Analysis of the Dominant Physical Capacity Components of Volleyball Players in the Train to Train Phase

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Abstract
The purpose of this study was to identify the most important physical components in volleyball, using a non-experimental quantitative descriptive approach. The sample consisted of 54 athletes aged 12 - 16 years from the Active Movement Volleyball School (AMVS), selected using purposive sampling. The physical condition assessment covered various biomotor aspects, namely leg muscle power, arm and shoulder muscle strength, abdominal muscle endurance, agility, hand-eye coordination, reaction, flexibility, cardiovascular endurance, speed, and balance. The results showed that the majority of players, both male and female, were in the "good" category in most physical indicators. Leg muscle power was categorized as good in 68% of male players and 77% of female players. Arm and shoulder muscle strength was rated as good in 61% of male players and moderate in 63% of female players. Abdominal muscle endurance was also quite good, with 71% of males and 58% of females in the good category. Other aspects such as agility, coordination, reaction, flexibility, endurance, and speed also showed dominance at the "good" level with percentage variations between 42% and 75%. Overall, this study shows that teenage volleyball players at AMVS have a fairly good physical condition profile, especially in muscle strength, coordination, and endurance, which are important components in volleyball performance.

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Abstrak
Tujuan penelitian ini adalah untuk mengidentifikasi komponen fisik yang paling penting dalam voli, menggunakan pendekatan deskriptif kuantitatif non-eksperimental. Sampel terdiri dari 54 atlet berusia 12–16 tahun dari Sekolah Voli Gerak Aktif (AMVS), yang dipilih menggunakan metode sampling purposif. Penilaian kondisi fisik mencakup berbagai aspek biomotorik, yaitu kekuatan otot kaki, kekuatan otot lengan dan bahu, daya tahan otot perut, kelincahan, koordinasi tangan-mata, reaksi, fleksibilitas, daya tahan kardiovaskular, kecepatan, dan keseimbangan. Hasil menunjukkan bahwa sebagian besar pemain, baik laki-laki maupun perempuan, berada dalam kategori "baik" pada sebagian besar indikator fisik. Kekuatan otot kaki dikategorikan sebagai baik pada 68% pemain laki-laki dan 77% pemain perempuan. Kekuatan otot lengan dan bahu dinilai baik pada 61% pemain laki-laki dan sedang pada 63% pemain perempuan. Ketahanan otot perut juga cukup baik, dengan 71% pemain laki-laki dan 58% pemain perempuan masuk dalam kategori baik. Aspek lain seperti kelincahan, koordinasi, reaksi, fleksibilitas, ketahanan, dan kecepatan juga menunjukkan dominasi pada level "baik" dengan variasi persentase antara 42% dan 75%. Secara keseluruhan, studi ini menunjukkan bahwa pemain voli remaja di AMVS memiliki profil kondisi fisik yang cukup baik, terutama dalam kekuatan otot, koordinasi, dan daya tahan, yang merupakan komponen penting dalam kinerja voli.

I. INTRODUCTION

The train to train phase is known as the "golden age of trainability," a period when individuals are highly responsive to physical stimulation, especially in terms of developing aerobic endurance, muscle strength, and motor coordination (Balyi, 1998). Long-Term Athlete Development (LTAD) is a systematic and gradual approach to ensure the optimal development of young players to high performance. One important phase in LTAD is the Train to Train phase, which usually occurs between the ages of 12 and 16 for boys and 11 and 15 for girls (Balyi, I., Way, R., & Higgs, 2013). Therefore, at this stage, it is important to identify the most dominant physical capacity components in supporting the performance of specific sports, including volleyball (Ramírez-Vélez, R., 2017).

The dominant physical capacity components are the main elements of physical ability that influence the quality of a player's performance in a sport. In volleyball, these dominant physical capacity components include the physical abilities that support the technical and tactical

skills of players during a match (Gabbett & Georgieff, 2007). The most prominent components in volleyball include explosive muscle power, muscle strength, agility, speed, and reaction time (Mario C. Marques et al., 2008). Each of these components has its own role in supporting specific movements in volleyball, such as jumping during a smash, blocking, and responding to feints from opponents.

Dominant physical capacity component analysis is an approach that aims to identify the types of physical abilities that most influence the performance of a player in a particular sport (Kurniawan et al., 2019). In the context of volleyball, this analysis is important because volleyball requires a combination of fast movements, high jumps, quick reactions, and strong muscles (Wang et al., 2025). By analyzing these most dominant physical components, coaches can develop more specific training programs tailored to the needs of players, especially in the train-to-train phase.

In the world of sports, especially volleyball, physical fitness is the main foundation for determining a player's performance during a match (Kementerian Pendidikan, Kebudayaan, Riset, 2021). Therefore, physical training and coaching must be designed systematically and measurably, in accordance with the players' development phase. Because this train-to-train phase focuses on developing specific basic physical abilities, it will serve as the main foundation for facing the demands of competition in the next phase.

In addition to providing practical contributions to the development of training programs, this analysis is also useful for volleyball clubs to determine how dominant their students' physical abilities are in terms of improving their performance in future competitions (Saprudin. (n.d.), 2022). It is hoped that the analysis of dominant physical capacity components in the train-to-train phase can be used as a reference in developing training programs for young players in the train-to-train phase that are more optimal, economical, and targeted at the development of modern sports performance in the future.

II. METHOD

This study uses a non-experimental quantitative descriptive method, which aims to objectively describe the characteristics of a particular population or phenomenon without conducting direct treatment or intervention. The sample in this study consisted of 55 children, with data collected at AMVS. Purposive sampling was used for sample selection in this study. The instrument used in this study was the Vertical Jump (Baechle, T. R., & Earle, 2008), *Push*-Up 30 second (Baumgartner, T. A., Jackson, A. S., Mahar, M. T., & Rowe, 2015), *Sit-Up* 30 second (Sudjarwo, 2006), *Ilionis Agility Test* (Nurhasan, 2001),*Wall Toss Test* 30 second (Mackenzie, 2005), *Ruler Drop Test* (Mackenzie, 2005), *Sit And Reach* (Hoeger, W. W. K., & Hoeger, 2014), 20 meter *shuttle run (Beep Test* (Léger, L. A., Mercier, D., Gadoury, C., & Lambert, 2988), 20 meter run (Nurhasan, 2001), *Stork Stand Test* (Johnson, B. L., & Nelson, 1986). Data collection in this study was conducted in two phases, namely the initial preparation stage and the data collection stage. Data processing in this research applied a quantitative descriptive analysis method, with data collected from physical tests analyzed through calculations of the average values of each physical component measured, such as leg power, arm and shoulder strength, core muscle strength, agility, hand-eye coordination, reaction time, flexibility, endurance, speed, and balance (Sudjarwo, 2006).

III. RESULT AND DISCUSSION

A. Result

This study analyzes the dominant physical components in adolescent volleyball players (Train to Train phase, approximately 12–16 years old), which is an important stage in the development of physical capacity and basic techniques. Based on the measurement results of a number of players, the following physical condition data was obtained:

Table 1. Summary of Physical Condition Test Results for Dominant Athletes in the Boys' Active Movement Volleyball School Train to Train Phase

No	Category	test item acquisition *a.									
		Vertical Jump	*Push Up*	*Sit Up*	*Agility*	*Wall Toss Test*	*Ruler Drop Test*	*Sit and Reach*	*Beep test*	Run 20 M	*Stork Test*
1	very good	7	7	4	7	0	0	4	0	25	0
2	good	68	61	71	0	54	46	39	68	54	29
3	Fair	25	32	25	50	18	54	54	29	14	54
4	Poor	0	0	0	36	29	0	0	4	7	18
5	Very poor	0	0	0	7	0	0	4	0	0	0

Based on the results of the analysis of the percentage of categories for each test item, it appears that most participants were in the "Good" category for almost all motor and

biomotor aspects tested. In muscle strength and endurance tests such as vertical jump, push-ups, and sit-ups, the dominance of the 'Good' category was very clear, although there were still a small number of participants who were able to achieve the "Very Good" category, especially in vertical jump and push-ups. Meanwhile, in the agility test, the results were slightly different; no participants were in the "Good" category, but were dominated by the 'Moderate' and "Poor" categories, indicating that agility is one aspect that needs further attention and training. Hand-eye coordination, measured through the wall toss test, also showed an uneven distribution, with a large proportion of participants falling into the "Good" and 'Poor' categories, and none reaching "Very Good," indicating challenges in developing this aspect of coordination. In the ruler drop test, participants' reaction abilities tended to fall into the "Good" and "Moderate" categories, with no achievements in the highest category, similar to the results of the wall toss test. Flexibility, as assessed through the sit and reach test, showed quite varied results, with most participants falling into the "Good" and 'Moderate' categories, but there were a few participants in the "Poor" category, indicating that there is still variability in flexibility. Cardiorespiratory ability, as measured by the beep test, showed good results, with most participants falling into the "Good" category and very few in the 'Poor' category. In the 20-meter sprint test, performance also tended to be good, with quite a few participants even falling into the "Very Good" category. However, in the balance test (stork test), the distribution of participants was more in the "Moderate" and 'Good' categories, with few participants in the "Poor" category. Overall, these results indicate that most aspects of the players' basic motor and biomotor skills are at a fairly good level of development, although there are some areas, particularly agility and coordination, that require more serious attention and development in the training program.

Table 1. Summary of Physical Condition Test Results for Dominant Athletes in the Active Movement Volleyball School for Girls, Train to Train Phase

No	Category	test item acquisition %									
		Vertical Jump	Push Up	Sit Up	Agility	Wall Toss Test	Ruler Drop Test	Sit And Reach	Beeptest	Run 20 M	Stork Test
1	Very good	0	8	4	0	4	8	0	0	17	0
2	Good	71	63	58	0	75	38	38	17	42	25
3	Fair	25	29	38	46	21	54	54	50	29	63
4	Poor	4	0	0	33	0	0	8	33	13	13
5	Very Poor	0	0	0	21	0	0	0	0	0	0

Based on the analysis of the percentage of scores obtained in each test item, it appears that most participants were in the "Good" category for almost all aspects of motor and biomotor skills measured, particularly in the vertical jump, push-up, sit-up, wall toss test, and ruler drop test. However, achievements in the "Very Good" category are still limited, only appearing in a few items such as push-ups, sit-ups, wall toss tests, ruler drop tests, and 20-meter runs, with the 20-meter run showing the best achievement in this category. On the other hand, agility showed less satisfactory results, with no participants in the "Very Good" or "Good" categories, but predominantly in the "Moderate" and 'Poor' categories, and even 21% of participants in the "Very Poor" category, indicating that agility is a weak point that needs improvement. The coordination test in the wall toss test showed that the majority of participants were in the "Good" and 'Moderate' categories, indicating fairly good progress even though there were no participants in the "Poor" category. Meanwhile, reaction ability through the ruler drop test was dominated by the "Moderate" category, indicating that this aspect is still in the development stage. In the sit and reach flexibility test, participants were generally in the "Good" and 'Moderate' categories, with a few participants in the "Poor" category, indicating that there is still a wide variation in flexibility ability. The beeptest, as an indicator of cardiorespiratory capacity, showed the highest distribution in the "Moderate" category, but there was also a significant percentage in the "Poor" category, indicating that aerobic endurance also needs attention in the training program. For the 20-meter sprint, although there were achievements in the "Very Good" category and dominance in the

"Good" category, there were still participants in the 'Moderate' and "Poor" categories, indicating the need to improve speed consistency in all players. Finally, balance ability, as tested through the stork test, showed that the majority of participants were in the "Moderate" category, while the rest were scattered in the 'Good' and "Poor" categories, indicating that balance is still an aspect that needs to be strengthened. Overall, the motor and biomotor performance of the players showed a positive trend in most items, but there were several important aspects, such as agility and endurance, that required special attention in the design of future training.

B. Discussion

General Interpretation of Results, The findings show that most aspects of the physical condition of youth volleyball athletes are in the "Good" category, both in the male and female groups. This indicates physical readiness in line with the Train to Train phase (12–16 years) in the Long-Term Athlete Development (LTAD) framework. This phase is an important period for developing basic biomotor abilities, such as strength, endurance, speed, and flexibility, which form the foundation for advanced technical skills (Amananti, 2024). This condition supports the view that adolescence is a strategic period for improving physical quality because it is influenced by accelerated biological growth (Almond et al., 2012). However, physical development is not yet evenly distributed across all aspects, so agility and coordination still need special attention in the planning of systematic training programs (Moeskops et al., 2019).

Muscle Strength and Endurance (Vertical Jump, Push-ups, Sit-ups). The assessment analysis results show that most indicators are in the "Good" category, which means that the athletes' overall abilities meet the established standards. However, there are several indicators that reach the "Very Good" category, reflecting specific strengths, such as explosive jumping ability and muscle strength in the upper and lower extremities. This condition indicates that although overall performance is relatively stable, there are certain aspects that have developed more optimally, possibly influenced by a training program that focuses on explosive strength and muscle endurance. In the context of volleyball, explosive strength is crucial to support jumping movements during smashes, blocks, and powerful serves, while muscle endurance is needed to maintain consistent performance throughout the match (Martin et al., 2024). Previous studies have reported that eight weeks of plyometric training and medicine ball throws can significantly improve upper and lower body muscle performance, including a 20% increase in counter movement jump height (Esposito et al., 2024) . Furthermore, the combination of strength and endurance training has been proven to optimize neuromuscular adaptation and physical capacity, which is very important considering the high frequency of jumps, punches, and physiological demands during a match.

Agility, The evaluation results show that the agility of both male and female athletes is still relatively weak, with the majority falling into the "Moderate" to "Poor" categories. This condition has significant implications for volleyball, which requires lateral mobility, reaction speed, and the ability to change direction suddenly. Agility facilitates players in performing lateral shuffle movements when defending, quick drop steps when the ball is directed to the back area, and position adjustments in dynamic game situations (Sheppard & Young, 2006). Furthermore, research shows that the main determinants of reactive agility in young volleyball athletes include explosive strength and perceptual-cognitive aspects, such as complex reaction speed, sensory sensitivity, and selective attention. (Gabbett & Benton, 2009; Serpell, Young, & Ford, 2011).

Hand-Eye Coordination (Wall Toss Test), The distribution of assessment results shows an uneven trend, with the majority of indicators falling into the "Moderate" to 'Good' categories, but none reaching the "Very Good" level. These findings indicate that the athletes' capacity is still not optimal, especially in terms of movement coordination. In fact, coordination is a fundamental element in volleyball because it is the foundation of technical skill success. For example, passing requires synchronization between body position, arms, and ball direction; serving requires integration of arm movement, wrist movement, and ball contact timing; while smashing requires a complex combination of

foot push, arm swing, and precise jump timing. Limited coordination can result in decreased accuracy, power, and effectiveness of attacks and defenses. Therefore, training programs aimed at improving movement coordination are a high priority. Some effective forms of training include wall passing, multi-ball drills, reaction-based drills, and shadow movement with ball control. These interventions have been proven to strengthen movement integration while improving the efficiency of basic skills in volleyball. (Gabbett & Georgieff, 2007; Forthomme et al., 2020; Palao, Manzanares, & Ortega, 2015). These findings are consistent with the literature emphasizing that coordination-based training not only improves technical execution but also supports neuromuscular adaptation that contributes to overall performance (Zarić et al., 2020).

Reaction (Ruler Drop Test), The interpretation of the results shows that most participants are in the "Good" and "Moderate" categories, which indicates that their physical and technical capacities are adequate, although there is still room for improvement. One aspect that needs special attention is reaction ability, given its crucial role in anticipating fast balls, both when facing smashes and opponents' serves. Athletes with good reaction times are able to adjust their body position efficiently, respond to the direction of the ball accurately, and increase their chances of success in defense and counterattacks. These findings are in line with Palao et al. (2015), who emphasized that reaction speed is a determining factor in the effectiveness of defensive and offensive techniques in volleyball. Pavlović et al. (2022) also showed that fast-paced games require instant decision-making based on visual and motor stimuli, making reaction one of the determinants of performance. Furthermore, Gabbett and Georgieff (2007) assert that in sports with fast reaction characteristics such as volleyball, efficient neuromuscular responses are essential to keep up with the dynamic tempo of the game. This is reinforced by recent research finding that simple reaction time and choice reaction time abilities are closely related to competitive performance levels in elite volleyball athletes. (Zemková & Hamar, 2018).

Flexibility (Sit and Reach), The assessment results show considerable variation, with some athletes already in the "Good" category, but others still in the "Poor" category. This reflects physical ability disparities, particularly in terms of flexibility. However, flexibility is important in volleyball because it helps prevent injuries, expands the range of motion for blocking, smashing, and serving techniques, and improves biomechanical efficiency. Research shows that good flexibility can reduce the risk of musculoskeletal injuries while supporting the effectiveness of movements (Behm et al., 2016; Silva et al., 2019; Šimonek et al., 2017). Therefore, structured exercises such as dynamic stretching before activity and static stretching after training should be prioritized to support the physical readiness and technical skills of volleyball athletes.

Cardiorespiratory Capacity (Beep Test), Analysis of the results shows a gap in achievement between male and female athletes, with the majority of males falling into the "Good" category, while females are more likely to fall into the 'Moderate' to "Poor" categories. This difference is particularly evident in aerobic endurance, which is crucial for supporting the duration of volleyball games that demand consistent performance, frequent high jumps, quick movements, and long rallies. Good aerobic capacity not only speeds up energy recovery between rallies, but also maintains technical quality and concentration, and reduces the risk of fatigue. Within the framework of Long-Term Athlete Development (LTAD), the development of aerobic endurance is a key foundation in the Train to Train and Train to Compete stages because it supports long-term physical readiness and resilience to physiological stress (Palao et al., 2009). International literature confirms that aerobic capacity plays a major role in maintaining performance in intermittent sports such as volleyball (Gabbett, 2008; Sheppard & Gabbett, 2008; Ford et al., 2011). Therefore, aerobic training needs to be integrated into long-term periodization in accordance with LTAD principles to optimize athlete development.

Speed (20-Meter Sprint), The assessment results show positive achievements with the emergence of the "Very Good" category, especially among male athletes, reflecting excellence in speed. This component is very important in volleyball, especially in the transition phase between attack and defense,

which requires quick position changes, closing spaces, and taking advantage of counterattack opportunities. Short-term acceleration ability is crucial because the characteristics of the game emphasize short sprints and quick changes of direction rather than long-distance running. International studies confirm that acceleration contributes directly to the effectiveness of defensive and offensive movements in high-intensity games (Sheppard & Young, 2006; Gabbett, 2008; Ziv & Lidor, 2010). Therefore, specific exercises such as court sprints, shuttle runs, and resisted sprints should be prioritized to improve the transition speed of volleyball athletes.

Balance (Stork Test) and Overall Implications, The assessment results show that the athletes' balance abilities are in the "Moderate" to "Good" categories, although they are not evenly distributed among all participants. Balance is a fundamental aspect of volleyball because it plays a role in basic techniques such as blocking and landing after a jump. This condition is important for maintaining body stability, preventing injuries, and improving the efficiency of movement transitions. Athletes with good balance are better able to anticipate the opponent's ball and control their landing after explosive actions. International literature also confirms that balance supports motor performance and injury prevention in sports with high jump frequency such as volleyball (Hrysomallis, 2011; Zemková, 2014). Therefore, both static and dynamic balance training should be consistently integrated into athlete development programs.

IV. CONCLUSION AND SUGGESTION

A. Conclusion

Based on the analysis results, it can be concluded that the dominant physical capacity components in volleyball during the train-to-train phase are seven aspects of physical condition that are dominant in volleyball, namely leg muscle power, arm and shoulder muscle strength, abdominal muscle endurance, hand-eye coordination, cardiovascular endurance, speed, and balance. These components greatly affect game performance, especially in jumping to perform smashes and blocks, agile and fast movements in defense, and endurance to maintain consistent energy throughout the game. Then there are three physical condition components that still need improvement, namely agility, reaction, and flexibility.

B. Suggestion

Coaches and training teams are advised to design more specific and structured training programs to optimally develop these dominant physical capacities. Training should combine technical and physical elements in a structured manner so that players have the skills to play.

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