The Medial Longitudinal Arch Is Supported By The Intrinsic Plantar Musculature

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Introduction

The medial longitudinal arch (MLA) has often been described as an important structure of the foot, and its role in shock absorption and its relation to movements have been previously analyzed. The foot functions as a dynamic mechanism during gait, supporting the body during stance, adapting to terrain, and acting as a rigid lever to efficiently propel the body forward. The MLA is one example of the complex architecture that allows the synergy of movements in normal gait. The MLA is formed by bony congruence, a variety of ligaments along with intrinsic, as well as extrinsic, muscles of the foot.

The role of movements of the foot, especially in relation to overuse injuries has been noted by a number of researchers. Pronation, excessive in either duration, total amount or rate has been cited as a cause of overuse injuries in runners. Clinically, navicular drop is used as a composite measure of pronation, and navicular height has been used as a measure to predict time to maximum pronation.

However, there seems to be some disagreement in the literature as to the role of foot structures in the maintenance of the medial longitudinal arch. There is a paucity of literature describing the activities of the muscles of the foot.\(^1\) This project was undertaken with the intent of elucidating the function of the intrinsic musculature of the plantar aspect of the foot in the maintenance of the MLA.

Methods

Nine healthy adults, free from lower extremity pathology, served as participants for this study. Navicular drop was used to measure the height of the MLA, according to methods described in previous publications,\(^2\) and has been shown to be a method that is closely correlated to radiographic features of MLA structure.\(^3\) The participants were seated and the foot placed in subtalar neutral, and the height of the navicular tubercle above the ground was measured. The subjects then stood, and the height of the navicular tubercle was measured again.

EMG were collected at 1000 Hz from the abductor hallucis brevis muscle. Maximal voluntary contraction (MVC) was maintained for 5 seconds while data were recorded. An orthopedic surgeon administered a subdermal injection of 1% lidocaine with epinephrine in the area of the tibial nerve, immediately posterior and distal to the medial malleolus. The amount was dependent on the weight of the subject, and varied between 3 and 10 cc, as determined by the physician. Anesthetic effect was determined by a loss of tactile sensation using Semmes-Weinstein filaments. EMG data were again recorded from the abductor hallucis muscle, and the participants were again measured for navicular drop, using the same method as previously described. Data were compared between conditions using a paired t-test, with the a priori level of significance set at 0.05.

Results

The values for integrated EMG following the nerve block were 28% of the control values for MVC. The results indicate that there was a significant decrease in EMG (\(p<0.01\)). Figure 1 depicts a typical change in the EMG following the anesthetic administration. The bottom channel shows a control trial while the top channel was recorded following the nerve block. The change in EMG corresponded to a significant increase (\(p<0.01\)) in the amount of navicular drop measured (mean: 6.5±2.6mm control vs. 9±2.8mm anesthetic). The changes are shown in figure 2.
Discussion

The results indicate that the intrinsic plantar muscles play a vital role in maintaining the height of the MLA. This information must be examined from a clinical perspective, in that navicular drop has been noted to be closely related to pronation. Various publications have linked excessive pronation to overuse injuries affecting areas from the foot to the low back. It seems that an increase in navicular drop will correspond to an increase in pronation, therefore leading to an increases likelihood of overuse injuries, especially for those whose occupations require significant amount of walking or those who engage in running activities.

While we only measured one muscle, the abductor hallucis brevis, it is logical to assume that the tibial nerve block was not selective to this muscle. Our results indicate that the musculature of the foot provides significant support for the MLA. This area has been overlooked previously, but such information may help clinicians determine a more optimal rehabilitation regimen for individuals recovering from foot injuries. This information could be used in the development of rehabilitation regimens to strengthen these muscles, if the overall goal is to minimize pronation, as might be seen in overuse injuries such as medial tibial stress syndrome.

References

Figure 1. EMG recordings during control (bottom) and anesthetized (top) conditions.

Figure 2. Change in navicular drop between control and anesthetized conditions.