Assessment of carrying angle in patients with lateral epicondylitis

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ABSTRACT

Introduction: The carrying angle is defined as an angle formed in elbow joint when it is fully extended and supinated. The lateral epicondylitis is often known as tennis elbow. It is caused by an overuse injury resulting from excessive load on the extensor tendons at the origin of the extensor carpi radialis brevis (ECRB) tendon. The objective of this study was to determine the carrying angle in lateral epicondylitis patients. **Methods:** This descriptive study was carried out in the Department of Orthopedics and Physiotherapy in Kathmandu Medical College and Teaching Hospital, Sinamangal and Duwakot, between December 15, 2023 to May 16, 2024 after getting the ethical clearance from the Institutional Review Committee. A total of 56 patients with lateral epicondylitis were included. The carrying angle was measured by a manual goniometer by drawing the axes in the arm and forearm. The data was analyzed with Statistical Package for the Social Sciences version 25.0. **Results:** Lateral epicondylitis was most commonly observed in the right hand (44), out of which 24 were females and 20 males. The lateral epicondylitis was common among the age group 31 to 40 years. The carrying angle in male participants with lateral epicondylitis was mostly between 5° to 10° (20), and in females, it was mostly between 11° to 16° (24). **Conclusions:** The lateral epicondylitis was more in the right elbow than the left. The mean carrying angle in the case of the lateral epicondylitis was greater in females than the males. This knowledge will be helpful for the clinician to explain the risk factors, such as ipsilateral rotator cuff tear and nerve entrapment.

Keywords: Carrying angle, lateral epicondylitis, tennis elbow.

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INTRODUCTION

Carrying angle is defined as an angle formed between the median axis of the arm and the median axis of the forearm during full extension with supination position.[1] Whereas, the average angle is between 5° to 10° in males and 10° to 15° in females.[2]

Lateral epicondylitis is common in individuals who play table tennis, squash, badminton, or engage in any activity involving repetitive wrist extension, radial deviation, and forearm supination.[3,4] It can also be caused by repetitive extension of the wrist and hands, which leads to overloading of the extensor muscles of the forearm. Additionally, the use of vibrating heavy machinery can contribute to its development. All of these factors may lead to anatomical variations that result in lateral wear.[5]

The changes in the carrying angle may lead to elbow joint instability and pain during exercise. Reduced elbow flexion can ultimately increase the risk of dislocation or fractures.[1,6] The objective of this study was to determine the elbow carrying angle in individuals with lateral epicondylitis.

METHODS

This descriptive study was carried out in the Department of Orthopaedics and the Department of Physiotherapy in Kathmandu Medical College and Teaching Hospital, Sinamangal and Duwakot from December 15, 2023 to May 16, 2024. The non-probability convenience sampling was done for the sample selection. Sample size was calculated using the mean and standard deviation of the carrying angle of humerus among cases of lateral epicondylitis (13.8±3.7) and in the control group (15.9±3.6).[7]

The sample size was calculated using the following formula,

$n = 2(Z\alpha+Z\beta)^2 \times S.D^2 / (Mean1-Mean2)^2$

Where, n = sample size; Zα=1.96; Zβ=0.84;

Standard deviation (S.D.)= 3.7

Mean1=13.8; Mean2= 15.9

The total minimum sample required was 55 (with 10% additional)

The total number of the sample was 56.

The study was conducted after getting the ethical clearance from the Institutional Review Committee (Ref. No. KMC-IRC 08122023/03). The carrying angle was measured by a manual goniometer with two drawing axes of the arm and forearm. The patients were asked to lie down in a supination position with the arm parallel to the body, and the forearm was extended and supinated. Before measuring the carrying angle, the palpation of the bony landmarks was done. The carrying angle was measured by drawing two axes. The first axis was drawn in the arm. The axis in the arm was straight and was defined by the lateral border of the superior surface of the acromion (proximal) to the midpoint of the lateral and medial epicondyles of the humerus. The second axis was made in the forearm. It was defined by the midpoint of the medial epicondyles and lateral epicondyles of the humerus to the midpoint of the distal end of the radius and ulnar styloid processes. Both axis bisects each other at the cubital fossa of the elbow joint. After that, the manual goniometer was placed at the bisected area at the anterior surface of the cubital fossa.[8] The goniometer consists of two arms. The one arm of the goniometer was placed on the arm axis, and the other one on the forearm axis, with the elbow kept fully extended and in supine position. The patients with a history of lateral epicondylitis with age above 20 years, in both genders in the Nepalese population were enrolled in the study. They were enrolled after taking the informed consent. Whereas the patient with a history of fracture of the humerus, radius and ulna, arthropathy of the elbow, history of previous injuries of the shoulder joint, elbow joint, history of trauma to the ulnar nerve, median nerve, and any form of surgery in the upper limb were excluded.

The distribution of lateral epicondylitis was studied in different genders, age groups, and at different sites of the affected area. This was further followed by the comparison of mean carrying angle among the different variables considered in the case of lateral epicondylitis. The data collected was entered in a Microsoft Office Excel worksheet, and statistical analysis was done using the Statistical Package for Social Science (SPSS) version 25.0. The p-value of less than 0.05 was considered statistically significant.

RESULTS

The distribution of lateral epicondylitis was maximum in the right hand 44(78.6%) among the total participants of 56, where female participants were 24 and male participants were 20 in number as shown in Figure 1.

Figure 1: Distribution of lateral epicondylitis on different sides of participants

The cases were most common in between 31 to 40 years age group 20(35.7%) followed by 51 to 60 years age group 17(30.3%) as shown in Figure 2.

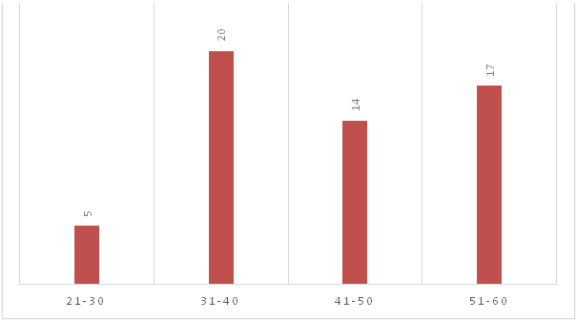

Figure 2: Distribution of cases of lateral epicondylitis among different age group of participants

The carrying angle in male participants with lateral epicondylitis was mostly between 5° to 10° (20) and in females it was mostly between 11° to 16° (24). The

carrying angle distribution among total participants was also common in between 5° to 10° (32) as shown in Figure 3.

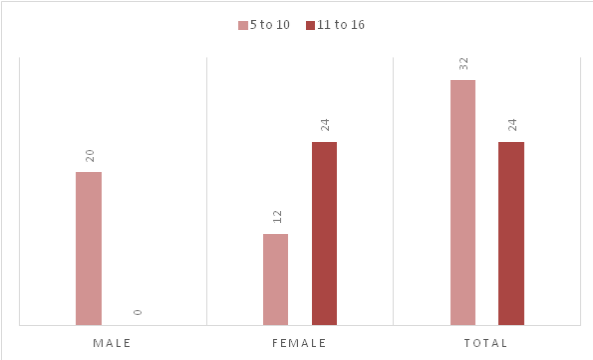

Figure 3: Distribution of carrying angle among the participants with lateral epicondylitis

The mean of carrying angle in the females (11.66±2.94) was higher in comparison to males (6.40±2.01) and the mean comparison was statistically significant (p-value <0.001). The mean of carrying angle in the left side of the cases (11.66±1.30) was higher in comparison to the right side of the cases (9.27±3.93) and the mean comparison was statistically significant (p<0.05). Similarly, the mean of carrying angle in the age group of 21-40 years (10.28±3.65) was comparatively more than the 41 to 60 years age group (9.38±3.67), but the mean comparison was statistically insignificant. (Table 1)

Table 1: Comparison of mean carrying angle among different variables among the cases of lateral epicondylitis

Variables		Carrying angle Mean±S.D.	p-value
Gender	Male	6.40±2.01	<0.001*
	Female	11.66±2.94	
Different Sides	Right	9.27±3.93	0.04*
	Left	11.66±1.30	
Age	21-40	10.28±3.65	0.36
	41-60	9.38±3.67	

*denotes statistical significance (p<0.05)

DISCUSSION

The carrying angle is formed in the elbow joint. When the elbow joint is fully extended and in the supinated position, forearm wouldn't be in a straight line with the arm; but it is laterally deviated and the angle is formed between the long axis of the arm and the long axis of the forearm.[9] Whereas, the average angle is between 5° to 10° in males and 10° to 15° in females.[2] The values above 15° are referred to as cubitus valgus, whereas values below 5° are termed cubitus varus.[9] Clinically, the increase in carrying angle can lead to elbow pain, instability during throwing activities or exercise, and may reduce elbow flexion function, and also increase the risk of dislocation or fractures of the elbow joints.[1]

The lateral epicondylitis is commonly known as tennis elbow. The lateral epicondylitis is caused due to repetitive microtrauma, overuse, larger magnitude traumas, and anatomical variation. It is caused by an overload of the common extensor tendon, particularly at the origin of the extensor carpi radialis brevis (ECRB) tendon.[4,10] The patient with the lateral epicondylitis has severe pain as a primary symptom at the elbow joint.[11] The symptoms and signs observed during physical examination were pain at the lateral aspect of the elbow, point tenderness over the lateral epicondyle, and pain during resistive wrist dorsiflexion with the elbow in full extension.[12] The most relevant finding of this study was that lateral epicondylitis was found more in the right hand. The distance between the origin and the musculotendinous junction of the ECRB muscle is the centre of the pathology in lateral epicondylitis. Increasing this distance between them will result in higher stress, and accordingly, the decrease in elbow carrying angle will cause additional stress on the extensor carpi radialis brevis.[13]

In this study, the lateral epicondylitis was common in females. Several studies have been conducted on the carrying angle on relation of lateral epicondylitis. The study done by Park et al. and Lee et.al. also showed that lateral epicondylitis was common in females than the males.[14,15]

In this study, the highest incidence of lateral epicondylitis was observed in the 31 to 40 years age group. This is fully supported by research conducted among housewives in Lahore, which found the highest incidence of lateral epicondylitis in the 30 to 35 and 35 to 40 age groups.[16]

In this study, 56 patients with lateral epicondylitis were enrolled. The mean carrying angle was 6.40±2.01 in males and 11.66±2.94 in females. This indicates that the mean carrying angle was greater in females than in males with lateral epicondylitis. Anatomically, the normal carrying angle is also greater in females than in males.[17] In cases of lateral epicondylitis, females likewise exhibited a higher carrying angle than males.

The limitations of this study include that the carrying angle was measured only in patients with lateral epicondylitis. Further studies involving a larger population with an equal number of males and females would be ideal and are recommended. Additionally, the carrying angle in lateral epicondylitis should be measured based on the dominant and non-dominant hands and as well as the based on the profession.

CONCLUSIONS

Lateral epicondylitis was more common in the right elbow than the left. The mean carrying angle in cases of lateral epicondylitis was greater in females than in males. This knowledge can be valuable for clinicians in identifying individuals at risk, explaining potential risk factors to patients and designing more effective prevention and management strategies.

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AUTHORS' CONTRIBUTIONS

SM did the concept and design of research literature, data collection, analysis and interpretation, manuscript preparation, and editing. PP did the data collection and manuscript editing. SC did data analysis and manuscript editing. CKR did manuscript editing and data interpretation and manuscript editing. All the authors have read and approved the final draft.

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INTRODUCTION

Football is one of the most popular sports in the world. Around one-fourth of the world's population plays football. It is estimated that more than half of the world's population considers themselves football fans.[1,2] Nepalese are not an exception to this. Dharan, a small city in the eastern part of Nepal in Koshi province, is known as mini–Brazil because of its passion for football. There are more than 20 registered football clubs in Dharan. They participate in different matches held in the country and nearby cities in India.

Injury is a constant threat in football, whether played for recreation or professional matches. The risk of injuries in a professional football match is about a thousand times higher than in industrial workers.[3] The risk factors may be intrinsic or extrinsic. Uneven ground surfaces, ill-fitting shoes, incorrect landing, and collision between the players are important risk factors.[4,5] Most injuries in football occur to the lower extremities, with the knee possessing the highest risk.[6] Knee injuries in football are of great concern because they result in substantial physical disability, financial cost, lost playing hours, and may even end a career. Knee injuries are the most common reason for surgery in footballers.

Most of the football clubs in Nepal do not have their football ground, so players have to practice on the field or public grounds which are poorly maintained. Similarly, because of their low socio-economic status, they have to use poor-quality gadgets. Also, there is no scientific tradition of training sessions based on warm-up duration, time played during games, proper rest, or any treatment strategy after injury. Most of the professional football clubs in Nepal do not have a medical team that looks after players' health. They are often taken care by team-mates or paramedics available at the field who are unaware of the symptoms and signs of common ligament injuries of the knee. So, ligament injuries are often missed. Because of suboptimal health care delivery system and ignorance many of the players play football matches even when they are not fit to play. This may lead to further damage to their injured knee consequently some of the player has to switch the profession. There is little work on the pattern of knee injuries in Nepal. It is not widely appreciated that ligament damage to the knee is more common than any other type of knee injury pathology. Knowing the type of injury and its anatomical location is important not only to prevent injuries but also for selecting appropriate treatment. Thus, the study aimed to determine the prevalence of knee injury among professional football players in Dharan sub-metropolitan city.

METHODS

It was a cross-sectional study conducted among football players of Dharan sub-metropolitan City, Koshi Province 1 of Nepal. Ethical approval was obtained from the Institutional Review Committee, B. P. Koirala Institute of Health Sciences. The study was conducted between March 2021 and May 2021. Out of 20 wards in Dharan, five wards were randomly selected by a lottery method. A ward is the smallest unit of local government in Nepal. A complete enumeration method was used to enroll football players playing football from the selected wards by face-to-face interview and clinical examination. The questionnaire included: personal demographic information, knee injury in detail, and current functional status of the knee. A knee examination was done after an interview by an orthopedic surgeon. Anterior drawer test and Lachman test were done for Anterior cruciate ligament (ACL) assessment, Posterior drawer test for posterior cruciate ligament (PCL), Mc Murray test for medial and lateral menisci, varus and valgus stress test for lateral and medial collateral ligament, respectively. Based on the history and clinical examination findings, a clinical diagnosis was made. The functional status of the injured knee was assessed by the Tegner-Lysolm Score, which was freely accessed via the internet. If any abnormal finding was noticed during data collection, the player was referred to the hospital for further management. Collected data were entered in Microsoft Excel 2010 and summarized and presented in charts and tables using Statistical Package for the Social Sciences (SPSS) software version 11.5.

RESULTS

Out of the 20 wards of Dharan sub-metropolitan city, ward numbers 8, 12, 16, 18, and 19 were selected by lottery method. Ninety-three participants were included in this study (17 from Ward 8, 18 from Ward 12, 17 from Ward 16, 21 from Ward 18, and 20 from Ward 19).

Of all the players, 77.5% were in the age group between 16-25 years, and 51.6% were studying at a higher secondary level. It has been observed that around one-third (29%) of players were malnourished, of which 8.6% were undernourished, 16.1% were overweight, and 4.3% were obese. (Table 1)

Table 1: Sociodemographic characteristics and nutritional status of participants (N=93)

Characteristics	Categories	No. of Participants	Percentage (%)

Age in years	≤15	3	3.2%
	16-20	38	40.9%
	21-25	34	36.6%
	26-30	11	11.8%
	31-35	5	5.4%
	>35	2	2.2%
Education level	Secondary	27	29%
	Higher Secondary	48	51.6%
	Bachelor and above	18	19.4%
BMI (kg/ht in m²)	<18.5	8	8.6%
	18.5-24.9	66	71%
	25.0-29.9	15	16.1%
	≥30.0	4	4.3%
Total		93	100%

Thirty-two players evaluated (34.4%) were playing forward, 36(38.7%) were midfield, 19(20.4%) were back, and 6(6.5%) were goalkeepers. Sixty-three players (67.8%) were playing football for more than five years. Most had training sessions once a day, played more than five days a week, and played for 1 to 2 hours in one session. Only 13 players (14%) played throughout the year; for the remaining, the training months in a year were found to be variable. (Table 2)

All the players had a warm-up session before they played football. The majority of them (73.1%) had 15 to 30 minutes of the warm-up session, and around 50.7% of them had sport-specialized training, running, and stretching.

Table 2: Sports information of the participants (N=93)

Sport information	Categories	No. of participants	Percentage (%)
Playing position	Forward	32	34.4%
	Midfield	36	38.7%
	Back	19	20.4%
	Goalkeeper	6	6.5%
Duration in sports (in years)	<1	5	5.4%
	1-5	25	26.9%
	6-10	30	32.3%
	>10	33	35.5%
No. of training sessions per day	1	86	92.5%
	2	6	6.5%
	≥3	1	1.1%
Training days per week	1	7	7.5%
	2-3	3	3.2%
	4-5	8	8.6%
	>5	75	80.6%
Length of training (hour) per session	<1	7	7.5%
	1-2	69	74.2%
	>2	17	18.3%
Training duration (months per year)	1-3	43	46.2%
	4-6	10	10.8%
	7-9	27	29%
	>9	13	14%
Length of warm-up per session in minutes	≤15	18	19.4%
	15-30	68	73.1%
	≥30	7	7.5%

It was found that 73 players (78%) had suffered some form of injury during their sports life. Of the total injuries, 80.2% had lower extremity injuries. The ankle joint was the most commonly injured body part (47.9%), followed by the knee (39.7%). Most injuries occurred during the match (65.8%).

Table 3: Injury patterns among participants (n=73)

Injury	Categories	No. of Participants	Percentage (%)
Knee injury	Knee only	20	27.4%
	Knee and other	9	12.3%
Other anatomical location of injury	Ankle	35	47.9%
	Low back	5	6.8%
	Thigh	5	6.8%
	Leg	4	5.5%
	Shoulder	1	1.4%
	Elbow	1	1.4%
	Forearm and wrist	1	1.4%
Time of injury occurrence	Training	25	34.2%
	Match	48	65.8%
Time away from sport	<1 Week	36	49.3%
	<1 Month	11	15.1%
	≥1 Month	26	35.6%

Of the 73 football players with injury, 29 had knee injuries. Out of them 20 had isolated knee injury and 9 had knee injury combined with some other injury. Bowling (24.1%), falling (24.1%), pivoting (24.1%), landing (17.2%), and sudden stops (10.3%) were the common mechanism of injury in order of frequency. Of the total knee injuries, 62.1% had severe injuries and were away from sports for more than one month.

Of the various clinical findings on the knee, the test for meniscus injury was positive for 10 participants, and the test for ACL insufficiency was positive for four participants. The tests for collateral ligament injury and cartilage injury were also positive in some players. Two participants had no history of injury to the knee but they had palpable thud on Mc Murray test for lateral meniscus on their bilateral knee. Various clinical diagnoses were made based on the clinical examination findings (Table 4). The participants were counseled for the probable injury and advised to go to the hospital for further investigations and management. Two participants with knee injuries had poor knee status according to Tegner Lysolm Scale who were referred to the hospital for further evaluation and treatment.

Table 4: Knee injury detail of the participants (n=29)

Knee Injury	Categories	No. of participants	Percentage (%)
Side	Dominant	21	72.4%
	Non-Dominant	8	27.6%
Mechanism	Bowling	7	24.1%
	Falling	7	24.1%
	Landing	5	17.2%
	Pivoting	7	24.1%
	Sudden Stop	3	10.3%

Clinical finding	Anterior drawer/Lachman test	4	13.8%
	Dial test	1	3.4%
	Effusion	1	3.4%
	McMurray test	8	27.6%
	McMurray test + Valgus stress test	1	3.4%
	McMurray test + Lachman test	1	3.4%
	Palpable thud	1	3.4%
	Prominent B/L tibial tuberosity	1	3.4%
	Tender Tibial tuberosity Left side	1	3.4%
	Tenderness on the lateral facet of patella	2	6.9%
	Tight Hamstring	1	3.4%
Clinical Diagnosis	Valgus Stress	1	3.4%
	ACL tear	4	13.8%
	ACL tear + Medial Meniscus tear	1	3.4%
	Chondromalacia patellae	1	3.4%
	Hamstring Strain	1	3.4%
	Lateral Meniscus tear	1	3.4%
	Lateral meniscus tear/discoid lateral meniscus	5	17.2%
	Medial Collateral Ligament tear	1	3.4%
	Medial Meniscus tear	4	13.8%
	Medial Meniscus tear + Medial Collateral Ligament tear	1	3.4%
	OCD patella	1	3.4%
	Posterolateral corner injury	1	3.4%
Time away from sport after injury	<1 Week	10	34.5%
	<1 Month	1	3.4%
	≥1 Month	18	62.1%
%Treatment received from	Doctor	3	10.3%
	Physiotherapy	1	3.4%
	Self-treatment	7	24.1%
	No treatment	19	65.5%
Current Functional Status (Tegner Lysolm Scale)	Poor	2	6.9%
	Fair	4	13.8%
	Good	9	31%
	Excellent	14	48.3%

DISCUSSION

In this study, we evaluated the prevalence of knee injury among football players in the sub-metropolitan city of Dharan. We assessed the players individually and collected details under four broad headings: 1. Personal demographic information, 2. Sports information, 3. Football injuries, and 4. Knee injury details and Functional status of the knee. The age of the players ranged from 14 to 38 years, with the majority lying between 16 and 25. It is seen that players started their professional football at an early age.

The injury prevalence was 78%, and 80.2% of the total injuries were lower extremities. The knee was the second most common joint injury, accounting for 39.7% in this study. Similar reports were found in the following studies. Gurau et al. in their studies found that lower extremities injuries were the most frequent in football players, representing on average 83.32±4.85% of all injuries, with a range of variation between 64.2% and 94%. Among the lower extremities' injuries, the thigh showed the highest percentage of 26.07±5.53%, followed by the ankle at 15.84±3.93%, the knee at 14.7±2.84%, and the hip/groin region at 12.96 ± 2.15%.[7] Shalaj et al. in their study found that traumatic injuries account for 71% of Kosovarian football players. The body parts most frequently affected by moderate injuries were the knee, followed by the thigh and then the ankle.[8] Ayub et al. in their study of five sports clubs in Peshawar found that the overall prevalence of injuries was 53.3%. The ankle was the most commonly injured lower extremity at 56.3%, followed by the knee at 28.9%, hip at 10.9%, and shin at 3.9%.[9] Forsythe et al. in their study of the incidence of injury for professional soccer players in the United States found that the most commonly injured region was the thigh (30.8% of all injuries), followed by the knee (13.5%) and ankle (12.5%).[10]

Conde-Pipo et al. in their study to assess the description, comparison, and correlation of the body composition profile of Latin American professional football players playing in European leagues found BMI of the players was in the range between 22.2 to 24.5 kg/m^2. However, in our study, 71% of players had a BMI of 18.5 to 24.9kg/m^2. But 8.6% of total players had a BMI less than 18.5kg/m^2, and 4.3% had more than 30kg/m^2. [11]

Dahlstrom et al. in their study explored if disparity about parents' educational level, player body mass index (BMI), and self-reported health are determinants of football injury in community-based football programs, separately or in interaction with age or gender found that based on gender and age-standardized values youths reporting injuries had on average 0.19 standard deviations higher BMI compared with youths not reporting injuries.[12] Also, Dane et al. looked at physical education students and found BMI was higher in injured athletes than in non-injured ones.[13]

In a study by Bakshi et al., the mean time to Return To play (RTP) for all 50 athletes was 388.71±198.52 days. The mean time to RTP for athletes with ACL/MCL injuries was 305.1±58.9 days, compared with 459.2±245.1 days ($p=0.004$) and 609.3±183.1 days ($p<0.0001$) for those with combined ACL and PCL/LCL injuries.[14] Our study also showed that most players had more than one month away from sports activities after trauma because most players had mild to moderate ligamentous injuries, and only a few had severe injuries.

High Tegner level athletes are more likely to return to their previous sport and to the previous level, similar to our study, with most players having excellent Tegner scores post injury and thus having good functional outcomes.[15] Playing without assessment and proper treatment can lead to further severe injury and permanent disability to the players in Dharan.

The limitations of this study was a small sample size. The diagnosis was made clinically. There was no imaging

modality to confirm the clinical diagnosis.

CONCLUSIONS

There was a high prevalence of knee injuries in football players of Dharan sub-metropolitan city. Poor nutritional status and poor health-seeking behavior were also prevalent, increasing the risk of injury.

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AUTHORS' CONTRIBUTIONS

BP designed the research, performed statistical analysis, and prepared the first draft of the manuscript. BP and ABS collected data, and contributed to prepare the first draft, AA, DT, and SS explained and interpreted the data and contributed to prepare the draft of the manuscript. All authors read and approved the manuscript.

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