Effect of Arch Height On Dynamic Balance and Neuromuscular Control in Young Adults

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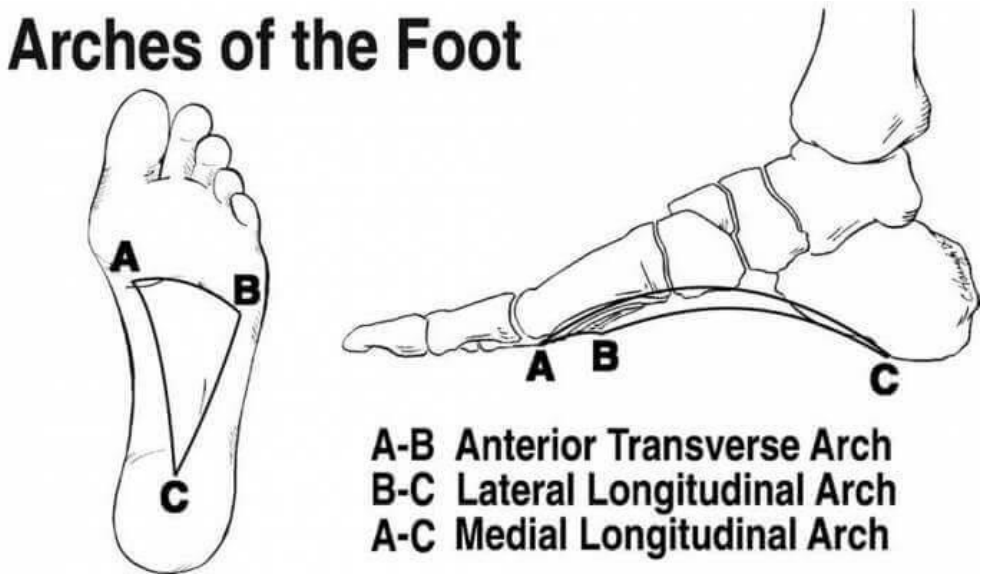
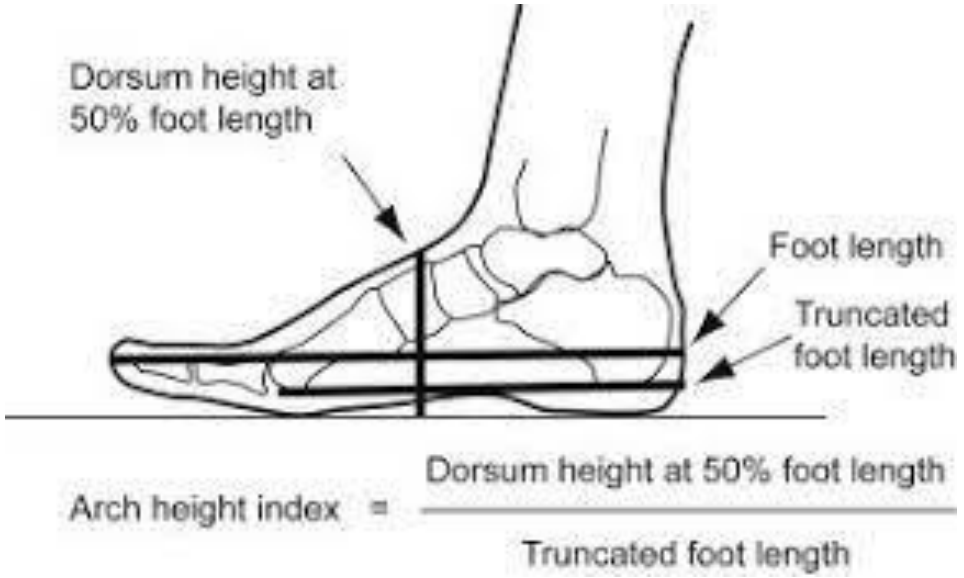
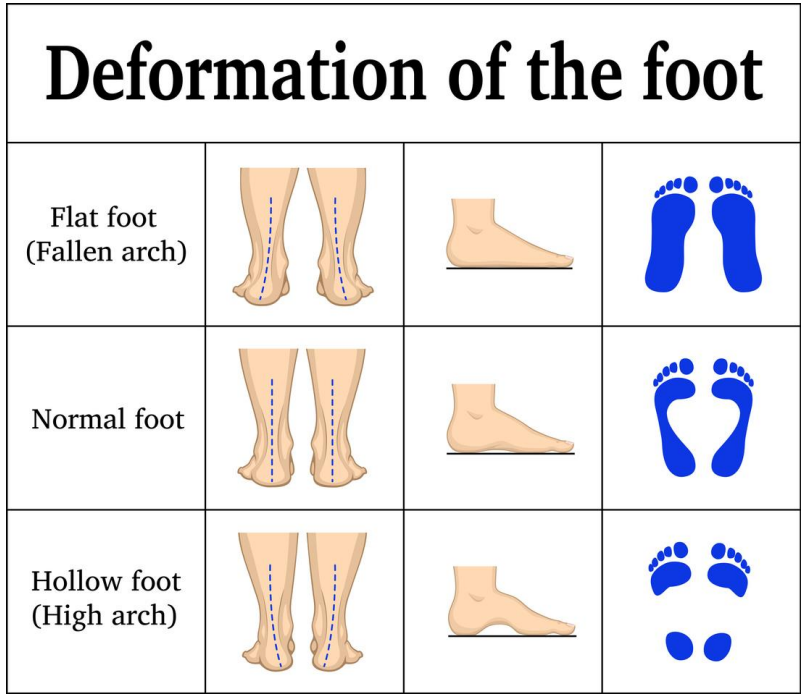




Foot Arches

Children start out with flat feet and their arches develop at ages 10-13 years [2]

Flat feet commonly present as flexible flat feet in adulthood, showing usually no pain or symptoms [2][3]



Background

Hip knee and ankle joints are all influenced by arch height

Ankle muscles were found to have greater strength and isometric contractions in the dorsiflexors and plantarflexors in low arched feet [1][4]

Negative knee adaptations, like increased knee abduction moments and increased knee valgus were found in low arched athletes [5][6]

At the hip joint it has been suggested that the total work of the hip muscles was greater in individuals with flat feet [7]

Balance

Maintaining stability and orientation of the body within a small base of support

Dynamic balance has been seen to be negatively affected by low arches compared to normal and high arches [8][9]

Dynamic Balance

Other Measures

- Foot enter of pressure (CoP) sway
- Lower leg muscle activation

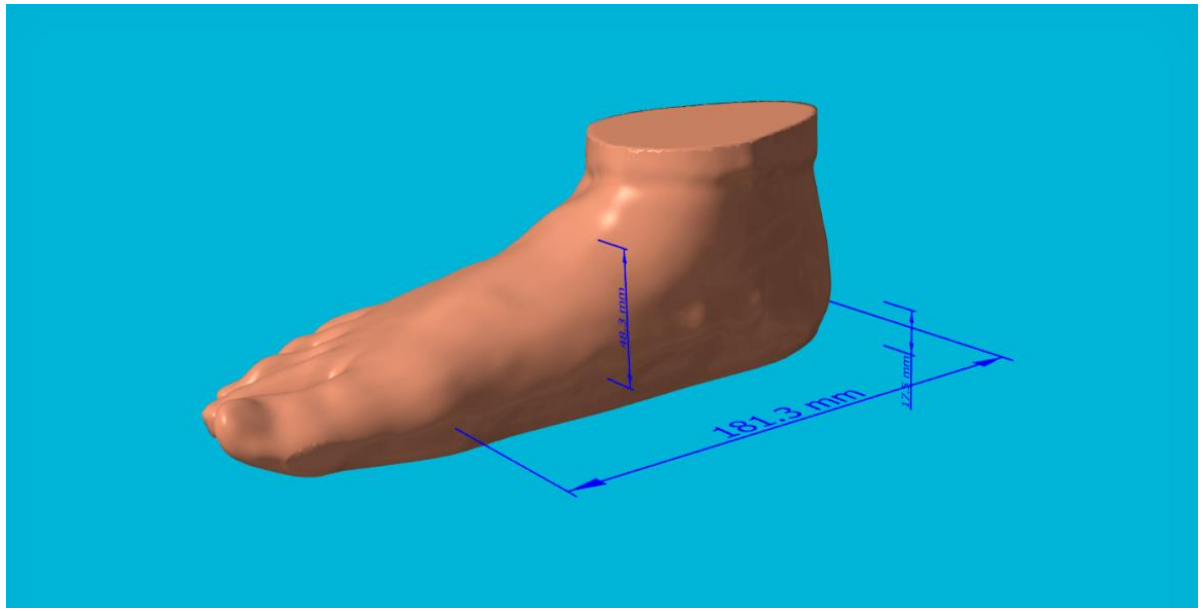
Chronic Ankle Instability (CAI)

- CAI showed smaller reach scores [11]
- CAI showed greater CoP path length and sway velocity [11]
- CAI showed more activation in TA in anterior direction and gluteus maximus in PL direction [11]

Hypotheses

Lower AHI will have a negative effect on dynamic balance scores and CoP

Those with lower AHI will show greater muscle amplitudes in the lower leg muscles that assist in dynamic balance



Volume Scan

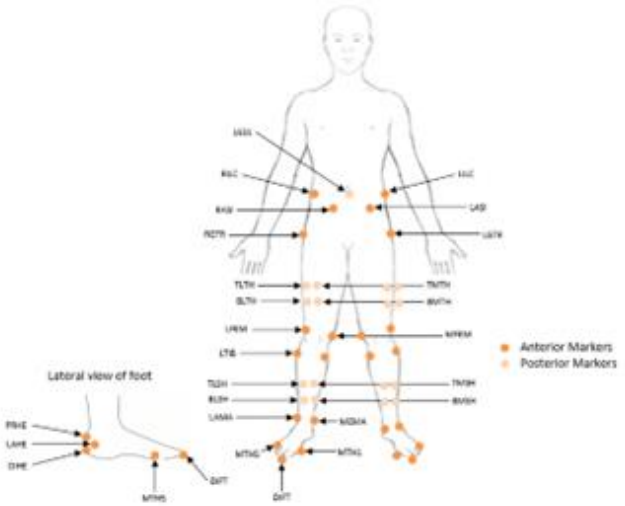
15 healthy young adults ages 23-25 years

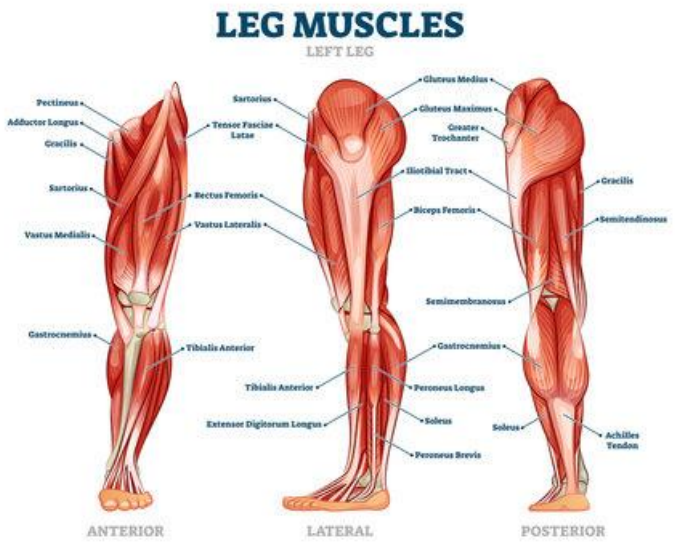
Dominant foot scanned using volume scanner to obtain arch height index (AHI) in sitting and single leg stance

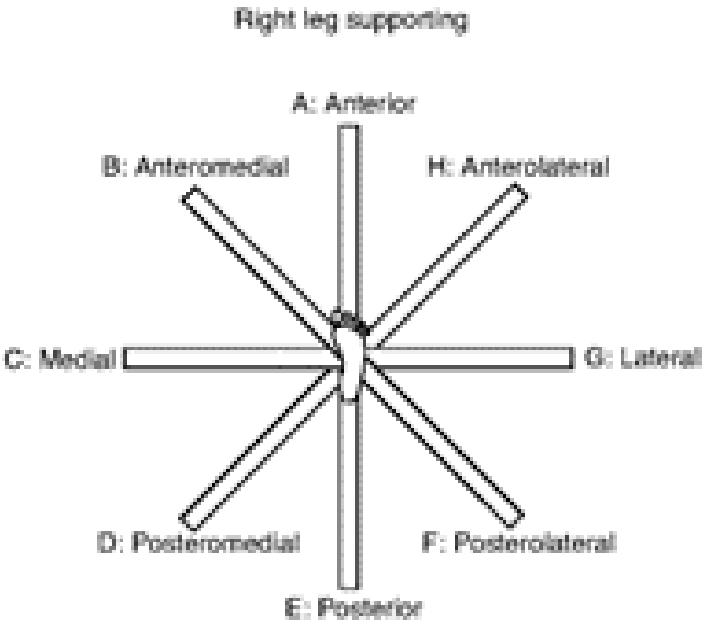
Human Body 3D Measurement Software used to orient and clip scans

Motion Capture

- Reflective markers attached to the lower body
- EMG sensors placed on 7 muscles of the thigh and shank
- 3D motion capture system with force plate
- Subjects performed Star Excursion Balance Test (SEBT) 3 times

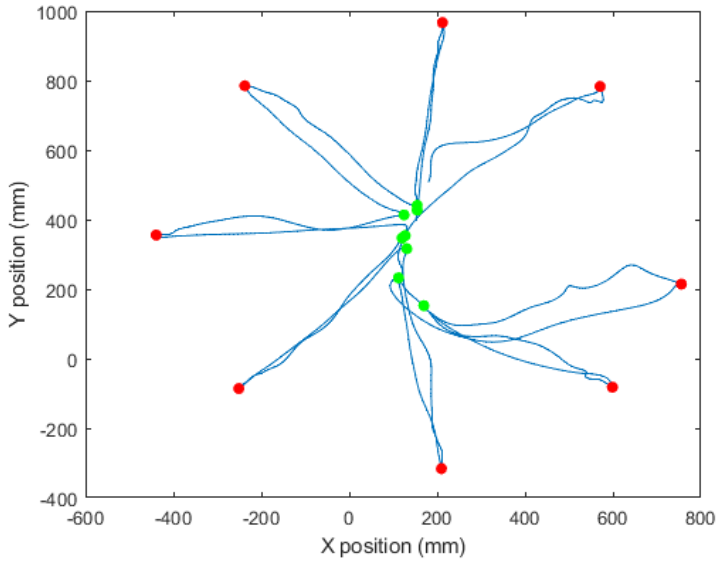


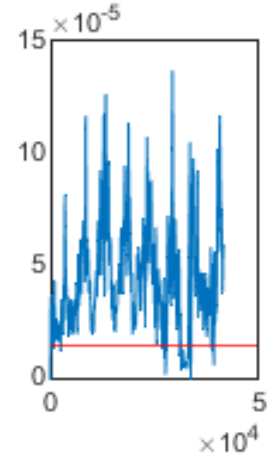


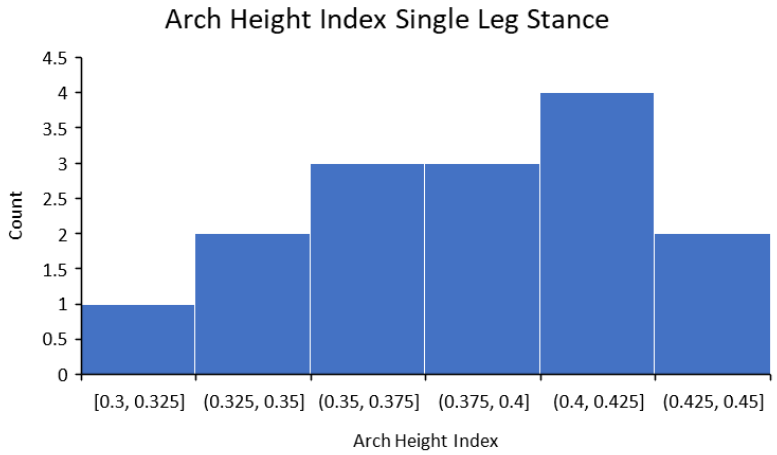


Data Analysis

- SEBT determined by trajectory of left toe reflective marker
  - Normalized by leg length
- CoP area obtained by taking area of ellipse in each direction
- Peak muscle amplitude was measured for each muscle in each direction
  - Normalized by peak muscle amplitude in static standing trial







Statistical Analysis

JASP software used for all statistical calculations

T-test used to determine if there was statistical difference between sitting and single leg stance AHI

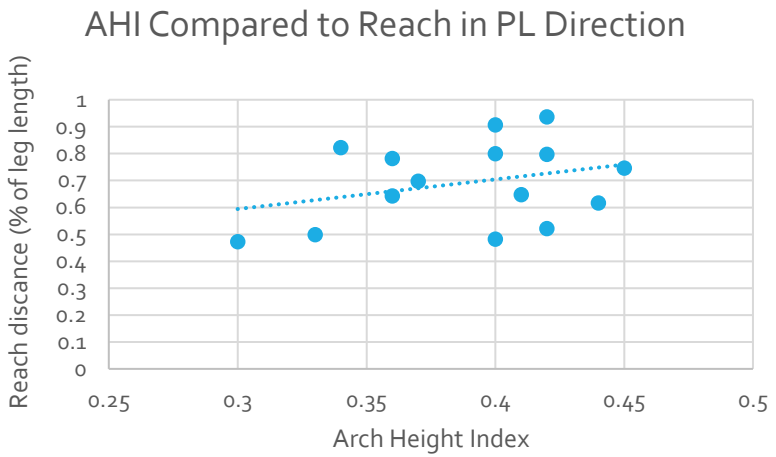
Correlation analyses were used to determine if there were any significant correlations between AHI and

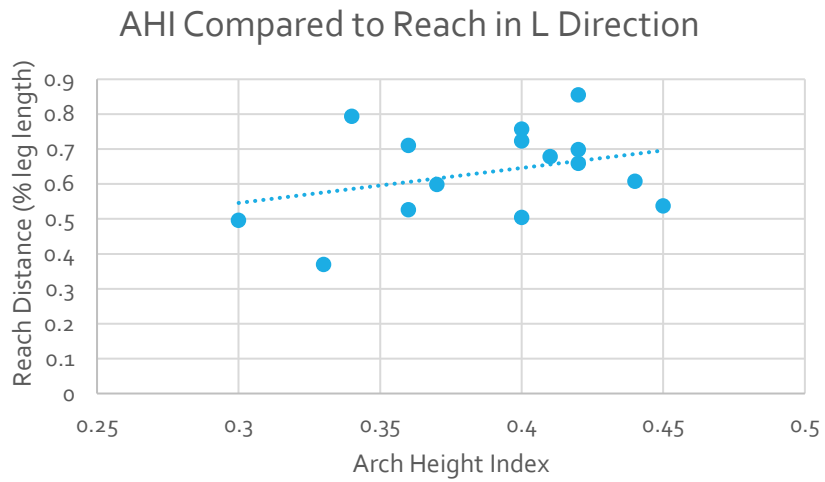
- Reach scores
- CoP sway area
- Peak muscle amplitude

Reach Distance

Moderate correlations found in lateral (L) and posterolateral (PL) direction

AHI Compared to Reach Distance									
	A	AM	M	PM	P	PL	L	AL	Total
r	-0.100	-0.024	0.109	0.299	0.202	**0.312**	**0.330**	-0.086	0.191
R^2	0.010	0.001	0.012	0.089	0.041	0.0973	0.109	0.007	0.036
p	0.722	0.933	0.699	0.279	0.471	0.258	0.230	0.760	0.496

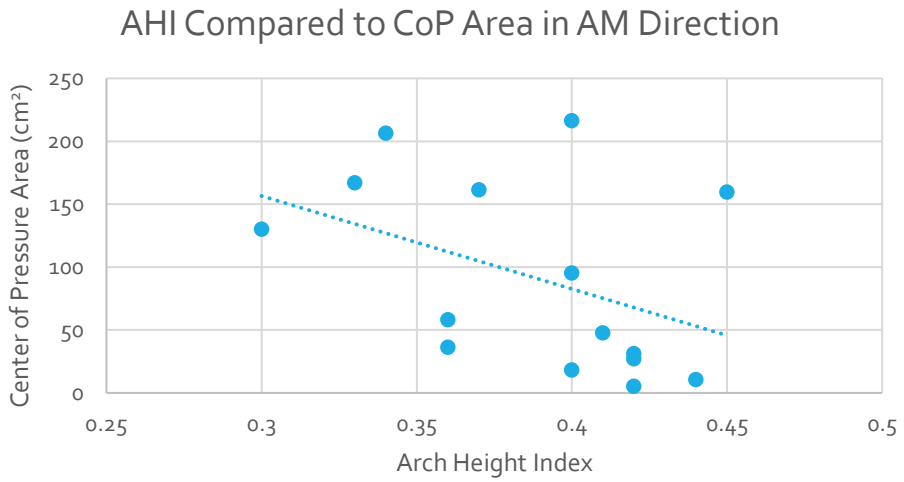




CoP Sway Area

Moderate negative correlation was found in the anteromedial (AM) direction

AHI Compared to CoP Area								
	A	AM	M	PM	P	PL	L	AL
r	0.008	**-0.423**	-0.110	0.249	-0.080	0.214	0.118	-0.077
R^2	6E-05	0.179	0.012	0.062001	0.006	0.046	0.014	0.006
P	0.978	0.116	0.695	0.371	0.778	0.443	0.675	0.786



Peak Muscle Amplitude

Rectus femoris and semitendinosus showed negative correlations and some statistical significance. Gluteus medius showed some positive correlations.

AHI compared to muscle amplitude									
		A	AM	M	PM	P	PL	L	AL
Gastrocnemius	r	0.199	0.162	0.213	0.266	0.23	0.207	0.255	0.184
	R^2	0.040	0.026	0.045	0.071	0.053	0.043	0.065	0.034
	p	0.477	0.565	0.447	0.337	0.409	0.459	0.359	0.511
Soleus	r	0.158	0.210	0.237	0.182	0.219	0.244	0.126	-0.008
	R^2	0.025	0.044	0.056	0.033	0.048	0.060	0.016	6E-05
	p	0.574	0.453	0.359	0.515	0.432	0.380	0.654	0.977
Peroneus Longus	r	0.292	0.247	0.272	0.230	0.148	**0.385**	0.223	0.210
	R^2	0.085	0.061	0.074	0.053	0.022	0.148	0.050	0.044
	p	0.290	0.375	0.327	0.410	0.598	0.157	0.425	0.452
Tibialis Anterior	r	0.121	0.103	0.025	0.047	-0.007	-0.052	-0.024	0.059
	R^2	0.015	0.011	0.001	0.002	5E-05	0.003	0.001	0.003
	p	0.668	0.715	0.929	0.868	0.981	0.855	0.932	0.836
Rectus Femoris	r	**-0.633**	**-0.692**	**-0.404**	**-0.500**	**-0.365**	**-0.424**	**-0.468**	-0.149
	r^2	0.401	0.479	0.163	0.250	0.133	0.180	0.219	0.022
	p	**0.011**	**0.004**	0.136	0.058	0.181	0.115	0.078	0.595
Semitendinosus	r	**-0.661**	**-0.632**	**-0.589**	**-0.563**	**-0.613**	**-0.616**	**-0.568**	**0.690**
	r2	0.437	0.399	0.347	0.317	0.376	0.379	0.323	0.476
	p	**0.007**	**0.011**	**0.021**	**0.029**	**0.015**	**0.017**	**0.027**	**0.004**
Gluteus Medius	r	**0.417**	**0.382**	0.146	0.130	0.149	0.202	0.245	**0.329**
	R^2	0.174	0.146	0.021	0.017	0.022	0.041	0.060	0.108
	p	0.122	0.160	0.604	0.645	0.596	0.469	0.379	0.231

Effect of AHI on Balance Performance

- Our study found few correlations between AHI and reach scores and CoP sway area
  - Flat feet criteria not met
- The shorter reach distances for low AHI seen in the PL and L direction could be due to increased knee valgus, which limits hip mobility to be able to reach in the lateral directions [6][14]
- Foot insoles correcting low arches may help lessen knee valgus

Effect of AHI on Muscle Control Strategies

- Both the rectus femoris and semitendinosus, had higher peak muscle amplitudes in most or all directions in individuals with flatter feet
  - Stabilize knee and ankle through slightly atypical balance movements
- Gluteus medius exhibited less peak muscle amplitude with low AHI in some directions
  - Abductors seen to have less strength in those with flat feet [14]
- Rectus femoris and semitendinosus have bigger contractions to make up for smaller gluteus medius contractions
- Ankle stability, gluteus medius and hip endurance exercises recommended

ALLOWS CLINICIANS TO CREATE SPECIALIZED PROGRAMS AND EDUCATE LOW ARCHED INDIVIDUALS

FURTHER STUDIES CAN LOOK AT THE SAME MEASURES, BUT HAVE INCLUSION CRITERIA TO ALLOW HIGH AND LOW ARCHES TO BE COMPARED IN GROUPS

SPORT SPECIFIC MOVEMENTS CAN BE STUDIED IN THE FUTURE

Implications and Further Studies

Resources

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Resources cont.

- [9] Sudhakar, Selvaraj, et al. "Impact of Various Foot Arches on Dynamic Balance and Speed Performance in Collegiate Short Distance Runners: A Cross-Sectional Comparative Study." *Journal of Orthopaedics*, vol. 15, no. 1, Mar. 2018, pp. 114–17. *EBSCOhost*, https://doi.org/10.1016/j.jor.2018.01.050.
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