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Original Article

Static and Dynamic Footprint Analysis among Young Indigenous Izzi Male Adults Residing in Abakaliki Metropolis

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Abstract

BACKGROUND: Footprint is a mark left behind by an individual while walking or standing which is an important tools in crime investigation.
METHODOLOGY: The present study was carried out in Abakaliki and 300 male subjects between ages of 18-30years participated in this research exercise. Each Subjects height were measured and asked to stand on an endorsement ink poured on a slab before undergoing static and dynamic footprints exercise of seven step walkway protocol using a white duplicating paper. The white duplicating paper was arranged on a floor and each subject footprint were obtained. The Footprint length (FTL), Footprint breadth ball (FBB) and Foot breadth at heel (FBH) were measured from the imprint left on the white duplicating paper of each subjects using a meter rule and pencil. The measurements were expressed in centimeters and analyzed into mean±standard and correlation coefficients using IBM Statistical Package for Social Science (SPSS) version 25.0. The significant level was set as P>0.01.
RESULTS AND CONCLUSION: The result shows slightly greater values in static footprint measurements than dynamic footprint and the result were significant. The studies is significance in ergonomics footwear designing.

Keywords:
Footprints, Static, dynamic

INTRODUCTION

Footprint is one of the most important tools in forensic science, anthropology, biomechanics and medical matters in crime and identification among individuals (Naples and Miller, 2004; Mukha *et al*., 2020). Footprint is as important as fingerprint evidence left in crime scene even without making ridges (Howsam and Bridgen, 2018). Thus, footprints are obtained from marks left on sand, dust, mud, blood and paint on hard surface and the dimensions of each individual imprints is considered as the overall shape, or morphology (Mukhra et *al*., 2018; Howsam and Bridgen, 2018).

However, the human footprints can be obtain either in static or dynamic forms (Di Maggio and Vernon, 2017), which varies among individuals as a results of morphological factors of each individuals such as foot shape, method of locomotion and the surface which the foot comes in contact with (Howsam and Bridgen, 2018). Thus, the morphology of human Footprint is also attributed to aging and has been noted as an important indicator in human aging process (Chao and Bernard, 2017).

Although, with the different level of footprint variation, researchers of forensic science have compared the known and unknown variables of foot imprint to support match or mismatch proposition and in stature estimation (Howsam and Bridgen, 2018; Reel *et al*., 2012; Henry *et al*., 2013a; Nataraja *et al*., 2014; Burrow, 2016; Okubike *et al*., 2018), among different age grouping, sex, gender, and ethnicity (Tsung *et al*., 2003; Krishan, 2008; Henry *et al*., 2013b; Abledu *et al*., 2015, Domjamic *et al*., 2015; Jyoti, 2015; Caplova *et al*., 2018).

Finally, Abakaliki metropolis is the capital of

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Ebonyi sate, southern part of Nigeria and comprises of different socio-cultural groups and the Izzi's are the original inhabitants of Abakaliki, thus, the present study was in static and dynamic footprint analysis among young indigenous Izzi male adults residing in abakaliki metropolis and developing a possible Level of significance for both static and dynamic variables which will serve as reference purpose in forensic, biomedical, anthropometric sciences and ergonomic in footwear designing.

MATERIALS AND METHOD

A total no of 300 hundred young male adult between ages of 18-30 participated in this research study. Subjects were from Izzi tribe and were educated on the purpose of the research. Subject with club foot and subjects with missing toe were excluded from the research exercise. The height of each subject was measured using a stadiometer and were expressed in centimeters. An endorsement ink was poured on a slab which was constructed with polyvinyl chloride and was 40cm long and 40cm. White duplicating paper were arranged into two segment; static segment and dynamic segment.

Static Footprint Exercise

With the endorsement ink on the plastic slab placed on the ground surface, the subject were asked to stand upright on the plastic slab before advancing to the clean white duplicating paper which was well arranged on the ground surface to collect the subject's right and left footprints.

Fig 1: Image illustrating static foot print exercise

Dynamic measurement of Footprint

After obtaining the static footprint, a seven step walkway protocol was designed using white duplicating sheets. The subjects were asked to stand on the plastic slab and then walk on the seven step walkway with their eyes fixed on the level point ahead of them. The imprint produces by participants during walking were selected (one left and one right from the other seven).

Anatomical Landmark of Footprint

After obtaining the footprint on the white duplicating paper the following anatomical landmark was carefully marked using pencil;

- Mid- rear heel (pterion)
- Medial metatarsal Point (MMP)
- Lateral metatarsal Point (LMP)
- Medial Calcaneal Concavity (MCC)
- Lateral Calcaneal Tubercle (LCT)

Using krishan method, the following land mark were map out; the designated longitudinal axis (DLA) this was drawn from the pterion to the lateral side of the first five pad margin and the base line (BL) this was drawn appendicular to the footprint extending from the pterion in both lateral and medial direction. The purpose of mapping out DLA and BL is to help establish a definite axial orientation for length measurement. The DLA enable one to take footprint length measurement from a specific landmark to the rear of the foot while keeping the line of the measurement parallel to the DLA

The following anatomical land mark were measured

Footprint length (FL1): which were measured from the pterion (p.t) to the most anterior part of the first toe and were marked as FTL1

Footprint length (FL2): which were measured from the pterion (p.t) to the most anterior part of the second toe and were marked as FTL2

Footprint length (FL3): which were measured from the pterion (p.t) to the most anterior part of the third toe and were marked as FTL3

Footprint length (FL4): which were measured from the pterion (p.t) to the most anterior part of the fourth toe and were marked as FTL4

Footprint length (FL5): which were measured from the pterion (p.t) to the most anterior part of the firth toe and were marked as FTL5

Footprint breadth at ball (FBB): which were measured from the medial metatarsal point (MMP) to the lateral metatarsal point (MLP).

Footprint breadth at heel (FBH): which were measured from the medial calcaneal concavity (MCC) to the lateral calcaneal tubercle (LCT).

DATA ANALYSIS

The static and dynamic footprints variables measured were analyzed statistically using IBM Statistical Package for Social Science (SPSS) version 25.0. The descriptive statistics were presented as mean ± standard deviation. The comparison of static and dynamic footprint was also carried out by correlating static and dynamic footprint values with height using Pearson- movement product and the correlation between footprint ball and footprint heel was also carried out. The level of significance was set at P>0.01.

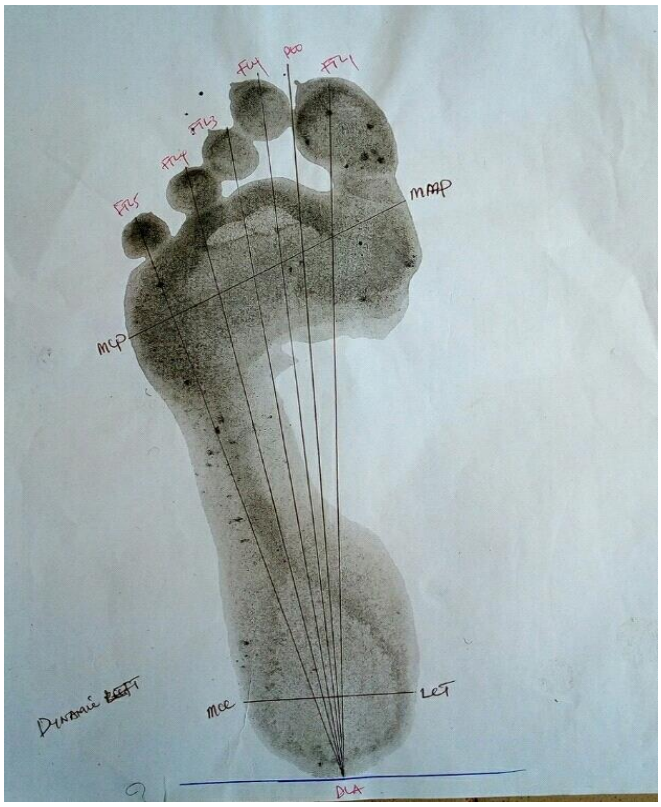

Fig 2: Image showing the various anatomical landmarks of the foot applied in the study.

RESULTS

Table 1 shows the descriptive analysis of physical characteristic of each individuals between the ages. The height measurements were expressed in centimeters and the Mean±Standard deviation of height measurement is 171.30± 6.66(cm).

Table 2 shows descriptive statics of static footprint mean ± standard deviation values which was expressed in centimeters. The left footprint length shows slightly higher values than the right footprint length values. The right footprint length values are FTL_1 (25.22±1.57), FTL_2 (24.75±1.48), FTL_3 (23.82±1.49), FTL_4 (22.67±1.38), and FTL_5 (20.98±1.33), while left footprint values are the FTL_1 (25.25±1.58), FTL_2 (24.76±1.50), FTL_3 (23.84±1.51), FTL_4 (22.59±1.44), and FTL_5 (21.07±1.38). The breadth (width) of the footprint at ball and heel is higher in right footprint than left footprint. The breadth result for right footprint values FBB (9.92±0.88) and FBH (5.80±0.62) while the breadth for left footprint values are FBB (9.91±0.84) and FBH (5.70±0.62).

Table3 shows the descriptive analysis of dynamic footprints in mean ± standard deviation and were expressed in centimeters. The left footprint length shows slightly higher values than the right footprint length values. The right footprint length values are FTL_1 (25.03± 1.43), FTL_2 (24.55±1.45), FTL_3 (23.58± 1.47), FTL_4 (22.46±1.37), and FTL_5 (20.76±1.39), while left footprint values are the FTL_1 (25.08±1.44), FTL_2 (24.59±1.48), FTL_3 (23.67±1.47), FTL_4 (22.47±1.37), and FTL_5 (20.80±1.29). The breadth (width) of the footprint at ball and heel is higher in right footprint than left footprint. The breadth result for right footprint values FBB (9.64±0.78) and FBH (5.51±0.56) while the breadth for left footprint values are FBB (9.59±0.78) and FBH (5.48±0.56).

Table 4 shows the correlation between height, static and dynamic footprint. The correlation coefficients is slightly greater in static foots than dynamic footprints and the left footprints coefficient values were slightly higher than the right footprints coefficient values. The P-value of both static and dynamic footprints was greater than 0.01 which is significant. The right foot values shows slightly lesser values than the left footprint coefficient and the result finding were, r= 0.798,0.797,0.794,0.782,0.766 and p= 0.00 for static right footprints length (FLT1-5) coefficient and r= 0.788,0.783,0.780,0.776, 0.769 and p=0.00 for dynamic right footprints length (FLT1-5), while static left footprint length (FLT1-5) values are r= 0.802,0.800,0.797,0.795,0.777 and p=0.00 (FLT1-5), r= 0.789,0.802),0.782,0.779,0.773 p= 0.00 for dynamic left footprint length. The footprint breadth at ball (FBB) and footprint breath at heel (FBH) shows r= 0.708, 0.649 and p=0.00 for static right foot and 0.676, 0.653 and P= 0.00 for dynamic right footprint while 0.702, 0.682 and p= 0.00 for static left footprint and 0.668, 0.664 and p= 0.00 for dynamic left footprint.

Table 5 shows the correlation of footprint breadth at ball (FBB) and dynamic footprint at heel (FBH) of static and dynamic footprints. The static footprint shows higher value than the dynamic foot prints and the medial border shows r=0.832 (static right), 0.802 (dynamic left) and r= 0.815 (static left), 0.801 (dynamic left) while at the lateral border r= 0.811 (static right), r=0.806 (dynamic right) and r=0.806 (static left), 0.799 (dynamic left). The p-value was 0.000 which shows that static and dynamic footprints are significant in both footprint breadth at ball and footprint at heel.

Table 1: Descriptive statistics for Physical Characteristics

Measurement (cm)	Mean±Standard deviation
Height	171.30±6.66
Age	22.84±3.23

Table 2 Descriptive Statistics for Static Footprint

Measurement (cm)	Mean ± Standard Deviation	
	Right	Left
FTL_1	25.22±1.57	25.25±1.58
FTL_2	24.75±1.48	24.76±1.50
FTL_3	23.82±1.49	23.84±1.51
FTL_4	22.67±1.38	22.59±1.44
FTL_5	20.98±1.33	21.07±1.38
FBB	9.92±0.88	9.91±0.84
FBH	5.80±0.62	5.70±0.62

Table 3 Descriptive Statistic for Dynamic Footprint (N=300)

Measurement (cm)	Mean ± Standard Deviation	
	Right	Left
FTL_1	25.03± 1.43	25.08±1.44
FTL_2	24.55±1.45	24.59±1.48
FTL_3	23.58± 1.47	23.67±1.47
FTL_4	22.46±1.37	22.47±1.37
FTL_5	20.76±1.39	20.80±1.29
FBB	9.64±0.78	9.59±0.78
FBH	5.51±0.56	5.48±0.56

Table 4 Descriptive Correlation between Height, Static Footprint and Dynamic Footprint

Measurement (cm)	Static Footprint Coefficients (r)			Dynamic Footprint Coefficients (r)		
	Right	Left	P value	Right	Left	p value
FTL_1	0.798	0.802	0.000	0.788	0.789	0.000
FTL_2	0.797	0.800	0.000	0.783	0.788	0.000
FTL_3	0.794	0.797	0.000	0.780	0.782	0.000
FTL_4	0.782	0.795	0.000	0.776	0.779	0.000
FTL_5	0.766	0.777	0.000	0.769	0.773	0.000
FBB	0.708	0.702	0.000	0.676	0.668	0.000
FBH	0.649	0.682	0.000	0.653	0.646	0.000

Table 5 Correlation between static and dynamic footprints of medial and lateral border of static and dynamic

Measurement (cm)	Right			Left		
	Dynamic	Static	p-value	Dynamic	Static	p-value
FBB	0.802	0.832	0.000	0.801	0.815	0.000
FBH	0.806	0.811	0.000	0.799	0.806	0.000

DISCUSSION

Different protocol in studying foot prints in static and dynamic forms have been established by scholars such as Krishan, (2007) and Reel *et al*., (2012) for the purpose of forensic identification (Naples and Miller, 2004; Mukha *et al*., 2020). The present study was designed using an endorsement ink in collecting static and dynamic footprints among young adult in Abakaliki metropolis. This studies further compare the static footprint values with dynamic footprints values and correlating the values thus, studies from Barker and Scheuer, (1998) used water-soluble poster paint to explain the variations of footprints and Howsam and Bridgen, (2018) used inkless shoeprint kit system in their studies.

The present studies observed slightly higher values in static footprint length than dynamic footprint length and the left foot of both static and dynamic footprints length (FTL_{1-5}) shows slightly higher values than the right foot of static and dynamic footprint with highest mean and standard deviation average was FTL_1 which is known as the toe foot. Thus, the longest of the footprint (FTL_1) was measured from the pterion to the big toe which showings 25.22cm ±1.57cm for static footprints and 25.25cm±1.58cm for dynamic footprints. Findings from Barker and Scheuer (1998) studies reported that footprint length as 25.54cm±18.4 for dynamic footprint which is greater than standing footprint length as 25.42cm±1.70 among 105 individuals. Studies from Howsam and Bridgen, (2018) suggested that, the findings of Barker and Scheuer (1998) can only come to agreement when walking footprint lengths is compare with ghosting. The present studies values is slightly smaller than values observed by Nataraja *et al*., (2015); Ukoha *et al*., (2013), Egwu, (2014).

The footprint breadth (width) of the footprints which was divided into footprint breath at ball (FBB) and footprint breath at heel (FBH), thus, the present result shows slightly greater values in static footprint than dynamic foot print. The width of the right footprint is slightly wider than the left footprint in both static and dynamic measurements. However, report findings by Ukoha *et al*., (2013) reported similar findings among male right and left footprints measurement with the present studies but slightly greater values than the present result. Result findings by Howsam

and Bridgen, (2018), observed that the static footprint breadth (width) is slightly wider than dynamic foot imprints which is similar to the present findings.

Finally, the correlation between static and dynamic footprints length shows slightly greater values in Left footprint correlation coefficients (r) than the right footprint and slightly greater values were observed at the right footprint breadth than the left footprint breadth as shown in table 4. The correlation between footprint breadth at ball and footprint breadth at heel also shows greater values on right footprint than the left as shown in table 5. Thus, the p values of the present studies was lesser than 0.01 and were significant as shown in table 4&5.

CONCLUSION

The present studies was carried out in Abakaliki metropolis which is the capital of Ebonyi sate, southern part of Nigeria and comprises of different socio-cultural groups. The Izzi's are the original inhabitants of Abakaliki. The studies observed that the static foot print values is slightly greater than dynamic footprint, however, the length of left footprint of both static and dynamic footprints is slightly longer than the right footprints and the breadth of the right footprint (static and dynamic) is wider than the Left footprint and result were significant. The present studies will contribute to knowledge of footprint, important in referencing purpose, and ergonomics for shoe designing.

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