Challenges in Exercise Physiology
Research and Education

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Similar to other subdisciplines in kinesiology, exercise physiology (EP) as a field is facing challenges in both research (creation and dissemination of new knowledge) and education (classroom instruction and student mentoring). In the current communication, we will learn from the history, analyze the current status of the field, and provide some perspectives based primarily on our knowledge and experience working as faculty members at the University of Wisconsin–Madison.

Historical Retrospectives

During its evolution as a scientific field, exercise physiology (EP) has benefited from the following main influences: basic scientific research on the human body, pursuit of physical fitness, disease prevention and medicine, and physical education (Powers & Howley, 2004). Pioneers such as A.V. Hill (UK), August Krogh (Demark), and Otto Meyerholf (Germany) who won the Physiology and Medicine Nobel Prize in 1922 have inspired generations of scientists to pursue a better understanding of human body function through vigorous observations and experiments. These traditions were best represented by the research conducted at the Harvard Fatigue Laboratory directed by David Bruce Dill from 1927 to 1947 and the Minnesota Laboratory of Physiological Hygiene started in 1941 and directed by Henry Taylor and later Elsworth Buskirk. The two world wars and the industrial revolution demanded greater fitness in soldiers and laborers and stimulated the efforts of studying the human body under physical demand and stress. For example, Dudley Sargent (1849–1924) gained much knowledge by training soldiers during World War I in Boston. After World War II and for almost three decades, T.K. Cureton at the University of Illinois Physical Fitness Laboratory accumulated tremendous expertise by conducting a wide range of exercise and nutritional experiments and trained many influential scientists in the field. The establishment of the President’s Council of Youth Fitness (1955) and AAHPERD Youth Fitness Tests (1957) were two other milestones of that era.

Seeking better disease prevention and medical treatment has always been an important part of medical research. The Tecumseh community health study led by Thomas Francis (1900–1969) and Henry Montoye was the first effort to link

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many epidemiological disorders and diseases to a lack of physical activity. Bruno Balke (1914–2004) put the theory to practice by creating the nation’s first cardiac rehabilitation program at the University of Wisconsin (UW)–Madison in the 1960s. The Cooper Institute for Aerobics Research (Dallas) and the Department of Kinesiology’s Noll Laboratory at Penn State University, just to name a few, continued this effort over the last century.

Throughout the evolution of EP, physical education has been an important participant, and the mushrooming physical education (later called kinesiology) departments were becoming the home of EP as an emerging field. For example, from 1950 to 1966, research laboratories at universities and colleges grew from 16 to 151 (Powers & Howley, 2004). The establishment of new professional societies, such as ACSM (1955) and NASPE (1974); the large volume of scientific literature; and the introduction of new textbooks all contributed to the development of EP as a field. Thus, from its early stages, EP has become an interdisciplinary field encompassing science (chemistry, physics, and biology), medicine (physiology, pathology, pharmacology, etc.), and education (Figure 1). The research areas of the Harvard Fatigue Laboratory (1927–1947) listed below clearly demonstrate the multidisciplinary nature of EP at the time and remarkably resemble research agendas of modern EP laboratories.

- Metabolism (maximal O\(_2\) uptake, oxygen debt, long-term work)
- Environmental physiology (altitude, dry and moist heat, cold)
- Clinical physiology (Gout, Schizophrenia, Diabetes)
- Aging (basal metabolic rate, maximal O\(_2\) uptake, maximal heart rate)
- Blood (acid–base balance, O\(_2\) saturation, monoxide)
- Nutrition (nutritional-assessment techniques, vitamins, foods)
- Physical fitness (Harvard Step Test)

![Figure 1](image)

**Figure 1** — Schematic representation of Exercise Physiology as an interdisciplinary field derived from science, medicine, and education.
Current Status and Trends

After almost a century, EP has evolved into a major subdiscipline of kinesiology among other fields in biological, social, and physical sciences and humanities. It is both a major research field of exercise and movement and a core course for undergraduate and graduate student education. With the rapid development of biology research and biotechnology starting in the later part of the last century, EP has assumed a central role in accomplishing the mission of a kinesiology department. This statement is reflected by the following aspects: (a) EP usually shares a higher number of faculty in the composition of kinesiology (e.g., 5/19 at UW–Madison), (b) EP attracts more graduate students than any other subdiscipline in most institutions (~40% at UW–Madison), (c) EP shares a greater portion of resource (budget, space, and facilities), and (d) it generates greater grant funding.

EP has gained its current status with good reason, mainly because it addresses a central and critical issue of the society, that is quality of life. Although this is true for most other fields in kinesiology, EP has many noteworthy characteristics. EP research addresses major issues of quality of life (health, fitness, disease, aging, environment, etc.). It integrates well with other major disciplines in medical sciences such as epidemiology, physiology, biochemistry/molecular biology, nutrition, gerontology, neuroscience, pathology, etc. EP collaborates with other fields to form multidisciplinary core research groups to study major issues affecting quality of life, such as obesity, fetal alcohol, sarcopenia, sleep apnea, cancer, etc. EP is a core discipline in the training of not only graduate students but also students for health professions, such as medical school, physical therapy, occupational therapy, athletic training, nursing, etc. Finally, EP constitutes a major aspect of physical education teacher education programs, which provide public schools with instructors and thus affect the health and physical conditions of future generations.

Because of the characteristics just mentioned, EP research and education have developed along the following lines in recent years: (a) EP research has become increasingly cellular, molecular, and genetic. Even though the tasks are similar as in the past, the questions asked are more fundamental and mechanistic. (b) EP research is more technologically driven. The infiltration of molecular biology into the various subfield of EP has played a major role in forming this trend (Booth, 1989). Recombinant DNA, gene knockout, gene chips, transgenic models, and imaging techniques have become popular research methods in the laboratory. (c) Research is more integrative in nature. It requires researchers to be more knowledgeable in multiple disciplines and depends more on joint expertise than on individual expertise for success. (d) Translational research has become increasingly popular over traditional laboratory experiments (i.e., the outcomes of the research are required to directly affect society and the quality of life of people). For example, hot topics, often represented by the NIH Request for Proposals, receive large-scale federal funding (obesity, for example) despite the general trend of lower fund allocation.

Challenges

The characteristics and trends of EP have presented researchers and educators with both challenges and opportunities. The challenges come from both external and internal sources and are in both research and education. First, generally speaking,
resources supporting EP have been reduced in relative terms during the past 6 years because of changes in the national and international environment in politics and the economy. Federal funding support especially (mainly NIH and NSF) has been shrinking. The expanding field and growing programs make competition for funding more intense. With increasingly sophisticated technology and escalating cost for research, it is challenging to sustain the rigor of investigatory work, especially basic research, and remain productive. Second, the changing environment has imposed new demands on EP researchers and educators. The current EP faculty and staff were largely disciplinarily trained over the past decades, and their training focused on a narrow subject in the field using laboratory experiments. This was the traditional approach, as well as the unwritten rule, for success. The various physical locations of kinesiology departments at different colleges further created boundaries and limited EP faculty from interacting with colleagues in other biological fields. Third, interactions between an individual faculty member and a group of graduate students (and/or postdocs and technicians) are conventional ways of operation in an EP laboratory. Although cross-disciplinary collaborations are common, they are usually technical contributions on defined problem subsets rather than a full-scale joint research agenda. For example, if we wish to study the mechanism and prevention of child obesity caused by lack of physical activity in a low-income community, physiologically we must study the hormonal, muscular, cardiovascular, and nutritional factors contributing to obesity; we must assess children’s activity levels at school and after school; and we must analyze their family history and genetic factors. These are unlikely to be accomplished with individual faculty expertise. We might also examine the psychological and socioeconomical issues preventing their participation in physical activity, which would require the involvement of researchers outside of EP. The structure of a kinesiology department is poised to conduct such research, but only limited EP research groups in the nation are accustomed to engaging in such large-scale, cross-disciplinary endeavors. Finally, the current convention for hiring new faculty emphasizes scientific background and training and technological expertise, with insufficient attention paid to teamwork ability. The practice of “cluster hires” at UW–Madison is intended to break down the disciplinary boundary and encourage cross-department/unit collaboration. So far, however, EP research has not risen to campus attention and made it a priority to join in this initiative.

The challenges we are facing are not limited to research but are also reflected in education. There is a general trend that an increasing number of students select graduate studies in professional fields (physical therapy, for example) rather than research. This is partly a result of the reduced job market for EP faculty and relatively few opportunities in the industry. For classroom instruction, while the undergraduate level of EP is well-established, there is a perceived lack of a standard cluster of knowledge to be taught at the graduate level. This is coupled with a lack of advanced textbooks organizing the graduate-level knowledge. The update in textbooks of knowledge gained through research has been slow. This is particularly evident in EP laboratory classes wherein hands-on work has either been replaced by computer simulation and DVD or significantly lags behind state-of-the-art knowledge. An increasing number of students view EP as a prerequisite for physical therapy and other professional fields rather than an independent and promising scientific discipline.
Perspectives

The challenges just mentioned are not unique to EP and probably reflect the requirement for the evolution of a scientific field that is a century old. These challenges also provide opportunities. Although we do not hold the crystal ball for the future of EP, we provide a few thoughts to share with our colleagues.

1. Since EP has been an interdisciplinary field since birth, we need to break down “silos and bunkers” (Kretchmar, 2008) and work as a group, regardless of individual background, training, interest, and expertise. We need to break the mode of “focus-focus-focus” that we are accustomed to and expand our horizons to include many potential collaborations within and outside the department. As the first step, we might look internally for potential joint research project and grant activities that could use our existing expertise and resources. We might have to reorganize our laboratory settings and infrastructure by, for example, sharing core equipment and personnel support to reduce cost and improve efficiency.

2. Infusion and collaboration with other disciplines are essential for success in funding and investigation. The epidemics challenging the health and quality of life of human beings such as obesity, cancer, diabetes, sarcopenia, and Alzheimer’s disease are multifaceted and require studies with a multidisciplinary approach. Because physical activity has been unequivocally proven to positively influence these diseases and disorders, EP should be a relevant party and play an active role.

3. Young faculty members are the future of the field. More attention should be paid to potential “cluster” needs during recruitment of new faculty. Individual science background and technological expertise should be balanced with commitment and ability to perform teamwork and collaboration. There should be continuous mentoring at the departmental level to ensure that new faculty are aware of and prepared to meet the challenges.

4. The emphasis of translational research has provided new job opportunities for EP. We not only need team leaders who can define problems and design research to solve the problems but also trained personnel who are familiar with new technology, information processing, data analysis, knowledge dissemination, education, etc. as part of the research team. Although education at the doctoral level still holds the key to our future, we also should study the job market for the bachelor’s and master’s degrees and design appropriate curricula leading to successful employment. A master’s degree in EP is viewed as a potentially demanding degree that can fill a particular spot. Successful stories of the master of science in cardiac rehabilitation in the 1960s to 70s and the master of science in physical therapy in the 90s are good examples of strategic planning.

5. EP has traditionally been regarded as an academic field without a direct link to the industrial and commercial world. With reduced federal and foundation funding support, we should expand our effort to seek partnerships with the private and corporate sectors and work flexibly with them to develop research agendas of common interests.

In summary, history has provided us with a good lesson: As an interdisciplinary field, EP needs to broaden rather than isolate itself. With the trend of research in
medical fields becoming more integrative and translational, EP should also adopt new strategies to survive and thrive in the new century.

References