INTRODUCTION

Cerebral Palsy (CP) is a static lesion in the brain that happens before, during or shortly after birth. It is a non-progressive disorder that leaves children with permanent motor impairments [1]. Many children with CP have spasticity, which is defined as a velocity-dependent resistance of muscles to stretch [2]. Joint contractures often form when spastic muscles become taut and inhibit the full range of motion (ROM) of the joint [3]. Furthermore, children with CP often have weak muscles [1]. The detailed reasons for why muscles become taut remain unknown. It has been suggested in some studies that short fascicle lengths (FL) in spastic muscles cause tightening [4] but other studies do not confirm these findings [5]. There are currently no studies where fascicle excursions were examined for dynamic conditions. The purpose of this study was to measure FL and muscle and fascicle excursions of the medial gastrocnemius (MG) for the full passive ROM of the ankle in children with CP and typically developing (TD) controls.

METHODS

The experimental group included 8 children with CP between the ages of 8 and 16. The control group included 14 age and sex-matched TD controls. Children with CP were recruited from the Calgary Cerebral Palsy Association and the Cerebral Palsy Association in Alberta. The control group was recruited from the Calgary community. Six of the eight experimental group children had a sex-matched twin sibling that was used for the control group. The children were seated in the chair of a Biodex™ System III dynamometer (Biodex Medical Systems Inc., New York, USA), and their foot was strapped to a footplate. EMG electrodes were placed on the MG and the tibialis anterior muscles. An ultrasound probe (Koninklijke Philips Electronics N.V., The Netherlands) was fixed to the lower leg to visualize the myotendinous (MT) junction first and the mid-belly of the MG muscle second. Torque, ankle angle and EMG data were collected for four passive trials covering the full ROM of the ankle joint. A common ROM was defined as the range from the lowest maximum dorsiflexion to the lowest maximum plantarflexion found between all subjects. The resting ankle joint angle (RJA) was defined with the leg completely relaxed and was measured. Fascicle lengths and MT displacements were measured from the ultrasound images. In cases where fascicle lengths were not fully visible, trigonometric relationships were used to calculate fascicle lengths from the measured pennation angle (α) and muscle thickness (Tm) (Figure 1). Non-parametric Mann-Whitney U-statistics (α=0.01) were used to test for differences in fascicle lengths, fascicle excursions and muscle excursions between experimental and control group children.

RESULTS

The common ROM was 87-126°. Fascicle lengths at all ankle angles were shorter for CP children (Figure 2), while fascicle excursions over the common ROM were not significantly different from TD control subjects. However, fascicle excursions as a percent of resting fascicle lengths were significantly greater for CP subjects (Figure 3). Muscle-tendon excursions over the common ROM were greater for control group subjects. Fascicle excursions as a percentage of muscle-tendon excursions were greater in children with CP compared to TD controls.
DISCUSSION

Our results show that fascicle lengths are shorter in children with CP than those in age-matched TD controls and therefore confirm previous results [4]. We also show that fascicle excursions as a percentage of resting fascicle lengths and as a percentage of muscle-tendon excursions are greater in CP children than TD controls over a common ROM. There was no significant difference in absolute fascicle excursions between the groups, but since the fascicles in CP subjects are much shorter, the relative fascicle excursions are greater. The short fascicles and the large relative fascicle excursions imply that the sarcomeres in CP children undergo much greater excursions than in TD controls. It has also been found in static experiments that sarcomere lengths in CP patients are on average much longer than in control subjects for corresponding joint angles [6]. Combined, these results suggest that sarcomeres operate over a greater range and at longer lengths in CP children than in TD age- and sex-matched control subjects. Therefore, it appears that muscle fibres are shorter and sarcomeres are longer in CP children than controls. This finding has important functional implications for CP patients struggling with strength and joint mobility. First, working at longer than normal sarcomere lengths would likely be associated with sarcomeres operating on the descending limb of the force-length relationship where muscle force is compromised because of lack of actin-myosin filament overlap [7]. Second, at these long sarcomere lengths, and with greater than normal sarcomere excursions during normal movements, passive forces would be increased compared to normal thus restricting full range of joint motion, or at least resisting full motion through passive forces to a greater extent than in TD control children.

CONCLUSIONS

Our results confirm previous findings that FL are shorter in children with CP compared to TD children. We also show that fascicle excursions relative to fascicle lengths and muscle-tendon excursions are greater in children with CP over a universal ROM. This novel result has important implications for the impairment of function in CP children during everyday movements.

REFERENCES


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