Section: Forensic Medicine

Original Research Article

A PROSPECTIVE AUTOPSY STUDY ABOUT DETERMINATION OF HEIGHT FROM ANTEROPOSTERIOR FOOT LENGTH

AL. Devi Bhiansha[1], R.Karthick[2], K.B. Elavenil[3]

[1]Associate Professor, Department of Forensic Medicine, Madurai Medical College, Tamilnadu, India
[2]Associate Professor, Department of Forensic Medicine, Government Namakkal Medical College, Tamilnadu, India
[3]Assistant Professor, Department of Forensic Medicine, Government Medical College, The Nilgiris, Tamilnadu, India

Received : 09/06/2026
Received in revised form : 23/07/2026
Accepted : 05/08/2026

Keywords:
Stature estimation, Foot length, Forensic anthropology, Human identification, Regression equation, Autopsy study.

Corresponding Author:
Dr. K.B. Elavenil,
Email: elavenilkb@gmail.com

DOI: 10.47009/jamp.2026.8.4.230

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2026; 8 (4); 1373-1377

ABSTRACT

Background: Establishing identity from fragmented, decomposed, charred, or otherwise compromised human remains is a major challenge in forensic practice. Stature is a key element of biological profiling and often aids in narrowing identification. This study examined the relationship between anteroposterior foot length and stature in adult autopsy subjects and sought to derive regression equations for estimating stature. **Materials and Methods:** A prospective descriptive cross-sectional study was conducted on 300 medico-legal autopsy cases. Measurements were obtained before the development of rigor mortis. Foot length was measured from the pternion to the acropodion using a vernier caliper, and stature was recorded in the supine position using a measuring tape. Both right and left foot lengths were assessed, and regression models were generated using correlation analysis. **Result:** Males showed greater mean foot length and stature than females. A strong positive relationship was observed between foot length and stature in both sexes. The highest correlation in males was noted for left foot length ($R=0.9611$; $R^2=0.9237$), whereas in females, the right foot showed the strongest association ($R=0.9334$; $R^2=0.8713$). In the overall sample, the right and left foot lengths showed nearly identical predictive strengths ($R=0.9531$ and 0.9527, respectively). The regression models provided high accuracy for stature prediction. **Conclusion:** Foot length is a dependable indicator of stature and can be used for height estimation with considerable accuracy. Population-specific regression equations derived from foot measurements may serve as valuable tools for forensic identification when complete remains are unavailable.

INTRODUCTION

Human identification is one of the primary objectives of forensic science and is particularly important in medico-legal investigations involving decomposed, charred, mutilated, dismembered, or skeletal remains. In such situations, conventional identification methods may not be feasible, making biological profiling essential. Age, sex, ancestry, and stature are key components of this profile, with stature estimation serving as an important aid in narrowing the identity of unknown individuals and correlating remains with missing persons records.[1,2] Traditionally, stature estimation has relied on long bones, such as the femur, tibia, and humerus, because of their strong relationship with body height. However, complete long bones are not always available for forensic casework. Mass disasters, accidents, explosions, and criminal dismemberment frequently result in incomplete or fragmented human remains. This limitation has prompted researchers to investigate alternative anthropometric measurements capable of predicting stature with reasonable accuracy when conventional skeletal elements are unavailable.[3,4]

Among the various anthropometric parameters studied, foot length has emerged as a reliable predictor of stature. Compared with several other body measurements, foot length has a stronger and more consistent association with height. The foot is anatomically robust and often remains preserved even when other body parts are damaged or lost. Because of this relative durability, foot measurements have become useful in forensic anthropology and human identification.[5,6] The biological basis for using foot length in stature estimation lies in the proportional relationship between the foot dimensions and the overall body

ISSN (O): 2687-5365; ISSN (P): 2753-6556

size. Several studies conducted across different populations have reported significant positive correlations between foot length and height. studies have demonstrated a strong positive relationship between foot length and stature and have proposed regression equations for stature estimation. Previous research has also shown that the predictive performance of these equations may improve when sex-specific models are used, highlighting the value of foot length as a reliable anthropometric parameter in forensic identification and stature reconstruction.[7,8]

Other investigators have likewise shown that foot length is a better predictor of stature than foot breadth and have recommended the development of population-specific equations for forensic use.[9-11] Despite the well-established relationship between foot length and stature, considerable variation exists between populations. Anthropometric characteristics are influenced by sex, ethnicity, genetic factors, nutrition, and environmental conditions. Consequently, regression equations developed for one population may not provide accurate estimates when applied to other populations. Variations in anthropometric characteristics across regions and between sexes have been shown to influence the performance of stature estimation models, underscoring the importance of establishing population-specific standards for forensic applications.[12,13]

Although many studies have explored stature estimation based on foot length, most have been conducted on living subjects. Autopsy-based studies remain relatively limited, despite their greater forensic relevance. Measurements obtained directly from deceased individuals under controlled conditions more closely reflect real-world medico-legal scenarios. Furthermore, region-specific autopsy data are scarce in many parts of India. Therefore, generating population-specific regression models from autopsy subjects may enhance the accuracy and practical applicability of forensic stature estimation.[8,14,15]

Aim: This study aimed to determine the relationship between anteroposterior foot length and stature in adult autopsy subjects and to develop a reliable regression model for estimating stature from foot length in the study population.

MATERIALS AND METHODS

This prospective descriptive cross-sectional study was conducted on 300 deceased individuals who underwent medico-legal autopsy at the Mortuary of Government Rajaji Hospital, Madurai, between October 2022 and September 2023. Ethical approval was obtained from the Institutional Ethics Committee, and written informed consent was obtained from the closest relatives of the deceased before the study initiation.

Inclusion and Exclusion criteria

This study included deceased subjects of both sexes aged 21-40 years brought for autopsy to the Mortuary of Government Rajaji Hospital, Madurai, and belonged to the southern districts of Tamil Nadu. Deceased subjects with dysmorphic feet, endocrine disorders such as dwarfism and gigantism, skeletal anomalies involving the spine, long bones, and foot, mutilated bodies, decomposed bodies, and unclaimed bodies were excluded from the study.

Sampling Method: A total of 300 eligible deceased individuals fulfilling the inclusion criteria were selected by purposive sampling during the study period.

Materials: The materials used in the study included a vernier calliper, measuring metric tape, and a calculator.

Methods: After obtaining consent from the relatives, demographic details, including age and sex, were recorded. Age was verified using available records, such as Aadhaar card, voter identity card, driving licence, police documents, case records, and Form 86. Anthropometric measurements were obtained before rigor mortis onset. Foot length was measured as the straight distance from the most posterior point of the heel (pternion) to the most anterior point of the longest toe (acropodian). The measurement was taken to the tip of the hallux or to the second toe when the second toe was longer.

With the body placed in the supine position, a vernier calliper was aligned along the medial border of the foot, and measurements were recorded to the nearest millimetre. Both right and left foot lengths were measured using the same technique as described above. Stature was measured in the supine position using a steel tape measure. The distance from the heel to the highest point of the head was recorded using a horizontal plate placed against the scalp. All measurements were documented in centimetres to the nearest millimetre.

Statistical analysis: Data were presented as mean and standard deviation. Pearson correlation analysis was performed to assess the relationship between foot length and stature. Linear regression analysis was used to derive regression equations for estimating stature from foot length. The coefficient of determination (R^2) and standard error of residuals were calculated to evaluate the predictive performance of the regression models. Scatter plots with fitted regression lines were generated to visually assess the relationship between foot length and stature. Data analysis was performed using Microsoft Excel and Epi Info version 7.2.1.

RESULTS

Male patients showed greater foot length and stature than female patients. The mean right foot length was 23.76 ± 1.74 cm in males and 22.60 ± 1.54 cm in females, while the mean left foot length was 23.44 ± 1.72 cm and 22.31 ± 1.52 cm, respectively. The mean stature was 167.03 ± 7.58 cm for males and 162.96 ±

ISSN (O): 2687-5365; ISSN (P): 2753-6556

6.16 cm for females. In the overall group, the mean right foot length, left foot length, and stature were 23.25 ± 1.82 cm, 22.94 ± 1.79 cm, and 165.51 ± 7.36 cm [Table 1].

Table 1: Descriptive characteristics of foot length and stature among male and female patients

		Male	Female	Total
Right foot length (cm)	Mean ± SD	23.76 ± 1.74	22.60 ± 1.54	23.25 ± 1.82
	Min-Max	21.0-27.1	20.2-25.9	20.2-27.1
Left foot length (cm)	Mean ± SD	23.44 ± 1.72	22.31 ± 1.52	22.94 ± 1.79
	Min-Max	20.7-26.8	19.9-25.6	19.9-26.8
Stature (cm)	Mean ± SD	167.03 ± 7.58	162.96 ± 6.16	165.51 ± 7.36
	Min-Max	154-186	149-175	149-186

In males, the left foot showed a marginally stronger association with stature (R = 0.9611; R^2 = 0.9237) than the right foot (R = 0.9610; R^2 = 0.9236), with a slightly lower residual error (2.1064 vs. 2.109). The regression equations obtained were Y = 68.3453 + 4.2285X ± 3 for the left foot and Y = 68.2894 + 4.1733X ± 3 for the right foot. In females, the right foot showed a slightly higher correlation (R = 0.9334; R^2 = 0.8713) than the left foot (R = 0.9324; R^2 = 0.8693), along with a lower residual error (2.2246 vs. 2.2417). The corresponding regression equations were Y = 83.8977 + 3.4999X ± 3 for the right foot, and Y = 83.9379 + 3.5430X ± 3 for the left foot [Table 2, Figure 1 and 2].

Table 2: Correlation and regression analysis of foot length for stature estimation among male and female patients

			Correlation coefficient (R)	Coefficient of determination (R^2)	Standard error of residuals	Regression equation
Sex	Male	Right foot	0.961	0.9236	2.109	Y = 68.2894 + 4.1733X ± 3
		Left foot	0.9611	0.9237	2.1064	Y = 68.3453 + 4.2285X ± 3
	Female	Right foot	0.9334	0.8713	2.2246	Y = 83.8977 + 3.4999X ± 3
		Left foot	0.9324	0.8693	2.2417	Y = 83.9379 + 3.5430X ± 3

Table 3: Correlation and regression analysis of foot length for stature estimation in the overall study group

		Correlation coefficient (R)	Coefficient of determination (R^2)	Standard error of residuals	Regression equation
Foot length	Right	0.9531	0.9084	2.2346	Y = 75.7907 + 3.8591X ± 3
	Left	0.9527	0.9077	2.2431	Y = 75.6359 + 3.9173X ± 3

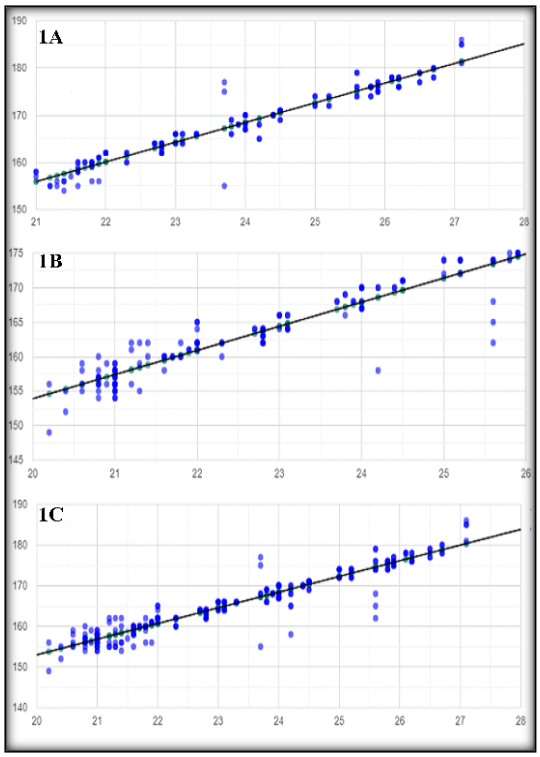

Figure 1: Correlation between right foot length and stature - 1A: Male; 1B: Female; 1C: Combined.

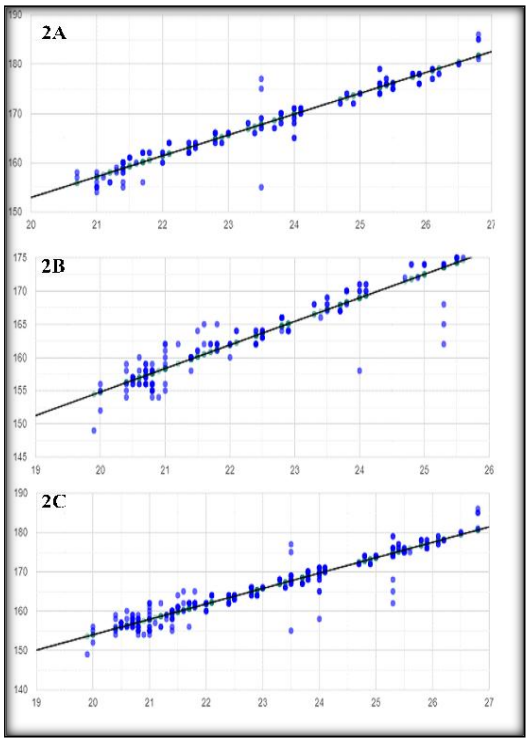

Figure 2: Correlation between left foot length and stature - 1A: Male; 1B: Female; 1C: Combined.

ISSN (O): 2687-5365; ISSN (P): 2753-6556

The right foot showed a marginally higher correlation ($R = 0.9531$; $R^2 = 0.9084$) than the left foot ($R = 0.9527$; $R^2 = 0.9077$), indicating that nearly 91% of the variation in stature could be explained by the foot length. The residual error was also slightly lower for the right foot (2.2346) than for the left foot (2.2431). The regression equations obtained were $Y = 75.7907 + 3.8591X \pm 3$ for the right foot and $Y = 75.6359 + 3.9173X \pm 3$ for the left foot [Table 3].

DISCUSSION

Estimating stature from foot dimensions remains an important component of forensic anthropology, particularly in cases involving fragmented, mutilated, or decomposed remains. Across different populations, foot length has consistently shown a positive relationship with stature, although the magnitude of the correlation varies according to demographic and regional characteristics. The findings of our study are in agreement with this overall pattern and further support the use of foot length as a reliable anthropometric parameter for stature reconstruction.

Sexual dimorphism in stature and foot dimensions has been consistently reported across populations. Kavyashree et al. observed greater stature among males (171.15 ± 6.89 cm) than females (159.10 ± 5.98 cm), with corresponding left foot lengths of 22.02 ± 3.59 cm and 20.73 ± 2.43 cm and right foot lengths of 21.98 ± 5.56 cm and 20.70 ± 2.38 cm.[16] Similar findings were reported by Rathod and Goudar where male stature ranged from 168.12 ± 6.92 cm to 170.74 ± 5.71 cm compared with 155.69 ± 5.50 cm to 156.19 ± 5.88 cm in females.[17] Mehta et al. likewise reported higher stature and foot length measurements among males (165.4 ± 8.46 cm; 25.84 ± 1.73 cm) than females (156.5 ± 6.56 cm; 23.35 ± 1.30 cm).18 Ingale et al. also demonstrated similar sex-related differences, reporting mean stature values of 171.3 ± 7.8 cm in males and 158.6 ± 6.5 cm in females, with foot lengths of 26.8 ± 1.3 cm and 24.1 ± 1.2 cm, respectively.[8] These observations are consistent with our study, where males exhibited greater foot dimensions and stature than females.

With regard to the strength of association between foot length and stature, considerable variation has been reported. Kavyashree et al. reported relatively modest correlation coefficients ranging from 0.36 to 0.44. Stronger associations were observed by Mehta et al., with correlation coefficients of 0.534 in males and 0.675 in females, and by Dhaneria et al., who reported a correlation coefficient of 0.756 between foot length and stature.[16,18,19] Rathod and Goudar documented correlations of 0.677 and 0.707 for right and left foot lengths in males and 0.592 and 0.582 in females, while pooled correlations increased to 0.811 and 0.823, respectively.[17] Sheik Shakeer Hussain reported correlation coefficients of 0.779 and 0.778 in males and 0.653 and 0.638 in females.20 Similarly, Ingale et al. demonstrated a pooled correlation coefficient of 0.83, whereas Sánchez-Ramírez reported values exceeding 0.8 in females and 0.7 in males.8,21 Compared with these studies, the present investigation demonstrated a stronger relationship between foot length and stature, supporting the reliability of foot length as a predictor of height.

Furthermore, the coefficient of determination exceeded 0.90 in both sex-specific and pooled analyses, indicating that foot length accounted for more than 90% of the variability in stature and highlighting its usefulness as a predictive anthropometric parameter.

Differences between right and left foot measurements have also been described. Rathod and Goudar found slightly higher correlations for the left foot than the right foot in both males and the pooled sample.[17] Sheik Shakeer Hussain reported only minimal differences between sides, while Magadum et al. identified right foot length as the most effective predictor of stature.[10,20] Similar side-related variations were observed in our study, although the difference between both feet was relatively small. Although both feet demonstrated comparable predictive performance, the right foot showed marginally higher correlation and lower residual error in the pooled analysis. The strongest association between foot length and stature was observed for the left foot in males, whereas the weakest was noted for the left foot in females. Nevertheless, the high correlation coefficients obtained for both feet in both sexes indicate that foot length is a reliable predictor of stature.

The utility of regression equations for stature estimation has been highlighted by several investigators. Rathod and Goudar proposed equations such as Stature = 89.297 + 3.158(RFL) and Stature = 89.163 + 3.189(LFL) in males, whereas Sheik Shakeer Hussain generated equations of $Y = 53.050 + 4.802X$ and $Y = 53.618 + 4.776X$ in males and $Y = 78.538 + 3.597X$ and $Y = 78.724 + 3.601X$ in females.[17,20] Ingale et al. further demonstrated that the standard error of estimate improved from 4.12 cm in the pooled analysis to 3.56 cm in males and 3.94 cm in females when sex-specific equations were applied.[8] These findings, together with the sex-specific regression equations generated in the present study, suggest that separate regression models may provide improved predictive accuracy for stature estimation.

Another important observation emerging from the literature is the population-specific nature of stature estimation equations. Venkatachalam et al. reported satisfactory agreement between actual and estimated stature but cautioned against applying regression equations indiscriminately to other populations.[22] Similarly, Dhaneria et al. emphasized regional anthropometric variation and the need for population-specific standards.19 Sánchez-Ramírez et al. also demonstrated that predictive performance varied according to population characteristics despite strong correlations.[21] The findings of the present study provide regression equations applicable to the studied

ISSN (O): 2687-5365; ISSN (P): 2753-6556

population and are consistent with previous reports emphasizing the importance of population-specific anthropometric standards.

CONCLUSION

Our study demonstrated a strong linear relationship between foot length and stature in both males and females. Regression equations were derived separately for each sex and for the combined sample, enabling reliable stature estimation from foot measurements. A strong correlation between foot length and stature was observed, consistent with findings from previous studies. Male participants showed slightly stronger correlations than females. Both right and left foot lengths demonstrated comparable predictive performance, with only minor side-related differences. These findings support the use of foot length as a reliable anthropometric parameter for stature reconstruction. The derived regression equations may be valuable in forensic and medico-legal investigations involving fragmented or incomplete human remains, particularly in mass disasters, explosions, and accidents. As anthropometric characteristics vary across populations due to genetic, environmental, and regional influences, population-specific studies remain important for improving the accuracy and applicability of stature estimation methods.

REFERENCES

1. Spradley MK. Metric methods for the biological profile in forensic anthropology: Sex, ancestry, and stature. Acad Forensic Pathol 2016; 6:391–9. https://doi.org/10.23907/2016.040.
2. Siddiqui T, Zioupos P, Marquez-Grant N. Stature estimation in forensic anthropology: Addressing the current status, challenges and future prospects. Forensic Sciences 2026; 6:23. https://doi.org/10.3390/forensicsci6010023.
3. Ghosh M, Kushwaha V, Sangal A, Kumar A. Estimation of stature from cranial dimensions at autopsy. J Forens Med Toxicol 2023; 40:46–8. https://doi.org/10.5958/0974-4568.2023.00011.x.
4. Anjani RCS, Alaydrus SM, Artaria MD, Yudianto A, Mahakkanukrauh P, Sinthubua A. Development of stature estimation formulas based on the metacarpal and metatarsal bone lengths of the Thai population. Aust J Forensic Sci 2026; 58:138–54. https://doi.org/10.1080/00450618.2025.2491371.
5. Bakirci S, Cay M. Height estimation by evaluating morphometric measurements of hands and fingers. Med Sci (Turkey) 2022; 11:1336. https://doi.org/10.5455/medscience.2022.08.188.
6. Karmalkar AS, Nikam VR. Prediction of stature from long bones versus hand and foot measurements: A comparative study of the Kolhapur population. Natl Med J India 2021; 34:154–7. https://doi.org/10.25259/NMJI_79_20.
7. Potdar AB, Kiran GT, Shrikanthan G, Potdar PA, Mittal A. Correlation of stature and foot length among medical students from southern parts of India. J Indian Acad Forensic Med 2016; 38:48. https://doi.org/10.5958/0974-0848.2016.00013.0.
8. Ingale S, Akarte D, Sangle D. Estimation of stature from anthropometric measurement of foot length in population above 18 years - A hospital based descriptive study. Journal of Carcinogenesis 2025. https://doi.org/10.64149/j.carcinog.24.2s.771-777.
9. Shukla N, Gupta M. The correlative study of human body stature with foot dimensions in Rajasthan population. RUHS Journal of Health Science 2024;9. https://doi.org/10.37821/ruhsjhs.9.2.2024.648.
10. Magadum A, Kotrannavar SS, Shirahatti A, Pattanshetti SV. Predictive role of foot length to estimate stature in the population of Belagavi region. Afr J Biomed Res 2024; 27:13823–7. https://doi.org/10.53555/AJBR.v27i4S.6572.
11. Harsh D, Singh DTK, Viqar DA. A prediction of height by foot length in young adults of Moradabad locality. Int J Environ Sci 2025:1213–6. https://doi.org/10.64252/5bhezj12.
12. Yadav S, Nayak VC, Palimar V, Gupta C, Chetal JR. An estimation of stature and sex using various anthropometric parameters in south Indian population. J Forens Sci Med 2023; 9:130–6. https://doi.org/10.4103/jfsm.jfsm_33_22.
13. Mishra VK, Roy D, Pandey SK. Estimation of stature from foot length in eastern Uttar Pradesh: A prospective cross-sectional study. J Punjab Acad Forensic Med Toxicol 2025; 25:42–8. https://doi.org/10.5958/0974-083x.2025.00007.6.
14. Chaudhari A, Chandegara P, Patel M, Govekar G, Patel U. Correlation between stature and arm span: A prospective regional study in South Gujarat. Int J Med Toxicol Leg Med 2020; 23:210–6. https://doi.org/10.5958/0974-4614.2020.00070.4.
15. Ajesh PP, Sreenivas SC. A post mortem study on estimation of stature from humerus in a North Kerala population. J Indian Acad Forensic Med 2021; 43:25–9. https://doi.org/10.5958/0974-0848.2021.00007.5.
16. Kavyashree AN, Bindurani MK, Asha KR, Lakshmiprabhasubhash. Study on correlation of foot length with stature. Natl J Clin Anat 2016; 5:191. https://doi.org/10.4103/2277-4025.297723.
17. Rathod P, Goudar ES. A study of estimation of stature by foot length among students and staff of al-ameen medical college, vijayapur. J Indian Acad Forensic Med 2018; 40:322. https://doi.org/10.5958/0974-0848.2018.00076.3.
18. Mehta UK, Dhakal A, Parajuli SB, Shah SK. Prediction of stature based on foot length in medical students of Birat Medical College & Teaching Hospital, Morang, Nepal. Birat J Health Sci 2019; 4:707–11. https://doi.org/10.3126/bjhs.v4i2.25441.
19. Dhaneria V, Shrivastava M, Mathur RK, Goyal S. Estimation of height from measurement of foot breadth and foot length in adult population of Rajasthan. J Anat Soc India 2016;65: S66. https://doi.org/10.1016/j.jasi.2016.08.212.
20. Sheik Shakeer Hussain S, Sheeju P.A., Balachandran A. Forensic estimation of stature from foot length: An autopsy-based study. Indian J Forensic Med Toxicol 2021; 15:3467–70. https://doi.org/10.37506/ijfmt.v15i2.14910.
21. Sánchez-Ramírez C. Body height prediction model from foot measurements in a Chilean population of university student athletes. Rev Argent Antropol Biol 2024;26. https://doi.org/10.24215/18536387e078.
22. Venkatachalam KSM, Felix AJW. Assessing agreement level between actual stature and regression estimates using foot length of adults. Int J Contemp Med Res [IJCMR] 2019;6. https://doi.org/10.21276/ijcmr.2019.6.2.26.

ISSN (O): 2687-5365; ISSN (P): 2753-6556