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Anatomical Dissection of Whole-Body Donors Improves Anatomy Lecture Performance in Undergraduate Students

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Abstract

Proficiency in anatomy is pivotal in the education of future healthcare workers and ensures safe medical practice. Traditional anatomy lectures can be supplemented by a laboratory component, such as human whole-body donor dissection. The primary purpose of this study was to determine if students who take a dissection-based laboratory concurrently with lecture improve lecture grades, compared with lecture alone. Eight consecutive semesters of ordinal course grades for the lecture and laboratory sections, as well as students' GPA, were used. Additionally, student responses to randomly selected primary and tertiary questions were recorded, and the percentage correct for each group (Lecture versus Lecture + Lab) was calculated. There was a significant difference in the likelihood of higher grades between the two groups ($p<0.0001$). The odds of higher grades in Lecture + Lab group were 4.013 times the odds of higher grades in the Lecture group (adjusted odds ratio (AOR): 4.013, 95% CI: 2.8356, 5.6794). In addition, GPA was significantly associated with lecture grades ($p<0.0001$). Students that took lab concurrently were more likely to answer primary (Lecture + Lab: 85% ± 20% vs. Lecture: 72% ± 23%; $p<0.0001$) and tertiary (Lecture + Lab: 71% ± 28% vs. Lecture: 55% ± 30%; $p<0.0001$) questions correctly than students that took lecture alone. Anatomical dissection of whole-body donors improves performance in didactic anatomy examinations and should be recommended to ensure proficiency in anatomical education. https://doi.org/10.21692/haps.2025.011

Key words: anatomy education, anatomical dissection, higher-order thinking, critical thinking

Introduction

Anatomy, the intricate study of the human body, sets the foundation of undergraduate education for future health care professionals. It is regarded as a core discipline of health science (McCumber et al., 2021) and is a prerequisite for many health-related programs (Asante et al., 2021). Proficiency in anatomy is essential for developing clinical skills in healthcare, particularly in surgical fields (Abdellatif, 2020). Concerns that insufficient anatomical knowledge may lead to increased morbidity and mortality has led to the inclusion of a dissection experience in some surgical residencies (Memon, 2018). Beyond surgery, support for dissection in the development of practical skills was supported across a surveyed group of medical professionals at all levels (Ahmed et al., 2010). Surveyed physical therapists indicated that they felt anatomy was important for safe clinical practice (Rompolski et al., 2023). Moreover, human gross anatomy provides an opportunity for bioethical and humanistic reflection, through which instructors strive to instill respect, compassion, and appreciation within enrolled students – important traits in a future health care professional (Weeks et al., 1995).

To achieve this proficiency, anatomy courses are typically instructed as a didactic lecture, with or without a practical laboratory component. The type of practical laboratory component varies between institutions and their respective programs. Laboratory types commonly include, but are not limited to, whole-body donor dissection, whole-body donor prosection, surface anatomy and palpation, osteology, virtual dissection/3-D software, plastinated models, body

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painting, clay modeling, and virtual reality (Rompolski, 2023; Rompolski et al., 2023). Whole-body donor dissection, specifically, is a form of experiential learning conducted on a human body donated to science for purposes of education and research (Korf et al., 2008). The dissection experience consists of student groups exploring anatomical regions of the body (i.e., back, upper extremity, etc.) to reveal and study muscles, nerves, and blood vessels, among other tissues. Compared with a non-dissection laboratory, dissection has several benefits, as it provides improved spatial understanding of the body (Abdellatif, 2020) including the compartmentalization of the body through fascia and connective tissues (Korf et al., 2008), an appreciation for human variation (Abdellatif, 2020; Huynh et al., 2021), increases motivation and spatial relationships (Nwachukwu et al., 2015; Thompson & Marshall, 2020; Asante et al., 2021; Huynh et al., 2021), and promotes professionalism (Nwachukwu et al., 2015).

Modality has been an area of debate over the last several years. One study found that medical students, trainees, and specialists agreed in a traditional Likert survey statement that "dissection is better than prosection," and was the most recommended learning tool across the groups (Ahmed et al., 2010). Similarly, a 2021 qualitative study reported that medical students found dissection to be interesting, the better way to learn, assists in retention, and should not be replaced by other forms of learning (Asante et al., 2021). Other studies have shown similar support for dissection (Abdellatif, 2020; Huynh et al., 2021; Korf et al., 2008; Nwachukwu et al., 2015; Pizzimenti et al., 2016; Phitayakorn et al., 2024; Thompson & Marshall, 2020). In contrast, recent literature has shown support for alternate forms of learning anatomy. A 2015 study argued that dissection is valuable but not essential (Patel et al., 2015). Additionally, one report argued that students retained benefits of human body donor laboratory - clinical reasoning, teamwork, and empathy, in a course that operates without the use of whole-body donors (Rompolski, 2023). Other studies have shown support for the use of alternate methods in anatomy instruction (Lombardi et al., 2014; Memon, 2018; Wilson et al., 2018).

While modality has been a debate, the use of practical laboratory component has steadily declined (McBride & Drake, 2018). Dissection, in particular, has declined in recent years due to limited availability of whole-body donors, decreased time allocated for lab, improvements in preservation, increased use of plastinated specimens, and technology (Abdellatif, 2020), as well as expense of donor body acquisition and preservation, time and skill required to dissect, health risks related to preservation agents, the COVID-19 pandemic, and increasing scientific information to cover in medical education (Phitayakorn et al., 2024). As of 2019, just over half of US medical schools incorporate donor body dissection in their curriculum (Schroeder et al., 2020).

Amid decline in use, qualitative views and quantitative measures on the benefits of anatomy lab remains largely positive (Ahmed et al., 2010). Increased time spent in dissection anatomy laboratory experiences increased laboratory and written examination scores for first year medical students, with the most significant effect for students in the lower-quartile (Pizzimenti et al., 2016). Similarly, undergraduate students who participated in prosection-based anatomy laboratory out performed students in lecture alone on written anatomical exams (Anderson et al., 2024). These studies, as well as several others in the literature support the inclusion of some form of laboratory component in anatomy courses given the positive impact on student performance. However, to our knowledge, no studies have previously specifically examined the difference in lecture examination performance between students enrolled in both a dissection-based laboratory and lecture, compared to students who take lecture alone.

Performance in anatomy is primarily assessed through written examination. Written exams conducted in anatomy lecture or lab vary in style but are commonly in multiple choice question (MCQ) format. In one study, MCQs in an anatomy course were categorized as primary, secondary, or tertiary, and sorted as such based on the level of comprehension of spatial and 3-D relationships required to answer the question (Anderson et al., 2024). Based on these constraints, primary questions were denoted lower-order knowledge type, such as *"what is the name"* or *"identify the structure."* Secondary questions required students to connect an anatomical structure with its function or blood/nerve supply, while tertiary questions required connection to both in order to determine outcome in the case of injury (Anderson et al., 2024). An example of such would be, "*A 32-year-old cyclist falls and sustains a midshaft fracture of the humerus. Following the injury, he is unable to extend his wrist and fingers, and experiences numbness over the dorsum of his hand. What nerve is likely injured, and what muscle group is primarily affected?"* Answering higher-order (secondary and tertiary) questions correctly suggests deeper comprehension, and was observed in students taking a prosection lab with anatomy lecture compared to the lecture alone (Anderson et al., 2024).

The purpose of the present study was to determine if undergraduate students taking a dissection-based anatomy laboratory concurrently with lecture earn higher final lecture grades and answer lecture-based higher order questions correctly more often than those taking lecture alone. We hypothesize that students participating in dissection will achieve higher overall course grades and answer more higher order questions correctly compared with students taking anatomy lecture alone.

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Methods

Human subjects research exemption was granted by the Internal Review Board (IRB) at West Virginia University (WVU) (IRB ID: 2401898785), an R1 research, land-grant institution in Appalachia. This research was conducted in the Exercise Physiology program, a large (700+ student) undergraduate pre-health program. Within this program, Anatomy for Exercise Physiology, a three-credit required human anatomy lecture course, provides an in-depth, integrative understanding of human anatomy with applications toward exercise in both healthy and diseased populations. The course runs concurrently with an optional Gross Anatomy Laboratory, a whole-body donor dissection laboratory section offered as an elective.

Course Design

The lecture course is taught in 80-minute traditional didactic lectures twice a week for 16-weeks. The course format is a regional approach to anatomy, including regions of the back, upper extremities, lower extremities, thorax, abdomen, as well as the head and neck. Within each region, the identification of human anatomical structures of the musculoskeletal, nervous, and circulatory systems are central course objectives. Upon completion of unit material, information is reinforced by a standard 52 question multiple choice (MC) unit examination (exam grades are calculated as number correctly answered/50 questions). MC questions are pulled from a question bank and include questions ranging in difficulty from primary to tertiary questions. Additional learning resources for the lecture include an optional textbook, optional 3-D human anatomy application, homework assignments, quizzes, and the option to enroll in the laboratory section as an elective. Any student that does not take the laboratory section concurrently is invited to attend the lab section for observation, but not dissection.

The laboratory section is a dissection-based anatomy lab, also taught 80-minutes twice a week for 16 weeks, and the material covered in lab runs concurrently with the material covered in lecture. Students work in groups of four on their respective whole-body donor. The members of each group work together to meticulously dissect the same anatomical regions covered in lecture, in the same sequence.

Modifications of the course design were made for Spring 2020 semester cohort amid the COVID-19 pandemic. All students enrolled in anatomy at that time took the first eight weeks of the course in person as normal, learning the back and upper extremity units. West Virginia University then moved all classes online for the remaining 8 weeks of the semester, and thus the lower extremity, abdomen/thorax/pelvis, and head/brain/brain units were instructed online using voice over PowerPoints and online exams. For the lab component, there were a few videos of dissection available and online exams required students to identify structures in still shot images.

The lecture had been taught for several years before the whole-body donor lab section was offered. In the first few years of the dissection laboratory, there were not enough seats to permit all students in the program to enroll in the dissection laboratory, so placement was prioritized by GPA. Students that had less than a 3.0 GPA were not eligible for the dissection laboratory. This restriction was removed for the Spring 2023 cohort when more sections were offered so all students that were interested in enrolling in the dissection laboratory were guaranteed a seat. Therefore, statistical analysis controlled for GPA.

Outcomes

The primary outcomes of this study were overall lecture grades, unit exam grades and performance on types of questions (primary vs. tertiary). Ordinal course grades, with A > B > C > D, for the lecture and laboratory sections, together with students' GPA, were pulled from the WVU Registrar's Office for eight consecutive semesters (Fall 2019-Spring 2023). Student identification was anonymous as data was shared with an ID number instead of names. To determine whether the participation in the dissection laboratory improved students' ability to answer higher order questions correctly, unit exam questions and student responses were pulled from Fall 2023 records. Two to five primary and tertiary questions from each unit exam were randomly selected for comparisons between groups.

Statistical Analysis

The percent of students achieving each ordinal grade was determined and separated by students' GPA, as displayed in Table 1. Because GPA was a prerequisite requirement for lab seven of eight semesters, most data points in the 2.5 – 3.0 GPA group were Lecture only. Therefore, for comparisons, any data points that existed for Lecture + Lab were matched based on GPA to Lecture only data points. A regression analysis using a proportional odds model was conducted to determine if there was a significant difference in the likelihood of higher lecture grades between the two groups (Lecture vs. Lecture + Lab) controlling for GPA. Student responses to selected primary and tertiary questions were recorded in an Excel spreadsheet as "Yes" or "No," depending on whether the student answered the randomly-selection question correctly. The percent correct ± SD for each group were reported and compared using Chi-squared tests. All statistical analyses were performed using R 4.4.1 (R Core Team, Vienna Austria) and the "rms" (Version 6.8-1) package.

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Results

The original data collected from the registrar's office included 713 students, including 348 that took Lecture alone and 365 that enrolled in Lecture + Lab. The percent of students achieving each ordinal grade are presented in Table 1.

Lecture Only			Lecture + Lab	
N = 348			N = 365	
GPA	3.302 ± 0.371		GPA	3.582 ± 0.304
A	28% (96)		A	69% (252)
B	36% (127)		B	24% (86)
C	19% (67)		C	6% (22)
DFW	17% (58)		DFW	1% (5)
3.5 – 4.0 GPA				
N = 103			N = 229	
GPA	3.758 ± 0.158		GPA	3.777 ± 0.154
A	63% (65)		A	81% (185)
B	24% (25)		B	16% (37)
C	9% (9)		C	2% (4)
DFW	4% (4)		DFW	1% (3)
3.0 – 3.5 GPA				
N = 169			N = 122	
GPA	3.249 ± 0.137		GPA	3.30 ± 0.137
A	14% (24)		A	52% (64)
B	50% (84)		B	35% (43)
C	19% (32)		C	11% (13)
DFW	17% (29)		DFW	2% (2)
2.5 – 3.0 GPA				
N = 14			N = 14	
GPA	2.858 ± 0.126		GPA	2.856 ± 0.130
A	0% (0)		A	21% (3)
B	36% (5)		B	43% (6)
C	50% (7)		C	36% (5)
DFW	14% (2)		DFW	0% (0)

Because GPA was a prerequisite requirement for lab seven of eight semesters, most data points in the 2.5 – 3.0 GPA group were lecture only. Therefore, for comparisons, any data points that existed for Lecture + Lab were matched based on GPA to Lecture only data points.

Table 1. *Ordinal grade achievement by GPA category*

There was a significant difference in the likelihood of higher grades between the two groups ($p<0.0001$). In particular, the odds of higher grades in Lecture + Lab group were 4.013 times the odds of higher grades in the Lecture group (adjusted odds ratio (AOR): 4.013, 95% CI: 2.8356, 5.6794). In addition, GPA was significantly associated with the lecture grades ($p<0.0001$). It is of note that GPA was non-linearly associated with lecture grades, as shown in Figure 1, when GPA was greater than 3.75, the likelihood of higher lecture grades increased more rapidly than when GPA was less than 3.75.

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Question data analysis was conducted on 113 students enrolled in anatomy in fall 2023. Students that took lab concurrently were more likely to answer primary (Lecture + Lab: 85% ± 20% vs. Lecture: 72% ± 23%; $p<0.0001$) and tertiary (Lecture + Lab: 71% ± 28% vs. Lecture: 55% ± 30%; $p<0.0001$) questions correctly than students that took lecture alone. These results are demonstrated in Figure 2.

Discussion

The purpose of this study was to determine if students taking a dissection-based human gross anatomy laboratory course concurrently with lecture earn higher final grades compared to those taking lecture alone. The results support the hypothesis that those participating in dissection achieve higher overall course grades than those students taking lecture without lab. Further, students taking lecture and laboratory sections concurrently were more likely to answer primary and tertiary questions correctly. These findings support that whole-body donor dissection improves performance on anatomy lecture written exams and adds to the body of literature in support for inclusion of a practical anatomy laboratory component when learning anatomy.

In this study, students earned higher grades when concurrently enrolled in anatomy lecture and lab which is consistent with former research examining the impact of concurrent lab and lecture, despite different course design (Pizzimenti et al., 2016; Anderson et al., 2024). For instance, Anderson et al. (2024) found that students enrolled in a prosection laboratory outperformed their non-lab counterparts by a full letter grade (Anderson et al., 2024). Pizzimenti et al. (2016) incorporated a rotating laboratory experience, meaning not every laboratory student was actively dissecting each class, but instead some students dissected while others completed quizzes and other activities or watched the dissection for "peer-based learning". Pizzimenti et al. (2016) found a significant increase in examination performance with greater time spent dissecting within the anatomy laboratory (Pizzimenti et al., 2016). Indeed, many scholars argue that time spent in the laboratory is the most important factor toward success in an anatomy course. Both greater time spent in the laboratory and better performance on the act of dissection itself was found to be associated with better overall final assessment performance in previous reports (Nwachukwu et al., 2015; Abdellatif, 2020). In the present study, the material covered in lecture and lab ran concurrently; thus, those students enrolled in both lecture and laboratory sections received twice the amount of time on the same information compared with students taking lecture alone. The current literature, in agreement with the results of the present study, support that anatomy laboratory courses are beneficial for mastering anatomical understanding and that the time spent in lab, regardless of laboratory type (e.g., dissection

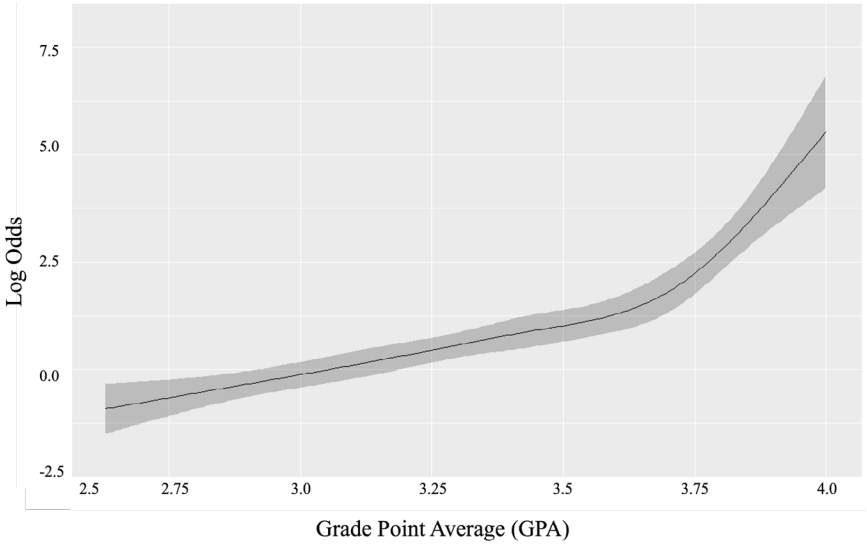

Figure 1. *Association between lecture grades and GPA is demonstrated with a smoothing curve and 95% confidence interval in grey shading, based on the Loess Smoothing Method.*

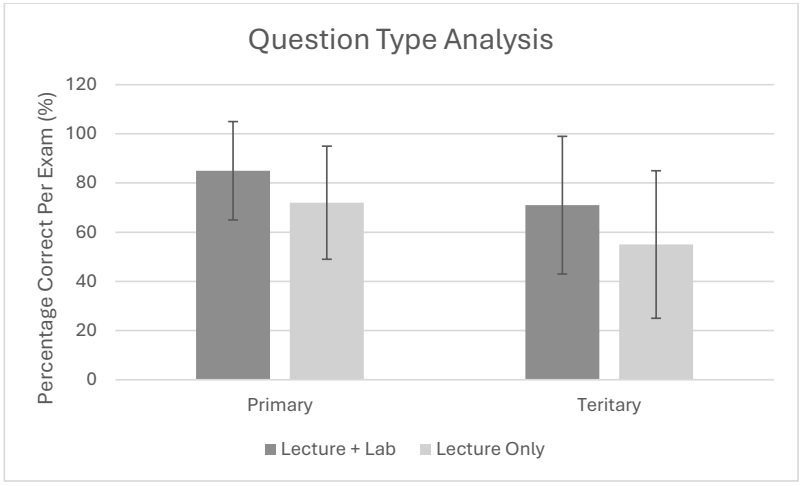

Figure 2. *Performance on primary vs tertiary question types across lab and non-lab students.*

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vs. prosection) improves overall performance (Lombardi et al., 2014; Pizzimenti et al., 2016; Wilson et al., 2018; Anderson et al., 2024). Other researchers argue that what matters most when learning anatomy is the experience in the lab itself (Wilson et al., 2018; Anderson et al., 2024).

The present study found students that took lecture and lab concurrently performed better on primary and tertiary questions, in alignment with previous findings (Anderson et al., 2024). Tertiary questions are more complex and require a deeper level of understanding, suggesting that students in anatomy laboratories develop higher order critical thinking and application skills. Higher order critical thinking and application skills are crucial for pre-health students as they enable students to analyze complex medical situations, make informed decisions, and apply theoretical knowledge to real-world scenarios. Critical thinking helps students evaluate evidence, recognize patterns, and consider multiple perspectives, while application skills ensure that students can translate classroom learning into practical skills, which is vital in clinical settings where theoretical knowledge must be applied to patient care. The development of these skills in undergraduate courses can benefit long term academic performance for pre-health students. Previously, Thomas et al. (2021) found enrollment in an undergraduate anatomy course was associated with better performance on anatomy-related assessments in medical school (Thomas et al., 2021).

Previous work showed greater time spent participating in dissection increased laboratory practical examination scores for many students, with the most significant effect for students in the lower-quartile (Pizzimenti et al., 2016). This study suggests there is correlation between study time and academic achievement that might preferentially benefit lower achieving students. The present study somewhat contradicts this finding as GPA was non-linearly associated with lecture grade: the likelihood of higher lecture grades increased more rapidly than when GPA > 3.75. Unfortunately, seven of eight semesters used in the present dataset had a GPA restriction set for the whole-body donor dissection elective, which likely limits the analyses. Therefore, future research should more fully explore the relationship between dissection and anatomy academic performance among lower achieving students.

The results support the hypothesis that participation in dissection can achieve higher overall course grades when compared to students taking lecture without a laboratory component. These data confirm the benefit of undergraduate students enrolling in anatomy lecture and laboratory concurrently. These findings may influence program development and future policies and may positively impact undergraduate and graduate participation in dissection internationally. As noted via the tertiary question analysis, students in dissection develop and use more critical thinking and application skills. Building capacity in these areas equips students with the ability to handle challenging undergraduate coursework as well as the rigors of professional and graduate programs in their future. Finally, participation in dissection allows for a richer learning experience, enabling students to obtain hands-on practice in collaboration with their peers. This study thus provides rationale arguing against the previously mentioned trend in decline of whole-body donor dissection (McBride & Drake, 2018; Abdellatif, 2020; Schroeder et al., 2020; Phitayakorn et al., 2024).

Despite these strengths, this study is not without limitations. Conducted at a single university in Appalachia, the sample included was relatively in terms of race/ethnicity, socioeconomic status, and geographic background, with most participants identifying as White/Caucasian. Future studies should aim to recruit more diverse samples, considering additional factors such as socioeconomic background, racial/ethnic composition, and rural versus urban residence. The question type analysis was limited to a single semester, and thus further examination on how laboratory components can promote higher order thinking skill development is warranted in future research.

Additionally, post-GPA requirement data is limited to one semester. Further the benefit of dissection on anatomy lecture examination performance in lower-quartile students could be elucidated in future studies by comparing student quartile performance, similar to previous work (Pizzimenti et al., 2016). Future research should also aim to include student perceptions of participation in laboratory, as former qualitative research has reported positive findings (Edmund Atta Asante et al., 2021; Huynh et al., 2021). Notably, data was included from Spring 2020, which as previously described was modified amid the COVID-19 pandemic and did not impact data significantly, despite lack of an in-person laboratory experience for half of the semester. As previously mentioned, there are a wide variety of resources available to students (textbooks, applications, etc.), and there is no way to control for which resources students elected to utilize. Finally, the primary limitation is that the Lecture + Lab cohort receives twice the amount of time on the same information compared with students taking lecture alone, serving as a large confounder. Given that both former studies utilizing a different form of laboratory component similar positive effects on grades to dissection (Lombardi et al., 2014; Patel et al., 2015; K. Rompolski, 2023; Wilson et al., 2018) and the lack of comparison of another type of laboratory activity in the present study and its impact on student performance, earning higher grades in this study may be better attributed to greater exposure of the course material including a hands-on experience rather than directly to dissection itself. This does however add to the body of knowledge on the benefits of a laboratory component in anatomy instruction.

Despite these limitations, findings of the study were overall positive regarding the dissection of whole-body donors and its impact on performance in anatomy, and adds to the body of knowledge on the benefits of a laboratory component in anatomy instruction.

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Conclusion

Anatomy is a foundational subject in undergraduate pre-health education and a critical prerequisite for future health care providers as proficiency in the subject ensures safe practice. Compared with students that take lecture alone, this study demonstrates that undergraduate students who take a dissection-based anatomy laboratory concurrently with lecture are four times more likely to earn higher grades in lecture. Additionally, these students are more likely to answer tertiary questions correctly, suggesting better understanding and development of higher order thinking skills. Anatomical dissection of whole-body donors improves academic performance and mastery of anatomical understanding and should be recommended to ensure proficiency in anatomical education.

About the Authors

Katherine Baker graduated with a BS in Exercise Physiology from WVU in 2024 and is currently pursuing an MD from WVU. Jim Thomas, MS, is an associate professor within the Division of Exercise Physiology at WVU with expertise in teaching human anatomy lecture and dissection laboratory courses. Wei Fang has a PhD in statistics and works as a biostatistician at the West Virginia Clinical and Translational Science Institute (WVCTSI). Miriam Leary, PhD, is an associate professor and the assistant chair in the Division of Exercise Physiology at WVU. Her research focuses on evidence-based teaching and learning practices with an emphasis on student success and retention of at-risk populations.

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