



Original Article

Partial correlation between lower muscle thickness, 10-meter walk test, and the timed up & go test in children with spastic cerebral palsy

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Abstract. [Purpose] The purpose of this study was to examine the correlation between lower extremity muscle thickness and gait ability through the 10-meter walk and timed up and go tests. [Subjects and Methods] A total of 28 children (20 males and 8 females) with spastic cerebral palsy undergoing physical therapy at D hospital in D city, South Korea participated in this study. Partial correlation analysis was performed to analyze the correlation between lower extremity muscle thickness and gait ability (10-meter walk test and timed up and go test). [Results] There was a positive correlation between muscle thickness and the 10-meter walk test (RF=0.41 and VL=0.52). Correlation between the muscle thickness and the timed up and go had a negative correlation (VL=-0.45, MG=-0.51, and LG=-0.39). [Conclusion] In children with cerebral palsy, knee extensor muscles that are more developed increased gait ability and calf muscles that are more developed increased sit to stand ability.

Key words: Cerebral palsy, Muscle thickness, Ultrasonography

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INTRODUCTION

Gait disturbance occurs in children with spastic cerebral palsy when increased spasticity reduces lower extremity control^{1, 2)}. A certain level of lower extremity muscle strength is required for their gait ability²⁾. Previous studies have showed that lower extremity muscle strength is closely related to gait ability in children with cerebral palsy and increased lower extremity muscle strength improved the gait ability of the children^{3, 4)}.

However, there are specific lower extremity muscles that affect the ability to improve gait. Children with cerebral palsy exhibit different gait patterns compared to normal children due to reduced lower extremity control⁵⁾. Therefore, we hypothesized that the lower extremity muscles of children with cerebral palsy that directly affect gait ability were different from those of normal children. Thus, this study analyzed the correlation between lower extremity muscle thickness and two representative tools for gait ability measurement (10-meter walk test [10MWT] and timed up and go test [TUG]) to find the muscles that are closely related to the gait ability of children with cerebral palsy.

SUBJECTS AND METHODS

A total of 28 children (20 males and 8 females) with spastic cerebral palsy undergoing physical therapy at D hospital in D city, South Korea participated in this study. The mean age, height, and weight of the participants were 15.0 ± 3.2 years, 157.1 ± 14.3 cm, and 49.5 ± 12.4 kg, respectively. The selection criteria for the participants were as follows: children who were

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diagnosed with cerebral palsy, the ability to sit without any assistance for more than 5 minutes, no visual impairment or hearing damage, and communication ability to the extent of following directions. Information about the study was provided to the participants prior to participation in accordance with the ethical principles of the Declaration of Helsinki. All participants agreed to participate in the project by providing written informed consent.

An ultrasound imaging device (Accuvix V10, Samsung Medison Inc., Korea) was used to measure lower extremity muscle thickness. The muscle thicknesses of the rectus femoris (RF), vastus lateralis (VL), tibialis anterior (TA), medial gastrocnemius (MG), lateral gastrocnemius (LG) of one lower extremity were measured.

The 10MWT and TUG were used to measure gait ability. Assistance was not provided for the entire length (10 m) of the 10MWT. The time participants walk through the middle 6 m section was recorded, except for 2 m acceleration and 2 m deceleration distances. The TUG test measures the time it takes a participant to stand up from a standard armchair, walk 3 m, turn around, walk back to the chair, and sit down. All measurements were conducted 3 times and reported as the mean value \pm standard deviation.

SPSS for Windows (version 22.0) was used to analyze the data. Partial correlation coefficient was used to analyze the correlation between muscle thickness and gait ability. A previous study showed that overweight people have a large muscle mass⁶. Body weight was used as a controlling variable to exclude confounding factors for lower extremity muscle thickness. The statistical significance level used was $\alpha=0.05$.

RESULTS

The correlation between muscle thickness and 10MWT was positive (RF=0.41 and VL=0.52, $p<0.05$). The correlation between muscle thickness and TUG was negative (VL=-0.45, MG=-0.51 and LG=-0.39, $p<0.05$) (Table 1).

DISCUSSION

This study used the 10MWT and TUG test as functional evaluation tools to assess gait ability. Lower extremity muscle thickness was measured using an ultrasound imaging device in order to analyze which lower extremity muscles were most strongly correlated to gait ability in children with spastic cerebral palsy. Individual body weight can be a confounding factor that may affect the result of the study because overweight individuals have a large muscle mass⁶. Therefore, this study used the partial correlation coefficient to control for the effect of individual body weight.

The results of this study showed that the correlation between muscle thickness and 10MWT was positive and that the correlation between muscle thickness and TUG was negative. Ross & Engsborg² showed that spastic cerebral palsy patients experience increased spasticity and decreased strength and that this affects the ankle joint more than the knee joint. Therefore, they depend more on proximal muscles that control the knee joint than the ankle joint during gait². Particularly, increased rectus femoris use increases step length when the calf muscle cannot be controlled appropriately, because the rectus femoris is a two-joint muscle that extends the knee and flexes the hip. A previous study showed that when the rectus femoris becomes weaker than the hamstring, the antagonistic muscle range of motion (ROM) decreases causing difficulty in gait^{2, 3}. The results from previous studies support that an increased muscle thickness of the RF and VL as quadriceps increases velocity in the 10MWT, which is indicative of gait ability.

TUG was correlated not only with VL muscle thickness but also with the muscles that control the ankle, such as the MG and LG. This is consistent with the results of a study by Damiano et al. that showed increased knee extensor muscle strength creates a positive correlation between gait velocity and GMFM score⁷. TUG measures the time it takes a participant to stand up from a chair, walk 3 m, turn around, walk back to the chair, and sit down. Therefore, both gait ability and the ability to stand from a chair were evaluated⁸. The results of our TUG showed the above results because distal muscles of lower extremity that control the ankle are weaker than proximal muscles that control the knee in children with cerebral palsy², but strength of the MG and LG which extend the knee and plantar flex the ankle joint are also required when standing from a chair.

In conclusion, this study showed a positive correlation between gait ability and the knee extensor muscles and that the sit to stand ability is positively correlated with calf muscles in children with cerebral palsy. One limitation of this study is that only muscle thickness was measured while lower extremity muscle strength was not measured. Further studies should analyze the correlation between gait ability and lower extremity muscle strength.

Table 1. Partial correlation between lower extremity muscle thickness, 10MWT, and TUG

		RF (cm)	VL (cm)	TA (cm)	MG (cm)	LG (cm)
		1.87 \pm 0.49	1.91 \pm 0.34	1.67 \pm 0.37	1.20 \pm 0.27	1.09 \pm 0.21
10MWT (m/s)	1.08 \pm 0.19	0.41*	0.52*	0.04	0.31	0.31
TUG (seconds)	11.59 \pm 2.21	-0.11	-0.45*	-0.09	-0.51*	-0.39*

* $p<0.05$ (Mean \pm SD), 10MWT: Timed 10-meter walk test; TUG: Timed Up & Go test; RF: rectus femoris; VL: vastus lateralis; TA: tibialis anterior; MG: medial gastrocnemius; LG: lateral gastrocnemius

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