



ORIGINAL ARTICLE

Electromyographic Activity of the Upper Limb in Three Hand Function Tests



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KEYWORDS

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Summary *Objective/Background:* Occupational therapists usually assess hand function through standardised tests, however, there is no consensus on how the scores assigned to hand dexterity can accurately measure hand function required for daily activities and few studies evaluate the movement patterns of the upper limbs during hand function tests. This study aimed to evaluate the differences in muscle activation patterns during the performance of three hand dexterity tests.

Methods: Twenty university students underwent a surface electromyographic (sEMG) assessment of eight upper limb muscles during the performance of the box and blocks test (BBT), nine-hole peg test (9HPT), and functional dexterity test (FDT). The description and comparison of each muscle activity during the test performance, gender differences, and the correlation between individual muscles' sEMG activity were analysed through appropriate statistics.

Results: Increased activity of proximal muscles was found during the performance of BBT ($p < .001$). While a higher activation of the distal muscles occurred during the FDT and 9HPT performance, no differences were found between them. Comparisons of the sEMG activity revealed a significant increase in the muscle activation among women ($p = .05$). Strong and positive correlations ($r > .5$; $p < .05$) were observed between proximal and distal sEMG activities, suggesting a coordinate pattern of muscle activation during hand function tests.

Conclusion: The results suggested the existence of differences in the muscle activation pattern during the performance of hand function evaluations. Occupational therapists should be aware of unique muscle requirements and its impact on the results of dexterity tests during

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hand function evaluation.

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Introduction

Hand and upper extremity function is essential to humans as it allows for the performance of a wide range of self-care, productive, and leisure activities (Chan & Spencer, 2004). Due to its importance, impairments in the upper extremities lead to restrictions on activity performance and impacts participation in social activities and engagements in meaningful occupations, ultimately affecting overall wellbeing and quality of life (van de Ven-Stevens et al., 2016).

Treating patients with hand and upper limb injuries is a common situation for occupational therapists; hand and wrist lesions account for approximately 20% of all cases seen in hospital emergency departments (Dias & Garcia-Elias, 2006), with most patients presenting further limitations to upper extremity function due to a restricted range of motion, pain, oedema, and muscle weakness caused by the trauma (Ydreborg, Engstrand, Steinvall, & Larsson, 2015). In addition to acute situations, restricted hand function also represents one of the leading causes of limited participation in daily activities by patients with chronic diseases, such as rheumatoid arthritis (Andrade, Brandão, Pinto, & Lanna, 2016) and stroke (Dawson, Binns, Hunt, Lemsky, & Polatajko, 2013).

Although the cause of injury varies in different countries (Che Daud, Yau, Barnett, Judd, Jones, & Muhammad Nawawi, 2016), the majority of the upper limb trauma affects working adults aged between 20 years and 64 years (de Putter et al., 2016), thereby causing a significant economic impact. Studies completed in the past decade have estimated the healthcare and productivity costs of upper limb lesions to be US\$ 410–740 million per year (de Putter, Selles, Polinder, Panneman, Hovius, & van Beeck, 2012; de Putter et al., 2016), with increased absenteeism and early retirement age observed among patients (Shi, Sinden, MacDermid, Walton, & Grewal, 2014; Tiippana-Kinnunen, Paimela, Peltonmaa, Kautiainen, Laasonen, & Leirisalo-Repo, 2013).

Assessment procedures that allow occupational therapists to obtain accurate and reliable information regarding patients' hand function are essential for setting realistic goals and measuring patients' progression during the rehabilitation of upper limb injuries (Carrasco-Lopez et al., 2016). Amongst the several resources available, standardised manual tests are extensively used during the evaluations of hand function to assess the upper limb coordination and skill through a series of tasks involving the manipulation of objects in established patterns (Ekstrand, Lexell, & Brogardh, 2016; Srikesavan, Shay, & Szturm, 2015; van de Ven-Stevens et al., 2016).

Despite focusing on the measurements of body functions and structures, standardised dexterity tests provide valid and reliable data that aids therapists in understanding the

impact of hand injuries on patients' activities of daily life. Commonly used standardised tests have high inter-rater and test-retest reliability, usually with an intraclass correlation coefficient (ICC) greater than 0.85 (Aaron & Jansen, 2003; Desrosiers, Bravo, Hebert, Dutil, & Mercier, 1994; Earhart, Cavanaugh, Ellis, Ford, Foreman, & Dibble, 2011).

However, given the existence of multiple standardised dexterity tests and an even greater variety of structured tasks involved in each assessment, there is no consensus on which test is more suitable for evaluating the entire function of upper extremities (van de Ven-Stevens et al., 2016). Moreover, there is an increasing concern regarding the way by which the scores assigned to hand dexterity can accurately measure hand function required for daily activities (Rallon & Chen, 2008; Rand & Eng, 2010; van de Ven-Stevens et al., 2016).

The study of muscle activation through surface electromyography (sEMG) allows a real-time, noninvasive assessment of the activation pattern of muscles during the activity performance (Gurney et al., 2016). Although sEMG has been used to evaluate the muscle activation patterns in several self-care (Meijer et al., 2014), productivity (Almeida, Cruz, Magna, & Ferrigno, 2013; Ferrigno, Cliquet, Magna, & Zoppi Filho, 2009), and leisure activities (Donoso Brown, McCoy, Fechko, Price, Gilbertson, & Moritz, 2014), few studies have analysed the different recruitment of muscle fibres during the performances of different hand function tests (Brorsson, Nilsdotter, Thorstensson, & Bremander, 2014; Calder, Galea, Wessel, MacDermid, & MacIntyre, 2011).

Considering the lack of studies describing the muscle activities of the upper extremities in standardised hand assessments, this study aimed to evaluate and compare the differences in muscle activation patterns during the performance of the box and blocks test (BBT), nine-hole peg test (9HPT), and functional dexterity test (FDT)—the three hand dexterity tests used by occupational therapists during hand function evaluation.

Methods

Participants

A convenience sample of 20 university students, aged 18–30 years, participated in this nonexperimental, descriptive, and cross-sectional study. These students were invited to participate through institutional e-mail or phone call. Participants were undergraduates in mechanical engineering, civil engineering, and occupational therapy, however, undergraduates in physical education and music were excluded because they could have specific upper limb-related skills, like dexterity, that could confound the

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