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Research Article

Influence of Flexible Flatfoot on Athletic Performance in Adolescent Male Recreational Football Players

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ABSTRACT

Introduction: Flat foot, a common condition among adolescents has been associated with impaired athletic ability. Football is a physically demanding sport and this study focuses to analyse the effect of flexible flatfoot on balance, agility and power of these players. The aim of this study is to evaluate the athletic performance in adolescents male recreational football players with flexible flatfoot. **Materials and Methods:** This cross-sectional study selected the participants through convenience sampling, as per the inclusion criteria from the schools across Bangalore after obtaining ethical clearance. The participants were split into two groups based on their Arch Index: Group A (normal arch) and Group B (flexible flatfoot). The balance was assessed using the Y test, Hexagon agility test was used to evaluate agility and lower limb explosive power was assessed using the standing broad jump test. **Results:** The data was evaluated using SPSS 27.0. Independent *t*-tests were implemented to compare group performance and statistical significance was accepted at $p<0.05$. Anterior reach difference was statistically significant in group B ($p=0.007$) whereas the Composite reach distance and Hexagon agility test was statistically insignificant between two groups ($p>0.05$). The standing broad jump test was seen to be statistically significant in group B ($p=0.004$). **Conclusion:** Athletic performance did not differ significantly between football players with and without flexible flatfoot.

Keywords: Ankle Injuries, Athletic Performance, Flatfoot, Football.

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INTRODUCTION

Football a popular team sport is characterized as a vigorous, high-intensity, intermittent, ball and contact sport in which players make hard cuts, sharp turns off a planted foot, and intense contact with the ball along with functional activities including acceleration, deceleration, jumping, cutting, pivoting, turning, heading and kicking of the ball (Lakshakar *et al.*, 2022). This sport is played worldwide both at professional and recreational level. The innate nature of the sport itself makes it vulnerable to lower extremity injuries. These athletes bear high weight bearing stress on ankle foot complex placing excessive load on the arches, which functions to provide stability by adjusting to variations in supporting surfaces (Levangie and Norkin, 2019). Since foot is the contact point during weight bearing and ambulation, the mechanical characteristic of the foot determines the energy transfer into the lower extremity and therefore, it helps to define the pattern of weight bearing and thus a potential for injury to the lower extremities (Shono *et al.*, 2022; Djun and Chay, 2021). Arches provide support and shock absorption which are essential for strong foot biomechanics (Safar *et al.*, 2022). Hence, any dysfunction in the morphology of these foot arches may be expected to affect the normal functioning, weight bearing pattern and definitely the performance of a player, who requires a strong and proficient foot work, just like a footballer.

One of the prevalent foot dysfunctions is flat feet (also known as pes planus) with a prevalence of 30 % in young population (Kardm *et al.*, 2025). This low arch disorder may be structural including bony involvement (known as rigid flat foot) or functional, involving muscle or soft tissues (called as flexible flat foot). In the later, when weight is not borne, foot seems to have a normal or nearly normal arch, but in weight bearing it loses height and appears flat (Vashisht *et al.*, 2023). Studies indicate, it affects both adults and children frequently (Xu *et al.*, 2022, Febriyanti *et al.*, 2024). Multiple studies have shown a higher prevalence of flat feet among runners and athletes (Takabayashi *et al.*, 2021, Dikici *et al.*, 2023). Simple clinical tests that investigate arch behaviour are used for identifying flexible flatfoot. The degree of arch collapse can be screened and measured using techniques like the navicular drop test and footprint test. With good psychometric properties, the arch index is also used to predict flat feet (Paecharoen *et al.*, 2023). A number of studies

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have been performed to evaluate whether pes planus contributes to overuse injuries and its implications on athletic performance (Sagat *et al.*, 2023, Birhanu *et al.*, 2023). This low arch in flexible flat feet is believed to cause the foot to become weak overtime that could impair motor function since the foot is the terminal link of the lower extremity functional chain, thereby increasing the risk of injury which impacts leg muscle-derived motor abilities eventually taking a toll on the footballers' skills. An elite player is well trained and can be expected to incur less injuries owing to their experience and expertise in contrast to the recreational footballer who may be more injury prone due to the relatively less training and practice. Thus, this study aims to evaluate the athletic performance in adolescents male recreational football players with flexible flatfoot with the objective of comparing their agility, balance, and lower-limb explosive power with the normal arch population. The study hypothesises that there is no significant difference in athletic performance of the recreational players with flexible flat foot.

MATERIALS AND METHODS

After obtaining the ethical clearance from institutional ethical committee (Ethical no. PT/PG/ETH-2025/020 dated 08-09-2025), forty-four male recreational football players aged 12-15 years, playing for at least 3 hr per week with minimum two months of experience on ground having BMI between 18.5 and 24.99 kg/m^2 were included as study participants. Only male athletes with flexible flat foot and having Arch Index (AI) >0.26 were eligible. Exclusion criteria included football players who played the sport every day for more than 2 hr per day, history of lower limb surgery within the last one-year, musculoskeletal injuries of lower limb in the last six months and limb length discrepancy greater than 1.5 cm. This cross-sectional study was undertaken for a period of 6 months and participants were selected by convenience sampling from the schools with football facility across Bangalore. Study procedure was explained to all the participants and a written consent was taken from the parents and school authorities, as the participants were minors. Participants were divided into two equal groups based on structural screening, with 22 subjects in each group. Group A included players with normal foot arches and Group B with flexible flatfoot. Foot type was classified using the footprint method of arch index calculation. For calculating Arch Index, inked footprint method using graph paper was selected (Paecharoen *et al.*, 2023). To record the subject's footprint, they were made to wash and dry their foot and then stand in a flat tub filled with concentrated indigo ink for 5 sec, following which they stood full weight bearing on a graph paper to give their footprint impression. Throughout the process, the therapist stood next to the athlete to avoid any imbalance. Prints were allowed to dry before taking the foot length measure from the heel to the highest imprint point of the forefoot (without the toes). This marked imprint was split into three equal sections. The surface area of the footprint was calculated in each of the three-foot regions: forefoot, midfoot, and hindfoot. The midfoot area was calculated by dividing its area by the total footprint's surface area to get the AI. The medial longitudinal arch is categorized based on the AI into elevated (AI<0.21), normal (AI 0.22-0.26), and low (AI >0.26) (Paecharoen *et al.*, 2023). The participants with low AI were grouped as flat foot. To differentiate them as flexible flat foot, investigator followed observational method wherein the arch was observed in non-weightbearing (tested leg crossed over the opposite knee at the ankle). If the arch was not visible in this position, it was considered as structural flatfoot and excluded from this study; whereas those with visible arch were made to stand unilateral full weight bearing to check for any changes in the arch. If the arch was collapsed, it was considered as flexible flat foot (Halabchi *et al.*, 2013). True limb length was measured using standard method for all the participants before recording the outcome measures. In supine lying, with the help of standard measuring tape true limb length was measured from ASIS to medial malleolus and readings were recorded (Gardiner, 2005).

Outcome measures

Y Balance Test (also known as modified version of Star Excursion Balance Test/SEBT) was administered to that assess dynamic balance, Hexagon Agility Test measured agility, and Standing Broad Jump Test (SBJT) was used to evaluate lower limb explosive power.

Y Balance Test (modified version of SEBT)

A "Y" figure was drawn on the ground. The angle between the two posterior arms of "Y" was 45° and the two posterior arms was positioned 135° from the single anterior arm of "Y". For calculating Anterior Reach Difference (ARD) (Foldager *et al.*,2023). The participants stood barefoot in the central intersection of the "Y" facing the anterior arm of the "Y" and touched anterior arm of "Y" to the maximum of their reach by each leg. One trial was allowed. A total of 3 readings were taken and average of these were recorded in centimetres. Anterior reach difference was calculated by subtracting left leg anterior reach distance from the right leg anterior reach distance. Composite Reach Distance (CRD) was also calculated to have better understanding of the balance. The participants stood barefoot in the central intersection of "Y" and touched all the three arms of "Y" to the maximum stretch with both the legs one by one. One trial and three attempts were made with the average of three taken as final reading in cm. The readings for composite reach distance were calculated by adding anterior, posteromedial and posterolateral distance. The total was divided by three times the limb length and multiplied by 100 to obtain the normalized values.

Hexagonal Test

After a 5 min warm up that included spot jump and jogging, the subject stood in the center of the hexagon (60 cm each side) drawn on a ground, with shoes off. The participant jumped with

both feet over each side of the hexagon returning to the center after each jump and was timed. 3 sets were done with 10 sec rest in between and average was calculated in seconds as final reading (Hernandez *et al.*, 2021).

Standing Broad Jump Test (SBJT)

The player stood behind a line and jumped far ahead of the line landing on both the feet. The distance in centimetres from the starting line to the first point of contact upon landing was measured. Average distance between three trials was determined and was divided by true limb length (in cm) to normalize the data. The normalized values which were given as a unitless ratio were used for data analysis (Rahman, 2021).

Statistical Analysis

An independent *t*-test from SPSS 27.0 software was used to compare the outcome measures between the groups considering p value < 0.05 to be significant.

RESULTS

The baseline anthropometric and demographic data for participants in Groups A and B were seen to be homogenous with statistically insignificant $p>0.05$ and hence both the group were comparable in age, height, weight and BMI (Table 1).

On comparison of the outcome measures, Anterior Reach Difference (ARD) was statistically significant between the two groups ($p=0.007$). Group B indicated superior anterior reach symmetry compared to Group A (Figure 1) as indicated by the mean difference of -1.42 (95% Cohen's d=-0.84) (Table 2).

The Right Composite Reach Distance (RCRD) ($p=0.31$), Left Composite Reach Distance (LCRD) ($p=0.09$) and the Hexagon agility test ($p=0.59$) did not show any statistically significant difference between Group A and Group B (Table 2). For both RCRD and LCRD as shown in Figure 2, Group B's mean scores were marginally higher than Group A's; however, the differences were not statistically significant ($p>0.05$), with a small effect size for RCRD (Cohen's d = -0.30) and a moderate effect size for LCRD (Cohen's d=-0.51). Mean of Hexagon agility test for Group A and Group B is showed in Figure 3 with mean values 7.16±1.72 and 7.42±1.43. There was a small effect size (Cohen's d=-0.16) and no statistically significant difference between the groups ($p=0.59$).

However, a statistically significant difference ($p=0.004$) was seen in the Standing broad jump test with Group B showing increased jump distance (Table 2). SBJT demonstrated a statistically significant difference ($p=0.004$) between the groups as showed in Figure 4. Group B showed 1.79±0.15, while Group A revealed 1.65±0.14. With a 95% confidence interval of -0.22 to -0.04, the mean difference was -0.14. A significant between-group differences were indicated by a large effect size (Cohen's d= -0.91).

DISCUSSION

The current study examined whether athletic performance metrics like dynamic balance, agility, and explosive power are impacted by flexible flatfoot in recreational football young players between the ages of 12 to 15.

The current study makes use of the anterior, posterolateral and posteromedial components of Y test which are the established relevant measures to assess lower extremity function (Picot *et al.*, 2021; Plisky *et al.*, 2006). Confirmed that asymmetry between the legs in the anterior reach distance and the total of the three reach directions-anterior, posterolateral, and posteromedial-were predictive of lower extremity injuries in high school basketball players.

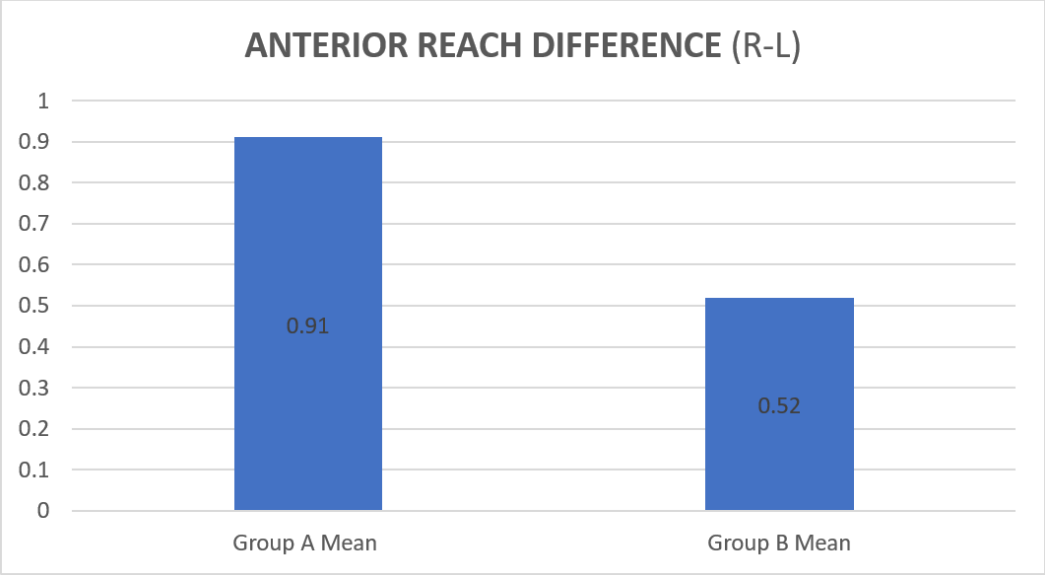

Figure 1: Anterior Reach Difference.

Table 1: Baseline data of the subjects.

	Group A (normal foot arch)	Group B (flexible flat foot)	*p* value
Age (years)	13.7± 1.2	13.8±1.1	0.77 (NS)
Height (meters)	1.6±0.1	1.6±0.1	1.00 (NS)
Weight (kg)	50.1±5.6	51.3±5.9	0.49 (NS)
BMI (kg/m^2)	18.8±0.8	19.2±0.9	0.12 (NS)

NS: Non-Significant *p* values; Above table shows the baseline comparison of two groups in terms of age, height, weight and BMI.

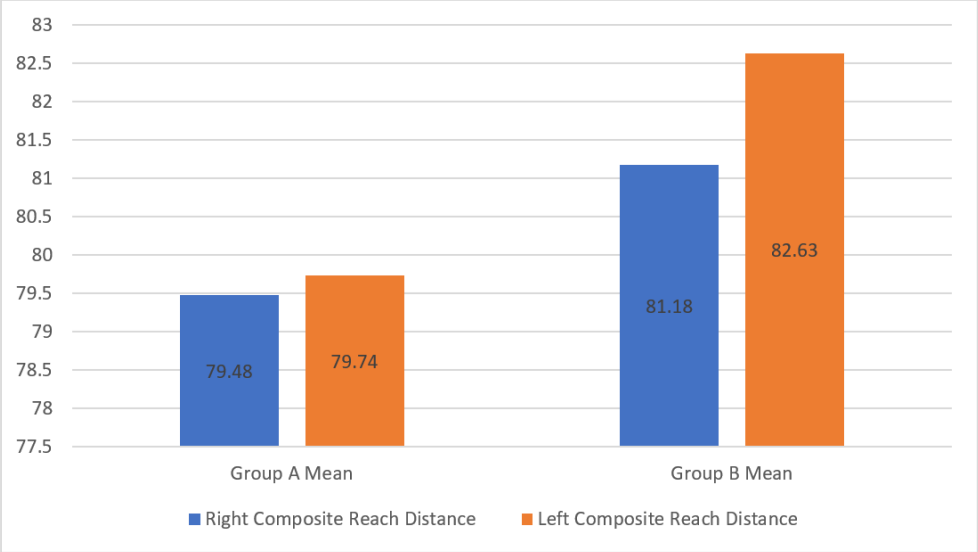

Figure 2: Right Composite Reach Distance and Left Composite Reach Distance.

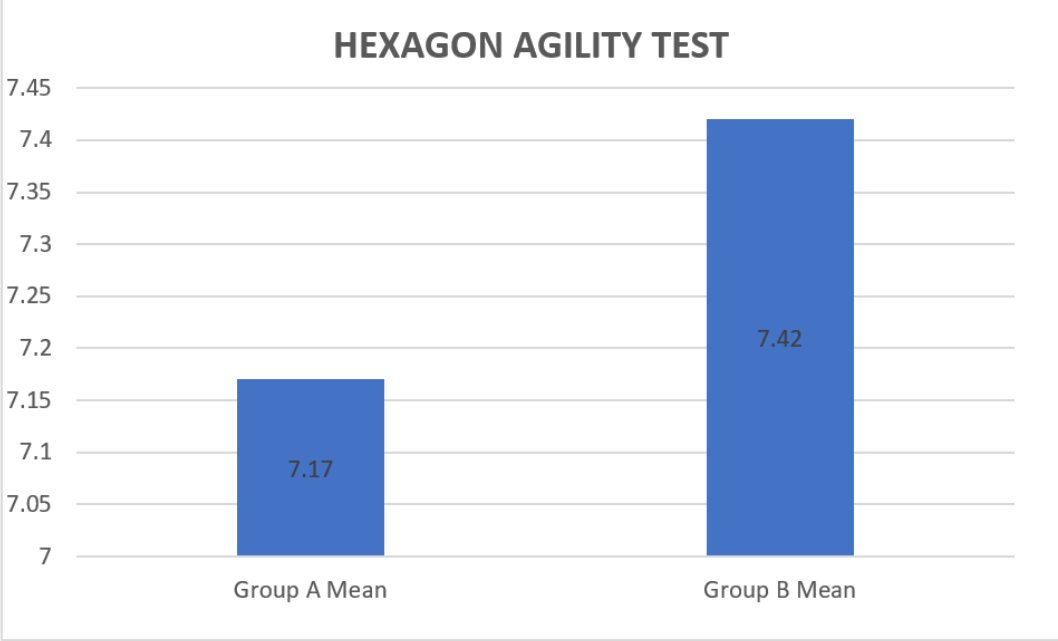

Figure 3: Hexagonal agility test.

Table 2: Descriptive statistics of Y-Balance Test, Hexagon Agility Test Scores, and Standing Broad Jump Performance.

Variable	Group A Mean±SD	Group B Mean±SD	*t* value	*p* value	95 % CI		Cohen's d
					Lower	Upper	
Y-test [ARD] (cm)	-0.91±1.58	0.51±1.77	-2.816	0.007*	-2.45	-0.40	-0.84
Y-test [RCRD] (cm)	79.50±5.56	81.22±5.62	-1.024	0.312	-5.13	1.67	-0.30
Y-test [LCRD] (cm)	79.81±5.71	82.72±5.56	-1.711	0.094	-6.34	0.52	-0.51
Hexagon Agility Test (sec)	7.16±1.72	7.42±1.43	-0.539	0.593	-1.22	0.70	-0.16
Standing Broad Jump Test	1.65±0.14	1.79±0.15	-3.024	0.004*	-0.22	-0.04	-0.91

*Significant *p* value; ARD= Anterior Reach Difference; RCRD= right composite reach distance; LCRD =left composite reach distance.This table compares the mean scores of Y-Balance Test, Hexagon Agility Test Scores, and Standing Broad Jump Performance reflecting their *p* value.

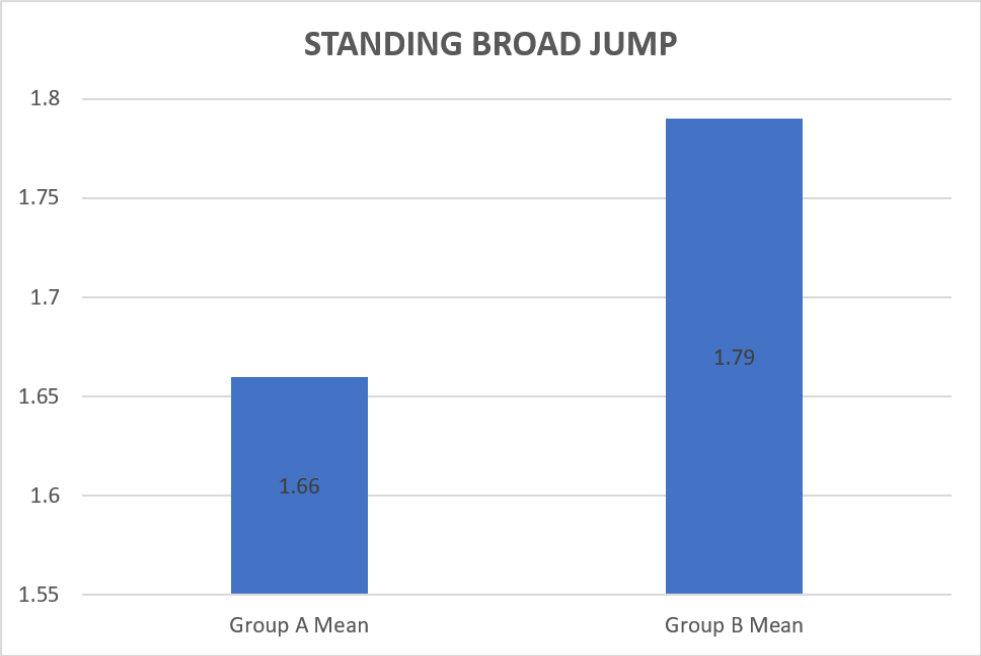

Figure 4: Standing Broad Jump.

In this study, anterior reach difference (R-L) showed a statistically significant difference between Group A and Group B ($p<0.05$). The higher ARD as observed in the group B (flat arch group), suggests that the flat feet players showed better limb symmetry contrary to the popular belief and literature review, suggesting greater potential for participation in the sports world for this population. These results can be attributed to an altered dynamic balance strategies and compensatory ankle-foot biomechanics that may be associated with the flexible flat foot, particularly increased pronation and dorsiflexion-related adaptations, during anterior reach tasks. Both RCRD and LCRD did not show any statistically significant difference between the flat feet and normal population suggesting that group B, despite of having a biomechanical deficit, is equally efficient in this balance component and hence flexible flat feet does not have any disadvantage on CRD. These results are in sync with research done by Kim *et al.* who compared the flat foot and normal foot to find no difference in dynamic stability with increased static stability in flat foot (Kim *et al.*, 2015). In contrast to these findings, Lee *et al.*, 2022 suggested that people with pes planus may not be able to maintain enough foot stability, due to inadequate counterforce and weakening of the ligamentous and fascial support of the medial longitudinal arch leading to balance issues.

The Hexagon Test was used to measure agility in football players and no statistically significant difference ($p>0.05$) was seen among the two groups compared. This implies that agility performance in teenage football players is not significantly impacted by flexible flatfoot. Similar results were given by Rahim *et al.*, 2017 who found no correlation between medial longitudinal arch characteristics and agility in children aged 5-6 years ($p=0.603$).

The standing broad jump performance indicated a statistically significant difference ($p=0.00$) between Group A and Group B with a higher score seen in Group B (mean=1.79± 0.15).

These results are in contradiction to those found by Sagat *et al.*, 2023 which stated that children with flat feet performed lower in both unilateral and bilateral standing broad jumps. These unconventional results of the current study may be attributed to the biomechanical adaptation in the adolescent football players developed during progressive musculoskeletal maturation and sports-specific training that minimizes the functional impact of flexible flatfoot.

CONCLUSION

The present study indicates that flexible flatfoot flexible flatfoot did not result in poorer agility or composite dynamic balance performance in this sample, while differences were observed in anterior reach and explosive power. Despite the biomechanical differences associated with low arches, players with flexible flatfoot performed equally well in agility and balance tasks and even showed superior explosive power in jumping, thereby accepting the hypothesis of the study. These findings challenge the traditional view that flatfoot is a disadvantage in sports and suggest that compensatory adaptations may mitigate its impact. Nevertheless, early intervention and sport-specific training remain advisable to reduce the risk of future injuries and optimize long-term performance, especially in terms of balance, agility and explosive power. Further research is warranted to better understand the relationship between foot arch morphology and explosive performance of these athletes. We suggest that the force plate analysis should be done in future to further investigate the findings observed in the present study. Furthermore, the study had a small sample size that may limit the generalizability of the results. As this was a cross-sectional study with a single assessment, longitudinal studies involving larger cohorts of football players are recommended to establish stronger evidence regarding the long-term impact of flexible flatfoot on athletic performance.

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ABBREVIATIONS

AI: Arch Index; **ASIS:** Anterior Superior Iliac Spine; **ARD:** Anterior Reach Difference; **BMI:** Basal Metabolic Index; **CRD:** Composite Reach Distance; **LCRD:** Left Composite Reach Distance; **RCRD:** Right Composite Reach Distance; **SBJT:** Standing Broad Jump Test; **SEBT:** Star Excursion Balance Test.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR'S CONTRIBUTION

Upasana Sharma: Concept, Study Design, Definition of Intellectual content, Literature Search, Data Acquisition, Manuscript Preparation. **Prasanna Mohan:** Study Design, Data Analysis, Statistical Analysis and Manuscript Review. **Shivani Jain:** Literature Search, Manuscript Editing and Critical Manuscript Review.

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