DIFFERENCES IN AEROBIC CAPACITY INDICATORS BETWEEN THE CROATIAN NATIONAL TEAM AND CLUB LEVEL VOLLEYBALL PLAYERS

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Abstract:

The aim of this study was to determine the possible significance of differences in the area of aerobic capacity among two groups of volleyball players. Laboratory measurements were performed on sixty-eight male subjects, all members of the A1 Croatian volleyball league, who were divided into two groups. The first group consisted of a higher level volleyball players (*n* = 34) with a recent national team status who appeared in qualification matches for the European or World Championships. The second group consisted of club-level players who were members of clubs playing in the A1 Croatian league and were never members of the national teams (*n* = 34). Their aerobic capacity was estimated by the progressive maximal test performed on a motor-driven treadmill. The following variables were studied: relative maximal oxygen uptake (VO_{2max} – ml kg^{-1} min^{-1}), relative maximal oxygen uptake at anaerobic threshold (VO_{2AT} – ml kg^{-1} min^{-1}), percentage of VO_{2max} at anaerobic threshold ($\%VO_{2max}$ – %), maximum speed before exhaustion (V_{max} – km h^{-1}), and speed of the treadmill at anaerobic threshold (V_{AT} – km h^{-1}). The group of the national-level volleyball players had numerically better results in all the measured variables and the *T*–test for independent groups showed a statistically significant difference (p<.05) in two of the five measured variables (V_{max} and V_{AT}), with large and moderate magnitudes which were observed in those two variables (Cohen's d 0.75 and 0.57). A player's participation in top-level clubs and national selections implies his exposure to an additional training volume, workouts of higher quality and intensity, which can ultimately have a positive effect on aerobic capacity indicators and certain neuromuscular adaptations of the lower extremities. Volleyball players with a higher level of aerobic capacity recover quickly between points and sets and they have the ability to delay fatigue, which can result in a better situational efficiency in long points, sets and matches. Players with better neuromuscular control and movement biomechanics can perform more efficiently during a volleyball match. Among other factors, this can be a possible reason for their selection in the national team.

Key words: *oxygen consumption, anaerobic threshold, biomechanics*

Introduction

From the physiological standpoint, volleyball is described as a high power, predominantly anaerobic sport (Popadić Gaćesa, Barak, & Grujić, 2009; Van Heest, 2003). High intensity active phases of the game alternate with passive stages (Sheppard, Gabbett, & Stanganelli, 2009) so that, according to the criterion of the predomination of energy processes, volleyball belongs to a group of mixed (anaerobic–aerobic) sports (Cardinal, 1993). Active phases consist of actions without the ball (stances and movements) and actions with the ball (serving, service receive, setting, spiking, blocking and defending), lasting on average around seven seconds (Van Heest, 2003; Viitasalo, et al., 1987). Passive phases include operations in which the intensity is low (rotation of players, side changes after completing a set, time-outs, discussions with the judges, etc.), lasting on average around 17 seconds. The total duration of a match, with an average of 4 sets, is about 100 min (Kountouris, 2005; Van Heest, 2003). During a set, of an average duration of 24 min (Kountouris, 2005), active phases take up around five min, so it is easy to conclude that a volleyball match consists of around 20% of active labor and 80% of breaks.

Although the game consists of intense and explosive actions, these actions are not repeated often enough to cause fatigue. Likewise, certain less intense game periods (games in the back zone or passive phases of the game) result in a metabolic degradation of lactic acid, so most published papers (Künstlinger, Ludwig, & Stegemann, 1987; Vescovi, 2002) indicate a quite low concentration of lactic acid (2-4 mmol/L) after a volleyball activity. According to recent studies, the ratio between active and passive phases in the RPS (Rally Point System – teams score a point on every rally, regardless of which team has served) is around 1:2.7 (Vescovi, 2002). Due to the aforementioned requirements, volleyball players must be able to quickly generate energy, which is also important for a quick recovery during passive phases. Accordingly, we can say that top-level volleyball players must have well-developed energy systems in order to successfully endure pace of a volleyball game since an athlete who possesses a solid aerobic foundation will be capable of increasing the "anaerobic threshold" and will recover more rapidly during rest intervals between points and sets (Van Heest, 2003). A volleyball player with a higher endurance capacity will demonstrate a lower level of fatigue during the game, which will result in a better performance. Differences in aerobic capacity indicators are a result of factors such as genetics and training (Lidor & Ziv, 2010). How can volleyball training improve aerobic capacity? The fact is that volleyball players who are members of top-level teams and who have been selected in the national team are subjected to a more extensive and intensive sports training (technical–tactical training, physical conditioning, mental training) than those who play in the inferior quality teams. Players who participate in national teams competitions are subjected to an additional quality and quantity of trainings and matches. That additional volume of load in both cases can cause certain specific physiological adaptation processes (Brooks, Fahey, White, & Baldwin, 1999; Fleck & Kraemer, 1999; Gabbett, Jenkins, & Abernethy, 2009; Gabbett, 2008), based on which quality of these players can differ from that of club-level players.

Previous similar studies usually used only VO_{2max} (Gabbett & Georgieff, 2007; Smith, Roberts, & Watson, 1992) as an indicator of aerobic capacity of male volleyball players. The results of the relative maximal oxygen uptake at the anaerobic threshold, the percentage of VO_{2max} at the anaerobic threshold, the maximum speed before exhaustion and the speed of the treadmill at the anaerobic threshold offer new information and deeper insight into aerobic fitness of volleyball players. Analysis of the chosen variables is also relevant in light of the expected rule changes after which the duration of passive phases will be significantly reduced (as a result of one technical time-out cancelation and because of the rule that, after the last point has been scored, the next one must start within 10 seconds, which will be strictly controlled by an additional score-board which will count down the mentioned 10 seconds). Certain competitions under the FIVB and CEV jurisdiction have already been played according to these new rules, such as the U23 World Championship and the European League. Aside from the facts that the mentioned rule changes will result in an increased ratio of active phases to passive phases and that teams will start points after shorter passive phases, insight into the capacity enabling a quicker recovery between points, which can also have an effect on the situational efficiency of volleyball players, certainly represents a stimulating research domain. Our research hypothesis presumed that higher-level players, who are members of national teams, would demonstrate considerably higher aerobic capacity indicators than club-level players.

Methods

Subjects

Sixty-eight male subjects from six clubs, all members of the Croatian First National Volleyball League, were divided into two groups. The first group consisted of 34 higher-level players with a recent national team status who participated in the 2006 European League, qualification matches for the 2007 European Championship, 2007 European Championship in Russia and in the qualification matches for the 2009 European Championship. The second group consisted of 34 club-level players. All subjects were familiarized with the testing procedure. The testing was carried out during the competition season.

Table 1. Average body height, body weight, body mass index and age of the tested volleyball players

Variable	National-level	Club-level
Body height (cm)	192.22±7.10	189.43±7.08
Body weight (kg)	87.24±9.98	84.64±11.21
Age (years)	22.3±4.0	22.0±3.1

Data are expressed as mean±SD.

Variables

The present study used the cross-sectional experiment design to compare functional characteristics of the two groups of volleyball players according to their national team status. The test was performed on a motor-driven treadmill (Run Race Competition HC1200 Technogym, Italy), with a 1.5% inclination. The Quark b2 "breath-by-breath" gas analysis system (Cosmed, Italy) was used for monitoring the respiratory gas exchange. Heart rate was monitored using a Polar Vantage NV (Polar Electro Oy, Finland) heart rate monitor. The following variables were studied: relative maximal oxygen uptake (VO_{2max} - ml kg^{-1} min^{-1}), relative maximal oxygen uptake at anaerobic threshold (VO_{2AT} - ml kg^{-1} min^{-1}), percentage of VO_{2max} at anaerobic threshold ($\%VO_{2max}$ - %), maximum speed before exhaustion (V_{max} - km h^{-1}) and the speed of the treadmill at anaerobic threshold (V_{AT} - km h^{-1}).

Procedure

The aerobic fitness indicators were determined by the progressive maximal exercise test. According to the test protocol, during the first minute the athlete was at rest on the treadmill while the cardio respiratory parameters were monitored. Then the subject began to walk at a speed of 3 km h^{-1}, and every half-minute the speed of treadmill was increased by 0.5 km h^{-1}. When the speed of 8 km h^{-1} has been reached the athlete changed the shape of locomotion and started to run. The maximal exertion test was interrupted when the plateau of oxygen consumption was noticed or when the subject indicated volitional cessation. The anaerobic threshold was determined using a non-invasive V-slope method (Meyer, Lucia, Earnest, & Kindermann, 2005). After determining the anaerobic threshold, the corresponding value of the speed of the treadmill could be determined. This study was approved by the institutional Review Board.

Statistical analyses

The data were analyzed using the statistical software Statistica for Windows (ver. 11.0). Independent samples *t*-test was used to determine the significance of differences between the two groups in indicators of functional characteristics. The Cohen's effect size (Cohen's d) was calculated based on the criteria of d<.30, small; d=.31 to .70, moderate; d>.71, large (Cohen, 1988). The level of significance was set at p<.05 and all data are reported as mean±SD.

Results

The obtained results indicated that the national-level volleyball players were taller (192.22±7.10 to 189.43±7.08 cm) and heavier (87.24±9.98 to 84.64±11.21 kg), while the average age (22.3±4.0 to 22.0±3.1 years) in both groups was almost identical.

The results of *t*–test for the two independent samples are presented in Table 2 showing test statistical differences in arithmetic means between the two groups for two out of five measured variables. The national-level volleyball players scored significantly better in kinematical parameter V_{max} (16.88±1.24 to 15.96±1.20 *km* h^{-1}) and V_{AT} (13.00±1.48 to 12.26±1.10 *km* h^{-1}).

Discussion and conclusion

The national-level volleyball players were taller and heavier. The average age in both groups was almost identical. There were no statistical difference (p=.07) in the variable VO_{2max}. Although the difference was not significant, the results suggested a better aerobic condition of volleyball players on national teams. This advantage allows them to recover faster between points, thus enabling a better performance in long-lasting matches since fatigue can cause a decline in performance quality (Davey, Thorpe, & Williams, 2001; Lyons, Al-Nakeeb, & Nevill, 2006; Mohr, Krustrup, & Bangsbo, 2003), the decision-making time decreases and decision-making errors increase (Royal, et al., 2006; Thomson, Watt, & Luikkonen, 2009). The values of VO_{2max} for the group of volleyball players on national teams are almost identical to the previous results obtained from similar samples, which ranged between 55-65 ml kg^{-1} min^{-1} (Bredeweg, 2003; Manna, Khanna, & Dhara, 2012; Jousellin, Handschuh, Barrault, & Rieu, 1984; Puhl, Case, Fleck, & Van Handel, 1982; MacLaren, 1993; Viitasalo, et al., 1987).

Possible reasons for better results of the national-team players are the exposure to a more extensive and intensive training as well as to the overall higher total workload since they participate in both the national teams and club games. It should be pointed out that national teams'actions often involve a number of friendly and qualifying tournaments. The system of competitions in the tournaments is such that 6-7 games are often played within 10 days and a quick recovery is crucial if positive sport result is expected. This model of training and competitions can lead to adaptive processes that result in better scores of VO_{2max} (Brooks, et al., 1999; Fleck & Kraemer, 1999). A large dispersion of results in the group of club-level players indicates a lower training intensity a certain number of subjects have had. The dissipation range of results for the group of national-level players is smaller, which can indicate exposure to a higher quality and quantity of training.

Table 2. Results of t-test for the tested groups of volleyball players

Variable	National level	Club level	t-value	df	p	Effect size
VO_{2max} (ml kg^{-1} min^{-1})	55.59±4.69	53.49±4.80	1.82	66	0.07	0.44
VO_{2AT} (ml kg^{-1} min^{-1})	48.48±5.37	46.97±3.89	1.32	66	0.19	0.32
% VO_2 (%)	0.87±0.06	0.88±0.05	-0.72	66	0.48	0.18
V_{max} (km h^{-1})	16.88±1.24	15.96±1.20	3.13	66	0.00**	0.75
V_{AT} (km h^{-1})	13.00±1.48	12.26±1.10	2.32	66	0.02**	0.57

Legend: VO_{2max} = relative maximal oxygen uptake; VO_{2AT} = oxygen uptake at anaerobic threshold; % VO2=% of VO_{2max} at anaerobic threshold; V_{max} = maximum speed before exhaustion; V_{AT} = speed of the treadmill at anaerobic threshold
**Significantly different from national (p<.05)

There was no statistically significant difference in variable VO_{2AT}. A possible reason is that the specific volleyball load cannot cause adaptation processes at the level received on the threshold. This seems logical considering the fact that, according to previous research, volleyball players spend as much as between 77% and 82% of the time during training sessions and matches in the zone below the anaerobic threshold (Vitasallo, et al., 1987). Higher scores in VO_{2AT} mean a greater resistance to fatigue, which can be reflected in a better performance of a player, and that can qualify him/her for the national team. Values of VO_{2AT} in both groups are located between 87 and 88% of the maximum, which indicates that the tested players are well trained athletes (Schnabel, Harre, & Borde, 1994), although the anaerobic threshold can occur at a wide range of $\%VO_{2max}$, even in well trained individuals (Brooks, Fahey, & Baldwin, 2004). A high percentage is probably a result of a lower glycolytic capacity which can be caused by specific loads during a volleyball game, that is, by a small number of points lasting longer than seven seconds.

Significantly higher results in two kinematical parameters – V_{max} (large magnitude observed – Cohen's d .75) and V_{AT} (moderate magnitude observed – Cohen's d .57), suggest a higher muscular and cardiovascular endurance in the group of national–level volleyball players. Similar differences in running mechanics were identified between players of different rank quality (Ziogas, Patras, Stergiou, & Georgoulis, 2011), as well as generally between the untrained and trained population (McGregor, Busa, Yaggie, & Bollt, 2009). Exposure to more extensive and intensive training loads can cause specific adaptation processes of the lower extremities, which can lead to a better neuromuscular control and biomechanics of movement (Un, et al., 2013; Masci, Vanozzi, Gizzi, Bellotti, & Felici, 2010), as well as to higher strength of certain leg muscles being important for running economy (Hadzic, Sattler, Markovic, Vaselko, & Dervisevic, 2010; Gabbett & Georgieff, 2007; Kyröläinen, Belli, & Komi, 2001). Such adaptation processes, caused by the additional training, may contribute to a better mechanics and running economy, as it is associated with the neuromuscular capacity to produce force (Millet, Jaouen, Borrani, & Candau, 2002; Nummela, et al., 2006).

These data may indicate that, even during long-lasting matches, top-level players can sustain a higher level of biomechanical performance, as they possess a higher muscular and cardiovascular endurance. These data are extremely important since, during longer-lasting matches, players perform numerous jumps and bumps that are crucial for victory since most points are won by game elements of spike and block (Marelić, Rešetar, Zadražnik, & Đurković, 2005). Based on these results the conclusion can be made that, although there is no statistically significant difference in VO_{2AT}, the group of elite players has better features for "mechanical work": with almost the same intake of oxygen, but higher maximum speed (V_{AT}) they can achieve a higher consumption of calories.

The mentioned results suggest that the group of volleyball players on national teams achieved numerically better results in all (five) the measured variables and significantly better results in two of them. Similar studies have not entered as profoundly into the analysis of certain variables of aerobic capacity, however, significant differences in favor of top-level volleyball players have been confirmed. These data can be interpreted in two ways. Volleyball players with a higher level of aerobic capacity recover quickly between points and sets, and thus have the ability to delay fatigue, which can result in a higher situational efficiency in long-lasting points, sets and matches. Among other factors, this could be a possible reason for their selection in the national team. In turn, playing in top-level clubs and national teams can have a positive effect on indicators of aerobic capacity. How? The training process is of a higher quality and intensity, players play in finals of national cups and in play-offs, thus extending the training and competition season. Being members of national teams, they are subjected to an additional volume of load, which includes playing friendly and qualifying tournaments. Preparations for the competitions often mimic the forth-coming tournaments, so they, similarly to the official ones, involve a number of matches played in a shorter period of time, which requires a certain adaptation of the organism. The identified significant differences in favor of the national-team players may be an indication that those players can react faster, with more power for a longer period of time and longer, which is extremely important during specific performance of various volleyball techniques.

References

Bredeweg, S. (2003). The elite volleyball athlete. In J. Reeser & R. Bahr (Eds.), *Handbook of sports medicine and science – Volleyball* (pp. 183-191). Malden, MA: Blackwell Publishing.

Brooks, G.A., Fahey, T.D., & Baldwin, K. (2004). *Exercise physiology: Human bioenergetics and its application*. New York: McGraw-Hill.

Brooks, G.A., Fahey, T.D., White, T.P., & Baldwin, K.M. (1999). *Exercise physiology: Human bioenergetics and its application*. Mountain View, CA: Mayfield Publications.

Cardinal, C.H. (1993). Volleyball – Physical preparation of athletes. *International Volley Tech, 3*, 20-24.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed). Hillsdale, NJ: L. Erlbaum Associates.

Davey, P.R., Thorpe, R.D., & Williams, C. (2002). Fatigue decreases skilled tennis performance. *Journal of Sports Sciences, 20*(4), 311-318.

Fleck, S.J. & Kraemer, W.J. (1999). *Designing resistance training programs* (2nd ed.). Champaign, IL: Human Kinetics.

Gabbett, T. (2008). Do skill-based conditioning games offer a specific training stimulus for junior elite volleyball players? *Journal of Strength and Conditioning Research, 22*(2), 509-517.

Gabbett, T., & Georgieff, B. (2007). Physiological and anthropometric characteristics of Australian junior national, state, and novice volleyball players. *Journal of Strength and Conditioning Research, 21*(3), 902-908.

Gabbett, T., Jenkins, D., & Abernethy, B. (2009). Game-based training for improving skill and physical fitness in team sport athletes. *International Journal of Sports Science & Coaching, 4*(2), 273-283.

Hadzic, V., Sattler, T., Markovic, G., Veselko, M., & Dervisevic, E. (2010). The isokinetic strength profile of quadriceps and hamstrings in elite volleyball players. *Isokinetics & Exercise Science, 18*(1), 31-37.

Joussellin, E., Handschuh, R., Barrault, D., & Rieu, M. (1984). Maximal aerobic power of French top level competitors. *Journal of Sports Medicine and Physical Fitness*, *24*(3), 175-182.

Kountouris, P. (2005). Time characteristics of volleyball matches in two consecutive Olympic competitions after the implementation of the new regulations. *Coaching Volleyball, 22*(6), 18-22.

Kyröläinen, H., Belli, A., & Komi, P. (2001). Biomechanical factors affecting running economy. *Medicine and Science in Sports and Exercise, 33*(8), 1330-1337.

Künstlinger, U., Ludwig, H.Y., & Stegemann, J. (1987). Metabolic changes during volleyball matches. *International Journal of Sports Medicine, 8*(5), 315-322.

Lidor, R., & Ziv, G. (2010). Physical characteristics and physiological attributes of adolescent volleyball players – A review. *Pediatric Exercise Science, 22*(1), 114-134.

Lyons, M., Al-Nakeeb, Y., & Nevill, A.M. (2006). The impact of moderate and high intensity total body fatigue on passing accuracy in expert and novice basketball players. *Journal of Sports Science and Medicine, 5*(2), 215-227.

MacLaren, D. (1993). Court games: Volleyball and basketball. In T. Reilly, N. Secher, P. Snell & C. Williams (Eds.), *Physiology of sports* (pp. 427-464). London: E. & F.N. Spon.

Manna, I., Khanna, G., & Dhara, P. (2012). Effect of training on anthropometric, physiological and biochemical variables of U-19 volleyball players. *Jounal of Human Sport and Exercise, 7*(1), 263 -274.

Marelić, N., Rešetar, T., Zadražnik, M., & Đurković, T. (2005). Modelling of situation parameters in top level volleyball. In D. Milanović & F. Prot (Eds.), *Proceeding Book of 4th International Scientific Conference, "Kinesiology - Science and Profession - Challenge for the Future", Zagreb, 2005* (pp. 459-462). Zagreb: Faculty of Kinesiology, University of Zagreb.

Masci, I., Vannozzi, G., Gizzi, L., Bellotti, P., & Felici, F. (2010). Neuromechanical evidence of improved neuromuscular control around knee joint in volleyball players. *European Journal of Applied Physiology, 108*(3), 443-450.

McGregor, S., Busa, M., Yaggie, J., & Bollt, E. (2009). High resolution MEMS accelerometers to estimate VO2 and compare running mechanics between highly trained inter-collegiate and untrained runners. *PlosOne, 4*(10), e7355. doi:10.1371/journal.pone.0007355

Meyer, T., Lucia, A., Earnest, C.P., & Kindermann, W. (2005). A conceptual framework for performance diagnosis and training prescription from submaximal gas exchange parameters – Theory and application. *International Journal of Sports Medicine, 26* (Suppl. 1), 38-48.

Millet, G.P., Jaouen, B.B., Borrani, F.F., & Candau, R.R. (2002). Effects of concurrent endurance and strength training on running economy and VO2 kinetics. *Medicine & Science in Sports & Exercise, 34*(8), 1351-1359.

Mohr, M., Krustrup, P., & Bangsbo, J. (2003). Match performance of high-standard soccer players with special reference to development of fatigue. *Journal of Sports Sciences, 21*(7), 519-528.

Nummela, A.T., Paavolainen, L.M., Sharwood, K.A., Lambert, M.I., Noakes, T.D., & Rusko, H.K. (2006). Neuromuscular factors determining 5 km running performance and running economy in well-trained athletes. *European Journal of Applied Physiology, 97*(1), 1-8.

Popadić Gaćesa, J.Z., Barak, O.F., & Grujić, N.G. (2009). Maximal anaerobic power test in athletes of different sport disciplines. *Journal of Strength and Conditioning Research, 23*(3), 751-755.

Puhl, J., Case, S., Fleck, S., & Van Handel, P. (1982). Physical and physiological characteristics of elite volleyball players. *Research Quarterly for Exercise and Sport, 53*(3), 257-262.

Royal, K., Farrow, D., Mujika, I., Halson, S., Pyne, D., & Abernethy, B. (2006). The effects of fatigue on decision making and shooting skill performance in water polo players. *Journal of Sports Sciences, 24*(8), 807-815.

Schnabel, G., Harre, D., & Borde, A. (1994). *Trainingswissenschaft*. [Science of training. In German.] Berlin: Sportverlag.

Sheppard, J., Gabbett, T.J., Stanganelli, L. (2009). An analysis of playing positions in elite men's volleyball: Consideration for competition demands and physiologic characteristics. *Journal of Strength and Conditioning Research, 23*(6), 1858-1866.

Smith, D.J., Roberts, D., & Watson, B. (1992). Physical, physiological and performance differences between Canadian national team and Universiade volleyball players. *Journal of Sports Sciences, 10*(2), 131-138.

Thomson, K., Watt, A., & Liukkonen, J. (2009). Differences in ball sports athletes speed discrimination skills before and after exercise induced fatigue. *Journal of Sports Science & Medicine, 8*(2), 259-264.

Un, C., Lin, K., Shiang, T., Chang, E., Su, S., & Wang, H. (2013). Comparative and reliability studies of neuromechanical leg muscle performances of volleyball athletes in different divisions. *European Journal of Applied Physiology, 113*(2), 457-466.

Van Heest, J.L. (2003). Energy demands in the sport of volleyball. In J.C. Reeser & R. Bahr (Eds.), *Handbook of sports medicine and science – Volleyball* (pp. 11-17). Malden, MA: Blackwell Publishing.

Vescovi, J.D. (2002). Effect of rally scoring on timing characteristics for NCAA Division I female volleyball games. *International Journal of Volleyball Research, 5*(1), 2-5.

Viitasalo, J., Rusko, H., Pajala, O., Rahkila, P., Ahila, M., & Montonen, H. (1987). Endurance requirements in volleyball. *Canadian Journal of Sports Sciences, 12*(4), 194-201.

Ziogas, G.G., Patras, K.N., Stergiou, N., & Georgoulis, A.D. (2011). Velocity at lactate threshold and running economy must also be considered along with maximal oxygen uptake when testing elite soccer players during preseason. *Journal of Strength and Conditioning Research, 25*(2), 414-419.

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RAZLIKE U POKAZATELJIMA AEROBNOGA KAPACITETA IZMEĐU SKUPINA HRVATSKIH REPREZENTATIVNIH I KLUPSKIH ODBOJKAŠA

Osnovni cilj ovog istraživanja bio je utvrditi značajnost razlika u pokazateljima aerobnih sposobnosti između dviju skupina odbojkaša seniora. Osnovni kriterij za svrstavanje odbojkaša u pojedinu skupinu bilo je sudjelovanje ili nesudjelovanje pojedinca u hrvatskim nacionalnim selekcijama koje su nastupale na kvalifikacijskim natjecanjima za europska ili svjetska prvenstva. Sukladno postavljenom kriteriju pojedinac je mogao biti svrstan u skupinu reprezentativnih (n=34) ili klupskih (n=34) odbojkaša. Aerobne sposobnosti procijenjene su standardnim protokolom koji se primjenjuje u Sportskom dijagnostičkom centru Kineziološkog fakulteta Sveučiilišta u Zagrebu. To je progresivni test opterećenja na pokretnom sagu uz konstantan nagib od 1,5%. Analizirano je pet varijabli: *relativni maksimalni primitak kisika* (VO_{2max} – ml kg^{-1} min^{-1}), *relativni maksimalni primitak kisika na anaerobnom ventilacijskom pragu* (VO_{2AT} – ml kg^{-1} min^{-1}), *postotak maksimalnog primitka kisika na anaerobnom pragu* (%VO_{2max} – %), maksimalna brzina pokretnog saga (V_{max} – km h^{-1}) i *brzina saga pri anaerobnom ventilacijskom pragu* (V_{AT} – km h^{-1}). Reprezentativni igrači postigli su numerički bolje rezultate u svim mjerenim varijablama, a *t*-test za nezavisne uzorke pokazao je da statistički značajna razlika ($p<0,05$) postoji u dvije od pet analiziranih varijabli (V_{max} i V_{AT}). Participacija igrača u kvalitetnijim klupskim i reprezentativnim programima te nastupi u kvalitetnijim utakmicama mogu doprinijeti adaptaciji pojedinih neuromuskularnih karakteristika donjih ekstremiteta te pojedinih pokazatelja aerobnoga kapaciteta. Bolja mišićna i kardiovaskularna izdržljivost te mehaničke karakteristike, koje se očituju u boljoj ekonomičnosti trčanja skupine reprezentativnih igrača, pružaju mogućnosti za brži oporavak odbojkaša između poena i setova, odgađaju pojavu umora i pridonose kvalitetnijoj biomehaničkoj izvedbi elemenata igre, što omogućava bolju situacijsku učinkovitost koja je i ključni faktor za reprezentativnu selekciju.

Ključne riječi: *aerobni kapacitet, primitak kisika, anaerobni prag, biomehanika*