
Correlation of Preadmission Organic Chemistry Courses and Academic Performance in Biochemistry at a Midwest Chiropractic Doctoral Program*

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Purpose: Organic chemistry has been shown to correlate with academic success in the preclinical years of medicine, dentistry, and graduate physiology. The purpose of this study is to examine the relationship between undergraduate organic chemistry grades and first-semester biochemistry grades at a Midwest chiropractic doctoral program. **Methods:** Students enrolled in a first-semester biochemistry course who had completed the prerequisite courses in organic chemistry offered at this same institution were entered into the study. The total grade for each of the three courses was calculated using the midterm and final exam raw scores with a weighting of 50% each. Analysis consisted of obtaining correlation coefficients between the total grades of organic 1 with biochemistry and organic 2 with biochemistry. Using the biochemistry total grade, the students were divided into quartiles and course grades for both organic chemistry 1 and 2 were calculated. **Results:** For the 109 students in the study, the correlation coefficient between the biochemistry and organic chemistry 1 and biochemistry and organic chemistry 2 courses was $r = 0.744$ and $r = 0.725$, respectively. The difference in organic chemistry grades between those in the first and fourth quartiles was 63.2% and 86.9% for organic chemistry 1 ($p < .001$) and 60.9% and 79.4% for organic chemistry 2 ($p < .001$). **Conclusion:** This study shows that organic chemistry can be used as an indicator of future academic success in a chiropractic biochemistry course. Knowledge of such a relationship could prove useful to identify students who may potentially run into academic difficulty with first-year biochemistry. (J Chiropr Educ 2010;24(1):30-34)

Key Indexing Terms: Achievement; Biochemistry; Chemistry, Organic; Chiropractic

INTRODUCTION

Standardized tests such as the Medical College Admission Test, Dental Admission Test, Pharmacy College Admission Test, and Optometry Admission Test are utilized respectively to rank students for admittance into schools of medicine, dentistry, pharmacy, and optometry. Chiropractic schools do not typically use preadmission entrance exams, although a Chiropractic College Admission Test does exist, but it has been infrequently utilized by only a few

chiropractic institutions. Therefore, academic performance is assessed using overall undergraduate grade point average (GPA) and grades in science prerequisite courses, such as organic chemistry. In the 1950s organic chemistry grades took on “mythical properties,” especially with the emergence and growing importance of biochemistry in the medical sciences.¹ Organic chemistry has been shown to correlate with academic success in the preclinical years of medicine, dentistry, and even graduate physiology.²⁻⁴ Undergraduate organic chemistry grades have even been positively correlated with the completion of a nursing program.⁵

With respect to chiropractic education, there has been only one study that observed a positive correlation between prerequisite chemistry GPA and year 1 chiropractic GPA ($r = 0.466$),⁶ and there has been only one study that observed a positive correlation between entry-level GPA and chiropractic

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first-year biochemistry GPA ($r = 0.548$).⁷ Therefore, to date, there have been no published studies investigating organic chemistry's role for specifically predicting academic success in a chiropractic program's biochemistry course. The purpose of this study is to examine the relationship between undergraduate organic chemistry grades and first-semester biochemistry grades at a Midwest chiropractic doctoral program. Examination of such a relationship could prove useful to identify students who may potentially run into academic difficulty with first-year biochemistry.

METHODS

This study utilized students enrolled in a first-semester biochemistry course at a Midwest chiropractic doctoral program between the dates of September 2004 and December 2007. The study was approved by the university's institutional review board. Students who had completed the preprofessional prerequisite courses in organic chemistry offered at this same institution were distinguished from those who had not. These two separate cohorts were then subsequently labeled the prerequisite and non-prerequisite groups, respectively. For the prerequisite group, the midterm and final exam raw scores for students enrolled in one or both organic chemistry prerequisite courses were abstracted and entered into an Excel spreadsheet. Upon the completion of the first semester in the chiropractic program, their midterm and final exam raw scores in the biochemistry course were added to the database. All other non-prerequisite student's biochemistry course grades were entered into a separate database for latter comparisons. Only first-attempt exam scores in organic chemistry and biochemistry were entered into the database, and therefore no student who had repeated either course had been entered twice.

The same instructor was utilized for both prerequisite organic chemistry courses (organic 1 and organic 2) and the biochemistry course. The curriculum and content covered in all three courses was held constant for the 10-semester duration of the study, and only minor changes to the exam questions were applied from one exam to the next. The midterm and final exams in the organic chemistry courses were comprised of written short-answer questions, whereas the biochemistry exams were comprised exclusively of multiple-choice questions.

The total grade for each of the three courses was calculated using the midterm and final exam raw scores with a weighting of 50% each. Data analysis consisted of obtaining Pearson's correlation coefficients between the total grades of organic 1 with organic 2, organic 1 with biochemistry, and organic 2 with biochemistry. Correlations ranging from 0.00 to 0.25 indicate little or no relationship, values from 0.25 to 0.50 indicate a fair degree of relationship, values of 0.50 to 0.75 indicate a moderate to good degree of relationship, and values above 0.75 are considered to be a good to excellent degree of relationship.⁷

Using the biochemistry total grade, the students were ordered numerically from lowest to highest and then divided into quartiles. The average course grade for both organic chemistry 1 and 2 was then calculated for each quartile so that statistical comparisons across quartiles could be made. A one-way analysis of variance was used to detect differences between the independent variables and post-hoc comparisons were performed using the Tukey HSD test. All reported p values are two-tailed and values below .05 were considered statistically significant. The statistical program used was SPSS 11.5 (SPSS Inc, Chicago, IL).

RESULTS

In the 10 semesters between September 2004 and December 2007, there were 109 and 337 students identified as either belonging to the prerequisite or non-prerequisite groups, respectively. Of the 109 prerequisite students, 93 completed both the organic chemistry 1 and 2 courses, while there were 16 students who were only required to complete the organic chemistry 2 course.

The results of this study convey a good degree of relationship between the chiropractic program biochemistry course and prerequisite organic chemistry 1 and 2 courses as the correlation coefficients observed were $r = 0.744$ ($p < .001$) and $r = 0.725$ ($p < .001$), respectively. As should be expected, there was also a strong relationship between organic chemistry 1 and 2 with a correlation coefficient of $r = 0.817$ ($p < .001$).

Figures 1 and 2 present the organic chemistry 1 and 2 grades for students when separated out by their academic performance in biochemistry by quartiles. The difference in average organic chemistry grades between those in the first and fourth quartiles

was 63.2% and 86.9% for organic chemistry 1 ($p < .001$) and 60.9% and 79.4% for organic chemistry 2 ($p < .001$). Post-hoc analysis found that the comparisons between all quartiles were significantly different ($p < .001$) except between the second or third quartiles for both organic chemistry 1 or 2.

DISCUSSION

Organic chemistry has been the basis for developments in pharmacology and clinical medicine and has been called the “defining premedical course.”¹ This term is supported by a study that surveyed undergraduates at a liberal arts college which found that for students who stated low grades as being the contributing factor for declining to pursue a carrier

in medicine, 78% of them named organic chemistry as the single course that had affected their plans.⁸ In regard to predicting chiropractic student success, the results observed in this current study make it clear that organic chemistry can be used as an indicator of future academic success in a chiropractic biochemistry course. This finding is further supported by a study which observed that among the 13 students who failed biochemistry at the University of Iowa College of Medicine, the majority of them had low grades in undergraduate organic chemistry.⁹

The correlation coefficients observed in this current study imply a good degree of relationship between organic chemistry 1 and 2 grades with the academic performance in biochemistry ($r = 0.744$ and $r = 0.725$, respectively), and this finding supports a previously observed relationship in a study at the University of Mississippi School

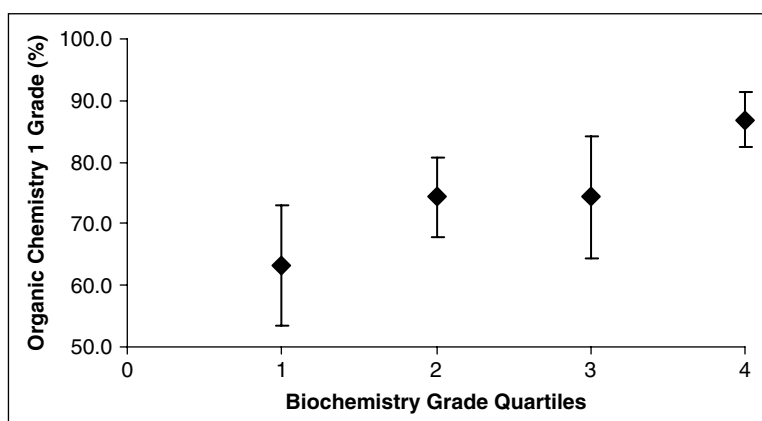


Figure 1. Comparison of organic chemistry 1 grades for students separated out by their academic performance in biochemistry by quartiles ($N = 93$, 23 per group). Post-hoc comparisons between groups found significant differences ($p < .001$) between all groups except for between quartiles 2 and 3.

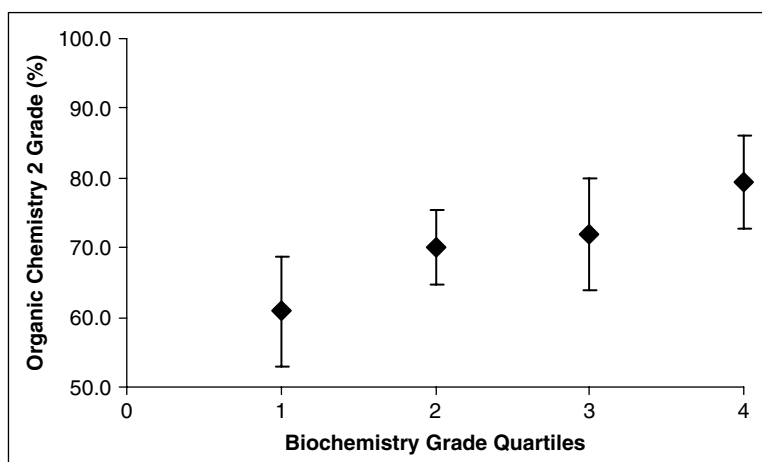


Figure 2. Comparison of organic chemistry 2 grades for students separated out by their academic performance in biochemistry by quartiles ($N = 109$, 27 per group). Post-hoc comparisons between groups found significant differences ($p < .001$) between all groups except for between quartiles 2 and 3.

of Dentistry where organic chemistry grades were a statistically significant predictor of performance on the biochemistry and physiology subtest of the National Board Dental Examination ($r = 0.709$).³ However, another subsequent study at the Harvard School of Dental Medicine did not find such a significant correlation between organic chemistry and the biochemistry and physiology subtest of the National Board Dental Examination ($r = 0.374$).¹⁰ In another study it was observed that undergraduate biology course work and not organic chemistry was significantly associated with academic success in pharmacy school.¹¹ This finding is somewhat surprising, especially because organic chemistry is thought to be the basis for understanding the biochemical mechanisms involved in pharmacology.

It was also observed in this current study that academic success in biochemistry was severely hampered for students who failed either one or both prerequisite organic chemistry courses because four of the nine students who had to repeat either organic 1 or 2 went on to fail the biochemistry course. This finding is supported by a study performed at the Southern Illinois University School of Medicine, which found that students who faced academic difficulty in their first year of medical school possessed more withdrawal, repeated, and incomplete courses during their undergraduate career.¹²

The relationships observed in this current study between undergraduate organic chemistry performance and academic success in biochemistry may serve for both academic counselors and biochemistry instructors as a means to identify incoming chiropractic students who may benefit from additional assistance provided by individual biochemistry instructors or by peer mentoring. This would be particularly important for students with very low entering organic chemistry GPAs or for those students who had to repeat organic chemistry 1 or 2 at least once in their undergraduate training.

Although organic chemistry in this current study has been found to be a good indicator of academic success in biochemistry, it may not be the only significant indicator of success. It has been observed that overall undergraduate GPA of chiropractic students also correlated with academic performance in biochemistry ($r = 0.548$).⁷ Therefore, it may be possible that undergraduate performance in biology or physics, which are also required prerequisite courses, may possess correlation coefficients that are just as strongly predictive as was observed with organic chemistry. This current study would have

been made stronger with the availability of such data, but the logistics of obtaining and including these data are difficult due to the alphabetical grading style employed by most undergraduate institutions.

A confounding variable in this study is that the instructor was the same for all three courses and, therefore, the results observed may be due more to familiarity with the instructor than the course itself. If this was the case, the prerequisite student's familiarity with the instructor should potentially translate to greater success in the biochemistry course over his or her non-prerequisite peers. However, when the biochemistry grades were compared between both groups, the prerequisite group performed 2.2% below the non-prerequisite group. One reason to explain this finding is that the prerequisite group was comprised of students who held bachelors degrees from nonscience disciplines, while the non-prerequisite group were predominantly Bachelor of Science graduates who may also have taken biochemistry courses during their undergraduate education. However, numerous studies have shown no statistical differences between medical school performances between students who chose science versus nonscience undergraduate majors. In addition, the quantity of science-based undergraduate courses taken during undergraduate premedical education provided no significant advantage.¹³⁻¹⁷ Another possible confounding factor is the fact that the examination methods differed between the organic chemistry and biochemistry courses using short-answer versus multiple-choice questions, respectively. This, however, should not have any impact on the conclusions of this study, because the testing methods utilized for both courses are common to most institutions. However, it can be argued that some students are better than others at using certain strategies for taking multiple-choice exams, and therefore it is possible that utilizing two different testing methods could confound and weaken the correlation between organic chemistry and biochemistry scores.

Although this study shows a positive relationship between organic chemistry and biochemistry, this study leaves some important questions unanswered, such as: 1) Does organic chemistry translate to success in other courses such as anatomy, physiology, microbiology, or palpation?; 2) Does organic chemistry alone correlate with overall first-semester GPA?; and 3) Does organic chemistry correlate with the performance on the chemistry part of the National Board of Chiropractic Examination? Because the experience of one institution may not

be sufficient evidence to make generalizations about all chiropractic students and chiropractic colleges, it will be necessary to repeat this study at institutions across the country. Further research at different institutions may serve to strengthen the validity of the finding of this study.

CONCLUSION

From this study it appears that academic performance in an undergraduate organic chemistry course may be a good indicator of performance in a first-semester biochemistry course at a Midwestern chiropractic doctoral program. Knowledge of such a relationship could prove useful to identify students who may potentially run into academic difficulty with first-year biochemistry. Such knowledge could be used to prepare these students to initiate early interventions, such as peer tutoring or reduced course loads.

CONFLICT OF INTEREST

The author has no conflict of interest to declare.

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REFERENCES

1. Brieger GH. The plight of premedical education: myths and misperceptions. Part II: Science "versus" the liberal arts. *Acad Med* 1999;74:1217–21.
2. Montague W, Odds FC. Academic selection criteria and subsequent performance. *Med Educ* 1990;24:151–7.
3. De Ball S, Sullivan K, Horine J, Duncan WK, Replogle W. The relationship of performance on the dental admission test and performance on Part I of the National Board Dental Examinations. *J Dent Educ* 2002;66:478–84.
4. Gwazdauskas FC, McGilliard ML, Vinson WE. External factors that affect grades in graduate physiology. *J Dairy Sci* 1986;69:2728–33.
5. Fladeland DM. Nursing program success, personality and learning style. Doctoral dissertation, University of Minnesota, 1995.
6. Green BN, Johnson CD, McCarthy K. Predicting academic success in the first year of chiropractic college. *J Manipulative Physiol Ther* 2003;26:40–46.
7. Zhang JQ. The correlation of student's entry-level GPA, academic performance, and the National Board Examination in all basic science subjects. *J Chiropr Educ* 1999;13:91–99.
8. Lovecchio K, Dundes L. Premed survival: understanding the culling process in premedical undergraduate education. *Acad Med* 2002;77:719–24.
9. Caplan RM, Kreiter C, Albanese M. Preclinical science course "preludes" taken by premedical students: do they provide a competitive advantage? *Acad Med* 1996;71:920–2.
10. Bergman AV, Susarla SM, Howell TH, Karimbux NY. Dental Admission Test scores and performance on NBDE Part I, revisited. *J Dent Educ* 2006;70:258–62.
11. McCall KL, Allen DD, Fike DS. Predictors of academic success in a doctor of pharmacy program. *Am J Pharm Educ* 2006;70:106.
12. Jackson EW, Dawson-Saunders B. History of not completing courses as predictor of academic difficulty among first-year students. *J Med Educ* 1987;62:880–5.
13. Yens DP, Stimmel B. Science versus nonscience undergraduate studies for medical school: a study of nine classes. *J Med Educ* 1982;57:429–35.
14. Sade RM, Lancaster C. The relation of undergraduate major to medical school admission and medical school performance. *J S C Med Assoc* 1983;79:401–4.
15. Elam CL, Johnson MM, Johnson R. Students' premedical preparations and academic performances in medical school and residency. *Acad Med* 1993;68:229–30.
16. Hall ML, Stocks MT. Relationship between quantity of undergraduate science preparation and preclinical performance in medical school. *Acad Med* 1995;70:230–5.
17. Smith SR. Effect of undergraduate college major on performance in medical school. *Acad Med* 1998;73:1006–8.