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ORIGINAL ARTICLE

Predictor index for anatomic leg length discrepancy as a screening tool for referral to tertiary care center of India

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ABSTRACT

OBJECTIVE: To assess the anatomical leg length discrepancy (LLD), correlation of discrepancy with body mass index (BMI), height, and weight; and to determine the predictor index in healthy Indians.

METHODS: This descriptive cross-sectional study was conducted at the Department of Anatomy, Teerthanker Mahaveer Medical College and Research Centre, Teerthanker Mahaveer University, from November 2020 to November 2021. Three hundred and forty-seven (187 males and 187 females) healthy adult Indians without any evidence of LLD were recruited. Lengths of lower extremity, height, weight of the participants were measured. LLD, basal metabolic index and predictor index were calculated. Data was analyzed through SPSS v25 software and P-value <0.05 was considered statistically significant.

RESULTS: Out of 374 subjects, 168 (44.9%) had mild LLD and 10 (2.67%) had moderate LLD in both genders. In moderate discrepancy cases, predictor index was observed to be ≥1.75. There was no statistically significant correlation between LLD and height, weight, or BMI. Measurements of leg length for the right leg were 89.13 ± 4.90 cm in males and 86.13 ± 4.28 cm in females ($p>0.05$), and for the left leg was 89.07 ± 4.94 cm in males and 86.20 ± 4.29 cm in females ($p<0.05$), respectively.

CONCLUSION: This study on 347 healthy adult Indians revealed 44.9% with mild LLD and 2.67% with moderate LLD. Moderate LLD cases had a predictor index of ≥1.75. No significant correlation was found between LLD and height, weight, or BMI. Gender-based variations existed in left leg length. Further research and early interventions are imperative for addressing moderate leg length discrepancy cases effectively.

KEYWORDS: Leg (MeSH); Leg Length Discrepancy (Non-MeSH); Predictor index (Non-MeSH); Osteoarthritis (MeSH); Height (MeSH); Weight (MeSH); Body Mass Index (MeSH); Anatomy (MeSH); Anthropometry (MeSH)

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INTRODUCTION

Nowadays, there are 1.71 billion individuals worldwide suffer from musculoskeletal disorders.[1] The WHO states that musculoskeletal problems are the most common cause of persistent pain and impairment.[2] Musculoskeletal disorders' like osteoarthritis, osteoporosis, and low-back pain is exacerbated by abnormal joint loading,[3] and Leg Length Discrepancy (LLD) is the most frequent cause of excessive and spontaneous joint loading in the lower limb.[4] LLD aggravates foot, knee, hip, and back problems.

LLD is an orthopedic condition,[4,5] that illustrate the inconsistent lengths of the lower extremities.[6] A total of 41.3% of the population exhibits an anatomic LLD between 0-4mm, 37.4% between 5-9mm, 20% between 9-20mm, 15.0% between 10-14mm, and 6.4% more than 14mm.[7] Previous researches were conducted on LLD, but most of the studies were done on post-operative patients such as hip arthroplasty,[8] Osteoarthritis and those who were scheduled for surgeries of lower limbs. Very few studies were done on healthy individuals to measure the discrepancy by anthropometric method only.

Sub-types of LLD:

(a) **Structural or Anatomical:** There are substantial changes in the osseous components of lower extremity. Discrepancy lies between the head of femur to the calcaneus bone of the lower extremity.[4]

(b) **Functional or Apparent:** In this type of discrepancy there are functional shortening occur due to the contracture of joints, pelvic rotation, biomechanics of foot, misaligned vertebral column, weakness and shortening of soft tissues.[5,9]

(c) **Environmental discrepancy:** It is mainly found in athletes who run for long duration over the sloping road in one direction.[4]

McCaw and Bates[5] have identified the categories of discrepancy on the basis of magnitude: Mild, Moderate and Severe

1. Mild (differences< 3cm)
2. Moderate (differences 3-6cm)
3. Severe (differences> 6cm)

Initially mild to moderate discrepancy doesn't cause serious complication but with the advancement of age, poor life style & incorrect posture, these discrepancies will affect the quality of life. Singh VA, et al suggested that LLD of 2cm mightn't be significant for a person who is 180cm, but may be significant for someone who is 150cm in height.[10] Predictor Index can be signified as a screening tool to identify patients with LLD who need early intervention.[10] In order to determine whether an intervention is warranted for a particular patient, the significant discrepancy must be determined based on height. So, there is a need for early diagnosis of LLD in young adult healthy subject. This study

Table I: Measurements of leg length by anthropometric method in study subjects

Cut off scores	Measurements of Leg length (Mean ± S.D)		t-value	p-value
	Male	Female		
Right Leg (cm)	89.13 ± 4.90	86.13 ± 4.28	8.82	P>0.05
Left Leg (cm)	89.07 ± 4.94	86.20 ± 4.29	4.76	P>0.05

Table II: Calculation of predictor index in moderate discrepancy cases

Gender	Mean ± S.D.		
	Height in moderate discrepancy cases	Leg Length Discrepancy	Predictor Index
Male	1.67 ± 0.02	3.075 ± 0.10	1.84 ± 0.05
Female	1.52 ± 0.05	3.33 ± 0.30	2.19 ± 0.17

Table III: Correlation of leg length discrepancy with demographic characteristics

Parameters	Mean ± S.D		Male	Female	p-value
	Male	Female	r-value	r-value	
Height (m)	1.65±0.05	1.59±0.05	0.081	0.083	p>0.05
Weight (kg)	58.36±9.3	53.13±7.0	-0.034	-0.09	p>0.05
Body Mass Index (kg/m^2)	21.6±6.3	20.95±2.70	-0.05	-0.05	p>0.05

aimed to estimate discrepancy in apparently healthy subjects with the help of noninvasive method, to find the association among LLD and anthropometric characteristics and to evaluate the predictor index for LLD.

METHODS

This descriptive cross-sectional study was conducted at Department of Anatomy, Teerthanker Mahaveer Medical College and Research Centre (TMMC & RC), Teerthanker Mahaveer University (TMU), Moradabad, Uttar Pradesh, India from November 2020 to November 21. In this study a total of 374 (N)[11] healthy adult Indian people were taken by the help of statistical formula for the cross-sectional study ($n = Z_{\alpha/2}^2 P(100- P) / E^2$). To check the gender differences, the total population was divided into 2 groups including 187 males (50%) and 187 females (50%). The selection of subjects for the study population was based on inclusion and exclusion criteria. Inclusion criteria of the study was Indian healthy individuals between the age 18–35 years and who had given consent, while Subjects who were Professional athletes, body builders, obese & suffering from any neuromuscular disorder were excluded. Ethical clearance was obtained from Institutional Ethical Committee (Ref. no-TMU/IEC/20-21/103) at TMMC & RC. Before the procedure, informed consent form was taken from each subject. All the procedures performed during the study were in accordance with the ethical standards with the Helsinki Declaration of 1975. Inter-observer and intra-observer errors were considered during measurements.

Measurement of Leg Length Discrepancy: Leg length of all the subjects was measured in supine position with the help of measuring steel tape. Bony landmarks including anterior superior iliac spine of hip bone and medial malleolus of tibia was palpated and marked on both sides. The distance between them was measured in cm in both right and left leg. The difference in length of both legs was considered as the discrepancy.[12,13]

Measurement of Height: The height was measured using stadiometer in cm (Sknol height measuring scale). Subject was asked to stand in anatomical position with their head aligned in Frankfort plane.[14]

Measurement of Weight: The weight was measured using a high precision digital weighing scale in kilograms (Health-sense weighing machine, weight limit 180kg). Each subject was asked to stand erect at the centre of scale. The number shown in the digital weighing machine was noted as weight.[14]

Calculation of Predictor Index: We calculated the predictor index by using following formula PI=LLD/Height[10]

Calculation of BMI: Body mass index is a ratio of weight to height of the individual.[15] BMI = weight/height^2

Statistical Analysis: SPSS software version 25 was used for statistical analysis. Data was presented as Mean ± Standard Deviations. Parameters comparison between two groups was done by independent (unpaired) t-test and correlation between the parameters was observed by the Pearson's correlation test.

RESULTS

Out of 374 subjects, 168 (44.9%) had mild LLD and 10 (2.67%) had moderate LLD in both genders. In moderate discrepancy cases, predictor index was observed to be ≥1.75.

Table I shows the leg length measurements by anthropometric method and mean values was found to be statistically insignificant in both gender.

Table II showed the calculated Predictor index in moderate discrepancy cases where mean values were found to be higher in female.

Correlation between the LLD and demographic characteristics was shown in table III.

There was slight positive insignificant correlation with the height and negative correlation with the weight and BMI.

DISCUSSION

The present study was a baseline study conducted among 374 subjects of Indian population to screen the normal healthy individual for Anisomelia. Medical practitioners thought out that the discrepancy in lower extremity is a general finding, although one should not confuse resemblance with normality. Normal refers to ideal limb asymmetry, that not so much affects the maneuver of subject, but it is never the ideal alignment for function of musculoskeletal system. Data of present study allow effectual precautions for structural damage to musculoskeletal system.

Prem PG. et al.[16] carried a study on the measurement of leg length inequality by both the clinical and radiographic methods. They measured the leg length by the anthropometric method from ASIS to the medial malleolus. They found the mean of both leg lengths by

anthropometric method to be 89.1 ± 6.20 and by radiographic method it was 89.4 ± 6.5. According to their study measurement of leg length with the help of anthropometric method i.e. from ASIS to the medial malleolus is highly accurate. Similar study was conducted by Haryono IR et al.[17] in the college students found the mean of right leg length was 85.95 ± 4.31 in normal healthy individual and 84.51 ± 4.54 in those subjects who had discrepancy in their legs. The mean of left leg was 85.95 ± 4.31 in normal individual and 83.96 ± 4.60 in such subjects who had inequality in their legs. Findings of our study in female parameters coincide with that of Haryono IR et al. who took the measurement from ASIS to the medial malleolus. Singh VA. et al.[10] conducted their study on the factors that can indicate the effective insufficiency of the lower limbs. Their data suggested that if the predictor index is ≥1.75 then that discrepancy may lead to kinematic imbalance.

According to our study height had mild positive correlation with LLD but Weight and BMI shows mild negative correlation with LLD ($p>0.05$). Soukka A. et al.[18] did the study on the discrepancy in lower limb in working age people. In their study they tracked down a relationship between Leg Length discrepancy and height of the individual. They thought out that males having more height as compared to females would be relied upon to show more discrepancy in their legs however didn't. The inconsistency in this information is hard to clarify. After that they suggested that there was partial positive correlation between discrepancy and height of the subject. Another study was done by Golightly YM et al.[19] on the relationship between the discrepancy in lower limb and symptoms of hip & knee joint. In their study they found there was no statistical significant correlation in discrepancy and BMI of the subject.

In the present study we found, approximately 45% individuals had mild discrepancy and 2.67% had moderate discrepancy in both gender. Mild difference in leg length exists in approximately 50% subjects of general population but these mild discrepancies remain undiagnosed due to compensatory mechanism during locomotion. Long leg dysplasia is most commonly compensated by obliquity in the pelvis and rotation of the pelvis.[20] Leg length insufficiency and pelvic obliquity may have two-way cause-and-effect relationship. It is probable that pelvic tilt is caused by LLD, while rotation of pelvis due to abnormal tonicity of supra-pelvic muscles can also cause discrepancy in leg length.[7,21]

Some studies suggested that mild discrepancies has minor effect on human body[22] but study done by Rannisto S. et al,[23] on Low back pain and its relationship with the LLD, found ≥6mm discrepancy had an association with low back pain in those who had long standing job profiles. Although, they did not found association between low back pain and Leg length discrepancy in sedentary people. Whether mild discrepancy will be a significant causative factor for musculoskeletal disorders depends on the height of the subject.

Height is the major factor to identify the significant discrepancy in healthy subject. In moderate discrepancy cases PI was ≥1.75. We found increased values of predictor index in those subjects who had below average height. In moderate cases, 6 subjects were female and their mean height was 1.52 ± 0.05 m, which was less than average height of female. Four subjects were male; their mean height was 1.67 ± 0.02 m, which was also less than average height of male. The mean height of female and male in India is 1.62 m and 1.77 m respectively.[24] The result of our study revealed that predictor index was more in below average height subject in both gender. Based on this we can say that mild discrepancy might be significant in below average height.

LIMITATIONS OF THE STUDY

In this study, only single method is used for the measurement of leg length discrepancy. Further studies can be done by using alternative methods of measurements like radiographic and kinematic gait analysis. Different age group can be taken and compared for the leg length discrepancy.

CONCLUSION

This study on 347 healthy adult Indians revealed 44.9% with mild LLD and 2.67% having moderate LLD in both genders with a predictor index of ≥1.75. Interestingly, no significant correlation was found between LLD and height, weight, or BMI. Gender-based variations were observed in leg length measurements, particularly in the left leg. These findings contribute valuable insights into LLD prevalence and its correlates in the Indian population, emphasizing the need for further research and early intervention strategies for individuals with moderate LLD.

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AUTHOR'S CONTRIBUTION

Following authors have made substantial contributions to the manuscript as under:

Sn: Acquisition of data, drafting the manuscript, approval of the final version to be published

SB & DA: Concept and study design, critical review, approval of the final version to be published

HN & NS: Analysis and interpretation of data, drafting the manuscript, approval of the final version to be published

SKJ: Acquisition of data, critical review, approval of the final version to be published

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Authors declared no conflict of interest

DATA SHARING STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request