Revised 2/9/05 with 2 new readings

KIN 414/598
Electromyographic Kinesiology
Spring 2005

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MEETING TIME: Wednesday, 6:40-9:30 PM

OFFICE HOURS: Mon. 2-3 PM, Wed. 6:00-6:30 PM, Thurs. 11 AM-12 noon. Please use the appointment sheet on my office door.
CLASS WEB PAGE: For copies of notes and handouts: www.public.asu.edu/~hinrichs/classes/kin414-598

OVERVIEW: This course provides an introduction to the theoretical basis and practical application of electromyography in the study of human motion. Topics include the electrophysiological basis of muscle actions and the EMG, mechanical properties of muscle, EMG recording and processing methods, and applications of EMG to the study of human motion. A lecture/discussion format will be used in conjunction with complementary laboratory demonstrations and exercises. Students are fully expected to contribute to lecture discussions of assigned readings and relevant topics.

OBJECTIVES: At the completion of this course it is desired that students are able to (1) understand the basic processes involved in the activation of skeletal muscle; (2) understand the basic processes involved in the acquisition and analyses of the electromyogram; (3) understand the benefits and limitations of the electromyogram and; (4) obtain hands-on experience in the acquisition, analyses, and interpretation of the electromyogram using state-of-the-art equipment.

TEXTBOOK: While no single textbook has been required for this course, students may find the following books to be useful references. Additional readings from the biomechanics and muscle physiology literature will be used in place of a textbook (see list attached).

- Basmajian, J.V. & DeLuca, C.J. (1985). *Muscles Alive. Their Functions Revealed by Electromyography* (5th Ed.). Baltimore: Williams & Wilkins.
- Kumar, S. & Mital, A. (1996). *Electromyography in Ergonomics*. London: Taylor & Francis.
- Loeb, G.E. & Gans, C. (1986). *Electromyography for Experimentalists*. Chicago: The University of Chicago Press.

EVALUATION	**WEIGHTING (414)**	**WEIGHTING (598)**
Written Assignments	40%	44%
Midterm Exam	30%	28%
Final Exam (May 11)	30%	28%

Note: the exams will contain primarily essay questions.

Written assignments include an article critique, three lab reports, and a term paper (details to follow). Note: graduate students receiving graduate credit (KIN 598) will be expected to write more detailed lab reports as well as conduct a small individual research project in lieu of a term paper (details to follow). The appropriate weighting scheme above (either 414 or 598) will be used to compute an overall average score for each student as appropriate. All grades will be curved. The approximate cutoff scores for KIN 414 will be as follows*:

A+: 92%, A: 88%, A–: 85%, B+: 82%, B: 77%, B–: 73%, C+: 69%, C: 63%, D: 55%

➔*Note: 598 grade cutoffs will be about 2% higher than those for 414.

LATE POLICY: All lab assignments will have a specific due date. A 5% deduction will be made for each 24-hour period (beginning at the *start* of the class period on the due date) that an assignment is turned in late. Note that any late assignment must be sent to Dr. Hinrichs via e-mail (hinrichs@asu.edu). Electronically submitted documents will be accepted for all assignments, but are not required. Students are responsible for the delivery, content, and formatting accuracy of all electronically submitted documents. *Neither missing class nor arriving late for class on the day an assignment is due prevents you from incurring a late penalty. Once an assignment is handed back, no late assignments will be accepted.*

ACADEMIC INTEGRITY POLICY: Arizona State University has an enforceable academic integrity policy. The full text of this is located online at http://com.pp.asu.edu/academic/acadintpol.html. While student collaboration is expected and encouraged during all laboratory exercises in this course, exams and submitted materials must be completed independently. Written assignments must give appropriate credit to authors of published work where necessary and appropriate.

Be sure to check the KIN 414-598 class web page regularly for updates and announcements.

TENTATIVE OUTLINE OF COURSE TOPICS AND READING ASSIGNMENTS

I. Lecture: Introduction and history of the study of muscle and EMG

- Basmajian, J.V. and De Luca, C.J. (1985). Chapter 1: Introduction. *Muscles Alive* (5th ed). Baltimore: Williams & Wilkins, pp. 1-18.

II. Lecture: Anatomical features and electrical properties of nerve and muscle: Electrophysiological basis of muscle activation

- Luttmann, A. (1996) Chapter 2: Physiological basis and concepts of electromyography, *Electromyography in Ergonomics* (Eds. Kumar and Mital), Taylor & Francis, pp. 51-95.

III. Lecture: Mechanical properties of muscle

- Gordon, A.M., Huxley, A.F., & Julian, F.J. (1966). The variation in isometric tension with sarcomere length in vertebrate muscle fibers. *Journal of Physiology (London)*, **184**, 170-192.
- Roberts, T.J., Marsh, R.L., Weyland, P.G. & Taylor, C.R. (1997). Muscular force in running turkeys: The economy of minimizing work. *Science*, **275**, 1113-1115.
- Winter, D.A. (1990) Chapter 7: Muscle mechanics, *Biomechanics and Motor Control of Human Movement*, John Wiley & Sons, pp. 165-189.

IV. Lecture/Lab: EMG recording and processing: electrodes, amplifiers, recording systems, sampling theory, electrode placement, quantification techniques

- Basmajian, J.V. & De Luca, C.J. (1985). Chapter 2: Apparatus, Detection, and Recording Techniques. *Muscles Alive* (5th ed). Baltimore: Williams & Wilkins, pp. 19-64.
- De Luca, C.J. (1997). The use of surface electromyography in biomechanics. *Journal of Applied Biomechanics*, **13** (2), 135-163.
- LeVeau, B. & Andersson, G. (1992). Output forms: Data analysis and application. Interpretation of the electromyographic signal. In *Selected Topics in Surface Electromyography For Use in the Occupational Setting: Expert Perspectives*. National Institute for Occupational Safety and Health. NEW!
- Vigreux, B., Cnockaert, J.C., & Pertuzon, E. (1979). Factors influencing quantified surface EMGs. *European Journal of Applied Physiology*, **41** (2), 119-129.
- Winter, D.A. (1990) Chapter 8: Kinesiological electromyography, *Biomechanics and Motor Control of Human Movement*, John Wiley & Sons, pp. 191-212. NEW! (substituting for Winter, 1996)
- Winter, D.A., Rau, G., Kadefors, R., Broman, H., & De Luca, C.J. (1980). Units, terms and standards in the reporting of EMG research. Report of the Ad Hoc Committee of the International Society of Electrophysiological Kinesiology.

V. Lecture/Lab: Normalization schemes

- Enoka, R.M., & Fuglevand, A.J. (1993). Neuromuscular basis of the maximum voluntary force capacity of muscle. In M. Grabiner (ed.), *Current Issues in Biomechanics*, pp. 215-235.
- Kelly, B.T. et al. (1996). Optimal normalization tests for shoulder activation: An electromyographic study. *Journal of Orthopaedic Research*, **14**, 647-653.
- Knudson, D. & Johnston, D. (1993). Comparison of EMG normalization methods in a sit-to-stand movement. *Journal of Human Movement Studies*, **25**, 39-50.
- Winter, D.A. (1991). Electromyogram recording, processing, and normalization: Procedures and considerations. *Journal of Human Muscle Performance*, **1** (2), 5-15.
- Yang, J.F., & Winter, D.A. (1984). Electromyographic amplitude normalization methods: Improving their sensitivity as diagnostic tools in gait analysis. *Archives of Physical Medicine and Rehabilitation*, **65** (9), 517-521.

VI. Lecture/Lab: Reliability of the EMG

- Di Fabio, R.P. (1987). Reliability of computerized surface electromyography for determining the onset of muscle activity. *Physical Therapy*, **67** (1), 43-48.
- Komi, P.V., & Buskirk, E.R. (1970). Reproducibility of electromyographic measurements with inserted wire electrodes and surface electrodes. *Electromyography*, **10**, 357-367.
- Vint, P.F. & Hinrichs, R.N. (1999). Longer integration intervals reduce variability and improve reliability of average integrated EMG values during maximum effort isometric exertions. *Journal of Applied Biomechanics*, **15**, 194-204.

- Yang, J.F., & Winter, D.A. (1983). Electromyography reliability in maximal and submaximal isometric contractions. *Archives of Physical Medicine and Rehabilitation*, **64**, 417-420.

VII. Lecture: Relevant Topics – Multiarticular, synergistic, and non-traditional muscle function

- Gregor, R.J., Cavanagh, P.R., & LaFortune, M. (1985). Knee flexor moments during propulsion in cycling-a creative solution to Lombard's Paradox. *Journal of Biomechanics*, **18**, 307-316.
- Ingen Schenau, G.J. van, Bobbert, M.F., & Rozendal, R.H. (1987). The unique action of bi-articular muscles in complex movements. *Journal of Anatomy*, **155**, 1-5.
- Lawrence, J.H. & Nichols, T.R. (1999). A three-dimensional biomechanical analysis of the cat ankle joint complex: I. Active and passive postural mechanics. *Journal of Applied Biomechanics*, **15**, 95-105.
- Lawrence, J.H. & Nichols, T.R. (1999). A three-dimensional biomechanical analysis of the cat ankle joint complex: II. Effects of ankle joint orientation on evoked isometric joint torque. *Journal of Applied Biomechanics*, **15**, 106-119.

VIII. Lecture/Lab: EMG-force relationship

- Bigland, B., & Lippold, O.C.J. (1954). The relationship between force, velocity, and integrated electrical activity in human muscles. *Journal of Physiology*, **123**, 214-224.
- Chaffin, D.B., Lee, M., & Freivalds, A. (1980). Muscle strength assessment from EMG analysis. *Medicine and Science in Sports and Exercise*, **12** (3), 205-211.
- Hof, A.L. (1984). EMG and muscle force: an introduction. *Human Movement Science*, **3**, 119-153.
- Komi, P.V. (1973). Measurement of the force-velocity relationship in human muscle under concentric and eccentric contractions. In S. Cerquiglini, A. Venerando, & J. Wartenweiler (Eds.), *Biomechanics III* (pp. 224-229). Baltimore, MD: University Park Press.
- Milner-Brown, H.S., & Stein, R.B. (1975). The relation between surface electromyogram and muscle force. *Journal of Physiology*, **246**, 549-569.
- Perry, J. & Bekey, G.A. (1981). EMG-force relationships in skeletal muscle. *CRC Critical Reviews in Biomedical Engineering*, **7**, 1-22.

IX. Lecture/Lab: Electromechanical delay

- Cavanagh, P.R. & Komi, P.V. (1979). Electromechanical delay in human skeletal muscle under concentric and eccentric contractions. *European Journal of Applied Physiology*, **42** (2), 159-163.
- Corcos, D.M., Gottleib, G.L., Latash, M.L., Almeida, G.L., & Agarwal, G.C. (1992). Electromechanical delay: An experimental artifact. *Journal of Electromyography and Kinesiology*, **2** (2), 59-68.
- Vint, P.F., McLean, S.P., & Harron, G.M. (2001). Electromechanical delay in isometric actions initiated from nonresting levels. *Medicine and Science in Sports and Exercise*, **33** (6), 978-983.

X. Lecture/Lab: EMG-fatigue relationship

- Bigland-Ritchie, B., Jones, D.A., Hosking, G.P., & Edwards, R.H.T. (1978). Central and peripheral fatigue in sustained maximum voluntary contractions of human quadriceps muscle. *Clinical Science And Molecular Medicine*, **54**, 609-614.
- Enoka, R.M. & Stuart, D.G. (1992). Neurobiology of muscle fatigue. *Journal of Applied Physiology*, **72**, 1631-1648.
- Fuglevand, A.J., Zackowski, K.M., Huey, K.A., & Enoka, R.M. (1993). Impairment of neuromuscular propagation during human fatiguing contractions at submaximal forces. *Journal of Applied Physiology*, **460**, 549-572.
- Garland, S.J., & Gossen, E.R. (2002). The muscular wisdom hypothesis in human muscle fatigue. *Exercise and Sport Sciences Reviews*, **30** (1), 45-49.

XI. Lecture: Relevant topics – Bilateral deficit and cross-education

- Howard, J.D. & Enoka, R.M. (1991). Maximum bilateral contractions are modified by neurally mediated interlimb effects. *Journal of Applied Physiology*, **70**, 306-316.
- Ohtuski, T. (1994). Changes in strength, speed, and reaction time induced by simultaneous bilateral muscular activity. In S.P. Swinnen, H. Heuer, J. Massion, & P. Casaer (Eds.), *Interlimb Coordination: Neural, Dynamical, and Cognitive Constraints* (pp. 259-274). San Diego, CA: Academic Press.
- Vandervoort, A.A., Sale, D.G., & Moroz, J. (1987). Strength-velocity relationship and fatiguability of unilateral versus bilateral arm extension. *European Journal of Applied Physiology*, **56**, 201-205.
- Zhou, S. (2000). Chronic neural adaptations to unilateral exercise: Mechanisms of cross education. Exercise and Sport Sciences Reviews, **28** (4), 177-184.

XII. Lecture: Relevant Topics – Training and aging effects on skeletal muscle

- Moritani, T. & DeVries, H.A. (1979). Neural factors versus hypertrophy in the time course of muscle strength gain. *American Journal of Physical Medicine*, **58**, 115-130.
- Sale, D.G. (1988). Neural adaptation to resistance training. *Medicine and Science in Sports and Exercise*, **20**, S135-S145.
- Faulkner, J.A., Brooks, S.V., & Zerba, E. (1990). Skeletal muscle weakness and fatigue in old age: Underlying mechanisms. *Ann. Rev. Gerontology and Geriatrics*, **10**, 147-166.
- Brown, A.B., McCartney, N., & Sale, D.G. (1990). Positive adaptations to weight-lifting training in the elderly. *Journal of Applied Physiology*, **69**, 1725-1733.
- Booth, F.W. & Gollnick, P.D. (1983). Effects of disuse on the structure and function of skeletal muscle. *Medicine and Science in Sports and Exercise*, **15**, 415-420.

XIII. Lecture: Relevant Topics – Muscle elasticity

- Alexander, R.McN. (1984). Elastic energy stores in running vertebrates. *American Zoologist*, **24**, 85-94.
- Asmussen, E. & Bonde-Petersen, F. (1974). Apparent efficiency and storage of elastic energy in human muscles during exercise. *Acta Physiologica Scandinavia*, **92**, 537-545.
- Biewener, A.A., & Roberts, T.J. (2000). Muscle and tendon contributions to force, work, and elastic energy savings: A comparative perspective. *Exercise and Sport Sciences Reviews*, **28** (3), 99-107.
- Cavagna, G.A., Dusman, B., & Margaria, R. (1968). Positive work done by a previously stretched muscle. *Journal of Applied Physiology*, **24**, 21-32.
- Chapman, A.E., Caldwell, G.E., & Selbie, W.S. (1985). Mechanical output following muscle stretch in forearm supination against inertial loads. *Journal of Applied Physiology*, **59**, 78-86.

Documentation for L2 status for KIN 414:

Criterion 1. "At least 50% of the grade in the course should depend on writing, including prepared essays, speeches, or in-class essay exams." This criterion is easily met because the exams are essay exams and the total weighting of the exams for the class is 60%. In addition to essay exams, other written assignments include one article critique, one formal lab report (in addition to two smaller lab reports), and one 10-15 page term paper (total weighting 40% for all written assignments).

Criterion 2. "The composition tasks involve the gathering, interpretation, and evaluation of evidence." This criterion is met with each written assignment mentioned above. The article critique involves reviewing and critically evaluating an assigned research article published in a refereed journal. From this the students will gain critical thinking and scientific writing skills. In each of the labs for this class students will collect, analyze, and interpret scientific data. For the term paper students will review a collection of articles on a topic of each student's choosing (following an instructor approved proposal). Hence the student has to gather the articles, interpret their results, and synthesize their meaning to answer a specific research question posed by the student.

Criterion 3. "The syllabus should include a minimum of two substantial writing or speaking tasks, other than or in addition to in-class essay exams." The two major writing assignments are (1) a formal lab report in journal article format (including introduction, review of literature, methods, results, and discussion) and (2) a 10-15 page term paper. Note, two other lab reports will be assigned but will have brief reports not in journal article format.

Criterion 4. "These substantial writing or speaking assignments should be arranged so that the students will get timely feedback from the instructor on each assignment in time to help them do better on subsequent assignments. Intervention at earlier stages in the writing process is especially welcomed." This criterion will be met by grading each written assignment promptly (1-2 class periods later) with feedback for the students to improve their writing. For example, feedback from the article critique will help the students write their formal lab report and their term paper. Feedback on the term paper proposal will help the students write a better term paper but also a better formal lab report since the proposal is essentially an introduction and brief review of literature on a given topic. Feedback from the minor lab reports will help the students analyze original scientific data, which in turn will help them with their formal lab report and term paper. The sequence of major written assignments is as follows: critique (due week 4), term paper proposal (due week 7), formal lab report (due week 11), and term paper (due week 15).