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The Effect of Skill-Based Maximal Intensity Training on Power, Agility and Speed (PAS) in Female Team Sport Players

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ABSTRACT The purpose of this paper was to investigate the effects of skill-based maximal intensity training on power, agility and speed (PAS) in female team sport players. Participants consist of 31 (basketball (n=10), handball (n=10) and volleyball (n=11) adult female players. The skill-based maximal intensity training programs were conducted for eight weeks. PAS measurements were carried out both at the beginning and the end of the training program. A paired t-test and ANOVA test were used to analyze the differences between and within groups. In the paper, skill-based maximal intensity training programs were found to be effective on PAS. In addition, significant differences were found between pre-PAS and post-PAS tests ($p<0.05$). According to the paper, it was concluded that this training model can boost training efficiency, while the improvement of PAS can provide a competitive advantage for the female players.

INTRODUCTION

Ball games require comprehensive skills, including physical, technical, mental, and tactical abilities. Among them, physical abilities exert marked effects on the skill of the players and the tactics of the team. Since ball games demand repeated maximum exertion such as dashing and jumping, players must therefore have physical abilities to complete rapid and powerful movements.

Female players in team sports, especially those that are played with a ball, have become a subject for many researches (Lockie et al. 2015; Moss et al. 2015). The observed increase in the performance of female athletes affected the basketball, handball and volleyball viewing experience positively. The reason for trainings aiming to develop the performance of female players comes into prominence. The purposeful power, aerobic endurance, agility, and speed have positive effects on the players' efficiency (Ozbar 2015; Ozbar et al. 2014).

Physical performance has important components like PAS for indoor team sports. These features are performed by the athletes during the game as part of various defensive and offensive maneuvers (Ben-Abdelkrim et al. 2007). Agility is a very important part of sports, especially team field sports where movements are performed through different planes. It is the ability to maintain and control the correct body position (Twist and Benicky1995), while quickly changing direction throughout a series of movements (Twist and Benicky1995). In addition to agility, speed and acceleration are crucial features of sports; (Baker and Nance 1999) and the ability to efficiently accelerate and reach maximum running speed is necessary for athletic success in sports (Murphy et al. 2003). The need for anaerobic power and short burst muscle strength plays a major role in sport games (Bencke et al. 2002; Lidor et al. 2005; Mohamed et al. 2009). A few studies have suggested that many sport games require not only aerobic power but also high anaerobic capacity for success (Hoffman and Maresh 2000; Kirkendall 2000; Norkowski 2000).

Sport activities (example, volleyball, rugby, basketball, and handball) have a variety of forms of explosive acts which include forward, side-to-side, backward shuffles, running at different intensities, such as jog, sprint and kicking, tackling, turning, jumping and persistent forceful contractions to control the ball towards defensive pressure (Siegher et al. 2003; Gabbett et al. 2006; Malatesta et al. 2003; Newton et al. 2006; Peterson et al. 2006; Bishop and Spencer 2004). Players must have high levels of physical performance capacity especially in muscle strength, speed of movement, arm spiking, jump with and without running up, strength of movement, agility, flexibility of shoulders, waist, knees, and wrist, for volleyball skills and tactics (Gabbett et al. 2006; Malatesta et al. 2003; Newton et al. 2006; Ozbar 2015). Peterson et al. (2006) and Bishop and Spencer (2004) mention that the basic movement form of handball requires the player to re-

form many diverse activities such as jogging, sprinting, and jumping. In these types of sports, players are required to accelerate, decelerate and change direction throughout the game in response to a stimulus such as a player's movement against the movement of the ball. Due to this, players try to carry the ball by dribbling and passing among a group of teammates and opponents in basketball and handball. These implementations must be repeatedly performed with maximal intensity for successful performance in volleyball, basketball and handball (Gabbet and Georgieff 2005; Ronglan et al. 2006). Eventually, many studies indicate that power, agility, and speed are required by players who play basketball, volleyball, and handball (Siegher et al. 2003; Gabbett et al. 2006; Malatesta et al. 2003; Newton et al. 2006; Peterson et al. 2006; Bishop and Spencer 2004).

Several researchers reported that PAS could be improved with various training models (Yap and Brown 2000; Dogan et al. 2015) and these features importantly contributed to game performance (Mayhew 1989). However, studies about the effects of skill-based trainings on PAS were limited. Some previous studies indicated that skill-based trainings significantly improved aerobic capacities and speeds of volleyball and rugby athletes (Gabbet 2008) as well as the aerobic and anaerobic performances of futsal athletes (Karahan 2012). On the other hand, Trajkovic et al. (2012) concluded that skill-based trainings did not affect power and agility improvement, but affects only the sprint performance of volleyball athletes.

Very few studies showed that skill-based trainings had important effects on the progress of physical performance (Delextrat and Martinez 2014; Behringer et al. 2011). Furthermore, determination of the progress on different sports and physical performance characteristics is an important research topic. In addition, there is no comparative information about which sport-specific drills may be more effective on the improvement of PAS. Therefore, the determination of the effects of basketball-, volleyball- and handball-specific drills performed at maximal intensity on PAS was aimed in this paper.

Purpose of Paper

The purpose of this study was to investigate the effects of skill-based maximal intensity training on power, agility and speed (PAS) in female team sport players. In addition, the improvement percentage of PAS for the female team sport players was determined.

MATERIAL AND METHODS

Participants

Thirty-one, semi-elite, healthy, adult female basketball (n=10), handball (n=10) and volleyball (n=11) players competing in divisions of Turkish University League voluntarily participated in this study. The demographic characteristics of the athlete groups are listed in Table 1. The groups were informed about the study and a consent form was obtained from all players. The study was approved by the Faculty of Medicine Ethics Committee of Erciyes University (Kayseri/Turkey) with the approval no: 2010/142, prior to the program.

Procedures

Participants were interviewed about their prior experience with the test being applied. Therefore, the participants were carefully familiarized with the testing protocol. All of the volunteers were assessed on the same day and the tests were performed in the same order. Performance tests were administered over two separate consecutive days both at the beginning and at end of the training program. Post-tests were conducted more than 48 hours after hard physical training to minimize the influence of fatigue on the test performance. All tests were performed on an indoor synthetic pitch and electronic timing gates were used to record completion times.

Testing

Demographic Characteristics

The body mass of the players were obtained and rounded off to the nearest 0.1 kg using a balance beam scale, while their height was measured using a stadiometer to the nearest 0.5 centimeters (Table 1).

Anaerobic Power

Running-based Anaerobic Sprint Test (RAST) was evaluated using infrared timing gates. On the command 'go', subjects run 6×35 metres with a 10-second recovery period between each run. Power output was calculated using the following equation:

Table 1: Demographic characteristics of athlete groups

Variables	*Basketball (n=10)Mean±SD*	*Volleyball (n=11) Mean±SD*	*Handball (N=10) Mean±SD*	*F*
Age (year)	20.6± 1.6	20.2 ± 1.1	20.3 ± 1.4	0.179
Sports experience (year)	7.4± 0.9	7.3 ± 0.9	7.6 ± 1	0.201
Body height (cm)	171.5± 8.1	172.7± 6.3	169.7 ± 5	0.679
Body mass (kg)	63.3± 960.	6 ± 7.5	61.7 ± 7.7	0.887

Power= [weight (kg) x distance (m^2) / time (s^3)] (Karahan 2012; Zagatto 2009).

Agility t-Test and Speed Test

The test was used to determine speed with directional changes, such as forward sprinting, left and right shuffling, and back pedaling, based on the protocol outlined by Paulo et al. (2000). These two tests used the infrared timing gates. When ready to sprint, the subjects commenced the sprint from a standing position. They were instructed to run as quickly as possible along a 30m distance. Speed was measured to the nearest 0.01 second. The fastest scores obtained from two trials were used as the speed scores (Paulo et al. 2000).

Training

The groups performed a standard 20-minute general systemic warm up followed by a dynamic range of motion exercises and a 5-minute cool down (jogging and stretching) just before and after all training applications. The basketball, handball and volleyball groups participated in an eight-week training program, which included non-sequential 4 days a week before the match season. Players in each group attended their specific training programs, which are established at 4 stations and are trained at maximal intensity. Minimum and maximum completion durations of each station are first measured and players are then warned during each repeat. Each station exercise time is recorded (with King-tech digital chronometer) for each player and she is informed to minimize the differences between the repeated physical loads of each exercise.

Basketball Training

***Station 1*:** In total, comprises of a 32 metres distance, with 8 metres interval and 45° angles from each other. 5 cones are replaced in an indoor basketball field. Turns are taken around 5 cones by dribbling the ball, with one right and one left turn. The projection of the pot is at an angle of 45°. At a distance of 6 metres away from the cone, after dribbling the ball and returning to the pot is done around the cone. For the left turn too, the projection of the pot is at an angle of 45°. Dribbling is done for a distance of 9 metres with the ball. After that, for a distance of 8 metres, cones are replaced vertically at 2 metres intervals to each other, in order to make slalom. After dribbling, a 10 metres sprint is completed.

Station 2: In 25 seconds, a 6 metres distance is required to cross to the ladle, followed by right turns then rebounds, left turns then rebounds, before work is done.

Station 3: A 5x20 metres dribbling with the ball is done. After each dribble, stop, jumps, shot and the shot is thrown.

Station 4: In the field, for a total of 20 metres distance, cones are replaced at 45° angles and 5 metres distance intervals to each other. In 25 seconds, reverse movement is done at each cone. After dribbling the ball, the shot is thrown to the ladle.

Handball Training

***Station 1*:** Seven cones and balls are replaced 9 metres away from the goal on the free-throw spring with 3 metres intervals. After getting the ball, shooting the goal is done nearby each cone following each turn.

Station 2: 4x20 metres sprint (fast break) and shooting the goal after each 20 metres sprint is completed.

Station 3: Four cones are replaced at 3 metres intervals. Shooting the goal is done over the rope at 1.8 metres height by jumping with a 3 step technique (single foot) on the goal line.

Station 4: The goal is shot over the rope at 1.8 metres height by jumping with a 3 step technique (single foot) on the free shoot line. 5 blocks are replaced toward the middle line, diagonally

(45°) from the 1 metre right and left area with 1.5 metres intervals. To the right and left of the area, after a 10 metres sprint, the movement is then repeated from the beginning.

Volleyball Training

Station 1: The spike of a pitch service is made from the service area to the opposite team's field. A 5 metres sprint run into the field number 6 region is made and the ball transfer with a bump pass to the setter who is located in the number 2 region that is thrown from the opposite team's field. The setter sends a high pass to the spiker at the number 4 region.

Station 2: A spike is made by the medium pass from the number 4 region, followed by a left plonjon and shoulder roll (rolling is a technique by extending to the right or left in attempting to get the ball up by playing the ball close to the field). Spike is made by the medium pass from the number 3 region followed by a left plonjon and shoulder roll. Spike is made by mid-height of the ball thrown from the number 2 region, right plonjon and shoulder roll. A 9 metres sprint is done from number 2 to region number 4.

***Station 3*:** Spike practices are made with balls that are raised at 1.5 metres on the net level and thrown to the number 4 region at two second intervals by a ball throwing machine.

Station 4: Block practices are made with two hands synchronously towards hanging balls at 30 cm heights on the volleyball net level (2.24 metres) with slip steps (right and left) at the number 4, 3 and 2 regions. Loading and resting principles of all training applications are given in Table 2.

Statistical Analysis

In this paper, the SSPS 17.0 package program was used for data analysis. All the data was tested for normality and the test of homogenous was done by the analyses of variances and Shapiro-Wilks test for further analyses. The statistical techniques of "arithmetic mean (M)" and "standard deviation (SD)" were used. Also, in the paper a paired sample t-test was used in comparison for pre-test and post-test of PAS. Likewise, a one way analysis of variance (ANOVA) was used to compare the improvement level of PAS. The significance level was taken as 0.05 in the comparisons ($p< 0.05$).

RESULTS

In this part of the paper, findings related to female team players PAS scores between pre and posttest are presented.

According to Table 3, the pre-test and post-test results of PAS were presented. It was seen that for all tested variables (PAS), significant differences were found between pre-test and post-test results ($p<0.05$).

Another result in the paper regarding the improvement percentage of PAS is presented in Figure 1.

In Figure 1, the improvement of PAS is presented. It was observed that no significant differences exist between the percentages of anaerobic power improvements in the three groups. However, the percentage of agility improvement in the basketball group was higher than that of volleyball and handball, and the percentage of speed improvement in handball group was higher than that of basketball and volleyball ($p<0.05$).

DISCUSSION

The purpose of this paper was to determine the effects of maximal intensity of different skill-based training on PAS to the female players. Therefore, measurements performed on skills included basketball, handball and volleyball with maximal intensity training.

In this paper, there were no significant differences among the female basketball, handball and volleyball players' baseline anaerobic power or agility performance variables, as well as the age, sports experience years, body height and mass characteristics.

Table 2: Loading and resting principles of all training applications

The number of repetitions for each station	*Loading time (s)*	*Recovery time for each repetition (s)*	*Number of sets and series*	*Recovery time between sets (min)*	*Recovery time between series (min)*	*Total time (min)*
5	24-27	30	3x2	3	8	44-48

Table 3: Pre-test and post-test results of PAS

	Tests	*M*	*N*	*SD*	*t*	*df*	*p*
Power	Basketball pre-test	336.85	10	42.822	-5.139	9	.001
	Basketball post-test	372.13	10	50.289			
	Volleyball pre-test	338.62	11	57.379	-3.544	10	.005
	Volleyball post-test	368.77	11	68.571			
	Handball pre-test	276.59	10	51.495	-6.355	9	.000
	Handball post-test	333.11	10	67.347			
Agility	Basketball pre-test	10.19	10	.530	6.339	9	.000
	Basketball post-test	9.41	10	.427			
	Volleyball pre-test	10.70	11	.279	5.153	10	.000
	Volleyball post-test	10.32	11	.376			
	Handball pre-test	10.69	10	.688	5.516	9	.000
	Handball post-test	10.03	10	.697			
Speed	Basketball pre-test	5.14	10	.263	9.381	9	.000
	Basketball post-test	4.98	10	.276			
	Volleyball pre-test	5.15	11	.151	4.865	10	.001
	Volleyball post-test	4.98	11	.230			
	Handball pre-test	5.61	10	.413	5.113	9	.001
	Handball post-test	5.16	10	.351			

It has been also suggested that success in many sport games appears to include high anaerobic capacity, and not aerobic power alone (Stevens et al. 2015; Kalinski et al. 2002; Hoffman et al. 2000; Kirkendall 2000). However, the mean speed time of pre-test in the handball group was significantly better than that of the basketball and volleyball groups. It can be explained that the previous sprint training density or frequencies of female handball players were lower than that of the other participated groups. The results showed that except for sprint speed, all groups are homogeneous in nature from the point view of anaerobic performance. According to the results, it can also be suggested that semi-elite women basketball, handball and volleyball athletes have similar physical performance characteristics such as anaerobic power and agility because of similar anaerobic energy requirements as to the demands of sport (Vescovi 2014; Popadic et al. 2009). According to the some papers, the anaerobic system provides speed and agility, explosive power and strength (Mohamed et al. 2009; Hatzimanouil et al. 2004). The results of the present paper support the fact that anyone professionally involved in handball is aware of

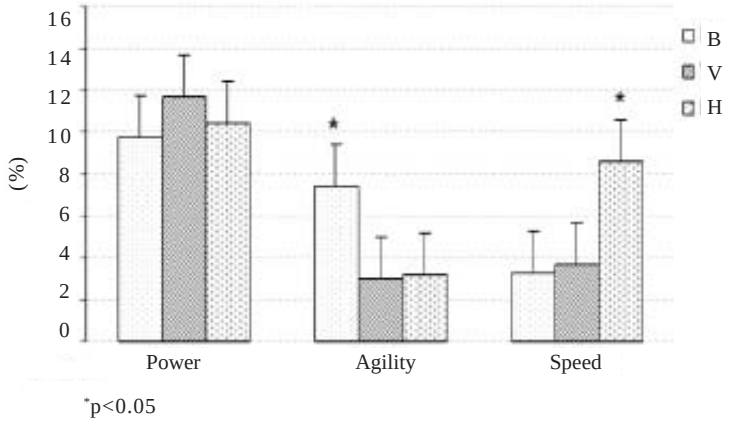

Fig. 1. Percentage of improvement in PAS

the game's high aerobic demands, but anaerobic power is also crucial for success in handball as well as the need to be perceived as an aerobic-anaerobic sport (Massuca et al. 2015). In addition, volleyball and basketball also require aerobic-anaerobic power depending on the part of the game. The diversity of movement differs from the kinds of sport. For example, sprint speed is an important constituent of physical performance especially during fast-break actions in basketball and handball. On the other hand, vertical jump height and explosive power (for example, in jumping and spiking) are important factors in volleyball (Marques 2014; Jin et al. 2007). Particularly, the jumping height is deterministic for the implementation of techniques and tactics (Jin et al. 2007). In another paper Mannan and Johnson (2015) stated that through volleyball specific plyometric training it has been displayed significant improvement in speed, power and agility of male volleyball players. Many basketball movements were performed either with or without the ball such as short sprints, abrupt stops, fast changes in direction, acceleration and different vertical jumps that have a very explosive character (Roden et al. 2014; Ben-Abdelkrim et al. 2007; Zwierko et al. 2007).

The most important result of this research was the determination of the differences between pre-test and post-test in basketball, volleyball and handball players for all tested variables. The results indicated that skill-based training of basketball, handball and volleyball was effective on PAS.

In a parallel paper and also the different kind of sport which is focus on the tennis players Barber-Westin et al. (2015) sated that after the 6 weeks training program significantly improved speed and agility in competitive junior tennis players. Training was especially more effective on power than agility and speed in volleyball. In addition, power and agility were affected more than speed in basketball, while power and speed were affected more than agility in handball, respectively. Although in this paper, there were no significant differences between groups for anaerobic power, it was observed that the mean values increased for power in female basketball, handball and volleyball players at the end of training program. In parallel with these results, Kotzamanidis et al. (2005) also found significant improvements in 30 metres sprint performances in the non-elite soccer players. They preferred a progressive-load combined training program conducted over 13 weeks. Mujika et al. (2009) applied a training program consisting of alternating heavy-light resistance (15-50% body mass) with soccer specific drills (small sided games or technical skills) as contrast protocol in their studies. Sprint training protocol was used as 30 metres line sprints with 2-4 sets of 4×30 metres with 180 and 90 seconds of recovery, respectively. They found significantly better scores at 15 metres sprint performances of the contrast group than the sprint group. In addition, Balciunas et al. (2006) investigated the effect of 4 months of different training modalities on power, speed, skill and anaerobic power in basketball players. They found the statistically significant differences in the RAST test results in basketball players and anaerobic power and skill increased only in the players from the power endurance group that was based on basketball game external structure. Another paper showed a significant increase in the anaerobic fitness of handball players caused by interval training with maximum intensity (Balciunas et al. 2006). But, although in this paper the skill-based training with maximal intensity applied on basketball, handball and volleyball, the statistically significant differences obtained in the RAST and training effects were as percentages on power.

The agility test focuses both, on the capacity to carry out intermittent exercise leading to a maximal or near maximal activation of the anaerobic system and the capacity of an individual's ability to recover from repeated exercise with a high contribution from the anaerobic system (Potter et al. 2014; Bishop and Spencer 2004). The result of this study indicates that the ability of basketball, handball and volleyball players to change direction quickly was found to be different between the groups during post-test. Basketball and handball players had more agility than volleyball players. According to the Nikolaos (2015) revealed differences among players of different playing position and time concerning their height, weight, BMI, balance, lower limb endurance and vertical jump. Renfro (1999) measured agility using the t-test with plyometric training while Robinson and Owens (2004) used vertical, lateral and horizontal plyometric jumps and showed improvements in agility. Gabbet et al. (2006) investigated the effect of skill-based training program in volleyball players and after the training program they found significant improve-

ments in the 5 and 10 metres sprint speed and agility. In an another paper investigated the effects of a 6-week plyometric training program on agility and the results of their paper show that plyometric training was an effective training technique to improve an athlete's agility (Miller et al. 2006). Previous studies had shown that by combining explosive strength training and plyometric exercises, optimal results should occur in terms of power output, speed, and agility (Adams et al.1992; Newton and Kraemer 1994; Ebben and Watts 1998). Kuipers (1996) and Taylor (2003) mentioned that training loads had an important effect on an athlete's performance and could be a determinant factor in achieving success. Therefore the fundamental goal of training forms is to optimize performance (Kuipers1996; Taylor 2003).

As could be seen, there was no information about which sport specific drills may be more effective on the improvement of PAS for female basketball, volleyball and handball players. Female players achieved the best result to change direction quickly in agility in post-test, and basketball and handball players had more agility than volleyball players.

CONCLUSION

The result of this paper was very encouraging and demonstrated the benefits of skill-based training on power, speed and agility for basketball, handball and volleyball after the training program. In the paper, it was seen that on the whole participants had similar scores before the training programs. However, after the training program, it was observed that significant differences were present in the scores of the female basketball, volleyball and handball players' power, agility and speed. It can be also said that skill-training drills used for basketball and handball are more effective on agility. On the other hand, training drills applied for volleyball and handball are more effective on anaerobic power and speed, respectively. From the point of view of match performance, PAS is important for every team sport branch included in this paper. Therefore, the use of similar training drills can be advised for PAS improvement in these sport branches. These findings on the structure and level of the motor abilities of female players are not only very important for both theory and practice in basketball, volleyball and handball but also can assist coaches as well as other training programs.

RECOMMENDATIONS

In the paper, female players' power, agility and speed skills were studied for those playing basketball and volleyball after the eight weeks maximal intensity training. There are limited number of studies on female team players and their motor skills. More studies need to be done which will focus on the female team players. Also, it should be considered that different types of trainings, affect other motor skills of the female players. Likewise, further research may subject the individual athlete' skill improvements according to the eight weeks maximal intensity training.

REFERENCES

Adams K, O'Shea JP, O'Shea, KL,Climstein M 1992. The effect of six weeks of squat-plyometric training on power production. *Journal of Applied Sport Science Research,* 6(1): 36-41.

Baker D, Nance S 1999. The relation between running speed and measures of strength power in professional rugby league players. *Journal of Strength and Conditioning Research*, 13: 230-235.

Balciunas M, Stonkus S, Abrantes C, Sampaio J 2006. Long term effects of different training modalities on power, speed, skill, and anaerobic capacity in young male basketball players. *Journal of Sports Science and Medicine,* 5: 163-170.

Barber-Westin SD, Hermet A, Noyes FR 2015. A six-week neuromuscular and performance training program improves speed, agility, dynamic balance, and core endurance in junior tennis players. *Journal of Atletic Enhancement,* 4: 1-2.

Behringer M, VomHeede A, Matthews M, Mester J 2011. Effects of strength training on motor performance skills in children and adolescents: A meta-analysis. *Pediatric Exercise Science*, 23: 186-206.

Ben-Abdelkrim N, El Faza S, El Ati J 2007. Time-motion analysis and physiological data of elite under 19 year old basketball players during competition. *British Journal of Medicine,* 41(2): 69-75.

Bencke J, Damsgaard R, Saekmose A, Jorgensen P, Klausen K 2002. Anaerobic power and muscle strength and characteristics of 11 years old elite and non-elite boys and girls from gymnastics, team handball, tennis and swimming. *Scandinavian Journal of Medicine and Science in Sports,* 12(3): 171-178.

Bishop D, Spencer M 2004. Determinants of repeated-sprint ability in well-trained team sport athletes and endurance-trained athletes. *Journal of Sports Medicine and Physical Fitness,* 44: 1-7.

Delextrat A, Martinez A 2014. Small-sided game training improves aerobic capacity and technical skills in basketball players. *International Journal of Sports Medicine,* 35(05): 385-391.

Dogan E, Tasmektepligil MY, Cankaya S 2015. An investigation of the leptin levels of footballers and wrestlers in terms of aerobic capacity. *Anthropologist,* 19 (2): 355-359.

Ebben WP, Watts PB 1998. A review of combined weight training and plyometric training modes: Complex training. *Strength and Conditioning Journal*, 18-27.

Gabbet T, Georgieff B 2005. Physiological characteristics of elite junior volleyball players over a competitive season. *Strength and Conditioning Journal*, 13: 2-7.

Gabbett T, Georgieff B, Anderson S, Cotton B, Savovic D, Nicholson L 2006. Changes in skill and physical fitness following training in talent-identified volleyball players. *Journal of Strength and Conditioning Research*, 20: 29-35.

Gabbet T, Kelly Jason N, Sheppard Jeremy M 2008. Speed, change of direction speed, and reactive agility of rugby league players. *Journal of Strength and Conditioning Research*, 22(1): 174-181.

Hatzimanouil D, Oxizoglou N 2004. Evaluation of the morphological characteristics and motor skills in the national junior handball teams of Greece and Yugoslavia. *Journal Human Movement Studies*, 46(2):125–40.

Hoffman JR, Maresh CM 2000. Physiology of basketball. *Exercise and Sport Science*, 733-744.

Jin Xb Liu, Zhang Zb, Gai Y 2007. Investigation on the features of young female volleyball players and important body shape and specific fitness in our country. *Journal of Xi'an Physical Education University*, 24: 94-97.

Kalinski M, Norkowski H, Kerner M, Tkaczuk W 2002. Anaerobic power characteristics of elite athletes in national level team-sport games. *European Journal of Sport Science*, 2(3), 1-21.

Karahan M 2012. The effect of skill-based maximal intensity interval training on aerobic and anaerobic performance of female futsal players. *Biology of Sport*, 29(3): 223-227.

Kirkendall DT 2000. Physiology of soccer. *Exercise and Sport Science*, 875-884.

Kotzamanidis C, Chatzopoulos D, Michailidis C, Papaiakovou G, Patikas D 2005. The effect of a combined high intensity strength and speed training program on the running and jumping ability of soccer players. *Journal of Strength and Conditioning Research*, 19: 369-375.

Kuipers H 1996. How much is too much? Performance of overtraining. *Research Quarterly for Exercise and Sport*, 67: 65-69.

Lidor R, Falk, Arnon M, Cohen Y, Segal G 2005. Measurement of talent in team handball. *Journal of Strength and Conditioning Research*, 19(2): 318-325.

Lockie RG, Schultz AB, Callaghan SJ, Jordan CA, Luczo TM, Jeffriess MD 2015. A preliminary investigation into the relationship between functional movement screen scores and athletic physical performance in female team sport athletes. *Biology of Sport*, 32(1): 41-51.

Malatesta D, Cattaneo F, Dugnani S, Maffiuletti NA 2003. Effects of electromyostimulation training and volleyball practice on jumping ability. *Journal of Strength and Conditioning Research*, 17: 573-579.

Mannan MS, Johnson P 2015. Impact of volleyball specific plyometric training on speed, power, and agility of male volleyball players. *Asian Journal of Multidisciplinary Research*, 23(1): 23-27.

Marques MC, Izquierdo M, Van den Tillaar R, Moir GL, Sanchez-Medina L, Gonzalez-Badillo JJ 2014. The reliability of force-time variables recorded during vertical jump performance and their relationship with jump height in power trained athletes. *International Sport Med Journal*, 15(2): 146-155.

Massuca L, Branco B, Miarka B, Fragoso I 2015. Physical Fitness Attributes of team-handball players are related to playing position and performance level. *Asian Journal of Sports Medicine*, 6(1).

Mayhew JL, Piper FC, Schwegler TM, Ball TE 1989. Contributions of speed, agility and body composition to anaerobic power measurements in college football players. *Journal of Applied Sports Science Research*, 3(4): 101-106.

Miller MG, Herniman JJ, Ricard MD, Cheatham CC, Michael TJ 2006. The effects of a 6 week plyometric training program agility. *Journal of Sport Science and Medicine*, 5: 459-465.

Mohamed H, Vaeyens R, Mattys S, Multael M, Lefevre J, Lenoir M, Philippaerts R 2009. Anthropometric and performance measures for the development of talent identification model in youth handball. *Journal of Sport Sciences*, 27(3): 257-266.

Moss SL, McWhannell N, Michalsik LB, Twist C 2015. Anthropometric and physical performance characteristics of top-elite, elite and non-elite youth female team handball players. *Journal of Sports Sciences*, (In press).

Mujika I, Santisteban J, Castagna C 2009. In season effect of short-term sprint and power training programs on elite junior soccer players. *Journal of Strength and Conditioning Research*, 23(9): 2581-2587.

Murphy A, Lockie R, Coutts J 2003. Kinematic determinants of early acceleration in field sport athletes. *Journal of Sport Science and Medicine*, 2: 144-150.

Newton RU, Kraemer WJ 1994. Developing explosive muscular power: Implications for a mixed methods training strategy. *Strength and Conditioning Journal*, 20-31.

Newton RU, Rogers RA, Volek JS, Hakkinen K, Kraemer WJ 2006. Four weeks of optimal load ballistic resistance training at the end of season attenuates declining jump performance of women volleyball players. *Journal of Strength and Conditioning Research*, 20: 955-961.

Nikolaos K 2015. Anthropometric and fitness profiles of young basketball players according to their playing position and time. *Journal of Physical Education and Sport*, 15(1): 82.

Norkowski H 2000. Assessment of the anaerobic capacity of the players in handball in the field settings. *Trening*, 45: 137-148.

Ozbar N, Ates S, Agopyan A 2014. The effect of 8-week plyometric training on leg power, jump and sprint performance in female soccer players. *Journal of Strength and Conditioning Research*, 28(10): 2888-2894.

Ozbar N 2015. Effects of plyometric training on explosive strength speed and kicking speed in female soccer players. *Anthropologist*, 19(2): 333-339.

Paulo K, Madole K, Garhammer J, Lacourse M, Rojenek R 2000. Reliability and validity of the t-test as a measure of agility, leg power, and leg speed in col-

lege-aged men and women. *Journal of Strength and Conditioning Research,* 14: 443-450.
Peterson MD, Avlar BA, Rhea MR 2006. The contribution of maximal force production to explosive movement among young collegiate athletes. *Journal of Strength and Conditioning Research,* 20: 867-873.
Popadic G, Jelena Z, Barak OF, Grujic NG 2009. Maximal anaerobic power test in athletes of different sport disciplines. *Journal of Strength and Conditioning Research,* 23(3): 751-755.
Potter D, Reidinger K, Szymialowicz R, Martin T, Dione D, Feinn R, Garbalosa JC 2014. Side step and crossover lower limb kinematics during prolonged sport like agility test. *International Journal of Sports Physical Therapy,* 9(5): 617.
Renfro G 1999. Summer plyometric training for football and its effect on speed and agility. *National Strength and Conditioning Association,* (3): 42-44.
Robinson BM, Owens B 2004. Five week program to increase agility, speed, power in the preparation phase of a yearly training plan. *National Strength and Conditioning Association,* 26(5): 30-35.
Roden D, Lambson R, De Beliso M 2014. The effects of a complex training protocol on vertical jump performance in male high school basketball players. *Journal of Sports Science,* 2: 21-26.
Ronglan LT, Raastad T, Borgsen A 2006. Neuromuscular fatigue and recovery in elite female handball players. *Scandinavian Journal of Medicine and Science in Sports,* 16(4): 267-273.
Siegler J, Gaskill S, Ruby B 2003. Changes evaluated in soccer-specific power endurance either with or without a 10 week, in season, intermittent, high-intensity training protocol. *Journal of Strength and Conditioning Research,* 2: 379-387.
Stevens AW, Olver TT, Lemon PW 2015. Incorporating sprint training with endurance training improves anaerobic capacity and 2,000-m erg performance in trained oarsmen. *The Journal of Strength and Conditioning Research,* 29(1): 22-28
Taylor J 2003. Basketball: Applying time motion data to conditioning. *Strength and Conditioning Journal,* 2: 57-64.
Tsunawake N, Tahara Y, Moji K, Muraki S, Minowa K, Yukawa K 2003. Body composition and physical fitness of female volleyball and basketball players of the Japan inter-high school championship teams. *Journal of Physiological Anthropology and Applied Human Science,* 22(4): 195-201.
Twist PW, Benicky D 1995. Conditioning lateral movements for multisport athletes: Practical strength and quickness drills. *National Strength and Conditioning Association,* 17(6): 43-51.
Vescovi JD 2014. Impact of maximum speed on sprint performance during high-level youth female field hockey matches: female athletes in motion (FAIM) study. *International Journal of Sports Physiology and Performance,* 9(4): 621-626.
Yap CW, Brown LE 2000. Development of speed, agility and quickness for the female soccer athletes. *Journal of Strength and Conditioning,* 22: 9-12.
Zagatto AM, Beck WR, Gobatto CA 2009. Validity of the running anaerobic sprint test for assessing anaerobic power and predicting short-distance performances. *Journal of Strengthand Conditioning Research,* 23(6): 1820-1827.
Zwierko T, Lesiakowski P 2007. Selected parameters of speed performance of basketball players with different sport experience levels. *Studies in the Physical Culture and Tourism,* 14: 307-312.