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Executive dysfunction and balance function post-stroke: A cross-sectional study

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Abstract

Objectives This study investigated the: (1) prevalence of executive dysfunction (ED); (2) demographic and clinical differences between participants with ED and without ED and; (3) independent association between executive function (EF) and balance post-stroke.
Design Prospective observational cross-sectional study.
Setting Four large acute hospitals.
Participants : Convenience sample of people with first stroke.
Main outcome : Balance function.
Secondary outcomes : EF, stroke severity, depression and global cognition.
Methods Descriptive statistics were used to report the prevalence of ED post-stroke. Comparisons of demographic and clinical characteristics were made between participants with ED and participants without ED using independent *t*-tests. Hierarchical multiple linear regression analysis determined the association between EF and balance post-stroke.
Results Participant ($n = 100$) age ranged from 31 to 98 years, time since stroke ranged from 4 to 180 days and the participants reported formal education ranging from 7 to 21 years. Participants with ED had more severe strokes (BADS) [median (IQR) vs median (IQR), *p*-value] [(44 (16) vs (51 (7), $p < 0.01$], poorer global cognition [24 (6) vs 29 (2), $p < 0.01$] and poorer balance [29 (40) vs 46.5 (17), $p < 0.01$] in comparison with participants without ED. Age ($\beta = -0.24$, $p < 0.05$), years in education, ($\beta = -0.21$, $p < 0.05$), stroke severity ($\beta = 0.71$, $p < 0.01$), time since stroke, ($\beta = -0.17$, $p < 0.01$) and EF ($\beta = 0.19$, $p < 0.05$) were independently associated with balance post-stroke. The total variance in balance explained by the model was 72%.
Conclusions ED is independently associated with balance post-stroke. Physiotherapists should consider this when developing rehabilitation strategies to improve balance post-stroke.

Keywords: Executive dysfunction; Balance function; Stroke; Physiotherapy

Introduction

The consequences of stroke are described in terms of motor, sensory, psychological, communicative challenges, in addition to cognitive deficits, manifested by impairments in orientation, memory, concentration, attention, and executive function (EF) [1]. EF is defined as the group of cognitive processes responsible for guiding, directing, and managing cognitive, emotional and behavioural functions, during novel tasks such as organizing thoughts and activities, prioritizing tasks, managing time efficiently, and decision-making [1] and is one aspect of cognition that has received increased attention in the literature [2–10].

The results of a review highlight that there are a limited number of studies that include measures of EF when investigating physical function post-stroke, nonetheless they were suggestive of a relationship between EF and physical performance [11]. Much of the focus has been on the associations

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between EF and activities of daily living (ADL) and there has been little investigation, to date, on the relationship between EF and aspects of function post-stroke. Liu-Ambrose et al. [3] demonstrated that ED was independently associated with poorer balance, mobility and exercise endurance in chronic stroke. A longitudinal study [7] reported that participants with poor EF three months and one year post-stroke had significantly poorer balance and lower levels of physical activity one year post-stroke than participants without such dysfunction. This may not be surprising given the importance of many aspects of EF, as defined by Donovan et al. [1], in performing exercise as part of a rehabilitation programme. In their work on defining functional cognition (the ability to accomplish everyday activities that rely heavily on cognitive abilities), the definition of EF outlined by Donovan et al. [1] is meaningfully functional for clinical interpretation by physiotherapists working in the area of stroke rehabilitation. From a clinical perspective, it is clear that a person post-stroke who demonstrates deficits in organising his or her thoughts and activities may experience difficulty in following a physiotherapy home exercise programme often provided on discharge from hospital [2]. The participation in goal-oriented behaviour is a crucial element to successful rehabilitation post-stroke and difficulty in the prioritisation of tasks may compromise the success of rehabilitation post-stroke e.g. choosing to engage in sedentary behaviour as opposed to engaging in additional self-directed exercise outside dedicated physiotherapy treatment time. Furthermore, people who demonstrate time-management deficits, e.g. difficulty in initiating and persisting at a series of exercises during physiotherapy rehabilitation and following a time table may result in reduced functional recovery post-stroke [2]. People post-stroke who lack the ability to self-monitor their performance and make appropriate decisions during rehabilitation, e.g. recognise that they have parked the wheelchair too far from the bed to conduct a safe transfer, may engage in unsafe physical manoeuvres in the clinical setting [11] and therefore potentially reduce the success of rehabilitation post-stroke.

Furthermore, advances in neuroanatomy, neurophysiology and functional magnetic resonance imaging studies have demonstrated that the cortical motor areas, basal ganglia and cerebellum are no longer exclusively associated with motor control but also have important roles in EF, cognition, language, perception and learning [12]. White matter tracts are known to link the dorsolateral prefrontal cortex, which is the anatomical origin of EF, to the striatum, basal ganglia, and thalamus [12]. This frontal-subcortical circuit links executive and motor brain processes and enables an organism to interact adaptively with its environment [12]. Damage to any of these locations or to the white matter tracts linking these locations has been shown to result in both ED and balance impairment in people with white matter subcortical lesions [12]. Therefore, the functional interconnectivity between executive and motor brain processes means that stroke-related pathology may cause impairments in both EF and physical function concurrently. It is well recognised that many cognitive resources are required in balance function, and that the more difficult the postural task, the more cognitive processing is required [13]. Horak[13] postulated that people with impairment of cognitive function may use more of their available cognitive processing to control posture and that falls can result from insufficient cognitive processing to control posture while occupied with a secondary cognitive task.

Research on the relationship between EF and aspect of physical function post-stroke has been preceded by extensive examination of this relationship in older adult populations [14–19]. An overview of this body of evidence has demonstrated that ED is linked with reduced balance [15], reduced balance confidence [14] and increased difficulty with the performance of dual-tasks [16,17,19] among older adults. This literature has contributed significantly to the understanding of the relationship between EF and physical function and provides rationale for the further investigation of this relationship in stroke populations. Understanding the nature of such a relationship may inform rehabilitation professionals in the appropriate design of exercise programmes for people with stroke to optimise participation and recovery.

The purpose of this study was to investigate: (1) the prevalence of ED in the first six months post-stroke; (2) the differences in demographic and clinical characteristics between participants with ED and without ED and; (3) the independent associations between EF and balance performance post-stroke.

Methods

A cross-sectional design was used. Participants were recruited from four teaching hospitals in Dublin from March 2011 to January 2012. A register of all patients with a suspected stroke in each recruitment site was recorded by the senior physiotherapists in stroke who discussed potentially suitable participants with the researcher (SH) on a weekly basis. The senior physiotherapists in stroke approached the potentially suitable participants, described the study to the patients and asked if they would agree to being approached by SH. If the patients agreed to being approached by SH, the study procedure was described in further detail and they were provided with a participant information leaflet. SH determined potential participant's suitability for entry into the study using the following selection criteria: formal diagnosis of first ever stroke; >18 years of age and ≤6 months post-stroke. Exclusion criteria were: pre-stroke vascular dementia or cognitive impairment; aphasia (≤13/20 on the shortened version of the Frenchay Aphasia Screening Test (FAST)) [20]; traumatic intracranial haemorrhage or subarachnoid haemorrhage; other neurological condition; too medically unstable to participate; visual or hearing impairment that would hinder participation in assessments (as determined by the consultant physician) and not English-speaking. Written informed consent was sought before commencement of