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Relationship between Upper Extremity Dynamic Balance and Hand Grip Strength in Professional Basketball Players-A Pilot study

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Abstract
Background: *Basketball is a contact pivot sport. Basketball moves are generally individual actions used by players in basketball to pass by defenders to gain a clean pass to a teammate to score points. Stability, mobility and strength are the 3 main components to determine the athlete's performance among the professional basketball players. There are limited studies and effective method of evaluation on field test that assess upper body stability, mobility and strength. This study aims to assess the relationship between upper extremity dynamic balance and hand grip strength in professional basketball players.*
Materials and Methods: *Convenience sampling technique was used to include 20 Professional basketball player's age between (18-28) years. After initial assessment of age, height, playing hours per day per week and upper limb length measurement. Upper extremity dynamic balance using Upper Quadrant Balance Test (UQ-YBT) and Hand Grip Strength (HGS) using Jamar hand held dynamometer were measured.*
Results*: Karl Pearson's correlation was used to measure the relationship between hand grip strength and upper extremity dynamic balance. Moderate positive correlation was found between Left-HGS and Left-UQYBT(r=+0.479), Right-HGS and Right-UQYBT(r=+0.556), (p>0.05).*
Conclusion: *This study conclude that, the tests are interrelated and also can be use to assess equal component of upper extremity ability. This observation may provide professional basketball trainer and physical therapist with a reliable and easy quick-to-administrate to evaluate upper extremity stability, mobility and strength in a clinical setting.*
Keywords: *Upper extremity dynamic balance; hand grip strength; professional basketball Player; Jamar hand held dynamometer.*

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I. Introduction

Basketball is one of the most popular games and is thought to be played throughout the world by many countries for about more than 450 million people. Basketball is a contact pivot sports and moves are generally individual actions which is used by basketball player to pass by defenders and gain a clean pass to score points. The movements which includes upper extremities are dribbling, over the head, layups, reverse layups, finger roll, bank shot, pot back, tip in, pump back, hook shot, shooting, passes like bounce pass, chest pass, over the head pass, baseball pass, jump pass, behind the back[1].

The rotator cuff is a group of muscles that help to keep the shoulder in place, providing stability and range of movement. The rotator cuff connects the upper arm bone (the humerus) to the shoulder blade (the scapula). Whenever shoulder is moving, the rotator cuff muscle is hard at work, keeping a balance between stability and mobility. Basketball players increased their shoulder rotation at target dribbling [2]. The most frequently injured parts in basketball is lower limb (56.25%), followed by upper limb (29.17%) fingers (16.67%) forearm and wrist (8.33%) shoulder (4.17) was observed due to overuse injury sport elements and contact injuries[3].

Some of the most common shoulder injuries in basketball players are bursitis of the shoulder, rotator cuff tendonitis and rotator cuff tear. In basketball, the rotator cuff is constantly in use while dribbling or playing defense. But it's the overhead motions that are particularly strenuous on the rotator cuff, which is why an inflamed rotator cuff from basketball is especially common from shooting hoops. Because of repetitive motion of shooting, it can quickly become irritated and then inflamed. As the result of an acute injury a tear may begin as a more minor tear or injury and which can progress to partial or full thickness tear of rotator cuff if basketball

player continues to with the injury. Upper Quadrant Balance Test (UQ-YBT) is used to measure shoulder mobility and stability has been shown to be a reliable test to assess unilateral upper extremity performance in a closed chain position[4].

Various movements of basketball like holding, catching, shooting and throwing the ball rely on the continuous use handgrip strength by wrist and digits flexors. Hand Grip Strength (HGS) is an indicator of the overall strength of the upper extremity and is correlated well with mortality and morbidity of several conditions[5, 6]. Researchers have studied the relationship between pre-operative muscle weaknesses as assessed by HGS and post-operative outcomes. Studies report that, a distal extremity task causes the activation of proximal shoulder muscles[7]. Upper extremity function and proximal stability provided by shoulder girdle is correlated with handgrip strength. Hand grip strength has been used to assess general strength for determining work capacity, the extent of injury and disease process and progress of rehabilitation. Upper extremity function can be assessed by using hand grip strength as a parameter[8].

Hartmann, Caine, et al. in a study concluded that, the important risk factor for injury is a history of previous injury which can cause muscle imbalance, ligament laxity and altered range of motion. Shoulder injury in professional athletes can be devastating for instance; a systematic review and meta-analysis conducted by Klouche et al. found that only 49.9% of competitive and professional athletes (from various sports) returned to play off after rotator cuff repair at equivalent level. These injuries have been associated with muscle weakness, proprioception, balance and strength imbalance between the agonist and antagonist muscles which can be assessed with both open or closed chain testing[9, 10].

At the professional level, numerous tests and training programs are being used to monitor the performances levels of players. These outcomes measures are used to adjust training techniques in an attempt to overuse injuries and prevent traumatic. Trying to specify clear criteria for a return to play and injury prevention which is one of the most active fields of sports medicine today. Identifying elite athletes with muscular imbalances and adaptation to sport, pathologic situation which can be related to previous injuries is very important in recognizing and using muscular testing in elite athletes[11].

Stability, mobility and strength are the 3 main components to determine the athlete's performance among over head athletes. There are limited studies done on field test that assess upper body stability, mobility and strength[9]. As above mention component are three important factors to evaluate the upper limb function in professional basketball player by determining these components basketball player can evaluate which ultimately prevent the further injury of upper extremities and determine the rehabilitation outcomes.

II. Materials And Methods

A pilot study was conducted on professional basketball players in and around Dakshina Kannada, Karnataka, India from 2020 September to June 2021. The study was approved by the institutional ethical committee. 20 professional basketball players (Dorien Borms[9] assuming r=0.38) fulfilling inclusion and exclusion criteria were recruited using convenience sampling technique and then players allotted to two fields test namely upper extremity dynamic balance using Upper Quadrant Balance Test (UQ-YBT) and Hand Grip Strength (HGS) using Jamar hand held dynamometer using computer-generated sequence technique. All participants were verbally explained about the study in brief and then were recruited in the study after written consent.

Study Design: Cross-sectional study design.
Study Location: Basketball club in and around Dakshina Kannada, Karnataka, India
Study Duration: 2020 September to June 2021.
Sample size: 20 professional basketball players.
Sample size calculation: A sample size was estimated based on the study by Dorien Borms et al.[9] r=0.38 1.96 at 95% confidence interval, 0.84 at 80% power level r = 0.38. The sample size actually calculated was 52 for cross- sectional study among which 20 were included for cross-sectional pilot study.
Subjects and selection methods: Professional basketball players were recruited based on inclusion and exclusion criteria
Inclusion criteria:

1. Basketball players age between 18-28 years.
2. Three or more years of competitive experience.
3. Regular participating players' minimum for 5 to 8 hours per week.

Exclusion criteria:

1. Basketball players having history of orthopaedic surgery of upper and lower quadrant or spine.
2. Pain in these regions interfering with sport participation within 6 months.
3. Weight training within 6 months.
4. Neurological, muscular and skeleton disorder.

Procedure and methodology

A pilot study design was employed in this study. In which 20 professional basketball players participated in the study. A written consent was obtained from each subject after detailed explanation of procedure. All the players were asked to fill a performa that includes age, weight, height, dominance of upper extremity and playing hours (minutes/day; days/week). After initial assessment all players were asked to do testing of Hand Grip Strength (HGS) using hand held dynamometer and field tests viz. Upper Quarter Balance Test (UQ-YBT) thus reduces assessor bias. Also, the tests was carried out in random fashion i.e. either UQ-YBT first or HGS first to reduce sequencing error. Each test was carried out for three times after one initial trial. Rest of 30 seconds was allowed between trial and 5 minutes between tests.

Outcome Measures

Both the outcome measures have good reliability and validity[4, 14, 20]. All players were assessed.

1. Measurement of Hand Grip Strength (HGS) using Jamar Hand Held Dynamometer.

The measurement was conducted according to standard procedures recommended by the American Society of Hand Therapists (ASHT). The participants were instructed to maintain that position during the test. The HGS of both hands was measured using the Jamar hand dynamometer. Reliability of the Jamar hand dynamometer is confirmed in many populations[14]. The testing range on a dual scale was (0-100kg) and same dynamometer was used throughout the study. Grip strength data were collected in shoulder 90^0 of flexion with elbow full extended, forearm in mid prone and wrist in extended position. For data collection, a practice trial was given to familiarize the players with the dynamometer. Before testing, the examiner demonstrated how to hold the dynamometer. Then the players were asked to squeeze continuously for 2–3 s on a verbal statement[14]. The same instructions were given for each trial. After the player position with the dynamometer, instruction was given to the player's to "squeeze as hard as possible". To control for the effects of fatigue, players were asked to rest for 30 second. For both hand, three trials was perform. Mean of 3 trials was recorded for calculation purpose which was used in further analysis[14].

2. Measurement of Upper Extremity Dynamic Balance using UQ-YBT.

Upper quarter balance test is a comprehensive valid and reliable field tool that measures stability and mobility of upper extremity in closed kinetic position. The player performs maximal reaching in three directions (medial, superolateral, and inferolateral) with one hand by maintaining the push up position with the extremity being tested. The test was repeated three times after one trial on each. The variable of interest for the study was normalised and maximal reach distances for each reach direction along with composite reach distance. The greatest successful reach for each direction were used for analysis. The maximal reach distance in each direction was divided by the subject's upper limb length to normalise each reach distance. To measure upper limb length, the player was asked to stand in an anatomical position while the investigator identifies the C7 vertebrae. After C7 was identified, the investigator instructs the subject to rise (abduct) the right limb to shoulder height (90^0). The examiner measured distance between the C7 spinous process to the most distal tip of the right middle finger (in centimetre) with measuring tape. Composite reach distance were calculated by averaging the greatest trial in each of the 3 normalised reach distances for analysis of the overall performance of the test.[4, 20]

Statistical analysis

Descriptive statistics were calculated including means, standard devastation of hand grip strength and upper extremity dynamic balance. Karl Pearson correlation coefficient(r) was used to determine the relationship between hand grip strength and upper extremity dynamic balance. P-value of ≤ 0.05 was considered statistically significant. All statistical analysis was performed using SPSS (version 26.0).

III. Results

In the present study it was observed that the mean age (in years) of the study participants were 22.4 ± 3.2 years. Among which 75% (15) players play for 2 hours and 25% (5) players play for 1 hour per day.

Table no. 1 Descriptive statistics of Left and Right Hand Grip Strength (HGS) and Left and Right Upper Extremity Balance Test (UQ-YBT)

	Mean	Std. Deviation
LHGS	35.15	3.801
RHGS	40.50	4.224
LUQ-YBT	89.45	3.052
RUQ-YBT	92.50	3.411

Table1. Mean and SD of HGS and UQ-YBT.

Table No.2 Correlation between Hand Grip Strength (HGS) and Upper Extremity Dynamic Balance Test (UQ-YBT), Correlation between Right Hand Grip Strength (RHGS) left and right respectively.

	UQ-YBT r-value	UQ-YBT P- value
LHGS and LUQ-YBT Pearson Correlation	.479*	.032
RHGS and RUQ-YBT Pearson Correlation	.566**	.009

Table 2. Correlation coefficient between UQ-YBT and HGS.

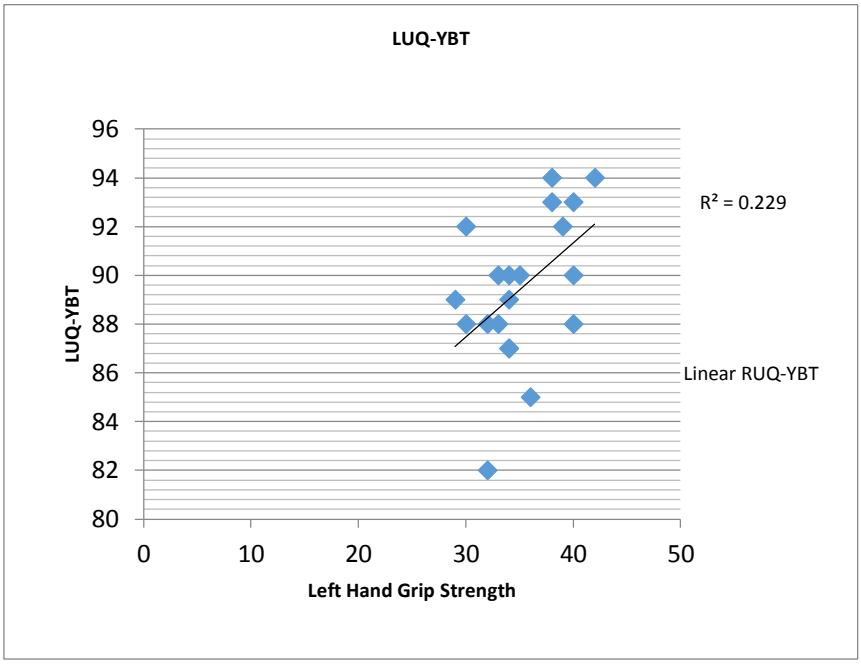

Fig.no.1 Scatter diagram representing LHGS and LUQ-YBT

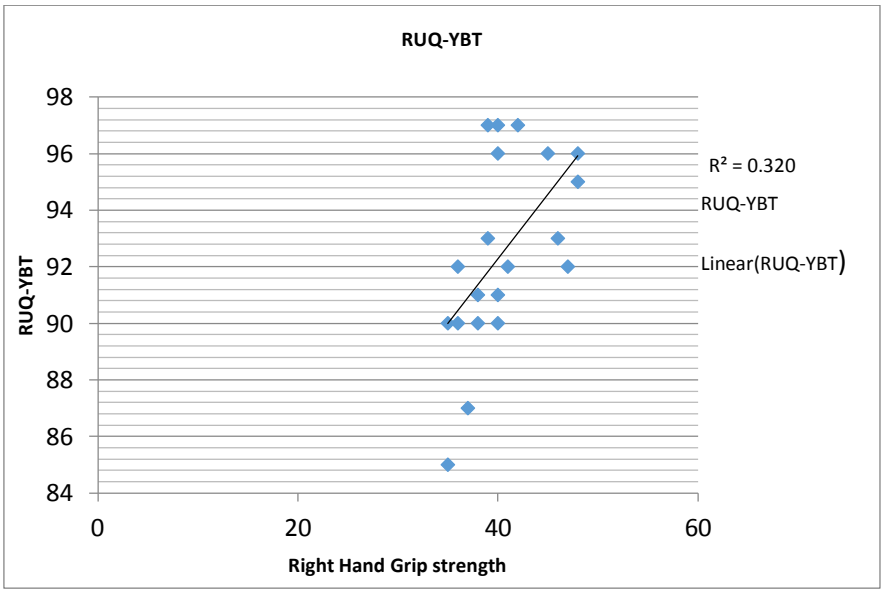

Fig. no.2 Scatter diagram representing RHGS and RUQ-YBT.

IV. Discussion

The purpose of the current study was to explore the relationship between hand grip strength and upper extremity dynamic balance in professional basketball players. All the 20 players included in this study had completed the test under supervision without fail. Statistically moderately positive correlation was observed between LHGS and LUQ-YBT ($p<0.05$) and RHGS and RUQ-YBT ($p<0.01$).

Handgrip strength has been used to assess general strength for determining work capacity, the extent of injury and disease process and progress of rehabilitation. In short, handgrip strength is a parameter to assess

the function of the upper extremity in open kinetic chain[24]. Handgrip strength is an indicator of the overall strength of the upper extremity and is correlated well with mortality and morbidity of several conditions[5]. Several researcher and literatures have found that Jamar hand held dynamometer is a validity, reliability, test and re-test and inter-rater and intrarater reliability to measure hand grip strength in open kinetic chain. ICC ranging from 0.975 -0.966 in basketball players by Vassilis Gerodimos, et al.[27] In this study, we used Jamar hand held dynamometer to measure HGS in professional basketball players. The professional basketball players in our study performed both dominant and non-dominant limb. In this present study we found that mean score of grip strength of dominant hand i.e. right hand grip strength (RHGS=40.50±4.224) was more as compare to non-dominant limb i.e. left hand grip strength (LHGS=35.15±3.8010). In a study by Vassilis Gerodimos, et al.[27] found that means grip strength of dominant hand was 42.88±20.69 and non-dominant hand was 42.24±20.32 which slightly higher than in present study.

Mean scores of UQ-YBT (left, 89.45±3.052 and (right, 92.50±3.411) in 3 reach direction and the composite score were higher than those reported in previous studies. In a study by Gorman PP, et al.[4] found that composite score of mean UQ-YBT was 85.1±8.0 which less then present study. Another study conducted by Dorien Borms, et al[9] found that composite score of mean UQ-YBT in dominant limb was 90.14±7.56 and non-dominant limb was 89.65±6.02 and a study by Westrick et al.[20] found that the mean of UQ-YBT in dominant hand was 86.5±8.1 and non-dominant hand was 88.1±7.4 which was also found to be quite similar to the current study.

Unlikely, in the present study relationship was expressed significant highly with considering the extent of correlation coefficient (weak, moderate, strong). According to the classification that we used, correlations were moderate positive correction between UQ-YBT and HGS both dominant i.e. right and non-dominant i.e. left hand (left, r=0.479 and right, r= 0.566) respectively, which shows that increase in one another variable corresponding to each other, which suggest that upper limb strength, stability and mobility are prerequisites among professional basket ball players. In contrast to this study, Westrick et al.[20] examined the relationship between the YBT-UQ and shoulder isometric strength, measured by a handheld dynamometer in a healthy non-overhead athletes. They found low relationship between the UQ-YBT and shoulder strength which was not in line with our result ($p>0.05$), in addition they found out a relationship between the UQ-YBT and measurement for core stability, evaluated by lateral trunk endurance test, and upper extremity stability, measured by Close Kinetic Chain Upper Extremity Stability Test (CKCUEST) ($P<0.05$).

We have used modified upper quarter Y- balance test kit as a field test in this current study for assessing upper extremity dynamic balance in professional basketball players. Several studies have been done on validity and reliability of modified UQ-YBT kit. One of study conducted by Josh Cramer, et al. on, exploration of score agreement on a modified upper quarter Y-balance test kit as compared to the upper quarter Y-balance test. And concluded that, the modified UQ-YBT produced similar results in both inter- and intra-rater measurements when compared to the commercialized YBT kit (and offers a cost-effective alternative for assessing upper quarter physical performance measures for clinicians with limited budgets.[24] Gorman et al., conclude in a study that, UQ-YBT as reliable test for measuring upper extremity reaches distance while in a closed chain position. The interclass correlation coefficient (ICC-3, 1) for test-retest reliability ranged from 0.80-0.99 while that for intra-rater reliability was 1.00.[10] Since, UQ-YBT has excellent intra-rater and inter-rater reliability claiming that is a reliable test for upper extremity dynamic balance in professional basketball players which can also to predict the risk of upper extremity injuries in overhead athletes.[4, 9, 15, 16, 20]

In the favor of our present study, Dorien Borms, et al. has given normative data based on age, gender and sports, which is clinically relevant for functionally screening overhead athletes and benchmarking their performance using UQ-YBT.[25] A paper published by M. Degot, Y. B. lache L, et al. concluded that, it can be considered as a reliable tool to quantify side-to-side difference in upper limbs and can be use as relevant tool on healthy athletic population for asymmetry measurement or after an injury to objectify functional deficit. Thus, in a rehabilitation context, the UQ-YBT score may be used as a criterion to complete the decision-making process for returning-to sport.[23] Recently several researchers have demonstrated that shoulder strengthening and stabilization exercises improve dynamic balance.[21] Studies have also been reported that following shoulder injury return to play of professional basketball players were high after shoulder instability, recurrent instability and shoulder dislocation.[22] UQ-YBT measure overhead athletes performance (professional basketball players) and can be used as injury-prevention efforts on examining the ability of performance.[8, 9, 10, 20]

A study conducted by Shaji J, et al. on, effect of shoulder stability exercises on hand grip strength in patients with shoulder impingement syndrome and found that, there is reduction in isometric hand grip strength of the affected shoulder side (16.3±8.8) compared to that of the non-affected shoulder (20.6±10.5).[16] Researchers have studied the relationship between pre-operative muscle weaknesses as assessed by hand grip strength and post-operative outcomes. Studies report activation of proximal shoulder muscles in response to distal extremity tasks. Results was similar to the current study which found positive correlation between hand grip strength and upper extremity dynamic balance and Williams et al. conducted study on muscular strength

spurts in adolescent male basketball players and he found that grip strength is correlated with upper extremity function and proximal stability provided by shoulder girdle on the basis of kinetic chain principles.[26]

Brittanham, et al. suggested that to develop an athlete's maximum strength and power potential, the primary focus of training program should be directed towards strengthening. In addition, several researches have reported that dynamic balance can help optimize over head athletic performance.[9] Dynamic balance screening has shown to provide additional information to identify professional basketball players at an elevated risk for injury and that following injury, changes in dynamic balance occur, which in turn decreases dynamic balance ability.[3, 21] Based on our own results and on studies by other authors, overall the results of this pilot study indicate that there is positive correlation between handgrip strength and upper extremity dynamic balance in professional basketball players. Thus, using this outcome measures physical therapy, coaches and trainer can use as a assessment tool for assessing physical function and planning the rehabitation as well as conditioning exercise program regardless of professional basketball players.

Some limitations of our study need to be considered. First we only included professional basketball players and sample size was small which could have influenced our results. This may be due to lack of experience of the participants with the procedure adapted in this study. Second, this study has included only professional basketball players' age limit between 18-28 years which could vary on other population groups. Third, this study can't be generalized with other groups like children and older population. Fourth, only professional players with no history of previous injuries were involved so, additional research is necessary to establish the responsiveness of UQ-YBT and hand grip strength wrist, elbow and shoulder pathology.

V. Conclusion

This study concluded that, there was moderate positive correlation between upper extremity dynamic balance and hand grip strength in professional basketball players. Thus, performance test are interrelated and also can be use to assess equal component of upper extremity ability. This observation may provide professional basketball trainer and physical therapist with a reliable and easy quick-to-administrate to evaluate upper extremity stability, mobility and strength in a clinical setting. It can help to determine rehabilitation goal for injured professional basketball player using these measuring tools.

References

[1]. Cohrad BR. The biomechanics of basketball agility. Sport Sci Rev.2014; 1:1:8.
[2]. Fujii K, Yamade Y and Oda S. Skilled basketball players rotate their Shoulder more during running while dribbling. Percept Mot Skill.2010; 110(3):983-994.
[3]. López Gonzále, Rodríguez Costa and Palacios Cibrián. Injury incidence rate among amature basketball players. Phys Rehab. 2015; 17(66):299-316.
[4]. Gorman PP, Butler RJ, Plisky PJ and Kiesel KB. Upper Quarter Y Balance Test: reliability and performance comparison between genders in active adults. J Strength Cond Res. 2012; 26(11):3043-8.
[5]. Chen CH, Huang YZ and Hung TT. Hand-grip strength is a simple and effective outcome predictor in esophageal cancer following esophagectomy with reconstruction: a prospective study. J Cardio Thorac Surg. 2011; 6(1):1-5.
[6]. Sultan P, Hamilton MA and Ackland GL. Preoperative muscle weakness as defined by handgrip strength and postoperative outcomes: A systematic review. BMC. Anesthesio. 2012; 12(1):1-0.
[7]. Horsley I, Herrington L, Hoyle R, Prescott E and Bellamy N. Do changes in hand grip strength correlate with shoulder rotator cuff function? J Shoulder Elb. 2016; 8(2):124-9.
[8]. Joshi S and Sathe T. Correlation between grip strength and scapular muscle. Int J Adv Res Innov Ideas Educ. 2018; 4(3):2111-7.
[9]. Borms D, Maenhout A, Cools AM. Upper Quadrant Field Tests and Iso-kinetic Upper Limb Strength in Overhead Athletes. J Athl Train. 2016; 51(10):789–96.
[10]. Salo TD, Chaconas E. The effect of fatigue on upper quadrant Y-balance test scores in recreational weightlifter: A randomized controlled trail. Int J Sport Phys Ther. 2017; 12(2):199-205.
[11]. Schiltz M, Lehance C, Maquet D, Bury T, Crielaard JM and Croisier JL. Explosive Strength Imbalances in Professional Basketball Players. J Athl Train. 2009; 44(1):39–47.
[12]. Ahmed T. The Effect of Upper Extremity Fatigue on Grip Strength and Passing Accuracy in Junior Basketball Players. J Hum Kinet. 2013; 37(1):71-9.
[13]. Karanjkar Y, Prabhu A, Vishal K. Correlation of Handgrip Strength to Postoperative Outcomes in Rotator Cuff Repair: A Preliminary Report. M L T J. 2019; 9(1):145-149.
[14]. Savva C, Mougiaris P, Xadjimichael C, Karagiannis C and Efatathios M. Test-retest Reliability of Handgrip strength as an outcome measures in patients with symptoms of shoulder impingement syndrome. J. Manip. Physiol. Ther. 2018; 41(3):252-7.
[15]. Priya S, Krishna HS, Theertha K, Sebastian S: Relationship between scapular muscle performance and grip strength in lateral epicondylits among computer operator. Int J Phy Ther Res. 2019; 7(6):3275-80.
[16]. Kachanathu SJ, Zedan AM, Hafez AR, Alodaibi FA, Alenazi AM, Nuhmani S. Effect of shoulder stability exercises on hand grip strength in patients with shoulder impingement syndrome. Somatosens Mot Res. 2019; 36(2) :97-101.
[17]. Parvatikar VB, Mukkannavar PB. Comparative Study of Grip Strength in Different Positions of Shoulder and Elbow with Wrist in Neutral and Extension Positions. J Exerc Sci Phy Ther. 2009; 5(2):67-75.
[18]. Isen J, Mcgue M, Lacono W. Genetic Influences on the Development of Grip Strength in Adolescence. Am J Phys Anthro. 2014; 154(2):189–200.
[19]. Gohal C, Khan M, Burrus T, Madden K, Gagnier J, Joseph P, et al. Impact of Shoulder Injuries on Quality of Life for Retired National Basketball Association Players: A survey study. Int J Sport Exerc Med. 2019, 5(12):154.
[20]. Westrick RB, Miller JM, Carow SD, Gerber JP. Exploration of the y-balance test for assessment of upper quarter closed kinetic chain performance. Int J Sport Phys Ther. 2012; 7(2):139.

[21]. Yu JH and Lee GC. Comparison of shoulder range of motion, strength, and endurance in amateur pitchers practicing repetitive overhead throwing. I E S. 2013; 21(2):135–140.
[22]. Ialenti MN, Mulvihill JD, Feinstein M, et al. Return to Play Following Shoulder Stabilization: A Systematic Review and Meta-analysis. Ortho J Sport Med. 2017; 5(9):1-6.
[23]. Degot M, Blache Y, Neyton L, Rogowski I. Intersession reliability of the upper quarter Y balance test score. Biomech Biomed Eng. 2019; 22(1):405–407.
[24]. Cramer J, Quintero M, Rhinehart A, Baker RT, et al. Exploration of score agreement on a modified upper quarter Y-balance test kit as compared to the upper quarter Y-balance test. Int J Sport Phy Thera. 2017; 12(1):117-124.
[25]. Borms D, Cools A. Upper extremity functional performance tests: reference values for overhead athletes. Int J Sport Med. 2018; 39(06):433-441.
[26]. Guimaraes E, Maia JA, Williams M, Sousa F, et al. Muscular Strength Spurts in Adolescent Male Basketball Players: The INEX Study. Int J Environ Res Pub Health. 2021; 18(2):776.
[27]. Gerodimos V. Reliability of Handgrip Strength Test in Basketball Players. J Hum Kin. 2012; 31(1):25-36.

Priya S, et. al. "Relationship between Upper Extremity Dynamic Balance and Hand Grip Strength in Professional Basketball Players-A Pilot study." *IOSR Journal of Sports and Physical Education (IOSR-JSPE,) 8*(4) (2021): 23-29.