Establishing common course objectives for undergraduate exercise physiology

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Simonson SR. Establishing common course objectives for undergraduate exercise physiology. *Adv Physiol Educ* 39: 295–308, 2015; doi:10.1152/advan.00020.2015.—Undergraduate exercise physiology is a ubiquitous course in undergraduate kinesiology/exercise science programs with a broad scope and depth of topics. It is valuable to explore what is taught within this course. The purpose of the present study was to facilitate an understanding of what instructors teach in undergraduate exercise physiology, how it compares with various guidelines, and to continue the conversation regarding what should be taught. A survey was created using course outcomes from the American Society of Exercise Physiologists, National Association for Sport and Physical Education, Ivy's 2007 *Quest* article, the National Athletic Training Association, the National Council for Accreditation of Teacher Education, and 36 undergraduate exercise physiology course syllabi. The 134-item survey was disseminated to individuals who use exercise physiology: university faculty members, clinical exercise physiologists, researchers, and other practitioners on various exercise physiology lists; 2,009 surveys were sent, and 322 surveys were completed (16% rate of return). There was a high degree of agreement about a lot of important content in undergraduate exercise physiology. Instructors of exercise physiology should focus their curriculum on regulation and homeostasis (including adaptation, fatigue, and recovery), aerobic systems, bioenergetics, muscle physiology, and fitness principles. In addition, attention should be paid to performance and technical skills. In conclusion, it is up to exercise physiologists to ensure quality of knowledge and practice. Doing so will improve the uniformity and quality of practitioners within the various kinesiology/exercise science fields and increase the value of a Kinesiology/Exercise Science degree and set it apart from other healthcare providers and fitness professionals.

teaching; accreditation; curriculum; professional preparation

KINESIOLOGY/EXERCISE SCIENCE is a growing field, with some programs seeing increased student majors of >50% over 5 yr (4). Exercise physiology is often a required course in several academic majors within kinesiology/exercise science, including, but not limited to, athletic training, exercise/movement science, health education and promotion, and physical education. Beyond being a component of the kinesiology/exercise science curriculum, exercise physiology is also growing as an academic major. Employment opportunities for exercise physiologists are on the rise (15). Students are increasingly choosing exercise physiology as an undergraduate major in preparation for careers in medicine, physical therapy, and occupational therapy as well (15). All of these students, from the personal trainer to the physician, are taking basic exercise physiology courses. This cornerstone course is being asked to address a myriad of needs, and it is this core course that is the topic of the present article.

Exercise physiology is the study of the systems that allow physical activity and the acute and chronic responses to that physical activity (6). The breadth and depth of exercise physiology are rapidly expanding and include responses of novices through elite athletes as well as pathophysiology, genetics, and some aspects of virtually every organ system (6). Undergraduate exercise physiology can be the last course in this content area that students take or can provide foundational concepts for other related courses, i.e., exercise testing and prescription, principles of conditioning, clinical exercise physiology, and graduate work in exercise physiology. Considering the importance of this content area, the broad scope and incredible depth of topics, and the potential need for an even greater understanding as healthcare reform continues, it is a valuable task to explore what is taught within the introductory exercise physiology course.

In courses where the content is so far reaching, determining what to teach and how to teach it challenges many (8, 10, 16). When many begin to teach, they teach what they were taught or they follow the curriculum in the chosen text. Is this the best way to determine what we teach in undergraduate exercise physiology?

Instructors often teach what they feel is important or what is found in the textbook. For example, if one teaches what in the textbook, which text should be used? A review of the table of contents of exercise physiology texts demonstrates how the field has changed over the last 30 yr and that the instructor covering the same content that they were exposed to in their undergraduate exercise physiology course may be inadequate. In addition, of 11 exercise physiology texts, 7 different methods of organization were used, with all including chapters on metabolism/bioenergetics, the cardiovascular system, the pulmonary system, the nervous system, and muscle (9, 17, 19, 24, 27, 34, 35, 37–39, 43). Most also included chapters covering the endocrine system, aerobic and anaerobic exercise, resistance exercise, training, body composition, weight control, disease prevention, thermoregulation, and environmental physiology. Growth, development, aging, clinical exercise physiology, prescription, and sex differences were found in some. Immunology, history, and altitude were found in a few. Psychology, biomechanics, anatomy, professions, diving, microgravity, molecular biology, research, flexibility, and fallacies/fads were chapter titles found in single texts. A page count of these same 11 undergraduate exercise physiology texts from a variety of publishers found the mean (± SD) to be 578 ± 198 pages (range: 295-1,028 pages) (9, 17, 19, 24, 27, 34, 35, 37–39, 43). Thus, one can see that most exercise physiology texts contain so much and varied content that it cannot all be covered in an undergraduate course. Again, how is the instructor to decide which chapters/content to include?

The use of specific learning outcomes directs content selection and enhances teaching through the increased instructor use of evidence-based instructional practices and improves student

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learning (14, 22, 31, 40, 42). When an instructor prepares student course outcomes, where does one obtain guidance as to what of the great breadth and depth of exercise physiology should be taught so that we ensure consistency and quality within the profession and among practitioners?

First, why is ensuring consistency and quality across programs and courses worthy of our attention? Faculty members have an ethical and professional obligation to ensure students taking the same course at different institutions have the same understanding of the content. Establishing standards leads to graduates prepared to enter the workforce with a solid educational foundation and holds programs accountable to the constituents they serve and to each other. Consistent monitoring of quality forces academic programs to keep up with changing fields, attract better students, tend toward more proficient faculty members, and provide a sound education (1, 3, 7, 13, 28).

Second, the source of the course outcomes matters. Accreditation agencies for the National Athletic Training Association and for teacher education have identified outcomes related to exercise physiology. Exercise physiologists and practitioners have also done so through the American Society of Exercise Physiologists (ASEP). The guidelines available as to what exercise physiology might entail include the following: *1*) 1999 ASEP Accreditation (7), *2*) 2008 National Association for Sport and Physical Education standards (29), *3*) Ivy's recommendations in a 2007 article in *Quest* (20), *4*) the National Athletic Training Association (12), and *5*) the National Council for Accreditation of Teacher Education (28–30). However, there are currently only five ASEP-accredited programs (5). In addition, while ASEP and Ivy have recommended reasonable outcomes, standard course objectives for undergraduate exercise physiology have not gained the widespread acceptance as have the outcomes in other content areas. The American Chemical Society (ACS)'s outcomes for chemistry programs and courses of all levels, Accreditation Board for Engineering and Technology's accreditation of Applied Science, Computer Science, Engineering, and Engineering Technology programs, or the Commission on Collegiate Nursing Education's (CCNE) accreditation of nursing curriculum are examples of a few successful efforts to promote consistency and quality across courses and academic programs (1, 3, 13).

There has not been a successful movement to ensure consistency and quality of the core knowledge, skills, and outcomes of the cornerstone exercise physiology course. It would benefit the field and those who work with exercise physiologists to find out what we actually intend to teach and either confirm the present standards or suggest updated standards. The creation of a common exercise physiology curriculum will allow instructors and institutions to *1*) identify how we can best prepare our students for their careers of choice, *2*) ensure employers that they are employing knowledgeable professionals, *3*) enable comparisons between courses and programs, *4*) use standardized testing, *5*) improve courses and programs, *6*) write department outcome objectives for programs, *7*) measure and compare student performance and improvement, and *8*) evaluate various teaching strategies (3, 5, 12, 30). The purpose of the present study was to facilitate an understanding of what instructors are teaching in undergraduate exercise physiology, how it compares with the various guidelines, and to continue the conversation regarding what should be taught in this ubiquitous course.

METHODS

The Institutional Review Board approved this study, and all participants provided informed consent. A survey was created to explore what the common curriculum of an undergraduate exercise physiology entails. The initial step in building the survey was to accumulate the previously mentioned outcomes. In addition, a request for course syllabi detailing student outcomes went out to 156 university faculty members identified as teaching undergraduate exercise physiology. Course outcomes were compiled from the 36 syllabi that identified student outcomes (from a pool of 50 syllabi received, 32% rate of return) and added to those edited, combined, and compiled from Ivy's 2007 *Quest* article, the 2006 National Association for Sport and Physical Education standards, the National Athletic Training Association, and the National Council for Accreditation of Teacher Education (12, 20, 28–30).

To identify key concepts and outcomes that must be covered in every undergraduate exercise physiology course, a 134-item survey that included demographic data, lecture course outcomes, and laboratory equipment was created on KwikSurveys (http://kwiksurveys.com/). The survey was disseminated to individuals who use exercise physiology in their careers: university faculty members, clinical exercise physiologists, researchers, and other practitioners who self-identified an interest/career in exercise physiology. While the number of university faculty members, researchers, and other practitioners identifying themselves as exercise physiologists is unknown, as of May 2014, United States Bureau of Labor statistics indicate ~6,660 exercise physiologists in the United States (10a). Survey recipients were identified via an internet search and open-access membership directories of professional associations using the key words "exercise physiology." This was not a random sample as there is no one list of all exercise physiologists from which to draw. In addition, professional organizations did not assist in the development and distribution of this survey, and potential respondents may have been missed. Two-thousand and nine surveys were sent from the principal investigator's e-mail. Three-hundred twenty-two surveys were completed for a 16% rate of return.

Survey respondents were asked to score each of the potential outcomes as follows:

1 = Essential
2 = Beneficial
3 = Nice if there is time and/or expertise
4 = Not necessary
5 = Should NOT be included
6 = Should be included in a course OTHER than undergraduate exercise physiology
No opinion

Survey result means, SDs, medians, and modes were calculated for all respondents combined and for each respondent job category. Outcomes and equipment were ranked by mean and then SD for all respondents combined and for each respondent job category individually.

RESULTS

The 50 syllabi received (32% rate of return) were highly variable in their level of detail and information; only 36 syllabi (72%) contained learning outcomes. Three-hundred twenty-one surveys of 2,009 requests were completed for a 16% rate of return. Response rates from online surveys tend to be lower than mailed, telephone, or face-to-face surveys, with response rates varying from 8% to 42%, suggesting the current study's response rate, while low, was within expectations (18).

The majority of respondents identified themselves as undergraduate faculty members (123 respondents, 38.32%). Research (90 respondents, 28.04%) and clinical exercise physiology (71 respondents, 22.12%) were the second and third most frequent types of employment. Personal trainers and strength and conditioning coaches comprised 17 respondents (5.30%) and 8 respondents (2.49%), respectively, and the remaining 13 respondents (3.73%) were from other fields, such as health promotion, nursing, chiropractic, etc. In accordance with the employment results, the majority of respondents indicated that their highest academic degree was a Doctorate (62.62%) with a Master's degree as the second most frequent response (28.04%). No other level of academic preparation was represented by >6% of respondents. Respondents were also highly experienced, with >20 yr (35.10%) being the most frequent response followed by 10–20 yr (29.5%).

Respondent input as to who should be required to take an undergraduate exercise physiology course is shown in Table 1. Others included any health-related field, coaches, psychologists, politicians, and nurses/physicians' assistants.

Taking together the course outcome results shown in Tables 2–5, 76 objectives had a mode of 1 (essential), 5 objectives had a mode of 2 (beneficial), 1 objective had a mode of 3 (nice if time/expertise), 13 objectives had a mode of 6 (include in another course), and no objective had a mode of 5 (should not be included). Four tiers of outcomes were established based on the level of respondent agreement. *Tier 1* contained 46 of the objectives for which >50% of respondents indicated an essential ranking. Furthermore, 26 of these objectives were rated as essential by >66.8% of respondents (Table 2). Agreement was >70% if beneficial rankings were included for the 46 objectives and >88% for the 26 top-ranked objectives. *Tier 2* contained an additional 37 objectives (total of 83 objectives when combined with *tier 1*) of all those for which >50% of respondents indicated a ranking of beneficial or essential; there were 16 additional objectives (total of 62 objectives) if the cutoff was limited to a two-thirds majority (Table 3). The remaining 12 outcomes included on the survey for which <50% of the respondents indicated an essential or beneficial ranking were in *tier 3* and are shown in Table 4. An additional 16 outcomes proposed by the survey respondents were in *tier 4* and are shown in Table 5.

Table 1. *Percentage of respondents indicating which professions should include an undergraduate exercise physiology course in the curriculum*

Profession	%
Exercise Physiology	95.51
Cardiac Rehabilitation	94.87
Personal Training	92.95
Physical Education	92.63
Athletic Training	90.71
Corporate Wellness/Health	89.74
Physical Therapy	86.86
Pulmonary Rehabilitation	83.97
Biomechanics	78.85
Medicine	78.53
Health Education/Promotion	74.68
Occupational Therapy	67.95
Dietician	59.29
Ergonomics	53.21
Chiropractic	51.28

Outcomes and equipment were also ranked by mean and then SD for all respondents combined and for each respondent job category and are also shown in Tables 2–6.

Tier 1 outcomes by content area were as follows:

- Regulation/homeostasis/adaptation contained the most outcomes with 30, the highest ranking of which can be found at *position 6*. Within this category,

1. Understanding fatigue and recovery contained 4 outcomes, with the highest being in *position 15*.

2. The nervous system contained 4 outcomes, with the highest found in *position 26*.

3. The endocrine system and environmental physiology contained 2 objectives, with the highest in the endocrine system being in *position 23* and the highest in environmental physiology being in *position 30*.

- Aerobic systems contained 15 outcomes, with the highest ranking found at *position 2* and the highest ranking skill found at *position 31*.
- Bioenergetics/energy transfer contained 12 outcomes, with the highest ranking found in *position 1*.
- Muscle physiology contained 11 outcomes, with the highest ranking found in *position 5*.
- Fitness principles contained 8 outcomes, with the highest ranking found in *position 18*.
- Performance-related outcomes contained 5 items, with the highest ranking found in *position 7*.
- Technical skills contained 2 objectives, with the highest in *position 31*.

While many of the same content areas were found beyond *tier 1*, the following additional content areas were also included:

- Development and sex
- Process skills (scientific thought, teamwork, etc.)
- Bone
- Pathophysiology

Content areas not previously included but found in the outcomes suggested by respondents, *tier 4*, were history and genetics.

As shown by the laboratory equipment results in Table 6, 19 items had a mode of 1 (essential), 1 item had a mode of 2 (beneficial), 5 items had a mode of 3 (nice if available), and no items had modes of 4 or 5 (not necessary or should not be included, respectively). There were nine items for which >50% of respondents indicated an essential ranking, and none of these were rated as essential by more than two-thirds of respondents (highest agreement was 57.8%). Agreement was >59% if beneficial rankings were included for the nine items. Another items (total of 13 items) were encompassed if all those for which >50% of respondents indicated a ranking of beneficial or essential were included.

Because of the amount of content most respondents believed should be covered in an undergraduate exercise physiology course, 64.2% indicated that the course should be a three-semester-long credit course (15 contact hours/credit hour), 17.8% preferred a 4-credit offering, and 5.3% supported 2 credits; 86.3% indicated that a required laboratory should be offered in conjunction with exercise physiology, and 54.5% believed that this should be worth 1 semester credit (30 contact

Table 2. *Tier 1 outcomes receiving an essential and/or beneficial ranking with >50% of respondents indicating essential outcomes, content area, most frequent response (mode), and ranking by employment category*

Outcome	Content Area	Mode	Essential Ranking, %	Essential and Beneficial Ranking Combined, %	Combined Overall Ranking	Ranking by Undergraduate Educators	Ranking by Researchers	Ranking by Clinical Personnel	Ranking by Personal Trainers	Ranking by Strength and Conditioning Coaches	Ranking by "Other"	Outcome Source
Demonstrate the ability to distinguish between aerobic and anaerobic metabolism.	Bioenergetics/energy transfer	1	96.1	99.6	1	1	1	1	1	1	2	
Define the various terms that apply to cardiovascular performance (heart rate, stroke volume, cardiac output, etc.)	Aerobic systems	1	93.0	97.5	2	6	5	2	8	6	2	
Describe the role of carbohydrates, fats, and proteins as fuels for aerobic and anaerobic metabolism.	Bioenergetics/energy transfer	1	92.6	98.4	3	3	7	3	1	1	2	NASPE
Explain the energy continuum (ATP, creatine phosphate, anaerobic glycolysis, and oxidative pathways) and how each metabolic pathway relates to various forms of exercise.	Bioenergetics/energy transfer	1	91.5	98.1	4	2	4	6	1	1	2	NASPE
Describe the muscle fiber types and identify differences between them.	Muscle physiology	1	88.2	95.6	5	8	2	10	18	9	49	Ivy
Describe the normal acute responses to resistance training.	Regulation/homeostasis/adaptation Muscle physiology	1	86.0	95.2	6	10	11	5	27	1	36	
Identify and explain factors that are associated with maximal exercise performance (maximal O_2 consumption, lactate threshold, economy of effort, sex, age, etc.) and fatigue (depletion of fuel, accumulation of lactic acid/H^+, neuromuscular failure, etc.).	Performance related	1	85.7	94.6	7	4	6	19	14	18	49	NASPE
Define the related terms: hypertrophy, atrophy, and hyperplasia.	Muscle physiology	1	84.6	94.3	8	16	12	8	18	9	2	
Explain/identify the "anaerobic threshold."	Bioenergetics/energy transfer	1	84.6	96.5	9	5	18	4	6	13	14	
Describe muscle actions, such as isotonic, isometric, isokinetic, concentric, and eccentric.	Muscle physiology	1	84.2	91.2	10	28	9	13	12	1	43	
Describe blood pressure responses associated with acute exercise, including changes in body position.	Aerobic systems	1	82.9	95.4	11	7	15	9	8	24	10	
Describe the mechanics of muscular contraction from depolarization of the motor neuron through the sliding filament theory.	Muscle physiology	1	82.0	89.9	12	19	3	33	31	42	49	NASPE
Demonstrate an understanding of the O_2 deficit, O_2 debt, and excess postexercise O_2 consumption.	Aerobic systems	1	80.2	94.2	13	9	8	26	1	32	19	
Describe the normal cardiac responses to acute exercise across the lifespan.	Regulation/homeostasis/adaptation Aerobic systems	1	78.6	94.7	14	21	10	11	15	24	2	NASPE
Demonstrate knowledge of the common theories of muscle fatigue.	Bioenergetics/energy transfer Muscle physiology Fatigue and recovery	1	76.8	91.7	15	12	20	21	34	53	39	Ivy
Demonstrate an understanding of the oxyhemoglobin dissociation curve.	Aerobic systems	1	76.3	91.3	16	15	17	41	15	6	34	
Describe the normal respiratory responses to acute exercise across the lifespan.	Regulation/homeostasis/adaptation Aerobic systems	1	75.7	92.2	17	23	19	14	23	24	2	NASPE
Identify and describe the health related components of physical fitness (cardiorespiratory endurance, muscular strength and endurance, flexibility, body composition, etc.).	Fitness and conditioning principles	1	75.6	87.1	18	38	23	17	11	6	1	NASPE
Describe the mechanisms of gas transport and the laws governing them.	Regulation/homeostasis/adaptation Aerobic systems	1	75.0	90.8	19	17	21	32	26	44	14	

Continued

Table 2.—*Continued*

Outcome	Content Area	Mode	Essential Ranking, %	Essential and Beneficial Ranking Combined, %	Combined Overall Ranking	Ranking by Undergraduate Educators	Ranking by Researchers	Ranking by Clinical Personnel	Ranking by Personal Trainers	Ranking by Strength and Conditioning Coaches	Ranking by "Other"	Outcome Source
Describe the normal vascular responses to acute exercise across the lifespan.	Regulation/homeostasis/adaptation Aerobic systems Bioenergetics/energy transfer	1	74.8	93.4	20	24	14	12	15	24	2	
Identify and explain various physiological factors limiting performance of various sports and physical activities.	Aerobic systems Muscle physiology Performance related Fatigue and recovery	1	74.2	91.5	21	13	22	23	10	44	24	
Explain the body's drive to maintain homeostasis as acutely responsive and adaptive mechanisms.	Regulation/homeostasis/adaptation	1	74.1	93.0	22	11	13	20	45	24	54	
Explain the factors related to recovery from physical activity.	Aerobic systems Bioenergetics/energy transfer Muscle physiology Fatigue and recovery Endocrine system	1	71.3	93.4	23	14	26	16	22	13	26	
Explain the importance of maintaining proper hydration before, during, and after exercise.	Regulation/homeostasis/adaptation Performance related Fatigue and recovery	1	69.8	90.3	24	22	34	18	13	62	36	
Demonstrate knowledge of the common theories of delayed onset muscle soreness.	Muscle physiology	1	67.5	89.0	25	18	31	22	39	53	56	
Describe the role of the nervous system in acute and chronic physical activity.	Regulation/homeostasis/adaptation The nervous system	1	66.8	88.9	26	20	25	15	38	40	67	
Describe acid/base balance and regulation.	Regulation/homeostasis/adaptation Aerobic systems	1	64.7	86.3	27	25	16	40	65	57	39	
Describe and compare cardiovascular/respiratory adaptations (across the lifespan) at rest and during submaximal and maximal exercise following chronic aerobic exercise.	Regulation/homeostasis/adaptation Aerobic systems	1	64.7	88.7	28	27	32	31	31	24	55	NASPE
Describe the metabolic adaptations (across the lifespan) at rest and during submaximal and maximal exercise after chronic aerobic and anaerobic exercise.	Regulation/homeostasis/adaptation Bioenergetics/energy transfer	1	64.3	89.9	29	29	27	24	33	13	14	NASPE
Explain the role of water and the importance of hydration in human performance.	Regulation/homeostasis/adaptation Performance related Environmental physiology	1	63.8	85.9	30	32	38	42	25	73	56	
Demonstrate the measurement of energy expenditure using various ergometers and the use of indirect calorimetry (gas collection) to evaluate exercise intensity and macronutrient catabolism.	Aerobic systems Technical skills	1	63.0	85.6	31	30	30	52	51	20	29	
Explain the reflex actions related to activation of the muscle spindle and Golgi tendon organ.	Regulation/homeostasis/adaptation The nervous system	1	62.8	84.1	32	36	33	35	48	61	42	NASPE
Analyze and identify the physiological requirements of sports and physical activities.	Aerobic systems Bioenergetics/energy transfer Muscle physiology Performance related	1	62.7	87.3	33	26	36	25	1	20	38	

Continued

Table 2.—*Continued*

Outcome	Content Area	Mode	Essential Ranking, %	Essential and Beneficial Ranking Combined, %	Combined Overall Ranking	Ranking by Undergraduate Educators	Ranking by Researchers	Ranking by Clinical Personnel	Ranking by Personal Trainers	Ranking by Strength and Conditioning Coaches	Ranking by "Other"	Outcome Source
Describe the physiologic principles related to warmup and cooldown.	Regulation/homeostasis/adaptation Fitness and conditioning principles	1	60.8	81.1	34	37	48	7	60	49	43	NASPE
Identify neuromuscular adaptations (across the lifespan) at rest and during submaximal and maximal exercise after chronic resistance training.	Regulation/homeostasis/adaptation Muscle physiology The nervous system	1	60.6	84.5	35	34	39	34	43	23	23	NASPE
Explain the various lung volumes and their practical application.	Aerobic systems	1	58.8	87.1	36	31	29	37	42	24	19	
Explain thermoregulatory responses to hot and cold environments across the lifespan.	Environmental physiology	1	58.7	82.1	37	35	35	30	54	49	56	NASPE
Describe proprioception.	Regulation/homeostasis/adaptation The nervous system	1	58.1	78.2	38	43	40	38	47	66	70	
Apply basic training principles (specificity, overload, progression, periodization, individual differences, warmup, cooldown, reversibility, etc.) in the design of safe exercise programs for developing health, physical fitness, or athletic performance for people of various age groups, fitness levels, and with various medical limitations, cultures, and ethnicity.	Fitness and conditioning principles	1	57.4	72.4	39	59	60	43	58	13	79	NASPE
Describe the role of the endocrine system in acute and chronic physical activity.	Regulation/homeostasis/adaptation Endocrine system	1	56.0	83.9	40	33	24	39	59	49	88	
Understand the theory behind and demonstrate the ability to use metabolic equations.	Bioenergetics/energy transfer	1	55.8	78.7	41	57	28	29	28	32	10	
Explain the distinction among the terms physical activity, exercise, and physical fitness.	Fitness and conditioning principles	1	54.4	82.4	42	41	42	27	45	32	46	NASPE
Explain current recommendations for physical activity across the lifespan.	Fitness and conditioning principles	1	52.6	76.3	43	53	51	36	29	22	13	NASPE
Explain the components of body composition and assess markers of obesity and body composition across the lifespan.	Regulation/homeostasis/adaptation Bioenergetics/energy transfer Fitness and conditioning principles	1	52.6	74.4	44	50	50	63	79	53	10	NASPE
Describe the relationship between regular physical activity and various indices of health across the lifespan.	Fitness and conditioning principles	1	50.7	74.8	45	55	43	45	35	32	18	NASPE
Demonstrate an ability to assess body composition using a variety of methods.	Bioenergetics/energy transfer Fitness and conditioning principles Technical skills	1	50.5	69.3	46	58	67	64	69	19	56	

"Other," responses from those in other fields than those shown. Sources that are blank were from submitted syllabi. NASPE, National Association for Sport and Physical Education (16). Reference 11 is Ivy. NATA, National Association of Athletic Trainers (18).

Table 3. *Tier 2 outcomes receiving an essential and/or beneficial ranking from >50% of respondents, most frequent response (mode), and ranking by employment category*

Outcome	Content Area	Mode	Essential Ranking, %	Essential and Beneficial Ranking Combined, %	Combined Overall Ranking	Ranking by Undergraduate Educators	Ranking by Researchers	Ranking by Clinical Personnel	Ranking by Personal Trainers	Ranking by Strength and Conditioning Coaches	Ranking by "Other"
Recognize the effects and risks of ergogenic aids on health and performance.	Muscle physiology	1	77.1	47	63	61	60	77	83	34	NASPE
Evaluate and interpret anaerobic or short-burst fitness across the lifespan (sprints, vertical jump test, Wingate bike test, etc.).	Fitness and conditioning principles	1	77.0	48	42	44	61	37	44	14	NASPE
Explain the physical signs of overtraining and provide recommendations for this problem.	Performance related	1	76.7	49	71	66	78	70	80	80	
Recognize developmental changes that take place in the cardiovascular and respiratory systems across the lifespan.	Development and Sex	1	75.0	50	56	47	28	30	24	19	NASPE
Demonstrate knowledge of the common theories of muscle cramps.	Muscle physiology	1	74.7	51	39	49	47	54	59	74	
Identify and use various resources to analyze and interpret published, peer-reviewed research to answer questions relevant to exercise physiology.	Process skills: scientific thought, teamwork, etc.	1	73.9	52	47	52	56	20	75	64	
Collaborate with others to examine and describe the systems and principles of exercise physiology.	Process skills: scientific thought, teamwork, etc.	1	73.4	53	45	55	58	20	60	29	
Describe the role of the kidneys in acute and chronic physical activity.	Regulation/homeostasis/ adaptation	1	73.3	54	44	41	46	53	64	76	
Use assessment data and apply basic training principles to enhance bioenergetics.	Bioenergetics/energy transfer Fitness and conditioning principles	1	71.7	55	48	69	62	6	44	27	NASPE
Explain the influence of growth, development, sex, and aging on neuromuscular function (muscular strength/endurance, flexibility, etc.).	Development and Sex	1	70.6	56	67	45	48	44	42	75	
Describe the role of the immune system in acute and chronic physical activity.	Regulation/homeostasis/ adaptation	1	68.7	57	52	37	50	66	49	80	
Explain the sex-related differences in fitness that occur at the onset of adolescence and across the lifespan.	Development and sex	1	68.7	58	51	53	54	52	32	65	NASPE
Explain the unique physiologic considerations of children, older adults, persons with diabetes, pregnant women, and persons who are overweight/obese.	Development and sex Bioenergetics/energy transfer	1	68.3	59	64	58	49	40	56	87	
Explain the role of nutrition in human performance.	Bioenergetics/energy transfer	1	67.5	60	60	57	65	36	81	92	Ivy
Monitor intensity during the warmup, primary activity, and cooldown components of an aerobic exercise session (blood pressure, heart rate, and rating of perceived exertion).	Technical skills	1	66.9	61	61	70	73	75	32	29	NASPE
Assess and evaluate muscular strength and muscular endurance across the lifespan.	Technical skills Muscle physiology	1	66.7	62	78	63	69	63	9	61	NASPE
Explain the physical signs of overtraining and provide recommendations for this problem.	Performance related	1	65.2	63	40	56	44	24	13	67	
Clearly and concisely communicate an appropriate interpretation of current trends and popular literature in relation to physical fitness, health, and human performance.	Process skills: scientific thought, teamwork, etc.	2	64.2	64	49	73	75	71	78	53	
Demonstrate knowledge regarding the effects of exercise training on bone density across the lifespan.	Bone	1	64.2	65	46	46	51	49	40	29	NASPE
Assess cardiorespiratory endurance through field testing and demonstrate competency in evaluating and applying that information in the development or modification of a conditioning program.	Technical skills	1	64.0	66	73	72	72	76	32	27	NASPE

Continued

Table 3.—*Continued*

Outcome	Content Area	Mode	Essential Ranking, %	Essential and Beneficial Ranking Combined, %	Combined Overall Ranking	Ranking by Undergraduate Educators	Ranking by Researchers	Ranking by Clinical Personnel	Ranking by Personal Trainers	Ranking by Strength and Conditioning Coaches	Ranking by "Other"
Apply the frequency, intensity, time, and type principle and compute the target heart rate zone in the design of exercise programs to enhance cardiorespiratory fitness.	Fitness and conditioning principles	1	63.8	67	74	71	76	63	32	43	NASPE
Demonstrate an understanding of the methods of research in the field of exercise physiology.	Process skills: scientific thought, teamwork, etc.	1	63.2	68	65	65	71	57	77	78	
Identify personal lifestyle factors that impact fitness, health, longevity, and quality of life.	Process skills: scientific thought, teamwork, etc.	1	63.2	69	76	75	55	74	78	72	
Demonstrate a basic understanding of coronary artery disease and how long term physical activity moderates selected risk factors for heart disease (blood pressure, cholesterol, diabetes, obesity, etc.).	Pathophysiology	1	62.3	70	80	68	70	49	70	29	NASPE
Explain how different combinations of training load, repetitions, sets, and rest intervals yield enhanced muscular performance relative to muscular strength, muscular endurance, and muscular power.	Fitness and conditioning principles	1	62.1	71	81	64	66	60	9	49	
Describe the metabolic characteristics of children and how differences in the energy continuum (compared with adults) relate to patterns of childhood activity.	Development and sex	2	61.8	72	66	62	68	56	58	62	NASPE
Explain the components of flexibility and how to modify each.	Fitness and conditioning principles	1	61.5	73	68	80	59	81	72	62	NATA
Explain the physiologic responses to hypobaric and hyperbaric environments.	Environmental physiology	1	59.9	74	54	54	57	72	71	66	
Identify the macronutrients and their roles in the human body.	Bioenergetics/energy transfer	1	59.6	75	70	76	83	41	88	90	
Explain the concept of optimal weight for athletic performance and acknowledge the dangers of excessive weight loss and excessive training.	Fitness and conditioning principles	1	59.0	76	82	77	80	82	73	56	NASPE
Be able to explain the principles and basic interpretation of electrocardiography.	Technical skills Pathophysiology Aerobic systems	1	57.3	77	69	81	86	91	63	82	
Administer field estimates of physical activity/energy expenditure (activity recall, pedometers, accelerometers, etc.).	Technical skills	2	56.0	78	72	74	77	81	82	47	NASPE
Demonstrate knowledge regarding the effects of growth on fitness and the effects of regular physical activity on growth.	Development and sex	1	55.9	79	62	59	53	62	48	24	NASPE
Understand the professional opportunities provided to exercise physiologists and the role they play in healthcare and wellness in addition to traditional practices in exercise and athletics.	Process skills: scientific thought, teamwork, etc.	1	55.7	80	79	84	67	73	60	71	
Identify and explain the action and effectiveness of the most common ergogenic aids.	Muscle physiology	2	54.2	81	77	82	84	67	83	77	Ivy
Practically apply the knowledge gained to other fields in exercise science and physical education, i.e., coaching, teaching, and clinical settings.	Process skills: scientific thought, teamwork, etc.	2	53.9	82	75	79	79	83	69	86	
Apply the basic training principles with consideration to safety and proper supervision to enhance muscular fitness in across the lifespan.	Fitness and conditioning principles Technical skills	6	52.0	83	89	78	74	80	87	73	NASPE
Evaluate flexibility of across the lifespan with an understanding of safety and validity issues concerning selected assessments.	Muscle physiology	1	77.1	84	88	87	81	88	66	89	NASPE

Table 4. *Tier 3 outcomes with <50% of respondents indicating essential and/or beneficial, most frequent response (mode), and ranking by employment category*

Outcome	Content Area	Mode	Essential Ranking, %	Essential and Beneficial Ranking Combined, %	Combined Overall Ranking	Ranking by Undergraduate Educators	Ranking by Researchers	Ranking by Clinical Personnel	Ranking by Personal Trainers	Ranking by Strength and Conditioning Coaches	Ranking by "Other"
Identify the micronutrients and their roles in the human body.	Technical skills Fitness and conditioning principles	6	33.2	85	83	86	91	68	88	95	
Provide instruction for skillful movement, physical activity, or fitness including the "how" and "why" of the movement, physical activity, or fitness.	Bioenergetics/energy transfer	6	33.2	86	87	93	87	84	76	93	
Exhibit a thorough understanding of weight management concepts (proper nutrition, physical activity, and behavior modification).	Technical skills	6	33.2	87	86	89	82	85	86	85	NASPE
Prescribe exercise that would optimize the development and maintenance of peak bone density.	Bioenergetics/energy transfer Fitness and conditioning principles	6	32.6	88	85	88	93	86	83	82	
Demonstrate knowledge concerning the prevalence of obesity in youth and explain the multiple factors contributing to obesity across the lifespan.	Technical skills Bone	6	32.0	89	90	83	94	93	92	19	NASPE
Recognize the physical, psychological, social and health implications of childhood obesity and the long-term health consequences of obesity tracking into adulthood.	Fitness and conditioning principles Development and Sex Pathophysiology	6	31.7	90	91	85	92	89	92	48	NASPE
Explore the truths and myths related to exercise participation, diet, nutrition, and weight management.	Fitness and conditioning principles Development and Sex Pathophysiology	6	31.7	91	84	91	89	92	94	39	
Use appropriate/safe stretching exercises and employ proper stretching technique (type, intensity, duration, repetitions, frequency) to improve or maintain flexibility.	Fitness and conditioning principles	6	31.4	92	92	90	85	87	90	84	NASPE
Tailor exercise programming to meet the individual needs of underweight, overweight, and obese individuals.	Fitness and conditioning principles Technical skills	6	29.5	93	94	92	88	90	68	90	NASPE
Display competency in using a variety of resistance equipment to strengthen the major muscle groups.	Fitness and conditioning principles Technical skills	6	28.0	94	95	94	90	95	90	67	
Identify symptoms of eating disorders (anorexia, binge eating disorder, bulimia, and muscle dysmorphia) and appropriate individuals/agencies for referral.	Technical skills Muscle physiology	6	24.2	95	93	95	95	94	95	94	NASPE

hours/credit hour), whereas 13.4% and 9.0% supported a 2- or 3-credit laboratory, respectively.

DISCUSSION

The purpose of the present study was to survey the content that instructors are teaching during undergraduate exercise physiology courses, to compare this with various existing guidelines and professional opinions, and to continue the conversation among exercise physiologists regarding what should be taught in this ubiquitous course. Better learning outcomes are developed and are more effective when created by a group of knowledgeable practitioners rather than a single

Table 5. *Tier 4 contains additional outcomes generated by survey respondents*

Outcome
American College of Sports Medicine position stands
Brief history of 20th century leaders in exercise physiology, including D. B. Dill and the Harvard Fatigue Laboratory
Brief History of work or applied physiology
Emphasis on older adults
Exercise and air pollution
Exercise, aging, and brain function
Fundamentals of exercise biochemistry and molecular physiology
Generating and interpreting graphs
Genetic and molecular basis of adaptations to exercise (perhaps in an upper-year undergrad course)
Genetic aspects of exercise physiology
Identify and understand the potential negative consequences of any physiological intervention
Identify the relationship among blood flow, peripheral resistance and viscosity, etc.
Inactivity-related disease
Role of animal models (research) in understanding a number of the listed concepts
Scientific writing, including a journal manuscript (laboratory report) and abstract
Talent identification, an appreciation for the human body and its capabilities

instructor (42). ASEP and agencies outside of exercise physiology have identified course content, and it is now time for more exercise physiologists to join the conversation and to work to teach a common curriculum. The benefits of a common exercise physiology curriculum are enhancement of student career preparation, employer confidence, courses, programs, course and program comparisons, standardized testing, department and student outcomes, and teaching (3, 5, 12, 30). The survey results reported here indicate that there is a high degree of agreement about a lot of important content in undergraduate exercise physiology and that this undertaking is not unreasonable.

Exercise physiology is one of the cornerstone courses in kinesiology/exercise science programs. Students from programs of study in athletic training, health education, physical education, and physical therapy are often required to take this course with the assumption that particular concepts are being learned; thus, external accrediting agencies are dictating some of the content of these courses. While there are few accrediting and no licensing programs for exercise physiology (7, 11), none are considered mainstream. The external evaluation of exercise physiology courses is extremely rare and generally limited to an ancillary role in athletic training and physical education accreditation. Exercise physiologists need to do more to identify, teach, and test critical content.

As one can see when reading the course learning outcomes, some of the course outcomes found on syllabi were more akin to lesson objectives rather than course outcomes. For example, the outcomes of *1*) "Define the various terms that apply to cardiovascular performance (heart rate, stroke volume, cardiac output, etc.)," *2*) "Define the following related terms: hypertrophy, atrophy, and hyperplasia," and *3*) "Explain/identify the anaerobic threshold," are lesson objectives. This may be due to institutional requirements and/or demonstrate that instructors may not understand writing course outcomes.

Survey respondents had varying levels of agreement with the outcomes provided by accrediting agencies. Of the *tier 1* outcomes, 18 outcomes came from NASPE and 2 outcomes were unique to Ivy (20, 28, 29). Sixteen NASPE outcomes, two Ivy outcomes, and one NATA outcome were found in *tier 2* of outcomes (12, 20, 28, 29). There were seven additional NASPE outcomes found in *tier 3* (14, 15, 28, 29). Seventeen of the twenty-five recommended pieces of equipment were also recommended by NASPE (28, 29). In addition, when one compares NASPE with Ivy's outcomes, there was little agreement. Ivy is an exercise physiologist who teaches and conducts research. NASPE is creating standards for physical educators. Eight of the NASPE outcomes were identified by exercise physiologists as being appropriate for a different class, perhaps exercise testing and prescription or principles of conditioning. Five additional outcomes probably qualified for this as well. Ergogenic aids are at 47 (from NASPE) and 81 (from Ivy). The difference is that NASPE requires a risk-benefit analysis, whereas Ivy is looking for the mechanism of action. It appears that exercise physiologists want students to understand mechanisms, whereas NASPE wants students to be able to assess fitness. Thus, while there is some agreement with the agency outcomes, exercise physiologists had several additional outcomes they felt should be of higher priority. Physiologists seem to have a greater desire for depth of knowledge and ability to think critically about mechanisms than the various certification/accreditation agencies.

The Commission on Accreditation of Exercise Science within the Commission on Accreditation of Allied Health Education Programs exercise physiology standards and guidelines do not list specific course outcomes. It instructs those seeking accreditation for applied or clinical exercise physiology programs to follow the knowledge, skills, and abilities found in the American College of Sports Medicine's *Guidelines for Exercise Testing and Prescription*. There are hundreds of these knowledge, skills, and abilities, and no indication is provided as to which course they might be acquired in (11, 33). In addition, many of the knowledge, skills, and abilities are lesson objectives rather than course outcomes. ASEP also has a mechanism for accrediting exercise physiology programs and provides broad cognitive outcomes grouped by content area. Of the 15 outcomes found in the ASEP exercise physiology core, 11 outcomes matched *tier 1* outcomes, 3 outcomes matched *tier 2* outcomes, and 1 outcomes ("Gain an understanding of the relationship of exercise physiology to the broader sports medicine field and identify professional associations in which to participate) was not included in the survey and not suggested by any of the respondents (7).

Ivy (20) grouped the application of exercise physiology into four basic categories: *1*) performance, *2*) fitness, *3*) growth, development, and aging, and *4*) disease prevention and rehabilitation. The basic categories used in this analysis were regulation and homeostasis, aerobic systems, bioenergetics, muscle, fitness and performance, and technical skills. While the survey items tended to group development, aging, and sex concepts in with the aforementioned categories, there were specific suggestions for content related to development and sex as well as process skills, bone, pathophysiology, genetics, and history.

There is some disagreement in the rankings of the outcomes based on respondents self-identified employment category. This survey was sent to those who were identified in various searches as "exercise physiologists." No attempt

Table 6. *Equipment receiving an essential and/or beneficial ranking with >50% of respondents indicating essential outcomes, most frequent response (mode), and ranking by employment category*

Equipment	Mode	Essential Ranking, %	Essential and Beneficial Ranking Combined, %	Combined Overall Ranking	Ranking by Undergraduate Educators	Ranking by Researchers	Ranking by Clinical Personnel	Ranking by Personal Trainers	Ranking by Strength and Conditioning Coaches	Ranking by "Other"
Blood pressure cuffs, sphygmomanometers, and stethoscopes	1	57.8	63.4	1	1	3	1	5	1	1
Medical balance scale (body weight and height)	1	56.2	61.8	2	4	7	1	3	8	1
Heart rate monitors	1	55.9	61.8	3	6	1	3	2	7	1
Treadmill	1	55.9	60.6	4	2	6	7	9	1	1
Stopwatches	1	54.0	62.7	5	3	4	8	6	1	1
Metabolic cart	1	51.6	61.2	6	7	2	9	1	1	8
Skin-fold calipers	1	51.6	61.2	7	9	8	4	6	1	11
Tape measures	1	51.2	59.9	8	8	9	6	6	1	9
Mechanically braked (Monark) cycle ergometers	1	50.9	59.0	9	5	5	12	17	24	6
Laboratory clock with a second hand	1	45.3	56.5	10	11	11	5	3	8	7
Electronically braked cycle ergometers	1	38.8	52.5	11	12	10	13	20	11	13
Metronome	1	36.3	55.6	12	10	12	15	11	17	17
Goniometers, sit and reach box, and rulers	1	35.1	50.3	13	14	15	11	13	13	10
Hand grip dynamometer	1	28.9	39.8	14	13	13	14	10	16	15
Anatomic charts and models	1	27.3	36.0	15	19	16	10	14	8	18
Vertical jump scale	1	25.5	29.8	16	15	14	18	16	12	15
Resistance exercise equipment: dumbbells, therabands, and stability balls	1	20.2	37.6	17	20	19	16	15	14	22
Bioelectrical impedance machine	1	18.6	35.4	18	16	24	20	17	25	20
Pedometers	1	18.3	36.0	19	24	20	17	12	19	12
Hydrostatic weighing tank	3	17.7	35.7	20	18	18	19	19	22	14
Accelerometers	2	14.9	34.2	21	23	22	21	24	18	19
Automated timing device (mats, lights, gates, etc.)	3	13.7	32.6	22	21	23	22	22	15	21
Electromyograph equipment	3	13.4	31.7	23	17	17	24	23	20	24
Isokinetic dynamometer	3	10.9	21.7	24	22	20	23	21	20	25
Back extension dynamometer	3	5.0	17.4	25	25	25	25	25	23	23

was made to specifically target the other major categories who responded. Personal trainers, strength and conditioning coaches, and healthcare practitioners were not sought out for this survey. Thus, these populations are poorly represented in this sample and the rankings within those professions are suspect. However, it is interesting to note the differences. While all the respondents except the "other" category had the same top outcome, that is where the agreement ended. Undergraduate faculty members placed bioenergetics in their top five positions followed by aerobic (3 of the top 10) and muscle (2 of the top 10) outcomes. Researchers placed a bioenergetics outcome as the first (4 of the top 10), but muscle physiology made up the second and third (3 of the top 10) and aerobic (3 of the top 10) rounding out the top 10 outcomes. Clinicians had the same top bioenergetics outcome (4 of the top 10), with aerobic falling second (2 of the top 10), muscle (3 of the top 10), and regulation taking the seventh spot. With the smaller personal trainer and strength and conditioning coach numbers, there was more opportunity for ties in the outcome rankings. Personal trainers ranked 4 bioenergetics outcomes and an aerobic outcome as their top (tied), placed bioenergetics and fitness outcomes (tied) next, and then placed 2 aerobic outcomes (tied) and then a performance outcome in the top 10. Strength and conditioning coaches had 3 bioenergetic and 2 muscle outcomes tied for first followed by 2 aerobic outcomes and a fitness outcome (tied) and then by 3 muscle outcomes and another fitness outcome (tied) to round out the top 10. There was much more variety in the rankings of the "others" in that these were the only respondents to place a fitness outcome first followed by 5 aerobic outcomes, 1 bioenergetic outcome, and 1 muscle outcome tied for second and aerobic, bioenergetic, and fitness outcomes tied for 10th.

There was again some disagreement between the various career paths as to what equipment should be found in an exercise physiology teaching laboratory. However, the level of disagreement was not as great as it was for the outcomes. While the exact ranking of equipment was not the same, the majority of respondents agreed that equipment to measure cardiovascular and metabolic responses to activity was the most important.

Those practitioners who require exercise physiology as part of the undergraduate education or use exercise physiology but who do not generally identify as exercise physiologists should perhaps complete a refined version of this survey: athletic trainers, personal trainers, physical educators, physical therapists, and strength and conditioning coaches. This would help the exercise physiology instructor ensure that those programmatic goals are also being met.

The results of this survey also indicated that there is a vast amount of content to be covered in an undergraduate exercise physiology course. A 3- or 4-credit course (15 contact hours/credit) with a laboratory is appropriate. Specific outcomes and standardized testing would help ensure that this content is being covered and that students are developing adequate knowledge and skills within. According to respondents to this survey, instructors of exercise physiology should focus their curriculum in regulation and homeostasis (in which adaptation, fatigue, and recovery were included), aerobic systems, bioenergetics, muscle physiology, and fitness principles. In addition, attention should be paid to performance and technical skills. Suggested course outcomes are shown in Table 7. These are combinations of several sources to address the content agreed on by the majority of survey respondents and are intended to be broad and inclusive. Readers will find two items incorporated that were not overwhelmingly endorsed by the exercise physiology respondents: bone (*tiers 2* and *3*) and the immune system (*tier 2*). Reasons for including bone are that worldwide, osteoporosis leads to >8.9 million fractures per year and makes a significant contribution to morbidity and mortality in developed countries (21). Lifelong physical activity, especially during childhood and adolescence, is critical to the development of bone mass and the prevention and treatment of osteoporosis (23, 36, 41). In regard to including the immune system as a regulatory mechanism, ongoing research indicates that the immune system plays a critical role in recovery, healing, and adaptation and that exercise's contribution to controlling inflammation may play a role in mitigating hypokinetic diseases (26, 32). While these content areas have not historically been strongly represented, new knowledge supports their inclusion moving forward.

If state and federal agencies are not going to regulate the practice of exercise physiology and related fields through licensure and if employers are not going to do so by requiring high-quality certifications of their employees, it is up to the exercise physiologists to ensure quality of knowledge and practice. The use of learning outcomes improves student learning (14, 22, 31, 40, 42). Establishing standard outcomes will better prepare students for their careers, create program accountability, and enhance curriculum monitoring (1, 3, 7, 13, 28). Following the lead of agencies such as the ACS, Accreditation Board for Engineering and Technology, CCNE, and ASEP to develop and adopt a common core for exercise physiology is a place to start. This may eventually lead to something similar to the ACS's standardized testing of those outcomes as well (3). Most chemistry majors in the United

Table 7. *Suggested course outcomes for undergraduate exercise physiology (presented in random order)*

Outcome	Content
1. Demonstrate an understanding of the structure, function, mechanics, control, limitations, and fatigue of the cardiorespiratory system to include ventilation, gas transport and exchange, hemodynamics, and cardiac output during rest and exercise.	Aerobic systems
2. Analyze and identify the physiological requirements of sports and physical activities.	Bioenergetics/energy transfer Muscle physiology
3. Demonstrate an understanding of bioenergetics, recognizing the different metabolic systems, their interactions, regulation, fuel sources, limitations, and how they apply to exercise and fatigue.	Bioenergetics/energy transfer
4. Understand the concepts involved in measuring energy, work, and power and describe/demonstrate the means by which the energy cost of exercise can be estimated and measured (including metabolic calculations).	Bioenergetics/energy transfer
5. Recognize the differences in the physiological response to exercise because of sex and as one progresses through the lifespan.	Development and sex
6. Demonstrate an understanding of the methods of body composition assessment and recognize healthy values for body fat and what impact body composition has on athletic performance and health.	Fitness and conditioning principles Regulation/homeostasis/adaptation
7. Identify and describe the health-related components of physical fitness (body composition, cardiorespiratory health and endurance, muscular strength and endurance, flexibility, etc.).	Fitness and conditioning principles
8. Demonstrate an understanding of the structure, function, mechanics, control, limitations, and fatigue of the neuromuscular system to include synaptic transmission, proprioception, muscle contraction, and fiber typing during rest and various modes of exercise.	Muscle physiology
9. Demonstrate knowledge regarding the effects of exercise training on bone density across the lifespan.	Bone
10. Demonstrate an understanding of homeostasis, the physiological and metabolic processes that facilitate exercise, recovery, and the adaptations that occur with acute and chronic exercise.	Regulation/homeostasis/adaptation
11. Describe the various regulatory mechanisms (endocrine, immune, and nervous systems) and their interactions with respect to exercise, fatigue, and adaptation.	Regulation/homeostasis/adaptation
12. Predict homeostatic, exercise, and adaptive responses to various environmental perturbations, i.e., temperature, barometric pressure, etc., and identify strategies to optimize adaptation, reduce performance compromises, and limit injury.	Regulation/homeostasis/adaptation

Adapted from syllabi and Refs. 1–4.

States have taken one or more of the standardized chemistry exams. These exams are also used as placement exams for graduate program admissions. Because the ACS is a very large organization with multiple divisions, it is ubiquitous within chemistry education. Almost everyone working toward a degree in chemistry is introduced to the society, and graduate students will probably present at one of the professional meetings during their academic career. In addition, as ASEP does on a small scale, the ACS widely certifies undergraduate programs, and even uncertified programs are aware of the process. Not only does accreditation improve teaching learning and enrich program quality, but the endorsement procedure enhances program evaluation, verifies integrity, identifies strength and opportunities for improvement, generates insights, and provides a vehicle to increase support from home and external institutions (3, 7, 25, 28). Hopefully an argument has been made for exercise physiologists to develop a common curriculum that is recognized as quality, complete, and required. The American College of Sports Medicine, American Kinesiology Association, and/or ASEP can then promote and endorse this process, not just in exercise physiology but in all kinesiology/exercise science content areas. Standardized exams can then be developed, programs accredited, and quality improved. Doing so will improve the uniformity and quality of practitioners within the various kinesiology/exercise science fields and increase the value of a Kinesiology/Exercise Science degree and set us apart from other healthcare providers and fitness professionals.

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Author contributions: S.R.S. conception and design of research; S.R.S. performed experiments; S.R.S. analyzed data; S.R.S. interpreted results of experiments; S.R.S. prepared figures; S.R.S. drafted manuscript; S.R.S. edited and revised manuscript; S.R.S. approved final version of manuscript.

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