**Title and Focus of Activity:** Kinetics and Kinematics of Gait in Healthy and Post-Stroke Populations

*Linking Foundation and Clinical Sciences; Innovation - Flipped Classroom Design*

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**Course information:**

Neuromuscular Physical Therapy I; 5 credits; 4th Term; Fall, Year II; follows courses in pathophysiology, neuroanatomy, movement science (learning basic kinetic and kinematic information) and differential diagnosis. This course introduces both theory and practical applications of motor control and motor learning to neuromuscular movement disorders.

**Learning Experience Description:**

Context: This session takes place during the first unit of the Neuromuscular Physical Therapy I course. Significant kinetic and kinematic data is presented in the later reach, mobility, and gait units of this course. Comprehension and performance on these topics is enhanced by reviewing the kinetic and kinematic concepts previously learned and applying them to neurological populations and literature.

Purpose: The purposes are: to improve student understanding and application of kinetic and kinematic principles in class activities through advanced preparation; to increase participation in active learning experiences that both reinforce and provide practical application of the theoretical principles; to utilize the advantages of very small groups to 1) gauge individual student skills and 2) monitor individual attentiveness, content understanding, and application of principles to novel information.

Online Self-Directed Learning module: This consists of an online Audio PowerPoint presentation (40-60 minute duration; recorded using Adobe Presenter). PowerPoint handouts with audio notes are also provided to students. Students review this material and come to class prepared to answer quiz questions related to the identified lecture learning objectives. Generation of online learning module may take several hours of instructor time, followed by annual improvements/updates based upon feedback and unit analysis.

Class Session Format:

1. Students attend one 1.5-hour (of the total 3-hour) scheduled class session; the remaining 1.5 hours of class time is compensated time credited to self-directed online module review.
   1. Administration of in-class graded quiz: quiz of 5-10 Multiple Choice, True-False or Short Answer questions administered. Questions are designed to gauge basic understanding of presented content.
   2. Review of quiz: Students are given immediate feedback on the quiz to ensure understanding of the foundational concepts.
   3. Fielding of student questions and related discussion: Students are provided the opportunity to ask questions regarding the content of the online learning modules. During this time, a basic review of overarching concepts and discussion related to points of confusion may be undertaken.
   4. Active Learning Session: Students are engaged in an active learning experience that facilitates application of the online learning module. An active learning session guide has been included below with sample discussion points and applications to the literature.

Time for student to complete the activity: Normally scheduled 3-hour class time divided as follows: Preparatory time: Self-directed review of audio lecture and printed materials review (~1.0-1.5 hours); Class time: One 1.5-hour of group (half cohort) instruction, activity, and discussion.

Readings/other preparatory materials:

1. Lecture notes
2. Audio presentations recorded using Adobe Presenter or similar software
3. Reference textbooks
   1. Neumann DA. Kinesiology of the Musculoskeletal System: Foundations for Physical Rehabilitation. 2nd Ed. St Louis, MO: Mosby; 2010.
   2. O’Sullivan, SB, Schmitz TJ. *Physical Rehabilitation*, 6th ed. Philadelphia: FA Davis; 2014; 192-201.
   3. Shumway-Cook A, Woollacott MH. *Motor Control: Translating Research into Clinical Practice.* 4th ed. Philadelphia PA: Lippincott Williams & Wilkins; 2012.
4. Articles used for active learning session (students not required to read articles):

*\*\*Note: these articles are selected due to their application to neurological populations and the presentation of graphs and figures sufficiently resemble textbook figures presented in the lecture to allow for interpretation by the students. Articles could be switched to meet specific course objectives and should be updated periodically to remain sufficiently current.*

* 1. Higginson JS, Zajac FE, Neptune RR, Kautz SA, Delp SL. Muscle contributions to support during gait in an individual with post-stroke hemiparesis. J Biomech. 2006;39:1769-1777.
  2. Leung J, Smith R, Harvey LA, Moseley AM, Chapparo J. The impact of simulated ankle plantarflexion contracture on the knee joint during stance phase of gait: a within-subject study. Clin Biomech. 2014;29:423-428.
  3. Wagner JM, Dromerick AW, Sahrmann SA, Lang CE. Upper extremity muscle activation during recovery of reaching in subjects with post-stroke hemiparesis. Clin Neurophys. 2007;118:164-176.

Learning Objectives:

1. Define the terms kinematic and kinetic
2. Describe basic biomechanical principles and terminology
3. Apply equations for work, torque, and power to human movement
4. Describe methods of kinematic and kinetic measurement analysis
5. Describe kinematic and kinetic features of normal gait
6. Apply an understanding of human kinetics and kinematics to intervention choices for patients and clients with neurologic pathology [7A].
7. Apply knowledge of kinematics, kinetics, and EMG to interpret the results of data presented in motor control literature.

Methods of evaluation of student learning:

* 1. Online content tested during in-class quizzes and on unit exam.
  2. Active learning session content is tested on the unit exams.

**Kinematics and Kinetics of Human Movement – Active Learning Session Guide**

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| **Question Presented to Students** | **Related Guided Discussion** |
| What is the difference between kinetics and kinematics? | * Definitions * What would this data look like if presented to us in a graph? (I.e. what would the X and Y axis labels be?) |
| What are Newton’s 3 Laws of Motion? | * Assist students to restate linear laws in terms of angular motion. |
| How does vector composition work? | * Simple addition of coplanar vectors * Tip to tail method |
| What are the 3 classes of levers? | * Students explain each type of lever with respect to orientation of the axis, load and effort. * Examples of each type of lever in the human body are generated by students. |
| Clinical application of levers (draw a simple diagram of a hip and pelvis in the frontal plane)   * 1. What type of lever is this?   2. Which of these forces (load or effort) has a longer moment arm and what does this mean?   3. What will happen if the hip abductors are weak? | 1. Students identify lever class (1st class) and draw on vectors representing the load (gravity acting through bodies COM) and the effort (hip abductors) 2. COM has a longer moment arm and therefor a mechanical advantage over the hip abductor muscles. 3. Review Trendelenberg gait pattern seen in neurological patient. May demonstrate or utilize video from internet sources. |
| Present students with Fig 1 from Leung et al.1 article and Fig 15-38 from Neumann2 text representing normal knee kinetics and kinematics of gait in the sagittal plane.   1. Can you match the light blue line in Fig. 1 to the normal knee data presented in the textbook figure? 2. In what ways does the data represented by the dark blue line differ from this normal data? 3. The dark blue line represents a simulated contracture. Which joint might be restricted? 4. Interpret your findings in question 2 in light of this new information. 5. How can we apply what we have learned to control knee hyperextension in our neurological patients with use of an AFO?     1 Leung J, Smith R, Harvey LA, Moseley AM, Chapparo J. The impact of simulated ankle plantarflexion contracture on the knee joint during stance phase of gait: a within-subject study. Clin Biomech. 2014;29:423-428.  2 Neumann DA. Kinesiology of the Musculoskeletal System: Foundations for Physical Rehabilitation. 2nd Ed. St Louis, MO: Mosby; 2010. | 1. Students should identify that the light blue line:    1. represents normal stance phase    2. striking similarity between true subject data and textbook normal 2. Students should identify (with guidance as needed)    1. Knee hyperextension at midstance    2. Reduced extensor moment early to midstance    3. Power absorption instead of power generation preceding midstance 3. Students may be allowed to practice simulating joint restrictions. Answer: an ankle joint plantarflexion contracture. 4. Students should identify (with guidance as needed)    1. Restricted ankle DF reduces forward rotation of lower leg over foot during stance phase    2. Increased knee extension is passive and not active    3. Power absorption represents eccentric knee flexor activity to control passive hyperextension    4. Note: an individual with neurological injury may experience more abrupt extension if unable to activate knee flexors eccentrically 5. Setting an AFO in 5 degrees dorsiflexion helps to control knee hyperextension. |
| Present students with Fig 1 from Higginson et al.3 article representing hemiplegic gait and compiled Figure from Neumann2 text representing normal hip, knee and ankle kinetics of gait in the sagittal plane.   1. What differences can you observe between the paretic and non-paretic limb? 2. What differences can you observe between the non-paretic limb and the textbook normal?     2 Neumann DA. Kinesiology of the Musculoskeletal System: Foundations for Physical Rehabilitation. 2nd Ed. St Louis, MO: Mosby; 2010  3 Higginson JS, Zajac FE, Neptune RR, Kautz SA, Delp SL. Muscle contributions to support during gait in an individual with post-stroke hemiparesis. J Biomech. 2006;39:1769-1777. | 1. Students should observe (with guidance):    1. Less hip flexion during swing on the paretic side    2. Paretic knee remains flexed throughout stance phase and demonstrates less flexion during swing phase    3. Ankle more DF during stance. Why?       * Likely a result of knee flexion 2. Students should observe (with guidance):    1. Decreased hip extension at terminal stance. Why?       * Shorter step?    2. Increased midstance knee extension. Why?       * Clear the opposite leg    3. Ankle does not PF at terminal stance. Why?       * Less push off to slow propulsion onto paretic limb. |
| Present students with Fig. 2 from Higginson et al3 presenting EMG data for healthy slow, paretic and non-paretic lower extremities during gait.   1. What differences can you observe in the paretic limb compared to normal?   3 Higginson JS, Zajac FE, Neptune RR, Kautz SA, Delp SL. Muscle contributions to support during gait in an individual with post-stroke hemiparesis. J Biomech. 2006;39:1769-1777. | 1. Students should observe (with guidance) abnormal co-contraction of antagonistic muscles in paretic limb.    1. Implications for stroke patients 2. Weak muscles also fighting opposition from inappropriately timed activation of antagonists |
| Present students with EMG data from Wagner et al.4 analyzing reach grasp in the first few months following stroke.   1. What differences can you observe between the acute stroke subjects and the control subjects? 2. What differences can you observe between the subacute and acute stroke subjects?   4 Wagner JM, Dromerick AW, Sahrmann SA, Lang CE. Upper extremity muscle activation during recovery of reaching in subjects with post-stroke hemiparesis. Clin Neurophys. 2007;118:164-176. | 1. Students should observe (with guidance) that acute subjects demonstrate:    1. Delayed muscle onset (only triceps biceps and ant deltoid active prior to movement)    2. Higher relative levels of muscle activation (%MVIC)    3. Longer movement time 2. Students should observe (with guidance) that subacute subjects demonstrate:    1. More like controls    2. Reduced movement time    3. More active before movement, but not to the level of controls    4. Still higher slightly higher level of activation (%MVIC) |