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Does glenohumeral external rotation gain and glenohumeral internal rotation deficit predict shoulder injury in novice and elite badminton players?

Ajit Dabholkar[1], **Shweta Attili**[2]

[1]Prof and Head, Sports Physiotherapy, School of physiotherapy, D.Y.Patil University, Nerul-400706, India, Email: ajitdabholkar1211@gmail.com

[2]MPT, Sports Physiotherapy, School of physiotherapy, D.Y.Patil University, Nerul-400706, India, Email: shweta.attili@gmail.com

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ABSTRACT

Introduction: Badminton incorporates repeated arm movements with overhead strokes. Prediction of shoulder injury in novice and elite badminton players was assessed by identifying glenohumeral internal rotation deficit (GIRD) and glenohumeral external rotation gain (GERG), posterior soft tissue tightness, scapular dyskinesis, scapular muscle strength (serratus anterior, upper, middle and lower trapezius) and glenohumeral rotators strength (internal and external rotators). *Materials and Methods:* Bubble inclinometer, measuring tape, universal goniometer, push- pull dynamometer, DASH scale -sports module, numerical rating scale. Pre-assessment on various outcomes were performed and the player was followed-up for 3 months, post-assessment on various

outcome were performed at the end of 3 months, results were studied and compared to predict shoulder injury. *Results & Conclusion:* Shoulder at risk of injury was identified in both the groups (novice & elite), evident GIRD & GERG, significant difference in posterior soft tissue tightness, increase in scapular muscles strengths, altered scapular stability observed by scapular dyskinesis test (SDT). This prediction can be used for designing appropriate treatment strategies for prevention of shoulder injuries in future.

Keywords: badminton, scapular dyskinesis, posterior soft tissue, GIRD, GERG

1. INTRODUCTION

Badminton is an individual, non-contact sport requiring jumps, lunges, quick change in direction and rapid arm movements from a wide variety of postural positions (Dabholkar et al., 2015). The overhead forehand stroke is performed more than overhead backhand stroke (Lieshout et al., 2002). Glenohumeral internal rotation, glenohumeral abduction and flexion takes place in overhead forehand stroke and glenohumeral external rotation, glenohumeral abduction and extension in overhead backhand stroke (Sorensen et al., 2010). Being a dominant arm sport, repetitive demands can lead to secondary changes and adaptations. These are evident when shoulders are compared bilaterally. Also there may be adaptation such as anterior capsule laxity and posterior soft tissue tightness due to repetitive nature of sport. This eventually leads to glenohumeral internal rotation deficit (GIRD) and glenohumeral external rotation gain (GERG) in the playing arm. Burkhart et al. proposed that GIRD may be associated with injury. GIRD/GERG ratio equal to or greater than 1 is a predictor of shoulder injury (Burkhart et al., 2003). Throwers with GIRD are 25% more likely to have a SLAP lesion (Sundaram et al., 2012; Grossman et al., 2005).

GIRD is also strongly associated with alteration of scapula position. Scapular dyskinesis are commonly associated with injuries or may exacerbate an existing injury leading to dysfunction of shoulder. The loss of control of scapular motion and position seen clinically occurs in a large number of injuries involving the shoulder joint and often is caused by injuries that result in the inhibition or disorganization of activation patterns in scapular stabilizing muscles (Dabholkar et al., 2015). When the muscles are weak or fatigued, scapulohumeral rhythm is compromised, and shoulder dysfunction results. Years of playing badminton on a competitive level is proved as a risk factor for acute badminton injuries, the incidence of acute badminton injuries increased constantly from the 0 to the 7th year of competitive badminton (Kluger et al., 1999). Shoulder injury is potentially a career ending problem for professional badminton players and it represents a significant clinical challenge for physiotherapist responsible for prevention of injury, assessment and appropriate treatment strategies. Thus early investigation is necessary to avoid further overuse shoulder injury. The impairments can be addressed and early intervention is possible which can help in preventing injury and thus enhancing performance.

2. MATERIALS AND METHOD

Materials

Bubble inclinometer (Baseline), measuring tape, marker, universal goniometer, push- pull dynamometer, DASH- disabilities of the arm, shoulder and hand scale (sports module), NRS – numerical rating scale were used in this study.

Method

A Cross- sectional study design was conducted for duration of 1 year, from the period of 08/2018 to 08/2019 in 35 Badminton players, 19 novice (beginners) played more than 3 months and 16 elite professionals played atleast for 3-4 years and both practicing regularly for minimum of 3 days/week.

Participants

Badminton player	
Elite players	Novice players
• Inclusion criteria: 1. Asymptomatic professional badminton players. 2. Elite professional players, playing since atleast 3-4 years 3. Players who have atleast played at district level of tournaments	• Inclusion criteria: 1. Asymptomatic professional badminton players. 2. Novice players, who had just started playing (beginners). 3. Players who played at basic levels (club level) and have not yet attended any tournaments.

4. Players who were practicing regularly for 3 days a week minimum.	4. Players who were practicing regularly for 3 days a week minimum.
• Exclusion criteria : 1. Players who have not played any level tournaments (district level as a minimum) 2. Players who did not follow regular practice schedule.	• Exclusion criteria : 1. Players who played any level tournaments 2. Players who did not follow regular practice schedule.
Players undergone any previous shoulder surgery or previous shoulder injuries, players who had any musculoskeletal or neurological conditions, rheumatological diseases or any other severe health conditions were excluded from the study.	

Procedure

Badminton players who were eligible according to the inclusion criteria were included in the study, Institutional review board approval and written consent for participation was undertaken. Proforma was filled by interviewing the subjects which included demographic data. Their playing schedule including duration (months/years) of playing , number of days played per week, number of hours played per week, pain experienced during game or after game in shoulder region (type of pain, site of pain, intensity through NRS) was documented. Complete pre-assessment of outcomes were performed and the players were followed-up for 3 months, complete post-assessment was carried out again at the end of 3 months. Baseline assessment was taken in the month of January 2019 and post 3 months follow up assessment was performed in the month of April 2019. Shoulder Injury prediction was performed by comparing and analyzing pre and post assessment results. Firstly, pre and post assessment data was compared within the groups (intra-groups) in novice and elite players respectively to study the risk of shoulder injury, and then the data was compared in between the groups (inter-group) to conclude which group was more prone to the injury.

The following outcomes measures were evaluated in subjects:-

Glenohumeral rotation using universal goniometer, GIRD/GERG ratio, Scapular (Upper, middle and lower trapezius) and glenohumeral rotators (internal and external) muscle strength was assessed by push-pull dynamometer. The scapular dyskinesis was tested by Scapular Dyskinesis Test (SDT). (McClure et al., 2009) Observations were documented. Lateral scapular Slide test (LSST) (Odom et al., 2001) was assessed and documented. Posterior soft tissue tightness (PSST) (Laudner et al., 2006) was assessed using bubble inclinometer. DASH scale (Sports module). The Disabilities of the Arm, Shoulder and Hand (DASH) scale (sports module) consists of 4 questions which interrogates about impact of sports played on the arm, shoulder and hand and vice versa in past week (http://www.dash.iwh.on.ca).

3. RESULTS

Test of normality was performed for all the above collected data, p-value for the test of normality was less than 0.05, therefore we used non-parametric test for the comparison (table 1 & 2).

Table 1 Demographic data of Novice and Elite badminton players

Demographic data	Mean ± SD (19 Novice)	Mean ± SD (16 Elite)
Male : Female	14 : 5	11 : 5
Age (Years)	24.57 ±6.27	24.5±7.13
Ht (Cms)	168.22±10.07	169.52±8.98
Wt (Kgs)	60.84±7.14	64.5±13.95
Right : left (Dominance)	18 : 1	15:1

Table 2 Playing schedule of Novice and Elite badminton players

Playing schedule	Mean ± SD (19 Novice)	Mean ± SD (16 Elite)
Playing since (yrs)	4.21 ± 1.47	6.56 ± 5.27

Days / week	3.73 ± 1.86	4.87 ± 1.08
Hours / day	3.42 ± 0.60	3.93 ± 1.23

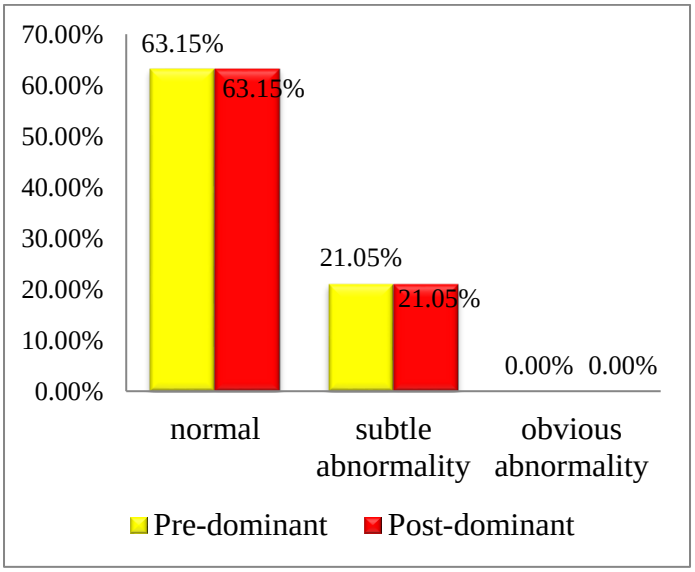
Table 3 Comparison of pre and post 3 months follow up assessment in Novice and Elite badminton players

Subjects	**Novice**			**Elite**		
Outcome measures	**Z**	**p-value**	**INFERENCE**	**Z**	**p-value**	**INFERENCE**
Range of motion (ROM)						
IR post Dom – IR pre Dom	-3.497[b]	.000	Significant	-3.125	.002	Significant
IR post Nondom- IR pre Nondom	-2.694[b]	.007	Significant	-3.133	.002	Significant
ER post Dom- ER pre Dom	-2.871[c]	.004	Significant	-3.125	.002	Significant
ER post Nondom-ER pre Nondom	-2.530[c]	.011	Significant	-1.732	.083	Significant
GIRD,GERG,Ratio						
Post GIRD – Pre GIRD	-2.536	.011	Significant	-.770	.441	NS
Post GERG – Pre GERG	-.513	.608	NS	-1.172	.241	NS
Post Ratio – Pre Ratio	-.140	.889	NS	-1.415	.157	NS
Muscle Strength						
IR Dom	-3.520[c]	.000	Significant	-3.126	.002	Significant
IR Non-dom	-2.961[c]	.003	Significant	-2.585	.010	Significant
ER Dom	-2.754[c]	.006	Significant	-2.667	.008	Significant
ER Non-dom	-2.040[c]	.041	Significant	-2.310	.021	Significant
SA Dom	-3.140[c]	.002	Significant	-2.652	.008	Significant
SA Non-dom	-3.176[c]	.001	Significant	-2.310	.021	Significant
UT Dom	-3.245[c]	.001	Significant	-3.358	.001	Significant
UT Non-dom	-2.919[c]	.004	Significant	-2.842	.004	Significant
MT Dom	-3.082[c]	.002	Significant	-3.387	.001	Significant
MT Non-dom	-2.970[c]	.003	Significant	-2.994	.003	Significant
LT Dom	-3.542[c]	.000	Significant	-3.035	.002	Significant
LT Non-dom	-3.314[c]	.001	Significant	-2.299	.022	Significant
Lateral scapular slide test						
AOS Post 1 – AOS Pre 1	-1.732[c]	.083	NS	.000	1.000	NS
AOS Post 2 – AOS Pre 2	-1.000[c]	.317	NS	-1.414	.157	NS
AOS Post 3 – AOS Pre 3	.000[d]	1.000	NS	-1.633	.102	NS
AOW Post 1 – AOW Pre 1	-1.000[c]	.317	NS	-1.000	.317	NS
AOW Post 2 – AOW Pre 2	.000[d]	1.000	NS	-1.414	.157	NS
AOW Post 3 – AOW Pre 3	-1.000[c]	.317	NS	-.816	.414	NS
90AB Post 1 – 90AB Pre 1	.000[d]	1.000	NS	.000	1.000	NS
90AB Post 2 – 90AB Pre 2	-1.000[c]	.317	NS	-1.000	.317	NS
90AB Post 3 – 90AB Pre 3	-1.000[b]	.317	NS	-.816	.414	NS
Posterior soft tissue tightness						

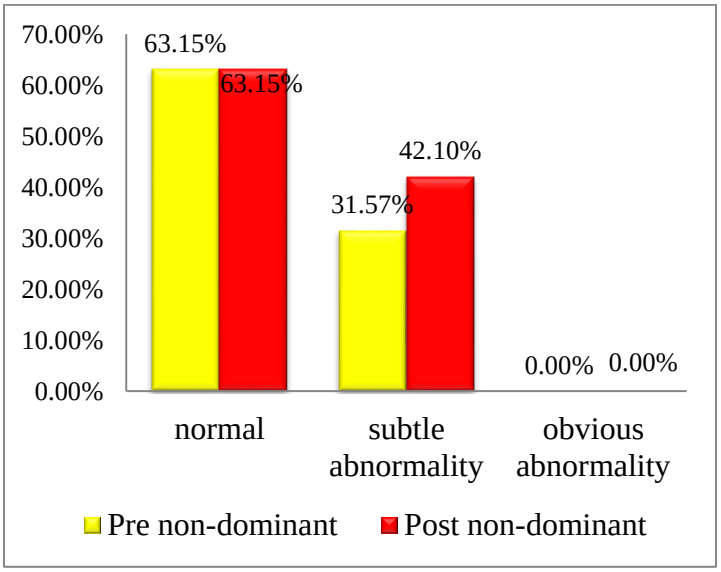
PSTT post Dom - PSTT pre Dom	-2.765b	.006	Significant	-2.684	.007	Significant
PSTT post Nondom – PSTT pre Nondom	-2.825b	.005	Significant	-2.565	.010	Significant
DASH-sports module						
Post DASH – Pre DASH	-1.890c	.059	NS	-1.298	.194	NS

Abbreviations: (IR- Internal rotation, ER- External Rotation, dom-Dominant, nondom- nondominant, post- post 3 months follow up assessment , pre- pre assessment , NS- nonsignificant , SA- serratus anterior bias, UT- upper trapezius bias, MT-middle trapezius bias , LT-lower trapezius bias ,AOS- Arms on side ,AOW- arm on waist ,90AB- 90 degree abduction and internal rotation, PSTT- posterior soft tissue tightness)

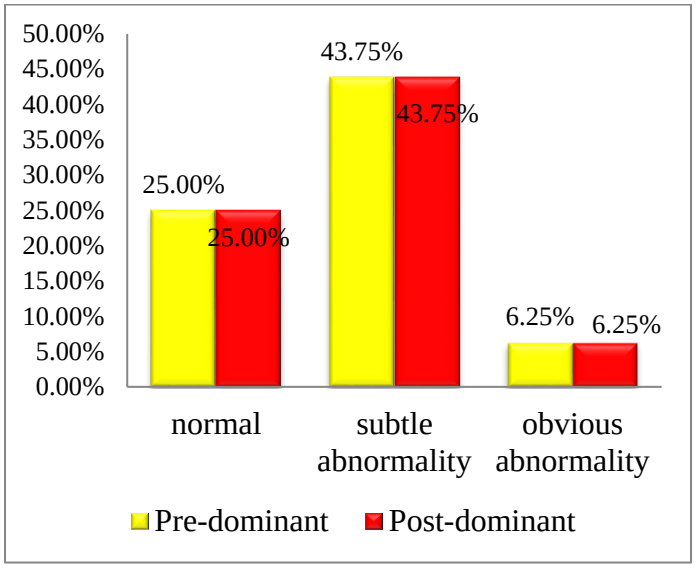
The results of pre and post 3 months follow up assessment of range of motion (dominant & non-dominant), GIRD ,GERG, GIRD/GERG ratio, muscle strength, lateral scapular slide test, posterior soft tissue tightness and DASH were performed by non-parametric Wilcoxon signed ranked test in Novice and Elite badminton players (Table 3, Graph 1 -4).



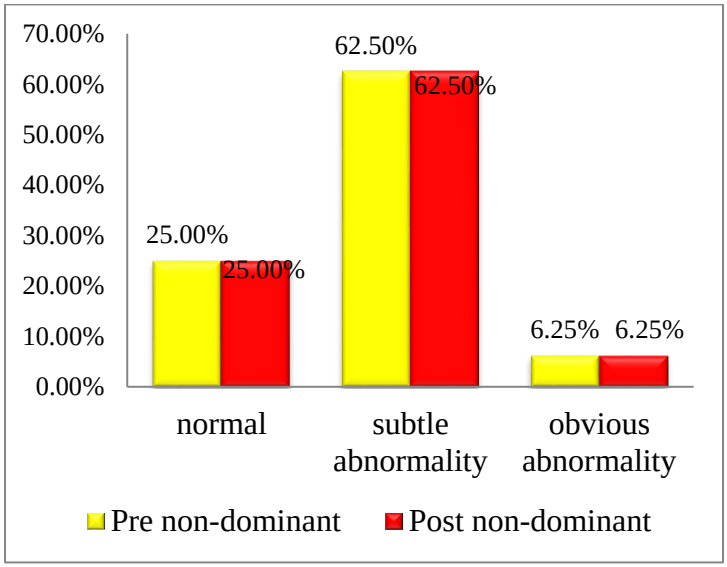
Graph 1 Scapular dyskinesis test in novice players (Dominant)



Graph 2 Scapular dyskinesis test in novice players (Non-dominant)



Graph 3 Scapular dyskinesis test in elite players (dominant)



Graph 4 Scapular dyskinesis test in elite players (non-dominant)

Table 4 Correlation between posterior soft tissue tightness, GERG, GIRD and GIRD/GERG ratio in Novice and Elite badminton players

Correlation of the parameters:			**Novice**		**Elite**	
			PSTT dominant difference	**PSTT non-dominant difference**	**PSTT dominant difference**	**PSTT non-dominant difference**
Spearman's rho	GERG difference	Correlation Coefficient	-.270	-.079	.228	-.292
		Sig. (2-tailed)	.264	.749	.396	.272
		N	19	19	16	16
	GIRD difference	Correlation Coefficient	.452	.153	-.291	-.217
		Sig. (2-tailed)	.052	.531	.274	.419
		N	19	19	16	16
	Ratio difference	Correlation Coefficient	.071	.067	-.300	-.494
		Sig. (2-tailed)	.773	.786	.259	.052
		N	19	19	16	16

(Difference - difference between pre and post 3 month follow up assessment)

In our study, we found posterior soft tissue tightness had fair inverse correlation with GERG, fair relationship with GIRD and negligible correlation with GIRD/GERG ratio in Novice players. Posterior soft tissue tightness had little direct correlation with GERG, fair relationship with GIRD and fair correlation with GIRD/GERG ratio in Elite players (table 4).

4. DISCUSSION

Change in Range of motion: Internal rotation and External rotation

In our study, significant difference was seen from pre assessment to follow up assessment post 3 months range of motion in both novice and elite players. Both novice and elite players showed increase in external rotation and decrease in internal rotation bilaterally (table 3). It was seen that differences are more noteworthy on dominant side as compared to non dominant side. Plausible reason can be, due to repetitive demands on dominant shoulder there is reduction in internal rotation range of motion leading to significant alteration in total arc thus increasing external range of motion as compared to non-dominant side (Dabholkar et al., 2005; Vad et al., 2003; Ruotolo et al., 2006; Couppe et al., 2014). In our study neither novice nor elite badminton players showed appreciably higher alterations than other when compared. Thus both the groups are prone to risk.

GERG, GIRD and its ratio (GIRD/GERG)

In our study significant difference was seen in GIRD from pre assessment to follow up assessment post 3 months, but no statistical difference was seen in GERG and GIRD/GERG ratio in novice players, it showed increase in GIRD i.e. decrease in internal rotation, showing shoulder injury risk trending in novice players (Table 3). No significant difference was observed in elite players from pre assessment to follow up assessment post 3 months in GIRD, GERG and GIRD/GERG ratio though the difference in range of motion was significant (Table 3). According to study by Kluger et al (1999) years of training is a risk factor for acute injuries in badminton player. Considering this, Novice players are more prone towards shoulder injury than Elite players which can be attributive to their playing duration.

Internal rotators and external rotators muscle strength

In our study, significant difference was observed in internal rotators (IR), external rotators (ER) muscle strength from pre assessment to follow up assessment post 3 months in novice as well as elite badminton player (Table 3). Though conditioning of shoulders is done bilaterally, difference can always be noted in between dominant / playing arm and non-dominant / non-playing arm, as greater force is exerted by playing arm during overhead strokes or smashes and other arm is relatively less used or is at rest during game. It is reported that badminton players have stronger internal and external rotators on the dominant side when compared to the non-dominant side and the internal rotators are stronger than the external rotators on the dominant as well as on the non-dominant side (Dabholkar et al., 2018).

Scapular Muscle strength and Scapular dyskinesis

In our study, significant difference was observed in muscle strength of serratus anterior (SA) and trapezius [upper (UT), middle (MT), lower (LT)] from pre assessment to follow up assessment post 3 months in novice as well as elite badminton players (Table 3). The overall increase in strength can be attributed to their fitness regimen and other physical or strengthening activities. Previous studies have showed strong relationship between scapular muscle strength and normal working of scapula is important for shoulder to be risk free, especially presence of scapular dyskinesis in asymptomatic overhead athletes evidently showed increased risk of shoulder injury/pain by 43% (Dabholkar et al., 2015; Hickey et al., 2018; Burn et al., 2016; Ghanbari et al., 2018).

Results of our study showed no significant difference in lateral scapular slide test (LSST) in both novice and elite players showing no remarkable scapular instability which can be attributive to good upper body muscle strength and balance due to their work out (Table 3). The results of scapular dyskinesis test (SDT) showed no relevant change which can be due to short duration in between pre and post assessment (Graph 1, 2, 3 & 4). Thus from the above results we can infer that shoulder injury risk was observed in both the groups.

Disabilities of arm shoulder and hand (sports module)

The DASH score sports module showed no significant difference statistically, inclusion of asymptomatic players and their enthusiasm towards game in which they ignore injury can be the reason (Table 3).

Posterior soft tissue tightness

In our study both novice and elite players showed significant difference from pre assessment to follow up assessment post 3 months in posterior soft tissue tightness. i.e. increase in posterior soft tissue tightness bilaterally (dominant as well as non dominant) as shown in table 3. Neither novice nor elite players showed remarkably higher values on comparison. Thus both the groups were equally at risk of shoulder injury.

Results of our study showed, correlation between posterior soft tissue tightness with GERG, GIRD and Ratio, showed fair/little inverse relationship with GERG and fair to moderate direct relationship between GIRD and posterior soft tissue tightness and negligible relationship with ratio bilaterally in novice players (Table 4). This shows increase in posterior soft tissue tightness increase GIRD and vice versa, thus predicting shoulder injury in novice players. The results of correlation in elite players, showed fair/little relationship with GERG and fair inverse relationship between GIRD and posterior soft tissue tightness and fair inverse relationship with ratio bilaterally (Table 4). This shows that increase in posterior soft tissue tightness will increase GERG, which inturn will increase GIRD in order to maintain total arc of motion, thus showing little risk of injury in elite players.

5. CONCLUSION AND CLINICAL IMPLICATION

It is evident that the shoulder is at risk and shoulder injury is predicted in both the group's i.e novice as well as elite badminton players. Though there was no significant difference in GERG, GIRD and GIRD/GERG ratio, significant decrease in glenohumeral internal rotation and increase in glenohumeral external rotation was detected along with significant difference in posterior soft tissue tightness. Similarly, though scapular muscles strengths showed marked increase, the scapular stability was altered. Thus follow-up assessments in on-season and off-season are necessary to maintain and prevent shoulder injury. Regular shoulder and scapular mobility, individual muscle activation and strengthening, posterior soft tissue stretching and kinetic chain prehab should be part of fitness regimen from initial phase. Early investigation detects abnormal findings and helps to plan early intervention thus preventing future shoulder injuries.

Limitations

Study was performed in particular age group (18 and above); in less number of subjects wherein biological and adaptive changes will differ from individual to individual including their playing techniques, posture, fitness regimen, prior strength conditioning and nutrition, so no generalization of results should be done in other population and further research is required in large population with longitudinal follow up.

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Author Contributions

All the authors contributed generally in all aspects of study and manuscript progress.

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Conflict of Interest

The authors declare that there are no conflicts of interests.

Informed consent

Written & Oral informed consent was obtained from all individual participants included in the study. Additional informed consent was obtained from all individual participants for whom identifying information is included in this manuscript.

Ethical approval

Ethical approval was taken from Institutional review board (approval no. DYPUSOP/019A/2018), School of physiotherapy, D.Y Patil University, Nerul, Navi Mumbai. India.

Data and materials availability

All data associated with this study are present in the paper.

Peer-review
External peer-review was done through double-blind method.

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