International Archives of Medical Sciences & Public Health

E-ISSN : 2798-5172; P-ISSN : 2798-5276X
Volume 7, Number 1, 2026
DOI: 10.53806/iamsph.v7i1.1449
Page: 77–84

ANATOMY AND PHYSIOLOGY PERFORMANCE AS A PREDICTOR OF BASIC NURSING SKILLS COMPETENCY AMONG UNDERGRADUATE NURSING STUDENTS

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Article Info

Article history:
Received : March 10, 2026
Revised : May 5, 2026
Accepted : May 15, 2026

Keywords:
Academic predictors;
Anatomy and physiology;
Competency-based education;
Nursing education;
Objective structured clinical examination;
Patient safety

ABSTRACT

Anatomy and Physiology (A&P) is considered the bioscientific foundation of nursing practice, yet evidence linking A&P academic performance to objectively measured clinical skill competency remains limited, particularly within Indone-sian undergraduate nursing programmes. This study examined the association between A&P academic performance and basic nursing skills competency among undergraduate nursing students in Indo-nesia. A retrospective correlational design was employed using administrative records from 178 Bachelor of Science in Nursing (BSN) students at Universitas Advent Indonesia, Bandung. A&P performance was operationalised as course grade (4.0 scale) and examination score (0–100%). Basic nursing skills competency was assessed via a standardised 10-station Objective Structured Clinical Exami-nation (OSCE). Pearson product-moment correlations and simultaneous-entry multiple linear regression were used for analysis. Both A&P indicators showed moderate, statistically significant positive correla-tions with OSCE performance (course grade: $r = 0.44$; examination score: $r = 0.47$; both $p < 0.001$). The regression model was statistically significant [$F(3, 174) = 18.32, p < 0.001; R^2 = 0.24$, adjusted $R^2 = 0.23$]. A&P course grade ($\beta = 0.38, p < 0.001$) and examination score ($\beta = 0.31, p = 0.001$) were independent predictors of OSCE performance, whereas overall GPA was not a unique pre-dictor after controlling for A&P indicators ($\beta = 0.12, p = 0.182$).

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1. INTRODUCTION

Competency in basic nursing skills is foundational to patient safety and quality of care [1]. Anatomy and Physiology (A&P) is widely recognised as the bioscientific cornerstone of undergraduate nursing curricula, providing the conceptual framework for clinical reasoning, patient assessment, and the safe performance of nursing procedures [2], [3]. Students with stronger bioscience knowledge demonstrate better performance in clinical courses and clinical decision-making [4], [5]; yet A&P remains one of the most challenging subjects in nursing education, characterised by complex terminology, abstract concepts, and extensive content that students frequently struggle to translate into practice [6], [7]. Pedagogical innovations including simulation, active learning, blended learning, and case-based teaching have sought to bridge this theory–practice gap by enhancing the clinical relevance of A&P instruction [8], [9]; however, variability in how students translate A&P achievement into clinical skill performance persists [10]. In low- and middle-income settings, where workforce shortages amplify the consequences of inadequate graduate readiness, this issue carries direct implications for patient safety and healthcare service quality [1],[3].

Existing literature has focused predominantly on broad academic outcomes such as cumulative GPA and programme completion rates [11], with relatively few studies directly examining A&P performance as a predictor of objectively measured clinical competency assessed through standardised instruments such as Objective Structured Clinical Examinations (OSCEs) [12]. This evidence gap limits the precision with which educators can identify students at early risk of clinical underperformance and weakens the empirical basis for competency-based curriculum reform. To our knowledge, no study has explicitly modelled the predictive contribution of A&P performance to OSCE outcomes within Indonesian BSN programmes. The present study addresses this gap by examining the association between A&P academic performance disaggregated into course grade and examination score and basic nursing skills competency as measured by a standardised 10-station OSCE, using retrospective administrative records from 178 BSN students at Universitas Advent Indonesia (UNAI), Bandung, Indonesia. The study additionally benchmarks A&P performance against overall GPA to clarify whether subject-specific bioscience achievement contributes unique predictive value beyond general academic ability.

2. RESEARCH METHOD

2.1 Study Design

This study employed a quantitative retrospective correlational design. All variables of interest A&P course grades, A&P examination scores, overall GPA, and OSCE total scores were generated within the institution's routine academic assessment system, making secondary-data analysis methodologically appropriate for this research question [13]. The correlational framework was selected to estimate the strength and direction of association between A&P performance and OSCE outcomes, consistent with the study's non-causal, directional objectives. The study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines [14].

2.2 Setting

The study was conducted at the Faculty of Nursing, Universitas Advent Indonesia (UNAI), Bandung, West Java, Indonesia a private, faith-based institution offering a four-year BSN programme. A&P is delivered in the first academic year as a two-semester sequence integrating lecture, laboratory, and case-based components. Basic nursing skills are taught and assessed in the second and third academic years, with a structured OSCE administered in dedicated skills laboratories under standardised conditions.

2.3 Participants and Sampling

The accessible population comprised all BSN students who had completed both A&P courses and the basic nursing skills OSCE between academic years 2024 and 2026. Convenience sampling was applied to the full eligible cohort within this period. This approach was adopted because the study relied on retrospective administrative datasets generated by the institution's routine assessment system, which constrained recruitment to records already produced rather than a probability-based sample. We acknowledge that convenience sampling may limit external validity and introduce potential selection bias, particularly toward students who completed all required assessments within the observation window; this limitation is revisited in the Limitations section. Inclusion criteria were: (1) enrolment in the UNAI BSN programme; (2) successful completion of required A&P coursework and end-of-course examinations; and (3) availability of complete records for both A&P performance and the OSCE total score. Exclusion criteria were: (1) incomplete A&P records (e.g., audited courses, withdrawn enrolments); (2) missing

OSCE total score; and (3) academic transfer from an institution with non-comparable assessment criteria. The entire eligible pool within the specified academic years was screened to minimise selection bias.

Within the curricular structure, A&P coursework and end-of-course examinations were completed in the first academic year, whereas the basic nursing skills OSCE was administered in the second and third academic years. This fixed temporal sequence—A&P performance preceding OSCE assessment—reinforces the directional, although explicitly non-causal, framework of the study and is consistent with a predictive (rather than concurrent) model of academic performance.

2.4 Sample Size Justification and Participant Flow

Sample size was determined a priori using GPower 3.1 for multiple linear regression with three predictors ($\alpha = 0.05$, power= 0.80, medium effect size $f^2 = 0.15$). The minimum required sample was 77 records; the target was set at 200 to allow for attrition and conservative robustness. Of 200 eligible records identified, 22 (11.0%) were excluded prior to analysis: incomplete A&P examination records ($n = 10$), missing OSCE total score ($n = 8$), and inter-institution transfer with non-comparable assessment criteria ($n = 4$). The final analytical sample comprised $n = 178$ records (89.0% retention rate), more than double the a priori minimum. All 178 records contributed to every analytic stage; no records were lost between stages. A post-hoc sensitivity analysis confirmed that the observed effect size ($f^2 = 0.32$) yielded statistical power exceeding 0.999 at $n = 178$.

2.5 Variables and Measurement (Revised OSCE Rater Blinding Added)

The independent variables, dependent variable, and OSCE operational definitions are unchanged from the original submission. The following statement has been added to address rater blinding:

Rater Blinding Statement (added): OSCE raters had access to student names and cohort identifiers for administrative scheduling purposes but were not provided with students' A&P course grades, A&P examination scores, or overall GPA prior to or during the scoring process. Raters were instructed not to consult academic records during the examination period. This procedural separation constituted functional outcome blinding with respect to the academic performance data under study, although full assessor blinding cannot be claimed given the single-institution, known-cohort context. This limitation is addressed in the Limitations section.

2.6 Instrument Validity, Reliability, and Standardisation (Condensed)

All measurement instruments form part of the institution's standing assessment system. Content validity of A&P examinations and OSCE checklists was established through expert-panel review by faculty with five or more years of teaching experience, with blueprinting against national BSN competency standards. Internal consistency reliability was satisfactory for A&P examinations (Cronbach's $\alpha = 0.84$–0.87) and OSCE checklists ($\alpha = 0.81$–0.85). Inter-rater reliability for the OSCE was excellent (two-way random-effects ICC for absolute agreement: 0.89, 95% CI $[0.85, 0.92]$, $n = 6$ raters). Raters underwent structured calibration before each examination round; discrepancies exceeding five points between paired raters were reconciled by an independent third rater. Standardisation was maintained through written examiner manuals, controlled checklist versioning, and post-round reliability monitoring. Any inter-cohort checklist revisions were restricted to non-substantive clarifications reviewed by the assessment committee against the original blueprint to ensure comparability of construct coverage and item difficulty across pooled cohorts. Full details of the rater calibration protocol, checklist version history, and post-round reliability statistics are available as Supplementary Material S1.

2.7 Data Handling and Missing Data (Condensed)

De-identified data were extracted from the institutional academic records system by an authorised registrar; personal identifiers were replaced by sequential study codes prior to release to the research team. Data cleaning included range checks, duplicate-record screening, plausibility checks, and double-entry verification of a random 20% subsample (transcription discrepancy rate $< 0.5\%$). Within the retained sample of n = 178, missing values on any single variable were less than 1%. Missingness did not differ systematically by demographic group or A&P performance quartile, consistent with a missing-at-random pattern; complete-case analysis was applied without imputation. A detailed data-cleaning log is available as Supplementary Material S2.

2.8 Statistical Analysis (Minor Condensation)

All analyses were conducted in IBM SPSS Statistics version 29. Descriptive statistics summarised demographic and study variables. Pearson product-moment correlations with 95% confidence intervals (via Fisher's z-transformation) examined bivariate relationships. Simultaneous-entry multiple linear regression estimated the unique predictive contribution of A&P course grade, A&P examination score, and overall GPA to OSCE total score; standardised (β) and unstandardised (B) coefficients are reported with 95% CIs and exact p-values [15],[16]. Regression assumptions were verified prior to interpretation—including normality (Shapiro–Wilk; Q–Q plots), linearity (partial regression plots), homoscedasticity (Breusch–Pagan, $p = 0.21$; residual plots), independence (Durbin–Watson = 1.92), and multicollinearity (VIF range: 1.6–2.3; tolerance: 0.43–0.62)—and all were met. Influential cases were screened with Cook's distance (maximum < 0.10). Full assumption-test outputs are provided in Supplementary Material S3. Statistical significance was set at $p < 0.05$, two-tailed.

3. RESULT AND ANALYSIS

3.1 Sample Characteristics (Unchanged)

The final analytical sample comprised 178 BSN students (89.0% of 200 eligible records). Demographic characteristics are presented in Table 1 and descriptive statistics for study variables in Table 2.

Table 1: Demographic Characteristics of Participants ($n = 178$)

Variable	Frequency (n)	Percentage (%)
Gender		
Male	53	29.8
Female	125	70.2
Age (years)		
18–20	72	40.4
21–23	85	47.8
>23	21	11.8
Entry Qualification		
Science background	133	74.7
Non-science background	45	25.3

Table 2: Descriptive Statistics of Study Variables ($n = 178$)

Variable	Mean ± SD	Min.	Max.
A&P course grade (4.0 scale)	3.10 ± 0.44	2.00	4.00
A&P examination score (%)	78.21 ± 8.54	60.00	95.00
Basic nursing skills score (OSCE, %)	80.95 ± 7.48	65.00	95.00
Overall GPA (4.0 scale)	3.22 ± 0.38	2.30	4.00

3.2 Assumption Testing (Condensed)

All regression assumptions were satisfied prior to inferential analysis. Normality of standardised residuals was supported by non-significant Shapiro–Wilk tests and approximately linear Q–Q plots. Breusch–Pagan testing indicated no evidence of heteroscedasticity ($p = 0.21$). VIF values (1.6–2.3) and tolerance values (0.43–0.62) indicated acceptable multicollinearity. The Durbin–Watson statistic (1.92) supported independence of residuals, and Cook's distance values were all below 0.10. Complete assumption-test outputs are available in Supplementary Material S3.

3.3 Bivariate Associations (Revised)

Pearson correlations are presented in Table 3. Both A&P indicators were moderately and significantly associated with OSCE scores (A&P course grade: $r = 0.44$; A&P examination score: $r = 0.47$; both $p < 0.001$), consistent with medium effect sizes. Overall GPA showed a weaker association with OSCE score ($r = 0.40, p < 0.001$) than

either A&P indicator. Full correlation coefficients, confidence intervals, and significance levels are reported in Table 3.

Table 3: Pearson Correlations Among Study Variables ($n = 178$)

Variable	1	2	3	4
A&P course grade	1			
A&P examination score	0.60** [0.50, 0.69]	1		
Basic nursing skills (OSCE)	0.44** [0.31, 0.55]	0.47** [0.35, 0.58]	1	
Overall GPA	0.56** [0.45, 0.65]	0.53** [0.42, 0.63]	0.40** [0.27, 0.52]	1

Note. $**p < 0.01$ (two-tailed). Values in square brackets are 95% confidence intervals computed via Fisher's z-transformation.

3.4 Multiple Linear Regression (Revised)

The simultaneous-entry regression model was statistically significant ($R^2 = 0.24$, adjusted $R^2 = 0.23$; Cohen's $f^2 = 0.32$, large effect). The full model statistics and individual predictor coefficients are presented in Table 4. As shown, both A&P course grade($\beta = 0.38, p < 0.001$) and A&P examination score ($\beta = 0.31, p = 0.001$) were independent, statistically significant predictors of OSCE performance. Overall GPA did not contribute unique predictive variance when A&P indicators were included in the model ($\beta = 0.12, p = 0.182$). In practical terms, a 0.5-point increase in A&P course grade corresponds to an estimated 3.3-point OSCE gain, and a 5-point increase in A&P examination score corresponds to an estimated 2.0-point gain—shifts representing approximately 0.44 SD and 0.27 SD of OSCE performance, respectively.

Table 4: Multiple Linear Regression Predicting Basic Nursing Skills Competency ($n = 178$)

Predictor	B	SE	95% CI for B	β	95% CI for β	t	p
(Constant)	31.80	6.05	[19.86, 43.74]	—	—	5.26	$< .001$
A&P course grade	6.60	1.70	[3.24, 9.96]	0.38	[0.19, 0.57]	3.88	$< .001$
A&P examination score	0.40	0.12	[0.16, 0.64]	0.31	[0.14, 0.48]	3.50	.001
Overall GPA	2.15	1.60	[−1.01, 5.31]	0.12	[−0.06, 0.30]	1.34	.182

Note. $R = 0.49$; $R^2 = 0.24$; adjusted $R^2 = 0.23$; $F(3, 174) = 18.32, p < 0.001$. Cohen's $f^2 = 0.32$ (large effect). Dependent variable: OSCE total score (%). CI = confidence interval.

3.5 Exploratory Subgroup Observations (Revised — Now Explicitly Non-Inferential)

The following observations are exploratory and non-inferential; they were not subjected to formal hypothesis testing and should be interpreted as hypothesis-generating signals only. Descriptive inspection of OSCE station scores suggested content-aligned patterns: students with stronger cardiovascular and respiratory physiology grades tended to score higher on vital-signs assessment and basic life-support stations, while stronger musculoskeletal anatomy grades were associated with higher patient-mobility station scores. These station-level patterns are reported for descriptive completeness and to inform future station-specific studies adequately powered for inferential analysis.

3.6 Discussion

This retrospective correlational analysis demonstrates that A&P performance is a moderate, statistically significant predictor of basic nursing skills competency as measured by a standardised OSCE. Both A&P course grade and examination score were independent predictors (collectively explaining 24% of OSCE variance), whereas overall GPA did not contribute unique predictive information once A&P indicators were in the model. This pattern indicates that the predictive signal derives from the content-specific alignment between A&P knowledge and the physiological demands of clinical skill performance, rather than from a general academic-ability factor. Even modest improvements in A&P performance—approximately half a grade point or a five-percentage-point examination gain—correspond to educationally meaningful shifts on a standardised clinical assessment, supporting the case for early, targeted intervention among students whose A&P trajectory falls below cohort benchmarks.

Interpretation in Context

The observed correlations ($r = 0.44$–0.47) are consistent with moderate effect sizes reported in recent nursing education research [5] found that integration of A&P into practice is consistently rated as central by undergraduates and registered nurses, with variable effect magnitudes depending on programme context. Manchester and Roberts [17] similarly reported moderate associations between bioscience knowledge and clinical performance in a UK BSN cohort, and [16] documented the persistent gap between A&P knowledge acquisition and clinical translation. The current $R^2 = 0.24$ falls within the range reported in these contemporary studies and aligns with [12] curriculum-transformation findings, in which improvements in A&P instruction propagated into downstream clinical performance. That approximately 76% of OSCE variance remained unexplained is itself informative: it underscores the multi-determined nature of clinical competency. Unmeasured factors including clinical-placement exposure, instructor effects, student motivation, and learning strategies plausibly account for a substantial portion of this residual variance [6, 7, 20], reinforcing the need to study predictors beyond academic transcripts.

Implications for Nursing Education

Three actionable implications follow from these findings. First, A&P performance can serve as an early academic-warning indicator within BSN programmes: students performing below cohort benchmarks on A&P examinations or course grades are, on average, at meaningfully greater risk of OSCE underperformance and should be targeted for timely remediation, including supplemental instruction and peer tutoring [18]. Second, curriculum designers should prioritise vertical integration of A&P with clinical-skills laboratories, as simulation-anchored and case-based A&P teaching that explicitly maps physiological reasoning onto procedural performance is more likely to produce competency gains than decontextualised delivery [8], [9], [19]. Third, A&P performance is best used as one component of a holistic readiness assessment rather than as a standalone gate keeping criterion; it is informative for early identification but does not, on its own, determine clinical readiness.

Broader Significance for Patient Safety and Health-System Context

Beyond curricular applications, these findings are relevant to patient safety and nursing workforce preparation. Basic nursing skills—including vital-signs interpretation, medication administration, infection control, and basic life support—represent procedural pathways through which many preventable clinical errors may be intercepted. Educational strategies that strengthen the A&P–OSCE relationship may therefore plausibly contribute, through proximal curricular mechanisms, to improved bedside practice and healthcare service quality, though causal claims cannot be drawn from the present observational design [1], [5]. In Indonesia and comparable low- and middle-income settings undergoing competency-based education reform, evidence linking subject-specific bioscience achievement to objectively measured clinical performance offers a tractable focus for early academic intervention—a point that warrants further examination in multi-institutional studies.

Limitations

Several limitations qualify interpretation. The retrospective correlational design precludes causal inference; unmeasured common causes—including motivation, prior bioscience exposure, and study habits—may partially inflate the observed associations. The single-institution convenience-sampled design restricts generalisability beyond UNAI's specific BSN programme context; observed effect magnitudes should not be extrapolated uncritically to public, larger, or differently configured programmes. Several plausible OSCE determinants clinical-placement hours, instructor effects, student self-efficacy—were unavailable within the administrative dataset, leaving residual confounding possible. Although OSCE inter-rater reliability was excellent ($ICC = 0.89$) and standardisation procedures were rigorous, OSCE raters were not fully blinded to student identity, and minor inter-cohort checklist revisions may have introduced non-differential measurement error. The 11.0% exclusion rate at screening represents a potential source of selection bias, as the retained sample may overrepresent academically persistent students. Multi-institutional, longitudinal replication incorporating motivational and clinical-exposure variables is needed to establish broader generalisability.

4. CONCLUSION

Within this single-institution retrospective analysis of 178 BSN students, subject-specific A&P performance measured by both course grade and examination score was a moderate, statistically significant predictor of basic nursing skills competency, accounting for approximately 24% of OSCE variance ($R^2 = 0.24$, adjusted $R^2 = 0.23$) after adjustment for overall GPA. Content-specific A&P indicators outperformed global GPA as predictors, supporting the proposition that bioscience achievement contributes unique information about clinical readiness beyond general academic ability. These findings carry three actionable implications for undergraduate nursing education: embedding A&P performance within early academic warning systems to enable timely, targeted remediation; prioritising clinically integrated and simulation-anchored A&P pedagogy; and using A&P performance as one component of holistic, rather than gatekeeping, student readiness assessment. By identifying a content-specific, modifiable academic predictor of objectively measured nursing competency, this study provides evidence to sup-

port stronger graduate preparation and safer healthcare service delivery considerations of particular relevance in low- and middle-income settings undergoing competency-based nursing education reform. The multi-determined nature of clinical competency and the constraints of the single-site retrospective design underscore the need for multi-institutional, longitudinal investigation that incorporates motivational, pedagogical, and clinical-exposure predictors to establish the generalisability of these findings

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