

EFFECT OF INCREASED MECHANICAL STIMULI ON FOOT MUSCLES FUNCTIONAL CAPACITY

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INTRODUCTION

As biological structures receive mechanical stimuli they are getting stronger. If muscles, tendons and bones are not in use they will decrease strength and their functional capacity. The biological structures of the foot can be trained by barefoot walking or workout through the speculated higher loading. No scientific evidence for a causal relationship between increased foot loading and functional improvement of foot structures could be found in the literature. The foot arch and the foot functional capacity is strongly related to the strength of the flexor muscles of the metatarsophalangeal joints (MPJ): M. flexor hallucis longus (FHL) and M. flexor digitorum longus (FDL) [1,2,3]. It was shown that a special designed minimal shoe (Nike FREE) increases the range of motion on the metatarsophalangeal joints (MPJ) and the ankle joint in normal walking and modifies the plantar pressure distribution in a way close to barefoot walking on grass. In a pilot study using wire EMG technique the muscle activity of the FHL was shown to be significantly increased during walking in the minimal footwear in comparison to walking in traditional running shoes. If training with the minimal footwear mimics barefoot training one can assume that using the minimal shoe will increase the loading of the foot structures and make them stronger.

The purpose of the study was to demonstrate the capacity of biological structures to adapt to mechanical stimuli modified through footwear and to quantify effects on strength and morphology of the foot and shank muscles. The research question was to quantify the impact of increased mechanical stimuli on (1) muscle strength and (2) anatomical cross sectional area (ACSA) of intrinsic foot and shank muscles.

METHODS

The research question was solved by a prospective longitudinal designed approach. The prospective study operated with an experimental ($n_E=25$) and a control group ($n_C=25$) both consisting of male and female subjects. The experimental intervention over a period of five months was the use of the minimal footwear in athletes preparatory (warm up) training while the control group used traditional training shoes for the same training programme. The measurement of muscle strength was performed by special custom build dynamometers. ACSA of FHL, FDL, M. triceps surae (TS), Mm. tib. post (TP) and ant.(TA), M. peroneus (PER) at the greatest circumference of the shank and ACSA of four of the intrinsic foot muscles (M. abductor hallucis, M. quadratus plantae, M. abductor digiti minimi, M. flexor digitorum brevis) were estimated by MRI (Siemens Symphony, 1.5 Tesla).

RESULTS AND DISCUSSION

The muscle strength changes through the intervention showed a significant ($p<.01$) increase of the MPJ flexors in the experimental group; no significant change in the controls.

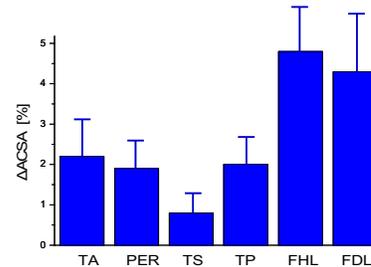


Figure 1: Relative increase of ACSA of six extrinsic foot muscle through the five months intervention (Mean and SEM); experimental group ($n_E=25$).

Table 1: Changes in MPJ flexor strength [N], subtalar inversion strength [Nm], plantar and dorsi flexors strengths [N]. Means and SEM. *: $p<.05$, **: $p<.01$.

	Experimental group		Control group	
	Pre	Post	Pre	Post
MPJ flexor strength	232 (10.9)	279 (11.6) **	228 (11.1)	237 (11.6) ns
Inversion moment	18.0 (1.4)	21.8 (1.6) *	17.5 (1.3)	17.7(1.2) ns
Plantar fl. strength	1065(72.2)	1254(73.2) *	1296(68.0)	1242(63.1) ns
Dorsi fl. strength	432(18.0)	460(18.9) *	415(20.6)	419 (14.8) ns

Plantar flexion strength increased only significantly ($p<.05$) in the experimental group. The maximum supinator muscles torque increased for the experimental group ($p<.05$) and showed no effect on the control group. While for the Mm tibialis anterior, peronei, tibialis posterior and triceps surae no significant changes in the ACSA were found, the ACSA of the Mm flexor hallucis and flexor digitorum increased by approximately 4% and by 5% for the Mm abductor hallucis and quadratus plantae in the experimental group.

CONCLUSIONS

The use of minimal footwear was related to changes in muscle strength and morphology. It was demonstrated that the footwear increased mechanical stimuli on the tendon muscle units. The muscle strength capacity of those muscles which were more intensively used by the minimal shoe increased significantly. Muscles which were similar activated in both conditions did not respond. One can conclude that footwear technology impacts the mechanical loading as well as the biological response of the loaded tissues.

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