Research in Developmental Disabilities 47 (2015) 39–47

Contents lists available at ScienceDirect

Research in Developmental Disabilities

Reliability and validity of the Four Square Step Test in children with cerebral palsy and Down syndrome

Aila Nica J. Bandong [a], Gilbert O. Madriaga [b], Edward James R. Gorgon [a,*]

[a] Department of Physical Therapy, College of Allied Medical Professions, University of the Philippines Manila, Pedro Gil Street, Malate, 1004 Manila, Philippines
[b] Department of Epidemiology and Biostatistics, College of Public Health, University of the Philippines Manila, Pedro Gil Street, Malate, 1004 Manila, Philippines

ARTICLE INFO

Article history:
Received 6 January 2015
Received in revised form 23 July 2015
Accepted 17 August 2015
Available online 27 August 2015

Keywords:
Assessment
Child
Clinimetrics
Physical therapy
Postural control
Postural equilibrium

ABSTRACT

Little is known about the measurement properties of clinical tests of stepping in different directions for children with cerebral palsy (CP) and Down syndrome (DS). The ability to step in various directions is an important balance skill for daily life. Standardized testing of this skill can yield important information for therapy planning. This observational methodological study was aimed at defining the relative and absolute reliability, minimal detectable difference, and concurrent validity with the Timed Up-&-Go (TUG) of the Four Square Step Test (FSST) for children with CP and DS. Thirty children, 16 with CP and 14 with DS, underwent repeat testing 2 weeks apart on the FSST by 3 raters. TUG was administered on the second test occasion. Intraclass correlation coefficients (ICC [1,1] and [3,1]) with 95% confidence intervals, standard error of measurement (SEM), minimal detectable difference (MDD) and the Spearman rank correlation coefficient were computed. The FSST demonstrated excellent interrater reliability (ICC = .79; 95% CI: .66, .89) and high positive correlation with the TUG (r = .74). Test–retest reliability estimates varied from moderate to excellent among the 3 raters (.54, .78 and .89 for raters 1, 2 and 3, respectively). SEM and MDD were calculated at 1.91 s and 5.29 s, respectively. Scores on the FSST of children with CP and DS between 5 and 12 years of age are reliable and valid.

1. Introduction

Children with cerebral palsy (CP) and Down syndrome (DS) often have poor compensatory postural reaction or anticipatory postural control that lead to limitations in acquisition of motor skills, difficulties in functional tasks involved in activities of daily living, and participation at home, play, and school (Gan, Tung, Tang, & Wang, 2008; Law & Webb, 2005; Liao, Mao, & Hwang, 2001; Malak, Kotwicka, Krawczyk-Waseilewska, Mojs, & Samborski, 2013; Mondal, Yadav, & Varghese, 2013; Palisano et al., 2001; Shumway-Cook & Woollacott, 2007; Westcott, Lowes, & Richardson, 1997). Children with CP who are ambulatory have balance problems associated with impairments such as postural deviations, greater co-activation of agonist and antagonist muscles during walking, delayed and disorganized timing of muscle recruitment, tone abnormalities, and difficulty increasing the amplitude of muscle response to increasing threats to balance (Liao et al., 2001; Woollacott & Shumway-Cook, 2005). In children with DS, impaired postural control is associated primarily with motor coordination

* Corresponding author. Tel.: +63 2 526 7125; fax: +63 2 526 2271.
E-mail address: ergorgon@up.edu.ph (E.J.R. Gorgon).

http://dx.doi.org/10.1016/j.ridd.2015.08.012
0891-4222/

difficulties, problems with sensorimotor integration, hyptonia, slow volitional reaction, inadequate co-contraction of muscles, intellectual disability, cartilage hypoplasia, and improper bone density (Malak et al., 2013; Meneghetti, Blascovi-Assis, Deleroso, & Rodrigues, 2009).

Balance control is an important component of movement and all daily activities (Huxham, Goldie, & Patla, 2001; Shumway-Cook & Woollacott, 2007). It involves the ability to recover from instability and anticipate instability (Gan et al., 2008). In order for therapists to effectively treat balance deficits in clinical practice, identification of specific balance impairments must be effective as well (Huxham et al., 2001; Marcini & Horak, 2010). Clinical balance tests are more practical and less technical alternatives to laboratory-based testing (Emery, Cassidy, Klassen, Rosychuk, & Rowe, 2005). Various clinical tests are available that have documented validity and reliability for balance assessment in children with CP and DS (Atwater, Crowe, Deitz, & Richardson, 1990; Bartlett & Birmingham, 2003; Franjoine, Gunther, & Taylor, 2003; Gan et al., 2008; Liao et al., 2001; Saether, Helbostad, Riphagen, & Vik, 2013; Westcott et al., 1997; Williams, Carroll, Reddihough, Phillips, & Galea, 2005; Zaino, Marchese, & Wescott, 2004). However, these clinical balance tests fail to reflect the requirements of many functional activities and life participation.

There is a need for clinical balance tests that can be utilized to examine a wider range of balance strategies in children with developmental disabilities (Franjoine et al., 2003). Most available tests assess balance in response to self-generated perturbations on a non-moving base of support (BOS). Such test conditions are biomechanically less demanding and require less information processing (Huxham et al., 2001; Marcini & Horak, 2010). Few tests, namely the Timed Up-&-Go, Pediatric Balance Scale, Berg Balance Scale, Functional Walking Test, and Timed Up and Down Stairs, involve a moving BOS and have evidence for psychometric properties (Gan et al., 2008; Liao et al., 2001). None of these tests measure other important dimensions of balance like stepping sideways or backwards, and making rapid changes in direction.

The Four Square Step Test (FSST) is a clinical test that assesses balance in the presence of task and environmental constraints. The FSST measures the time an individual takes to step rapidly in four different directions (Dite & Temple, 2002). The psychometric properties of the FSST in various adult client populations have been well documented in the literature (Blennerhassett & Jayalath, 2008; Choi, Dobson, Martin, Bennell, & Hinman, 2014; Dite, Connor, & Curtis, 2007; Dite & Temple, 2002; Duncan & Earhart, 2013; Goh, Chua, Hong, & Ng, 2013; Kloos, Fritz, Kostyk, Young, & Kegelmeyer, 2014; Nilsagard, Lundholm, Denison, & Gunnarsson, 2009; Wagner, Norris, Van Dillen, Thomas, & Naismith, 2013; Whitney, Marchetti, Morris, & Sparto, 2007). The FSST's usefulness in assessing balance in other age groups has received scarce attention in the literature.

A recent pilot study involving 4 children with CP has suggested the potential utility of the FSST in the pediatric population (Gorgon, Madriaga, Gomez-Cailao, Abdon, & Boniquit, 2014). Preliminary estimates of interrater and test–retest reliability (ICC = .83 and .98, respectively) have been positive, and ease of setup and short administration time have been reported. In older children with DS (8–17 years), the FSST has excellent interrater and moderate test–retest reliability (ICC = .78 and .70, respectively) and moderate negative correlation with the functional reach test ($\rho = -.58$) (Verma, Samuel, & Aranha, 2014). Given the findings, further examination of the psychometric properties of the FSST is warranted. This study was aimed at determining the relative (interrater and test–retest) reliability, absolute reliability, minimal detectable change, and concurrent validity with the TUG of the FSST in children with CP and DS with ages 5–12 years.

2. Materials and methods

2.1. Research design

This study employed an observational methodological design (Portney & Watkins, 2009). Methodological designs evaluate the validity and reliability of measuring instruments (Portney & Watkins, 2009). Repeated measurements of balance using the FSST were carried out on a group of children with CP and DS. The protocol for the study was approved by the Ethics Review Committee of the University of the Philippines Manila—College of Allied Medical Professions. Assent and written informed consent were acquired from all participants and participants' primary caregivers.

2.2. Participants

A convenience sample of 30 Filipino children with CP ($n = 16$) and DS ($n = 14$) were recruited from outpatient pediatric therapy clinics and a special education center in Metro Manila, Philippines (Table 1). Therapists and special education teachers in the recruitment sites assisted the authors in identifying eligible children and contacting the children's primary caregivers. The following inclusion criteria were applied: (1) age of 5–12 years; (2) for children with CP, a classification level of I, II, or III on the Gross Motor Function Classification System (GMFCS) (Palisano et al., 1997); (3) ability to ambulate without physical assistance for at least 6 meters with or without a gait aid; (4) ability to follow at least 3 unrelated commands; and (5) ability to recognize colors and/or numbers. Children were excluded from the study if they: (1) were medically diagnosed with severe visual impairment, severe cognitive impairment, behavioral problems, or severe receptive language disorder; (2) had uncorrected visual impairment; (3) had a known vestibular and auditory disorder, ear infection, cochlear implant, or hearing aid; (4) were taking labyrinthine active drugs within the last 6 months; (5) had recent episodes of dizziness or migraine; and (6) had a recent musculoskeletal injury in the lower limbs such as a bone fracture or ligamentous sprain.