Should exercises and training be specific in motor learning?

Lisa Harvey and colleagues have made a major contribution to the rehabilitation of spinal cord injuries so it is a pleasure to have a chance to engage with them in a discussion of some aspects of their paper (Harvey et al 2011).

The aim of this study was to investigate whether people with recently acquired paraplegia benefit from an intensive motor training program aimed at improving unsupported sitting. All subjects undertook standard inpatient rehabilitation that included physiotherapy and occupational therapy training for transfers, wheelchair skills, dressing, and showering. Experimental subjects received three additional 30 min sessions per week for 6 weeks, of exercises directed at improving the ability to sit unsupported. At the end of the study both experimental and control participants had improved. However, there were no significant differences between the groups rendering, in the authors’ opinion, the additional training redundant.

The results of this study raise some interesting questions about the specificity of exercises and training in motor learning and in the acquisition of skill; in particular, can one expect exercises aimed at improving specific movements (eg, Fig 1, Harvey et al 2011) to generalise into improved performance of complex functional tasks such as dressing, showering, brushing teeth, and wheelchair skills? The history of specificity studies tells us this may not occur unless the action being trained has similar biomechanical characteristics to the activity to be learned. This issue is of some importance for physiotherapists in many fields of neurorehabilitation.

People with paraplegia perform most of their activities of daily life in a wheelchair. Learning to balance in sitting is therefore fundamental to vocational, recreational, sporting, and social participation, and to quality of life. For physiotherapists and occupational therapists to train complex functional tasks in sitting, they must be able to analyse the nature of the task to derive effective therapeutic interventions (Gentile 2000): in this instance, in planning an exercise program, it is necessary to have some understanding of the biomechanics of sitting balance in able-bodied subjects and the critical features of balance, as well as the effects of muscle weakness and paralysis on actions performed in sitting.

Biomechanical studies of able-bodied subjects have shown us that leg muscles play an active role in supporting and balancing the body mass over the base of support (thighs and feet) when we move about in sitting. In studies of reaching forward beyond arms’ length, leg muscles were active before the arm moved at both slow and fast speeds (Crosbie et al 1995). The distance to be reached was also affected by the extent of thigh support (Dean et al 1999). Reaching sideways in sitting (in the frontal plane) is more destabilising than reaching forward (in the sagittal plane) since the body weight is shifted on to one leg and the perimeter of the base of support is reached earlier. Few studies have examined lateral movements in sitting. In one study, when subjects were asked to move their body mass as far to the right as possible, the lower limbs were active even in the preparatory phase (Sekiya & Takahashi 2001). For people with paraplegia however, avoidance of overbalancing requires the centre of mass (COM) to be kept within the base of support; this depends to a large extent on the ability to pay attention to surroundings, to identify and act quickly enough to potential threats to stability, as well as to develop the ability to adapt the movement to task and environmental demands.

Balance can be defined as the ability to control the body mass relative to the base of support. The body is almost never still. Strictly speaking, sitting cannot be ‘unsupported’ as the thighs and feet form the base of support. The term ‘unsupported sitting’ implies maintaining a stable posture. However, this is only one of the functionally significant components of balance (Melville-Jones 2000). In everyday life, the postural system must meet three goals, it must maintain a steady state (balance) in the presence of gravity, it must generate adjustments that anticipate self initiated goal-directed movements, and it must be adaptive during these movements, and in response to unexpected perturbations. When the centre of mass moves outside the base of support – a point beyond which we cannot maintain balance without making a new base of support – we do this by stepping, holding on to a stable object, or we overbalance, reach out, and fall.

There is another useful way to look at balance. Ghez (1991) described a ‘family of adjustments’ needed to maintain a posture and to move. These adjustments have three goals: to support the head and body against gravity and other external forces, to maintain the centre of mass aligned and over the base of support, and to stabilise parts of the body while other parts are moved. Balance, therefore forms the foundation of all voluntary motor skills (Massion & Woollacott 1996) and is a real problem when muscles are paralysed or weak. As these muscles control hip, knee, and ankle joints, these individuals need to learn to balance using muscles of the upper body.

In order to enable patients to regain functional skills, the rehabilitation therapist sets goals for the patient and arranges the environment in which the action takes place. However, it is the patient who must organize a movement that matches the environment and produces the desired outcome. Using Gentile’s taxonomy, reaching sideways to touch or pick up an object on the floor (eg, Fig 1, top left, Harvey at al 2011) and sitting up again, gives the patient the ‘idea of the movement’ (Gentile 2000). They get an idea of how far they can move laterally and still return to upright sitting without losing balance by testing the limits of stability and expanding these limits to achieve their objective. If the movement is not practised in the context of an everyday activity, and if it is not made challenging and therefore difficult (but not impossible), it becomes meaningless, and boring – ie, producing the movement is abstract rather than concrete. Functional tasks have a concrete goal, eg, picking up the soap from the floor when showering.

Some of the subjects found the ‘exercises boring and repetitious’. Exercises can be boring and repetitive unless we are training to go skiing, run a marathon, or cycle in a charity race when we have concrete goals and motivation is high and we really push ourselves. So one wonders, was the training program sufficiently challenging and goal
directed? Did the methodology allow sufficient challenge for the participants to learn how to adapt to environmental demands, pay attention to critical features, and actively engage in practice. Acquiring skill does not only mean to repeat and consolidate but also to invent and progress (Whiting 1980); practice is a particular type of repetition without repetition (Bernstein 1967). Did they practise moving at different speeds, were they encouraged to push themselves to their ‘limits’? Did they have the chance to make mistakes – making errors is part of learning.

Interestingly, it seems that the results of this study support the principle of specificity of training. The study has also opened up a most interesting area of investigation, and we are sure the article will stimulate considerable interest as it has for us.

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References


Response

We thank Professors Shepherd and Carr for their letter and interest in our paper (Harvey et al 2011). We largely agree with their insightful comments and interpretation of the literature.

We have three brief comments in response to their discussion:

1. We should have clarified that by ‘unsupported sitting’ we were referring to sitting without trunk support. As Shepherd and Carr rightly point out, it is not possible to sit (or stand) without some sort of support.
2. We are aware that a couple of participants from the Sydney study site commented that the training was tedious, which may have prompted Professors Shepherd and Carr to question the structure of our training. That is, they questioned whether the training could have been better structured to make it less tedious for participants and hence more effective. We would challenge any therapist to achieve the same intensity of training for 6 weeks as we achieved for one specific motor task in this clientele without a couple of participants passing comment about the repetitious nature of the training. This is particularly so for this consecutive sample of predominantly 18 to 25 year old males admitted to a government-funded spinal unit. Our therapists were highly experienced in working with this clientele and set goals, progressed training, provided variety, and set up a motivating training environment appropriate for this age group.
3. In a parallel trial, we used exactly the same training strategy and demonstrated a treatment effect (Boswell-Ruys et al 2010). The only differences between the studies were that participants had chronic spinal cord injury and were not concurrently receiving training for functional activities. This prompted us to conclude that intensive and specific training for unsupported sitting (that is, without trunk support) in people with recent spinal cord injury is redundant if they are concurrently receiving intensive training for functional activities. We stand (or sit) by this conclusion.

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References