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Research Article

Analysis ofPhysical fitness and Anthropometric Fitness with Respect to Ranking in the Iranian National Table Tennis Team Selection

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Abstract

Background: The aim of the present study was to assess the physical fitness and anthropometric characteristics variables associated with individual performance in elite table tennis players according to ranking. On the direction of this aim 16 male National table tennis Players'

Materials and Methods: participated in this study. Sixteen elite players divided into A players (n = 8; 26 ± 5.14 years) and B players (n = 8; 25.63 ± 4.46 years) participated in the study. According to ranked some physical fitness, physiological and anthropometric variables were recorded of each subject. To determine Physical fitness, participants performed anaerobic power; wingeyt test, Aerobic power; 1600 m running and anthropometric test.

Results:

A players showed higher values in maximum oxygen consumption and somatotype component. A mesomorph – endomorph somatotype was registered for the lower ranked, On the other hand somatotype of first 8 table tennis players could be defined as ectomorph –mesomorph. The somatotype was predominantly mesomorphic, while better players showed a more ectomorphic somatotype, meaning ecto-mesomorphic. Elite male table tennis players (A players) showed better physical fitness and somatotype compared to B players.

Conclusion:: It seems anthropometric and physical fitness are important parameters for performance. The dominance of the ectomorph - mesomorph body type reveals a potential advantage of this body type, that increases the success probability, Due to the scarcity of data on elite table tennis players, these results can serve as reference values for different table tennis practitioners. examine statistical differences between groups and p value < 0.05 was considered to be significant.

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1.Introduction

In today's advanced world, the general view is that world-class sports records belong exclusively to super humans, with no place for ordinary athletes. Scientific findings and results from various competitions over the past years demonstrate significant progress in table tennis, making it rare to find athletes with absolute security margins. Elite athletes possess unique characteristics that enable them to outperform others. Success in many sports, directly or indirectly, relates to both anthropometric characteristics and physical fitness (1, 2). Table tennis is no exception. It is a complex sport, and its energy requirements are met through both aerobic (oxidative) and anaerobic (glycolysis) metabolism. Table tennis requires excellent motor skills such as speed, power, endurance, agility, balance, and good reflexes. Given the energy demands in table tennis, anaerobic glycolysis and phosphagen pathways are dominant during very short maximal efforts, coupled with the aerobic system during recovery. Many table tennis coaches have focused on maximal aerobic capacity. Consequently, the aerobic system also plays a crucial role in energy production and rapid replenishment of energy reserves during short rest periods (3, 4, 5). These subtle factors often determine the boundary between winning and losing in a competition (5, 6). From this perspective, success in table tennis necessitates the ability to perform high-intensity efforts, recover quickly between rallies and matches, and sustain performance. Furthermore, physical characteristics such as agility, reaction time, explosive power, and coordination are key to performance and can be enhanced through training (5,7).

It is evident that neuromuscular adaptations are specific to different training stimuli. Power is one of the most vital characteristics of muscle function and a critical ability for any athlete in competitive sports. From a sporting perspective, the ability to perform high-intensity to maximal exercises in less than a few seconds is called power (7,8). Based on this, any increase in power must result from improvements in strength, speed, or a combination of both. The main goal of strength training in high-level competitive sports is the specific advancement of players and the correlation between the athlete's activities and the specific type of strength training performed. in that sport (7,8). Numerous table tennis trainers have focused on maximal aerobic capacity, Maximal oxygen uptake (VO2max) in Brazilian national-ranked players, determined on a treadmill (43.9 ± 1.5 mL/kg/min) and stationary bicycle, was similar (41.3 ± 1.4 mL/kg/min) The VO2max measured in a specific table tennis test was 44.0 ± 4.5 mL/kg/min. This test involved using a robot to throw balls, and the ball throwing frequency in this test was 59.1 ± 6.9 balls per minute (5).These findings indicated that table tennis players have a very low aerobic capacity—approximately 40 to 50 mL/kg/min—which is less than that observed in other racket sports like tennis (approximately 58 mL/kg/min), squash (approximately 64 mL/kg/min), and badminton (approximately 60 mL/kg/min). Despite table tennis having a higher aerobic contribution during matches, table tennis players exhibit lower aerobic capacity compared to other racket sports and should therefore pay more attention to this physical component, mainly for elite and defensive players (7,9,).

Anaerobic power is estimated using the Wingate test. Elite Slovenian national male players (n=4) showed peak power of 9.60 ± 0.79 W/kg body mass and mean power of 7.95 ± 0.88 W/kg body mass, while elite Slovenian female players (n=4) had peak power of 8.03 ± 0.78 W/kg body mass and mean power of 6.55 ± 0.54 W/kg body mass. These values were higher than those for young elite tennis players (peak power: 8.6 W/kg body mass; mean power: 7.4 W/kg body mass). Zagatto et al. showed that anaerobic capacity in table tennis was moderate. Study results indicate that greater anaerobic capacity allows for higher intensity rallies (5,9). Based on the analysis of findings, a table tennis player typically has a relatively low oxygen consumption (approximately 40 to 50 mL/kg/min) (10). High-intensity training allows for the improvement of sport-specific aerobic and anaerobic components. However, to our knowledge, no study has investigated the response of different training methods to improve aerobic and anaerobic components in table tennis players. Recently, in endurance athletes, combining low-intensity training and high-intensity training with a training time ratio of approximately 4:1 resulted in greater improvements in most key endurance performance variables (including VO2max) compared to high-volume, threshold, or high-intensity training alone. Whether a combined strategy of high-volume, low-intensity training and low-volume, high-intensity training is also beneficial for improving aerobic and anaerobic components in table tennis players is a question that requires further research. However, since light to moderate movements constitute a significant portion of movements performed by table tennis players, a combined training strategy (i.e., high-volume, low-intensity training and low-volume, high-intensity training) may be logical for improving aerobic and anaerobic components in table tennis(9,10).

Researchers are constantly striving to identify inexpensive, practical, yet reliable methods for assessing human health status, abilities, and athletic capacities. Among these methods are anthropometry and physical fitness. Anthropometry is recognized as a non-invasive and inexpensive method that can yield a wealth of information from subjects in a short time(11,12). Monitoring anthropometric characteristics and body composition in table tennis can assist coaches in identifying talented players and optimizing training programs. Furthermore, the human physique can be classified using somatotype, with the Heath-Carter method being a popular assessment approach. In brief, this method involves a three-level numerical rating scale indicating endomorphy (relative adiposity), mesomorphy (relative musculoskeletal robustness), and ectomorphy (relative linearity or slenderness). The physical demands and technical skills in racket sports like table tennis depend on anthropometric characteristics and somatotype. Optimal body composition for a specific racket sport is crucial for developing a successful athletic career. Additionally, anthropometric characteristics and body composition play an important role in talent identification in racket sports, especially in table tennis(11,12). Anthropometric characteristics widely collected and utilized in previous table tennis studies included body mass, height, and Body Mass Index (BMI). Knowledge regarding the anthropometric profile of table tennis players is based on rare research comparing players of different levels, leading to inconsistent results. . For example, a study on Brazilian table tennis players showed that international male players were shorter than national and regional players, but this was not the case for females (11,12).

Knowledge regarding the anthropometric profile of table tennis players has compared players of different levels, leading to inconsistent results. Spanish male table tennis players are balanced mesomorphs, while females were endomorphic mesomorphs. Chilean male table tennis players were mesomorphic endomorphs(11,12,13). Body composition has been one of the main components of health- and sport-related physical fitness. The two components of the human body, fat mass and fat-free mass, have been considered and can be estimated by measures such as skinfold thickness or directly assessed. No differences in muscle tissue, fat tissue, and skinfold thickness were observed between Chilean national team players and university table tennis players. Similarly, no differences in fat mass or fat-free mass were shown among Brazilian table tennis players at international, national, and regional levels. Furthermore, a study comparing skinfold thickness across different sports showed that table tennis was among the sports with higher fat mass (1,7,14). Generally, table tennis players have short to medium height, normal body mass, and normal fat mass. Fat mass does not distinguish table tennis players based on performance level. Also, existing knowledge about anthropometric characteristics and body composition relies on a limited number of sources. Therefore, the above observations should be considered with caution, and further research in this area, especially regarding the anthropometric characteristics of table tennis players from dominant countries in the sport such as China, is essential (1,11). Performance in table tennis, as in any sporting event, is the result of several factors, including "the amount and structure of training performed, the body's readiness and adaptation to training, motivation level, facilities, etc."

Therefore, physiological parameters form only part of any performance, and thus the role of any "sports physiologist" is similarly limited. Thus, factors that involve physiological processes and are somewhat controllable can be measured and ultimately improved. (7,10). Physical fitness tests attempt to measure performance. The benefits of physical fitness testing in table tennis are primarily for precise training planning. First and foremost, we can identify and determine a player's weaknesses and strengths (5, 10). This can be done by comparing test results with those of other athletes in the same training group or a similar demographic. Previous test results from large groups are often published as normative tables. Physical fitness testing is primarily used to help design the most appropriate sports training program to achieve better results in table tennis. To gain a more precise understanding of the physiological and metabolic demands involved in table tennis, it is essential to learn about the game's dynamics. Thus, describing game parameters such as temporal structure, considering the total playing time and rest time of this sport, research has investigated the total match duration and shown that for men it ranges from 8 to 38 minutes and for women between 9 to 41 minutes. The average rally time for men is between 3.1 to 4.6 seconds. Physiologically, heart rate (HR) and its various manifestations—such as maximal heart rate (HRmax), mean heart rate (HRmean), and minimal heart rate (HRmin)—are generally the parameters studied to form one of the few direct physiological indicators applied during competition. Studies analyzing HRmean to determine table tennis intensity have yielded average values of 135-163 beats per minute in various research. Furthermore, HRmax values have been reported to be in the range of 177-183 beats per minute (10, 15).

Today, table tennis demands high motor ability. Maximum power and local muscular endurance are of higher importance in this sport, as a table tennis rally lasts only a few seconds, and explosive power plays a decisive role. In many studies, the Wingate test is used to determine anaerobic power. The Wingate anaerobic test is accepted for assessing muscular power, muscular endurance, and fatigability. This test is one of the most widely used anaerobic performance tests globally. It was chosen because numerous laboratories have confirmed its very high reliability and its validity as a test that can provide information on peak power and local muscular endurance. Peak power is the highest mechanical power extracted from the test, considered as the average power over any 5-second interval. Mean power is the average power maintained throughout the six 5-second segments. The fatigue index is the rate of power decrease during the test, expressed as a percentage of peak power. Training at the anaerobic level is as important for a table tennis player as training at the aerobic level. Table tennis is a unique game that simultaneously requires explosive power and endurance. In modern table tennis, physical fitness is of paramount importance. Unlike other racket sports such as tennis and badminton, scientific information regarding performance, physiological responses during table tennis matches and training, and practical recommendations for enhancing aerobic and anaerobic performance are insufficient. Competition seems to be "the ultimate test of performance ability" and, therefore, "the best indicator of training success." Nevertheless, "when attempting to maximize performance, it is important to determine a player's ability in individual aspects of performance." Since body composition is modifiable with training, a number of studies have sought to describe skeletal and morphological changes resulting from training in various sports and maturity stages(3, 5, 9, 15). However, information on how somatotype differs during formative stages of table tennis and its impact on performance is very limited. Therefore, the goal of our research was to identify the physiological and anthropometric characteristics of selected players in the Iranian adult national table tennis team selection competitions.

2. Materials and Methods

The statistical population of the present study included 16 top table tennis players in the country who competed in the national team selection. The sample size was considered equal to the population size. To obtain the necessary information, 16 elite players who participated in the national team selection competitions were divided into two groups of 8 based on their achieved rank. They were tested to assess anthropometric, physical, and motor factors. Height, weight, and skinfold thickness tests were used to evaluate the anthropometric profile, while the 1609-meter test (aerobic power) and Wingate test were used to assess the physiological profile of the players for physical fitness. Most physical fitness tests were conducted at the National Olympic Academy's Physical Abilities Assessment Center.

The kolmogorof-smirnov test was applied to determine the nature of data distribution. Since a normal distribution was confirmed, a t- test for independent samples was performed to examine statistical differences between groups and p value < 0.05 was considered to be significant.

3. Results

Table1 shows the Physical fitness and anthropometric test. There were no significant differences in Body fat%, BMI, Anaerobic power, Endomorphy and mesomorph between the first 8 and the lower ranked table tennis players, while there were significant differences in aerobic power and somatotype component. A mesomorph – endomorph somatotype was registered for the lower ranked and somatotype of first 8 table tennis players could be defined as ectomorph. – mesomorph .

Table1. Physical fitness, anthropometric characteristics of the participants (mean ±sd)

		N	Mean	SD	df	P
Height	a	8	172	4.47	14	0. 86
	b	8	175	5.43		
Weight	a	8	67.4	6.21	14	0.69
	b	8	73.5	5.36		
Body fat%	a	8	18.16	2.06	14	0.824
	b	8	20.08	2.28		
BMI	a	8	22.8	.74	14	0.168
	b	8	24	1.23		
Anaerobic power	a	8	4.57	0.71	14	0.378
	b	8	4.86	0.62		
Aerobic power	a	8	47.2	5.84	14	0.044*
	b	8	42.77	4.23		
Endomorf	a	8	3.54	1.38	14	0.568
	b	8	3.92	1.43		
Mesomorf	a	8	3.86	0.59	14	0.428
	b	8	3.61	1.03		
Ektomorf	a	8	4.36	0.52	14	0.038*
	b	8	3.47	0.76		

Significantly different: * $p < 0.0$

Discussion

The aim of this study was to analyze specific physical fitness with respect to ranking in the Iranian national table tennis team selection. The objective of the present study was to evaluate differences in anthropometric characteristics and the most specific physical fitness variables related to the individual performance of elite table tennis players as a function of competition. In this article, we have considered the adaptations of table tennis players and their characteristics according to their achieved rank. The relatively small number of research studies in this field limits the scientific information available to coaches regarding specific procedures, physiological profiles, and table tennis competition characteristics. Research has shown that players can increase their aerobic capacity and power through regular training programs tailored to the physiological profile of successful professional players (6, 14, 16). Table tennis is a sport where a rally lasts between 10 to 15 seconds (3, 9). Power, speed, strength, agility, and body flexibility are dominant factors in this sport, such that performance and success in this sport require optimal physical fitness (5, 17, 18). In this sport, the predominant energy system is the anaerobic system (ATP-PC), also known as the phosphagen and lactic acid system, but having desirable aerobic power is also a key factor for success in this sport because a competition may sometimes last between 35 to 45 minutes (3, 5). Consequently, the aerobic system also plays a crucial role in energy production and rapid replenishment of energy reserves during short rest periods (5, 16, 19). The present study showed a significant difference in the aerobic capacity of the top 8 players compared to the second group. VO2max is considered an optimal indicator for a player's aerobic fitness. In this regard, studies on elite Asian and European players have shown a VO2max range between 43.9 to 67.9 mL/kg/min, values reported in the present study for men fall within this range (3, 5, 19). Compared to other racket sports, a lower VO2max value was observed among participants in the present study compared to padel, tennis, and badminton players(17, 19). However, in tennis players, mean values of 58 mL/kg/min were observed after a specific test, which were higher than the values in the present study. Additionally, mean values of 46 mL/kg/min were observed in badminton players and 36.4 mL/kg/min in female players, which are lower than the results obtained in the present study(19, 20).). Like other sports, table tennis has an aerobic component. A high level of endurance allows an individual to maintain strokes for a longer duration in a game and recover faster during the game. Therefore, maintaining a high level of maximal oxygen consumption is important, hence the importance of training and evaluating it. The best players usually have higher levels of endurance. Endurance is a term that describes two separate but related concepts: muscular endurance and cardiorespiratory endurance, each contributing uniquely to player performance, and thus the importance of each varies for different players. Endurance is a quality of a table tennis player that allows them to maintain high speed during top-spin strokes with high ball rotation. Muscular endurance is the ability of the shoulder muscle group to maintain repeated powerful strokes and fast movements on the court.

The resulting fatigue is limited to a specific muscle group (shoulder girdle), and the duration of activity is usually very short. Muscular endurance has a strong correlation with muscular strength and anaerobic development. Cardiorespiratory endurance relates to the whole body. This endurance supports the table tennis player's ability to sustain prolonged activity in long table tennis matches. Cardiorespiratory endurance relates to the development of the cardiovascular and respiratory systems and, consequently, aerobic development. Therefore, the term aerobic endurance is used to denote cardiorespiratory endurance. VO2max is defined as the highest rate of oxygen consumption achievable during maximal or exhaustive exercise. Accordingly, it is beneficial for a table tennis player to have high aerobic endurance so that their anaerobic metabolism can recover during rest periods of the game. Many studies have been conducted on physical fitness factors and physiological characteristics in various sports, including table tennis (4, 5, 9, 14). For example, a study in Australia on adult table tennis players, consistent with our research results, showed that with increasing professional activity level of players, maximal oxygen consumption (VO2max) increases(21). In 2007, a similar study was conducted on tennis players; the results of this research showed that the oxygen consumption capacity in tennis players reaches 50 to 70 mL/kg/min (3, 22). Although the aerobic system appears to be the dominant energy pathway during a table tennis match, the anaerobic system is the most important pathway for resynthesizing adenosine triphosphate (ATP) during periods of high effort. Therefore, anaerobic capacity is crucial for table tennis performance during short and long rallies (i.e., athletic efforts) that involve power, speed, strength, and agility activities

In table tennis, winning or losing a match is often determined in moments of high effort. Therefore, higher efficiency of anaerobic energy production leads to faster movements and more powerful strokes that can be decisive for scoring points and games (3, 5, 19).

Aleen conducted a study in 1986 on 21 Australian and Swedish male and female table tennis players. The research results indicated a significant difference between the physical fitness variables of the two groups of athletes (22). In another study conducted on 7 top players from Sweden, the VO2max was found to be 65 mL/kg/min. In these players, heart rate varied considerably during matches. Furthermore, the heart rate of elite Swedish players was reported to be 20 to 30 beats per minute below maximal heart rate. In another study conducted on elite Japanese players, research findings showed that the maximal oxygen consumption of elite Japanese table tennis players was higher than that of ball players (handball, volleyball, etc.), and the weakness of these players in back muscle strength and vertical jump was reported to be due to insufficient strength training (4, 5, 19).

While the aerobic system appears to be the dominant energy pathway in a table tennis match, the anaerobic system is the most important system for resynthesizing adenosine triphosphate during periods of high effort, while the aerobic system allows for repeated powerful strokes, fast movements on the court, and ensures rapid recovery, which helps maintain the player's ideal state (i.e., focus and readiness) for their next effort during the game. a study was conducted to determine the athletic profile and somatotype of young table tennis players. In this study, the mesomorphic somatotype was identified as the predominant somatotype in table tennis (3, 5, 23).

Research conducted on tennis players showed that approximately 80% of the energy required for this sport is supplied through anaerobic metabolism and the phosphagen system (24). Another study on table tennis players demonstrated the positive effect of strength, force, explosive power, and speed on player performance (25). Additionally, in another similar study, a high negative correlation (r = -73%) was reported between an increase in anaerobic tone and a decrease in the fatigue index (26).

Despite the considerable work that has been done, significant information is still needed to claim comprehensive knowledge of table tennis. In this article, we have focused solely on the physiology of the table tennis player. The importance of muscular and cardiorespiratory endurance training for table tennis players has been demonstrated by sports scientists. Endurance is essential for players to fully realize their skills and tactics at the table. Table tennis players are often not only physically exhausted after a match but also under considerable mental pressure. Therefore, it is important for coaches to remember that although the anaerobic alactic system is the most energetic system used during periods of activity in a table tennis game, a strong capacity for endurance is what helps a player recover faster for the next match and the day after the match. Comprehensive knowledge in modern table tennis players is lacking. Specifically, data for young players between 10 and 17 years old are limited (7, 10, 27, 28). In the anthropometric characteristics of high-level table tennis players based on ranking, research results showed that: table tennis players exhibited differences in body composition, anthropometry, and somatotype based on ranking; the somatotype in the first group was ecto-mesomorphic predominantly ectomorphic, and in the second group, endomorphic; fat mass in the first group was less than 16 to 20%, while the second group was less than 19 to 23%. Better players showed a more ectomorphic somatotype. These data provide useful information for coaches on how somatotype differs during the formative stages of table tennis and its impact on performance.

Compared to other racket sports, high-level table tennis players showed less fat mass than elite rowers and closer to elite badminton, squash, Padel and tennis players. Additionally, table tennis players were shorter than those in other racket sports (19, 20, 29, 30, 31). These specific characteristics can be attributed to the explosive nature of table tennis competition, characterized by fast and continuous movements. Table tennis players required significant activity in their lower limb muscles to perform short explosive movements, rapid changes of direction, and effective hitting of the ball in decisive strokes such as forehand and forehand top-spin repeatedly throughout the game. Therefore, high fat mass values hinder performance by limiting movement speed while increasing the risk of knee injury. Table tennis players exhibited a similar somatotype, Although body composition cannot be considered a unique factor for performance, the differences observed here may be the first important approach to identifying what can distinguish a table tennis player among others. In this regard, technical-tactical skills and movement speed can be mediated by higher muscle mass (i.e., higher strength and force production) and lower fat mass (i.e., lower energy cost and better movement economy), which is especially important in table tennis given its ballistic nature and high coordination demands (1, 8, 12, 23, 31,32).

Nevertheless, the role of optimal physical fitness for achieving higher rankings in table tennis during formative stages needs further investigation.

Conclusion

Table tennis players showed morphological differences based on ranking. Overall, table tennis players had less than 20% fat mass and approximately 45% fat-free mass. The somatotype was predominantly mesomorphic, while better players showed a more ectomorphic somatotype, meaning ecto-mesomorphic. Fat-free mass appears to be associated with better performance in table tennis players. The endomorphic somatotype had a negative relationship with performance, while the ectomorphic profile appears to be more effective. These results can indicate the importance of muscle mass in table tennis players during the formative stages.

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Compliance with ethical standards

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Ethical approval the research was conducted with regard to the ethical principles.

Informed consent Informed consent was obtained from all participants.

Author contributions

Conceptualization: A.M., B.R; Methodology: A.M., D.B; Software: : A.M., B.R; D.B; Validation: S.A., A.B.; Formal analysis: B.R; D.B; Investigation S.A., A.B., Resources: R.G.; Data curation A.M., D.B; Writing - original draft: A.M., B.R; Writing - review & editing: A.M., B.R; D.B; Visualization: A.M Supervision: B.R Project administration A.M; Funding acquisition: A.M., D.B.

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