THE EFFECTS OF A FOOT STRENGTHENING PROGRAM ON INTRINSIC FOOT MUSCLE SIZE AND STRENGTH – A PILOT STUDY

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INTRODUCTION

Recent studies have shown that the transition to running in minimalist or partial minimalist shoes can result in greater incidence of injury than running in traditional running shoes[1,2]. Based on those results, it has been suggested that transitioning to minimalist shoes should be preceded by a preparatory strengthening program.

Intrinsic foot muscles help control motion of the foot, support the medial longitudinal arch, and assist with shock absorption. It has been hypothesized that the structure of traditional or supportive shoes results in weakened intrinsic foot muscles, which may be related to the increased injury rate in runners transitioning from traditional to minimalist running shoes.[3] Stronger intrinsic muscles will be able to better support the metatarsals as well as the plantar fascia, thereby reducing the risk of injury to these structures.

Two studies have shown that performing activities in minimalist shoes increases intrinsic foot muscle size, but the studies did not directly measure increases in strength[4,5]. Therefore, the purpose of this study was to determine whether a foot strengthening intervention alters intrinsic muscle size and strength. It was hypothesized that both size and strength of these muscles would be significantly increased following this program.

METHODS

Ten recreational runners (5 male, 5 female; average age 22 ± 2 years, average mileage 15-30 miles/week) with no experience running barefoot or in minimalist shoes have participated in this ongoing study to date. Runners participated in a pre-training testing session, then performed 8 weeks of strength training. This program included a progression of single and double leg calf raises, foot doming, doming and hopping and toe flexion exercises. Intrinsic muscle size and strength were measured post-training. Pre- and post-training testing included ultrasound assessment of intrinsic foot muscle size, and strength.

Ultrasound images were recorded from the abductor hallucis (ABDH), flexor hallucis brevis (FHB), flexor digitorum brevis (FDB) and quadratus plantae (QP). Images were recorded using a 10 MHz GE LogiqP5 linear probe. For the FHB the probe was aligned with the shaft of the first metatarsal, using the metatarsal head as a consistent bony landmark. The FDB and QP were recorded after finding the navicular tuberosity, then moving the ultrasound probe to the plantar surface of the foot. The probe was oriented transversely across the sole of the foot. The ABDH was recorded with the probe in the same orientation, using the navicular as a reference landmark. Measurements taken from the images included the thickness of the FHB and cross-sectional areas (CSA) of the ABDH, FDB, and QP.

Muscle strength measurements were recorded using a hand-held ergoFet dynamometer, which was secured to a custom built wooden support system (Figure 1). Strength was assessed during doming (arch flexion) and toe flexor activities. During the doming testing, subjects stood with one foot in a Brannock device and the lower leg strapped to a support beam (Figure 1A). The dynamometer was placed on the dorsum of the foot, above the navicular tuberosity (Figure 1B). The subject performed the doming movement using a maximal voluntary isometric contraction for approximately 3 seconds. Toe flexor strength was assessed from the big toes individually (1Toe Flexor), and the 2nd, 3rd, and 4th toes together (234Toe Flexor). The subject’s foot was placed on a raised, flat surface with the heel against a support and the toe(s) gripping either an S-beaner or bar and flexed their toes (Figure 1b). The S-beaner or bar was secured to the dynamometer by
an adjustable turn buckle. Trained researchers observed the motions throughout the testing in an effort to ensure subjects were limiting the recruitment of extrinsic muscles. Strength data were monitored and recorded in real-time.

Pre- and post-training data for each side were compared using paired t-tests (α=0.05), with feet separated into dominant and non-dominant sides.

RESULTS AND DISCUSSION

All muscle sizes on both feet increased significantly from pre- to post-training. Doming and 234Toe flexor strength of both feet also increased significantly from pre- to post-training, while 1Toe flexor strength increased significantly on the non-dominant side only.

Based on these data, this intervention appeared to produce the intended result of significantly increasing intrinsic foot muscle strength. These results are promising for runners who want to transition to minimalist footwear. This type of footwear removes cushioning and arch support, placing greater demands on foot and arch musculature. This type of strengthening may also be beneficial to runners who want to move away from motion control shoes or foot orthoses. Stronger intrinsic muscles may reduce the risk of injuries associated with arch flattening such as plantar fasciitis and stress fractures...

REFERENCES


Table 1. Pre- and post-training data for muscle size and muscle strength

<table>
<thead>
<tr>
<th>Muscle size</th>
<th>Dominant</th>
<th>Non-Dominant</th>
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<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
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<tr>
<td>ABDH CSA (cm²)</td>
<td>1.89 ± .63</td>
<td>2.09 ± .62</td>
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<tr>
<td>FDB CSA (cm²)</td>
<td>1.74 ± .49</td>
<td>1.98 ± .49</td>
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<tr>
<td>FHB thickness (cm)</td>
<td>1.25 ± .13</td>
<td>1.44 ± .25</td>
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<tr>
<td>QP CSA (cm²)</td>
<td>1.77 ± .45</td>
<td>1.98 ± .41</td>
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<td>Strength (kg)</td>
<td>5.37 ± 2.43</td>
<td>6.84 ± 4.32</td>
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<td>1ToeFlex</td>
<td>5.45 ± 2.97</td>
<td>7.46 ± 4.03</td>
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<tr>
<td>Doming</td>
<td>6.19 ± 4.38</td>
<td>11.02 ± 4.59</td>
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