BIOMECHANICAL BASIS OF HUMAN MOVEMENT

Problem Title	Sit-to-Stand: A Needs Analysis in a Care Home Setting

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Learning Outcome(s)	
1	Describe the kinematic patterns in a range of successful sit-to-stand techniques
2	Compare the effectiveness of different techniques for care home residents
3	Prepare advice for care home residents on how to stand up most safely from a chair

Concepts / Competencies expected to engage with	● Force and acceleration ● Torque and angular acceleration

Course Level	Undergraduate, introductory biomechanics course	

This problem involves data analysis	Yes	No	Maybe X

Approximate Length	60 mins

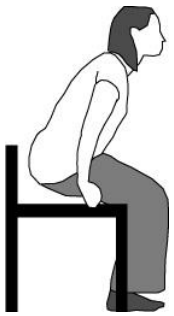
Class/ Group Size	3-5 per group; ideally no more than 30-40 students per facilitator

Useful References	• Caruthers, E. J., Thompson, J. A., Chaudhari, A. M. W., Schmitt, L. C., Best, T. M., Saul, K. R., & Siston, R. A. (2016). Muscle forces and their contributions to vertical and horizontal acceleration of the center of mass during sit-to-stand transfer in young, healthy adults. *Journal of Applied Biomechanics, 32*(5), 487–503. https://doi.org/10.1123/jab.2015-0291 • Gilleard, W., Crosbie, J., & Smith, R. (2008). A longitudinal study of the effect of pregnancy on rising to stand from a chair. *Journal of Biomechanics, 41*(4), 779-787. https://doi.org/10.1016/j.jbiomech.2007.11.015 • Norman-Gerum, V., & McPhee, J. (2020). Comprehensive description of sit-to-stand motions using force and angle data. *Journal of Biomechanics*, 112. https://doi.org/10.1016/j.jbiomech.2020.110046

Mode of Instruction	Synchronous or asynchronous

The Scenario:

At the care home where you have just started working, you have noticed that a number of the residents have great difficulty in standing up from a chair: some cannot consistently reach the standing position by themselves, and others lack confidence in being able to do so without a risk of falling. You understand that strength and balance issues probably play an important role in this, but you also suspect that technique is a major consideration. You've never thought about how you stand up – it's second nature for you – but you realise that a careful analysis of the sit-to-stand movement would give you a better understanding of the challenges faced by the residents, and of how you might be able to help the latter overcome them. You decide to put the knowledge from your biomechanics classes to work!



The Questions:

1. What techniques can be adopted in standing up from a chair, and what is the sequence of movements during each?
2. What biomechanical objectives – translatory and rotatory – need to be met in order to stand up without losing balance?
3. Which sit-to-stand technique would you recommend to the care home residents, and why?

Expected Outcomes:

Depending on the group, some or all of the following learning activities might be included:

Identifying Sit-to-Stand Kinematics (essential): Students are asked to observe and, ideally, record other members of their group standing from a seated position. Videos can be provided, if necessary. Initially no mention of strategies or constraints ("No arms" etc.) should be made; these can emerge from the activity and subsequent discussion. Phases of the motion can be identified, and the key sequence of movements should be agreed upon. [Q1]

Quantification of the Kinematics (optional): Variables such as joint angles and the Centre of Mass (CM) path could be analysed, depending on the software and hardware available.

Draw a Free-Body Diagram (optional): Students could complete a free-body diagram for the person at a point just after they have raised themselves off the chair seat; both the Arms and No Arms conditions might be considered.

The Kinetic Challenges (essential): Students are asked to identify the key linear and angular kinetic requirements if the observed kinematics are to be produced, linking forces to CM acceleration and torques to the requirement to avoid falling backwards or forwards. [Q2]

Recommended Strategies (essential): The combination of strategies that would provide the residents with the best chance of standing up successfully should be discussed and agreed. Topics for discussion might include the starting position of the feet, the role of the upper body, and the use of the hands (and how they can help in both linear and angular terms). The effectiveness of proposed strategies can be explored through practical demonstrations, and with the introduction of challenging conditions such as a particularly low chair. [Q3]

Groups could be asked to complete a written worksheet and/or feed their ideas back to the larger group.

Guided Questions (Hints):

1. In which direction(s) does the person's CM need to be accelerated during the sit-to-stand motion?
2. In which direction(s) must the net external force point in order to achieve this?
3. Which point(s) could we consider as the centre of rotation as we analyse the overall rotation of the whole body?
4. Which directions of torque about the point(s) identified in #3 are generated by the external forces applied to the person?
5. How does an initial lean forward make the task of standing up easier?
6. What alternative strategies can be used to stand up if you are **not** allowed to lean forward at the start of the motion?
7. How do the alternative strategies in #6 facilitate standing up? Which might be safest in terms of minimising the risk of a fall?
8. How does chair/seating design affect the sit-to-stand task?

Follow-up learning activities, if needed:

1. The analysis so far has focused on motion in the sagittal plane. Repeat the process for motion in the frontal plane, and make any necessary additions to your advice to the care home resident.
2. Search for advertisements for chairs marketed to elderly people and/or care home residents. Identify any key features of these chairs and evaluate their potential for allowing easier and safer standing up.
3. Identify the joint torques that could contribute to overcoming the effects of gravity. Which of these torques is/are most likely to be limiting for a care home resident?