Health and Skill Related Physical Fitness Variable between Male and Female Junior Volleyball Players: A Comparative Study

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Abstract. Physical fitness, which is crucial for both health and skills, plays a pivotal role in volleyball performance. The research methodology employed a comparative design involving 72 junior volleyball players (36 men and 36 women) selected through purposive sampling. Health-related fitness parameters assessed included VO2Max and flexibility, while skill-related parameters encompassed speed, agility, power, and coordination. Data analysis utilized independent t-tests to identify significant differences between the two groups. The findings indicated that male volleyball players exhibited significantly higher VO2Max values (X = 31.29 ml/kg/min) compared to female players (X = 28.33 ml/kg/min) with a p-value of 0.001. Conversely, female players demonstrated superior flexibility (X = 36.06 cm) compared to male players (X = 33.40 cm) with a p-value of 0.028. Regarding skill parameters, male players outperformed in speed (X = 6.92), agility (X = 18.72), and power (X = 50.66), all with p-values < 0.05. On the other hand, female players exhibited better coordination (X = 5.11) compared to male players (X = 3.94) with a p-value of 0.003. In conclusion, there are significant disparities in various physical fitness parameters related to health and skills between male and female junior volleyball players.

Keywords: Health, Skill, Physical Fitness

1 Introduction

Physical fitness is one of pivotal determinants that influences sports performance [14], [44], [60]. Physical fitness is characterized by a healthy body condition capable of optimal performance in diverse daily activities. It is classified into two categories: physical fitness associated with health and physical fitness associated with skills in a sport [28], [64]. Health-related fitness serves as a fundamental cornerstone in human life [59], essential for individuals in general as well as athletes, to maintain optimal physical fitness that bolsters their daily pursuits and accomplishments. Health-related fitness components encompass muscle strength, muscle endurance, cardiovascular endurance, flexibility, and body composition. On the other hand, skill-related fitness pertains to the physical abilities crucial for effectiveness and efficiency in sports or activities demanding specific skills.

A. M. Sholikhah et al. (eds.), *Proceedings of the International Seminar of Sport and Exercise Science (ISSES 2024)*, Advances in Health Sciences Research 81,
https://doi.org/10.2991/978-94-6463-593-5_23

Volleyball, a dynamic and physically demanding sport, necessitates distinctive physical attributes and skills. Key fitness components linked to skills in volleyball encompass speed, agility, power, balance, coordination, and reaction time [24] are very important for optimal performance in the game of volleyball. By comprehending the distinctions in these factors between male and female players, valuable insights can be gained for coaches and academics to tailor training programs that enhance performance, minimize injury risks, and enable players to execute technical skills effectively, respond promptly to game situations, and perform complex movements.

Despite the extensive research on physical fitness in volleyball players, there remains a scarcity of studies that specifically delve into the comparative analysis of fitness concerning gender-specific skills, particularly at the junior level where young athletes are at a pivotal stage [7]. This critical juncture presents an opportunity for targeted interventions that can have long-lasting effects on their abilities and overall career development. Hence, conducting this comparison in a structured and empirical manner holds significant importance.

This research aims to bridge this gap by conducting a thorough comparative analysis of fitness components related to skills among male and female junior volleyball players. Through the assessment of crucial fitness elements, the study aims to pinpoint areas where gender disparities are most prominent, laying the groundwork for gender-specific workout routines. Furthermore, these insights may enhance the overall comprehension of how physiological and developmental factors impact performance in junior athletes.

Hence, this study has four primary objectives: (1) Measure and compare physical fitness components crucial for health, specifically flexibility and cardio endurance, among male and female junior volleyball players; (2) Evaluate and compare physical fitness components essential for skills, including speed, coordination, agility, and power, among male and female junior volleyball players; (3) Analyse the potential implications of the identified differences for enhancing training and performance; (4) Provide recommendations for future research and practical applications in the realm of exercise science and training.

Through the attainment of these objectives, this research aims to enhance the scientific comprehension of distinct fitness factors in junior volleyball players and facilitate the creation of enhanced and streamlined training programs.

2 Method

2.1 Participants

This research employs a cross-sectional comparative study method, characterized by an observational analysis of data from a population at a single point in time [9], [30], [55]. The research was carried out at the Sports Laboratory School (SELABORA) of Yogyakarta State University. The study sample comprised 72 participants, divided into two groups: the first group consisted of male football players (n=36), and the second group comprised female volleyball players (n=36). The selection of participants for this study utilized a purposive sampling method, requiring that individuals had a minimum of one year of volleyball practice, were free from injuries, and were willing to undergo the series of tests without coercion. For detailed characteristics of the study sample, refer to Table 1.

Table 1. Participant's physical characteristics (mean ± SD)

Group	N	Age	Height (m)	Weight (kg)	BMI
Male	36	13.19±1.45	1.63±0.08	51.92±9.17	19.36±2.85
Female	36	12.58±1.53	1.56±0.04	50.09±4.07	20.54±1.63

2.2 Data Collection

Data collection techniques in this research involved utilizing tests and measurements. Participants were required to be in good health, free from injuries, abstain from strenuous exercise for at least 48 hours, and refrain from consuming food before the tests. Prior to testing, participants were instructed to warm up and stretch for 10 minutes. Body composition was also assessed during the testing process, with strong verbal encouragement given to motivate participants to exert maximum effort.

The instruments employed to evaluate the level of physical fitness pertaining to skills encompass the following tests: the 40-meter Sprint test for speed assessment, Wall Catch Test for coordination evaluation, Vertical Jump Test for power measurement, Multistage Test for aerobic endurance assessment, Agility-T Test for agility evaluation, and Sit and Reach test for flexibility measurement.

Sprint Speed test 40-meter. This test was conducted based on the criteria stated by [35]. Begin by marking the 40-meter track with start and finish line cones. Participants should position themselves at the starting line with one foot behind it, poised to commence running. Upon hearing the command "Go," participants should sprint from the start to the finish line as swiftly as possible, with the timer commencing when movement begins. The stopping time is recorded as the participant crosses the finish line. Each participant is allowed two attempts to achieve their optimal performance, with a rest interval of approximately 2-5 minutes between attempts to prevent fatigue.

Alternate-Hand Wall-Toss. The test commences with the participant positioned 2 meters away from a wall, holding a tennis ball in one hand. Subsequently, the participant throws the ball against the wall with one hand and catches it with the other hand after it rebounds. This action is repeated for a duration of 30 seconds. Scoring is determined by the quantity of successful ball catches. In instances where the ball drops or is not caught, the participant must promptly retrieve the ball and resume the test. The evaluation of this test is contingent upon the number of successful throws and catches achieved.

Vertical Jump (VJ) Test. Vertical Jump (VJ) is employed as an indirect method to assess lower body strength in the vertical dimension [1]. The equipment required includes a board affixed to the wall at a height ranging from 150 to 350 cm, powdered chalk such as talcum powder or flour, and a blackboard eraser. To conduct the test, begin by dusting the fingertips with lime powder or magnesium carbonate. The participant then stands upright near the wall with feet together, positioning the scale board to the left or right. Subsequently, the hand closest to the wall is extended straight up, with the palm placed on the scale board to mark the reach. Participants commence in a crouched position with the dominant hand or arm raised vertically, while the other arm hangs by the body's side without aiding in the jumping motion. Upon jumping as high as possible and touching the board with their fingertips to leave a mark, the assessment is based on the difference between the jumping and standing achievements. Each participant is given two attempts to perform this test, and the best result is recorded.

Multistage Fitness Test. Multistage is a field test that is straightforward yet provides a reasonably precise estimation of maximum oxygen consumption for a variety of applications or objectives [12]. The multistage test in this resarch was carried out based on the criteria proposed by [33]. Participants had to shuttle between two designated lines precisely 20 meters apart. The running pace was regulated by auditory signals (beeps). Starting at 8.5 km/h, the speed for the test incremented by 0.5 km/h with each successive stage. The participant's ultimate score on this test was the final shuttle reached at the specified running pace. The test concluded when the participant failed to reach the next line twice consecutively following the auditory cue.

Agility T-Test. The Agility T-Test is a tool for measuring agility that employs a T-shaped field pattern to evaluate an individual's agility level. This test assesses agility in forward, backward, and sideways movements. The test procedure follows the guidelines set by [35]. The results of this test are determined by the fastest time recorded. Timing begins as the participant moves from the starting line and concludes when the participant returns to the starting line.

Sit and Reach. Flexibility is measured using the sit and reach test. Participants sit with their feet positioned approximately hip-width apart against the testing box, extend their knees, place their right hand over the left, and then reach forward slowly as far as possible by sliding their hands along the measuring board. Each participant has two chances to perform this test, and the best result is recorded. Test norms are established based on [19]

Statistical Analysis. Data analysis was conducted using SPSS version 27.0. The data is presented as mean ± standard deviation (SD). The analysis employs a two-tailed independent sample t-test to examine differences in group averages with a significance level set below 5% ($p<0.05$). Before proceeding with the main test, prerequisite tests are performed: (1) normality test using Shapiro-Wilk; and (2) homogeneity test using Levene Statistics. These prerequisite tests require a significance level above 5% ($p>0.05$).

3 Result and Discussion

3.1 Result

The researchers conducted a normality test using the Shapiro-Wilk method to assess if the data in this study followed a normal distribution. The results indicated that all variables had a p-value > 0.05, indicating normality. Further information can be found in Table 2.

Table 2. Normality Test Results

Variable	Group	Shapiro-Wilk		
		Statistic	**df**	**Sig.**
Sprint -40 m (s)	Male	.947	36	.085
	Female	.976	36	.600
Alternate-Hand Wall-Toss	Male	.954	36	.144
	Female	.957	36	.175
Agility-T Test (s)	Male	.989	36	.975
	Female	.972	36	.479
Vertical Jump (cm)	Male	.982	36	.804
	Female	.942	36	.059
VO2Max(ml.kg.min)	Male	.971	36	.466
	Female	.959	36	.201
Sit and Reach (cm)	Male	.958	36	.193
	Female	.969	36	.389

To proceed with a comparative study, the next essential assumption test is the homogeneity test. This test validates that the variance between groups is consistent. Results from Levene's test indicate that all research variables have a p-value > 0.05, confirming homogeneity of variance in this analysis. Additional information is available in Table 3.

Table 3. Homogenity Test Results

Variable	Levene Statistic	df1	df2	Sig.
Sprint-40 m (s)	.138	1	70	.711
Alternate-Hand Wall-Toss	2.512	1	70	.117
Agility T Test (s)	3.066	1	70	.084
Vertical Jump (cm)	3.410	1	70	.069
VO2Max (ml.kg.min)	2.685	1	70	.106
Sit and Reach (cm)	3.066	1	70	.084

The comparative analysis of health-related fitness parameters between male and female volleyball players revealed notable differences. Male players exhibited a higher average VO2Max value (X = 31.29 ml/kg/min) compared to female players (X = 28.33 ml/kg/min). Conversely, in flexibility measured by sit and reach, female players (X = 36.06 cm) outperformed male players (X = 33.40 cm) with a significant p-value of 0.028. Detailed results are available in Table 4.

Table 4. Comparison of health related fitness parameters between male and female volleyball players

Health	Gender	N	X	SD	t	p
VO2Max (ml/kg/min)	Male	36	31.29	3.89	3.574	<0.001
	Female	36	28.33	3.09		
Sit and Reach (cm)	Male	36	33.40	4.56	2.247	0.028
	Female	36	36.06	5.44		

N= number of participants, X= mean, SD= standard deviation, t= T score, p<0.05

The comparative analysis of skill-related fitness parameters between male and female volleyball players revealed significant differences. Male players demonstrated faster sprint times in the 40-meter test (M = 6.92) compared to female players (M = 7.36), with a p-value of 0.003. Additionally, in the agility test using the T-test, male players exhibited superior performance with an average time of 18.72 seconds, while female players averaged 20.04 seconds, with a p-value < 0.001. Furthermore, in the power ability test measured by the vertical jump, male players achieved a greater jump height (X = 50.66 cm) than female players (X = 36.44 cm), with a p-value < 0.001.

However, in the coordination test utilizing the Alternate-Hand Wall-Toss method, female volleyball players (X = 5.11) exhibited superiority over male volleyball players (X = 3.94) with a p-value of 0.011. More details can be found in Table 5. This suggests that female volleyball players generally excel in the coordination aspect compared to their male counterparts.

Table 5. Comparison of skill related fitness parameters between male and female volleyball players

Skill	Gender	N	X	SD	t	p
Sprint-40 m (s)	Male	36	6.92	.59	-3.031	0.003
	Female	36	7.36	.66		
Alternate-Hand Wall-Toss	Male	36	3.94	1.56	-2.601	0.011
	Female	36	5.11	2.18		
Agility T Test (s)	Male	36	18.72	1.60	-3.977	<0.001
	Female	36	20.04	1.18		
Vertical Jump (cm)	Male	36	50.66	9.01	7.507	<0.001
	Female	36	36.44	6.93		

3.2 Discussions

The research findings reveal significant differences between male and female groups across all fitness components studied, including: Multistage Fitness Test (t(71) = 3.574, p < 0.001), Sit and Reach (t(71) = 2.247, p = 0.028), Vertical Jump (t(71) = 7.507, p < 0.001), 40m Sprint (t(71) = -3.031, p = 0.003), Alternate-Hand Wall-Toss (t(71) = -2.601, p = 0.011), and Agility (t(71) = -3.977, p < 0.001). The male group outperformed the female group in skills tests for: Vertical Jump (X = 50.66, SD = 9.01), 40m Sprint (X = 6.92, SD = 0.59), and Agility (X = 18.72, SD = 1.60). Conversely, the female group excelled over the male group in skills tests for: Alternate-Hand Wall-Toss (X = 5.11, SD = 2.18) and Sit and Reach (X = 36.06, SD = 5.44).

Based on the research findings, a simple conclusion can be drawn: the male group generally excels in power, speed, agility, and cardiorespiratory fitness components compared to the female group. In contrast, the female group demonstrates superiority in coordination and flexibility compared to the male group. These differences are likely influenced by physiological developmental characteristics during puberty or genetics, rather than the training program, as both groups underwent identical training programs.

Power. Power output is affected by various factors such as muscle tissue size and length [45], muscle mass [54], muscle architecture [17], [39] and musle tissue type [42]. Furthermore, it is well known that the characteristics of these factors or the skeletal muscles can be different based on the genders [4]. Meanwhile, vertical jump performance is influenced by biomechanical and psychological factors, including anthropometric characteristcs. The study also indicate variatins in vertical jump results between mae and female athletes [2]. In this study, specifically, male athletes aged 12 tend to outperform female athletes in vertical jump performance. [26] provide insightful explanations for why gender differences are prominently observed across various populations, including elite and highly trained athletes, from a biological standpoint. These distinctions may stem from variations in muscle characteristics between males and females. [22] also attribute these differences to the notable changes that surface during puberty. During this phase, male athletes typically exhibit higher muscle mass due to increased lean body mass, while females undergo an increase in fat percentage, leading to a simultaneous decrease in muscle mass in response to puberty [5].

Speed. Almost similar to power, speed (sprint) ability is influenced by complex multifactors, and one of them is maximal strength factor [16]. In this study, boys tended to achieve shorter times in the 40m sprint compared to girls. The variances observed in sprint performance could be attributed to variances in the maximal strength characteristics between males and females [56]. In this matter, [56] Explain that the differences appear due to the hormonal interaction (testosterone-estrogen) which are gender-specific, leading to alterations in maximal strength. Moreover, a study by [22] support this explanation, the study reveals that boys tend to undergo a notable rise in maximal strength in contrast to girls, primarily due to elevated testosterone levels. On the other hand, girls experience a significant increase on estrogen when they hit puberty [62]. The surge in estrogen levels during puberty might influence the rise in body fat percentage, subsequently impacting maximal strength and sprint performance. In this regard, other findings by [27] and [18] explain that anthropometric variances can also impact sprint performance. While fat percentage measurements were not specifically conducted on the research subjects in this study, the results indicated discrepancies in sprint time improvements between boys and girls, with boys demonstrating greater advancements despite having nearly identical BMIs.

Agility. In this study, boys exhibited superior agility t-test performance results compared to girls. These results are corroborated by several pertinent studies indicating that men generally outperform women significantly in agility tasks [67]. Agility is a complex motor function that involves various basic motors and various other complex factors simultaneously [25]. [50] explain that speed is strongly related to agility. Meanwhile, according to [11] The most important factors in developing agility are speed, strength, power, anthropometric variabels, and technique. Apart from these factors, differences in gender specific characteristics are known to also influence agility performance [67]. In this scenario, changes in neuromuscular function and muscle size differ between sexes during puberty. Puberty leads to larger muscle size in boys, whereas girls exhibit higher muscle activation. In this scenario, changes in neuromuscular function and muscle size differ between sexes during puberty. Puberty leads to larger muscle size in boys, whereas girls exhibit higher muscle activation [20]. However, as the muscle size increase in girls cannot equal that of boys, boys end up stronger than girls. This strength disparity could potentially impact the speed and agility of children post-puberty.

Coordination. In this study, girls exhibited superior coordination abilities in wall catch compared to boys. Both boys and girls underwent identical training programs without distinction. The reason behind girls' better coordination in wall catching could possibly be attributed to the notion that girls mature earlier than boys, although some aspects remain unexplained.

Girls undergo puberty at a faster rate than boys [6], [32]. A study by Larson et al. [31] found that girls are superior to boys in a timed-task coordination test. Meanwhile, research by Smits-Engelsman et al. [49] revealed that girls excelled in the manual dexterity test (fine motor skills), whereas boys outperformed in the aiming and catching test (gross motor skills). Additionally, some studies indicate that there is no significant disparity between boys and girls, although girls exhibit slightly better performance overall [41].

Research by [65] revealed that boys in the younger age category demonstrate superior object control skills compared to girls, a distinction that tends to become more pronounced with age. Furthermore, these disparities are often attributed to varying interests in participation in different types of physical activities and sports based on gender. [51]. The impact of gender on disparities in coordination abilities remains a topic of ongoing debate in research. The complexity of understanding the development of coordination in children highlights the necessity for additional research in this area.

Cardiorespiratory. In the cardiorespiratory domain, it is understood that women generally exhibit superior cardiac function compared to men, although each gender has its own set of advantages and disadvantages [52]. Research conducted by Prabhavathi et al. [43] and D. Xiang et al. [58] indicates that the hormone estrogen provides cardioprotective benefits, offering women with higher estrogen levels resistance against cardiac diseases. Conversely, excessive or inadequate levels of the testosterone hormone from their ideal amount in men have been associated with adverse effects on heart function, as highlighted by studies from Morris & Channer [38] and Goodale, Sadhu, Petak, & Robbins [21]. However, various studies show that men tend to have a higher VO2max than women [47], [48]. As explained by Kenney, Wilmore, & Costill [29], the average girl has 70-75% of the VO2max of boys after puberty. This difference is believed to be caused by steroid hormonal changes in boys and girls during puberty [10]. In this scenario, boys typically undergo a rise in muscle mass, whereas girls experience an increase in body fat percentage. The elevation in fat percentage linked to BMI subsequently leads to a reduction in VO2max in girls [8]. Moreover, women generally possess less muscle mass than men, resulting in a lower absolute VO2max if presumed to have equivalent oxidative capacity [66].

Flexibility. It is widely acknowledged that adult women typically exhibit greater flexibility than men [61]. Meanwhile, flexibility abilities do not differ in the younger population [13]. One potential factor contributing to this contrast could be the hormonal and anatomical muscle changes that occur after puberty. It is evident that boys display increased muscle strength and higher muscle mass compared to girls after puberty. On the other hand, research by Robles-Palazón et al. [46] ndicates that an increase in muscle mass leads to heightened muscle stiffness due to accelerated bone growth, subsequently resulting in decreased flexibility [40]. Moreover, enhanced strength can lead to heightened tendon stiffness [57], potentially diminishing flexibility [53]. Unlike men, women are recognized for not undergoing a substantial increase in muscle mass, thus avoiding significant muscle or tendon stiffness. Furthermore, women's superior flexibility can be attributed to a higher presence of collagen tissue [23], more estrogen hormone [3], and other physiological and biological factors resulting from an increase in these two things [37]. In this study, girls demonstrated superior flexibility compared to boys, aligning with findings from various other studies that corroborate similar research outcomes, such as those from [34], [36], [63].

The discussion above leads to the conclusion that boys generally outperform girls in most fitness tests related to skills and health, except for throwing, catching, and flexibility tests where girls excel. However, beyond the findings of this study, there exist numerous unexplained factors contributing to the differences in test results between boys and girls due to the constraints of this research. Firstly, the research that explores the impact of puberty generally compares various physical parameters before, during, and after puberty. This study does not confirm whether the children have undergone puberty. Secondly, to elucidate the puberty process, other studies could incorporate assessments of maturity rather than solely relying on chronological age. Biological theory suggests that a child's maturity cannot be solely determined by age. Nevertheless, this research did not conduct measurements related to age maturity. Thirdly, due to constraints in time, equipment, and costs, researchers did not encompass all fitness parameters (related to health or skills). A comprehensive study in this regard could shed light on the topic of gender differences in various fitness components.

4 Conclusion

The study found that male volleyball players had significantly higher VO2Max values compared to female players, while female players showed superior flexibility. In terms of skill parameters, males outperformed in speed, agility, and power, whereas females excelled in coordination. These significant disparities in physical fitness between male and female junior volleyball players suggest the need for targeted and gender-specific training programs to enhance their performance and development.

Acknowledgement The authors would thank the Universitas Negeri Yogyakarta for all supporting their study.

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