Why did Grandpa drop the glass?

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IT IS COMMON KNOWLEDGE that healthy aging is associated with deterioration of motor function across a range of tasks. Such changes have profound impact on everyday activities and overall quality of life. It is also well known that aging changes various levels of the sensorimotor system, from a reduction in the number of muscle fibers, α-motoneurons, and neurons in the primary motor cortex (2, 3) to slowing of sensory and motor conduction velocity and reduction in the numbers of tactile mechanoreceptors (8). One of the main challenges has been to link those well documented changes at the various physiological levels to the changes in motor coordination during functionally meaningful actions. In this issue of the Journal of Applied Physiology, Pranav Parikh and Kelly Cole (6) cleverly meet this challenge by examining motor coordination in prehensile tasks that mimic natural everyday hand actions in the elderly healthy.

The problem of understanding motor coordination during prehensile tasks is multi-faceted. First, there is no agreement among researchers in the field of motor control on how even the simplest movements are organized by the central nervous system. Second, the number of elements (neurons, muscles, joints, etc.) is usually much larger than the number of typical task constraints, leading to numerous problems of motor redundancy (1). For prehensile tasks, this factor becomes increasingly more significant with the addition of each digit to the action. Specifically, each digit produces six components of the vectors of force and moment of force on the contact surface of the object. In typical five-digit grips, the number of those elemental mechanical variables is 30, whereas for the precision two-digit grip it is 12. Most everyday tasks are associated with fewer constraints. This means that, at the level of mechanics, the system is redundant (5), that is, it affords numerous (an infinite number of) solutions to the problem of finding a combination of elemental mechanical variables to satisfy task constraints. Third, the problem does not end at the level of mechanics. The problem of redundancy becomes even greater when one tries to take into account the actual muscular design of the hand (4). In particular, the mappings between the mechanical variables, sensory information, and muscle activations significantly add to the complexity of the problem.

The problem of motor coordination during prehensile tasks is daunting even at the least controversial, mechanical level of analysis. Parikh and Cole made the first important step along the route toward discovering how the human brain controls the hand and how these processes change with aging. Their study is a brilliant example of an experimental approach that identifies the level of analysis and limits the task to a minimalistic one, involving only two digits. This design allowed the authors to measure all the relevant mechanical variables produced by the digits. Despite the minimalist design, the tasks used in the study are highly relevant to everyday actions such as threading a needle, turning a key, and holding a fragile piece of china.

There are three important findings in the Parikh and Cole study. First, older adults begin with misaligned points of application and directions of the force vectors produced by individual digits in the less precisely constrained grip-and-lift task. This leads to greater unnecessary moments of force acting around the roll axis of the object, which can potentially lead to errors in object orientation. The study also confirmed previous observations of higher grip forces and slower actions by the older adults. These well documented features of hand actions by elderly persons may reflect not some primary deficiencies in hand control, as could be presupposed by the physiological changes in the elderly sensorimotor system, but adaptive features that alleviate the potentially detrimental effects of misaligned forces on important performance variables (7). Second, with relatively minimal practice the group of older adults aligned their digits better, reduced their grip force, and minimized unnecessary moments of force applied by the digits on the object in the grip-and-lift task. In fact, most performance variables in both tasks (external moments, digit-tip force directions, grip force amplitude, and performance time) improved in the group of older adults with practice. Thus there is certainly an optimistic message that relatively little practice can have significant beneficial effects on motor coordination in the elderly. Furthermore, the apparently different characteristics of performance show parallel changes with practice supporting the idea that some of them may be adaptive to others.

Third, the only measure not to improve with practice in the elderly was the moment-to-moment variability in digit-tip force angle during the precision orientation (key-slot) task. As the authors suggest, this moment-to-moment variability may be the result of the physiological changes in the elderly sensorimotor system, which could ultimately lead to problems with more dexterous hand actions.

There are a number of challenges that Parikh and Cole’s study brings to light. One example is to directly map the mechanical variables onto the neurophysiological ones. This would require accepting a hypothesis on how natural human movements are controlled and finding a way to quantify physiological variables relevant to the motor control processes. Another challenge is in continuing to quantify natural, unconstrained hand actions. One of the limitations to doing this is the current force/torque sensor technology, which generally restricts the digit placement on the object. This issue is critical given the results of Parikh and Cole’s study regarding differences in digit placement in the elderly. Similarly, these sensors do not easily allow for measuring forces/torques on different shaped objects that we actually encounter in everyday life.
One of our respected colleagues once said “Motor control is an area of movement studies done by researchers who cannot measure properly.” At the time, this statement definitely had an element of truth. The study of Parikh and Cole is an example of motor control research that is based on highly accurate measurements with clearly formulated goals and hypotheses that have both basic and applied significance. This combination of rigor, inventiveness, and exactness is still relatively rare in the field of motor control. This study sets a great example for all of us to follow. Maybe, at some point in the future, we will be able to answer the question formulated in the title of this note.

DISCLOSURES

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

AUTHOR CONTRIBUTIONS

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