DOI: 10.7860/JCDR/2023/58020.17677

Original Article

Physiotherapy Section

Effectiveness of Fitness Testing for Assessment of Male Basketball Athletes- A Cross-sectional Study

AMITA AGGARWAL[1], CHAITANYAA WANI[2], YASH JAISWAL[3]

ABSTRACT

Introduction: Basketball players should have physical characteristics which include sports-specific skills and demands. Activities including sprinting, and jumping require abilities with speed, power, strength, and agility. These have to be evaluated using fitness tests which help in having a good impact on the game. Assessment of their performance will be helpful for designing and monitoring the efficacy of basketball athletes' training regimes.

Aim: To assess the body composition and fitness tests specific to cardiorespiratory fitness, upper and lower limb strength, endurance, flexibility and agility in 20-29 years male basketball players.

Materials and Methods: It was an observational cross-sectional study which was conducted on 30 male basketball players in Dr. DY Patil Medical College, Pune, Maharashtra, India from June 2017 to December 2017. Participants were assessed for specific fitness tests conducted in two days. Agility, upper extremity strength, lower extremity endurance including flexibility, was tested on the first day, followed by body composition, cardiorespiratory fitness, upper extremity endurance and lower extremity strength on another day.

Results: The mean age of the male basketball players was 21.8 years. The mean Body Mass Index (BMI) was 22.53 Kg/m^2. It showed a poor (35.58±4.80) cardiorespiratory fitness using the Beep Test. For the upper limb, there was poor flexibility (13.01±3.45). However, the lower limb endurance (60.33±19.80) and agility (12.08±0.66) showed excellent results.

Conclusion: The study concluded that lower extremity fitness was better than upper extremity in male basketball players.

Keywords: Agility, Body composition, Flexibility, Muscular endurance, Muscular strength

INTRODUCTION

Basketball is a high intensity contact sport. The fame of basketball has increased with an estimated 11% of the world's population. About 450 million individuals are currently playing across 213 countries affiliated with Fédération International de Basketball (FIBA) [1]. As a high intensity sport, it involves the use of an anaerobic energy system greater than aerobic [2]. This permits high bodily demands ofvarious systems like musculoskeletal, cardiovascular, and metabolic systems [3].

Though handgrip strength is essential for passing the ball, explosive strength of the lower limb is needed for adjustment during movements such as lateral shuffling, sprinting etc., [4,5]. Players are exposed to loading and jumping forces of high intensity [5]. Studies reported high knee injuries during the game [6-8]. The odds of ankle twists are higher than overuse damage [9]. It requires a good physical fitness evaluation to prevent the risk of injuries before the game [10,11].

Fitness involves different physical screening tests of variables possible. For the upper limb, during bounce backs and strength required for passing the ball, endurance and flexibility components need to be evaluated [4]. For the lower limbs, swiftness and agility are necessary along with strength and stamina [12].

As the risk of sports injury increases with a decrease in fitness among players, it necessitates a good prescreening assessment. This will help in better recovery of players after injury according to their physical needs [13]. A higher prevalence of injury was reported during training than competition [14].

Previously many studies have been done on basketball players examining the rate of injury in different age groups and common types of injuries. Studies also included balance testing, cardiorespiratory assessment, and lower limb strength testing; but upper limb fitness was hardly brought into consideration. The upper limb serves as the first contact point for the ball and is responsible for skillful ball manipulation [15]. Overhead movements and fall on outstretched hand can be seen as causal factors for upper limb injuries during basketball [16]. A study on elite female basketball players reported a 12% incidence of upper extremity pain and injury [17]. This study was an effort to assess different components of fitness including upper and lower limb strength, endurance, and flexibility along with body composition, speed and agility, and cardiorespiratory fitness among young male basketball players of age group (20-29 years).

MATERIALS AND METHODS

The cross-sectional observational study was conducted at Dr. D.Y. Patil College of Physiotherapy, Pune, Maharashtra, India, from June 2017-December 2017. Ethical clearance was obtained from the institutional subethics committee (DYPCPT/ISEC/50/2017). A total of 30 male basketball players aged between 20-29 years were recruited using purposive sampling. All the players gave informed written consent for the study.

The prevalence of injury in basketball games per player in a season has been 3.6% [14]. With an acceptable difference of 7% and 95% confidence interval, the calculated sample size was 30, using Winpepi software version 11.65.

Inclusion criteria: Male basketball players aged between 20-29 years, with a minimum of five years of training experience, and a minimum of 6 hours/week of training were included in the study.

Exclusion criteria: The subjects with any joint instability, history of fracture in the last one month, any cardiac or respiratory condition were excluded from the study.

Study Procedure

Demographic data was collected regarding different components of fitness. The test was conducted in two days to provide sufficient rest for the players. Thus, it was designed accordingly-Illinois Test, shoulder and wrist elevation test, sit and reach test, handgrip test, and Squat Test were done on 1st day; while Push-up Test, stand broad/long jump, body composition assessment and 20-metre Shuttle Run Test/Beep Test was done on the 2nd day.

- **For assessing the body composition:** BMI [18] was recorded using Tanita electronic scale.
- **For assessing the cardiorespiratory fitness:** VO_2 max was calculated using a 20-metre Shuttle Run Test/Beep Test [19]. Cones, as markers, were kept at a distance of 20 m and the subjects were asked to run between the same with the pace maintained in relation to the beep heard. As the subject reached the other end of the distance and heard another beep the shuttle continued. The process was repeated until the athlete won't be able to maintain pace with a beep [Table/Fig-1]. For 20-29-year-old males, the Beep Test grading are- very poor (under 33), poor (33-36.4), fair (36.5-42.4), good (42.5-46.4), excellent (46.5-52.4), and superior (over 52.4).

[Table/Fig-1]: Beep test/20 m Shuttle Run test.

- **Evaluation of upper extremity fitness:**

1) Strength: It was assessed using a Handgrip Test [20]. The subject was seated in a chair with shoulder adducted, elbow 90 degrees flexed and wrist with forearm in a neutral position. Then the Jamar dynamometer was held in the subjects hand and instructed to apply smooth grip force for atleast 5 seconds. An average of 3 trials was used for measurement. For 20-29 years, males norms of right-hand grip strength include P10 (33.9 to 41.2), P30 (41.3 to 45), P50 (45.1 to 50.5), P70 (50.6 to 56.2), and P90 (greater than 56.3) while left-hand grip strength norms are P10 (34 to 39.3), P30 (39.4 to 43.5), P50 (43.6 to 47.7), P70 (47.8 to 53.6) and P90 (greater than 53.7) [Table/Fig-2].

[Table/Fig-2]: Handgrip test.

2) Endurance: It was tested using the Push-up Test [21,22]. Subjects were asked to keep hands at shoulder distance apart and feet together (shoes on) on the floor. While keeping the spine in neutral, subjects were asked to move a maximum towards the floor. The number of repetitions completed was recorded as upper extremity endurance. For 20-29 years, male norms for push-up test grading are very poor (0-3), poor (4-9), below average (10-16), average (17-29), above average (30-39), good (39-47) and excellent (above 57) [Table/Fig-3].

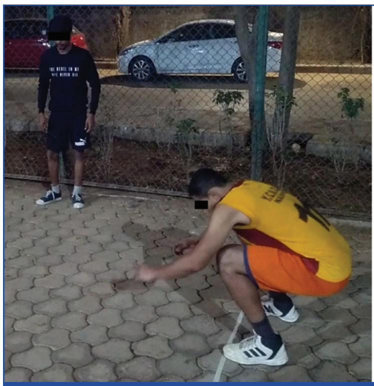
[Table/Fig-3]: Push up test.

3) Flexibility: In shoulder and wrist elevation test after recording arm length from shoulder to middle of finger, the subject was asked to lie in a prone position on the floor [23]. Then, with the chin in contact with ground subject has to raise his hands maximum towards the ceiling. Recording was obtained as arm length- trial recording from floor to arm. For upper limb flexibility norms followed are poor (greater than 12.50), fair (11.50 to 12.50), average (8.25 to 11.49), good (6 to 8.24), and excellent (less than 6) [Table/Fig-4].

[Table/Fig-4]: Shoulder and wrist elevation test.

- **Evaluation of lower extremity fitness:**

1) Strength: In a long jump, the subject placed both legs over the mark, and using the arms and legs, jump horizontally as far as possible, staying upright with feet together. The distance from the mark to the nearest impression, made by the subject, was measured. Normative data for standing long jump includes grading as-0% (<1.90), 1-10% (1.90-2.04 m), 11-20% (2.05-2.19 m), 21-30% (2.20-2.34 m), 31-40% (2.35-2.49 m), 41-50% (2.50-2.64 m), 51-60% (2.65-2.79 m), 61-70% (2.80-2.94 m), 71-80% (2.95-3.09 m), 81-90% (3.10-3.39 m) and 91-100% (3.40-3.75 m) [Table/Fig-5] [24,25].
2) Endurance: It was measured using a Squat test [26]. A good height chair that makes a right angle at the knees while sitting was used. Standing with feet shoulder width apart and hands in front, the subject performed a squat and lightly touched the chair before standing back up. The number of squats performed was recordedand graded in males of age 20-29 years, grading as- very poor (less than 21), poor (21-23), below average (24-26), average (27-29), above average (30-32), good (33-34), excellent (greater than 34) [Table/Fig-6].
3) Flexibility: Sit and reach test involves long sitting on the floor. Feet (shoes off) were placed flat against the box with the examiner holding both knees flat against the floor. The subject leans forward slowly as far as possible and holds the greatest stretch for two seconds. There should be no jerky movements



[Table/Fig-5]: Standing broad/long jump test.
[Table/Fig-6]: Squat test. (Images from left to right)

and the fingertips remain level and the legs flat. Repeat twice and record the best score. Norms followed for grading-need improvement (24 cm), fair (24 to 29 cm), good (30 to 33 cm), very good (34 to 39 cm), and excellent (40) [Table/Fig-7] [27].

[Table/Fig-7]: Sit and Reach test.

- **For assessing speed and agility:** The dimension of the course was 10×5 m and the Illinois Test was done [28]. Four cones were used to mark the start, finish and the two turning points. Another 4 cones were placed down the centre spaced 3.3 m apart. The subject started from the start line. With a 'Go' command, the stopwatch was started, and the subject got up as quickly as possible and ran around the course in the direction instructed, without knocking the cones to the finish line, at which the timer was stopped.The faster of the two trials was used for scoring in seconds. Norms for grading are poor (more than 19.3 s), below average (18.2-19.3 s), average (16.2-18.1 s), above average (15.2-16.1 s), and excellent (less than15.2 s).

STATISTICAL ANALYSIS

Normative data were obtained for all the assessment tests using Win Pepi software (version 11.65). Mean and SD were calculated for each parameter.

RESULTS

The average BMI obtained for the basketball players (mean age 21.8±1.9 years) was 22.53±3.48 kg/m^2. The cardiorespiratory fitness as recorded using the Beep Test was poor. Upper limb handgrip strength and endurance reported were graded as P30 (30%) and average, though upper limb flexibility was poor. Lower limb strength and endurance as reported with the jump test and the Squat Test was recorded as 21-30% rank and excellent. The mean for lower limb flexibility was 31.76±5.42. For the Illinois Test (s) among the basketball players, the mean obtained was 12.08±0.66 s which is considered to be excellent [Table/Fig-8] [18-21,23,25-28].

Variables		Mean±SD	Interpretation
Body Mass Index (BMI) kg/m^2		22.53±3.48	Normal (18.5-23) [18]
VO_2 Max		35.58±4.80	Poor (33-36.4) [19]
Handgrip strength (Kilograms)	Right	44.28±8.15	P30 (41.3-45.0)
	Left	40.15±5.76	P30 (39.4-43.5) [20]
Push ups		19.93±8.08	Average (17-29) [21]
Shoulder and wrist elevation test (inch)		13.01±3.45	Poor (>12.50) [23]
Standing long jump (m)		2.24±0.24	21-30% (2.20-2.34) [25]
Sit and reach test (centimetres)		31.76±5.42	Good (30-33) [27]
Squat test		60.33±19.80	Excellent >34 [26]
Illinois test (seconds)		12.08±0.66	Excellent (<15.2) [28]

[Table/Fig-8]: Various fitness tests variables in the basketball players [18-21,23,25-28].
Mean±SD with interpretation for various fitness tests variables in male basketball players

DISCUSSION

The present study was conducted with the aim to assess the physical fitness of male basketball players. There were 30 participants in the study aging between 20-29 years. Male basketball players with minimum of five years of training were included. They were assessed on the basis of their strength, endurance, and flexibility of their upper and lower limbs. Players were also assessed on the basis of their cardiorespiratory fitness, body composition, speed and agility to find their fitness levels.

One of the most important findings of this study is that the players showed great performance in speed and agility along with lower extremity muscle endurance and flexibility, while on the other hand, they have poor cardiorespiratory endurance.

Studies have linked anthropometry and fitness test scores with the team performance, rate of injuries along with player position [29,30]. Drinkwater EJ et al., found skill along with speed and agility as critical fitness components in basketball games [31]. Also, a study by Usgu S et al., stated that functional training can significantly improve overall body strength, flexibility and agility and can act as an alternative method for resistance training in basketball players. Traditional resistance training yields only a limited change for improving overall strength. In functional training a better force transfer between the upper and lower extremities through a linkage system occurs. Any addition of arm swing in vertical jump resulted in better power generation with greater heights during the jump [32].

As basketball requires a combination of both anaerobic and aerobic systems, it is still considered that the primary energy system used is the anaerobic system [33]. In addition, basketball requires integrated physical characteristics, including muscular strength, endurance, flexibility, speed, agility, take-off power, and dexterity [31,34]. It is a sport requiring high-intensity activities such as jumping (for rebounds, blocks, and shots), turns, dribbles, sprinting, screens, and low-intensity activities like walking, stopping, and jogging. Frequent pauses in the game allow players to recover between bouts of play/activity, thus helping to repeated high-intensity spells of play [35].

The BMI of these individuals was within normal limits. The speed and agility test performed (Illinois Test) showed excellent results in male basketball players, which clearly explains the demand for this particular skill in the sport. On the other hand, the cardiorespiratory fitness being tested with the help of the Beep Test/20 m Shuttle Run Test showed poor results. This indicates the poor cardiorespiratory health of the players.

As the game requires high-intensity activities and involves frequent stoppages, the demand for an aerobic system becomes comparatively less than anaerobic demands. Also, the sport allows as many substitutions as the team likes, thus the players do get a resting period [36]. Circuit training had shown improvements with cardiorespiratory endurance [37].

The rate of injury to the lower extremity is extremely high in the sport, in which the knee and ankle are the commonest sites of injury [38]. The reason behind the injuries can be activities like twisting, jumping, sudden turning or any external forces. Hence, to avoid injuries the players should undergo a proper training regime under guidance [16]. A study done by Ito E et al., on differences in injury types among basketball players shows that knee, foot, and ankle contribute more than 60% of injury rates in the age group of 20-29 years. The lower extremities are the most commonly injured area in basketball players. The playing surface (a hard, concrete/ wooden basketball court), affects body weight loading on the lower extremity, and repetitive action of jumping, landing, dashing, cutting, and stopping increases the incidence of ankle and knee injuries in basketball players [8].

In this study,the basketball players showed good lower extremity muscle endurance and flexibility, but comparatively less muscular strength. Bird SP and Markwick WJ in a study on basketball athletes' musculoskeletal screening and functional testing, found a greater physiological load of an average of 46 jumps with 105 high intensity sprints during competitive games among players. Players performed an average of 1000 movement pattern changes (one every 2.0 seconds) consisting of shifting and sprints [5].

This indicates high demand for lower extremity activities that require muscular flexibility, strength, and endurance. This not only helps in improving the performance of the players but also helps in reducing the chance of injury. Basketball, being a multidirectional sport, requires the highest frequency of lateral movement, maximum jumps and a high intensity run. This highlights the importance of lower limb fitness training during sport specific drill and pre-training periods [39].

Looking at the performance of the upper extremity, strength and endurance showed average results while flexibility showed poor results. The handgrip strength of both right and left was rated P30 (30%), which is considered below average. Manipulation of basketball during a game requires understanding of the upper limb biomechanics. Contact injuries are major cause for the occurrence of upper extremity injuries. Strengthening the muscles to withstand high impact forces can help in reduction of injuries [40].

Apart from the upper and lower limb movements, a functional stability around a lumbar region is also required. This includes strength and endurance for core muscles. Mobility at the distal extremities requires a proximal stability component for better force generation and distribution [41].

The absence of warm-up or familiarisation before testing for handgrip strength between test and retest measurements could be one of the reasons for a poor result. Subjects may learn over trials a better technique to squeeze harder. Therefore, indeed, Svensson E et al., suggested a familiarisation session and 3 maximal trials during main testing [42]. Grip strength is influenced by concentration, physical activity level, and training or biomechanical factors such as hand size with handle size [43].

A study on junior basketball players found that upper extremity fatigue affects the performance of players and is related to their passing and throwing precision [4]. This indicates players should avoid upper extremity fatigue which affects the level of performance and therefore should include upper extremity exercises in their training regime. Thus, it will help improve catching, holding, shooting, and throwing the ball [5]. Also, to achieve improved training, the specificity component should be taken into account. It guides the demands of a specific game and targets the training regime [39]. While setting the protocol, another important aspect to consider is that it should also include the demands of basketball player who differs as they move from regular play to competition [44].

Limitation(s)

A single test was used for assessment of each fitness component.

CONCLUSION(S)

The study concluded that lower extremity fitness was better than upper extremity in basketball. Handgrip strength is essential for throwing, passing, dribbling, and carrying the ball. Aerobic capacity in the players was very poor and needs to be improved as it is highly demanded by the sport. On the other hand, speed and agility along with lower extremity endurance and flexibility were excellent among these players, which help in the sport and reduce the chances of the hip, knee, and ankle injury among these players. Age and gender-specific analysis of assessment of fitness can be done. Also, fitness assessment of the spine component can be included.

REFERENCES

[1] International Basketball Federation. Quick facts. Available at: http://www.fi ba.com. Accessed Feb 11 2013.
[2] Ostojic SM, Mazic S, Dikic N. Profiling in basketball: Physical and physiological characteristics of elite players. J Strength Cond Res. 2006;20:740-44.
[3] Balčiūnas M, Stonkus S, Abrantes C, Sampaio J. Long-term effects of different training modalities on power, speed, skill and anaerobic capacity in young male basketball players. Journal of Sports Science and Medicine. 2006;5(1):163-70.
[4] Ahmed T. The effect of upper extremity fatigue on grip strength and passing accuracy in junior basketball players.Journal of Human Kinetics. 2013;37:71-79.
[5] Bird SP, Markwick WJ. Musculoskeletal screening and functional testing: Considerations for basketball athlete. The International Journal of Sports Physical Therapy. 2016;11(5):784-802.
[6] Deitch JR, Starkey C, Walters SL, Moseley JB. Injury risk in professional basketball players: A comparison of Women's National Basketball Association and National Basketball Association athletes. Am J Sports Med. 2006;34(7):1077-83.
[7] Cook JL, Khan KM, Kiss ZS, Griffiths L. Patellar tendinopathy in junior basketball players: A controlled clinical and ultrasonographic study of 268 patellar tendons in players aged 14-18 years. Scand J Med Sci Sports. 2000;10:216-20.
[8] Ito E, Iwamoto J, Azuma K, Matsumoto H. Sex-specific differences in injury types among basketball players. Open Access J Sports Med. 2014;6:01-06.
[9] Carter EA, Westerman BJ, Hunting KL. Risk of injury in basketball, football, and soccer players, ages 15 years and older, 2003–2007. Journal of Athletic Training. 2011;46(5):484-88.
[10] Norman K, Stobaus N, Gonzalez MC, Schulzke JD, Pirlich M. Hand grip strength: Outcome predictor and marker of nutritional status. Clin Nutr. 2010;30:135-42.
[11] Ortega FB, Ruiz JR, Castillo MJ, Sjostrom M. Physical fitness in childhood and adolescence: A powerful marker of health. Int J Obes (Lond). 2008;32(1):01-11.
[12] Erculj F, Blas M, Bracic M. Physical demands on young elite European female basketball players with special reference to speed, agility, explosive strength, and take-off power. J Strength Cond Res. 2010;24(11):2970-78.
[13] Cook G, Burton L, Hoogenboom B. Pre-participation screening: The use of fundamental movements as an assessment of function–Part 1. N Am J Sports Phys Ther. 2006;1(2):62-72.
[14] Hakizimana M. Epidemiology and management of basketball related injuries in Rwanda. University of the Western Cape 2005.
[15] Laver L, Kocaoglu B, Cole B, Arundale AJH, Bytomski J, Amendola A. Basketball sports medicine and science. Berlin, Heidelberg: Springer; 2020.
[16] Mendhe S, Borkar P. Epidemiology of musculoskeletal injuries in basketball players: Systematic review. International Journal of Physical Education, Sports and Health. 2021;8(2):111-16.
[17] Garbenytė-Apolinskienė T, Salatkaitė S, Šiupšinskas L, Gudas R. Prevalence of musculoskeletal injuries, pain, and illnesses in elite female basketball players. Medicina (Kaunas). 2019;55(6):276. Published 2019 Jun 14.
[18] Zeng Q, He Y, Dong S, Zhao X, Chen Z, Song Z, et al. Optimal cut-off values of BMI, waist circumference and waist: Height ratio for defining obesity in Chinese adults. Br J Nutr. 2014;112(10):1735-44.
[19] Paliczka VJ, Nichols AK, Boreham CA. A multi-stage shuttle run as a predictor of running performance and maximal oxygen uptake in adults. British Journal of Sports Medicine.1987;21(4):163-65.
[20] Schlüssel MM, dos Anjos LA, de Vasconcellos MT, Kac G. Reference values of handgrip dynamometry of healthy adults: A population-based study. Clinical Nutrition. 2008;27(4):601-07. https://doi.org/10.1016/j.clnu.2008.04.004.
[21] Golding A, Myers C, Sinning W.Y's way to physical fitness (3rd ed.): The Complete Guide to Fitness Testing and Instruction. Champaign, IL: Published for YMCA of the USA by Human Kinetics Publishers;1989.
[22] Aggarwal A, Abraham B, Palekar TJ. Upper limb fitness testing in gymnasium going people. Indian Journal of Physiotherapy and Occupational Therapy. 2020;14 (1)19-22.
[23] Johnson Barry L, Nelson JK. Practical measurement for evaluation in physical education, 4th ed. Minneapolis. Burgess Publishing Company, 1969.
[24] Chu DA. Explosive power & strength complex training for maximum results. Champaign IL: Human Kinetics;1996.
[25] Antonetti V. Total fitness for men- metric edition kindle edition. No Paper Press LLC;18 March 2013.

[26] Wood R. Squat Test: Testing your fitness at home.Topend Sports Website, 2008. https://www.topendsports.com/testing/tests/home-squat.htm. Accessed 6 October 2022.

[27] American College of Sports Medicine, Leonard A. Kaminsky. ACSM's Health-Related Physical Fitness Manual. 4th ed. Lippincott Williams & Wilkins;2013.

[28] Davis B, Bull R, Roscoe J. Roscoe Training for Physical fitness. In; DAVIS, B et al. Physical education and the study of sport. Spain; Harcourt Publishers Ltd., 2000,121-122.

[29] Drinkwater EJ, Hopkins WG, McKenna MJ, Hunt PH, Pyne DB. Modelling age and secular differences in fitness between basketball players. J Sports Sci. 2007;25(8):869-78.

[30] McKenzie G. Basketball: Identification of anthropometric and physiological characteristics relative to participation in college basketball. Natl Strength Cond Assoc J. 1985;7(3):34-36.

[31] Drinkwater EJ, Pyne DB, McKenna MJ. Design and interpretation of anthropometric and fitness testing of basketball players. Sports Med. 2008;38(7):565-78.

[32] Usgu S, Yakut Y, Kudas S. Effects of functional training on performance in professional basketball players. Turk J Sports Med. 2020;55(4):321-31.

[33] Hoffman J, Maresh C. Physiology of basketball. In: Exercise and Sport Science. Ed: Garrett W, Kirkendall D. Philadelphia, Lippincott, Williams and Wilkins. 2000;733-44.

[34] Pyne DB, Montgomery PG, Klusemann M, Drinkwater E. Protocols for the physiological assessment of basketball players. In Tanner RK, Gore CJ, editors, Physiological Tests for Elite Athletes. 2nd/17th ed. Human Kinetics Publishers. 2013;273-87.

[35] Delextrat A, Cohen D. Strength, power, speed, and agility of women basketball players according to playing position. Journal of Strength and Conditioning Research. 2009;23(7):1974-81.

[36] Ghosh AK. Anaerobic threshold: Its concept and role in endurance sport. Malays J Med Sci. 2004;11(1):24-36.

[37] Permadi A, Adhi Putra I, Wahjuni E. Circuit training to increase cardio-respiratory endurance in male basketball players. Indian Journal of Public Health Research & Development. 2020;11(2):989-94.

[38] Jildeh TR, Castle JP, Buckley PJ, Abbas MJ, Hegde Y, Okoroha KR. Lower extremity injury after return to sports from concussion: A systematic review. Orthopaedic Journal of Sports Medicine. 2022;10(1):23259671211068438.

[39] Taylor JB, Wright AA, Dischiavi SL, Townsend MA, Marmon AR. Activity demands during multi-directional team sports: A systematic review. Sports Med. 2017;47(12):2533-51.

[40] Miller S, Bartlett RM. The effects of increased shooting distance in the basketball jump shot. J Sports Sci. 1993;11(4):285-93.

[41] Arora C, Singh P, Varghese V. Biomechanics of core musculature on upper extremity performance in basketball players. J Bodyw Mov Ther. 2021;27:127-33.

[42] Svensson E, Waling K, Hager-Ross C. Grip strength in children: Test–retest reliability using Grippit. ActaPaediatr. 2008;97:1226-31.

[43] Gerodimos V. Reliability of handgrip strength test in basketball players. J Hum Kinet. 2012;31:25-36.

[44] Palmer JA, Bini R, Wundersitz D, Kingsley M. Training and match demands differ between the regular season and finals in semi-professional basketball. Front Sports Act Living. 2022;4:970455.

PARTICULARS OF CONTRIBUTORS:

1. Associate Professor, Department of Physiotherapy, Dr. D.Y. Patil College of Physiotherapy, Pune, Maharashtra, India.
2. Assistant Professor, Department of Physiotherapy, Dr. D.Y. Patil College of Physiotherapy, Pune, Maharashtra, India.
3. Physiotherapist, Department of Physiotherapy, Dr. D.Y. Patil College of Physiotherapy, Pune, Maharashtra, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Amita Aggarwal,
Flat No. 1004, A Wing, Kamalraj Haridwar Society, Dighi, Pune, Maharashtra, India.
E-mail: amita15pgi@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]

- Plagiarism X-checker: Jun 02, 2022
- Manual Googling: Nov 10, 2022
- iThenticate Software: Nov 28, 2022 (7%)

ETYMOLOGY: Author Origin

AUTHOR DECLARATION:

- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **May 25, 2022**
Date of Peer Review: **Jul 12, 2022**
Date of Acceptance: **Nov 29, 2022**
Date of Publishing: **Mar 01, 2023**