

Effects of foot orthoses on change of pain and ankle stabilizing muscle in children with flatfoot

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Objective: The purpose of this study was to exam changes in the ratio of cross-sectional area (CSA) of tibialis anterior (TA), tibialis posterior (TP) and peroneus longus (PL), which are ankle stabilizing muscles, following rigid foot orthoses (RFO) application in children with flatfoot and to confirm the correlations between change of the CSA ratio and changes of pain after RFO application.

Methods: This study was conducted between July 2019 and March 2021. The diagnostic criteria for flatfoot were as follows: (1) resting calcaneal stance position (RCSP) angle $< -4^\circ$; (2) calcaneal pitch (CP) $< 18^\circ$ and Meary's angle (MA) $> 4^\circ$ on foot radiographs; and (3) numeric rating scale score for foot or leg pain ≥ 2 . Patients with gait disabilities or foot deformities due to neurological or orthopedic conditions were excluded. The primary outcome was the changes in the CSA ratios of the ankle stabilizing muscles, which were measured by ultrasound. As children grow older, their muscles also grow. So, the ratio was calculated using the values measured by ultrasound and then the changes in the ratio of each muscle to the total area of TA, TP, and PL were compared (TA ratio = CSA of TA / CSA of TA + CSA of TP + CSA of PL, TP ratio = CSA of TP / CSA of TA + CSA of TP + CSA of PL, PL ratio = CSA of PL / CSA of TA + CSA of TP + CSA of PL). The secondary outcomes were the changes in the RCSP angle; changes in radiographic measurements including CP, MA, talonavicular coverage angle (TNCA), and talocalcaneal angle (TCA); and pain domain of foot function index (FFI), which assesses symptoms such as pain and gait disabilities. The children wore RFOs in their shoes for 12 months. The assessments of outcomes were performed at the baseline (T0) and after 12 months after RFO application (T1).

Results: The assessments was completed in 14 patients (9 boys, 5 girls). After RFO application, TA ratio and TP ratio were significantly decreased, and PL ratio was significantly increased. Also, RCSP angle and pain domain of FFI were significantly decreased and CP was significantly increased. Significant correlation was found between PL ratio change and RCSP angle change. Pain domain of FFI was significantly correlated with changes in the PL and RCSP angles.

Conclusions: RFO reduces the compensatory action of ankle invertors when children with flatfoot walk, thereby increasing the PL ratio, and pain decreases as the PL ratio increases. Therefore, RFO is effective in reducing pain by changing the proportion of ankle stabilizing muscles in children with flatfoot.

Figure 1. Study flow chart.

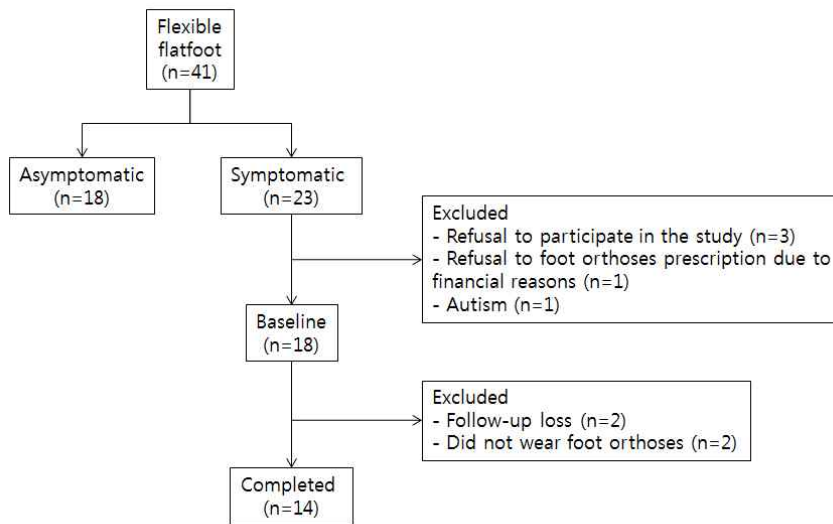


Table 1. Participants' demographic characteristics and radiographic measurements.

	T1 (mean±SD)	T2 (mean±SD)	p value
Age (years)	11.46±2.11	12.46±2.11	
Sex (male/female)	9/5	9/5	
RCSP angle (°)	-9.05±3.75	-7.12±2.24	0.015*
Pain domain of FFI score	17.64±2.54	11.75±3.55	0.009*
CP	10.48±2.87	12.04±3.44	0.023*
MA	8.54±3.45	8.10±3.35	0.377
TNCA	27.45±8.64	25.23±6.43	0.538
TCA	34.22±5.37	32.02±5.22	0.415

T1, before rigid foot orthoses (RFO) application; T2, 12 months after RFO application; RCSP, resting calcaneal stance position; FFI, foot function index.

*Statistically significant ($p < 0.05$).

Table 2. Participants' radiographic measurements.

	T1 (mean±SD)	T2 (mean±SD)	p value
CP	10.48±2.87	12.04±3.44	0.023*
MA	8.54±3.45	8.10±3.35	0.377
TNCA	27.45±8.64	25.23±6.43	0.538
TCA	34.22±5.37	32.02±5.22	0.415

T1, before RFO application; T2, 12 months after RFO application; CP, calcaneal pitch; MA, Meary's angle; TNCA, talonavicular coverage angle; TCA, talocalcaneal angle. *Statistically significant ($p < 0.05$).

Table 2. Comparison of CSA (cm²) and the ratio of each muscle to total ankle stabilizing muscles.

	T1 (Mean±SD)	T2 (Mean±SD)	t	p value
CSA of TA	5.64±1.54	7.88±1.42	3.517	0.000*
CSA of TP	2.42±0.86	3.84±0.64	3.516	0.000*
CSA of PL	3.14±0.77	5.48±0.92	3.516	0.000*
TA ratio	0.50±0.08	0.45±0.04	-3.242	0.002*
TP ratio	0.22±0.07	0.22±0.04	-1.540	0.015*
PL ratio	0.28±0.07	0.32±0.05	2.586	0.009*

T1, before rigid foot orthoses (RFO) application; T2, 12 months after RFO application; CSA, cross-sectional area; TA, tibialis anterior; TP, tibialis posterior; PL, peroneus longus.

*Statistically significant (p < 0.05).

Table 3. Correlations among the changes in CSA ratios of ankle stabilizing muscles, changes in RCSP angle and radiographic measurements, and changes in pain domain of FFI.

		ΔRCSP	ΔCP	ΔMA	ΔTNCA	ΔTCA	ΔPain of FFI
ΔTA ratio	r	0.153	-0.044	0.184	-0.063	0.278	-0.339
	p value	0.394	0.871	0.495	0.756	0.073	0.184
ΔTP ratio	r	-0.018	0.295	0.025	0.234	-0.195	0.064
	p value	0.913	0.066	0.884	0.154	0.286	0.793
ΔPL ratio	r	-0.405	-0.236	0.044	-0.248	-0.154	-0.402
	p value	0.039*	0.194	0.879	0.201	0.424	0.034*
ΔPain of FFI	r	0.418	0.165	0.316	-0.073	-0.274	
	p value	0.015*	0.752	0.245	0.114	0.223	

CSA, cross-sectional area; RCSP, resting calcaneal stance position; FFI, foot function index; TA, tibialis anterior; TP, tibialis posterior; PL, peroneus longus; CP, calcaneal pitch; MA, Meary's angle; TNCA, talonavicular coverage angle; TCA, talocalcaneal angle.

*Statistically significant (p < 0.05) in the Spearman correlation analysis.

Table 4. Correlations between the changes in CSA ratios of ankle invertor and evtor muscles and changes in RCSP angle and radiographic measurements.

		ΔRCSP	ΔCP	ΔMA	ΔTNCA	ΔTCA
ΔTA ratio	r	0.153	-0.044	0.184	-0.063	0.278
	p value	0.394	0.871	0.495	0.756	0.073
ΔTP ratio	r	-0.018	0.295	0.025	0.234	-0.195
	p value	0.913	0.066	0.884	0.154	0.286
ΔPL ratio	r	-0.405	-0.236	0.044	-0.248	-0.154
	p value	0.039*	0.194	0.879	0.201	0.424

CSA, cross-sectional area; RCSP, resting calcaneal stance position; CP, calcaneal pitch; MA, Meary's angle; TNCA, talonavicular coverage angle; TCA, talocalcaneal angle; TA, tibialis anterior;

Table 5. Correlations between changes in pain domain of FFI and changes in CSA ratios of ankle invertor and evtor muscles, RCSP angle, and radiographic measurements.

Pain domain of FFI	ΔTA ratio	ΔTP ratio	ΔPL ratio	ΔRCSP	ΔCP	ΔMA	ΔTNCA	ΔTCA
r	-0.339	0.064	-0.402	0.418	0.165	0.316	-0.073	-0.274
p value	0.184	0.793	0.034*	0.015*	0.752	0.245	0.114	0.223

FFI, foot function index; CSA, cross-sectional area; TA, tibialis anterior; TP, tibialis posterior; PL, peroneus longus; RCSP, resting calcaneal stance position; CP, calcaneal pitch; MA, Meary's angle; TNCA, talonavicular coverage angle; TCA, talocalcaneal angle.

*Statistically significant (p < 0.05) in the Spearman correlation analysis.