Original Article

Relationship between some motoric and technical performance characteristics of U17 Turkish national badminton players

BEYHAN ÖZGÜR¹, FATİH HOTAMAN²

¹ High School of Physical Education and Sports, Mardin Artuklu University, TURKEY

² Akçaabat Science High School, Trabzon, TURKEY

Published online: July 31, 2020

(Accepted for publication: July 22, 2020)

DOI:10.7752/jpes.2020.s3296

Abstract:

This study investigates the relationship between some motoric and technical performance characteristics of U17 Turkish national badminton players. The participants of the study are five males, median age of 15 with seven years of training history, and nine females, median age of 15.5 years with six and a half years of sports experience. Participants' height, body weight, BMI, 20m speed, 20 m reaction speed, 20 m backward speed, quickness, standing long jump, vertical jump, flexibility, medicine ball throwing, hand-grip strength, back strength, leg strength and aerobic power have all been tested. Short serve, high serve, clear, drop shot and smash tests have been used to determine technical performance components. The total points (TP) in the technical tests have also been calculated. The relationship between the motoric and technical performance values of the participants has been evaluated by Spearman Correlation analysis. In males, significant relationships have been observed between high service with BMI and TP, 20 m speed with clear and TP, standing long jump with drop shot and smash, vertical jump with clear and TP, hand-grip strength and TP ($p<0.05$). In females, significant relationships have been found between medicine ball throwing with clear and TP, hand-grip strength with clear and TP, back strength with clear and TP, leg strength with clear and drop shot, aerobic power and drop shot ($p<0.05$). It has been observed that technical performance increased with the development of speed-power qualities in males and with the increase in strength in females. Therefore, while planning the physical preparation program for athletes of this age group, in addition to general studies, it is recommended to focus more on speed and explosive power for males, and strength training for females.

Keywords: Explosive power, speed, strength, drop shot, smash, clear

Introduction

Badminton is an Olympic sport played in five different events; men's singles, women's singles, men's doubles, women's doubles and mixed doubles, and played in a rectangular court of 80 m² separated by a net (Salim, Lim, Salim, & Baharuddin, 2010; Karatnyk, Hrechaniuk, & Pityn, 2015). The players hit the shuttlecock with a racket across the net into the other opponent's area in order to score a point (Ting, Sim, & Abas, 2015). Competitions are characterized by short rest periods followed by short-term, dynamic, challenging and high-intensity rallies that require maximum effort from the players (Butterworth, Turner, & Johnstone, 2012; Cristian and Timofte, 2014; Jang, Kim, & Park, 2018). In previous studies, it has been reported that the rally time generally lasts between 1-45 seconds. In addition, the mean rally and rest intervals have been stated as 10 and 26 seconds, respectively (Abdullah, 2014; Abian, Castanedo, Feng, Sampedro, & Abian-Vicen, 2014; Leong and Krasilshchikov, 2016). The speed of the shuttlecock reaches up to 426 km/h during these fast and challenging rallies where approximately one hit per second takes place (Kamruddin and Mannan, 2019). It has been reported that 68-83 rallies take place in competitions lasting 30-60 minutes (Cabello, Padial, Lees, & Rivas, 2004; Abdullahi and Coetzee, 2017). This structure of the game indicates that the alactic and lactic systems are dominant during the rallies, while the aerobic system is effective throughout the competition (Dhabliya, Dabholkar, & Yardi, 2014). In order to adapt to the challenging conditions of competitions, players perform many movements including sudden stops and starts, quick acceleration, jumps, rapid direction changes at short distances, and explosive lower and upper body movements. For this reason, the top-level performance of the players depends on their bodies working at a high level; they need high levels of power, speed, explosiveness, quickness, strength, balance, flexibility and aerobic endurance (Hong, Wang, Lam, & Cheung, 2014; Lam, Lee, Park, Ryue, Yoon, & Ryu, 2018; Nadzalan, Mohamad, Lee, & Chinnasee, 2018; Sturgess & Newton, 2008; Wahyudi, Hartono, & RC, 2018).

Top performance in badminton depends not only on physical and physiological components but also on the ability to use different racket techniques. These techniques vary according to the areas played in the court: lob, net shot, net kill, short and high serves in the front-court; drive, block and push in the mid-court; clear, drop

shot and smash in the rear-court (Cristian, and Timofte, 2014; Gao, 2017; Wahyudi, Hartono, & RC, 2018). Due to this versatile and complex structure of badminton, not only the physical, physiological, tactical and technical components should be investigated but their relationship to each other when performing performance analysis needs to be looked into as well (Campos, Daros, Mastrascusa, Dourado, & Stanganelli, 2009; Gao, 2017).

Most of the previous researchers have generally investigated the relationship between the anthropometric and motoric features of badminton players concerning game performance (Tiwari, Rai, & Srinet, 2011; Mahulkar, 2016; Manikandan, 2016; Yadav, 2017; Omveer, 2017). There is a study that examines the relationship between some psychological characteristics and the technical performance of badminton players (Arya and Kumar, 2015). It has been investigated whether the physical performance characteristics of badminton players were related to the unforced errors they made during the competition (Hotaman, Ozgur, & Cosan, 2018). However, to date, there has been no study which examines the relationship between the physical performance characteristics and technical performance components in national Turkish badminton players. By investigating the relationship between these components, contribution may be made to the planning of efficient and specific training programs. From this point of view, the study of the relationship between the physical and technical performances of U17 Turkish national badminton players has been determined as the goal of this study.

Material & methods

Participants

The participants of the study are five males, median age of 15 with seven years of training history and nine females, median age of 15.5 years with six and a half years of sports experience.

Procedure

Prior to the research, athletes and coaches were given a participation consent form which included information on the title, goal, and physical and technical tests planned for the study - those who accepted were included in the study. The research was carried out according to the Helsinki Declaration Principles and was approved by the Marmara University Institute of Health Sciences Ethics Committee (11.09.2017-165).

Technical Skill Tests

Short service test: Before beginning the test, the athletes were informed about the shuttlecock to pass between the net band and the 50.8 cm high rope from the band at the service shot. The participants shot twenty short serves to the marked target areas. 1-5 points were given depending on the area where the shuttlecocks dropped and 0 points if the ball did not pass through the specified area or was hit out of bounds (Kamar, 2003).

High service test: The athletes were informed that the shuttlecock had to pass over the rope which was located at a distance of 152.4 cm from the front service line in the opposite court and at a height of 251.46 cm. Then they performed twenty high serves to the target areas. 1-5 points were given according to the regions where the balls dropped. 0 points were given when the shuttlecock went out of bounds or did not exceed the specified height to cross the net (Hicks, 1973).

Clear test: The athletes were located 320 cm from the net on the court. They were informed that the shuttlecock had to pass over the rope at a height of 251.46 cm, 152.4 cm from the front service line in the opposite court. The shuttlecocks were shot randomly by a feeder (right, middle, left, corners) to the back-court area to the athletes. The athlete moved to the area where the shuttlecock was shot and performed twenty clears. 1-5 points were given according to the areas where the shuttlecocks dropped. 0 points were given if the ball went out of bounds or did not pass the specified height (Hicks, 1973).

Drop shot test: Participants took their positions 320 cm away from the net. They were informed that the shuttlecock had to pass over the rope, which was 320 cm away from the net and 251.5 cm high, and between the net and the rope positioned at the height of 76.2 cm from the net. The feeder randomly hit shuttlecocks hit into the back court area (right, middle, left, corners). The athletes moved to areas where the shuttlecock was shot and performed twenty drop shots (Hicks, 1973).

Smash test: The athletes took their positions at a distance of 320 cm from the net. They were informed that the shuttlecock had to pass between the net band and the ropes 106.68 cm high. The feeder hit twenty shuttlecocks to the back court area and the participants moved accordingly to perform the smash. 1-5 points were given according to the area where the shuttlecocks dropped (Hicks, 1973).

Physical Performance Tests

Height (cm): The athletes stood leaning against a tape measure, their backs up against the wall, without shoes and heels touching. While in this position, the measurement was noted by pressing down on the top of the head with a ruler (Hotaman et al., 2018).

Bodyweight (kg): The measurement was made with a Sinbo SBS-4414 brand scale of 0.01 kg and the athletes were bare feet.

Body mass index (BMI) (body weight/height²): It was obtained by dividing the body weight by square meters.

20-meter speed test (sec): The athletes started running on a 20-meter flat course and tried to finish the track as quickly as possible. The participants performed two attempts and their best score was recorded (Cosan, Demir, & Mengütay, 2002).

20-meter reaction speed test (sec): The athletes took a starting position on a 20-meter flat course. The tester pressed the button on the photocell which sounded the signal. As soon as the participants heard the signal, they started running and tried to complete the track as quickly as possible. Two attempts were made and the best time was recorded (Cosan et al., 2002).

20-meter backward speed test (sec): The athletes tried to complete the 20-meter course running backwards as quickly as possible. The photocell was sounded when the participants started the run and stopped automatically when they arrived at the finish line. Two attempts were made and the best time was recorded (Cosan et al., 2002).

T-test (sec): The T-test was used to measure the quickness of the athletes. To carry out this test, athletes completed a total of 36.57 meters of the course as specified; A-B straight, B-C slide, C-B slide, B-D slide, D-B slide and B-A backwards. Two attempts were made and the best score was recorded (Patterson, Udermann, Doberstein, & Reineke, 2008).

Standing long jump (cm): Athletes tried to jump as far as possible from the starting point of the tape measure, which had been glued to the floor before testing. Two attempts were performed and the best was recorded (Cosan et al., 2002).

Vertical jump (cm): Lower limb explosive power values of athletes were tested using the Takei Jump Meter (Hotaman et al., 2018).

Sit and reach test (cm): Athletes tried to reach forward with both hands on top of the box on the floor where they were sitting without bending their knees (Özer, 2006).

Throwing medicine ball (cm): Athletes tried to throw a 2 kg medicine ball as far as possible, just behind the starting line, one step ahead. Two attempts were made and the best score was recorded (Cosan et al., 2002).

Dominant hand-grip strength (kg): The athlete, while standing upright, squeezed the dynamometer (Takei 5401) with their hands. Measurements were made from the dominant arm. Three attempts were performed and the best score was recorded (Özer, 2006).

Back strength (kg): Athletes placed their feet on the dynamometer stand (Takei 5402). Then, with their back straight, body slightly bent forward, and knees and arms tightened; they pulled the dynamometer bar to the maximum extent. Three attempts were made and the best result was recorded (Heyward, 2002).

Leg strength (kg): The athletes placed their feet on the dynamometer stand with their knees at 130-140°. With arms stretched, back straight, and trunk slightly bent forward, they pulled the dynamometer bar with their hands to the maximum extent using their legs until their knees were stretched. Three attempts were performed and the best result was recorded (Heyward, 2002).

Aerobic power (shuttle run) Test (ml/kg/min): An area of 20 meters long was determined on a smooth and non-slippery surface. The running test started at a pace of (8.5 km / h) and increased every minute (0.5 km / h) until the participants were exhausted. Estimated maximal oxygen utilization capacity was determined according to the distance reached at the end of the run (Leger, Mercier, Gadoury, & Lambert, 1988).

Data collection and analysis

Descriptive statistics of the participants were calculated as median, minimum and maximum. The relationship between physical and technical performance values was evaluated by Spearman Correlation analysis.

Results

Results of the physical performance characteristics of the participants are shown in table 1 and table 2.

Table 1: Physical performance characteristics of the male badminton players

Variables	Median	Minimum	Maximum
Height (cm)	178.00	174.00	180.00
Bodyweight (kg)	76.00	63.00	78.00
BMI (kg/boy ²)	23.45	20.29	24.82
20-meter speed (sec)	3.26	3.11	3.38
20-meter reaction speed test (sec)	3.71	3.69	3.86
20-m backward speed (sec)	4.00	3.80	4.03
T-test (sec)	9.23	9.03	9.46
Standing long jump (cm)	246.00	232.00	257.00
Vertical jump (cm)	61.00	57.00	73.00
Sit and reach (cm)	28.00	19.00	34.00
Throwing medicine ball (cm)	1160.00	978.00	1230.00
Hand-grip strength (kg)	46.10	41.03	60.01
Back strength (kg)	151.50	131.50	156.70
Leg strength (kg)	147.50	119.00	161.50
Aerobic power (ml/kg/min)	52.20	51.90	54.25

Table 2: Physical performance characteristics of the female badminton players

Variables	Median	Minimum	Maximum
Height (cm)	164.00	160.00	174.00
Bodyweight (kg)	52.00	50.00	60.00
BMI (kg/boy ²)	19.53	17.65	21.88
20-meter speed (sec)	3.71	3.30	3.99
20-meter reaction speed test (sec)	4.17	3.90	4.44
20-m backward speed (sec)	4.92	4.44	5.72
T-test (sec)	11.02	10.30	11.46
Standing long jump (cm)	192.00	177.00	218.00
Vertical jump (cm)	43.00	40.00	53.00
Sit and reach (cm)	35.50	25.00	42.00
Throwing medicine ball (cm)	720.50	654.00	882.00
Hand-grip strength (kg)	32.45	28.00	40.70
Back strength (kg)	92.75	76.50	102.50
Leg strength (kg)	81.50	70.00	124.50
Aerobic power (ml/kg/min)	43.30	32.90	63.00

Descriptive data of the technical performance characteristics of the participants are presented in table 3 and table 4.

Table 3: Technical performance scores of the male badminton players

Variables	Median	Minimum	Maximum
Short serve	164.00	160.00	174.00
High serve	52.00	50.00	60.00
Clear	19.53	17.65	21.88
Drop shot	3.71	3.30	3.99
Smash	4.17	3.90	4.44
TP	4.92	4.44	5.72

TP: Total point

Table 4: Technical performance scores of the female badminton players

Variables	Median	Minimum	Maximum
Short serve	45.50	28	65
High serve	84.50	74	92
Clear	89.00	67	97
Drop shot	9.00	1	43
Smash	83.50	75	88
TP	317.50	265.00	357.00

TP: Total point

As seen in table 5, significant relationships were found between BMI with high service and TP, 20 m speed with clear and TP, long jump with drop shot and smash, vertical jump with clear and TP, and hand-grip strength and TP ($p < 0.05$).

Table 5: The relationship between the physical and technical performances of the male badminton players

Variables	Short serve	High serve	Clear	Drop shot	Smash	TP
Height (cm)	-.100	.410	.500	-.200	-.300	.100
Bodyweight (kg)	-.154	-.605	-.616	-.872	-.462	-.872
BMI (kg/boy ²)	-.500	-.975**	-.800	-.700	.000	-.900*
20-meter speed (sec)	-.100	-.872	-1.000**	-.700	-.300	-.900*
20-meter reaction speed (sec)	.500	-.564	-.700	-.300	.000	-.600
20-m backward speed (sec)	.738	.211	-.105	-.105	-.211	-.105
T-test (sec)	.200	.205	.500	.400	.600	.300
Standing long jump (cm)	.300	.359	.600	.900*	.900*	.700
Vertical jump (cm)	.100	.872	1.000**	.700	.300	.900*
Sit and reach (cm)	-.600	-.359	.000	.300	.700	.100
Throwing medicine ball (cm)	-.300	-.821	-.600	-.600	.100	-.800
Hand-grip strength (kg)	-.100	-.718	-.700	-.800	-.300	-.900*
Back strength (kg)	.616	.053	.154	.410	.564	.154
Leg strength (kg)	-.300	.308	.600	.000	.100	.200
Aerobic power (ml/kg/min)	.462	-.105	-.462	.103	-.154	-.051

**Correlation is significant at the 0.01 level, *Correlation is significant at the 0.05 level.

As presented in table 6, there were significant correlations between the throwing of the medicine ball with clear and TP, hand-grip strength with clear and TP, back strength with clear and TP, leg strength with clear and drop shot, and aerobic power and drop shot.

Table 6: The relationship between the physical and technical performances of the female badminton players

Variables	Short serve	High serve	Clear	Drop shot	Smash	TP
Height (cm)	.445	-.259	.420	.447	.000	.496
Bodyweight (kg)	.036	-.297	-.102	.205	-.491	-.030
BMI (kg/boy ²)	-.036	.273	-.432	-.071	-.162	.000
20-meter speed (sec)	-.276	.255	-.050	-.420	-.244	-.134
20-meter reaction speed (sec)	-.142	.145	.159	-.420	-.176	-.025
20-m backward speed (sec)	.042	.443	.276	-.143	.202	.276
T-test (sec)	-.536	.349	-.226	-.403	-.235	-.335
Standing long jump (cm)	.197	-.269	.252	.473	.122	.139
Vertical jump (cm)	-.193	-.410	-.105	.435	-.241	-.248
Sit and reach (cm)	-.351	.392	-.209	-.471	-.336	-.243
Throwing medicine ball (cm)	.444	.264	.854*	.134	.580	.678*
Hand-grip strength (kg)	.611	.315	.695*	.034	.613	.753*
Back strength (kg)	.553	.240	.785*	.000	.479	.730*
Leg strength (kg)	.357	-.338	.786*	.755*	-.084	.622
Aerobic power (ml/kg/min)	.243	-.255	.000	.723*	-.126	.251

**Correlation is significant at the 0.01 level, *Correlation is significant at the 0.05 level.

Discussion

This study was the first to investigate the relationship between some motoric and technical performance characteristics of national badminton players. Due to insufficient research in the literature, close studies were used as support in the discussion.

It is unclear whether the height of a player is a critical determinant of success in badminton (Reilly, Secher, Snell, & Williams, 1990). In a previous analysis, it was found that the players' height and game performance did not show a significant relationship (Omveer, 2017). In another study, it was reported that the unforced errors made by badminton players and their height were not related (Hotaman et al., 2018). In addition, it was reported that there was no significant relationship between the players' competition rankings and their height (Hazır, Salman, Devrilmez, & Satiroglu, 2018). In the current study, no significant relationship has been found between height and technical strokes in either males or females.

It is emphasized that the excess bodyweight, fat percentage and BMI of badminton players limit the ability to move quickly and explosively during a game (Reilly et al., 1990). In a previous study, it was found that the bodyweight and the number of unforced errors in the back court showed a positive correlation (Hotaman et al., 2018). In another observation, a significant relationship was reported between competition ranking with bodyweight and lean body mass of both male and female badminton players. In other words, athletes with low body weight and lean body mass values achieved better competition rankings (Hazır et al., 2018). On the other hand, a study was also reported that stated there was no significant correlation between body weight and competitive performance (Omveer, 2017). In this study, a significant negative correlation has been observed between BMI with high service and TP in males. Accordingly, it may show that the increase in BMI negatively affects the technical strokes of the players.

Speed is one of the most important components for badminton players. With the proper amount of speed, players can respond quickly to an opponent's action (Weicneck, 2011). In a previous analysis, it was observed that speed and badminton performance showed a significant relationship as fast players performed better (Tiwari et al., 2011; Omveer, 2017). On the contrary, some studies have reported that speed and badminton performance are not related. For instance, in one study, it was presented that there was no relationship between players' game performance and speed (Yadav, 2017). In another study, there was no significant relationship between a player's unforced errors made during competition and speed (Hotaman et al., 2018). Moreover, it was also reported that there was no correlation between the speed qualities of the players and their competition ranking (Hazır et al., 2018). In the current study, a significant negative correlation was found between 20 m speed with clear and TP in males. In other words, technical scores increased with the increase in speed.

Badminton players need to be very fast in order to make a quick and accurate change of direction during intense and difficult rallies (Groppel and Roetert, 1992). In some studies in the literature, a significant relationship was reported between agility and game performance (Singh, Raza, & Mohammad, 2011; Omveer, 2017). On the other hand, other studies showed that quickness and badminton game performance are not related. For example, Hazır et al. (2018) reported that there was no relationship between badminton competition ranking and agility. Hotaman et al. (2018) reported that the agility component was not associated with unforced errors made during the competition. In the current study, there was no significant relationship between agility and technical performance values in either males or females. The current study also found no significant relationship between agility and technical performance values in either males or females. The reason for this may be explained by the technical performance test protocols performed in the study as athletes easily reached the shuttlecocks shot by the feeder during the test. Therefore, it is thought that athletes do not need to move very quickly in order to be successful in the game.

It is stated that high and long jumps, and abrupt stop and start movements in badminton are dependent on the level of the explosive power of the athlete's legs (Omosegaard, 1996). One study conducted found that the players' explosive leg power values and game performance were related (Omveer, 2017). In another study, a significant relationship was reported between vertical jump and game performance (Tiwari, 2011). In another study conducted during an official competition, a significant correlation was found between the long jump values in men and the unforced error values in the front-court and in total, athletes with better standing long jump levels made less unforced errors (Hotaman et al., 2018). In this study, the explosive leg power and technical performance values have shown a significant relationship in men; these relationships were between standing long jump with drop shot and smash, vertical jump with clear and TP.

For the badminton players, the explosive power of the upper limbs is also very important because the ability of players to perform an effective smash exceeding 400 km/h depends on the explosive power produced by the arms (Omosegaard, 1996). In this study, while the data on clear and TP was associated with the strength to throw a medicine ball in females, no relationship was found in males. The reason for this is in the current study the hit rate and speeds of the smash were not tested.

There is a demand for the capacity to produce high levels of strength in badminton as high-level players have been reported to have strong knee, hip and ankle extensors muscles (Reilly et al., 1990; Omosegaard, 1996). In a previous study, it was reported that arm, abdominal and leg strength in game performance showed a significant relationship (Mahulkar, 2016). In contrast, another study reported that game performance and leg strength were not associated (Yadav, 2017). Moreover, Hazır et al. (2018) reported that the lower limb strength of the female athletes and the competition ranking were related, whereas in the men's there was no relation. In this study, positive correlations were observed in females between the hand-grip strength with clear and TP, back strength with clear and TP, leg strength with clear and drop. In addition, a negative relationship was found between hand-grip strength and TP in males.

In a previous study, a significant correlation was reported between the flexibility component of the players and the game performance (Omveer, 2017). In another study, while wrist flexibility and the game performance of the players were found to be significantly related, there was no significant relationship between body flexibility and performance (Singh et al., 2011). In this study, flexibility and technical performance values of males and females were not related.

High-levels of Aerobic power capacity contributes to the recovery between rallies, training and matches as well as long-lasting competitions (BWF, 2011). In this study, no relation has been found between aerobic power and the technical strokes of males, whereas a significant relationship has been found between aerobic power and drop in females.

Conclusions

In the current study, technical performance components were significantly correlated with BMI, speed and explosive power characteristics in male players, while a significant relationship was found between technical performance components and strength and aerobic power values in females. In other words, it can be said that technical performance increases with the development of the speed-power qualities in males and with the increase in strength in females. From this point of view, while planning the physical preparation program for athletes of this age group, in addition to general trainings, it is recommended that there is more focus on speed and explosive power for males, and in strength training for females. In this study, the low number of participants may be considered as a limitation. Nevertheless, it should be taken into consideration that a limited number of athletes (5-8) are selected every year for the national team. In the future, research on different age categories should also be carried out.

Conflicts of interest

There was no conflict of interest in this study..

References

- Abdullah, S. (2014). Effect of high intensity interval circuit training on the development of specific endurance to some of essential skills in youth badminton players, *Journal of Advanced Social Research*, 4(3), 77-85.
- Abian, P., Castanedo, A., Feng, X. Q., Sampedro, J., & Abian-Vicen, J. (2014). Notational comparison of men's singles badminton matches between Olympic Games in Beijing and London, *International Journal of Performance Analysis in Sport*, 14(1), 42-53.
- Abdullahi, Y., & Coetzee, B. (2017). Notational singles match analysis of male badminton players who participated in the African Badminton Championships. *International Journal of Performance Analysis in Sport*, 17(1-2), 1-16.
- Arya, D., & Kumar, S. (2015). Relationship between psychological skills and badminton skills performance. *International Journal of Physical Education, Sports and Health*, 2(1), 288-290.
- Butterworth, D. A., Turner, J. D., & Johnstone, A. J. (2012). Coaches' perceptions of the potential use of performance analysis in badminton, *International Journal of Performance Analysis in Sport*, 12(2), 452-467.

- BWF, Wright L. (Ed.). BWF coaches' manual level 1. Kuala Lumpur, Malaysia: Badminton World Federation; 2011.
- Cabello, D., Padial, P., Lees, A., & Rivas, F. (2004). Temporal and physiological characteristics of elite women's and men's singles badminton, *International Journal of Applied Sports Sciences*, **16**(2), 1-12.
- 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 Biomotricity*, **3**(2), 146-151.
- Coşan, F., Demir, A., & Mengütay, S. (Ed.). (2002). *Türk çocuklarının fiziki uygunluk normları* [Physical fitness norms of Turkish children]. İstanbul: Olimpiyat Oyunları Hazırlık ve Düzenleme Kurulu Eğitim Yayınları.
- Cristian, V., & Timofte, D. (2014). Coordinative and performance capabilities level to badminton juniors, *Marathon*, **6**(2), 136-143.
- Dhabliya, M., Dabholkar, T. Y., & Yardi, S. (2014). Nerve conduction studies of upper extremity in badminton players, *Indian Journal of Physiotherapy and Occupational Therapy-An International Journal*, **8**(4), 72-76.
- Gao, R. Y. (2017). A comparison between talent identification and development (TID) for badminton in China and the UK. The University of Stirling Faculty of Health Sciences and Sport Master's Thesis. Stirling: University of Stirling.
- Groppe, J. L., & Roetert, E. P. (1992). Applied physiology of tennis, *Sports Medicine*, **14**(4), 260-268.
- Hazır, S., Salman, M., Devrilmez, E., & Şatıroğlu, S. (2018). Elit badmintoncularda bazı performans bileşenleri ve şampiyona sıralaması arasındaki ilişki: cinsiyetler arası karşılaştırma [The relationship between some performance components and competition ranking in elite badminton players: gender comparison], *Spor Bilimleri Dergisi*, **29**(1), 27-38.
- Heyward, V. H. (2002). *Advanced fitness assessment and exercise prescription* (2nd ed.). Champaign IL: Human Kinetics.
- Hicks, V. (1973). *The how to of badminton from player to teacher*. US: Texas.
- Hong, Y., Wang, S. J., Lam, W. K., & Cheung, J. T. M. (2014). Kinetics of badminton lunges in four directions, *Journal of Applied Biomechanics*, **30**(1), 113-118.
- Hotaman, F., Özgür, B., & Coşan, F. (2018). 17 yaş grubu milli badmintoncuların müsabaka sırasında yaptıkları basit hatalar ile fiziksel performansları arasındaki ilişki [The relationship between u17 national badminton players unforced errors during the competition and their physical performances], *Spor Bilimleri Araştırmaları Dergisi*, **3**(1), 73-84.
- Jang, H. S., Kim, D., & Park, J. (2018). Immediate effects of different types of stretching exercises on badminton jump smash, *The Journal of Sports Medicine and Physical Fitness*, **58**(7-8), 1014-1020.
- Karatnyk, I., Hrechaniuk, O., & Pityn, M. (2015). Structure and content of competitive activity of 15-17 years old badminton players, *Journal of Physical Education and Sport*, **15**(4), 834-837.
- Kamar, A. (2003). *Sporda yetenek beceri ve performans testleri* [Ability skill and performance tests in sports], Ankara: Nobel Yayın Dağıtım.
- Kamruddin, E., & Mannan, S. (2019). The influence of expertise on anticipation of badminton single serves, *International Journal of Racket Sports Science*, **1**(2), 1-14.
- Leger, L. A., Mercier, D., Gadoury, C., & Lambert, J. (1988). The multistage 20 metre shuttle run test for aerobic fitness. *Journal of Sports Sciences*, **6**(2), 93-101.
- Lam, W. K., Lee, K. K., Park, S. K., Ryue, J., Yoon, S. H., & Ryu, J. (2018). Understanding the impact loading characteristics of a badminton lunge among badminton players. *PloS One*, **13**(10), e0205800.
- Leong, K. L., & Krasilshchikov, O. (2016). Match and game performance structure variables in elite and youth International badminton players, *Journal of Physical Education and Sport*, **16**(2), 330-334.
- Mahulkar, S. S. (2016). Relationship of strength and flexibility with skill performance in badminton players, *International journal of Physical Education, Sports and Health*, **3**(5), 38-40.
- Manikandan, S. (2016). Relative importance of anthropometric biomotor and skill performance to playing ability of college badminton players. *International Journal of Physical Education, Sports and Health*, **3**(2 Part C), 156-158.
- Nadzalan, A. M., Mohamad, N. I., Lee, J. L. F., & Chinnasee, C. (2018). Relationship between muscle architecture and badminton-specific physical abilities, *Human Movement*, **19**(1), 44-50.
- Omosegaard, B. O. (1996). *Physical training for badminton*. Denmark: Malling Beck.
- Omveer. (2017). A study on prediction of playing ability in badminton from selected anthropometrical physical and physiological characteristics among inter collegiate players, *International Journal of Advanced Research and Development*, **2**(5), 50-54.
- Özer, K. (2006). *Fiziksel uygunluk* [Physical fitness]. İstanbul: Nobel Yayın Dağıtım.
- Patterson, S. M., Udermann, B. E., Doberstein, S. T., & Reineke, D. M. (2008). The effects of cold whirlpool on power, speed, agility, and range of motion, *Journal of Sports Science & Medicine*, **7**(3), 387-394.
- Reilly, T., Secher, N., Snell, P., & Williams, C. (1990). *Physiology of sports* (2nd ed.). London: E & F N Spon.

- Weicneck, J. (2011) *Futbolda kondisyon antrenmanı* [Condition training in football]. Ankara: Spor Yayınevi ve Kitapevi.
- Salim, M. S., Lim, H. N., Salim, M. S. M., & Baharuddin, M. Y. (2010). Motion analysis of arm movement during badminton smash. In 2010 IEEE EMBS Conference on Biomedical Engineering and Sciences (IECBES) (pp. 111-114). IEEE.
- Singh, J., Raza, S., & Mohammad, A. (2011). Physical characteristics and level of performance in badminton: a relationship study, *Journal of education and practice*, **2**(5), 6-10.
- Sturgess, S., & Newton, R. U. (2008). Design and implementation of a specific strength program for badminton. *Strength & Conditioning Journal*, **30**(3), 33-41.
- Ting, H. Y., Sim, K. S., & Abas, F. S. (2015). Kinect-based badminton movement recognition and analysis system, *International Journal of Computer Science in Sport*, **14**(2), 25-41.
- Tiwari, L. M., Rai, V., & Srinet, S. (2011). Relationship of selected motor fitness components with the performance of badminton player. *Asian Journal of Physical Education Computer Science in Sports*, **5**(1), 88-91.
- Wahyudi, M., Hartono, M., & RC, A. R. (2018). Technical skill analysis of badminton blow on teenager players of Pendowo Club Semarang, *Journal of Physical Education and Sports*, **7**(2), 119-123.
- Yadav, S. K. S. (2017). Relationship of selected motor fitness variables with the performance of badminton players, *International Journal of Physical Education, Sports and Health*, **4**(2), 145-147.