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AN INVESTIGATION INTO FOOT STRUCTURE AND FUNCTION OF INDIAN MALLAKHAMB PLAYERS

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SUMMARY
Biomechanics of Mallakhamb, a traditional Indian gymnastic sport remains unexplored. Therefore, present study compared structure and function of ankle-foot complex of Mallakhamb players (n=29) with age-matched controls (n=29) following ethical approval. Foot function measured in terms of active ankle plantar flexion; endurance of calf muscles and gait velocity were significantly greater among Mallakhamb players ($p<0.001$; $p<0.001$; $p<0.001$ resp.)
Foot structure measured in terms of its response to static loading in standing using Chippaux-Smirak Index (CSI) and dynamic loading during walking using plantar pressure distribution specifically on midfoot was not different between 2 groups.
Ankle-foot complex of Mallakhamb players demonstrated greater function compared to age-matched controls although foot structure did not vary.

INTRODUCTION
Traditional sports, dances and postures in Indian culture remain unexplored biomechanically. Present study is a part of a mega project designed to study biomechanics of such traditionally exclusive postures. Mallakhamb is a traditional Indian sport in which a gymnast performs feats and poses in concert with a vertical wooden pole or rope on a barefoot which functions as a pivot; demanding fine motor control and agility. Therefore aim of the study was to compare structure and function of ankle-foot complex of Mallakhamb players with age-matched controls.

METHODS
Ethical approval was sought from Institutional ethical review board. Twenty nine Mallakhamb players (24 females and 5 males; mean age 15 yrs) and 29 healthy subjects (24 females and 5 males; mean age 14 yrs) participated following signed informed consent. Foot structure was recorded by studying its response to static and dynamic loading using CSI in standing and plantar pressure distribution during walking (specifically midfoot) with novel pedar system. Static foot-print obtained in standing position was used to measure CSI [1].
During level walking at self-selected pace, average of five mid-gait steps from three trials were used to measure peak pressures over 7 regions of foot; namely-lateral heel, medial heel, midfoot, lateral forefoot, medial forefoot, hallux and toes. Plantar pressure data from 18 subjects was not included for further analysis after discovering that raw data (*sol files) were corrupt due to excessive perspiration of foot.
Foot function was recorded in terms of ankle mobility, endurance of calf muscles and gait velocity. Active ankle range of motion in sagittal plane recorded with Silicon coach software was used to measure ankle mobility. Calf raise test was used to measure endurance of calf muscles [2]. Gait velocity was measured with digital camcorder at a sampling rate of 25 Hz while subjects walked 3 trials between 2 calibration sticks placed 1 m apart [3].
All variables on each side i.e. right and left were compared with respective sides between groups using independent sample t test (level of significance determined at $p \leq 0.05$)

RESULTS AND DISCUSSION
Ankle plantar flexion (MP=56^0, Controls=51^0); endurance score of calf muscles (MP=28, Controls=20) and gait velocity (MP=1.4m/sec; Controls=1.2m/sec) were significantly greater among Mallakhamb players ($p<0.001$; $p<0.001$; $p<0.001$ resp.) indicating better foot function.
However there was no difference in foot structure between both groups. Medial longitudinal arch height during standing and peak plantar pressures over midfoot during walking did not differ between 2 groups (refer to Table 1).

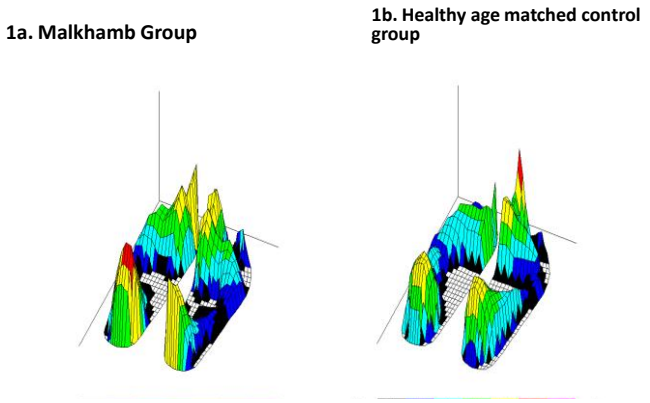

Figure 1: Typical peak pressure distribution over midfoot.

Mallakhamb sport involves immense flexibility, particularly of ankle-foot complex which serves as a pivot during various feats and poses. Secondly, Mallakhamb players

received exclusive flexibility training. Therefore it was speculated that sport specific adaptation and training effect may reflect in lengthening of midfoot; resulting in lower medial longitudinal arch height and higher peak pressures over midfoot. However, it is likely that use of in-shoe measurement system underestimates present findings from measurement of plantar pressure distribution.

CONCLUSIONS

Ankle-foot complex of Mallakhamb players demonstrated greater function compared to age-matched controls although foot structure did not vary between groups.

Further in-depth biomechanical analysis using pressure platform is warranted to rule out possible limitation of in-shoe pressure measurement.

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Table 1: Comparison between Mallakhamb players and age-matched controls

	Right side			Left side		
	Mallakhamb	Control	p value	Mallakhamb	Control	p value
Ankle plantar flexion (deg)	55±6.1	51±5.2	0.014*	56±4.9	51±5.9	0.000*
Calf raise test score	28±4	20±3	0.000*	27±3	19±4	0.000*
CSI score	0.5±0.1	0.4±0.1	0.136	0.5±0.1	0.4±0.1	0.076
Peak pressure (kPa)	117.2±27.8	109.1±29.6	0.378	97.7±47.4	80.2±17.5	0.131

* $p \leq 0.05$