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Does Ability to do Proactive Stepping Reflect Ability to do Reactive Stepping?

Original scientific paper

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Abstract

Stepping is the strategy used in standing to prevent fall. Reactive stepping is made when perturbed to fall. Reactive stepping is less assessed in clinical setting, instead, proactive stepping is assessed to measure the risk of fall. Reactive stepping is commonly tested in research settings. This study was done to find relationship between proactive stepping and reactive stepping in healthy adults. We found that proactive stepping ability did not reflect reactive stepping ability. The study suggests that outcomes of proactive stepping measures must be used with caution to understand individual's ability to do reactive stepping and prevent falling.

Keywords: *fall, postural reaction, stepping, CSRT*

Postural control is the act of maintaining a position, and achieving or restoring a state of balance, in the event of loss of balance or during an activity (Sibley et al., 2013a). Falls occur due to a loss of balance from which an individual is unable to recover their posture.

Anticipatory postural adjustments (APA) are the first level of action by the central nervous system (CNS) to maintain postural control during an activity, or in preparation for a movement. When the APA are insufficient to maintain balance or posture during the movement, or when there is an unanticipated disturbance to posture, the CNS uses Reactive postural adjustments (RPA). These RPA occur when the line of gravity moves out of the base of support (Kanekar & Aruin, 2014).

Different assessment methods are required to assess APA and RPA. Mancini and Horak (2010) explored the relevance of the most commonly used clinical balance assessment tools to differentiate balance deficits. They concluded that commonly used functional clinical balance assessment tools, such as the Activities of Balance Confidence test, Tinetti balance and Gait test, Berg balance scale, and the timed "up and go test" were not developed to distinguish different types of balance deficits. These measures generally reflect APA and not RPA.

Stepping or creating a new base of support is the RPA strategy used in standing when perturbed to fall. The Tether release method and moving platforms are the common methods used in the research to test the RPA (Barrett et al., 2012; McIlroy &

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Maki, 1996). The method to provoke RPA in both methods are different. In the moving platform the base on which the subject is made to stand is moved to produce a RPA, which is similar to real life scenario. In tether release method the subject is made to lean forward/backward against a weight tethered to the waist of the subject. RPA is expected to be produced when the tethered weight is released suddenly. Usage of both these methods in regular clinical practice is limited due to the construction of the devices. Generally, stepping is assessed as voluntary stepping using methods like Choice Step Reaction Test. CSRT measures the ability to respond and step quickly. The test reflects the individual's APA component of stepping. A strong association has been found between performance in the CSRT and neuropsychological, sensorimotor, and balance measures (Lord & Fitzpatrick, 2001). CSRT-M is a modified form of original CSRT, which is easy to construct and use in clinical environment (Delbaere et al., 2016). We were interested to know whether assessing APA using measures like CSRT-M will reflect individual's ability to do RPA. Understanding this relationship between anticipatory and reactive elements of postural reactions will support the use of measures like CSRT-M in clinical practice to assess anticipatory component and reassure about the reactive stepping ability. Moreover, this will also help us to understand whether training stepping voluntarily is likely to improve reactive stepping ability to prevent fall.

In this study, we tested the relationship between APA in CSRT-M and RPA stepping in moving platform.

Materials and Methods

This study was approved by the institution's ethics committee (REF; CSP/19/NOV/81/367)

Healthy adults were screened for range of motion, muscle power, normal kinesthetics and exteroceptive sensation in the lower limb before inclusion in the study. Individual with any deficits or history of injury to the lower limbs that can affect the performance of CSRT-M and stepping on the moving platform were excluded.

The process of testing was explained and demonstrated prior to obtaining signed consent for participation. Subjects were tested first with CSRT-M followed by forward stepping on the moving platform.

The CSRT-M was constructed using a thin flexible non-slip mat (80cm x 120cm) marked with two rectangular standing panels (28.5cm x 13.5cm) and four rectangular stepping panels (28.5cm x 13.5 cm), one in each front of each standing panel and one on each side (see Fig 1). The construction and measurement process in CSRT-M are based on a published literature (Delbaere et al., 2016). In the CSRT-M, verbal commands are used to instruct the step (i.e. place the whole foot) onto specific rectangle panels in a set sequence of 20 steps as quickly as possible. Subjects were asked to follow the instructions and place their foot in the relevant boxes. The left foot was placed in the left side boxes and the right foot in the right boxes. The stepping must be done as quickly as possible and the foot should be returned to the central boxes quickly.

The instructions for stepping were based on the standard commands given for the test. Trials were repeated if a participant stepped with the wrong foot or missed the rectangle by more than half of the foot. Out of a total 20 steps, the time taken for the last 12 steps was measured, with the first 8 steps used as a practice trial. Subjects were instructed to stand on the mat with their foot in the central boxes.

The instruction were: 1. side right, 2. side left, 3. front right, 4. front left, 5. side left, 6. front right, 7. side right, 8. side left, 9. front right, 10. front left, 11. side right, 12. front right, 13. side right, 14. Front left, 15. front left, 16. side left, 17. front right, 18. side right, 19. front left, 20. side left.

Figure 1.
CSRT-M mat

The moving platform was constructed with two wooden panels, such that one can slide over the other. The sliding mechanism was constructed with a channel on one of the boards to direct the sliding in one direction. The size of each wooden panel was 62 cm x 62 cm. (Fig 2, Fig 3). At the start of the testing the upper panel was moved forward over the lower panel. The channel permitted the upper panel to slide 50 cm forward. The subject was made to stand on the moving platform facing the therapist at the end of top panel. The therapist moved the platform towards the subject with his foot, quick enough to produce a forward step by the subject. The subject was then asked to step out of the moving platform, and platform was reset. The subject was asked to stand on the platform again, and the procedure was repeated again. Three trials were done for each subject. The stepping was recorded for analysis, with the camera placed four and half feet away from the center (of length) of the moving platform, and the position of the camera checked for viewing angle to capture the full stepping. The camera recorded from when the subject moved on the platform till the subject completed the last trial. During the procedure another therapist or assistant was standing by the side to support the subject if they lost balance.

Figure 2.
Moving Platform – top view

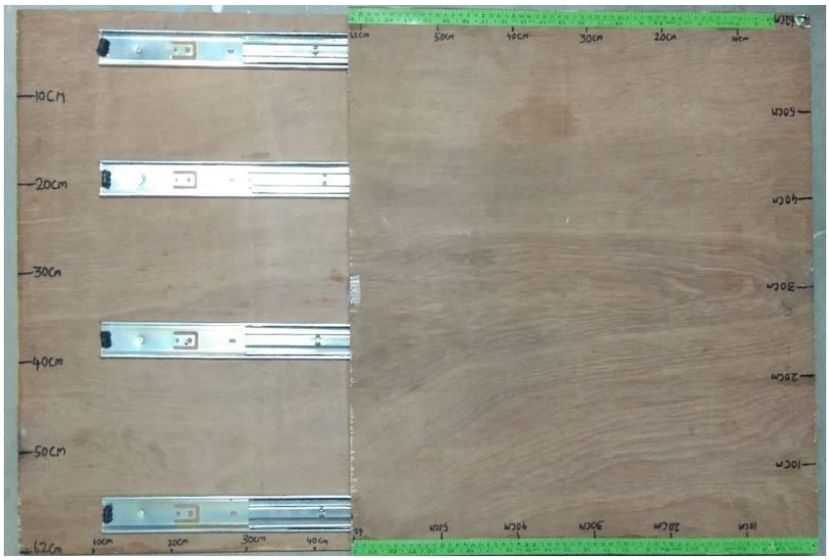

Figure 3.
Moving Platform – side view

Data Analysis

The time taken to step in moving platform was measured with an open source software – Tracker© (version 5.3.1). The average of three trials and minimum duration of all the three trials were taken for analysis. The time taken for the last 12 steps in the CSRT-M was taken for analysis. The relationship between the step time on the moving platform and the step time in the CSRT-M was tested using Pearson's correlation coefficient.

Results

The correlation coefficient between CSRT-M and average step duration, and CSRT-M and minimum step duration were calculated. The correlation revealed a non-significant relation between the CSRT-M and reactive stepping on the moving platform.

Table 1.
Demographic profile

Male (n)	15
Female (n)	8
Age (mean years & SD)	45.2 (3.2)

Table 2.
Correlation between CSRT-M score and step duration in moving platform

CSRT-M	Average step time	Minimum step time	Pearson's r		p-value	
N = 23	N = 23	N = 23				
(mean seconds &SD)	(mean milliseconds & SD) -a	(mean milliseconds & SD) -b	a	b	a	b
37.3 (3.91)	.916 (.246)	.654 (.234)	.07	.15	.7	.4

$p < .05$. a and b columns correspond to
average and minimum step time correlation with CSRT-M.

Discussion

We found that the time for volitional or proactive stepping measured by CSTR-M does not correlate with the reactive step timing measured with moving platform. This reveals CSTR-M cannot reflect ability to do a reactive step, equally, the ability to do anticipatory stepping may not reflect individual's ability to do a reactive stepping.

The ability to do volitional stepping and reactive stepping appear to be different abilities of an individual. In volitional stepping, the individual has sufficient time to prepare and perform the task. In CSTR-M, although the stepping is done following commands from the therapist, there is no impending threat to fall, hence, the response is still under the control of the individual. In the case of stepping on a moving platform, the subject is given a threat to his control of standing to provoke stepping. In this occasion, the timing of response is crucial to prevent a fall.

Carty et al. (2015) conducted a 12-month prospective study with 200 subjects to assess whether the ability to recover from a forward loss of balance with a single step and concluded that reactive stepping behavior was an independent predictor of fall (Carty et al., 2015). The author recommended that exercise interventions designed to improve reactive stepping behavior may protect against future falls. To plan an appropriate therapy and assess the improvement, APA and RPA must be assessed with appropriate outcome measures and instruments in the clinical setting (Mancini & Horak, 2010; Pollock et al., 2000).

Borrelli et al. (2019), reported that perturbation provoked stepping reactions are less frequently used in clinical assessment of traumatic brain injury. Whilst manual perturbations are more commonly used, use of mechanical devices are more easily measurable and reproducible (Borrelli et al., 2019). Sibley et al. (2013b) studied the methods used to assess reactive postural control in the clinical setting by physiotherapists in Ontario, Canada, and reported that despite the availability of valid standardized measures, respondents relied primarily on non-standardized approaches and observational assessment. Even though it is established that reactive stepping must be assessed to know the individual's ability to prevent fall, such assessments are done less frequently in clinical settings. Lack of time and environmental constraints were the common barriers limiting the relevant postural control assessment (Sibley et al., 2013a; Sibley et al., 2013b). Use of simple tools like a moving platform to assess step reaction is a feasible method in a clinical setup, as it requires minimal space. However, to measure time, the performance has to be video recorded or there must be addition of further technology to measure the time. The CSRT-M, which does not require major infrastructure requirement to assess stepping, is able to assess only volitional stepping, and could not reflect the reactive stepping based on our finding. Assessing reactive stepping in clinical practice is critical as it reflects individual's ability to prevent a fall. Tools like moving platform could be used wherever possible to assess reactive stepping.

Conclusion

An array of measures are available to measure APA compared to RPA. However, RPA is important to prevent falls. Hence, to assess ability of an individual to make effective compensation against a perturbation sufficient enough to un-balance towards a fall, the ability to perform protective stepping or RPA has to be assessed with appropriate instrumentation.

Author Contribution

SR: Designed the study, analysed the results, drafted the manuscript; KN: collected the data, identified references; SM: Analysed the results, edited the manuscript.

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Declaration of Interest

No potential competing interest to be discussed for this study.

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