

Identification model of 12 year-old boys' badminton talents

Sapta kunta Purnama, Muhammad Furqon Hidayatullah*, Rumi Iqbal Doewes

Department of Sports Science, Faculty of Sports, Sebelas Maret University, Surakarta, Central Java, Indonesia.

* Correspondence: Muhammad Furqon Hidayatullah; mohammadfurqon@staff.uns.ac.id

ABSTRACT

Talent identification of in badminton was needed as a prediction of the future performance of young players who will achieve success at the national or international level in badminton. The aim of the study was to establish a model for identifying badminton talent in 12-year-old boys. An observational design was used. The sample included 29 boys aged 12 years with no prior badminton experience and 29 boys who were members of a badminton club. All participants completed eight anthropometric tests and 16 physical fitness tests. The differences results between two groups were used as criteria for 12-year-old boys' badminton talent. To determine the best talent predictor, a stepwise discriminant analysis was performed. Based on stepwise discriminant analysis, 11 measurements (four anthropometric and seven physical fitness) were identified that maximally discriminate between talented and non-talented badminton players. Using Fisher's linear discriminant functions based on these 11 measures, 98.3% of participants were correctly classified, indicating high validity. The distinguishing characteristics between talented and non-talented players included BMI, total skinfold thickness, arm circumference, arm length, upper limb muscle power, speed, side-to-side agility, 4-corner agility, VO₂max, wrist flexibility, and eye-hand coordination. Among these, four anthropometric tests and six physical fitness tests were particularly effective in differentiating between talented and non-talented players.

KEYWORDS

Model; Talent Identification; Badminton; Boys

1. INTRODUCTION

The continued success of sports clubs is based on the effective talent identification. Talent identification in sports can be seen on a temporal continuum based on the objectives of the identification or selection process: identifying and selecting for the moment (immediate performance) versus identifying and selecting future timepoints (prediction). Selection objectives (performance vs predictions) influence perceptions of talent and selection decisions made. In high-performing sports organizations, prediction of elite players (“talent identification”), is a priority, thus enabling the efficient use of resources in the development of athletes for future success (Roberts et al., 2019). In Indonesia, the Ministry of Youth and Sports of the Republic of Indonesia has also implemented a system of guiding and developing sports talent by modifying sport search but until now the results have been unsatisfactory. Thousands of sports search test data, namely anthropometric measurements and physiological abilities of children representing provinces throughout Indonesia, have not been utilized optimally. The data is only utilized technically for the analysis of the sport search software, limited to knowing the talentedness of the students taking the test. This shown that talent scouting efforts in Indonesia have not been maximized, the quantity of human resource capital which is quite a lot has not been utilized in fostering sports achievements. With a large quantity of human resources, it means that there are also many superior seeds hidden in it, therefore efforts are needed to find these superior seeds.

The badminton is one of the priority branches and is a mainstay in Indonesia, so training in badminton should always be monitored and evaluated as feedback to maintain and improve its achievements. The Indonesian Badminton Association (PBSI) must have a system for developing from an early age to developing high achievements. In coaching at an early age, one important factor is the recruitment system or talent identification for athletes to be coached. Identification of talent for badminton in Indonesia does not yet have the best system. Minimum standards related to the selection or recruitment system for young athletes have not been standardized. Identification of talent in the badminton applied in Indonesia often relies on the approach of observation and coach experience. The participation of the trainees in badminton clubs is more dominant due to the interest of the parents or the trainees themselves. Coaches or trainers in recruiting training participants have not taken into account whether the trainees are talented enough or have the potential to improve their achievements in the badminton. Big clubs or badminton education and training centers carry out the selection of prospective athletes under their guidance by choosing those who win in a competition. With this system, the probability that potential athletes will be selected but chronologically not practicing badminton for a long time is not selected, because they will not occupy the top rankings.

Talent identification is a process carried out to identify superior qualities, being able to predict the talent of a child as a young player in a sport, so that children who have this talent can develop and achieve maximum success both at the national and international levels. Cobley et al (2020) define talent identification as a previously identified quality that promotes (or predicts) future exceptionality. This definition allows both general factors, such as broad abilities (eg, basic movement skills, intelligence), holistic performance (eg, netball game-performance) and sport-specific skills (eg, court movement and positioning) to be considered as talent predictors. Identification of talent in badminton can be interpreted as an effort that is carried out systematically to identify someone who has superior quality in the badminton, so that it is estimated that someone will be successful in the training process and can achieve high achievements. In order for this identification to be accurate, the talent identification model needs to take advantage of the physical characteristics of athletes that are considered important for sports. Badminton is included in open skills (open loop), which is a sport that requires a high degree of accuracy in decision making, response, and various physical abilities. Physical characteristics such as anthropometry and physical condition have been identified as critical factors and contribute to athlete performance in various sports (Robertson et al., 2021). Several measurements such as BMI, skinfold thickness, elbow breadth (Bhandari & Koley, 2019), length (arm and leg) (Bisht et al., 2019), circumference (arm, thigh, calf) (Marwat et al., 2021), strength, power, flexibility, speed, aerobic agility and endurance (Campos et al., 2009), coordination and balance (Wong et al., 2019) have been used as profile measures for badminton athletes, so they should be considered for inclusion in tests used for selection purposes. This is because there is not just one anthropometric profile or physical condition as a prerequisite for participating in the highest level of play (Robertson et al., 2021). Thus for accuracy in identifying badminton talent, these variables must be involved. Through this talent identification, it is possible to identify talented athlete candidates and the achievement development process becomes clear, besides that further training (talent development) becomes more effective and efficient than fostering prospective athletes whose talents are not yet known. Therefore in this study, efforts were made to establish a talent identification model to produce a series of tests that could be used to identify the 12-year-old boys' badminton talent.

2. METHODS

2.1. Design and Participants

Researchers used a survey design to obtain measurement information directly from the subject. Research purpose is developing the preparation of test kits or measuring instruments to carry out an assessment of physical abilities or movement skills. In this research what will be developed or compiled

is a measuring tool to determine badminton talent, especially to be applied to 12-year-old badminton players.

The research participants were 58 boys, which consisted of two groups, namely control and target. In the control group, 29 boys aged 12 years who did not play badminton (considered non-talented) participated in this study. The target group was selected badminton players ranked 1-4 in the age group 12-13 years, chronological age participating in badminton practice for at least 3 years and the frequency of practice is at least 3 times a week. The determination of the age of 12 years is related to the age for starting training in badminton is 10-12 years old (Bompa & Buzzichelli, 2019). Abdullaevna & Oribovna (2022) explains that rapid growth, maturation of the body, ongoing psychological changes – all of these affect the functional state of adolescents. The 11-12 years is a period of activity that shown a significant increase in energy. The subjects used were men, this was explained by Zheng (2019) that human growth and development have disequilibrium at different ages. The quality of children's sports will indicate a "sensitive period" of development, namely a sensitive period of development of physical qualities, which is an important basis for athletes to choose material. The average ability of boys in sports quality tests such as outbreak, speed endurance, sensitivity and balance shown an increase with age. Meanwhile, the growth in sports quality for the girl slowed down around the age of 13.

2.2. Procedure and Measurements

The participants completed 26 tests consisting of anthropometry and physical condition. Before the test is carried out, standard instructions and demonstrations according to the test guidelines are given to participants. All tests are carried out in the same place. The test was carried out in the morning and athletes were instructed not to engage in strenuous exercise the day before the test session.

2.2.1. Anthropometry

All subjects were measured anthropometrically: height, weight, BMI, 7 skinfold thicknesses (calf, thigh, biceps, abdominal, suprailac, subscapular, triceps), length (arm and leg), circumferences (arm, thigh and calf), and elbow breadth. Height was measured without shoes using a stadiometer with an accuracy of 0.1 in meters (m). Body weight was measured using a scale in a state of minimal clothing in kilograms (kg). BMI is calculated using the following formula: $\frac{Weight}{Height \times Height}$. Skinfold thickness was measured using a skinfold caliper, in the following order: measurement of calf, thigh, biceps, abdominal, suprailac, subscapular, triceps. Length and circumferences measured using measuring tape

in centimeters (cm) to the nearest 0.1 cm. Elbow breadth is measured through the small calliper. All measurements were taken from the left side of the body.

2.2.2. Physical Condition

All subjects were measured for their physical condition: abdominal muscle strength/resistance using a sit-up test, arm strength using a push-up test, leg strength using a leg dynamometer, upper limb muscle power using a medicine ball throw, leg muscle power using a vertical jump test, spinal flexibility using sit and reach test, wrist flexibility using wrist elevation test, speed using speed 20m test, agility using side to side agility test and 4-corner agility test, aerobic power (VO_{2max}) using shuttle run test, eye-hand coordination using hand wall toss test, static balance using static single-leg standing balance and dynamic balance using Y-balance test.

In the sit-up test and push-up test, the subject performs the test for 30 seconds, the number of repetitions of the test is recorded. On the leg dynamometer, subject pulled on the chain as hard as he could, trying to straighten his legs, feet remained flat on the bottom of the dynamometer, results were recorded based on maximum performance when the legs were nearly straight at the end of the lift, calculated in the nearest kilogram. In the medicine ball throw using a 3 kg medicine ball, the subject throws as far as possible without moving the lower limb, the effort is given to the subject 3 times, the best result is recorded. In the vertical jump test, the highest achievement was the leg muscle power ability measured in centimeters (cm). After three attempts, the best results were recorded. To determine the amount of leg muscle power (P) is determined by the formula $P = [\sqrt{4.9 \times \text{body weight (kg)} \times \sqrt{\text{jump} - \text{reach score (m)}} \times 9.81$. In the sit and reach test, the subject's legs are straightened so that they stick to the sit and reach box. The test is carried out with the subject stretching the arms forward while keeping the head and back against the wall, then this position is held for 2 seconds. Results are recorded based on the distance from the fingertips to the edge of the box in cm. Attempts were given to the subject 3 times. In the wrist elevation test, the subject lies face down on a mat with a stick in hand.

The test is carried out with the subject raising their hand holding the stick as high as possible. Results are recorded based on the vertical distance from the floor to the stick in cm. Attempts were given to the subject 3 times. In the 20m speed test, the test is carried out with the subject running as fast as possible within 20 meters. Results are recorded in seconds. Attempts were given to the subject 2 times. Side to side agility and 4-corner agility tests were carried out on the badminton court with the subject without using a racket. The test is carried out with the subject moving quickly to the side and

touching the points with the dominant hand. The point in the side to side agility test is placed next to the subject, while the point in the 4-corner agility test is placed in the corner of the field. Attempts were given to the subject 10 times, 5 times for the side to side agility test and 5 times for the 4-corner agility test. The digital stopwatch is pressed when the test starts and stops when the last point is touched and then returns to the midpoint. Results are recorded in seconds. In the shuttle run test, two lines marked cones are placed 20 meters apart. The test is carried out with the subject running back and forth continuously following the "beep" sound. Each "beep" sound, the subject must reach the line in time. Velocity starts at 8.5 km/h then increases by 0.5 km/h every minute. In the hand wall toss test, the wall is 2 meters apart and marked. The test was carried out with the subject throwing the ball at the wall with one hand and being caught with the opposite hand for 30 seconds. Subject stops after 30 seconds indicated by a timer signaling stop.

Results are recorded based on the number of correct catches made. In static single-leg standing balance, the test is carried out with the subject standing on one of his legs (dominant and non-dominant leg) as long as possible and not moving, the leg being tested must be straight while the leg that is not being tested is bent at an angle of 90° . During the test, the subject must close his eyes and position his hands crossed in front of his chest. Results are recorded in seconds. Efforts were given to the subject 3 times. When one of the following faults occurs, time is stopped: (1) The foot not being tested touches the floor or leg being tested; (2) The participant's hand leaves their position from chest; (3) Participants open eyes; (4) Participants are able to maintain and stand in position for more than 50 seconds. In the Y-balance test, the test is carried out with the subject trying to maintain balance while maintaining a single-leg stance while reaching as far as possible with the contralateral leg, then returning to the middle position. The directions covered in the Y-balance test are posterolateral, posteromedial, and anterior. Efforts are given to the subject 3 times each leg (right leg and left leg). Results are recorded based on the maximum range distance. Because there are 3 directions to reach, to calculate the Y-balance test score for each leg using a composite score with the equation = $[(\text{sum of greatest reach in each direction}) / (3 \times \text{leg length})] \times 100$.

2.3. Statistical Analysis

Discriminant analysis is used to assign individuals into talented or non-talented groups. Discriminant analysis interprets patterns of differences between groupings of variables as a whole in an attempt to understand the dimensions by which groups differ (Robertson et al., 2021). Descriptive statistics are used to determine the mean and standard deviation of the two groups. Multivariate analysis was used to differentiate the two groups. Stepwise discriminant analysis was used to analyze data with

a minimum significance set at <0.05 . Using stepwise discriminant analysis, researchers extract the subset of variables that maximally discriminate between the two groups. The F-value is used to stop the discriminant analysis extraction procedure with a significance <0.05 to be entered. Coefficient fisher's linear discriminant functions are used as discriminant functions to analyze the classification of players as "talented" or "non-talented" in badminton. Data analysis was performed with SPSS 17.

3. RESULTS

3.1. Data Descriptions

The results showed that there were multivariate differences in anthropometric variables and physical conditions (Wilks' Lambda = .122; $F = 9.854$; $p < 0.05$) (Table 1).

Table 1. Multivariate test results for anthropometric and physical conditions variables

Wilks' Lambda	F	p value
.122	9.854	.000*

Significant univariate differences were found in the anthropometric tests, namely BMI (Wilks' Lambda = .723; $F = 21.412$; $p < 0.05$), leg length (Wilks' Lambda = .908; $F = 5.663$; $p < 0.05$), arm length (Wilks' Lambda = .891; $F = 6.821$; $p < 0.05$), and arm circumferences (Wilks' Lambda = .900; $F = 6.232$; $p < 0.05$) (Table 2).

Table 2. Description of data and results of different anthropometric tests

Anthropometric Test	Group				Wilks' Lambda	F	p value
	Talented (n = 29)		Non-talented (n = 29)				
	Mean	SD	Mean	SD			
BMI (kg/m ²)	23.38	1.10	24.72	1.11	.723	21.412	.000*
Total skinfold thickness (7 skinfold thickness) (mm)	67.62	1.57	68.31	1.61	.953	2.738	.104
Leg length (cm)	73.72	1.00	74.69	1.96	.908	5.663	.021*
Arm length (cm)	61.44	1.16	60.64	1.18	.891	6.821	.012*
Arm circumferences (cm)	21.87	1.08	22.59	1.10	.900	6.232	.016*
Thigh circumferences (cm)	38.18	1.03	37.97	1.43	.992	.426	.517
Calf circumferences (cm)	25.67	1.13	25.62	1.60	1.000	.015	.903
Elbow breadth (cm)	6.54	0.78	6.83	0.86	.967	1.905	.173

Significant univariate differences were found in the physical condition tests, namely upper limb muscle power (Wilks' Lambda = .742; $F = 19.492$; $p < 0.05$), speed (Wilks' Lambda = .833; $F = 11.260$; $p < 0.05$), side to side agility test (Wilks' Lambda = .705; $F = 23.471$; $p < 0.05$), VO_{2max} (Wilks' Lambda = .876; $F = 7.939$; $p < 0.05$), and wrist flexibility (Wilks' Lambda = .786; $F = 15.281$; $p < 0.05$) (Table 3).

Table 3. Data description and test results for different physical condition tests

Physical Condition Test	Group				Wilks' Lambda	F	p value
	Talented (n = 29)		Non-talented (n = 29)				
	Mean	SD	Mean	SD			
Abdominal muscle strength / resistance (repetition)	16.41	3.53	15.52	3.79	.985	.868	.356
Arm strength (repetition)	21.69	1.83	21.07	2.85	.983	.971	.329
Leg strength (kg)	47.62	2.44	47.18	2.90	.993	.393	.533
Upper limb muscle power (m)	7.78	0.60	6.91	0.88	.742	19.492	.000*
Speed (m/s)	4.05	0.19	4.23	0.22	.833	11.260	.001*
Side to side agility test (seconds)	20.21	0.56	20.93	0.56	.705	23.471	.000*
4 - corner agility test (seconds)	47.80	0.63	48.00	0.76	.980	1.125	.293
VO_{2max} (mL/kg/minute)	33.63	4.23	30.63	3.89	.876	7.939	.007*
Spine flexibility (cm)	32.34	3.22	31.34	5.86	.989	.649	.424
Wrist flexibility (cm)	41.62	3.48	38.00	3.31	.772	16.508	.000*
Leg muscle power (P)	118.92	13.03	118.89	18.99	1.000	.000	.994
Eye-hand coordination (repetition)	13.66	2.61	12.72	2.19	.963	2.170	.146
Dominant leg static balance (seconds)	19.13	1.05	18.63	1.10	.946	3.182	.080
Non-dominant leg static balance (seconds)	18.80	1.68	19.10	1.62	.991	.494	.485
Right dynamic balance composite (m)	91.39	0.30	91.36	0.37	.998	.088	.767
Left dynamic balance composite (m)	94.01	0.19	93.98	0.22	.997	.190	.664

3.2. Discriminant Analysis

Stepwise discriminant analysis showed that the measures that discriminate against talented and not-talented badminton players were *side to side agility test* (Wilks' Lambda = .705; $F = 23.471$; $p < 0.05$), *BMI* (Wilks' Lambda = .593; $F = 18.848$; $p < 0.05$), *VO_{2max}* (Wilks' Lambda = .487; $F = 18.956$; $p < 0.05$), *speed* (Wilks' Lambda = .391; $F = 20.626$; $p < 0.05$), and *eye-hand coordination*. (Wilks' Lambda = .352; $F = 19.137$; $p < 0.05$), *arm circumferences* (Wilks' Lambda = .319; $F = 18.133$; $p < 0.05$), *arm length* (Wilks' Lambda = .280; $F = 18.370$; $p < 0.05$), *skinfold thickness total* (Wilks' Lambda =

.232; $F = 20.323$; $p < 0.05$), *wrist flexibility* ($Wilks' \text{ Lambda} = .203$; $F = 20.903$; $p < 0.05$), *4-corner agility test* ($Wilks' \text{ Lambda} = .186$; $F = 20.558$; $p < 0.05$), and *upper limb muscle power* ($Wilks' \text{ Lambda} = .171$; $F = 20.298$; $p < 0.05$). These 11 measures are statistically significant with $Wilks' \text{ Lambda} = .171$; $Chi\text{-square} = 89.239$ with a significance of $p < 0.05$, which means that the mean discriminant scores of the two groups differ significantly. Furthermore, the squared canonical correlation value (.830) indicates the degree of relationship between discriminant outcomes or the amount of variability that can be explained by the 11 measures of badminton talent. 83% of badminton talent can be explained by the discriminant model formed.

3.2.1. Badminton talent model based on discriminant function

The badminton talent model is explained by the discriminant function obtained based on stepwise discriminant analysis on the coefficient fisher's linear discriminant functions. A function of 10 measures was defined, allowing researchers or coaches to classify each 12-year-old boy into one of the categories namely talented badminton players and non-talented badminton players. The following describes 2 functions (a function for talented badminton players and a function for non-talented badminton players). Each child will be tested by testing and measuring BMI, total skinfold thickness, arm length, arm circumferences, upper limb muscle power, speed, side to side agility test, 4-corner agility test, VO_{2max} , wrist flexibility, and eye-hand coordination. Then the test results are entered into the function. The highest value of the two functions will indicate the child is entered as a talented badminton player or a badminton player who is not talented.

- Talented badminton player: $24.972(BMI) + 6.687(\text{skinfold thickness total}) + 60.196(\text{arm length}) - 21.464(\text{arm circumferences}) + 71.834(\text{upper limb muscle power}) + 48.085(\text{speed}) + 3.829(\text{side to side agility test}) + 139.345(\text{4-corner agility test}) - 3.523(VO_{2max}) + 11.905(\text{wrist flexibility}) - 1.180(\text{eye-hand coordination}) - 6059.717$
- Non-talented badminton players: $26.434(BMI) + 8.370(\text{total skinfold thickness}) + 56.896(\text{arm length}) - 19.098(\text{arm circumferences}) + 69.723(\text{upper limb muscle power}) + 56.798(\text{speed}) + 9.903(\text{side to side agility test}) + 135.788(\text{4-corner agility test}) - 4.111(VO_{2max}) + 11.412(\text{wrist flexibility}) - 1.879(\text{eye-hand coordination}) - 5987.870$

3.2.2. Identifying talent characteristics relevant to badminton

Based on the discriminant function described above, Table 4 shows the number of samples that are correctly classified using this function. The results show that 98.3% of the subject is classified correctly. Furthermore, the cross-validation between the initial model and the classification

discriminant model showed that 91.4% of the cases that were grouped with the cross-validated classification were correctly classified. Cross-validated shows that 2 talented group is predicted as a non-talented player and 3 non-talented group is predicted as a talented player.

Table 4. Identification of talent characteristics that are relevant to the sample

Classification	Group	Predicted Group Membership			
		Athlete	Non Athlete	Total	
Original	Count	Talented player	28	1	29
		Non-talented player	0	29	29
	%	Talented player	96.6	3.4	100.0
		Non-talented player	.0	100.0	100.0
Cross-validated	Count	Talented player	27	2	29
		Non-talented player	3	26	29
	%	Talented player	93.1	6.9	100.0
		Non-talented player	10.3	89.7	100.0

4. DISCUSSION

The study results indicated that the anthropometric and physical conditions tests can be used to distinguish between talented and non-talented badminton players. This study also shown a relevant badminton talent identification model, this is shown from 98.3% of subjects classified correctly based on the discriminant function formed. In this study, a model for identifying badminton talent for boys aged 12 years based on discriminant analysis resulted in 4 anthropometric tests (BMI, total skinfold thickness, arm length, arm circumferences) and 6 physical condition tests (upper limb muscle power, speed, side to side agility test, 4-corner agility test, VO_{2max} , wrist flexibility, eye-hand coordination) to distinguish between talented and non-talented badminton players. In previous studies, identification of badminton talent has also been carried out using discriminant analysis, but the samples used were elite, sub-elite, and beginner badminton players (Robertson et al., 2021). So the results will be different if it is applied for the purpose of talent identification or screening for 12 years-old boys.

4.1. Anthropometry

Anthropometry is the first measure that needs to be considered in identifying talent because it is related to the body posture of a person which will later affect performance. In line with this, Toselli et al (2021) explained that anthropometric characteristics largely determine the optimal physical level and, therefore, a good level in the game, and can differ depending on the type of sport practiced.

Individuals' linear dimensions, body diameter, body mass, and skinfolds, are considered to be the main components of the elite player's somatic body profile. Anthropometric characteristics can be decisive in improving or determining performance and ability levels because differences in the ratio of body parts and differences in body structure provide different possibilities for efficient movement. Each sport requires different anthropometric characteristics because it related to the motion characteristics needed in each sport. Based on discriminant analysis, anthropometric measurements that differentiate talented and non-talented badminton players are BMI, total skinfold thickness, arm circumferences, and arm length. The results showed that talented badminton players have BMI, total skinfold thickness, and arm circumferences tend to be lower than non-talented badminton players. This size indicates that a talented badminton player needs to have a normal body because normal BMI represents a more dominant muscle component in badminton players than excess body fat. In line with this, Poliszczuk & Mosakowska (2010) reported that generally the fat content was found to be relatively low in leading badminton players in Poland. In line with this, Nikbakht (2011) reported that the relationship between skinfold thickness, leg muscle power, and body speed is generally considered negative. For arm circumferences, it can be said that it is effective in terms of hand grip strength in badminton (Aydoğmuş & Özcan, 2020) and has a strong correlation with elbow breadth ($r = .68$) and shoulder breadth ($r = .63$) (Poliszczuk & Mosakowska, 2010). Furthermore, with regard to arm length, this plays a role when the player hits the shuttlecock as high as possible so that it will be easily hit over the net and directed to the opponent's empty area of defense. In line with this, Manikandan (2016) also reported that arm length can be used to predict the ability to play badminton with 4% of the variance in badminton ability contributed by arm length. Jaworski & Zak (2015) also stated that at every stage of sports training, arm length has proven to be an important prerequisite for badminton.

4.2. Physical Condition

Physical condition is defined as an important component in the improvement and maintenance of jointly developed which if developed together can improve performance. Physical quality is very influential on the achievement of an athlete to achieve achievements because technique, tactics and mentality can be developed further if they have good physical quality. Therefore, physical training is focused on the elements of motion which aims to improve the energy and muscle quality of athletes so that athletes have longer endurance in carrying out each action. This is in accordance with the opinion of Abbas & Kayed (2021) that physical condition plays a very important role in improving athlete performance such as motor skills and performance. Based on discriminant analysis, the physical condition measures that differentiate talented and non-talented badminton players are upper limb

muscle power, speed, side to side agility test, 4-corner agility test, VO_{2max} , wrist flexibility, and eye-hand coordination.

The results showed that upper limb muscle power is a measure that distinguishes between talented and non-talented badminton players, in which talented badminton players appear superior in the upper limb muscle power test. Upper limb muscle power is the ability of a group of upper limb muscles to produce physical work by maximally exerting power from the upper limb muscles in a short time. Aydoğmuş & Özcan (2020) explain that the muscle power parameter is important for effective hitting because top-level badminton athletes can reach 320 km/hour in smashes. Indora et al (2022) reported that upper limb muscle power is one of the components used for better hitting performance, this is indicated by the significant positive correlation obtained for upper limb muscle power with smash speed and accuracy. Furthermore, the study showed that speed is a measure that distinguishes between talented and non-talented badminton players, in which talented badminton players perform faster. With regards to speed, Gabriela & Traian (2019), explain that badminton is a sport that prioritizes speed both in terms of reactions, movements, decisions, repetitions, or performance. Speed is a psychomotor skill that can be developed through practice. A child with psychomotor skill will have good movement on the court which in turn can produce better shots because they position themselves correctly and quickly on the court.

The results showed that agility is a measure that distinguishes between talented and non-talented badminton players, in which talented badminton players perform better, both side to side agility tests and 4-corner agility tests. The side to side agility test is assess the player's agility around the player's position, while the 4-corner agility test is assess the player's agility in the corners of the field. These two agility tests are used because badminton players need to have agility around their positions and in the corners of the court, because the incoming shuttlecock's path often moves. In line with this, Gabriela & Traian (2019) explains that the shuttlecock is hit every 5 seconds or even less, meaning that the player has about 2-3 seconds to move and get a good position for the shot, then at the same time, players have about 1 second to return to the middle of the court in starting position and prepare for their next shot. VO_{2max} is a measure that differentiates between talented and non-talented badminton players, in which talented badminton players perform better. With regard to VO_{2max} which can distinguish between talented and non-talented, it can be explained that badminton is an intermittent sport that requires energy channeled from the aerobic (60-70%) and anaerobic (30%) systems to sustain the demands of a match which are directly related to short or long rallies and the duration of the match, so that the aerobic power capacity must be possessed by badminton athletes (Campos et al., 2009).

Our findings showed that wrist flexibility is a measure that differentiates between talented and non-talented badminton players, in which talented badminton players perform better. In line with the results of this study, Jaworski & Zak (2015) reported the importance of wrist flexibility in badminton players. High wrist flexibility, making hand movements more flexible when doing strokes starting from wrist movements followed by considerable arm activity. The shuttlecock can be hit with the appropriate speed and power so that the flight path of the shuttlecock that is hit is also appropriate. This is important when a player needs to play a low serve or when a player needs to use strokes to return a shuttlecock that is close to the net and requires a short flight distance. Furthermore, the results showed that eye-hand coordination is a measure that differentiates between talented and non-talented badminton players, in which talented badminton players perform better. In this regard, it was explained that racquet sports require eye-hand coordination. Eye-hand coordination is the ability of the central nervous system to coordinate information received from the eyes to control, guide, and direct hands in completing a given task (Wong et al., 2019). Jaworski et al (2020) reported that a relatively high correlation coefficient was obtained between sport skill level and movement frequency, reaction time to visual stimuli, and eye-hand coordination. The coefficient of multiple determination shown that the sport skill level of badminton players is most strongly determined by spatial orientation (42%), followed by movement frequency (28%) and kinesthetic differentiation (17%). Dane et al (2008) also reported that sports activity is related to eye-hand visual reaction time and visuospatial intelligence. So the ability to coordinate must be considered carefully in the technical and tactical training of badminton players because they greatly determine the level of achievement.

5. CONCLUSIONS

The study results concluded that BMI, total skinfold thickness, arm circumferences, arm length, upper limb muscle power, speed, side to side agility test, 4-corner agility test, VO_{2max} , wrist flexibility, eye-hand coordination can identify talent characteristics that are relevant for the badminton in 12 years-old boys. The following are functions that can be applied in selecting talented and non-talented badminton players:

- Talented badminton player: $24.972(\text{BMI}) + 6.687(\text{total skinfold thickness}) + 60.196(\text{arm length}) - 21.464(\text{arm circumferences}) + 71.834(\text{upper limb muscle power}) + 48.085(\text{speed}) + 3.829(\text{side to side agility test}) + 139.345(4\text{-corner agility test}) - 3.523(VO_{2max}) + 11.905(\text{wrist flexibility}) - 1.180(\text{eye-hand coordination}) - 6059.717$
- Non-talented badminton players: $26.434(\text{BMI}) + 8.370(\text{total skinfold thickness}) + 56.896(\text{arm length}) - 19.098(\text{arm circumferences}) + 69.723(\text{upper limb muscle power}) +$

$$56.798(\text{speed}) + 9.903(\text{side to side agility test}) + 135.788(4\text{-corner agility test}) - 4.111(\text{VO}_{2\text{max}}) + 11.412(\text{wrist flexibility}) - 1.879 (\text{eye-hand coordination}) - 5987.870$$

6. REFERENCES

1. Abbas, D. I. M., & Kayed, D. M. W. (2021). Evaluation study of the physical condition of sports sciences faculty students at the Arab American University during the COVID-19 pandemic. *International Journal of Innovation, Creativity and Change*, 15(4), 929–946.
2. Abdullaevna, S. D., & Oribovna, R. A. (2022). Gender stereotype in adolescence: The study of the formation of properties. *Journal of Positive School Psychology*, 6(10), 3283–3288.
3. Aydoğmuş, M., & Özcan, N. (2020). Investigation of the relationship between arm skin thickness and circumference measurement and hand grip strength of children attending badminton sport. *Turkish Journal of Sport and Exercise*, 22(1), 111–115.
4. Bhandari, S., & Koley, S. (2019). Study of back strength and its correlations with selected anthropometric variables and performance tests in district level badminton players. *International Journal of Health Sciences*, 9(3), 71–76.
5. Bisht, H. S., Singh, J., Pradesh, M., Correspondence, I., Amity, A., & Dhauta, R. (2019). Anthropometric and physiological profile of badminton players of Uttarakhand. *Human Movement and Sports Sciences*, 4(1), 665–669.
6. Bompa, T. O., & Buzzichelli, C. A. (2019). *Periodization: Theory and methodology of training*. Human Kinetics.
7. Campos, F. A. D., Daros, L. B., Mastrascusa, V., Dourado, A. C., & Stanganelli, L. C. R. (2009). Anthropometric profile and motor performance of junior badminton players. *Brazilian Journal of Biometricity*, 3(2), 146–151.
8. Cobley, S., Baker, J., & Schorer, J. (2020). Talent identification and development in sport: An introduction to a field of expanding research and practice. In *Talent identification and development in sport* (pp. 1–16). Routledge.
9. Dane, S., Hazar, F., & Tan, U. (2008). Correlations between eye-hand reaction time and power of various muscles in badminton players. *International Journal of Neuroscience*, 118(3), 349–354.
10. Indora, N. K., Anand, P., Chettri, S., & Kumar, V. (2022). Correlation of upper limb explosive power with smash velocity and performance in badminton players: A cross-sectional study. *Journal of Clinical and Diagnostic Research*, 16(5), 9–11.
11. Jaworski, J., & Zak, M. (2015). The structure of morpho-functional conditions determining the level of sports performance of young badminton players. *Journal of Human Kinetics*, 47(1), 215–223.
12. Jaworski, J., Lech, G., Ambroży, T., & Zak, M. (2020). Profile of coordination motor abilities in elite judokas and badminton players compared to non-athletes. *Biomedical Human Kinetics*, 12(1), 17–24.
13. Manikandan, S. (2016). Relative importance of anthropometric, biomotor, and skill performance to playing ability of college badminton players. *International Journal of Physical Education, Sport and Health*, 3(2), 156–158.
14. Marwat, N. M., Khan, M. A., Anjum, G. S., Khan, M. I., & Waziri, H. K. (2021). Physical and anthropometric fitness of school level badminton players of Dera Ismail Khan (KP), Pakistan. *PalArch's Journal of Archaeology of Egypt/Egyptology*, 18(8), 3669–3674.
15. Milon, A. G., & Milon, B. T. (2019). Study about the importance of speed in children selection in badminton. *Gymnasium*, 20, 94–104.

16. Nikbakht, M. (2011). Relationships between somatotype, anthropometry and physical fitness variables in untrained university students. *Journal of Physical Education and Sport*, 11(2), 101–104.
17. Poliszczuk, T., & Mosakowska, M. (2010). Anthropometric profile of Polish elite badminton players. *Medicina Sportiva*, 26(1), 45–55.
18. Roberts, A. H., Greenwood, D. A., Stanley, M., Humberstone, C., Iredale, F., & Raynor, A. (2019). Coach knowledge in talent identification: A systematic review and meta-synthesis. *Journal of Science and Medicine in Sport*, 22(10), 1163–1172.
19. Robertson, K., Laureys, F., Mostaert, M., Pion, J., Deconinck, F. J. A., & Lenoir, M. (2022). Mind, body, and shuttle: Multidimensional benchmarks for talent identification in male youth badminton. *Biology of Sport*, 39(1), 79–94.
20. Toselli, S., Campa, F., Maietta Latessa, P., Greco, G., Loi, A., Grigoletto, A., & Zaccagni, L. (2021). Differences in maturity and anthropometric and morphological characteristics among young male basketball and soccer players and non-players. *International Journal of Environmental Research and Public Health*, 18(8), 1–16. <https://doi.org/10.3390/ijerph18083902>
21. Wong, T. K. K., Ma, A. W. W., Liu, K. P. Y., Chung, L. M. Y., Bae, Y. H., Fong, S. S. M., Ganesan, B., & Wang, H. K. (2019). Balance control, agility, eye-hand coordination, and sport performance of amateur badminton players: A cross-sectional study. *Medicine*, 98(2), 1–6. <https://doi.org/10.1097/MD.00000000000014134>
22. Zheng, J. (2019). *Research progress and trend of functional physical training for young badminton players* [Unpublished master's thesis, Southwest Petroleum University, China].

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

This research received no external funding.

COPYRIGHT

© Copyright 2025: Publication Service of the University of Murcia, Murcia, Spain.