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Influence of High-Intensity Intermittent Training on Explosive Force and Anaerobic Power in Volleyball

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Abstract:

-Objectives:

As in any sport, whether played individually or as a team, volleyball requires a unique combination of physical qualities such as explosive power, agility, coordination and flexibility. Players must be able to react quickly to flying balls, perform explosive jumps to attack or block, and maintain a stable posture and balance during dynamic play phases.

A good physical preparation for volleyball therefore includes a varied mix of exercises and techniques aimed at strengthening the specific muscles used in this sport, improving cardio-endurancerespiratory, develop reaction speed and promote coordination of movements.

Among these exercises, the intermittent exercises which constitute an example of the orientation of the training in accordance with the analyses of the various factors of the performance in Volleyball-ball, the objective of this study was to know the effects of high intensity intermittent training on the explosive force of the lower limbs and on anaerobic power.

-Equipment and methods:

Twelve players of volleyball under 21 years (186,8+0,36 cm, 69,83+15,05 kg) have participated in this study. Two groups have been composed: a control group and experimental group. The players have realized a test of Squat Jump and the measure if the anaerobic power . After the per-test had been effected, the experimental group realized intermittent work of high-intensity a reason of two session per week during the eight weeks. The proposed exercises had been composed with setoff 4 minutes (20 seconds work and 10 seconds of passive rest) with four repetitions. During the duration of the effort (20 seconds) a various activities like the plyometric exercises, the squats with or without charge. Jumps had been integrated. The test of student has been applicated for the different statistics.

-Results:

After the obtained results of Squat Jump has been ameliorated for the (3,40% ; P<0,05) from 38,7± 5 to 43,5± 6 anaerobic power (2,30% ; P<0,05) from 94,68±5 to 99,14±3 . The results of this year has shown that the intermittent exercises high intensity have been more significant in the development of the squat jump and the anaerobic power of volleyers.

-Keywords: the High-Intensity Intermittent Training – the Explosive Force - the Anaerobic Power- Volleyball.

I. Introduction

Unlike many other sports such as handball, football, or basketball, volleyball has no time restrictions. Matches unfold in sets, with a team needing to win three sets of 25 points each to secure victory. In the event of a fifth set, it is

played to 15 points. This absence of a time limit means that the duration of a match can vary considerably, depending on the intensity of the exchanges and the teams' ability to score points.

An excellent physical preparation is required due to the pace of competitions volleyball players may face, such as leagues, international tournaments, world championships, or the Olympic Games. This high pace demands thorough training planning, where all physical factors must be considered to prevent injuries.

Volleyball players face a series of unique physical challenges, including the intensive repetition of jumps throughout a match. This intense physical demand necessitates specific preparation to strengthen leg muscles and improve endurance to maintain optimal performance throughout the game.

Furthermore, volleyball is characterized by a discontinuous alternation of actions during a match. Game sequences are short and intense, with an average of only 8 seconds of play followed by 12 seconds of recovery. This fragmented nature of the game demands excellent physical condition and the ability to recover quickly between points to maintain a high level of performance throughout the match.

Intermittent high-intensity exercise is characterized by repeated periods of high intensity, interspersed with recovery phases of rest or low-intensity activity, which has garnered interest from many researchers. Due to these recovery phases, high workloads can be sustained for a longer cumulative time during this type of training compared to continuous exercise. Intermittent high-intensity exercise allows for significant improvement in VO2max compared to moderate training over the same duration, similar adaptations with submaximal or low-intensity efforts of the same duration, it is more motivating and varied than continuous training, and it improves both aerobic and anaerobic endurance.

Intermittent high-intensity work is a mixed aerobic and anaerobic demand; the energy contribution from these two energy systems depends on the different characteristics of intermittent exercises.

This method has been widely used in the fields of physical activities and sports where the goal is to be as dynamic as possible and maximize repetitions during the 20 seconds of effort. If additional loads are used, do not exceed 50% of 1 repetition maximum (RM). Based on this protocol, we attempted to propose a high-intensity intermittent training program with the integration of highly varied activities such as plyometric exercises, squats with or without weights, jump roping, etc., during the efforts with passive recovery. The objective of this article is to determine the effectiveness of high-intensity intermittent training on aerobic power and vertical jump in volleyball.

II. Materials and Methods

2.1Subjects : Twelve volleyball players (aged 19 ± 1 years; 186.8 ± 0.36 cm, 69.83 ± 15.05 kg) competing in the Algerian 'League 1' participated in this study. The morphological and physical characteristics of the subjects are presented in Table 1. Two groups were formed: a control group (N=6) (Ctrl) and an experimental group (N=6) (Exp). All players were briefed on the experiment and the purpose of the study. They were all in good health, competitive, and their last injuries dated back more than a year.

	N	Age (years)	height (cm)	weight (kg)	Vertical jump (cm)	Anaerobic power (Watt)
Control Group	6	19,5	186± 5	69,5± 6	38,6± 2	94, 68±8
Experimental Group	6	19,5	186± 8	69 ,5 ± 8	38,7± 5	94,68±5

Table 1: Morphological and Physical Characteristics of the Subjects

2.2 Experimental Approach:

The experimental group (Exp) completed 16 sessions over the eight weeks, with two sessions of high-intensity intermittent training per week, while the control group (Ctrl) followed the same duration (16 sessions) with two sessions of regular intermittent training per week. The vertical jump test (Squat Jump) using Opto-jump was conducted by all players before the program (P0) and at the end of the program (P8). This allowed us to compare the results obtained between the two tests before and after the training

2.3 Procedures :

2.3.1 the squat Jump : The vertical jump test, 'Squat Jump,' was conducted by all players using the Myotest under the same temporal conditions (in the same afternoon between 5 pm and 6 pm), with consistent climatic conditions (20°C) in a gymnasium. Subjects were familiarized with the test objective and protocol.

The Squat Jump is among the field tests used to measure athletes' jumping abilities and muscle elasticity, invented by Bosco in the field of training. The subject begins the test in a flexed position at 90° (knee joint) to perform a maximal upward push. Hands are placed on the hips to avoid arm involvement. The

Squat Jump measures dry non-plyometric vertical jump, without stretching; for reliable results, the test must be conducted following a very precise protocol, especially regarding the starting position and landing on the ground. This jump assesses the quality of starting from a standstill.

The result: in centimeters, is linked to the subject's maximum voluntary concentric force of the lower limbs.

2.3.2 **The Anaerobic Power:** Anaerobic power was calculated using Lewis's formula.

Lewis, as cited by Fox and Mathews (1998), proposes to evaluate anaerobic power using the following formula:

Pm (Watt) = √4.9 × m × √h
Pm: Absolute power (Watt)
m: Subject's body mass (kg)
h: Height reached during the jump (m).

2.4 **The Control Group** All players in the control group completed the entire regular intermittent exercise regimen based on short-duration sprints with intensities exceeding 100% of the VO2max (maximal aerobic velocity). Each intermittent exercise was individually practiced based on the results of the VO2max test (Yoyo test). The program was conducted with an average of two sessions per week for a month and a half, with each session lasting 60 minutes. All sessions were scheduled in the gymnasium. The test was conducted before and at the end of the program

2.5 **The Experimental Group :** The subjects followed a six-week program consisting of 2 sessions per week, with each session lasting 60 minutes. The session structure was based on high-intensity intermittent exercises with modifications to the activity content during the effort. Players completed sets of 4 minutes, adhering to 20 seconds of effort followed by 10 seconds of 'passive' recovery. The nature of the effort varied greatly, including high-intensity running, jumping, plyometrics, and strength exercises with or without load, performed by all players. Subjects completed 4 sets of 4 minutes with a 2-minute recovery between repetitions. The Squat Jump test was conducted before and at the end of the program.

2. 6Statistical Analysis : Values were expressed as mean ± standard deviation (Mean ± SD). Statistical significance was accepted at $p < 0.05$. Comparison between the measured variables' results for both groups (control – experimental) was assessed using the unpaired T-test. A paired T-test was used to compare differences between paired data within groups before and after the six-week program. SPSS version 16 was used for all analyses (SPSS Inc., Chicago, IL).

III. Résults

3.1 Comparison of vertical jump and anaerobic power results for the control group: After 6 weeks of training, anaerobic capacity and anaerobic power did not change (Fig. 1) (P > 0.05).

Variables	**N**	**X±SD**		T	P
		Pré-test	**Post test**		
SJ (cm)	6	38,6± 2	38,6± 3	2,02	0,05
P ana (Watt)	6	94, 68±8	94,68±7	0,07	0,05

Table 2: Results of vertical jump and anaerobic power for the control group.

"SJ: Squat Jump

P ana: Anaerobic Power

According to the results in Table 2, we observed no significant difference between players in the studied variables (vertical jump and anaerobic power) (P < 0.05).

3.2 Comparison of vertical jump and anaerobic power results for the experimental group:

Variables	**N**	**X±SD**		T	P
		Pré-test	**Post test**		
SJ (cm)	6	38,7± 5	43,5± 6	19	0,05
Pana (Watt)	6	94,68±5	99,14±3	4,8	0,05

Table 3: Results of vertical jump and anaerobic power for the experimental group

"SJ: Squat Jump

P ana: Anaerobic Power

From the results in Table 3, we observed a significant difference between players in vertical jump and anaerobic power (P < 0.05).

Vertical jump increased by 3.40%, from 38.7 ± 5 to 43.5 ± 6 cm, and anaerobic power increased from 94.68 ± 5 to 99.14 ± 3 watts (2.30%) .

3.3 Comparison of Squat Jump results (vertical jump) for both groups (Control-Experimental):

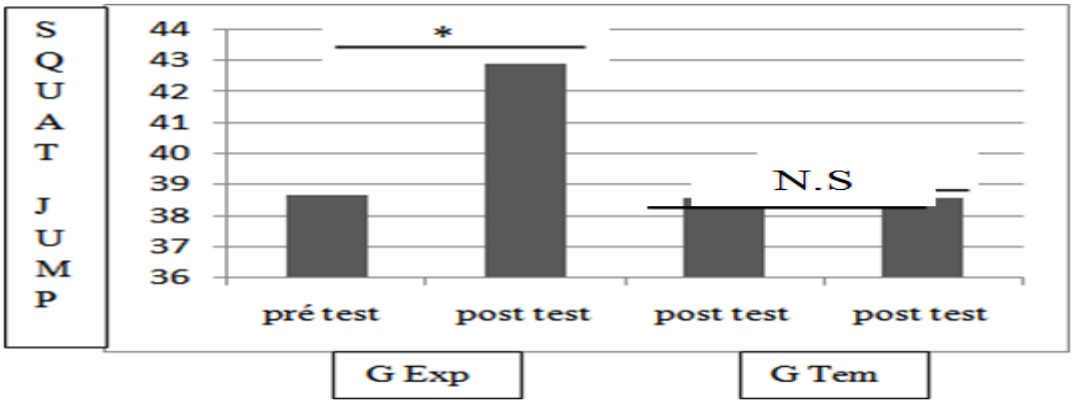

Figure 1: Comparison of vertical jump results for both groups.

3.4 Comparison of anaerobic power results for both groups (Control-Experimental):

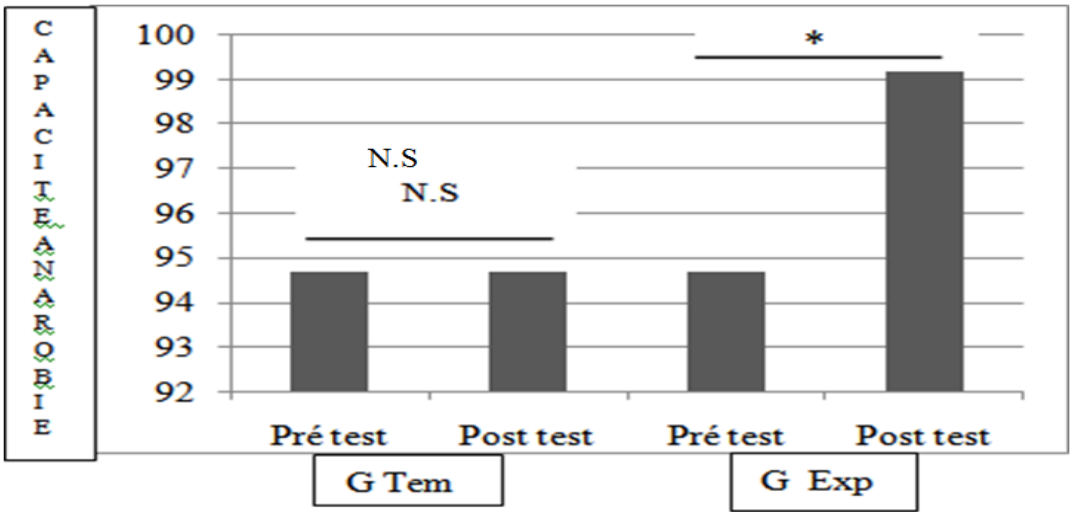

Figure 2: Comparison of anaerobic power results for both groups.

IV. Discussion

Based on the analysis and interpretation of the results obtained after implementing the proposed programs, we observed no significant difference between pre-test and post-test for the control group, i.e., players who followed the program based on regular intermittent exercises did not influence the development of explosive strength and anaerobic power. In contrast, the experimental group, which completed a six-week program based on high-intensity intermittent exercises, showed an impact on the development of the studied parameters. Vertical jump increased by 3.40%, from 38.7 ± 5 to 43.5 ± 6 cm, and anaerobic power increased from 94.68 ± 5 to 99.14 ± 3 watts (2.30%) ($P < 0.05$)."

"Indeed, some authors demonstrate that the use of short-duration intermittent exercises allows for the development of anaerobic capacities [5, 16, 21, 2]. The intensity of intermittent exercises is related to physiological adaptations [30]. The

nature of the effort depends on the type of work performed; other factors besides endurance, such as coordination or strength, can be developed [11, 13]. Our results confirm those of Cometti [13], who advocated for quality work by proposing 'intermittent-force.' He replaced running repetitions with strength work with or without load, or with bounding exercises. Tabata [43] also showed that intermittent training led to improvements in both aerobic and, especially, anaerobic capacities. In another study, Bayati [4]

compared a repeated sprint program with intermittent exercise (125% of PMA) over four weeks, with three sessions per week. The results of this study showed that both groups significantly improved their VO2 max, Tlim at VO2 max, and maximal power in the Wingate test.

The contribution of anaerobic metabolism to energy provision depends on the intensity and duration of exercise. Throughout short periods of highly intensive work, the majority of the energy required for muscle contraction would be provided anaerobically through the breakdown of PCr (phosphocreatine) and anaerobic glycolysis [2, 6, 31, 32].

Astorino et al. (2) examined the effects of high-intensity intermittent training on cardiovascular function, VO2max, and muscle strength after completing the program. The results showed significant improvements ($P < 0.05$) in VO2max, O2 pulse, and muscle power analyzed by the Wingate test.

Foster et al. compared the effects of two training protocols (high-intensity intermittent training based on the Tabata method and training at the aerobic and anaerobic threshold levels). The subjects completed an eight-week program with three sessions per week. The results demonstrated an increase in aerobic parameters such as VO2max and in anaerobic parameters such as maximal power and mean power measured by the Wingate test [19].

The prescription of high-intensity intermittent training involves manipulating several variables such as exercise duration and intensity or the mode of work. Manipulating any of these variables can lead to

acute physiological responses [7].

V. Conclusion

This study highlighted the influence of high-intensity intermittent training with modifications to the proposed work modality on vertical jump and anaerobic power. The exercises integrated during the exercise durations were highly varied, including plyometrics, squats with or without load, and bounding performed at high speed.

The results led to the following conclusions:

What is the effectiveness of high-intensity intermittent training in developing explosive strength and anaerobic power in volleyball players?

The results showed a difference between the two groups based on the type of work applied.

The implementation of the experiment after the construction of the six-week program with one session per week showed that vertical jump and anaerobic power were respectively improved.

References

[1]. Astorino TA, Allen RP, Roberson DW, Jurancich M. Effect of High-Intensity Interval Training on Cardiovascular Function, Vo2max, and Muscular Force. J Strength Cond Res 2012;26:138-145.

[2]. Bangsbo J. Aerobic and anaerobic training in soccer. Denmark: Stormytrik Bagsvaered; 2007.

[3]. Barnett C, Carey M, Proietto J, Cerin E, Febbraio MA, Jenkins D. Muscle metabolism during sprint exercise in man: influence of sprint training. J Sci Med Sport 2004; 7:314–322.

[4]. Bayati M, Farsad B, Gharakhanlou R, Agaha-Alinejad H. A pratical model of low-volume high- intensity interval training induces performance and metabolic adaptations that resemble “all-out” sprint interval training. J Sports Sci Med 2011; 10: 571-576.

[5]. Billat V, Slawinski J, Bocquet V, Demarle A, Lafitte L, Chassaing P, Koralsztein JP. Intermittent runs at the velocity associated with maximal oxygen uptake enables subjects to remain at maximal oxygen uptake for longer time than intense but submaximal runs. Eur J Appl Physiol 2000 ; 81:188-196.

[6]. Bisciotti G. L’incidenza fisiologica dei parametri di durata, intensità e recupero nell'ambito dell'allenamento intermittente. SDS 2004 ; 60-61: 90-96.

[7]. Buchheit M, Laursen PB. High-Intensity Interval Training, Solutions to the Programming Puzzle. Sports Med 2013; 10:13-29.

[8]. Burgomaster KA, Heignhauser GJ, Gibala MJ. Effect of short term sprint interval training on human skeletal muscle carbohydrate metabolism during exercise and time-trial performance. J Appl Physiol 2006;100: 2041–2047.

[9]. Burgomaster KA, Cermak NM, Phillips SM, Benton CR, Bonen A, Gibala MJ. Divergent response of metabolite transport proteins in human skeletal muscle after sprint interval training and detraining. Am J Physiol Regul Integr Comp Physiol 2007; 292:1970– 1976.

[10]. Bosco C. Cycle étirement raccourcissement du muscle squelettique et considération physiologiques sur la force explosive chez l'homme. Paris :INSEP ; 1985.

[11].Cometti G. Football et musculation .Paris : Actio ; 1993.

[12].Cometti G. Manuel de pliométrie. Dijon : Actio ; 2006.

[13].Cometti G. Etude des effets de différentes séquences de travail de type intermittent. Dijon : CEP ;2003. [14]. Daniels J, Scardina N. Interval training and performance. Sports Med 1984;1:327–334.

[15].Dupont G, Akakpo K, Berthoin S**.** The effect of in-season, high-intensity Interval training in soccer players. J Strength and Cond Res 2004 ; 18(3) : 584–589.

[16].Dupont G, Bosquet L. Méthodologie de l'entraînement. Paris : Ellipse ; 2007.

[17]. Esfarjani F, Laursen PB. Manipulating high-intensity interval training: Effects on the lactate threshold and 3000m running performance in moderately trained males Journal of science and medicine in sport. Journal of Science and Medicine in Sport 2007; 10: 27-35.

[18]. Fontani G, Ciccarone G, Giulianini R. Etude des demandes physiques du Volley-ball en rapport avec les nouvelles règles du jeu, Institut de Physiologie humaine; Sienne, 2000.

[19]. Foster C et al**.** The Effects of High Intensity Interval Training vs Steady State Training on Aerobic and Anaerobic Capacity**.** J Sports Sci Med 2015 ; 14(4): 747–755.

[20]. Gibala MJ, McGee SL. Metabolic adaptations to short-term high-intensity interval training: a little pain for a lot of gain?. Exerc Sport Sci 2008; 36:58–63.

[21]. Gibala MJ, Little JP, Van Essen M. Short-term sprint interval versus traditional endurance training: similar initial adaptations in human skeletal muscle and exercise performance. J Physiol 2006; 575:901–911.

[22]. Gibala MJ, Little JP, MacDonald MJ, Hawley JA. Physiological adaptations to low-volume, high-intensity interval training in health and disease. J Appl Physiol 2012 (5); 590:1077-1084.

[23]. Häkkinen K. Changes in physical fitness profile in female volleyball players during the competitive season. J. Sports Med Phys Fitness 1993; 33(3): 223-232.

[24]. Hamilton AL, Nevill ME, Brooks S, Williams C. Physiological responses to maximal intermittent exercise: Differences between endurance-trained runners and games players. J. Sport Sci 1991; 9: 371-382.

[25]. Harmer AR, McKenna MJ, Sutton JR .Skeletal muscle metabolic and ionic adaptations during intense exercise following sprint training in humans. J Appl Physiol 2000; 89:1793–1803.

[26]. Hazell TJ, MacPherson R, Gravelle B, Lemon WR. 10 or 30-s sprint interval training bouts enhance both aerobic and anaerobic performance Eur J Appl Physiol 2010;110:153–160.

[27]. Helgerud J, Engen LC, Wisløff U. Aerobic endurance training improves soccer performance Med. Sci. Sports Exerc 2001; 33 (11):1925–1931.

[28]. Kaynak K, Korkmaz S, Eryılma Z, Aydoğan S, Mihailov D. The effects of 20-m repeated sprint training on aerobic capacity in college volleyball players. Biomedical Human Kinetics 2017; 9: 43–50.

[29]. Lamina S, Goddy O, Ezema C, Ezugwu A, Anele T. Effect of interval training programme of resting heart rate in subject with hypertension: a randomized controlled trial. The Nigerian Health Journal 2013; 13 (1) : 26-32.

[30]. Laursen PB, Jenkins DG. The scientific basis for high-intensity interval training: optimising training programmes and maximizing performance in highly trained endurance athletes. Sports Med 2002; 32:53–73.

[31]. MacDougall JD, Hicks AL, MacDonald JR, McKelvie RS, Green HJ, Smith KM . Muscle performance and enzymatic adaptations to sprint interval training. J Appl Physiol 1998; 84:2138–2142.

[32]. McCartney N, Spriet LL, Heigenhauser GJ, Kowalchuk JM, Sutton JR, Jones NL. Muscle power and metabolism in maximal intermittent exercise. J Appl Physiol 1986; 60:1164–1169.

[33]. Marques MC, Tillar R, Vescovi JD, Gonzalez-Badillo JJ .Changes in strength and power performance in elite senior female professional volleyball players during the in-season: A case study. J Strength Cond Res 2008; 22: 1147–1155.

[34].Marques MC, Marinho DA. Physical parameters and performance values in starters and nonstarters volleyball players. A brief research note. Motricidade 2009; 5(3): 7-11.

[35].Polglaze T, Dawson B. The physiological requirements of the positions in state league volleyball. Sports Coach 1992;15: 32-37. [36]. Ratel S, Duché P, Williams CA.Muscle fatigue during high-intensity exercise in children. Sports Med 2010; 36(12): 1031-1065. [37]. Rognmo Ø, Hetlandb E , Helgerudb J , Hoff J, Slørdahla SA. High intensity aerobic interval exercise is superior to moderate intensity exercise for increasing aerobic capacity in patients with coronary artery disease. European Journal of Cardiovascular Prevention and Rehabilitation 2004; 11:216–222.

[38]. Sheppard JM, Gabbett TG, Stanganelli LC. An analysis of playing positions in elite men's volleyball: considerations for competition demands and physiologic characteristics. J. Strength Cond Res 2009; 23: 1858-1866.

[39]. Smith DJ, Roberts D, Watson B. Physical, physiological and performance differences between Canadian national team and Universiade volleyball players. J. Sports Sci 1992;10: 131-138.

[40]. Sperlich B, Zinner C, Heilemann I, Kjendlie P,Holmberg H, Mester J. High-intensity interval training improves VO2peak, maximal lactate accumulation, time trial and competition performance in 9–11-year-old swimmers. Eur J Appl Physiol 2010; 110:1029– 1036.

[41]. Stathis CG, Febbraio MA, Carey MF, Snow RJ. Influence of sprint training on human skeletal muscle purine nucleotide metabolism. J Appl Physiol 1994;76:1802–1809.

[42]. Stöggl T, Sperlich B. The training intensity distribution among well-trained and elite endurance athletes . Front. Physiol 2015; 6:295.

[43]. Tabata I et al. Effects of moderate-intensity endurance and high-intensity intermittent training on anaerobic capacity and VO(2max).
Medicine & Science in Sports & Exercise 1996 ; 28 : 1327-1330.

[44]. Thibault G, Marion A. Interval training a practical model. Coaches rep 1999; 6: 16-20.

[45]. Tomlin D, Wenger HA. The relationship between aerobic fitness and recovery from high intensity intermittent exercise. Sports Med 2001; 31: 1-11.

[46].Tschakert G , Kroepf J , Mueller A, Moser O ,Groesch W, Hofmann P .How to Regulate the Acute Physiological Response to "Aerobic" High-Intensity Interval Exercise.J Sports Sci Med. 2015;14(1): 29–36.

[47].Tjonna et al. Aerobic Interval Training Versus Continuous Moderate Exercise as a Treatment for the Metabolic Syndrome. J Circulation American Heart Association 2008; 118:346-354.

[48].Vittasalo JT, Rusko H, Pajala O, Rahkila P, Ahila M, H. Montonen Endurance requirements in volleyball. J. Appl. Sports Sci 1987; 12: 194-201.

[49].Weston K, Wisløff U, Coombes J. High-intensity interval training in patients with lifestyle-induced cardiometabolic disease: a systematic review and meta-analysis British Journal of Sports medicine 2014; 48 :1199-1199.