A PERSONAL VIEW | P-MIG Special Collection

The 2019 P-MIG Student Survey report and capturing the undergraduate perspective of physiology programming

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INTRODUCTION

The Physiology Majors Interest Group (P-MIG) is an active cohort of physiology educators who share a common mission to enhance disciplinary practices at the undergraduate level (3, 17, 18). P-MIG members, hailing from diverse programs, institutions, and geographical locations, work collaboratively to evaluate current undergraduate physiology and physiology-related degree program characteristics. One objective of these ongoing assessments is to establish parameters to consider for inclusion in consensus guidelines for undergraduate physiology programming. Comprehensive disciplinary recommendations will encompass three areas to promote the career readiness of physiology students: 1) curricular guidelines to enhance physiology knowledge and applications; 2) professional skills and aptitudes; and 3) advising resources.

To set a firm foundation from which to develop physiology program-level guidelines, P-MIG has curated a wide range of resources examining the current state of undergraduate physiology education. Examples of input sources and formalized assessments include the following: characterization of known physiology program characteristics via evaluation of internet-based resources (16), robust discussions among attendees at P-MIG annual meetings and in conjunction with presentations at conferences hosted by other societies (American Physiological Society, Human Anatomy and Physiology Society, Association of Chairs of Departments of Physiology), P-MIG committee work, and faculty surveys (5, 7, 15).

One perspective of the undergraduate educational experience that has not been broadly captured is input coming directly from the physiology students themselves. Therefore, during the spring of 2018, the P-MIG leadership team developed and administered a 28-question pilot survey to 1) collect feedback regarding demographic and academic characteristics of students enrolled in physiology coursework; 2) learn more about their career aspirations; and 3) assess perceptions of physiology coursework and degree program resources. A total of 673 physiology students from 10 physiology and physiology-related degree programs from across the United States participated in this pilot survey. A subsequent iteration of the Student Survey was drafted during the spring of 2019. Questions and response options from the 2018 survey were reviewed for relevance and quality of the data provided and modified when necessary.

Ongoing P-MIG Curriculum Committee and Advising Committee discussions prompted recognition of the importance of including a question series evaluating community college attendance and course transferability between institutions. The National Academy of Sciences report (12) emphasized the potential of community colleges to broaden participation in science, technology, engineering, and mathematics (STEM) and influence undergraduate education in the life sciences and other
STEM disciplines. About one-half of the STEM students in the U.S. have completed community college coursework, and ~30% of beginning medical students have also had some community college education (13). It may be logical, then, to assume that many undergraduates pursuing physiology degrees at 4-yr colleges and universities may have completed some, and up to one-half, of their college coursework at community colleges. Thus it is important to evaluate the academic pathways of transfer students, as well as credit transferability of specific courses, when planning and revising curriculum and programs of study for physiology majors at 4-yr institutions.

The aim of the 2019 P-MIG Student Survey was to learn more about the academic characteristics and experiences of undergraduates currently enrolled in physiology courses or degree programs from across the United States. Aggregate results from this survey may contribute an important perspective to foster alignment of programmatic curricular guidelines with physiology undergraduates’ educational needs and experiences.

METHODS

Survey Development and Format

The 2019 Student Survey was designed as a 23-question Qualtrics survey (Qualtrics, Provo, UT) comprised of four sections: 1) demographic characteristics of current physiology students; 2) academic characteristics of physiology students, including community college course completion and experiences with transferred coursework; 3) perceptions of physiology coursework and programming, including the Core Concepts of Physiology (10), participation in co-curricular opportunities, preparedness to enter the workforce, and postgraduation plans; and 4) experiences with academic advising. Survey questions and response options are available in Appendix A. The estimated time for survey completion was 8 min. This project, including the survey protocol and survey questions, was reviewed by the Human Subject Office at the University of Iowa and determined to hold exempt status.

Volunteer Recruitment

An e-mail was distributed through the P-MIG listserv in April 2019 soliciting faculty interest for administration of the 2019 Student Survey to students enrolled in physiology coursework or undergraduate physiology programs. Faculty who responded to the e-mail were provided with a participant recruitment announcement that included a description of the purpose of the survey, general instructions for survey completion, and a web link to access the Student Survey. Prospective participants were informed that individual responses would remain confidential (the exception being the optional question asking for their name or identification number if their instructor offered participation credit; see below), that they could skip any questions they preferred not to answer, and that aggregate results may be presented by P-MIG.

The second question in this series asked survey participants if they could skip any questions they preferred not to answer, and that aggregate results may be presented by P-MIG.

The demographic and academic characteristics of survey respondents are provided in Table 1. The majority of respondents were female (75%), white/Caucasian (63%), and in the second or third year of the academic program (49% and 25%, respectively). Students reported above average academic ability based on grade point average (3.5 or above, 50%) and SAT/ACT scores. From this self-reported snapshot of students engaged in physiology coursework, 19% indicated they were first-generation students, and 24% were underrepresented minorities.

Degree Interests: Majors, Minors, and Certificate Programs

Two questions were included in the Student Survey to provide insight into the degree interests of survey respondents (Table 2). Participants were asked to select the area or areas of study that most closely matched their primary degree program from a list of six choices plus “Other”. The six categories listed and associated areas of study arose from responses to a similar but open-ended question included in the pilot 2018 Student Survey (unpublished data). Physiology/human physiology was the most frequently reported primary degree program interest (37% of respondents), followed by allied health-affiliated degree programs (24%). Qualitative evaluation of written responses revealed that Psychology was the most frequently reported program of study in the “Other” category, listed by 30 of the 95 respondents who provided a text entry. Interestingly, 1,555 responses were generated from the 1,376 survey participants who completed this question. Thus 179 (13%) of respondents indicated the intention to pursue more than one primary area of study.

The second question in this series asked survey participants if they were seeking a minor or certificate in addition to their...
primary program of study. Approximately one-half of respondents indicated pursuing a minor (47%) or certificate (3%). A text entry field was available for respondents to list minors or certificates of interest. Entries were qualitatively sorted into broad categories of similar academic disciplines. Of the 713 written responses provided, the 3 most frequently reported minors were associated with foreign language and cultural studies (22%), psychology (19%), and non-physiology STEM disciplines (biochemistry, biology, chemistry, mathematics; 16%).

Community College Attendance and Transferable Coursework

Several questions queried whether students had previously enrolled in a community college course and the feasibility of transferring course credits to their home institution. The first question in this series simply asked, “Have you ever enrolled in a course at a community college?” The majority of respondents (n = 843 of 1,373 participants who provided a response for this question, 61%) reported prior enrollment in a community college course. A follow-up question was posed to ascertain the timing of

| Table 1. Demographic and academic characteristics of 2019 Physiology Majors Interest Group Student Survey participants |
|---------------------------------------------------------------|
| Response Options                                             | Respondents, N (%) |
| Age, yr (n = 1,389)                                          |                   |
| <18                                                           | 8 (1)             |
| 18–20                                                         | 930 (67)          |
| 21–22                                                         | 354 (26)          |
| 23–24                                                         | 50 (4)            |
| 25–29                                                         | 27 (2)            |
| >30                                                           | 19 (1)            |
| Prefer not to answer                                         | 1 (0)             |
| Gender (n = 1,388)                                           |                   |
| Female                                                        | 1,037 (75)        |
| Male                                                          | 350 (25)          |
| Other                                                         | 0 (0)             |
| Prefer not to answer                                         | 1 (0)             |
| Ethnicity* (n = 1,388)                                       |                   |
| White/Caucasian                                               | 978 (63)          |
| Hispanic or Latino                                            | 252 (16)          |
| Asian                                                         | 180 (12)          |
| Black or African American                                     | 74 (5)            |
| American Indian or Alaskan Native                             | 26 (2)            |
| Native Hawaiian or Pacific Islander                           | 16 (1)            |
| Other                                                         | 21 (1)            |
| Prefer not to answer                                         | 9 (1)             |
| First-generation student (n = 1,388)                         |                   |
| Yes                                                           | 266 (19)          |
| No                                                            | 1,114 (80)        |
| Prefer not to answer                                         | 8 (1)             |
| International student (n = 1,388)                            |                   |
| Yes                                                           | 33 (2)            |
| No                                                            | 1,352 (97)        |
| Prefer not to answer                                         | 3 (0)             |
| Class standing (n = 1,374)                                   |                   |
| First-year student                                           | 144 (11)          |
| Second-year student                                          | 678 (49)          |
| Third-year student                                           | 356 (25)          |
| Fourth-year student                                          | 166 (12)          |
| Graduate student†                                            | 19 (1)            |
| Other                                                         | 11 (1)            |
| GPA (n = 1,375)                                               |                   |
| <2.0                                                          | 5 (0)             |
| 2.00–2.49                                                     | 51 (4)            |
| 2.50–2.99                                                     | 150 (11)          |
| 3.00–3.49                                                     | 479 (35)          |
| 3.50–3.79                                                     | 346 (25)          |
| 3.80–4.00                                                     | 339 (25)          |
| Prefer not to answer                                         | 5 (0)             |
| SAT/ACT scores (n = 1,389)                                  |                   |
| <860/<16                                                      | 6 (0)             |
| 860–970/16–18                                                 | 21 (2)            |
| 980–1090/19–21                                                | 98 (7)            |
| 1100–1190/22–24                                              | 208 (15)          |
| 1200–1290/25–27                                              | 357 (26)          |
| 1300–1410/28–30                                              | 292 (21)          |
| 1420–1510/31–33                                              | 202 (15)          |
| 1520–1600/34–36                                              | 63 (5)            |
| Prefer not to answer                                         | 142 (10)          |

Values are N, no. of responses selected for each response option (with the percentage relative to the total responses in parentheses). n, Total no. of respondents who selected one of the response choices for each demographic or academic characteristic; Percentages may not total 100% due to rounding or the selection of more than one response option. GPA, grade point average. *There were 1,556 total responses, indicating some respondents selected multiple ethnicities. †Combined three categories (graduate student in physiology program, graduate student in nonphysiology program, and non-degree-seeking graduate student).
community college course completion (during high school, as stand-alone coursework without full-time enrollment, or while enrolled as a full-time student) and if coursework from other 4-yr institutions had been transferred to the home institution. Responses are summarized in Table 3. The transfer of course credits was more likely to occur between community colleges and 4-yr institutions than between 4-yr institutions. Furthermore, the majority of respondents reported the completion of community college coursework while in high school (44%) or as stand-alone coursework (i.e., without full-time enrollment at a community college; 31%). A small proportion of survey respondents reported full-time enrollment at a community college or 4-yr institution before transferring to the current institution (7% and 3%, respectively). Of those transferring credit, the majority of students (n = 730, 72%) reported that they did not experience any issues, and coursework transferred as expected.

Open-ended question options were included in this question series to gain insight into student perceptions of the coursework transfer process, inclusive of community college courses, as well as transfer coursework between 4-yr institutions. Qualitative evaluation of the written comments (n = 70) revealed the following summary responses:

1. Some coursework did not transfer as expected: course not accepted at new institution, less course credit awarded than expected, issues with processing transcripts, prior coursework did not meet the general education requirements at the new institution.
2. Timing: delay in hearing how courses would transfer, short window for course registration before the beginning of a term.
3. It was hard to adjust: different academic atmosphere and expectations, hard to find a peer group.
4. Some institutions have useful online tools, advising, and other resources to improve clarity for how courses will transfer between institutions, and this made the transfer process work smoothly.

Perceptions of Core Concepts of Physiology

In recent years, the P-MIG Curriculum Committee has evaluated the use of the core concepts of physiology in physiology curricula (6, 8, 15). The pilot 2018 Student Survey asked participants to rate 1) the extent to which each core concept had been learned in a physiology course, and 2) the importance of each core concept based on its relevance to a future career, using a five-choice Likert scale, ranging from unimportant to vitally important. The authors of the 2019 survey refined the core concepts-related questions and response options with the intent to assess perceived depth of mastery of each core concept. Thus the Likert criteria descriptions included terminology such as “recognize,” “understand,” and “mastered,” along with action-oriented examples correlating with each descriptor. A single survey question was presented in a matrix table format with the name and a brief description of one core concept provided in each row and a list of six descriptors on the horizontal axis: “This concept was not presented in my physiology coursework”; “I recognize this concept

| Survey Question | Response Options | Total, N (%) |
|-----------------|-----------------|-------------|
| Your primary program of study (major) (select all that apply)?* | Physiology/Human Physiology | 578 (37) |
| | Allied Health (Nursing, Pharmacy, Radiation Science/Therapy, Athletic Training, Nutrition Sciences/Dietetics) | 378 (24) |
| | Health (Health Administration, Health Promotion, Health Sciences, Public Health) | 155 (10) |
| | Non-Physiology Basic Science (Biology, Biological Sciences, Biochemistry, Chemistry, Microbiology, Neuroscience) | 147 (9) |
| | Exercise Physiology/Exercise Science | 122 (8) |
| | Biomedical Sciences/Biomedical Engineering | 80 (5) |
| | Other (text entry) | 95 (6) |
| Are you seeking a minor or a certificate in addition to your primary program of study?† | No | 685 (49) |
| | Minor (text entry) | 655 (47) |
| | Certificate (text entry) | 45 (3) |

Values are N, no. of responses selected for each response option (with percentage of total responses in parentheses). Percentages may not total 100% due to rounding. *A total of 1,555 responses were provided by the 1,376 participants who answered this question, indicating some participants selected multiple programs of study. †A total of 1,385 responses were provided by the 1,535 participants who answered this question.

Table 2. Degree interests of physiology students

| Survey Question | Response Options | Total, N (%) |
|-----------------|-----------------|-------------|
| Your primary program of study (major) (select all that apply)?* | Physiology/Human Physiology | 578 (37) |
| | Allied Health (Nursing, Pharmacy, Radiation Science/Therapy, Athletic Training, Nutrition Sciences/Dietetics) | 378 (24) |
| | Health (Health Administration, Health Promotion, Health Sciences, Public Health) | 155 (10) |
| | Non-Physiology Basic Science (Biology, Biological Sciences, Biochemistry, Chemistry, Microbiology, Neuroscience) | 147 (9) |
| | Exercise Physiology/Exercise Science | 122 (8) |
| | Biomedical Sciences/Biomedical Engineering | 80 (5) |
| | Other (text entry) | 95 (6) |
| Are you seeking a minor or a certificate in addition to your primary program of study?† | No | 685 (49) |
| | Minor (text entry) | 655 (47) |
| | Certificate (text entry) | 45 (3) |

Values are N, no. of responses selected for each response option regarding their experiences with coursework completion between institutions (with percentage of the proportion of responses relative to the total number of participants who answered this question in parentheses). Percentages represent n = 1,267. A total of 1,588 responses were recorded, indicating some respondents selected more than one response option; thus the percentages total is > 100%.
but am not sure I can apply it to physiological functions”; “I have a moderate understanding of this concept and can provide 1-2 physiological examples”; “I have mastered this concept and can explain it to others”; “This concept is important to understand for my future career”; and “I expect to remember this concept in 5 years.” The rationale for inclusion of the latter two descriptors was to gauge perceptions of each core concept as an enduring conceptual construct that might be recalled in occupational settings, representing the application of prior knowledge. All 15 core concepts were included in the matrix table, listed in alphabetical order. Survey participants were instructed that they could select more than one descriptor for each core concept. Results from the choice options pertaining to core concepts mastery were analyzed separately from the concept retention and career applications responses.

Self-reported level of mastery of core concepts is presented in Table 4. The five core concepts most frequently identified by physiology students as having reached mastery level were homeostasis, structure/function, cell membrane, cell theory, and energy. The five core concepts least frequently identified by students as having reached mastery level were genes to proteins, evolution, causality, physics/chemistry, and mass balance. Across all core concepts, the average number of students reporting mastery (380 ± 73) or moderate understanding (394 ± 45) were greater than that of recognition (114 ± 57) or reporting mastery (380 ± 73) or moderate understanding (394 ± 45).

Table 4. Self-reported mastery of core concepts of physiology

| Core Concept                  | Recognition (n=862) | Mastery (n=905) | Moderate Understanding (n=921) | Not Recognized (n=922) | Rank Order |
|------------------------------|---------------------|----------------|-----------------------------|------------------------|------------|
| Homeostasis                  | 486 (56)            | 291 (34)       | 47 (5)                      | 38 (4%)                | 1          |
| Structure/function           | 461 (51)            | 335 (37)       | 66 (7)                      | 43 (5%)                | 2          |
| Cell membrane                | 452 (49)            | 372 (40)       | 57 (6)                      | 40 (4%)                | 3          |
| Cell theory                  | 411 (49)            | 373 (40)       | 92 (10)                     | 46 (5%)                | 3          |
| Energy                       | 431 (47)            | 378 (41)       | 72 (8)                      | 39 (4%)                | 5          |
| Interdependence              | 414 (45)            | 378 (41)       | 78 (8)                      | 49 (5%)                | 6          |
| Flow down gradients          | 417 (44)            | 395 (42)       | 90 (10)                     | 44 (5%)                | 7          |
| Scientific reasoning         | 399 (42)            | 369 (39)       | 129 (13)                    | 60 (6%)                | 8          |
| Cell-to-cell communication   | 384 (41)            | 427 (45)       | 83 (9)                      | 46 (5%)                | 9          |
| Levels of organization       | 355 (39)            | 422 (46)       | 94 (10)                     | 47 (5%)                | 10         |
| Genes to proteins            | 368 (38)            | 413 (43)       | 121 (13)                    | 63 (7%)                | 11         |
| Evolution                    | 333 (33)            | 420 (42)       | 162 (16)                    | 93 (9%)                | 12         |
| Causality                    | 261 (26)            | 475 (47)       | 169 (17)                    | 106 (10%)              | 13         |
| Physics/chemistry            | 265 (25)            | 438 (42)       | 228 (22)                    | 124 (12%)              | 14         |
| Mass balance                 | 257 (25)            | 426 (41)       | 224 (22)                    | 128 (12%)              | 14         |

Values are no. of respondents who selected each response option (followed by the percentage relative to the total responses per core concept in parentheses). n, Total number of respondents who selected one of the four response choices for each core concept. Percentages may not total 100% due to rounding.

The top core concepts ranked most likely to be remembered in 5 yr included homeostasis (24% of respondents), cell membrane (23%), cell theory (23%), and energy, flow down gradients, and structure/function (all 22%). With regard to applicability to future careers, homeostasis (29%), structure/function and interdependence (both 27%), and levels of organization, scientific reasoning, and causality (all 25%) were predicted to be the most important core concepts.

Co-curricular Activities, Postgraduation Plans, and Perceptions of Career Preparedness

Participation in co-curricular activities that build career skills, including course-based experiential or applied learning opportunities (e.g., internships, study abroad), research, employment, and outreach or volunteering activities that students had either completed or planned to complete before graduation, was assessed. The number and percentage of respondents who reported participation in each type of experiential activity are presented in Table 5, which also depicts planned participation by academic standing. Job shadowing, community service activities and volunteering, and internships were the top three reported co-curricular activities, with greater than one-half of all respondents reporting the intention to engage in each one of these opportunities.

Table 5 summarizes the responses to the survey question, “Do you have a job, graduate school, or professional school offer for after graduation?” The majority of respondents (n = 677, 54%) reported it was too early in their academic preparation to consider postgraduation plans. Overall, 13% of respondents (n = 162) reported obtaining employment or acceptance into a graduate or professional program within their field of study. Evaluation of postgraduation plans by academic standing revealed this percentage is higher for fourth year undergraduates, at 33%. A small number of participants reported employment or acceptance in areas other than their field of study (4% of all respondents and 5% of fourth-year students). A number of survey participants reported actively searching, applying, or awaiting responses (n = 228, 18%). An additional subset indicated they planned to take a gap year (n = 124, 10%); third- and fourth-year students selected this response option more frequently than first- or second-year students. The majority of respondents (n = 760, 61%) strongly agreed with the sentiment of being optimistic regarding employment in their preferred fields following graduation (Table 7).

Perceptions of Academic Advising

Students were asked to report their level of agreement with various statements on the accuracy and helpfulness of the advising guidance they receive (Table 8). Academic advisors (inclusive of formal academic advisors and faculty providing academic advising) were rated most favorably for providing guidance related to course choices and progress toward degree completion.
Advising related to non-coursework opportunities for professional development was evaluated less favorably.

Students most commonly reported receiving formal advising one to two times per year (n = 683 out of 1,251 students who completed this question, 55%) or three to four times per year (n = 428, 34%). Fewer students reported having five or more formal advising sessions per year (n = 103, 8%) or not receiving formal advising (n = 37, 3%). Outside of formal advising, almost all students who responded to these questions reported seeking out additional career or professional development advice (n = 1,169, 93%). The most common sources of outside advice were friends (n = 961, 77%), family (n = 928, 74%), and online resources (n = 668, 53%). Less common sources included an identified mentor (n = 402, 32%) or student clubs (n = 346, 27%).

DISCUSSION

The 2019 P-MIG Student Survey captured many important inputs from current physiology students. Some of the results furthered our understanding of the current demographic and academic characteristics of this population. Other responses provided insights into perceptions of physiology coursework, physiology programming, and advising resources in preparation for a future career. Gathering written responses was helpful in further elucidating the undergraduate experience directly from students, which is particularly useful as P-MIG considers best practices for establishment of program-level recommendations and future iterations of this survey tool.

Table 5. Expected participation in co-curricular activities

| Activity                                      | All Responses, N (% Respondents) | First year (n = 116) | Second year (n = 610) | Third year (n = 323) | Fourth year (n = 136) | Other (n = 26) |
|-----------------------------------------------|----------------------------------|----------------------|-----------------------|----------------------|-----------------------|----------------|
| Job shadowing                                 | 867 (72)                         | 81 (70)              | 435 (71)              | 237 (73)             | 95 (70)               | 19 (73)        |
| Outreach/community service                    | 696 (57)                         | 65 (56)              | 364 (60)              | 185 (57)             | 70 (51)               | 12 (46)        |
| Internship                                    | 606 (50)                         | 58 (50)              | 338 (55)              | 141 (44)             | 58 (43)               | 11 (42)        |
| Employment related to field of study          | 580 (49)                         | 59 (51)              | 277 (45)              | 153 (47)             | 77 (57)               | 14 (54)        |
| Research                                      | 534 (44)                         | 44 (38)              | 268 (44)              | 138 (43)             | 69 (51)               | 15 (58)        |
| Certificate related to field of study         | 301 (25)                         | 31 (27)              | 161 (26)              | 77 (24)              | 25 (18)               | 7 (27)         |
| Service-based learning in a course            | 285 (24)                         | 29 (25)              | 131 (21)              | 89 (15)              | 31 (23)               | 6 (19)         |
| Study abroad                                  | 282 (23)                         | 33 (28)              | 159 (26)              | 64 (20)              | 21 (15)               | 5 (19)         |
| Other (text entry)                            | 14 (1)                           | 2 (2)                | 9 (1)                 | 2 (<1)               | 1 (<1)                | 0 (0)          |

Values are N, no. of respondents who selected each response option (with percentages of the proportion of responses relative to the total number of survey participants who answered this question in parentheses) (n = 1,211 total). A total of 4,165 responses were recorded, indicating some respondents selected more than one response option; thus the percentages total is >100%.

Table 6. Postgraduation plans

| Response Options | All Responses, N (% Respondents) | First Year (n = 122) | Second Year (n = 636) | Third Year (n = 331) | Fourth Year (n = 139) | Other (n = 26) |
|------------------|----------------------------------|----------------------|-----------------------|----------------------|-----------------------|----------------|
| Survey question: Do you have a job, graduate school, or professional school offer for after graduation? | | | | | |
| Yes, in my field of study. | 162 (13) | 9 (7) | 62 (10) | 40 (12) | 46 (33) | 5 (19) |
| Yes, but not related to my field of study. | 55 (4) | 4 (3) | 23 (4) | 20 (6) | 7 (5) | 1 (4) |
| No, but I am actively searching. | 228 (18) | 7 (6) | 79 (12) | 96 (29) | 36 (26) | 9 (35) |
| No, I plan to take a gap year. | 124 (10) | 1 (<1) | 34 (5) | 57 (17) | 30 (22) | 2 (8) |
| No, it is too early in my academic preparation. | 677 (54) | 101 (83) | 436 (69) | 118 (35) | 15 (11) | 7 (27) |
| Other. | 9 (<1) | 0 (0) | 2 (<1) | 0 (0) | 5 (4) | 2 (8) |

Values are N, no. of respondents who selected each response option and n, total no. of respondents for each year. Values in parentheses are the percentages of the proportion of responses relative to the total no. of survey participants who answered this question (n = 1,255 total). The percentages may not total >100% due to rounding.

Demographic and Academic Outcomes

Most faculty administered the 2019 Student Survey in a specific physiology course, although one institution distributed it to all majors within its program (University of Iowa). This may account for the relatively large response rate from predominantly second-year undergraduates who are typically enrolled in core physiology coursework at this time point. The demographic and academic characteristics of participants who completed the 2019 Student Survey were consistent with responses collected during the 2018 survey (unpublished data). Namely, the majority of respondents reported being female (68% in 2018 and 75% in 2019), white/Caucasian (81% and 63%, respectively), and of above-average academic ability. Although there is some overlap in participating programs (i.e., five programs administered both the 2018 and 2019 surveys), presumably a different cohort of students responded to each round of survey data gathering. These data are also congruent with the demographic characteristics of selected undergraduate students attending the 2014 and 2015 Experimental Biology conferences, as reported by Nichols et al. (11). We recognize that a significant consideration in the interpretation of these data may be related to an unequal distribution of participants across programs, particularly programs of varying institutional size and type, and academic standing. As the aim of this survey was to capture preliminary data and broadly identify undergraduate physiology student characteristics and perceptions, and responses from participants from differing institutions tended to show similar response patterns, we do not report subsets of the data by these important demographic considerations. Future
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consistent with the P-MIG curriculum survey results and what
concepts more frequently than recognition. Most core concepts,
reported a moderate understanding to mastery of individual core
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cept area for prospective medical students (4).

We ascertained student perceptions of core concepts of physi-
ology in physiology coursework. The purpose of the core con-
cepts of physiology is to promote enduring knowledge and
transfer of prior learning to novel applications, as might be
countered in the professional setting (6, 8). Survey participants
ported a moderate understanding to mastery of individual core
cepts more frequently than recognition. Most core concepts,
therefore, appear to be represented across physiology coursework
consistent with the P-MIG curriculum survey results and what
faculty report they are teaching in their physiology coursework
(15). Two general observations arose from evaluation of student
perceptions of core concepts. First, homeostasis and structure/

Table 7. Perceptions of career preparedness

| Survey Question | Level of Agreement | Responses, N (%) |
|-----------------|--------------------|------------------|
| Knowledge of physiology is important to achieve my career goals. (n = 1,253) | Strongly agree | 948 (76) |
| | Slightly to moderately agree | 205 (16) |
| | Neutral | 84 (7) |
| | Disagree | 16 (1) |
| My COURSEWORK has provided the necessary knowledge, skills, and abilities to succeed in my field after graduation. (n = 1,249) | Strongly agree | 677 (54) |
| | Slightly to moderately agree | 410 (32) |
| | Neutral | 145 (12) |
| | Disagree | 17 (1) |
| My undergraduate PROGRAM is preparing me to enter the workforce. (n = 1,251) | Strongly agree | 630 (50) |
| | Slightly to moderately agree | 400 (33) |
| | Neutral | 184 (15) |
| | Disagree | 37 (3) |
| I am optimistic that following graduation I will work in my preferred field. (n = 1,249) | Strongly agree | 760 (61) |
| | Slightly to moderately agree | 341 (27) |
| | Neutral | 129 (10) |
| | Disagree | 19 (2) |

Value are N, no. of respondents who selected each level of agreement (with the percentage relative to the total number of responses per question in parentheses). n, Total no. of survey participants who selected a response to each survey question. Percentages may not total 100% due to rounding.

Survey samplings will be constructed in a way to coordinate distribution to a wider range of institutional types and include a greater number of third- and fourth-year physiology undergraduates.

As expected, the majority of survey participants were seeking degrees in physiology or physiology-related programs (e.g., allied health or pre-healthcare professions tracts). A number of students reported plans to double-major (13%) or earn one or more minors or certificates (50%). Complementary areas of study include other STEM fields, as well as language/cultural studies and psychology. It is likely that this is driven by overlapping required courses (in the case of other STEM fields and psychology) or a recognition of cultural competency as a core competency area for prospective medical students (4).

We ascertained student perceptions of core concepts of physiology in physiology coursework. The purpose of the core concepts of physiology is to promote enduring knowledge and transfer of prior learning to novel applications, as might be encountered in the professional setting (6, 8). Survey participants reported a moderate understanding to mastery of individual core concepts more frequently than recognition. Most core concepts, therefore, appear to be represented across physiology coursework consistent with the P-MIG curriculum survey results and what faculty report they are teaching in their physiology coursework (15). Two general observations arose from evaluation of student perceptions of core concepts. First, homeostasis and structure/ function were the two core concepts common to the top rankings for self-reported mastery, the expectation to be remembered in 5 yr, and deemed to be career-relevant. Second, while cell membrane, cell theory, and energy were ranked within the top core concepts mastered and expected to be remembered (e.g., students reported high familiarity with these concepts), they were less frequently identified to be relevant for a future career. Alternatively, causality, interdependence, levels of organization, and scientific reasoning were among the top concepts reported as important for a future career. Thus an apparent discrepancy exists between what survey participants indicate they have learned or are currently learning in their physiology coursework and what might be relevant in a professional setting. One explanation for this discrepancy might be academic standing, as the majority of respondents report second-year status. Perhaps improved alignment between core concept familiarity and career relevance would emerge as students complete upper-level, advanced coursework in the major; however, we did not evaluate this. Even more broadly, and given these data are self-reported, it remains unknown what the knowledge level of these students actually is. Administration of validated assessments, such as Phys-MAPS (14), may be one mechanism for undergraduate programs to evaluate conceptual learning in physiology. Along similar lines, a given core concept’s enduring nature and/or applicability to their career remains yet to be directly examined.

Career Readiness: Co-Curricular Activities and Postgraduation Plans

One notable finding from the 2019 Student Survey was high interest in co-curricular opportunities. For example, 4,166 responses were provided from 1,221 survey participants regarding completion or planned participation in these types of activities. With the current survey design, it was not feasible to determine how many students plan to participate in one versus two, three, or more activities; however, the mathematical

Table 8. Advising-related questions

| Perceptions of the ability of specific staff (for example, academic advisors) or faculty members to provide accurate and helpful guidance for _ | Level of Agreement | Responses, N (%) |
|---------------------------------|--------------------|------------------|
| Course choices and progress toward degree completion | Strongly agree | 648 (52) |
| | Slightly to moderately agree | 408 (33) |
| | Neutral | 155 (12) |
| | Disagree | 35 (3) |
| Future career plans | Strongly agree | 486 (39) |
| | Slightly to moderately agree | 442 (33) |
| | Neutral | 241 (19) |
| | Disagree | 77 (6) |
| Non-coursework related opportu-

Values are N, no. of respondents who selected each level of agreement (with the percentage relative to the total number of responses in parentheses) (n = 1,246 total). Percentages may not total 100% due to rounding.
average suggests students may engage in multiple pre-professional opportunities before graduation. Two considerations for undergraduate physiology programming can be put forth from this generalization:

1. Undergraduate physiology students appear to recognize the value of blending discipline-specific content knowledge with gaining professional experience and development of career skills, as evidenced by the relatively high number of students who report planning to engage in one or more co-curricular activities before graduation.

2. Evaluation of planned participation in co-curricular activities by academic standing suggests that undergraduates may begin to seek out experiential opportunities relatively early in their academic preparation. Physiology programs should provide guidance regarding professional skills, prioritization of co-curricular opportunities, and professional school requirements early in a student’s career. This could occur through stand-alone courses, modules within existing courses, or additional required activities (7).

To gauge interest in coursework designed to enhance professional development, the following question was included in the prior pilot 2018 P-MIG Student Survey: “Some undergraduate physiology programs offer stand-alone courses aimed at building skills and abilities, such as critical thinking, working effectively in a group setting, oral and written communication, how to think as a scientist, etc. that are transferable from the academic to the professional setting. Which statement below most closely matches your opinion of this type of course?” Of the 559 students who selected one of the four response options for this question, 43% indicated they had previously completed this type of course and found it helpful. In contrast, only 11% of respondents reported they had completed this type of course and did not see a strong benefit. Twenty-four percent of respondents indicated that this type of course was not offered by their program. An additional 23% reported that their program does not offer this type of course, but, if it did, they would be interested in taking it. In summary, the majority of participants (66%) expressed a favorable view of coursework aimed at developing professional career skills and aptitudes (unpublished data).

We did not determine what proportion of engagement in course-based experiential learning and other co-curricular activities was a degree requirement versus elective coursework. We also did not examine student motivation for participation in co-curricular or volunteer activities, or ease of access to co-curricular and other activities that support professional development and career readiness. These are areas that may warrant greater exploration in the future.

Consistent with the number of first-, second-, and third-year undergraduates who completed the 2019 Student Survey, the majority of participants reported that it was too early in their academic preparation to seek employment or apply to graduate or professional programs. Of third- and fourth-year students, nearly four times more students reported employment in their field of study or acceptance into a related graduate/professional program than in a different field. Given the timing of survey administration, which was during the months of April and May, many students reported they were awaiting admittance decisions or actively searching for employment. Student attitudes regarding gap-year participation is another area that warrants greater focus in the future.

Community College Attendance and Transferable Coursework

A block of questions was included in the 2019 Student Survey to assess community college attendance, the timing of when courses were taken at community colleges (e.g., during high school, during summer sessions, before enrollment at a 4-yr institution), and the ease of transferring coursework between institutions. While data exist for general STEM disciplines, to our knowledge there is limited published data regarding the community college “pipeline” into established physiology degree programs (see Ref. 9). In our sample of seven participating physiology programs, community college attendance ranged from 37% to 79% of respondents. We did not determine from what discipline areas transferred courses were, which limits our ability to discuss whether they represent prerequisite science courses, general education courses, or required disciplinary (major) courses. Yet, based on the data collected, the majority of students are incorporating community college learning into their pathway to earning a degree from a 4-yr institution. This finding is congruent with the National Academy of Sciences report (12) that emphasized the potential of community colleges to broaden participation in STEM disciplines and influence undergraduate education in the life sciences. This may be especially important for underrepresented-minority and first-generation students, who may be more likely to attend community colleges before 4-yr institutions (9). For perspective, 24% and 19% of 2019 Student Survey respondents reported underrepresented-minority and first-generation status, respectively.

Advising Resources

Given that student success and persistence to graduation is of concern for students and programs, it is encouraging to see that a majority of students reported that they were satisfied with the level of advising they had received pertaining to course selection. The survey sample was largely from the University of Arizona, which utilizes a program-based, centralized, professional advising system, which may contribute to this finding, as evidence suggests greater student satisfaction with professional advising centers versus distributed faculty advising (1). Future surveys will attempt to discern how transfer course selections may be impacted by the advising model, access to academic advisors in advance of coursework completion, utilization of institution-specific database systems to evaluate transferable coursework, and the type of coursework completed. Less satisfaction with advising was reported for advisor knowledge of non-coursework opportunities and future career guidance compared with progress toward degree completion. Again, we did not determine whether the advising model corresponds with perceived satisfaction. However, no matter the academic advising system, it is clear that enhanced guidance and resources regarding future career opportunities and co-curricular involvement may be warranted. This conclusion aligns with what advisors themselves report as a current need in physiology program (5).

Considerations and Future Directions

Inclusion of inputs from a greater number of physiology and physiology-related programs, including international programs, would greatly strengthen the characterization of the undergraduate experience in physiology education. For example, the largest number of respondents from the 2019 survey were from a large, public, Hispanic-serving institution. We recognize the
Table A1. Questions included in the 2019 Physiology Majors Interest Group Student Survey

**Demographic Characteristics of Physiology Students**

The purpose of the first set of questions is to learn more about the demographic and academic characteristics of students enrolled in physiology coursework.

1. Your age (yr):
   - <18
   - 18–20
   - 21–22
   - 23–24
   - 25–29
   - >30
   - Prefer not to answer

2. Your gender:
   - Male
   - Female
   - Other
   - Prefer not to answer

3. Your ethnicity (select all that apply):
   - American Indian or Alaskan Native
   - Asian
   - Black or African American
   - Hispanic or Latino
   - Native Hawaiian or Pacific Islander
   - White or Caucasian
   - Other (text entry)
   - Prefer not to answer

4. Are you the first person in your immediate family (parents, siblings, children) to attend college?
   - Yes
   - No
   - Prefer not to answer

5. Are you an international student?
   - Yes
   - No
   - Prefer not to answer

6. Your SAT/ACT score:
   - <850/<16
   - 860–970/16–18
   - 980–1090/19–21
   - 1100–1190/22–24
   - 1200–1290/25–27
   - 1300–1410/28–30
   - 1420–1510/31–33
   - 1520–1600/34–36
   - Prefer not to answer

7. Your current class standing:
   - First-year student
   - Second-year student
   - Third-year student
   - Fourth-year student
   - Graduate student, in a physiology program
   - Graduate student, in a nonphysiology program
   - Non-degree-seeking graduate student
   - Community college student
   - Other (text entry)
   - Prefer not to answer

8. Your current GPA:
   - <2.00
   - 2.00–2.49
   - 2.50–2.99
   - 3.00–3.49
   - 3.50–3.79
   - 3.80–4.0
   - Prefer not to answer

9. Your primary program of study (major) (select all that apply):
   - Physiology/Human Physiology
   - Exercise Physiology/Exercise Science
   - Biomedical Sciences/Biomedical Engineering
   - Non-Physiology Basic Science (Biology, Biological Sciences, Biochemistry, Chemistry, Microbiology, Neuroscience)
   - Allied Health (Nursing, Pharmacy, Radiation Science/Therapy, Athletic Training, Nutrition Sciences/Dietetics)
   - Health (Health Administration, Health Promotion, Health Sciences, Public Health)

Continued
Table A1.— Continued

10. Are you seeking a minor or certificate in addition to your primary program/major? If so, list below.
   - No
   - Minor (text entry)
   - Certificate (text entry)

11. Have you ever enrolled in a course at a community college?
   - Yes
   - No
   - Prefer not to answer

12. Check any of the following that apply:
   - I enrolled in one or more courses at a community college while in high school.
   - I previously enrolled in one or more courses at a community college before transferring to my current institution.
   - I was previously enrolled full-time at a community college before transferring to my current institution.
   - I am currently enrolled in one or more courses at a community college.
   - I transferred to my current institution from a different 4-year undergraduate institution.
   - I have not transferred course credits from one institution to another.
   - Other (text entry)

13. If you have transferred enrollment from a previous institution to your current institution, check any of the following that apply:
   - My coursework transferred as expected, I did not experience any issues.
   - There was an issue with credits that transferred. Explain (text entry).
   - I had access to advisors at my new institution prior to transferring.
   - My new institution offered an orientation session for transfer students; it helped with the transition.
   - My new institution offered an orientation session for transfer students but it did not sufficiently prepare me. Explain (text entry).
   - I experienced other unexpected challenges. Explain (text entry).

14. P-MIG is interested in learning more about the feasibility of transferring coursework from one institution to another in order to complete a physiology degree program. Is there anything else important for P-MIG to know about your experience as a transfer student (good or bad) that was not included in the previous question?
   - Not applicable
   - Yes (text entry)

The next set of questions will ask about your physiology coursework.

15. The core concepts of physiology are “big picture” concepts that apply to numerous physiological processes. A description of each core concept is listed below. Indicate your perceptions related to each core concept. You may select more than one option for each core concept.*
   - This concept was not presented in my physiology coursework.
   - I recognize this concept, but I am not sure I can apply it to physiological functions.
   - I have a moderate understanding of this concept and can provide 1-2 physiological examples.
   - I have mastered this concept and can explain it to others.
   - I expect to remember this concept in 5 years.
   - This concept is important to understand for my future career.

16. Which of the following experiential learning activities have you already completed or plan to complete prior to graduation? Select all that apply.
   - Internship
   - Study abroad
   - Research
   - Job shadowing
   - Service-based learning activities, as part of a course
   - Outreach/community service activities related to my program of study (volunteering)
   - Employment related to my field of study
   - Earning a certificate in an area related to my field of study
   - Other (text entry)

17. Rate your level of agreement with the following statements.
   Likert scale criteria: Disagree, Neutral, Slightly to Moderately Agree, Strongly Agree
   - Knowledge of physiology is important to achieve my career goals.
   - My COURSEWORK has provided the necessary knowledge, skills, and abilities to succeed in my field after graduation.
   - My undergraduate PROGRAM is preparing me to enter the workforce.
   - I am optimistic that following graduation I will work in my preferred field.

18. Do you have a job, graduate school, or professional school offer for after graduation?
   - Yes, in my field of study.
   - Yes, but not related to my field of study.
   - No, but I am actively searching for a job, applying to programs, or awaiting acceptance.
   - No, I plan to take a gap year.
   - No, it is too early in my academic preparation.
   - Other (text entry).

   Academic Advising

Almost done! The next few questions are related to the academic advising you have received within your program.

19. Rate your level of agreement regarding the ability of specific staff (for example, academic advisors) or faculty members to provide accurate and helpful guidance for the following:
   Likert scale criteria: Disagree, Neutral, Slightly to Moderately Agree, Strongly Agree
   - Course choices and progress toward degree completion
   - Future career plans
   - Non-coursework related opportunities that would benefit my professional development

   Continued
importance of gathering data from other minority-serving institutions as well as other programs exhibiting diverse characteristics to broaden the scope of undergraduate inputs. In addition, gathering information from students currently enrolled in community colleges who plan to transfer to a 4-yr physiology or physiology-related degree program would be helpful in the future to establish guidelines to facilitate this process. Although students largely reported satisfaction with the course transfer process, irrespective of institutional affiliation, this survey did not capture the viewpoints of students who experienced limitations that precluded enrollment in physiology coursework at 4-yr institutions.

In addition to the previously described refinements to the survey administration process and question development, several other areas have been identified for consideration in future iterations of the Student Survey. Two such recommendations include gathering program information from faculty who may administer future surveys to better contextualize student responses, and development of a validated student survey tool that could be made available to programs for self-evaluation and monitoring changes in student characteristics over time.

Conclusions

The 2019 P-MIG Student Survey and direct inputs from current physiology undergraduates reveal four main areas for P-MIG and individual degree programs to consider with regard to generation of program-level guidelines and practices. First is the importance of pathways for transferable coursework, especially between community colleges and 4-yr physiology degree programs. Improving the clarity of course transfer options may facilitate the recruitment of students into physiology and physiology-related degree programs, especially students from any underrepresented population. The second broad recommendation is to consider mechanisms to enhance participation in co-curricular or course-based experiential learning opportunities. These types of experiences are deemed highly desirable by students and provide additional opportunities for development of professional and career skills before graduation. Third, physiology students report high engagement in the undergraduate experience, as evidenced by the number of students pursuing more than one degree credential, minors, and certificates, as well as co-curricular activities. However, this begs the question: Are undergraduate physiology students, similar to undergraduate students from many disciplines and institutions from across the United States (2), feeling overcommitted and overwhelmed by their self-reported high level of academic engagement? The fourth and final consideration for physiology programming arising from the 2019 P-MIG Student Survey, therefore, is continued effort to align course objectives, opportunities for professional development, and development of resources available to formal academic advisors as well as faculty. This may aid individualization of the undergraduate experience relative to occupational goals. Taken together, the collective data provide information from current physiology students that serves to inform the generation of consensus guidelines regarding curriculum, professional skills, and advising in undergraduate physiology, as well as development of a more robust survey tool for continued evaluation of student characteristics and perceptions.

This paper is published as part of a special collection/special issue from P-MIG, a grassroots organization that has formed to help develop programmatic guidelines for undergraduate degrees in the discipline and to serve those engaged in undergraduate physiology or physiology-related programs. To find out more about this collective, or get involved, please visit our website (https://www.physiologymajors.org/) and consider joining our list serv.

APPENDIX A: QUESTIONS INCLUDED IN THE 2019 P-MIG STUDENT SURVEY
See Table A1.

APPENDIX B: SELECTED SELF-REPORTED DEMOGRAPHIC AND ACADEMIC CHARACTERISTICS BY INSTITUTIONAL AFFILIATION
See Table B1.
Table B1. Selected self-reported demographic and academic characteristics by institutional affiliation

| Demographic/Characteristic | Gonzaga Universitya (n = 19) | Indiana State Universityb (n = 84) | Michigan State Universityc (n = 7) | University of Arizonaa (n = 882) | University of Daytond (n = 53) | University of Iowae (n = 105) | University of Minnesotaf (n = 71) |
|---------------------------|-----------------------------|-----------------------------------|-----------------------------------|---------------------------------|-------------------------------|-------------------------------|----------------------------------|
| Age, yr                   |                             |                                   |                                   |                                 |                               |                               |                                  |
| 18–20                     | 19 (100)                    | 46 (55)                           | 2 (29)                            | 655 (74)                        | 29 (55)                       | 53 (50)                       | 23 (32)                          |
| 21–22                     | 0 (0)                       | 29 (35)                           | 5 (71)                            | 165 (19)                        | 24 (45)                       | 48 (46)                       | 34 (48)                          |
| Gender                    |                             |                                   |                                   |                                 |                               |                               |                                  |
| Female                    | 13 (68)                     | 59 (70)                           | 7 (100)                           | 666 (76)                        | 42 (79)                       | 82 (78)                       | 49 (69)                          |
| Male                      | 6 (32)                      | 25 (30)                           | 0 (0)                             | 215 (24)                        | 11 (21)                       | 23 (22)                       | 22 (31)                          |
| Race/ethnicity            |                             |                                   |                                   |                                 |                               |                               |                                  |
| Asian                     | 2 (10)                      | 3 (3)                             | 1 (15)                            | 130 (13)                        | 0 (0)                         | 8 (7)                         | 11 (15)                          |
| Black/African             | 0 (0)                       | 9 (10)                            | 0 (0)                             | 45 (4)                          | 1 (2)                         | 2 (2)                         | 4 (5)                            |
| American Native           |                             |                                   |                                   |                                 |                               |                               |                                  |
| Hawaiian/Pacific Islander |                             |                                   |                                   |                                 |                               |                               |                                  |
| White/Caucasian           | 19 (91)                     | 69 (79)                           | 6 (86)                            | 567 (56)                        | 47 (82)                       | 95 (83)                       | 58 (75)                          |
| First-generation status   |                             |                                   |                                   |                                 |                               |                               |                                  |
| Yes                       | 0 (0)                       | 16 (19)                           | 1 (14)                            | 186 (21)                        | 5 (9)                         | 16 (15)                       | 7 (10)                           |
| No                        | 18 (95)                     | 68 (81)                           | 6 (86)                            | 690 (78)                        | 47 (89)                       | 89 (85)                       | 64 (90)                          |
| Class standing            |                             |                                   |                                   |                                 |                               |                               |                                  |
| First year                | 0 (0)                       | 19 (23)                           | 2 (29)                            | 74 (8)                          | 0 (0)                         | 17 (16)                       | 2 (3)                            |
| Second year               | 19 (100)                    | 24 (29)                           | 0 (0)                             | 527 (60)                        | 15 (28)                       | 21 (20)                       | 16 (23)                          |
| Third year                | 0 (0)                       | 26 (31)                           | 0 (0)                             | 204 (23)                        | 36 (68)                       | 37 (35)                       | 23 (32)                          |
| Fourth year               | 0 (0)                       | 13 (15)                           | 5 (71)                            | 63 (7)                          | 2 (4)                         | 28 (27)                       | 22 (31)                          |
| Seeking a minor or certificate |                         |                                   |                                   |                                 |                               |                               |                                  |
| Minor                     | 8 (38)                      | 47 (55)                           | 2 (29)                            | 408 (46)                        | 33 (63)                       | 48 (46)                       | 36 (53)                          |
| Certificate               | 2 (10)                      | 3 (3)                             | 0 (0)                             | 20 (2)                          | 2 (4)                         | 7 (7)                         | 1 (1)                            |
| Community college attendance |                             |                                   |                                   |                                 |                               |                               |                                  |
| Yes                       | 7 (37)                      | 47 (56)                           | 5 (71)                            | 557 (63)                        | 24 (45)                       | 83 (79)                       | 34 (48)                          |
| No                        | 12 (63)                     | 37 (44)                           | 2 (29)                            | 317 (36)                        | 29 (55)                       | 22 (21)                       | 36 (51)                          |
| Coursework transfer process |                             |                                   |                                   |                                 |                               |                               |                                  |
| Occurred as expected      | 4 (50)                      | 44 (67)                           | 4 (67)                            | 474 (74)                        | 19 (70)                       | 66 (65)                       | 37 (65)                          |
| Prior access to advisors  | 0 (0)                       | 7 (11)                            | 1 (17)                            | 73 (11)                         | 2 (7)                         | 13 (13)                       | 2 (4)                            |

Values are N, no. of responses for each response option listed (followed by the corresponding percentage of the total responses per institution per survey question in parentheses); n, total no. of participants from each institution. Percentages may not total 100% due to rounding, the selection of more than one response option, the selection of no response option, or selection of response options not listed in table. Program characteristics (collegiate affiliation, department, degree program, total number of majors in the program) are as follows: ¹School of Nursing and Human Physiology, Department of Human Physiology, BS Human Physiology, 210 majors; ²College of Health and Human Services, Department of Kinesiology, Recreation, and Sport, BS Exercise Science, 320 majors; ³College of Natural Science, Department of Physiology, BS Physiology, 410 majors; ⁴College of Medicine, Department of Physiology and Medical Sciences, BS Health Sciences, 2017 majors; ⁵School of Education and Health Sciences, Department of Health and Sport Science, BS Education (Exercise Physiology, Pre-Physical Therapy, Exercise Science, Dietetics), 380 majors; ⁶College of Liberal Arts and Sciences, Department of Health and Human Physiology, BS Human Physiology, 817 majors; ⁷College of Liberal Arts, Department of Integrative Biology and Physiology, BA Human Physiology, 376 majors.

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DISCLOSURES

No conflicts of interest, financial or otherwise, are declared by the authors.

AUTHOR CONTRIBUTIONS

J.R., J.L.M., C.I.S., P.L.C., and A.R.C. conceived and designed research; J.R. performed experiments; J.R. and A.R.C. analyzed data; J.R., J.L.M., C.I.S., P.L.C., and A.R.C. interpreted results of experiments; J.R. and A.R.C. drafted manuscript; J.R., J.L.M., C.I.S., P.L.C., and A.R.C. edited and revised manuscript; J.R., J.L.M., C.I.S., P.L.C., and A.R.C. approved final version of manuscript.

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