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Original Article

A STUDY OF FOOTPRINTS OF TREE-CLIMBING COMMUNITIES OF SOUTH INDIA

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Abstract :

The paper details the morphological adaptations of the foot shape and its arches to sustained professional tree climbing activity. Foot inversion, as required by climbers on a long term and regular basis reshapes the bony architecture of the foot and the medial longitudinal arch over a period of time. These changes can be observed and measured, noninvasively through study of footprints.

This community study on the progressive adaptation of the arch to the rigors of climbing was recorded through footprints collected from the climbers with varied experience in the profession. The collation of observations show that the medial arch continues to shrink with sustained inversion, raising the dome of the instep.

The progressive compensatory rise in arch height however, is arrested abruptly after a phase, with failure of the arch to accommodate further to more stress – leading to slipping and falls from heights. The article discusses the bio-mechanisms and kinetics of foot adaptation to the rigors of climbers and analysis the cause of accidental falls, even though most of the accidental fall victims have had a number of years of climbing experience.

Keywords: medial longitudinal arch, foot, coconut palm, community, inversion

Introduction :

The human foot, though designed to bear weight and facilitate bipedal locomotion also shows the combined effects of heredity and acquired lifestyle. Adaptation in shape and modifications in soft tissue and osteological components of the foot to large extent are dictated by kinetic stresses and strains it is subject to. Functional biomechanics play a visually verifiable and metrically quantifiable anatomical remodeling of foot structure.

The role of foot arches in aiding the early of biped to adapt to a terrestrial existenceis a landmark milestone in development of the hominid. The ligaments, joints, bones, muscles and soft tissue components of the foot, contribute in their own unique ways in making man, the only one among his mammalian cousins, to have mastered the art of walking on hind limbs as units[1]. The question raised here is, are these time honored evolutionary anatomical features of the foot absolute?[2] Can prolonged and sustained strain induced by specific usages such as in tree climbing, influence the foot structure to revert to its simian prototype? Are these changes, if any, measurable ?[3]

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The footprint is a unique record of the weight bearing status. The print impress itself is a metrically assessable permanent database. Evaluation of the hemi-dome (hollowness) produced by the medial edge of the human foot, essentially the measurements of the components of the medial longitudinal arch[4] should present us with data which can be compared and analyzed. In this paper we present our findings on the evaluation of both feet of a hundred adult males from local communities that practice tree-climbing. The results are compared with those collated from measurements in lay population of males

Material & Methods

Footprints of both feet were recorded on graph sheets,

using ink pads as staining medium (Fig. 1 & 2) Adult males from Thiyya, Idiga, Billava and Namdhari communities of three contiguous districts of the southwest coast of India formed the nidus for this study. The horizontal length, breadth and surface area of the hollow semilunar space in the prints were measured using Meyer's line as reference. The height of the medial arch was measured as a perpendicular drawn from the tuberosity of the navicular to the horizontal (Fig.3). The study was conducted across communities spread across three contiguous south India states (Tamilnadu, Kerala and Karnataka)

Tabulations and graphical records for visually identifiable gross changes and adaptations were prepared. The control group consisted of adult males drawn at random from similar age range. Field observations of the plantation industry, of palmyrah (toddy), areca and coconut were made to note the techniques of tree climbing used by professionals. The results were subject to statistical analysis and evaluation. None of the volunteers for this project was subject to any hospital-based investigation or invasive procedure. Visual observations on external features of feet in professionals were also made.

Results & Observations

The metrical values of both feet in tree climbers of varied ages and years of experience in occupation, along with the values of the control group are shown in Tables I to IV. The measurements show an average of 88.63 mms, 39.95 mms, 53.03 mms and 2538 sq mms for left side (length, breadth, height and surface area). In controls the same parameters showed 70.14 mms, 27.34 mms, 49.7 mms and 1345 sq mms for left and 72.2, 27.4, 49.81 and 1391.89 sq mms for right foot.

There is an obvious increase in all parameters, length, breadth, height and surface area in climbers compared to controls. It is also noted that the increase is directly proportional to the number of years of practice of the profession. However, oddly, the increase – trend gets arrested with the climbers attaining about 3 decades experience in profession, in fact, there is an overall dip in all dimensions thereafter. The decrease is seen in length, breadth and increase in arch height.

Visual observations showed both feet in most climbers, especially those with a number of years of adherence to profession, had 'in-situ' partial inversion of foot. The hallux itself was invariably separated wide from the fellow toes (hallux valgus). Calcaneovarus and adduction deformation of both feet were also seen. Callosities were found pressure spots on plantar surface and on the medial edge dermal changes could be not just due to the stresses transmitted by climbing, but also to the friction and tribadic pressures brought about by rapid descent from the tree tops.

The results of statistical analysis of data using students unpaired 't' test reveals that the 'P' value is highly significant in the parameters of length, breadth and surface area for both feet. The P value for arch height is significant for left foot, and highly significant for the right (Table V & VI).

Discussion

The tree-climbing activity is traditionally carried out by isolated communities, the men-folk adept in the art of tree climbing. The communities engaged in this professional calling are the Idiga, Thiyya Namdhari and Billava. The trees

Table I: mean of age of normal and tree-climbers with mean of experience

Normal (age)	Mean	Std. Error of Mean
	40.74	051
Tree Climbers (age)	42.92	1.11
Experience(Tree climbers)	20.14	1.15

Table II : mean of age parameters of left & right foot in normal & tree-climbers (with Standard Error of Mean)

Normal	Left		Right	
	Mean	Std. Error of Mean	Mean	Std. Error of Mean
A. Length	70.14±	2.08	72.20	2.71
B. Breadth	27.34	1.28	27.40	1.19
C. Height	49.70	1.19	49.81	1.26
D. Surface Area	1345.06	98.26	1391.00	99.88
Tree Climbers				
A. Length	88.63	1.19	89.00	1.15
B. Breadth	39.95	1.00	39.02	0.74
C. Height	53.03	0.69	53.29	0.64
D. Surface Area	2538.82	84.28	2587.97	76.20

Keywords : medial longitudinal arch, foot, coconut palm, community, inversion - Arunachalam Kumar

Table III : Mean of parameters according to duration of experience in tree climbing

Experience (years)		<10 years		10-20 years		20-30 years		>30 years	
Side	Parameters	Mean	Std.err of Mean	Mean	Std.err of Mean	Mean	Std.err of Mean	Mean	Std.err of Mean
Left side	A. Length	85.11	2.49	87.18	1.90	92.96	2.20	91.36	2.95
	B. Breadth	35.07	1.67	39.76	1.36	44.28	2.37	42.43	2.63
	C. Height	51.25	1.43	53.08	1.19	53.06	1.41	56.432	1.28
	D. Surface Area	2232.11	162.85	2547.06	116.78	2802.6	189.79	2661.4	224.57
Right side	A. Length	87.14	2.28	88.74	1.68	93.63	2.35	92.50	3.56
	B. Breadth	35.82	1.28	38.85	1.20	42.21	1.33	4.036	2.36
	C. Height	52.41	1.32	53.38	1.13	52.81	1.27	55.61	1.25
	D. Surface Area	2304.11	140.12	2545.91	112.18	3016.42	158.97	2523.36	206.96

Table IV: percentage increase according to mean of experience in climbers compared with controls

LEFT SIDE				
Experience	<10	10-20	20-30	>30
Length (A)	21.34	24.29	32.53	30.25
Breadth (B)	28.27	45.43	61.96	55.19
Height (C)	3.12	6.8	6.7	13.54
Surf. area (D)	65.96	89.36	108.37	97.86
RIGHT SIDE				
Length (A)	20.69	22.91	29.68	28.12
Breadth (B)	30.73	41.79	54.05	47.29
Height (C)	5.22	7.19	6.04	11.66
Surf. area (D)	65.64	83.03	116.85	81.41

Table VI : comparison between normal to tree-climbers (Students unpaired 't' test)

Side	Parameters	'T' test for Equality of Means		
		T	P	Inference
Left	A. Length	-7.844	0.000	Very highly Significant
	B. Breadth	-6.790	0.000	Very highly Significant
	C. Height	-2.434	0.016	Not significant
	D. Surface Area	-7.750	0.000	Very highly Significant
Right	A. Length	-7.063	0.000	Very highly Significant
	B. Breadth	-8.101	0.000	Very highly Significant
	C. Height	-2.647	0.009	Highly Significant
	D. Surface Area	-8.440	0.000	Very highly Significant

are scaled through a series of upward hops along the vertical face of the trunk, the exercise calling for flexion, abduction extension and lateral rotation of hip, flexion extension at knee, plantar and dosiflexion at ankle, inversion at the subtalar articulations and flexion at metatarsophalangeal and interphalangeal joints of the foot. To assist leverage, a 'rattan' loop is worn around the waist, which in turn is wound around the tree trunk. A similar loop worn across the ankles prevents the splaying of

Fig. 1: Footprints of normal adult male

Fig.2: Footprints of tree-climber with 10-20 years experience

Table V : Students unpaired 't' test for equality of means

		't' test for Equality of Means		Inference
		t	Sig.2 tailed	
Left	A. Length	-2.597	0.011	Significant
	B. Breadth	-3.047	0.003	Significant
	C. Height	-1.435	0.154	Not significant
	D. Surface Area	-2.055	0.043	Significant
Right	A. Length	-2.234	0.028	Significant
	B. Breadth	-2.740	0.007	Highly Significant
	C. Height	-0.681	0.498	Not significant
	D. Surface Area	-2.609	0.009	Highly Significant

feet, keeping them approximated to the trunk surface at all times of ascent or descent[5]. The climb induces tremendous gravitational strain on the tibiotalar and intertarsal joints. Each professional climber works around 4 hours a day and scales 25-30 trees.

The percentages of the people who had fallen from coconut trees and had faced injuries in the different experience groups were with less than 10 year of experience 15%, in 11-20 years of experience, 26.6%, In 21-30 years of experience it was 44% and in those with 30 years of experience the value was 41.3%. A total of 35.5 % (78 cases out of 220 climbers) fell down from coconut trees while doing their job[8].

The results of this study show that with sustained and prolonged strain the foot undergoes permanent and quantifiable shape change The forced inversion, abuts on the osteo-myo-fascial bow of the medial longitudinal arch which over time, shows an increase in length, breadth, surface area and height.[6]. These changes through quite rapid in the first few years of climbing, level off in the second decade of engagement, after which the dimensions once again show a spurt in all parameters. However, after three decades of climbing, the percentage values of increase drops for length, breadth and surface area, but continues to rise for the height of arch.[7]

It is our inference that the foot dynamics and kinesiological exertions strain the factors maintaining the medial arch, the stress being overcome through a generalized

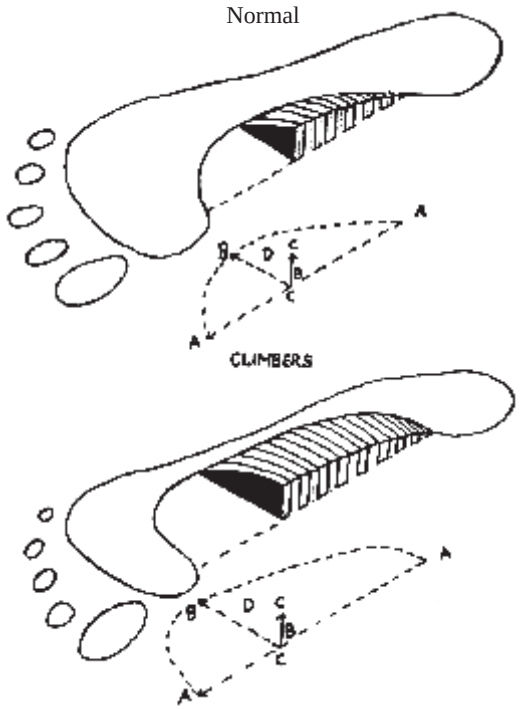

Fig: 3: Showing increase in length (A) and surface area (D) in climbers compared to normals

augmentation in size and strength through intrinsic physiological compensatory counteractions. The failure of compensatory changes, with age and exposure (beyond 3 decades) leads to an arrest of these mechanisms, which now show a reduction in dimensions (and probably strength too.) The continued increase in arch height is mainly due to permanency of osteological changes in the foot architecture. The probable development of pressure induced epiphysis or bony spurs or buttresses in the tarsi through usage make the morphological adaptations in these bones permanent[10, 11]. The medial arch in experienced tree climbers is raised, not so much through fascial inputs, but remains so by the rigidity of the deformed bony arch base.

It is also interesting to note that, accidental falls and fatalities that are recorded from time to time from groves, usually involve very experienced and old climbers. The percentages of the people who had fallen from coconut trees and had faced injuries in the different experience, in those with 10 year of experience it was 15%, in those with 11-20 years of experience it was 26.6%, in those with 21-30 years of experience, it stood at 44% and in those with more

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than group 30 years of experience it was 41.3%. A total of 35.5 % (78 cases out of 220 climbers) fell down from coconut trees while doing their job. The mystery of why an experienced and highly skilled laborer should slip may now be explained through our observations that, there is abrupt cessation in progressive arch adaptation and functional efficiency after 30 years climbing. The bony arch alone, now divested of its resilience provided by arch-sustaining ligaments, is unable to sustain the stress and weight of the aged climbers [11].

It is hoped that anthropometric studies such as this one may serve to build up retrievable records of the anatomical and functional dynamics of the physical attributes of communities of 'dying' professions such as tree-climbing [12,13].

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