A Study of Footprints in Athletes and Non-Athletic People

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Footprint analysis is a simple, cost-effective and readily available method for evaluation of flat feet, to identify a person in forensic content and for shoe manufacturing.

Objective: To examine the footprints in athletes and non-athletes and to compare their footprint measurements.

Material and Method: Four hundred and ninety-two athletes and four hundred and thirty-one non-athletes were recruited. Their age range was eighteen to thirty-five years. The athletes were classified by sport level: national and non-national athletes. Footprint devices, foot impression system, produced by Berkemann Company was used. The right and left foot of each subject were measured separately in a standing position. Descriptive Statistics, ANOVA, chi-square test and simple correlation were used in this study.

Result: The length between the heel to the first toe was shorter than that of to the second toe in national athletes. This finding was opposite to the non-athletes. The metatarsal distance in national athletes were significantly wider than the others. The ratio of the length of footprint and body height showed significant difference between athletes and non-athletes. The Flat Index of national athletes was longer than the others. In males, the percentage of the state of contacting the ground of the fifth toe was significantly higher among athletes than non-athletes.

Conclusion: The footprint parameters were somewhat different between persons who had experience in sport level and general non-athletic people.

Keyword: Footprint analysis

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study was performed in order to obtain footprint information in athletes and to compare footprint measurements with general, non-athletic subjects. It was hypothesized that geometric indices such as Flat Index, the length of the footprint and state of contact with the ground of the fifth toe derived from the athletes would differ from those general non-athletic subjects.

**Objective**

To examine the footprint parameters in Thai athletes and general non-athletic people and to compare these variables.

**Material and Method**

This study was conducted by the Division of Physical Education, Ministry of Education and Department of Orthopaedic Surgery, Siriraj Hospital. Both feet of 492 athletes; 314 males and 178 females and 431 in the non-athlete group; 168 males and 263 females, ranging in age from 18 to 35 years old were studied. In athletes, the subjects were classified as national and non-national athletes. The interview was performed to obtain the demographic data and sport level. Each subject was weighed and his or her stature measured.

The footprint was made using the footprint equipment produced by Berkeman Company. The footprint provided the size dimensions of the foot’s plantar surface that actually touched the hard surface, which produced a two-dimensional footprint impression. Before footprint analysis was performed, the objectives and procedures were explained. The procedure resulted in a standing footprint being obtained from the right and the left foot of each subject. The data collection took place at several sport fields in the Bangkok metropolitan area.

After the subjects removed shoes and socks, the plantar surface of each bare foot was cleaned. The subject stepped onto the footprint equipment, leaving a clear impression of the foot’s plantar surface on the paper. When the printing was completed, the subject lifted the foot from the equipment and the procedure was repeated with the other foot. The lengths, widths of footprints were taken using a transparent ruler. The unit of measurement was in centimeters. The footprint and its measurements are demonstrated in the figure (Fig. 1).

In taking foot-length measurements, the point of reference at different parts of the footprint were assigned including the point number 1 to 11 and G reference. The definition of the length or distance was determined as follows (12);

- distance between point No. 1 and No. 2 was the length measured from the first toe to the heel (A),
- distance between point No. 2 and No. 3 was the length measured from the second toe to the heel (B),
- distance between point No. 4 and No. 5 was the metatarsal distance (D),
- distance between point No. 4 and No. 6 was the length of the base of the longitudinal arch contour (C),
- distance between point No. 6 and No. 7 was the widest part of the heel (F),
- distance between point No. 8 and No. 9 was the width of the footprint that did not touch the ground or longitudinal arch contour (E),
- distance between No. 10 and No. 11 was the narrowest part of the footprint, point G was the markpoint that the little toe touched the ground; darkened print G means the little toe contact the ground. The Flat Index was calculated from dividing C by E (FI = C ÷ E).

**Statistical analysis**

Mean and standard deviations were obtained for all continuous measures. The relationship between right and left foot measurements, the distance E and body weight were determined by Pearson correlation coefficient. The mean difference between athletes and non-athletes was calculated by using one-way ANOVA. Scheffe’s method was used when the mean difference show statistical significance. The difference of frequency that the little toe contacted the ground...
was assessed by using Chi-square test. Significant level was at 0.05.

**Results**

Of the 923 subjects classified by sport level, 431 cases (46.7%) were non-athletes, 142 cases (15.4%) and 350 cases (37.9%) were national, non-national athletes respectively. The average age of the subject was 23.97 years and the age range was 18 to 35 years old. The demographic data are shown in Table 1.

The static footprint was recorded for each foot during the half body weight-bearing position. The length and width of the footprint were measured. To determine whether the separate foot should be investigated at a time, the linear relationships between the right and left footprint measurements were examined. Table 2 shows that there was significant relationships. Thus, the data for the right and left foot were pooled for further analysis and interpretation.

To investigate the difference for footprint measurements considered by sex; for male subjects, the length of the footprint (distance A) for non-athletes, national athletes and non-national athletes were 23.99 cm, 24.65 cm, and 24.11 cm respectively. There was statistical significance between the non-athlete group and national athletes (p-value < 0.001). Similarly, the metatarsal distance (distance D) in athletic subjects was higher correlated than those of non-athletes. It was found that there has no statistical significance differences for the height of the longitudinal arch (distance E) (p-value = 0.417). The Flat Index which is the ratio of the length to the height of the longitudinal arch (CE); male subjects in the non-athletic group, national and non-national athletes was 3.99, 4.34, and 3.97 respectively. There was no statistical significance differences among three groups. Similar results were observed among female subjects. The mean value, standard deviation, F-ratio and p-value of these distances are listed in Table 3.

Differences of footprint measurements among groups were investigated separately between male and female subjects. Similar results were observed in both sexes. The length of the footprint (distance D), and body height and length of footprint ratio were significantly different between non-athletic subjects and both national and non-national athletes are shown in Table 3. The value of each measurement was greater among athletes than the non-athletic subjects. On the other hand, the height of the longitudinal arch contour (distance E) and Flat Index (ratio of length and height of longitudinal arch contour) were not significantly different between the groups.

When comparing the length between the heel to the first toe (A) and the heel to the second toe (B) in each group, it showed that distance A was shorter than that of distance B in national athletes (distance A = 24.13 cm. distance B = 24.22 cm. p-value

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<tr>
<th>Table 1. Demographic data of the subjects classified by sport level</th>
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<td><strong>Non-athletes (n = 431)</strong></td>
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<td><strong>Sex</strong></td>
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<td><strong>Age (years)</strong></td>
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<td><strong>Weight (kg)</strong></td>
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<td><strong>Height (cm)</strong></td>
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<th>Table 2. Relationship between right and left footprint measurements</th>
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<td><strong>Distance</strong></td>
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<td>Height: length ratio</td>
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The finding was opposite to those non-national athletes and the non-athletic group. The relationship between body height and A, and body weight and E in each group among each sex was shown in Table 4. There were highly significant correlation between body height and A were observed in each group between each sex. However, only body weight and E of both male and female in non-national athletic group shows statistacally significant correlated.

Table 5 shows the state of contacting the ground of the fifth toe of each group. Study results showed statistically significant different only among three groups of male.

Discussion
This investigation was undertaken to determine the difference of the footprint measurements, obtained from athletes classified into national and non-national groups. compared with the non-athletic group. The study revealed that the athletes have a longer footprint length and wider metatarsal distance than those of the non-athletic group. Therefore, the foot in athletes might be bigger in foot size. The common sharing of the load between the feet would be well disposed since the wide of the support base. However, the size and shape of the foot have some hereditary basis and environmental influences such as wearing of particular types of footwear that may deform the foot.

The relationship between body height and footprint length (A) ratio was about 7:1 in athletes and slightly larger than non-athletes. This finding might be due to the nature and regularity of exercise in athletes leading them to be taller than non-athletes.
Regarding the state of contacting the ground of the fifth toe, it was formed to be of a higher percentage in athletes. It suggests that the intrinsic muscles of the foot namely the flexor digitorum brevis, the flexor hallucis brevis are basically active in this group. The intrinsic muscle function would help to stabilize the arch along with the plantar aponeurosis and help in maintaining the toes flat on the ground until lift-off has occurred(13).

Conclusion

This investigation was performed to study the difference of footprint parameters between normal population and athletes. It was found that the footprint parameter such as footprint length, intermetatarsal distances and Flat Index were somewhat different between subjects who had experience in sports and those who did not.

References

การศึกษารอยพิมพ์ฝ่าเท้าในนักกีฬาและบุคคลที่ไม่ใช่นักกีฬา

ธีรวัฒน์ กุลทนันทน์, สิทธิ์ เตชะกัมพุช, นที ดอนโพธิ์งาม

การวิเคราะห์รอยพิมพ์ฝ่าเท้าเป็นวิธีการที่ทำได้ง่าย และประหยัด ใช้สำหรับประเมินภาวะเท้าแบบ ระบุตัวบุคคลในทางมิติ เวลา เริ่มต้นในการออกแบบรองเท้าในอุตสาหกรรมผลิตรองเท้าวัตถุประสงค์: เพื่อศึกษารอยพิมพ์ฝ่าเท้าในนักกีฬาและบุคคลที่ไม่ใช่นักกีฬา และทำการเปรียบเทียบเค้าที่วัดได้วัดและวิธีการ: ตัวอย่างที่นำมาศึกษา เป็นนักกีฬา 492 คน และบุคคลที่ไม่ใช่นักกีฬา 431 คน มีอายุระหว่าง 18 ถึง 35 ปี เกณฑ์การวัดเริ่มต้นก่อนพื้นที่ แบ่งออกเป็น นักกีฬาทีมชาติไทยที่มีนักกีฬาที่ไม่ใช่ทีมชาติ โดยใช้เครื่องวัดรอยพิมพ์ฝ่าเท้าในแบบ Foot impression system ของบริษัท Berkemann รอยพิมพ์ฝ่าเท้า วัดทั้งเท้าขวาและซ้ายในท่ายืน สถิติที่ใช้ได้แก่ สถิติพรรณนา การวิเคราะห์ความแปรปรวน การทดสอบไคสัมพันธ์ และสหสัมพันธ์ อย่างง่ายผลการศึกษา: กลุ่มตัวอย่างที่เป็นนักกีฬา ความยาวของส้นเท้า ถึงนิ้วหัวแม่เท้าสั้นกว่าความยาวจากส้นเท้าถึงนิ้วซึ่งพบว่าตรงกันข้ามกับบุคคลที่ไม่ใช่นักกีฬา ระยะ metatarsal distance ในนักกีฬากว้างกว่าบุคคลที่ไม่ใช่นักกีฬา ข้อมูลต่างระหว่างความสูงของรองเท้ามีความแตกต่างกันระหว่างนักกีฬาที่มีนักกีฬาที่ไม่ใช่นักกีฬา แบ่งออกเป็นนักกีฬา สภาวะพื้นที่มีความสูง ความสูงรวมของนิ้วเท้า พบว่ามีความสูงนิ้วเท้า การสัมผัสพื้นที่มีการสัมผัสพื้นมากกว่าบุคคลที่ไม่ใช่นักกีฬาสรุป: รอยพิมพ์ฝ่าเท้าในนักกีฬามีความแตกต่างในความยาวเท้ามีติดต่อมาก ซึ่งบุคคลที่ไม่ใช่นักกีฬาอย่างนี้สังเกตุทางสถิติ