UF College of Health & Human Performance
Department of Applied Physiology and Kinesiology
UNIVERSITY *of* FLORIDA

EXERCISE METABOLISM

APK 7117 (COURSE #23013) 3 HRS CREDIT ~ FALL 2020

Updated: August 26, 2020

INSTRUCTOR: **Scott K. Powers**
Office: 112 FLG
Office Phone: 352-294-1713
Email: spowers@hhp.ufl.edu
Preferred Method of Contact: email

OFFICE HOURS: Monday and Wednesday: 1:30PM-2:30PM
Other hours by appointment.

MEETING TIME/LOCATION: FLG 280 Wednesday, 10:30AM-1:40PM

COURSE DESCRIPTION: Principles of metabolic regulation during exercise; effects of chronic exercise on muscle metabolism.

PREREQUISITE KNOWLEDGE AND SKILLS: Graduate course in exercise physiology required.

REQUIRED AND RECOMMENDED MATERIALS: Purchase of a textbook is not required and a suggested reading list is provided at the end of the syllabus. Copies of the lecture slides will be posted on the course website (Canvas) prior to each lecture.

COURSE FORMAT: This course is scheduled as a hybrid format. This format supports both face-to-face instruction and online instruction (recorded lectures and live zoom discussions). The lecture outline provided in this syllabus identifies the class days that involve face-to-face classroom instruction and those days that are entirely online. Note, that we are currently scheduled to meet face-to-face on

three occasions during the semester. More details about the course format will be provided by the instructor during the first class that will meet virtually (via zoom) at the scheduled course meeting time (10:30AM).

COURSE CONTENT: This course will follow an integrative approach toward understanding exercise metabolism and will incorporate a problem-based learning method that will emphasize the importance of both critical thinking and a thorough understanding of the strengths and weaknesses of different experimental approaches to investigate questions related to exercise metabolism. Questions are encouraged at any time during the face-to-face lectures and discussion. A brief overview of specific course learning objectives follows.

COURSE LEARNING OBJECTIVES: Following completion of this course, you should be able to do the following:

- List and define several techniques to study metabolism at the cellular, tissue, and whole organism level.
- Describe the application of molecular and proteomic techniques to study metabolism
- Define and discuss what investigators need to know about the pharmacokinetics and pharmacokinetics of drugs used in experiments
- List and discuss the primary sources of reactive oxygen species in muscle cells. Further, explain the process of oxidation and reduction of macromolecules. Finally, identify the primary enzymatic and non-enzymatic antioxidants in cells
- Illustrate and discuss the hydrolytic model of oxidative phosphorylation
- Define the lactate threshold and discuss the potential mechanisms responsible for the rise in blood lactate concentration during exercise. Discuss the various fates of lactate molecules produced in skeletal muscle fibers
- Discuss the limiting factors for maximal oxygen uptake and determinants of endurance performance
- Describe the events that regulate protein synthesis and increase skeletal muscle mass. Explain the evidence indicating that satellite cells play a required role in mechanical load-induced muscle hypertrophy
- Describe the experimental models used to study inactivity-induced muscle atrophy
- Discuss the role of the renin-angiotensin system in maintaining skeletal muscle mass
- List and discuss the major proteolytic systems in skeletal muscles
- Discuss the cellular events that occur during a myocardial ischemia perfusion insult
- Discuss the mechanisms responsible for exercise-induced preconditioning of both cardiac and skeletal muscles

- Provide an overview of the function of both the innate and acquired immune system
- Discuss the effect of both acute and chronic exercise on the immune system
- Discuss the interaction between diet, exercise, and weight loss
- List and discuss the theory behind the four major types of diet plans for weight loss

COURSE AND UNIVERSITY POLICIES:

ATTENDANCE POLICY: Class attendance is not mandatory and there are no points associated with attendance. However, missing class will likely have a negative impact on learning and therefore, could negatively influence your exam scores and final grade in the course.

GUIDELINES FOR CLASSROOM MASK WEARING AND COVID-19: Both the instructor and students are required to wear a mask in the classroom at all times. Students will be requested to sit in locations that are 6 feet (or more) apart from other others. Our classroom is large so this rule will be easy to follow. For the safety of others, any student that refuses to wear a mask will be asked to leave the class and will not be permitted to return to the class without student affairs COVID-19 education office permission. If you have any questions about the mask wearing policy, please feel free to contact the instructor directly to discuss the matter.

COMMUNICATION WITH INSTRUCTOR: The best way to communicate with your instructor is via email (spowers@hhp.ufl.edu) to schedule a time to meet virtually via zoom. Please do not use the email address in e-learning. You are responsible for checking course postings on eLearning (CANVAS).

PERSONAL CONDUCT POLICY: Students are expected to exhibit behaviors that reflect highly upon themselves and our University. Moreover, students are expected to join the lecture on time but tardiness is acceptable when personal conflicts require the student to enter the zoom lecture later than the scheduled time.

Laptop computers and tablet devices for note taking are welcome for use during the course. Upon entry into the virtual lecture, **please silence your cell phone**, or mute your microphone.

Failure to adhere to the UF Honor Code will result in disciplinary action by the university. UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and

our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (http://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obliged to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult the instructor.

EXAM MAKE-UP POLICY: Make-up exams will be available for students that cannot take exams during the assigned period due to health problems or an emergency. Documentation of the illness or emergency will be required. Please contact instructor in advance for approval of make-up exams. Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies that can be found in the online catalog at: https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx."

ACCOMMODATING STUDENTS WITH DISABILITIES: Students with disabilities who experience learning barriers and would like to request academic accommodations should connect with the Disability Resource Center by visiting their Get Started page at https://disability.ufl.edu/students/get-started/. It is important for students to share their accommodation letter with their instructor and discuss their access needs, as early as possible in the semester.

COURSE EVALUATIONS: Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

PRIVACY: For online course with recorded materials a statement informing students of privacy related issues such as:
Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent

to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

GETTING HELP:

Students requiring assistance with health and/or wellness or students seeking academic help can use the following sources:

Health and Wellness

- U Matter, We Care: If you or a friend is in distress, please contact umatter@ufl.edu or 352 392-1575
- Counseling and Wellness Center: https://counseling.ufl.edu/, 352-392-1575
- Sexual Assault Recovery Services (SARS) - Student Health Care Center, 392-1161
- University Police Department, 392-1111 (or 9-1-1 for emergencies) http://www.police.ufl.edu/

Academic Resources

- E-learning technical support, 352-392-4357 (select opti on 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml
- Career Connections Center, Reitz Union, 392-1601. Career assistance and counseling. https://career.ufl.edu/
- Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.
- Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. http://teachingcenter.ufl.edu/
- Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. http://writing.ufl.edu/writing-studio/
- Student Complaints On-Campus: https://sccr.dso.ufl.edu/policies/student-honor-code-student-conduct-code/ On-Line Students Complaints: http://distance.ufl.edu/student-complaint-process/

GRADING:

Grading-big picture: Students will be evaluated based on grades from three lecture examinations worth 30 points each (3 X 30 points = 90 points

total) and a literature review worth 10 points. Exams will consist of short answer discussion and some exams may contain a section of multiple-choice questions. Exams will be administered face-to-face during the regular class period.

Lecture exams: 100% of the exam content will come directly from the lectures and suggested reading materials. Moreover, students will be provided with study questions for material covered on each of the three exams. These study questions will serve as guidelines in the preparation for each exams.

Guidelines for writing literature review (due November 18, 2020)

The objective of this assignment is to allow the student to select a topic of interest to exercise metabolism for extensive study. That is, the student reviews the literature and crafts a summary of our existing knowledge on the selected topic. The literature review should be clearly written using an accepted style for scientific reviews (i.e. see Journal of Applied Physiology for examples). The review should contain the following components:

1. Introduction: Brief introduction of the topic to be reviewed (one page or less, i.e. 200 word limit).

2. Body of review: (maximal page length, 8 pages-double spaced): The body of the review should address key issues that are germane to the topic. Sub-headings should be used to improve readability. A concise and clear writing style is important for reader understanding. Summaries or conclusions at the end of a major section may be appropriate. Note that tables or figures are often useful for illustration or summary of data or important ideas. All figures should have captions and if the figure is not original, the source of the figure should be provided.

3. Summary and conclusions: (one page~150-250 words): The summary or conclusion section should clearly summarize the major points of interest contained in the review. Suggestions for additional research may be included here.

4. List of references: number of references may vary-please use any consistent reference style. In general, original references from the literature should be cited in a scientific review. Nonetheless, for areas not covered in

your specific review, it is appropriate to direct the reader other published reviews on the topic.

Six key points to remember about scientific writing:

1. Good organization of ideas is essential.

2. The writing style should be clear and concise. Remember to practice simple rules of pedagogy when writing this review.

3. Use headings to subdivide major sections. Use sub-headings when appropriate to further divide ideas into logical units.

4. Use figures or tables when appropriate (GOOD illustration or figure is worth 1000 words).

5. When presenting a long list of complicated ideas, it is a good idea to end each major section with a brief summary of the major points.

6. Remember, revision is the key to a polished writing project. Therefore, start writing your review early in the semester and revise, revise, and revise.

Grades will be assigned based on points earned in the course. The relative point value of the three examinations and the literature review are as follows:

Evaluation Components (number of each)	Points Per Component	Approximate % of Total Grade
Lecture Exams (3)	30 pts each = 90 pts	90%
Literature review	10 pts	10%

Total possible points = 100

GRADING SCALE: Note that lecture exam scores and homework grades will be posted on the canvas course website typically within 7 days after the date of the exam. Final grades in the class will be determined by the total points earned during the course of the semester. Final point totals that are not whole numbers

will be handled in the following way. Any point total with a fraction of another point will be rounded up if the fraction reaches 0.5 points or higher. More detailed information regarding current UF grading policies can be found here: https://catalog.ufl.edu/UGRD/academic-regulations/grades-grading-policies/.

Please note that any requests for additional extra credit or special exceptions to these grading policies will be interpreted as an honor code violation (i.e., asking for preferential treatment) and will be handled accordingly.

The letter grading scale for the course is as follows:

Letter Grade	Points Needed to Earn Each Letter Grade	GPA Impact of Each Letter Grade
A	≥ 93	4.0
A-	90-93	3.67
B+	87-89.99	3.33
B	80-86.99	3.0
C+	77-79.99	2.33
C	70-76.99	2.0
D+	67-69.99	1.33
D	60-66.99	1.0
E	<59.99	0

Exercise Metabolism 2020
Course Organization

Unit 1: Techniques/tools to study metabolism

Topics include: Metabolic techniques-overview, pharmacological tools, microarray, proteomics, mitochondrial function, tools to alter gene expression, redox biology/exercise and oxidative stres

Unit-2: Exercise metabolism: Old school topics with a new twist

Topics include: 1) Bioenergetics; 2) lactate metabolism; and 3) metabolic limitations to VO2 max and endurance performance

Unit 3: Regulation of muscle protein turnover

Topics include: 1) Regulation of muscle protein synthesis/muscle growth and 2) Mechanisms responsible for inactivity-induced muscle atrophy

Unit-4: Hot topics in exercise metabolism

Topics include: 1) exercise preconditioning of cardiac myocytes; 2) exercise preconditioning of skeletal muscle fibers; 3) exercise and the immune system/COVID-19; and 4) Diet, exercise, and weight control

WEEKLY COURSE SCHEDULE:

Tentative Exercise Metabolism-Fall 2020 lecture schedule*
***Note that the lecture schedule is subject to change. Changes will be announced in class and online during the e-Learning website.**

Class meeting date/meeting format	Topics discussed	Suggested readings
September 2 Unit 1 Virtual (zoom) class (10:30AM) + pre-recorded lectures	1) Course Introduction 2) Tips on writing literature review 3) Techniques to study metabolism-big picture 4) Pharmacological techniques to study metabolism	Lecture notes
September 9 Unit 1 Face-to-face classroom discussion (10:30AM) + pre-recorded lectures	1) Molecular and proteomic techniques to study metabolism 2) Assessment of mitochondrial function	Lecture notes
September 16 Unit 1 Virtual (zoom) class (10:30AM) + pre-recorded lectures	1) History of free radical biology 2) Sources and sites of production or reactive oxygen species in muscle 3) Exercise and oxidative stress: friend or foe?	(1-3)
September 23 Face-to-face classroom exam (10:30AM)	Exam 1-covers unit 1	
September 30 Unit 2 Virtual (zoom) class (10:30AM) + pre-recorded lectures	1) Bioenergetics revisited-hydrolytic model of OXPHO 2) Exercise and lactate metabolism	(4-7)

October 7 Unit 2 Virtual (zoom) class (10:30AM) + pre-recorded lectures	**1) Limitations to VO_2 max 2) Metabolic limitations to endurance performance**	(8, 9)
October 7 Unit 3 Virtual (zoom) class (10:30AM) + pre-recorded lectures	**Regulation of load-induced muscle growth**	**(10-13)**
October 14 Unit 3	**Mechanisms responsible for disease and inactivity-induced muscle atrophy**	**(14-17)**
October 21 Face-to-face classroom exam (10:30AM)	**Exam 2 covers units 2&3**	
October 28 Unit 4 Virtual (zoom) class (10:30AM) + pre-recorded lectures	**Exercise-induced cardioprotection (cardiac preconditioning)**	**(18, 19)**
November 4 Unit 4 Virtual (zoom) class (10:30AM) + pre-recorded lectures	**Exercise preconditioning-skeletal muscles**	**(20-22)**
November 11	**Holiday-no class**	
November 18 Unit 4 Virtual (zoom) class (10:30AM) + pre-recorded lectures	**COVID-19: Exercise and the immune system**	**(23-25)**
November 25	**Holiday-no class**	
December 2 Unit 4 Virtual (zoom) class (10:30AM) + pre-recorded	**Diet, exercise, and weight management**	**(26-30)**

lectures		
December 9 (Take home)	**Exam 3 covers unit 4**	

Suggested Readings

1. Powers SK, Deminice R, Ozdemir M, Yoshihara T, Bomkamp MP, Hyatt H. Exercise-induced oxidative stress: Friend or foe? J Sport Health Sci. 2020.

2. Powers SK, Jackson MJ. Exercise-induced oxidative stress: cellular mechanisms and impact on muscle force production. Physiol Rev. 2008;88(4):1243-76.

3. Powers SK, Radak Z, Ji LL. Exercise-induced oxidative stress: past, present and future. J Physiol. 2016;594(18):5081-92.

4. Brooks GA. The tortuous path of lactate shuttle discovery: From cinders and boards to the lab and ICU. J Sport Health Sci. 2020.

5. Brooks GA. Lactate as a fulcrum of metabolism. Redox Biol. 2020;35:101454.

6. Ferguson BS, Rogatzki MJ, Goodwin ML, Kane DA, Rightmire Z, Gladden LB. Lactate metabolism: historical context, prior misinterpretations, and current understanding. Eur J Appl Physiol. 2018;118(4):691-728.

7. Willis WT, Jackman MR, Messer JI, Kuzmiak-Glancy S, Glancy B. A Simple Hydraulic Analog Model of Oxidative Phosphorylation. Med Sci Sports Exerc. 2016;48(6):990-1000.

8. Poole DC, Burnley M, Vanhatalo A, Rossiter HB, Jones AM. Critical Power: An Important Fatigue Threshold in Exercise Physiology. Med Sci Sports Exerc. 2016;48(11):2320-34.

9. Bassett DR, Jr., Howley ET. Limiting factors for maximum oxygen uptake and determinants of endurance performance. Med Sci Sports Exerc. 2000;32(1):70-84.

10. Bamman MM, Roberts BM, Adams GR. Molecular Regulation of Exercise-Induced Muscle Fiber Hypertrophy. Cold Spring Harb Perspect Med. 2018;8(6).

11. Jorgenson KW, Phillips SM, Hornberger TA. Identifying the Structural Adaptations that Drive the Mechanical Load-Induced Growth of Skeletal Muscle: A Scoping Review. Cells. 2020;9(7).

12. Pearson SJ, Hussain SR. A review on the mechanisms of blood-flow restriction resistance training-induced muscle hypertrophy. Sports Med. 2015;45(2):187-200.

13. Wackerhage H, Schoenfeld BJ, Hamilton DL, Lehti M, Hulmi JJ. Stimuli and sensors that initiate skeletal muscle hypertrophy following resistance exercise. J Appl Physiol (1985). 2019;126(1):30-43.

14. Powers SK, Kavazis AN, DeRuisseau KC. Mechanisms of disuse muscle atrophy: role of oxidative stress. Am J Physiol Regul Integr Comp Physiol. 2005;288(2):R337-44.

15. Powers SK, Morton AB, Ahn B, Smuder AJ. Redox control of skeletal muscle atrophy. Free Radic Biol Med. 2016;98:208-17.

16. Powers SK, Ozdemir M, Hyatt H. Redox Control of Proteolysis During Inactivity-Induced Skeletal Muscle Atrophy. Antioxid Redox Signal. 2020.

17. Powers SK, Morton AB, Hyatt H, Hinkley MJ. The Renin-Angiotensin System and Skeletal Muscle. Exerc Sport Sci Rev. 2018;46(4):205-14.

18. Powers SK, Smuder AJ, Kavazis AN, Quindry JC. Mechanisms of exercise-induced cardioprotection. Physiology (Bethesda). 2014;29(1):27-38.

19. Powers SK, Murlasits Z, Wu M, Kavazis AN. Ischemia-reperfusion-induced cardiac injury: a brief review. Med Sci Sports Exerc. 2007;39(9):1529-36.

20. Powers SK, Bomkamp M, Ozdemir M, Hyatt H. Mechanisms of exercise-induced preconditioning in skeletal muscles. Redox Biol. 2020;35:101462.

21. Morton AB, Smuder AJ, Wiggs MP, Hall SE, Ahn B, Hinkley JM, et al. Increased SOD2 in the diaphragm contributes to exercise-induced protection against ventilator-induced diaphragm dysfunction. Redox Biol. 2019;20:402-13.

22. Smuder AJ, Morton AB, Hall SE, Wiggs MP, Ahn B, Wawrzyniak NR, et al. Effects of exercise preconditioning and HSP72 on diaphragm muscle function during mechanical ventilation. J Cachexia Sarcopenia Muscle. 2019;10(4):767-81.

23. Nieman DC. Coronavirus disease-2019: A tocsin to our aging, unfit, corpulent, and immunodeficient society. J Sport Health Sci. 2020.

24. Nieman DC, Wentz LM. The compelling link between physical activity and the body's defense system. J Sport Health Sci. 2019;8(3):201-17.

25. Nieman DC. Coronavirus disease-2019: A tocsin to our aging, unfit, corpulent, and immunodeficient society. J Sport Health Sci. 2020;9(4):293-301.

26. Hall KD. A review of the carbohydrate-insulin model of obesity. Eur J Clin Nutr. 2017;71(3):323-6.

27. Hall KD, Guo J. Obesity Energetics: Body Weight Regulation and the Effects of Diet Composition. Gastroenterology. 2017;152(7):1718-27 e3.

28. Johnston BC, Kanters S, Bandayrel K, Wu P, Naji F, Siemieniuk RA, et al. Comparison of weight loss among named diet programs in overweight and obese adults: a meta-analysis. JAMA. 2014;312(9):923-33.

29. Thom G, Lean M. Is There an Optimal Diet for Weight Management and Metabolic Health? Gastroenterology. 2017;152(7):1739-51.

30. Hall KD. A review of the carbohydrate-insulin model of obesity. Eur J Clin Nutr. 2018;72(1):183.