Using the physiology of normal aging as a capstone integration exercise in a medical physiology course

Jonathan D. Kibble
Department of Medical Education, University of Central Florida, Health Sciences Campus, Orlando, Florida

Abstract

As the Baby Boomer generation reaches old age, there has been a significant increase in the number of older adults needing healthcare over the past decade. The physiology of aging is therefore a highly relevant topic for the preclinical medical curriculum. I describe a new capstone unit on the physiology of aging, placed at the end a medical physiology course, to provide a vehicle for integration of prior learning about physiology of each individual body system. Students were provided with online self-study modules as preparation for a mandatory small group case-based learning activity. A detailed case of an elderly female patient being assessed for fall risk was provided. Students were required to document a “Review of Systems” predicting decreased system functions due to senescence and to prepare a group concept map illustrating how physiologic deficits contributed to fall risk in the patient. Students successfully completed the activity and reported generally good satisfaction with the experience. The activity was judged an effective tool for students to consolidate prior learning and to apply physiology to an important medical topic. The lesson also provided several opportunities for curriculum integration with cell biology, biochemistry, anatomy, and clinical skills components.

Physiology courses and textbooks often end with integrative topics that allow for application and integration of individual body system physiology (1, 2). Exercise is perhaps the best example of a capstone integration topic and is especially relevant as Lifestyle Medicine takes center stage in the modern practice of medicine. Indeed, we have included exercise physiology in our medical physiology course for many years and were grateful to have guidance from the American Physiological Society’s Medical Physiology Learning Objectives (3) when developing that unit. In this Illumination, I will describe a new unit based on the physiology of aging, which aimed to enhance medical student learning about aging as well as provide a vehicle for application of systems physiology and for curriculum integration with other disciplines.

It is hard to overstate the need for doctors to be knowledgeable about changes in body function brought about by aging. Recent Census data show that the number of US Citizens over 65 yr of age has increased by around one-third in the past decade (4). Adults over 65 are twice as likely to be admitted to hospital than adults 45–64, and Medicare spending is projected to double over the next decade (5). Unfortunately, the Medical Physiology Learning Objectives do not have a separate section on aging and currently only identify the changes that occur in reproductive endocrinology, common central nervous system (CNS) changes, audibility, lung function, and VO2max as isolated topics. Fortunately, in addition to the primary literature, there are a few excellent overviews that can help to define the appropriate scope of a unit on the medical physiology of aging (1, 2, 6).

At the University of Central Florida, medical physiology is taught together with anatomy in a 16-wk Structure and Function course. In the final week of the course, we have historically used acid-base balance, body temperature regulation, and exercise as integrative topics. This year we added the new unit on aging as the last topic before the final examination. Students were provided with two online self-learning modules (SLMs), which were voiceover PowerPoints with summary notes provided, as preparation for a mandatory small group case-based learning (CBL) session. The learning objectives for the first SLM were to describe the cellular and molecular mechanisms of primary aging and to distinguish senescence from age-associated disease. The first SLM offered opportunity to review earlier curricular topics in cell biology such as oxidative stress, DNA repair, and apoptosis. The objectives of the second SLM were to define the concept of homeostasis (i.e., reduced functional reserve) and to summarize the changes seen in each body system due to senescence. The total run time for the two SLMs was ~50 min; students were given 2 h of scheduled class time off to study ahead of the mandatory CBL session. In terms of knowledge assessment, students were provided with a formative online quiz to self-assess their knowledge and the final course summative examination included items on these learning objectives.

Correspondence: J. D. Kibble (e-mail: Jonathan.kibble@ucf.edu).
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The mandatory CBL session was based on the case of an 82-yr-old woman with concerns for pain from long history of arthritis, poor circulation in her feet with swelling bilaterally, and loss of sensation; she has concerns for lack of mobility, fear of falling, and decreased independence. The case was formatted in consultation with faculty teaching in the clinical skills program to ensure it included the elements students were expected to know about when obtaining a medical history from a geriatric patient, including assessment of the activities of daily living, fall risk, nutrition, vision and hearing, cognitive and psychological assessment, and psychosocial elements such as social and economic support. The case also included some medical imaging such as a chest X-ray and patient photographs to allow for some further anatomy and clinical skills integration. The student groups had three tasks to accomplish: first, provide a physiological “Review of Systems,” highlighting body systems where primary aging mechanisms appeared to have created the most loss of function in the patient. Second, comment specifically on interactions between her normal aging processes and the compounding effects of concurrent disease (chronic glucocorticoid treatment for rheumatoid arthritis in this case). Third, draw a concept map highlighting the major physiological changes in older patients that lead to increased risk of falls.

Due to the COVID-19 pandemic, the 2-h CBL session was conducted online via Zoom. The class of 120 students was

Figure 1. Example of a concept map from the case-based learning exercise showing physiological deficits contributing to fall risk in an elderly female patient. ANS, autonomic nervous system; CNS, central nervous system; GH, growth hormone; IGF, insulin-like growth factor.
divided into 20 groups. Students worked on their tasks for 90 min in their online breakout rooms. They were facilitated by a roving group of five faculty members, who were each assigned to assist four rooms and had previously received a faculty answers guide. The students had to submit a group concept map after 90 min and were returned to a whole class debrief for the last 30 min. During the debrief student groups were called upon at random to share their screen and describe their answers, followed by peer comments and faculty feedback to close the session. At this stage in the course, the students were very familiar with their teams and with presenting work to the class having previously completed many team-based learning and CBL sessions together. Students were also adept in developing team concept maps, which were a consistent deliverable for other CBL sessions throughout the course.

As I reflect on this new unit, I was broadly satisfied that the learning goals were met. The students were fully occupied during the small group session, but all managed to finish on time. The first task was straightforward since the material was covered in SLM2. Groups all identified key concepts: the cardiovascular consequences stemming from decreased vascular compliance and decreased cardiac reserve; the pulmonary sequelae stemming from loss of lung parenchyma and decreased lung recoil pressure; the possible problems stemming from decreased gastrointestinal motility; the consequence of losing renal cell mass both on tolerance to changes in fluid and electrolyte and the decreased production of renal hormones; lower urinary tract dysfunction; declining hormone levels, especially postmenopause but with notable exceptions for cortisol and PTH; decreased elasticity and thinning of the skin with impaired wound healing; loss of muscle mass leading to weakness, lower exercise tolerance, and increased risk of insulin resistance; and factors leading to decreased bone density, decreased peripheral nervous system functions, decreased functionality of special senses, and CNS functions. Students performed well in the second task, reviewing their endocrine physiology to highlight problems with Cushing Syndrome in this patient, especially the additional hormonal pressures on bone that led to high risk of fragility fractures (i.e., low estrogen, low activated vitamin D, high PTH, and high cortisol) were well described, together with the negative effect of decreased load-bearing exercise, as key factors in bone demineralization. Figure 1 provides a reference map summarizing the major points of relevance to fall risk in this patient, noting that in her case cognitive functions were very good.

The University of Central Florida Institutional Review Board designated this report “Not Human Subjects Research” but allowed the communication of aggregate survey results to aid in evaluation of the module. The survey items, shown in Table 1, were modified from the Reduced Instructional Materials Motivation Survey (7), which is based on Keller’s ARCS model of Attention, Relevance, Confidence, and Satisfaction (8). Overall, the students were moderately pleased with the unit with mean item scores in the 3.4–4.2 range on a 5-point scale. The student comments were split between positive sentiments: “I really liked being able to integrate all systems of physiology while learning this lesson on aging. It helped solidify the knowledge base I already had, and I really enjoyed it,” and a negative sentiment that stemmed from the proximity of new learning to a major exam, “I think I would have been more engaged and excited about this lecture's material if it were not so close to the final exam.” The SLMs can be improved to be more efficient and engaging, and perhaps the primary knowledge could be integrated during the course to avoid an additional load right at the end. However, I judged the unit on aging to be a success overall, allowing students both to solidify prior learning and apply physiological concepts to a critically important area for medical trainees.

**DISCLOSURES**

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

**AUTHOR CONTRIBUTIONS**

J.D.K. conceived and designed research; J.D.K. analyzed data; J.D.K. interpreted results of experiments; J.D.K. prepared figures;

| Survey Question                                                                 | Mean Score |
|---------------------------------------------------------------------------------|------------|
| 1) It is clear to me how the content of this material is related to things I already know | 4.2 (1.0)  |
| 2) The quality of the presentations helped to hold my attention                  | 3.8 (1.1)  |
| 3) As I worked on this lesson, I was confident that I could learn the content     | 3.9 (1.0)  |
| 4) I enjoyed this lesson so much that I would like to know more about this topic.  | 3.4 (1.3)  |
| 5) I really enjoyed studying this lesson                                         | 3.6 (1.1)  |
| 6) The content and style of the presentations in this lesson convey the impression that its content is worth knowing | 4.2 (1.0)  |
| 7) I learned some things that were surprising or unexpected                       | 3.7 (1.3)  |
| 8) After working on this lesson for a while, I was confident that I would be able to pass a test on it | 3.4 (1.1)  |
| 9) The variety of reading passages, exercises, illustrations, etc., helped keep my attention on the lesson | 3.4 (1.1)  |
| 10) It was a pleasure to work on such a well-designed lesson                     | 3.9 (1.0)  |

Data are expressed as means (SD); n = 62 respondents out of 120 students. Items were scored on a 5-point Likert scale: 1 = not true; 2 = slightly true; 3 = moderately true; 4 = mostly true; and 5 = very true.
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