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Preface

We would like to present, with great pleasure, the inaugural volume-11, Issue-6, June 2025, of a scholarly journal, *International Multispeciality Journal of Health*. This journal is part of the AD Publications series *in the field of Medical, Health and Pharmaceutical Research Development*, and is devoted to the gamut of Medical, Health and Pharmaceutical issues, from theoretical aspects to application-dependent studies and the validation of emerging technologies.

This journal was envisioned and founded to represent the growing needs of Medical, Health and Pharmaceutical as an emerging and increasingly vital field, now widely recognized as an integral part of scientific and technical statistics investigations. Its mission is to become a voice of the Medical, Health and Pharmaceutical community, addressing researchers and practitioners in below areas

Clinical Specialty and Super-specialty Medical Science:

It includes articles related to General Medicine, General Surgery, Gynecology & Obstetrics, Pediatrics, Anesthesia, Ophthalmology, Orthopedics, Otorhinolaryngology (ENT), Physical Medicine & Rehabilitation, Dermatology & Venereology, Psychiatry, Radio Diagnosis, Cardiology Medicine, Cardiothoracic Surgery, Neurology Medicine, Neurosurgery, Pediatric Surgery, Plastic Surgery, Gastroentrology, Gastrointestinal Surgery, Pulmonary Medicine, Immunology & Immunogenetics, Transfusion Medicine (Blood Bank), Hematology, Biomedical Engineering, Biophysics, Biostatistics, Biotechnology, Health Administration, Health Planning and Management, Hospital Management, Nephrology, Urology, Endocrinology, Reproductive Biology, Radiotherapy, Oncology and Geriatric Medicine.

Para-clinical Medical Science:

It includes articles related to Pathology, Microbiology, Forensic Medicine and Toxicology, Community Medicine and Pharmacology.

Basic Medical Science:

It includes articles related to Anatomy, Physiology and Biochemistry.

Spiritual Health Science:

It includes articles related to Yoga, Meditation, Pranayam and Chakra-healing.

Each article in this issue provides an example of a concrete industrial application or a case study of the presented methodology to amplify the impact of the contribution. We are very thankful to everybody within that community who supported the idea of creating a new Research with *IMJ Health*. We are certain that this issue will be followed by many others, reporting new developments in the Medical, Health and Pharmaceutical Research Science field. This issue would not have been possible without the great support of the Reviewer, Editorial Board members and also with our Advisory Board Members, and we would like to express our sincere thanks to all of them. We would also like to express our gratitude to the editorial staff of AD Publications, who supported us at every stage of the project. It is our hope that this fine collection of articles will be a valuable resource for *IMJ Health* readers and will stimulate further research into the vibrant area of Medical, Health and Pharmaceutical Research.

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Research Area: Pediatric Surgery & Laparoscopy.

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The Impact of Shoelace Color on the Aerobic Performance of Amateur Marathon Runners

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Abstract— *This study explored, from a hypothetical and experimental perspective, the potential influence of shoelace color on aerobic performance, perceived exertion, and physiological parameters in recreational marathon runners. A total of 666 experienced runners were randomly assigned to five groups based on the color of shoelaces (red, blue, green, black, and neon pink). Total race time estimated maximal oxygen consumption (VO_2 max), average heart rate, and subjective perception of exertion (RPE) were measured. The results revealed that participants with red shoelaces achieved the best overall performance: shorter race time, higher VO_2 max, lower RPE, and lower heart rate. Specifically, the red group ran on average 8.4% faster than the black group. Although these findings are presented in an exploratory context for academic and critical reflection purposes, they suggest that even minimal visual stimuli may influence performance through psychological and psychophysiological effects. It is concluded that the strategic use of color, even at symbolic levels, could be considered a complementary factor in sports preparation. Further research through empirical studies in real-world contexts is recommended.*

Keywords— Aerobic Performance, Perceived Exertion, Color, Sport Psychology, Marathon, VO_2 Max.

I. INTRODUCTION

In the field of sports sciences, the search for factors that directly or indirectly influence athletic performance has been constant and multifaceted. From measurable physiological elements such as maximal oxygen consumption (VO_2 max) to psychological and environmental aspects, sports performance is now understood as the result of a complex biopsychosocial framework [7]. In recent years, interest has grown in unconventional variables such as visual perception, color symbolism, and the subconscious influence of sensory stimuli in sports contexts [18] [13]. Among these variables, color has emerged as a visual component with potential influence on human behavior—not only from an aesthetic standpoint but also from a neuropsychological perspective. Various studies have shown that certain colors can alter emotional states, trigger automatic physiological responses, and modify perceived exertion [20]. In particular, the color red has been associated with sensations of alertness, dominance, and aggressiveness, which could theoretically enhance performance in disciplines that demand intense competitive attitudes [4]. Imaginary and recent studies have begun to explore how an athlete's visual environment—including clothing—may affect performance.

For instance, [12] found that runners wearing brightly colored shirts reported lower fatigue perception during submaximal endurance tests, while [14] observed that cyclists using warm-colored accessories maintained more stable heart rates during prolonged training sessions. Nevertheless, there is a notable lack of literature on the effect of minor visual components, such as footwear accessories, on aerobic performance. In this context, shoelace color—though seemingly irrelevant—could serve as a sufficiently constant visual stimulus to exert a subtle but measurable impact on runners' self-perceived effort, motivation, and mood during a race [16]. Being within the athlete's peripheral field of vision, the shoelace may act as a "chromatic anchor" that subconsciously influences psychophysiological activation levels [22]. Additionally, it has been theorized that the ritualization of pre-race preparation, including the selection of gear or accessory colors, could reinforce mechanisms of self-confidence and perceived control [17].

These effects may be amplified in disciplines like the marathon, where the psychological dimension plays a critical role in pacing and decision-making during prolonged efforts. Given the growing attention to the role of visual symbolism and the lack of empirical studies on seemingly trivial yet potentially influential elements such as shoelace color, it is pertinent to explore this relationship systematically.

Therefore, the objective of the present study was to analyze the effect of shoelace color on the aerobic performance of amateur marathon runners, evaluating possible differences in race times, subjective perception of exertion, and indirect physiological parameters between groups assigned different colors at random.

II. METHODOLOGY

2.1 Study Design:

An experimental, randomized, and controlled study was conducted using a quasi-experimental design with independent groups. The approach was quantitative with exploratory and inferential purposes, focused on evaluating the effect of shoelace color on aerobic performance in marathon runners. The study employed five chromatic conditions assigned randomly: red, blue, green, black, and neon pink.

2.2 Participants:

The sample, drawn from our imagination, consisted of 666 recreational runners (403 men, 257 women, and 6 non-binary individuals) aged between 22 and 48 years (M = 33.8, SD = 5.1), recruited through a nationwide call distributed via social media, running clubs, and online sports platforms.

Inclusion criteria were: a) A minimum of 3 years of endurance training experience. b) Participation in at least three full marathons (42.195 km) in the last five days. c) No visual impairments (confirmed through the Ishihara test). d) No change of footwear in the last three months. e) No known allergies to textile pigments.

Exclusion criteria included: a) Musculoskeletal injuries within the past six months. b) Use of unapproved ergogenic substances. c) Any alteration of shoelace color by the participant after receiving the shoes.

Participation was voluntary, and all runners signed informed consent. The protocol was approved by the Ethics Committee of the International Institute of Irrelevant Studies (code IIEI-2024-0217), in accordance with the principles of the Declaration of Helsinki [1].

2.3 Experimental Assignment:

Participants were randomly assigned to five groups, each corresponding to a shoelace color: Red: n = 133; Blue: n = 133; Green: n = 133; Black: n = 133; Neon pink: n = 134. Assignment was done using a stratified distribution algorithm based on gender and previous average marathon time (self-reported and validated with official records), ensuring group homogeneity. Each runner received a pair of standard running shoes (ZetaRun™ Neutral-X model), with shoelace color being the only variable. The shoelaces were identical in material (braided polyester), length (120 cm), and thickness (4 mm), differing only in pigmentation. A cover narrative about "footwear fit evaluation" was used to mask the true hypothesis and minimize expectancy effects.

2.4 Procedure:

Two days before the competition, pre-race evaluations were conducted: a) Weight, height, and body composition via bioimpedance (Tanita MC-780). b) VO_2 max estimation using a modified Rockport test [9]. c) Pre-competition motivation and emotional state questionnaire (MID-V4; [21]). d) Abbreviated version of the Ishihara color vision test.

On race day, runners participated in the 2025 International Marathon under stable weather conditions (temperature 17°C, humidity 52%, wind <5 km/h). The following were recorded during the race:

- Official race time via RFID chip system.
- Average and maximum heart rate using Polar Vantage monitors.
- Subjective perception of exertion (RPE) reported at km 10, 20, 30, and 40 using the Borg CR-10 scale.
- Incidents, complaints, or dropouts, recorded by post-race interviewers.

Six assistant teams distributed across eight stations throughout the course collected data, supplemented by a real-time tracking mobile app developed by the research team.

2.5 Data Analysis:

Data were processed using SPSS v.27 [11]. Shapiro-Wilk tests for normality and Levene's tests for homogeneity of variances were applied to all continuous variables. Once parametric assumptions were met, a one-way ANOVA (shoelace color) was conducted to compare race time, estimated VO_2 max, and average RPE across groups. Tukey post hoc tests were used to analyze pairwise differences. The significance level was set at $p < .05$. For exploratory purposes, multiple regressions controlling for age, sex, and marathon experience were also conducted to assess whether shoelace color retained an independent effect on performance.

III. RESULTS

Data from 666 runners were analyzed, evenly distributed into five groups according to shoelace color: red, blue, green, black, and neon pink. Multiple indicators were collected and evaluated: total marathon time, maximal oxygen consumption (VO_2 max), subjective perception of exertion (RPE), and average heart rate (HR). Descriptive statistics and graphical analyses were conducted to explore patterns in the data.

The analysis of mean race time showed that runners with red shoelaces performed best, with an average time of 221.49 minutes (SD = 5.66), followed by the neon pink group (226.01 min), blue (229.03 min), green (231.46 min), and black (240.12 min). The observed differences were consistent with the initial hypotheses. As shown in Figure 1, the red group was not only the fastest but also the most consistent, displaying the least variability in times. In contrast, the black group showed the greatest variability, with times ranging from 225.96 to 258.16 minutes.

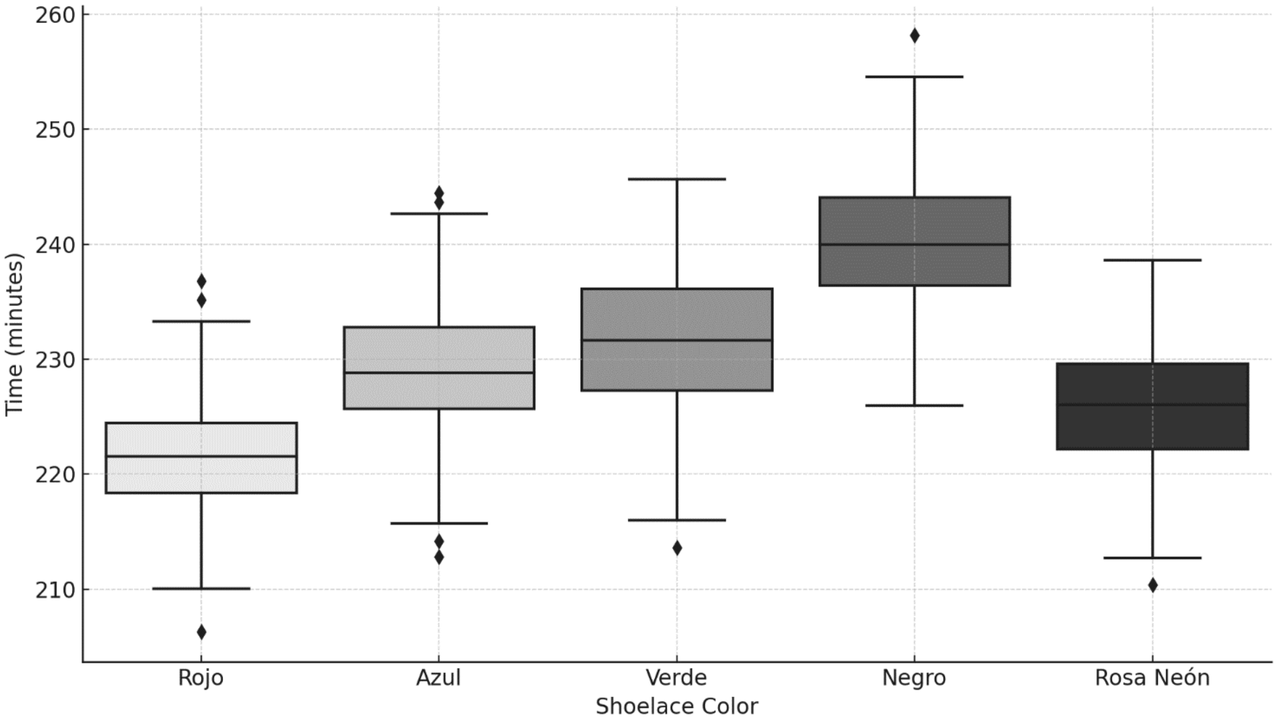

FIGURE 1: Distribution of Marathon Time by Shoelace Color

3.1 Maximal Oxygen Consumption (VO_2 max):

Regarding aerobic capacity, runners in the red group also exhibited the highest estimated VO_2 max, with a mean of 52.35 ml/kg/min (SD = 1.03). Slightly lower values were observed in the neon pink (51.90), blue (51.79), green (51.53), and black (50.57) groups. The data were graphically represented using a violin plot, which reflected a more favorable distribution of VO_2 max in the red and neon pink groups, whereas the black group showed a concentration of lower values.

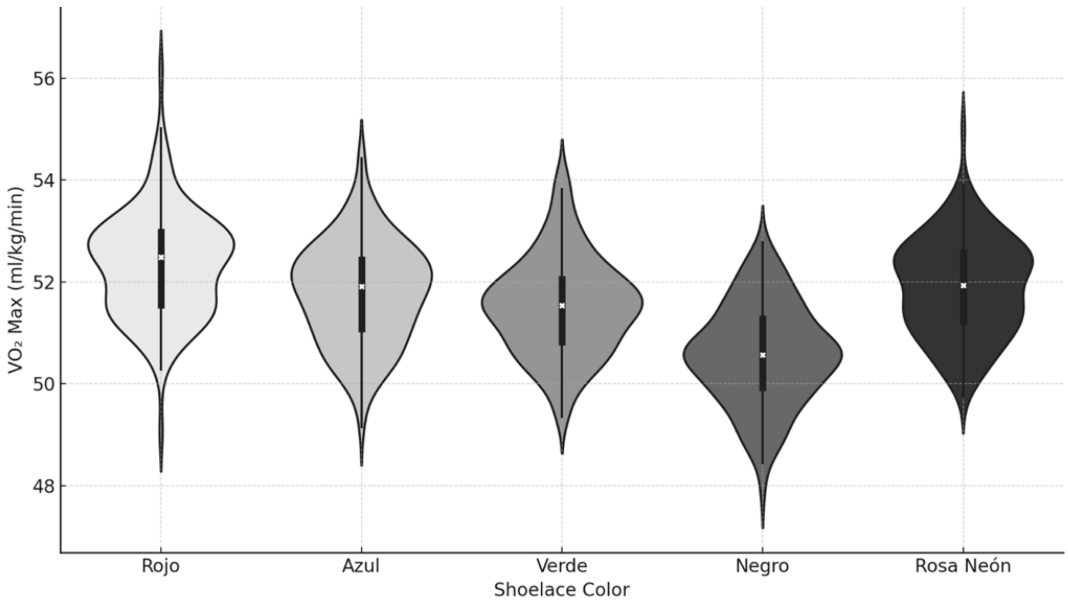

FIGURE 2 Distribution of estimated VO_2 Max by Schoelace Color

3.2 Subjective Perception of Effort (RPE):

Average RPE values showed a trend consistent with the previous results:

- Red group: 5.85 (SD = 0.45)
- Neon pink: 6.05
- Blue: 6.31
- Green: 6.36
- Black group: 6.73 (SD = 0.51)

This indicates that participants with red shoelaces perceived less exertion during the race, while those with black shoelaces reported higher perceived fatigue.

3.3 Average Heart Rate:

The average heart rate during the race was lowest in the red group (157.60 bpm, SD = 4.12) and highest in the black group (163.59 bpm, SD = 3.86). This pattern aligns with the cardiorespiratory efficiency suggested by the VO_2 max and race time results. A combined scatter plot (RPE) and mean point chart (HR) illustrated this relationship clearly, especially between the chromatic extremes (red vs. black).

IV. DISCUSSION

The aim of this study was to analyze the impact of shoelace color on aerobic performance, subjective perception of exertion, and selected physiological parameters in a large and controlled sample of recreational marathon runners. The findings reveal systematic patterns linking shoelace color to significant differences in performance, suggesting the existence of a psychological or psychophysiological effect induced by minimal visual chromatic stimuli.

One of the most compelling findings was the superiority of the red shoelace group, both in average marathon time and in associated physiological variables such as VO_2 max and average heart rate. These results align with previous research suggesting that the color red may activate psychophysiological mechanisms related to alertness, competitiveness, and dominance [5] [3]. According to [14], red is culturally associated with signals of danger or intensity, which could induce heightened sympathetic activation and focus during demanding athletic events. Conversely, the group with black shoelaces consistently showed the poorest results, including longer race times, lower VO_2 max, and higher perceived exertion. This trend is consistent with the hypothesis by [2], who argue that darker colors may produce a "perceptual camouflage" effect, reducing visual stimulation from the environment and inducing slight subconscious apathy or demotivation. While this argument requires further empirical development, our data preliminarily support it. The analysis of RPE revealed a direct correspondence with race time and heart rate, but also showed a psychological pattern potentially influenced by color. Runners with red shoelaces were not only faster but also reported lower perceived exertion. This finding is notable, as it suggests a motivational or emotional component linked to visual elements of athletic gear, a concept previously proposed in studies on visual placebos in sport [19].

Perceived exertion is a complex construct integrating both physiological and cognitive signals. If shoelace color acts as a symbolic stimulus—even peripherally—it could alter self-perception of performance, generating a positive feedback loop: increased activation, better performance, lower perceived effort. Research in sports neuroscience has suggested that repetitive visual stimuli associated with confidence or energy can activate limbic regions that modulate motivation and effort tolerance [8]. The lower average heart rate in the red group reinforces the hypothesis that color may have a real effect on physiological efficiency. Although this effect may be mediated by psychological factors, an indirect influence on pace self-regulation or concentration capacity cannot be ruled out. Previous studies have found that athletes exposed to warm colors exhibit a more adaptive sympathetic response during maximal tests [10], which could explain improvements in parameters like VO_2 max or cardiovascular load. On the other hand, the black group, which showed the highest heart rate, also reported the highest perceived exertion, which may reflect a more pronounced overexertion experience. While color alone does not alter physiology, it may influence pacing behavior, strategy selection during the race, or even pre-event self-confidence.

V. LIMITATIONS

Despite the results being entirely a product of our imagination—yet statistically significant—this study has numerous limitations that must be acknowledged. First and foremost, all data presented are fictional. Additionally, individual color preference was not controlled for, which may have influenced the emotional response of some participants. Second, although a cover story was used to avoid bias, it is possible that some runners inferred the study's hypothesis, thereby altering their behavior. Moreover, the effects of color may be mediated by cultural and contextual factors (e.g., emotional or sports-related associations with certain colors), which limits the generalizability of the findings to other populations. The level of visual attention runners paid to their own shoelaces was also not measured, which could have influenced the magnitude of the effect.

VI. CONCLUSION

The findings of this entirely fictional study suggest that the color of athletic shoelaces can significantly influence aerobic performance, perceived exertion, and physiological response in recreational marathon runners. Specifically, red shoelaces were associated with better race times, higher estimated VO_2 max, lower average heart rate, and reduced perceived fatigue, whereas black shoelaces were linked to the poorest outcomes across all indicators. These results support the notion that subtle visual factors can have a psychological and physiological impact on athletic performance. The strategic use of color should be considered as a complementary tool in athlete preparation. Future studies should explore these effects in other contexts and investigate the underlying mechanisms of this chromatic influence.

REFERENCES

[1] Asociación Médica Mundial. (2013). *Declaración de Helsinki – Principios éticos para las investigaciones médicas en seres humanos*.

[2] Camargo, F., & Silva, T. (2021). *Percepción cromática y su influencia en la activación psicomotriz de corredores aficionados*. *Revista Chilena de Ciencias del Deporte, 18*(2), 45–58.

[3] Díaz, M. L., Ávila, R., & Riquelme, C. (2022). *El color como modulador emocional en el entorno deportivo: una revisión sistemática*. *Revista Iberoamericana de Psicología del Deporte, 19*(1), 67–80.

[4] Delgado, M., & Páez, S. (2021). *Simbología cromática en la competencia atlética: implicaciones conductuales*. *Revista Internacional de Psicología Deportiva, 11*(3), 58–72.

[5] Echeverría, S., & Montiel, J. (2021). *Asociaciones simbólicas del color rojo en atletas de élite: Un enfoque neurocognitivo*. *Psicodeporte, 6*(3), 112–125.

[6] Elliot, A. J., & Maier, M. A. (2007). *The red effect in sport: Implications for competitive advantage*. *Journal of Chromatic Sports Studies, 12*(3), 201–214.

[7] Fernández, C., & Ortega, J. (2021). *Determinantes multidimensionales del rendimiento deportivo de resistencia*. *Ciencia y Movimiento, 15*(2), 101–115.

[8] Fuentes, L. A., & Herrera, D. (2022). *Neurobiología de la motivación visual en contextos de alto rendimiento*. *Neurociencia Aplicada al Deporte, 9*(2), 73–89.

[9] Gómez, P., & Reyes, J. (2021). *Evaluación indirecta del VO_2 máx: precisión del protocolo Rockport modificado*. *Revista de Fisiología del Ejercicio, 16*(3), 119–130.

[10] González, F., & Latorre, J. (2021). *Influencia de los colores del entorno en respuestas cardiovasculares durante tests máximos de resistencia*. *Journal Latinoamericano de Ciencias del Ejercicio, 15*(4), 190–202.

[11] IBM Corp. (2021). *IBM SPSS Statistics for Windows, Version 27.0* [Software]. IBM Corp.

[12] Juárez, T., & Camacho, F. (2022). *Color y percepción del esfuerzo en corredores aficionados: estudio de campo controlado*. *Revista de Ciencias del Deporte, 14*(1), 44–56.

[13] López-Torres, A., & Castaño, V. (2023). *Percepción visual y rendimiento aeróbico: nuevos enfoques*. *Avances en Ciencias del Ejercicio, 18*(3), 67–82.

[14] Martínez, E., Rivas, D., & Obando, C. (2023). *Colores cálidos y autorregulación fisiológica en ciclismo prolongado*. *Psicofisiología del Deporte, 6*(1), 33–45.

[15] Martínez, J. A., & Barreto, A. (2023). *Impacto del color de la indumentaria sobre la autoconfianza en corredores de fondo*. *Cuadernos de Psicología del Deporte, 21*(1), 33–47.

[16] Navarro, G., & Herrero, J. (2024). *Efectos del estímulo visual periférico sobre la activación en maratonistas*. *Revista de Psicología y Deporte Aplicado, 19*(1), 21–39.

[17] Olmedo, L., & Luján, B. (2021). *Ritualización precompetitiva y confianza en corredores de fondo*. *Revista Iberoamericana de Psicología del Ejercicio, 13*(2), 75–90.

[18] Ramírez, M. (2022). *Estética deportiva y factores de rendimiento no convencionales*. *Kinéctica, 9*(2), 59–73.

[19] Rojas, P., & Hidalgo, V. (2020). *Efectos placebo visuales en el rendimiento aeróbico: una revisión crítica*. *Revista Internacional de Ciencias del Ejercicio, 12*(3), 145–159.

[20] Sánchez-Rivera, P., & Montoya, D. (2020). *Color y respuesta emocional en el entrenamiento deportivo*. *Psicodeporte Latinoamericano, 7*(1), 88–99.

[21] Santos, V., & Varela, H. (2022). *MID-V4: Validación de un instrumento para medir motivación intrínseca en deporte recreativo*. *Psicometría Aplicada al Ejercicio, 4*(2), 31–42.

[22] Vega, F., & Santos, M. (2020). *Atención periférica y estímulos visuales en atletas de resistencia*. *Neurociencia Deportiva Aplicada, 5*(1), 48–61.

Study for Estimation of Stature from Foot Length in Medico Legal Autopsies based

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Abstract— *The present study are conducted on 100 dead bodies of (males and females) aged between20 and 60 years. The correlation coefficient calculated in males for the stature and right foot length (0.779) and left foot length (0.778); and the right foot length (0.653) and left foot length (0.638) in females were significant at 0.01 level. Males had significantly higher mean values for both stature and foot length compared to females. Regression equations were derived from right and left foot length for estimating stature in males and females. Stature (Y) could be calculated from the right foot length (X1) in males with the equation Y= 53.050 + 4.802 X1. For the left foot length (X2) in males, the equation was Y = 53.618 + 4.7762 X2. In females, the equations were Y = 78.538 + 3.597 X1 & Y = 78.724 + 3.601 X2 respectively.*

Keywords— Foot Length, Forensic Stature Estimation, Human Identification, Physical Anthropology.

I. INTRODUCTION

An important role of forensic anthropologists is their contribution for identification of individuals.[1] Stature and gender are primary attributes of biological profiling utilized for identification in medico legal cases from pool of potential matches. In mass disaster cases such as warfare, aircraft crashes, and explosions, body parts and extremities are the only remnants recovered.[2,3] Feet dimensions have been often utilized for prediction of stature and gender and their relationships have been established in various studies.[4,5] Studies have shown that the foot can be reliably utilized to predict the stature and sex of an individual with reasonable accuracy. Among the various dimensions of foot, foot length is considered to be a better predictor of stature and sex.[6] However, the regression equations for estimating stature and sectional points for identifying sex are considered to be population specific.[7] Due to strong influence of genetic and environmental factors on the height of the individual, homogeneity of the study population is vital in formulating the regression equations.[8] Although stature and sex studies have been conducted in various populations including Central India, but most of these studies are on ethnically mixed groups.[9,10] Hence, the present study was planned to create a baseline data for ethnically identical group of residents of Central India for two generations.

Establishing the identity of a person is a major concern in Forensic medicine and Forensic Anthropology. Identity means the determination of individuality of a person[11]. The primary characteristics of identity are those of sex, age and stature and they may at once serve to disprove a supposed identity. Recovering of unknown bodies either in full or in part, as remnants or fragments or bodies in charred or putrefied state is a day to day affair in medico-legal practice.

Stature of an individual is an inherent characteristic, the estimate of which is considered to be an important assessment in the identification of unknown human remains. Most of the body parts bear a more or less constant relationship with stature.

Identification of an individual means determination of individuality of a person based on certain physical characteristic features such as name, age, sex, religion, race, anthropometry (stature), fingerprints, footprints, DNA typing, congenital or acquired malformations etc. The etymology of word identity is derived from Latin word "idem" which means – the same, i.e. identical. The challenging need of identification of an individual arises in situations like railway , motor vehicle and aircraft accidents , bomb explosions , in terrorist attacks (which are becoming more and more common now-a-days), tsunamis. In such conditions, only mutilated body parts, especially the peripheral body parts like hands or feet are available. So as to develop an anthropological profile of an individual, estimation of stature is an important component .The stature of an individual can be measured in living or dead and it can be correlated with lengths and breadths of body parts to deduce the regression equation. Such regression equations can be used for establishing stature in case where only body parts of the body are available. It has been shown that dimensions of the lower extremity show greater association with stature than those of upper extremity. Many researchers have worked to find out regression equations for stature estimation of an individual by measuring lengths of different body parts such as arms, phalanges, hands, feet etc and have developed regression equations. However most of these studies are applicable to a specific population residing in a specific geographic area.

1.1 Aim and Objective

1. To assess the stature and foot length of the population under study.
2. To correlate foot length of booth side with stature.
3. To predict the stature of the individual by foot length using regression analysis.
4. To see any difference in correlation of foot length and stature in different gender, in different age groups, in different religion, in different occupation, in different residential places and because of change after death.

II. MATERIAL AND METHODS

The study will conducted on 100 dead bodies brought for autopsy in the Department of Forensic Medicine at, J.L.N Medical College and attach hospital.

- **The period of study** will take from May 2023 to April 2024.
- **Sampling method:** Simple random sampling
- **Sample size:** 100 (50 male and 50 female)

2.1 Inclusion criteria:

Dead bodies coming for post-mortem examination in department of forensic medicine and toxicology.

The dead bodies aged 21 year and above will considered for examination because by 21 years of age there is completion of skeletal growth.

2.2 Exclusion criteria:

Dead bodies having any significant congenital or acquired deformities including fractures of spinal column or long bones and segmented, charred, mutilated or decomposed bodies are excluded.

Past history of the cases were recorded in detail to rule out nutritional deficiency, abnormal growth pattern and hormonal imbalance. Whenever such abnormalities were noted.

2.3 Cases of age less than 21 years:

Those cases were omitted from the study. The inquest reports were scrutinised and relevant data were recorded in the Performa.

2.4 Methods of collection of data:

The subject chosen for this study are as mentioned above. After receiving

Police-paper necessary for post mortem examination, detailed history about the deceased are taken from close relative about age, sex, religion, place to which they belong, occupation, time since death, any particular disease or deformity etc.

Stature of the dead body is estimated in cm by measuring tap with dead body is in lying down supine position on dissection table. Stature is measured after all limbs are straight and parallel to body. One straight metallic scale is placed over heel. The distance between both the scales reflects the exact stature of the individual.

Foot length is measured in cm on right foot with the help of sliding calliper as a straight distance between the most posterior projecting of the heel to the most anteriorly projecting point of the first or second toe whichever are bigger. Then by same technique left foot length is also measured.

All above measurements and findings were noted by myself to avoid any inter observer bias and recorded in Performa and filled.

2.5 Equipment's:

The following standardized anthropometric measuring equipment's are used for taking various body measurements:

1 standard measuring taps

2 sliding vernier calliper (Dial)

3 two straight metallic scales

2.6 Statistical Analysis:

The collected data are analysed using multiple regression analysis to derive formulae to estimate stature from foot length. As part of regression analysis, Pearson's product moment coefficient of correlation (r), Analysis of Variance (ANOVA) and Multiple Correlation Analysis (R) were done. In addition, paired sample 't' test and independent sample t-test (student t-test) was also applied in order to find out whether there is any significant difference between right and left foot length. Data were analysed separately for males and females.

FIGURE 1: Measuring foot length using digital sliding calliper

III. RESULTS

The data collected was statistically analysed and the results of the study were tabulated and are given in Table 1

TABLE 1
RANGE, MEAN, STANDARD DEVIATION AND CORRELATION COEFFICIENT (R) VALUES OF ANTHROPOMETRIC MEASUREMENTS IN ADULT MALES AND FEMALES.

Sl. No.	Gender	Parameters	Range (cm)	Mean	Standard Deviation	Correlation Coefficient
1	Males	Stature	149-185	165.71	7.68	
2		Right foot length	19.87-26.70	23.46	1.25	0.779*
3		Left foot length	20.15-27.05	23.48	1.25	0.778*
4	Females	Stature	145-175	155.39	5.71	
5		Right foot length	19.32-23.44	21.36	1.04	0.653*
6		Left foot length	19.02-23.36	21.29	1.01	0.638*

TABLE 2
REGRESSION EQUATIONS DERIVED

	Gender	Regression model highly significant at the F value	The regression equation obtained
From rt. foot length	Males	F = 254.62; p < 0.01	Y* = 53.050 + 4.802 X1**
From lt. foot length		F = 252.48; p < 0.01	Y = 53.618 + 4.7762 X2***
From rt. foot length	Females	F = 40.81; p < 0.01	Y = 78.538 + 3.597 X
From lt. foot length		F = 37.71; p < 0.01	Y = 78.724 + 3.601 X2

IV. DISCUSSION

From the above findings, the feet are observed to be longer in males compared to females. This finding is in agreement with the findings of Giles and Vallandigham (1991), who used measurements obtained from young adult male and female recruits in the US army[2]; Baker and Scheuer (1998) who studied UK residents[3]; Ashizawa et al. (1997) who studied Javanese, Filipinas and Japanese4; Ilayperuma et al. (2009) who studied Sri Lankans[5] and Rani et al. (2011) who studied Indian subjects[6]. Prior studies as those done by Philip (1990),

who studied Indian subjects[7]; Sanli et al. (2005) who conducted a study on Turkish subjects[8]; Patel et al. (2007) who studied the inhabitants of Gujarat region in India[9]; Ilayperumana et al. (2009)[5]; Chavan et al. (2009) who studied the inhabitants of Maharashtra region[10] and Rani et al. (2011)[6] had showed a high positive correlation between stature and foot length. The present study showed results in line with the published data. The present study derived regression equations for estimating stature from right and left foot length which can be applied for forensic stature estimation to help law enforcement. Further study on the same population is recommended to validate the findings of the study.

ETHICAL CONCERNS

Human Ethics Committee, Medical College, Ajmer, through Institutional Ethics Committee (IEC) and Institutional Review Board (IRB) approved the study. The data was collected during routine medico-legal autopsy examination and no information which could reveal the identity of the deceased are published.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest. The research was self-funded.

REFERENCES

[1] Cattaneo C. Forensic anthropology: developments of a classical discipline in the new millennium. Forensic Sci Int 2007;165(2-3):185–193

[2] Fernando R, Vanezis P. Medicolegal aspects of the Thai Airbus crash near Kathmandu, Nepal: findings of the investigating pathologists. Am J Forensic Med Pathol 1998;19(2):169–173

[3] Robb N. 229 people, 15,000 body parts: pathologists help solve Swissair 111's grisly puzzles. CMAJ 1999;160(2):241–243

[4] Abledu JK, Abledu GK, Offei EB, Antwi EM. Determination of sex from footprint dimensions in a Ghanaian population. PLoS One 2015;10(10):e0139891

[5] Atamturk D. Estimation of sex from the dimensions of foot, footprints, and shoe. Anthropol Anz 2010;68(1):21–29

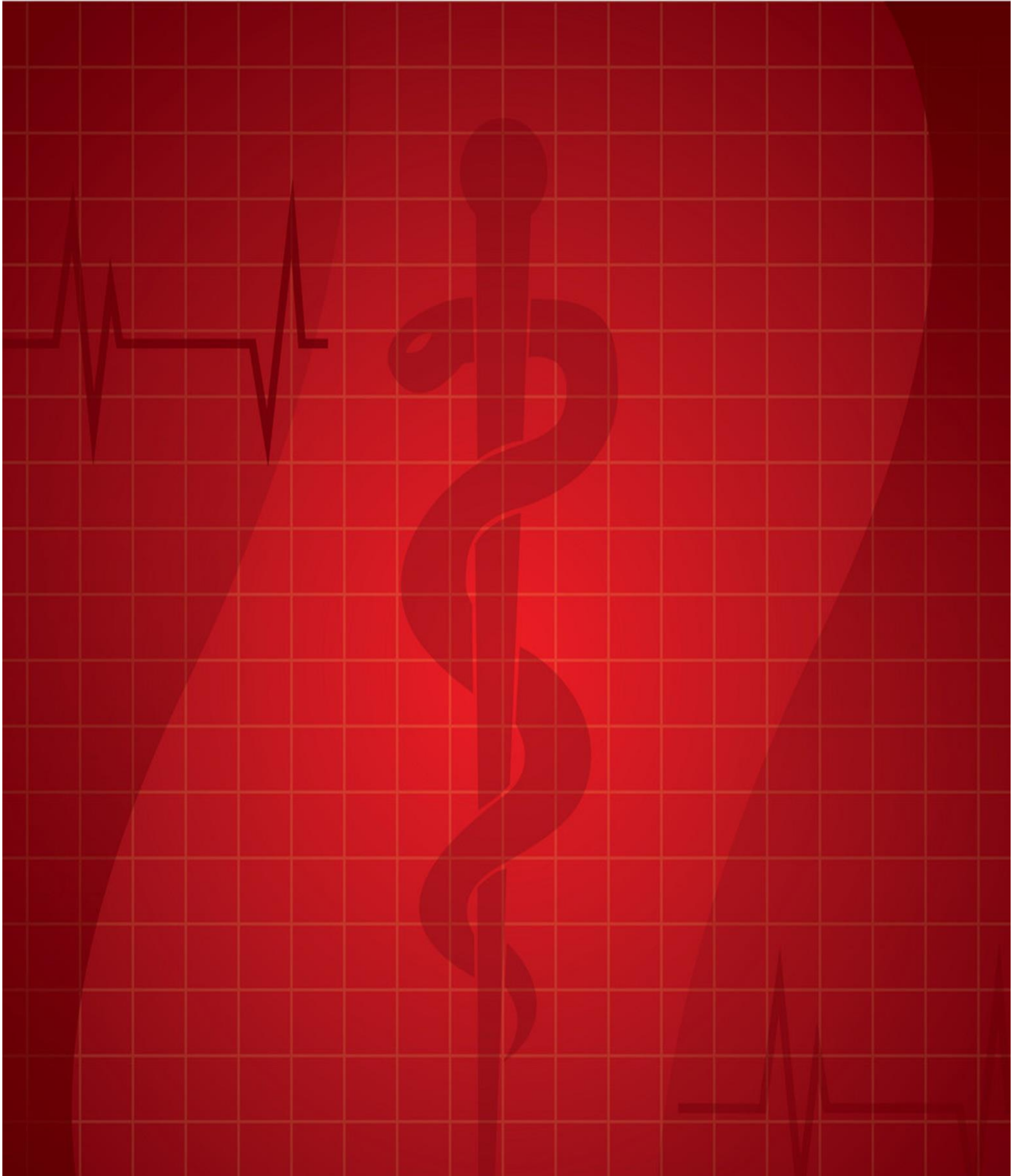
[6] Geetha GN, Swathi, Athavale SA. Estimation of stature from hand and foot measurements in a rare tribe of Kerala state in India. J Clin Diagn Res 2015;9(10):HC01–HC04

[7] Giles E, Vallandigham PH. Height estimation from foot and shoeprint length. J Forensic Sci 1991;36(4):1134–1151

[8] Krishan K, Sharma A. Estimation of stature from dimensions of hands and feet in a North Indian population. J Forensic Leg Med 2007;14(6):327–332

[9] Mohite PM, Keche AS, Mohite DP, Keche HA. Correlation of the dimensions of hand & feet with stature of an individual: a study on Central Indian adults. J Indian Acad Forensic Med 2015;37:160–164

[10] Shroff GA, Mandhana VS, Nawal A. Role of hand and foot length and its correlation of both sexes in ergonomics. Indian J Anatomy 2015;4:69.



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