analyze the historical influence of biochemistry teaching on the understanding of Digestive Physiology topics.
- Inductive-deductive: to generalize predictive patterns from the observed data and contrast them with established pedagogical principles.

The following variables were studied:

- Academic performance in Digestive Physiology. (Continuous grade obtained in the final evaluative seminar on Processes of digestion and absorption of nutrients).
- Mastery of basic content. (Continuous score on the diagnostic exam for Molecular Biology and Metabolism and Nutrition).

- Overall mastery of biochemistry. (Combination of both subjects, categorized into percentiles (low P33, medium P34-P66, high P67).

In addition to the following sociodemographic and attitudinal variables:

- Sex (nominal, female/male).
- Liking for biochemistry, ordinal (5-point Likert scale).

Empirical methods:

- Diagnostic exam: a written test applied before teaching the Digestive Physiology topic, with 7 multiple-choice items (4 options, 1 correct), 3 on Molecular Biology and 4 on Metabolism and Nutrition, on essential content for the section on Digestion and absorption of nutrients and validated by three biochemistry experts; administered with a duration of 45 minutes in a controlled environment.
- Questionnaire with questions based on a 5-point Likert scale to measure liking for biochemistry immediately after the diagnostic exam.
- Documentary analysis: review of the analytical programs, schedules of the Molecular Biology, Metabolism and Nutrition, CARDIREN subjects, and the evaluation records to collect the grades obtained by students in the Digestive Physiology seminar.

Mathematical-statistical methods:

- Statistical analyses were performed using Jamovi 2.6.44 statistical software with 95% confidence intervals for all relevant estimates (regression coefficient (β), Spearman's correlation (p), difference in means/medians).
- Descriptive statistics (median, interquartile range [IQR], minimum and maximum) and inferential statistics were used. To compare academic performance in Digestive Physiology according to sex, Student's t-test was applied, after verifying normality
- (Shapiro-Wilk) and homoscedasticity ($p>0.05$). For non-normal variables ($p<0.05$), non-parametric tests were used: Spearman's correlation (to evaluate the relationship between performance and liking for biochemistry, mastery of Molecular Biology

content, and Metabolism and Nutrition content) and Kruskal Wallis (to compare performance according to levels of liking and overall mastery).

- Additionally, multiple linear regression was performed to analyze the combined effect of these domains as predictors of performance. The study complied with institutional ethical guidelines, including informed consent.

RESULTS AND DISCUSSION

Table 1 shows the correlations between prior knowledge domains and academic performance in Digestive Physiology. Spearman's correlation analyses showed highly significant associations between mastery of basic Molecular Biology content (p=0.696; p<0.001) and academic performance in the Digestive Physiology topic, and between mastery of basic Metabolism and Nutrition content (p=0.760; p<0.001) and the same performance. Furthermore, a significant correlation was found between both domains (p=0.609; p<0.001), suggesting that prior knowledge from these subjects is interrelated and contributes to academic success in the Digestive Physiology topic.

Table 1. Correlations between academic performance in digestive physiology (process of digestion and absorption of nutrients) and prior knowledge domains. Puerto Padre Medical Sciences Branch, Las Tunas. Academic year 2024-2025

Correlated variables	*P*	*p*
Mastery of Molecular Biology vs. Performance	0,696*	<0,001
Mastery of Metabolism and Nutrition vs. Performance	0,760*	<0,001
Mastery of Molecular Biology vs. Mastery of Metabolism and Nutrition	0,609*	<0,001

Source: Diagnostic exam and evaluation record.

Students with intrinsic motivation towards a subject or topic tend to learn and perform better than those who study out of obligation.[5] This principle aligns with the observations of

Basulto González[6] regarding the global rejection of sciences, attributed to rote and decontextualized content and teaching methods that lack meaningfulness.

In biochemistry, it is crucial to highlight the social nature of its content (molecular and cellular) linked to its practical utility, impact on sustainable development, applications in services, industry, and environmental conservation.

The authors add that biochemistry requires mentally manipulating invisible molecular structures and metabolic pathways, without tangible anatomical references or immediate clinical correlations; the gap between its abstract complexity and its real clinical application is very wide for medical students. They generally underestimate its usefulness until later years when they encounter subjects related to nutrition and pharmacology, among others. Approaches are suggested that link each concept with medical applications from the first day, along with visual and interactive tools to reduce abstraction and demonstrate that mastery of biochemistry is not an academic requirement, but an essential diagnostic and therapeutic tool in real-world medicine.

In line with this perspective, Hernández Guerra *et al.*[7] propose using health problems as a viable alternative to promote basic-clinical integration in learning Basic Biomedical Sciences, as it allows students to develop logical-intellectual and professional skills.

Academic performance, in Table 2, showed an upward trend as liking for biochemistry increased ($p=0.959$; $p<0.001$). All students with no liking (level 1) failed (median=2.00; IQR=0.00), while those with strong liking (level 5) achieved the highest grades (median=4.75; IQR=0.36). The differences between groups were statistically significant (H=38.3; $p<0.001$; $\varepsilon2=0.934$) and post-hoc contrasts (Dunn's test) confirmed these differences ($p<0.05$), except between levels 3 and 5 ($p=0.067$).

Table 2. Academic performance in Digestive Physiology (process of digestion and absorption of nutrients) according to liking for biochemistry. Puerto Padre Medical Sciences Branch, Las Tunas. Academic year 2024-2025

Liking (Likert)	No.	Median (IQR)	Comparisons (Dunn)	*p*
1	14	2,00 (0,00)	3, 4, 5	p<0,001***
2	7	3,30 (1,30)	1, 5	0,019*
3	3	3,80 (0,10)	1, 5	p<0,001***
4	6	4,10 (0,30)	1, 5	0,007**
5	12	4,75 (0,36)	1, 2, 4	p<0,001***

Source: Questionnaire and evaluation record.

A study conducted by Torres Zapata *et al.*,[8] "Performance and school climate in the biochemistry learning unit", at a university in Mexico, analyzed the relationship between school climate and academic performance in the biochemistry learning unit, without finding a statistically significant association between liking for the subject and academic performance. However, these results differ from those achieved in the current research where a positive relationship between both variables was indeed evidenced.

These observations are consistent with those reported by Villazana Romero[9] at the Faculty of Human Medicine (cycles V and VI) of a university in Huancayo, Peru.

There were no statistically significant differences in satisfactory academic performance in Digestive Physiology between women and men ($t(23)=0.743$; $p=0.461$) with a small effect size ($d=0.299$) and a 95% confidence interval for the mean difference that included zero [-0.32; 0.68], which confirms the absence of relevant differences. The assumptions of normality and homogeneity of variances were met, as observed in Table 3.

Table 3. Satisfactory academic performance in Digestive Physiology (Process of digestion and absorption of nutrients) according to sex. Puerto Padre Medical Sciences Branch, Las Tunas. Academic year 2024-2025

Variable	Female	Male	P	D
Academic Performance Mean ± SD	4,31±0,601	4,13±0,602	0,461	0,299

Source: Questionnaire and evaluation record.

This study did not find significant differences in academic performance in Digestive Physiology between female and male students. Although the studies cited below do not specifically address the relationship between biochemistry and physiology, they are pertinent for contextualizing the possible role of sex as a variable in academic performance in health sciences. Thus, the result coincides with research such as that of Rodríguez Núñez et al., [10] who also found no differences by sex in the performance of Nursing students. However, it contrasts with other works, such as that of Sosa Mora,[11] who reported better overall academic performance in female medical students, attributed to psycho-educational factors.

The authors infer that sex does not determine academic performance by itself, but rather in interaction with contextual factors. In the case of teaching Digestive Physiology, specific competencies are evaluated where pedagogical strategies and individual characteristics - more than sex- are considered determinants; interactions that should be explored in future research.

Table 4 presents the analysis of academic performance according to the overall mastery of biochemistry (combination of Molecular Biology and Metabolism and Nutrition) categorized into High, Medium, and Low levels using percentiles. The Kruskal Wallis analysis revealed statistically significant overall differences ($X^2(2)=27.8$ *p*<0.001) with a large effect size ($\varepsilon^2=0.677$). Post-hoc comparisons (DSCF) showed that the High group significantly outperformed the Medium and Low groups (both *p*<0.001), but no significant differences were observed between the latter two (*p*=0.274).

Table 4. Academic performance in Digestive Physiology (Process of digestion and absorption of nutrients) as a function of overall mastery of biochemistry. Puerto Padre Medical Sciences Branch, Las Tunas. Academic year 2024-2025

Statistic	High	Medium	Low
N	14	14	14
Medium (IQR)	4,70 (4,90-4,50)	2,80 (3,95-2,00)	3,80 (3,20-2,00)
Rank (Min-Max)	4,30-5,00	2,00-4,60	2,00-3,80
Comparisons	-	vs Alto: < 0,001	vs Alto: < 0,001
		vs Bajo: 0,274	vs Medio: 0,274

Source: Diagnostic exam and evaluation record.

The study of biochemistry is essential in Medicine: it provides basic knowledge to understand that health depends on the harmonious balance of the biochemical reactions that occur in the body, while disease arises from abnormalities in biomolecules, reactions, or biochemical processes;[12] therefore, the subjects Molecular Biology, and Metabolism and Nutrition are actually pillars for understanding physiological processes. In the section on the digestion of macronutrients and its impact on human nutrition, the contribution of both subjects is significant.

Molecular Biology studies the molecular components of the human being, highlighting the relationship between their structure, properties, functions, and their importance for the body. It ranges from simple biomolecules (monosaccharides, amino acids, sterols, and fatty acids) to macromolecules.

Metabolism and Nutrition studies the phases of incorporation of compounds into the body from ingestion, addressing characteristics of digestion, organs involved, key enzymes, final products, and their absorption. The topic Molecular bases of human nutrition integrates acquired knowledge (structure, function, metabolism) to delve deeper into the quantitative/qualitative needs of carbohydrates, lipids, and proteins, based on a balanced diet and the relationship between malnutrition and diseases.

Table 5 presents the results of the multiple linear regression analysis to predict academic performance in Digestive Physiology (process of digestion and absorption of nutrients). Both predictors showed significant contributions: mastery of basic Metabolism and Nutrition content presented a strong effect (β=0.57; *p*<0.001) and mastery of Molecular Biology demonstrated a moderate but relevant effect (β=0.33; *p*<0.006). The model explained 61.8% of the variance in academic performance (*R²=0.62*), showing significant predictive capacity. The assumptions of normality, homoscedasticity, and absence of collinearity were satisfactorily verified.

Table 5. Results of the multiple linear regression to predict academic performance in Digestive Physiology (Process of digestion and absorption of nutrients). Puerto Padre Medical Sciences Branch, Las Tunas. Academic year 2024-2025

Predictor	B	95% CI	β	P	VIF
Constant	-0,50	(-1,51 ; 0,52)	-	0,328	-
Molecular Biology	0,41	(0,12 ; 0,69)	0,33	0,006	1,33
Metabolism and Nutrition	0,73	(0,43 ; 1,02)	0,57	< 0,001	1,33

B: Unstandardized coefficient, β: Standardized coefficient, VIF: Variance inflation factor, $R^2=0.62$, Adjusted $R^2=0.60$, $F(2.39)=31.6$; $p< 0.001$.
Source: Diagnostic exam and evaluation record.

Mastery of basic content in Molecular Biology, and Metabolism and Nutrition showed a significant contribution to academic performance in the topic of digestive processes.

This relationship has been previously established in the article "Factors influencing dropout and failure rates among students in a university Mathematics course"[13] where deficiency in prior knowledge was identified as a key factor in academic failure and dropout problems. A similar case was documented at the University of Informatics Sciences in Havana, where researchers demonstrated that deficiencies in the subjects Introduction to Programming and Programming I have a decisive impact on subsequent performance in Programming II and III. [14]

Although other subjects are involved in the mentioned studies, it confirms that when content is organized sequentially, students can build new learning on solid foundations, thus avoiding the accumulation of conceptual gaps.

The transition between the first and second year of Medicine requires a solid integration between basic sciences and their clinical application. Biochemistry knowledge provides students with analytical capacity to integrate new scientific advances, as well as the fundamental basis for subsequently understanding content in microbiology, immunology, genetics, pharmacology, and physiology.[15]

Mastery of Digestive Physiology, particularly the processes of digestion and absorption of nutrients, is relevant in the training of health professionals. Adequate food and nutrition are basic elements for maintaining health, while their alterations represent key etiological factors in various pathologies. Given this reality, it is imperative that the physiological sciences faculty optimize their academic results through coordinated work in other subjects, for example, Health Promotion and Disease Prevention.

In relation to this aspect, Regalado Fernández *et al.*[16] have evaluated the presence of food and nutrition science content in the first two years of the Medical degree, addressing problems such as: irregular and insufficient distribution of this content, fragmented treatment limited to certain subjects, and lack of integration between key topics such as energy metabolism and digestive system function.

To address this problem, it is suggested to implement permanent monitoring in discipline meetings, departmental meetings, and subject collectives, with constant communication between professors of Molecular Biology, and Metabolism and Nutrition with those of Physiology. This collaborative work should focus on precisely defining the basic content required for the section related to digestion, and unifying methodological teaching approaches. Only in this way will the necessary articulation be achieved for this knowledge to positively impact student training, as established by the Biological Bases of Medicine discipline.

Scientific contribution

The research provides quantitative evidence and predictive analysis that validates the influence of basic biochemistry knowledge on academic performance in Digestive Physiology in Medicine. The results not only explain the recurrent difficulties in the topic but also demonstrate the need for vertical articulation of content between the first and second years. The positive correlation obtained offers a scientific basis for designing early pedagogical interventions that improve the retention of key knowledge.

CONCLUSIONS

The value of biochemistry knowledge as a predictor of academic performance in Digestive Physiology was determined. Performance in basic biochemistry, assessed in Molecular Biology, and Metabolism and Nutrition, directly influenced the understanding of Digestive Physiology, especially in the section on Digestion and absorption of nutrients, in medical students.

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Conflict of interest statement

The authors declare no conflict of interest.

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