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Changes in lower extremity strength may be related to the walking speed improvements in children with cerebral palsy after gait training

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ABSTRACT

Background: Cerebral palsy (CP) has a high probability of resulting in lower extremity strength and walking deficits. Numerous studies have shown that gait training has the potential to improve the walking abilities of these children; however, the factors governing these improvements are unknown.

Aims: This study aimed to evaluate the relationship between change in lower extremity strength, walking speed and endurance of children with CP following gait training.

Methods and procedures: Eleven children with CP (GMFCS levels = II-III) completed a gait training protocol three days a week for six weeks. Outcome measures included a 10 m fast-as-possible walk test, 6 min walking endurance test and lower extremity strength.

Outcomes and results: The group results indicated there were improvements in walking speed, walking endurance and lower extremity strength. In addition, there was a positive correlation between percent change in lower extremity strength and walking speed and a negative correlation between the percent change in lower extremity strength and the child's age.

Conclusions: Our results imply that changes in lower extremity strength might be related to the degree of the walking speed changes seen after gait training. Younger children may be more likely to show improvements in lower extremity strength after gait training.

What this paper adds

One of the primary therapeutic goals of children with CP and their families are to maintain or improve walking. The results from this study further substantiate that gait training will likely achieve this therapeutic goal. The results from this exploratory study also suggest that there may be a relationship between the changes in a child's lower extremity strength, and their walking speed improvements after gait training. This implies that a child may need to have sufficient gains in lower extremity strength after gait training to demonstrate clinically relevant walking speed improvements. The results also implied that there may be a negative relationship between the percent change in the lower extremity strength after gait training and the child's age. This suggests that younger children with CP may have a greater potential for muscle plasticity after gait training.

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1. Introduction

Cerebral palsy (CP) is a blanket term for a group of permanent but mutable motor development disorders stemming from a primary brain lesion and often results in secondary musculoskeletal alterations (Hadders-Algra & Carlberg, 2008; Rosenbaum, Paneth, Leviton, Goldstein, & Box, 2007). Over time, these musculoskeletal alterations promote a decline in walking speed and cadence, and an increase in double support duration during the gait cycle (Bell, Ounpuu, DeLuca, & Romness, 2002; Johnson, Damiano, & Abel, 1997; Norlin & Odenrick, 1986). The severity of these impairments has been suggested to promote restrictions in the child's participation across a broad range of life domains, including self-care, education and recreation (Imms, 2008). Previous studies have identified that there is likely a relationship between lower extremity muscle strength and walking speed (Damiano & Abel, 1998; Damiano, Martellotta, Sullivan, Granata, & Abel, 2000; Ross & Engsberg, 2007), cadence (Damiano et al., 1995; Ross and Engsberg, 2007), walking efficiency (Goh, Thompson, Huang & Schafer, 2006) and the Gross Motor Function Measure in children with CP (Berry, Giuliani, & Damiano, 2004; Damiano et al., 2000; Eek & Beckung, 2008; Goh et al., 2006; Ross & Engsberg, 2007). However, the outcomes across the previous strength training intervention studies employed with these children have been quite mixed and at times unsuccessful (Damiano, Kelly & Vaughn, 1995; Damiano, Arnold, Steele & Delp, 2010; Eek, Tranberg, Zügner, Alkema & Beckung, 2008; Moreau et al., 2016; Unger, Faure & Frieg, 2006). This has led to uncertainty as to if muscular weakness is the primary limiting factor for all children with CP (Moreau et al., 2016). Despite this conjecture, no investigation has considered if a combination of strength and gait training will result in more predictable improvements in a child's walking abilities.

A recent meta-analysis and systematic review has indicated that gait training has a good chance of improving the walking speed of children with CP (Moreau et al., 2016). Predominantly, the prior gait training protocols have been performed on a treadmill while the child's body weight was partially supported by an overhead support system. The general prescription employed across these prior studies has consisted of supporting the child's body weight and gradually reducing the amount of support to 10% or less by the end of the 6–12 weeks of gait training (Duncan et al., 2007). The speed of the treadmill has also been gradually increased in each training session with the goal of walking as fast as possible (Sullivan, Knowlton & Dobkin, 2002; Pohl, Mehrholz, Ritschel, Rückriem, 2002). For these protocols, the treadmill motion often helps to facilitate the leg movement patterns for improved symmetry, and promotes the presence of normal afferent somatosensory cues throughout the mass practice paradigm (Dietz, Müller & Colombo, 2002; Harkema et al., 1997; Kurz, Stuberg, DeJong & Arpin, 2013; Pearson, Misiaszek & Fouad, 1998). Performing gait training on a treadmill has also been suggested to be beneficial because the child is relatively stationary, which allows the therapist to observe changes in the child's walking pattern over several consecutive steps. This allows the therapist to analyze how the child should alter the leg kinematics to improve the walking pattern. In addition, performing gait training on the treadmill allows the therapist to provide subtle tactile cues that will direct the child's attention or perturb the child's walking pattern.

Despite the positive findings across the literature, there are several limitations to the existing gait training literature such as heterogeneity of the motor impairments across the study populations and variations in the treatment parameters (i.e., frequency, duration, etc.). In addition, inspection of the individual results seen in these prior studies clearly reveals that some children with CP have drastic improvements in their walking speed, while others are clearly non-responders. Currently, it is unknown why some children with CP respond better to gait training. In our prior investigations, we have noted that the group results may display improvements in the lower extremity strength after gait training (Kurz, Corr, Stuberg, Volkman, & Smith, 2011; Kurz, Stugber, & DeJong, 2011; Kurz, Wilson, Corr & Volkman, 2012). Since lower extremity strength has been suggested as one factor that may be limiting the walking abilities of children with CP, we speculated that the amount of change seen after gait training may be related to the amount of improvement in the child's lower extremity muscular strength. No previous studies have examined the relationship between changes in the lower extremity strength and response to gait training. To begin to address this knowledge gap, we explored the possibility that the extent of the lower extremity strength changes seen after gait training was linked with the extent of the improvements in a child's walking speed and endurance.

2. Methods

2.1. Participants

Using the effect size (0.86) from our prior gait training study (Kurz, Stuberg et al., 2011), 10 children with CP should provide greater than 80% power to detect a change in the walking speed at a 0.05 alpha level. Hence, eleven children (12 ± 1 years old) diagnosed with spastic CP who had a Gross Motor Function Classification System (GMFCS) level of II or III were recruited to participate in this exploratory study (Table 1). Inclusion criteria also accounted for the individual's ability to walk independently with or without an assistive device and no additional assistance required. The age range was determined based on the feasibility of compliance with study protocol, and similarity of the children included in our prior investigations. Exclusion criteria included orthopedic surgery or Botox injections within the last 6 months. Children classified as GMFCS level I were not included in this investigation because they are typically not receiving physical therapy services due to a high level of function. Subjects were recruited from the patient population that is routinely seen at the Munroe-Meyer Institute for physical therapy and gait analysis. Most of the children recruited were participating in school-based therapy and continued during this study. The school-based therapy has a primary focus of improving participation within the classroom and typically does not include gait training. The University of Nebraska Medical Center Institutional Review Board approved all experimental procedures, and the parents consented and the children assented to participating in the experiment.