Research in Developmental Disabilities 45–46 (2015) 253–260

Contents lists available at ScienceDirect

Research in Developmental Disabilities

The role of exaggerated patellar tendon reflex in knee joint position sense in patients with cerebral palsy

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ARTICLE INFO

Article history:
Received 27 November 2014
Received in revised form 30 May 2015
Accepted 21 July 2015
Available online 26 August 2015

Keywords:
Proprioception
Tendon jerk
Hypertonia
Spasticity

ABSTRACT

The aim of this pilot study was to determine if exaggerated patellar tendon jerk affects knee joint position sense (JPS) in cerebral palsy (CP) patients, by comparing JPS of the knee between participants with normal and exaggerated reflexes. The thresholds for reflex classification were based upon the data from able-bodied volunteers. JPS was measured as the ability of a subject (with eyes closed) to replicate a knee joint position demonstrated by an examiner. Tendon jerk was measured as the moment of force in response to patellar tendon taps. Data was collected from 27 limbs of CP patients ($N = 14$) and 36 limbs of able-bodied volunteers ($N = 18$). JPS was less accurate ($p = 0.014$) in limbs with non-exaggerated reflexes (50.28 ± 43.63%) than in control limbs (11.84 ± 10.85%). There was no significant difference ($p = 0.08$) in JPS accuracy between limbs with exaggerated reflexes (18.66 ± 15.50%) and control limbs.

Our data suggests that one component of sensorimotor impairment, JPS, is not as commonly affected in CP patients as previously reported. JPS of the knee is reduced in limbs with non-exaggerated reflexes; however in limbs with exaggerated reflexes which is seen in the majority of CP patients, JPS is not affected.

What this paper adds?

- Joint position sense is not as commonly affected in cerebral palsy as previously reported.
- Joint position sense in cerebral palsy patients is reduced in limbs with non-exaggerated reflexes but not in limbs with exaggerated reflexes.

Abbreviations: CP, cerebral palsy; EMG, electromyography; EX, exaggerated reflex; JPS, joint position sense; NEX, non-exaggerated reflex; R, reflex moment of force; r, radius of force action; R_a, average reflex moment of force; R_r, reflex reaction force.

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http://dx.doi.org/10.1016/j.ridd.2015.07.021
0891-4222/

1. Introduction

Proprioception incorporates information from muscles, joints and cutaneous receptors to interpret such senses as: joint position sense (JPS), joint position movement (kinesthesia) and the sense of resistance or load (Gandevia, Refshauge, & Collins, 2002; Riemann & Lephart, 2002). JPS is restricted to awareness of a body segment's position in space and as such is considered a static component of proprioception.

The role of muscle spindle afferents in proprioception is well established (Matthews, 1990; Proske & Gandevia, 2009; Winter, Allen, & Proske, 2005). Type Ia muscle spindle afferents respond predominantly to the dynamic component of muscle motion, e.g., the velocity and acceleration of changing muscle length, rather than the static component of muscle length. On the contrary, Type II muscle spindle afferents are more sensitive to static muscle length and less sensitive to the dynamic component of muscle motion (Matthews, 1972). Hypothetically, both Types Ia and II muscle spindle afferents may contribute to JPS.

The tendon tap reflex reaction, also known as tendon jerk, is the shortening of a muscle in response to muscle lengthening elicited by a tendon tap. Tendon jerk is due to activation of Type Ia muscle spindle afferents in response to the rapid muscle lengthening induced by the tendon tap. The amplitude of the tendon jerk depends predominantly on the excitability of the spinal alpha motor neuron pool, which is established through a complex combination of inhibitory and facilitatory influences from spinal and supraspinal pathways (Matthews, 1990; Pierrot-Deseilligny, 1983).

Both JPS and tendon jerk are commonly measured with standard clinical tests that are performed to evaluate the motor system in patients affected by neurological disorders such as cerebral palsy (CP). The measurement of tendon jerk is crucial in the differential diagnosis of many neurological conditions (Hinderer & Dixon, 2001). It is common practice to measure tendon jerk by grading the amplitude of reflexive limb motion on 5-point scale. While there is no agreement on a standard test for JPS (Grob, Kuster, Higgins, Lloyd, & Yata, 2002), the most commonly accepted practice involves evaluating a participant's ability to replicate limb position in space without visual assistance (Goble 2010).

Previous studies have shown that in children with CP, proprioception is reduced. It has been postulated that this occurs because the somatosensory information flow is impaired in these patients (Hohman, Baker, & Reed, 1958; Jones, 1976; Opila-Lehman, Short, & Trombly, 1985; Van Heest, House, & Putnam, 1993; Wingert, Burto, Sinclair, Brunstrom, & Damiano, 2009).

One of the most common features of patients with CP is an exaggerated reflex response (hyperreflexia), including that of their short latency component tendon jerk (Mayer & Esquenazi, 2003). It is commonly accepted that stretch reflex pathways are involved in the JPS of able-bodied volunteers; however, the impact of hyperreflexia on JPS is unknown. Hyperreflexia relates to increased responsiveness of Ia afferents, so it seems plausible that JPS might be improved in some CP patients due to hyperreflexia. It is unclear how JPS affects functional motor skills during sitting, walking or transferring of CP patients. It has been reported that in hypertonia patients, proprioception is adversely affected (10-15% reduced) but not as significantly as other features of motor skills such as muscle strength and selective motor control (Wingert et al., 2009). It is not currently agreed up whether hyperreflexia adversely affects all features of motor skills. A better understanding of how hyperreflexia affects JPS might provide some insight into current CP treatments and their influence on motor function.

The aim of this pilot study was to determine whether the presence of exaggerated tendon jerk in CP patients affects JPS of the knee, by comparing JPS of the knee between participants with non-exaggerated reflexes and exaggerated reflexes. The thresholds for classification of exaggerated reflexes was determined using the data collected from able-bodied volunteers.

2. Materials and methods

2.1. Participants

Thirty-two participants were recruited for this study; of them, 14 were patients with spastic CP (female = 9, male = 5) and 18 were able-bodied volunteers (female = 13, male = 5).

The CP group consisted of a cross-sectional sample of 14 ambulatory patients with bilateral limb involvement (age: Mean $\pm$ SD: 15 $\pm$ 5.7 years; range: 7–28 years). The data for one subject was collected for only one side of the body due to technical problems. (We have data for one leg in subject P14). All patients were able to ambulate independently or with mobility devices (Gross Motor Function Classification System range I to III). Inclusion criteria were: (1) no surgery or botulinum toxin (BTX-A) injection done within one year and (2) able to understand and follow verbal instructions.

The control group consisted of 18 able-bodied volunteers (age: Mean $\pm$ SD: 22 $\pm$ 1.6 years; range: 20–24 years). The inclusion criteria were: (1) no neurological or physiological impairments, i.e., no damage to muscles, nerves, or ligaments; (2) no systematic disease or pain; (3) no trauma history; (4) average physical activity level; and (5) not a high-performance athlete.

All participants were examined in the Motion Analysis Laboratory of the local orthopedic hospital. The study was approved by the appropriate Institutional Review Board. Written consent was acquired from all participants; for those under 18 years of age, consent was obtained from a parent or guardian. Anthropometric data (age, body height, and mass) was collected for all participants (Tables 1 and 3). Testing was performed on a total of 27 limbs from CP patients and 36 limbs from able-bodied volunteers (Tables 2 and 4).