The effect of intrinsic and extrinsic foot muscle exercises on the arches of the foot

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Introduction

The pes planus deformity has been identified as a risk factor predisposing people to lower extremity injuries (Kaufman et al. 1999). Although several studies investigated the role of the muscles in maintaining the longitudinal arch of the foot (Basmajian et al., 1963; 1979; Gray, 1969, Kitaoka et al., 1997), little information exists concerning whether foot architecture can be influenced by strength training. The purpose of this study was to investigate whether a foot muscle exercise program can modify the architecture and/or function of the foot during walking.

Methods

7 male and 16 female persons with pes planus participated in the study (age 30 (SD 7.1); bw 80 kg (SD 17.0 kg). The subjects performed a strength training program four times per week for a period of 6 weeks. The exercises included concentric and eccentric training for the intrinsic and extrinsic foot muscles (figure 1). To assess the effects of the exercise program on foot structure, arch indices, contact area, and plantar peak pressures for 5 walking trials (one-step-procedure) were evaluated before and after the completion of the program. Ink footprints were obtained in standing position to analyse the foot angle (FA) and the Chippaux-Smirak Index (CSI) (Forriol, F. et al. 1990, figure 2). Peak pressures and foot-to-ground contact area were determined by using an EMED pressure distribution platform. Dependent t-tests were performed to examine treatment effects.

Figure 1: Example of an exercise to strengthen foot musculature

Figure 2: Foot indices (CSI = ratio between c and b in %; FA =α)
Results

As shown in table 1 the exercise program led to no changes in the CSI and FA. For the walking condition, however, the peak pressures beneath the medial heel, the medial and lateral midfoot, the metatarsal heads V and II and the hallux showed significant changes. The subjects showed reduced peak pressures under the longitudinal arch, contrasted by increased pressures at the medial rearfoot and forefoot (figure 3).

Table 1: Foot indices, contact area and pressure values before and after the exercise program

<table>
<thead>
<tr>
<th></th>
<th>CSI (%)</th>
<th>FA (°)</th>
<th>Area (cm²)</th>
<th>Lat Heel (kPa)</th>
<th>Med Heel (kPa)</th>
<th>Lat Mid (kPa)</th>
<th>Med Mid (kPa)</th>
<th>MTH V (kPa)</th>
<th>MTH IV (kPa)</th>
<th>MTH III (kPa)</th>
<th>MTH II (kPa)</th>
<th>MTH I (kPa)</th>
<th>Hallux (kPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>Mean</td>
<td></td>
<td>40.7</td>
<td>31.3</td>
<td>167.3</td>
<td>330</td>
<td>337</td>
<td>122</td>
<td>100</td>
<td>258</td>
<td>292</td>
<td>390</td>
<td>390</td>
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<tr>
<td>SD</td>
<td>8.9</td>
<td>11.1</td>
<td>23.7</td>
<td>70</td>
<td>69</td>
<td>63</td>
<td>53</td>
<td>116</td>
<td>62</td>
<td>116</td>
<td>116</td>
<td>118</td>
<td>141</td>
</tr>
<tr>
<td>Post</td>
<td>Mean</td>
<td>41.3</td>
<td>31.1</td>
<td>168.1</td>
<td>331</td>
<td>359</td>
<td>103</td>
<td>81</td>
<td>232</td>
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<td>419</td>
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</tr>
<tr>
<td>SD</td>
<td>8.0</td>
<td>11.2</td>
<td>25.9</td>
<td>62</td>
<td>73</td>
<td>57</td>
<td>42</td>
<td>98</td>
<td>45</td>
<td>91</td>
<td>122</td>
<td>163</td>
<td>137</td>
</tr>
<tr>
<td>p</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
<td>≤0.01</td>
<td>≤0.01</td>
<td>≤0.001</td>
<td>≤0.05</td>
<td>n.s.</td>
<td>n.s.</td>
<td>n.s.</td>
<td>≤0.05</td>
</tr>
</tbody>
</table>

Figure 3: Changes in peak pressures

Discussion

The absence of changes in the foot indices after treatment shows that it was not possible to elevate the arch during standing by strength training. However, the training of the foot and leg muscles resulted in a change in the plantar pressure pattern during walking, which emphasizes the importance of foot muscle activity during the stance phase. Although the foot architecture is maintained primarily by passive structures in standing (Basmajian et al., 1963), the foot and leg muscles are necessary to stabilize the foot during the dynamic loads in walking. The pressure pattern, following the muscle exercise program, indicates a higher rigidity of the foot with a heightened longitudinal arch and increased influence of medial forefoot structures.

References


