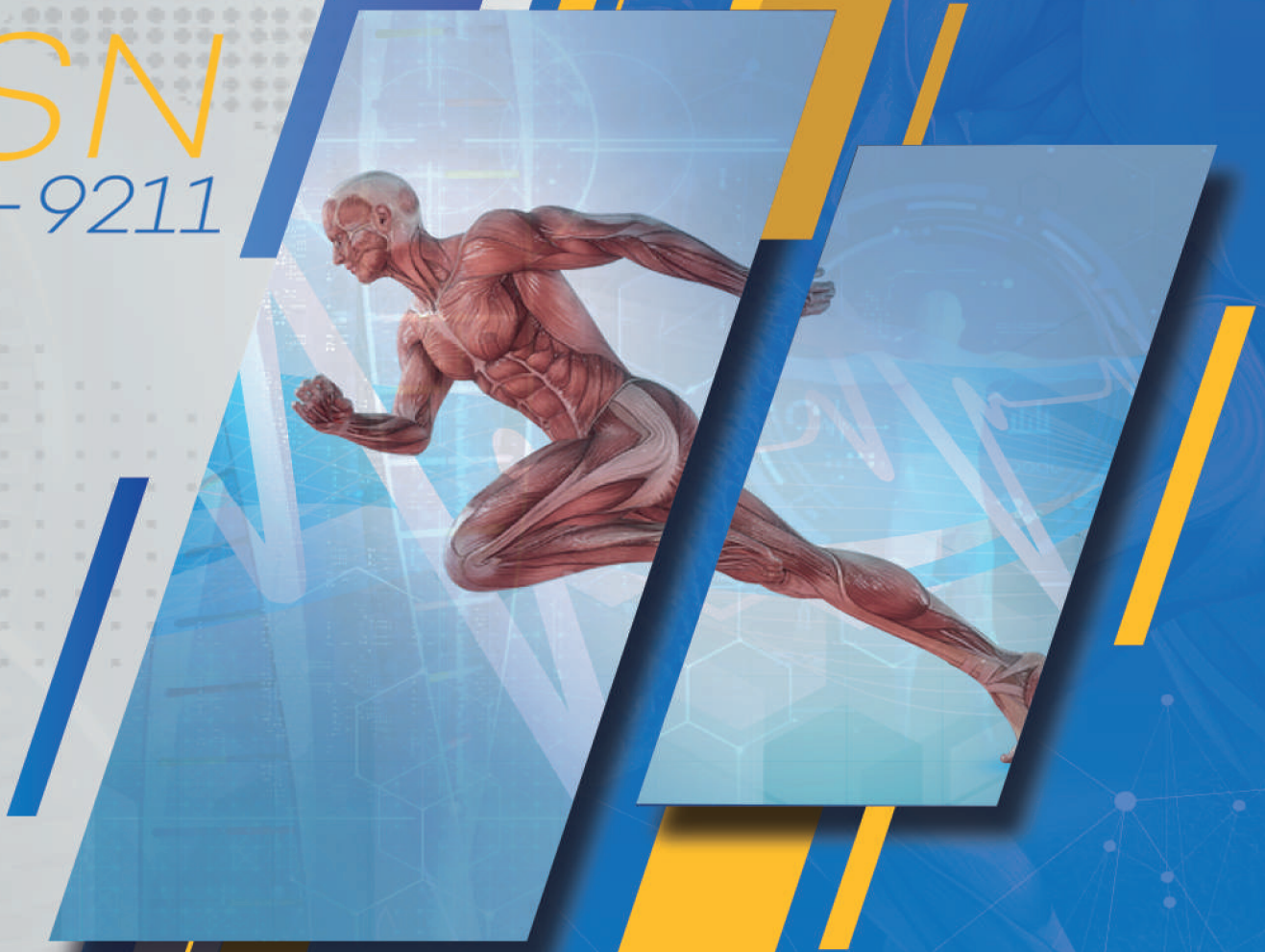
SJSR SWEDISH JOURNAL OF SCIENTIFIC RESEARCH

Volume 7 - Issue 3
JULY 2020

ISSN 2001-9211



Chairman Message

I Would like to welcome you on behalf of myself and my colleagues in the Editorial Board of the Swedish Journal of Scientific Research (SJSR), our online journal visitors of researchrs, publishers and students of science.

SJSR is a peer-reviewed, Open Access journal Thatpublishesoriginal research, reviews, and clinicalstudies covering a wide range of subjects in sport sciences.

The main objective of this journal is that we want to put enormous efforts in developing the scientific research in sport & physiology. This would help us make the first step to contribute in changing the healthy lifestyle of sport amateurs,and developing scientific accomplishments & establishing new records in professional sport & international standards.

with the incredible development of technology & telecommunicationsystems, the world has become a tinty village, and it becamepossible for an online electronic journal like SJSR to accopmlish the most sophisticated levels of correspondence between scientists, inventors, researchers and students in the sport science field.

We always strive to search you and be there with you whenever, wherveer you are

Chairman

Dr. Ali Faleh Salman

SJSR Editorial Board

The Swedish Journal of Sientific Research (SJSR) ISSN 2001-9211. Volume 7. Issue 3 July 2020

The Swedish Journal of Scientific Research

Original Article

Physical and Performance Adaptations to High-vs Low-intensity Interval Training in Physical Education Students

Qasem Dabeek[1,2], Raoua Triki[2], Ismail zakarneh[3], Mohanad Omar[2], Ala Nada[4], Omar AlSharab[2,5]

[1]Higher Council for Youth and Sport, Tubas, Palestine, [2]Higher Institute of Sport and Physical Education of Ksar-Said, Ksar-Said, Tunisia, [3]Department of Physical Education Military, Al Istiqlal University, Jarico, Paletaine, [4]Ministry of Education and Higher Education, Nablous, Palestine, [5]Ministry of Education, Tulkarm, Palestine

ABSTRACT

This study aimed to investigate the effect of high-vs low-intensity interval training (HIIT vs LIIT) in physical and performance adaptations among physical education students at An-Najah National University of Palestine. The investigation was conducted on 20 Palestinian physical students during the preparation course for the academic year 2016/2017. Participants were divided randomly into two training groups (N =10). The intervention program lasted 8 weeks, with three training sessions a week and a pre-test and post-test on each variable were carried out to measure physical abilities (speed, power, flexibility, agility and endurance). Differences within and between groups were analyzed using two-way analysis of variance (ANOVA) for repeated measures (time × groups). Results showed that LIIT protocol improves significantly all physical capacities where the highest percentage of variation observed in flexibility (350%), following by the capacity of endurance (11.89%), power (9.85%), speed (9.48%), and finally the agility which achieved a rate of (5.85%), while, The HIIT program also improves significantly all variables measured with a percentage of variation (150%) for flexibility, (10.89%) power, (9.36%) endurance, (7.84%) speed, and finally the agility has achieved the smallest improvement rate of (2.92%). Both low and high-intensity training are effective training method for motor development of the athlete but it is important to adopt the suitable protocol in term of intensity and volume of training according to the capacity to develop.

Key words: LIIT, HIIT, Physical performance, Physical education students, Palestine

INTRODUCTION

Physical fitness development has become increasingly interesting in the field of scientific progress in order to investigate new scientific method more effective to raise the level of physical ability and physiological adaptation of individuals to reach the highest levels of fitness performance.

The use of multiple training components is commonplace to address different functional parameters, metabolic adaptation, neuromuscular performance and aerobic fitness (Garber and al., 2011). Therefore, there is interest in identifying efficient training methods and optimize the magnitude of cardiovascular and neuromuscular adaptation resulting from physical training, while minimizing the time and effort devoted to training and using a single training mode, is a topic of considerable interest within the exercise community including classical studies of

Access this article online

Website: http://sjsr.se/

ISSN: 2001-9211

Address for correspondence:
Qasem Dabeek, Higher Council for Youth and Sport, Tubas, Nablus, Palestine. E-mail: qdabeek@gmail.com

interval training for athletic performance (Tschakert and Hofmann., 2013; Seiler., 2010; Billat., 2001).

The most common protocols of interval training are the low-intensity interval training (LIIT) using a high volume training and the high-intensity interval training (HIIT) using a low volume training and they differ from their effect of metabolic adaptation and the development of physical abilities and physiological capacities (MacInnis and Gibala., 2017).

To differentiate two different protocols of interval training based on exercise intensity, HIIT is defined as 'near maximal' efforts which is performed at an intensity ≥ 80% (but often 85–95%) of maximal heart rate. In contrast, LIIT is characterized by efforts performed at intensities ≤ 70% (65-55) and it has been found to improve aerobic capacities such as endurance.

Manipulation of the intensity and duration of work and rest intervals changes the relative demands on particular metabolic pathways within muscle cells, as well as oxygen delivery to muscle, adaptation of central and peripheral systems, neural recruitment patterns, muscle bioenergetics as well as enhanced morphological and skeletal muscle acid–base status (Buchheit et al., 2009; Enoka and Duchateau, 2008; Zierath and Hawley., 2004; Holloszy and Coyle., 1984). The rate at which these adaptations occur is variable (Vollaard et al., 2009) and appears to depend on the volume, intensity and frequency of the training.

While both LIIT and HIIT are important components of an athlete's training program, but it is important to best manipulate these components in order to achieve optimal intense exercise in response to the demands of athletic performance.

The aim of this study was to investigate the effect of two different training protocols (Low-intensity interval training and high-intensity interval training) on speed, agility, power, endurance and flexibility among the physical education students at An-Najah National University of Palestine.

METHODS

Subjects

The study was conducted on 20 physical education Palestinian students (age 21.05 ± 2.66 years, height 177.12 ± 2.24 cm, weight 70.15 ± 2.97 kg, BMI 22.13 ±1.82). Participants were selected from An-Najah national university during the physical preparation phase of the academic year 2016/2017.

Students were divided randomly into two training groups (N =10) and performed 24 session of two different interval training protocols, the first group (HIIT) has completed 24 sessions of high-intensity interval training protocol while the second group (LIIT) has received 24 sessions of low-intensity interval training protocol.

Participants were informed of the purpose of the study, as well as of risks and benefits. All participants gave an informed consent for voluntary participation, Additional, exclusion criteria included high fasting blood glucose (fasting blood glucose of >100 mg. dl-1), previous history of respiratory problems, coronary heart disease, and daily smoking.

Participants were instructed to keep usual food and rest habits during the study in order to better isolate the effects of the proposed training. Anthropometric features of the sample are shown in Table 1.

Procedure

The study was conducted in the first third of the academic year 2016-2017, between September and November at An-Najah national university of Palestine.

The program lasted for 8 weeks, with three non-consecutive training sessions per week. The (HIIT) group has completed 24 sessions of high-intensity interval training protocol (10 min warm up with 50 % HRmax, 3 sets of (8) ×30sec min with 75-90% HRmax, 2 min active recovery with 50 % HRmax between sets and 5 min stretching) while the (LIIT) group has received 24 sessions of low-intensity interval training protocol (10 min warm up with 50 % HRmax, 3 sets

Table 1: Anthropometric and body composition characteristics (means ± SD) among different weight status during measurement periods

Variables	HIIT (N=10)	LIIT (N=10)
Age (year)	22.15±1.66	21.75±2.86
Height (cm)	178.12±3.68	177.12±2.29
Body mass (kg)	70.54±5.21	71.02±2.78
BMI (kg/m^2)	21.66±1.67	22.22±0.48

HIIT: High-intensity interval training group; LIIT: Low-intensity interval training group.

(8) ×30sec min with 45-65% HRmax, 2 min of passive recovery between sets and 5 min stretching) according to HIIT and LIIT whole body method based on functional exercises (combining strength, coordination and plyometric exercises) (Machado and al., 2019) (Figure 1).

The players underwent a pre-test and post-test before and after the 8-week training in order de evaluate physical capacities (speed, endurance, power, flexibility and agility). For each test, measures were taken in two days. In order to reduce measure variability to the minimum, the same protocol was followed. Participants could not have caffeinated or alcoholic drinks nor have any kind of food in the three hours prior to the test.

Day One

Body composition

Bioelectrical impedance analysis was used (Tanita BC-601, Tanita Corp., Tokio, Japón). Three measures were taken on the equipment to obtain the weighted average value of the following variables: weight (kg), body mass index (BMI), and % fat.

1500m test

Students must run continuously for 1500m. The run start with an audio signal. Participant trays to finish the 1500 run in the shorter time possible.

Sit and reach test

This test involves sitting on the floor with legs stretched out straight ahead. Shoes should be removed. The soles of the feet are placed flat against the box. With the palms facing downwards, and the hands on top of each other or side by side, the subject reaches forward along the measuring line as far as possible and holds that position. The score is recorded to the nearest centimeter or half inch as the distance reached by the hand.

Day Two

Illinois agility test

The dimensions and route direction for the Illinois agility run (IAR) are shown in Figure 2, and was conducted in accordance with established methods (Jarvis et al., 2009; Roozen, 2004; Wilkinson et al., 2009). Subjects should lie on their front (head to the start line) and hands by their shoulders. On the 'Go' command the stopwatch is started, and the athlete gets up as quickly as possible and runs forwards 15 meters to run around a cone, then back 15 meters, then runs up and back through a slalom course of four cones. Finally, the athlete runs another 15 meters up and back past the finishing cone, at which the timing is stopped.

Sprint test (30m)

The sprint tests began with a standardized warm-up. Players than run 30-m recorded by paired photocells

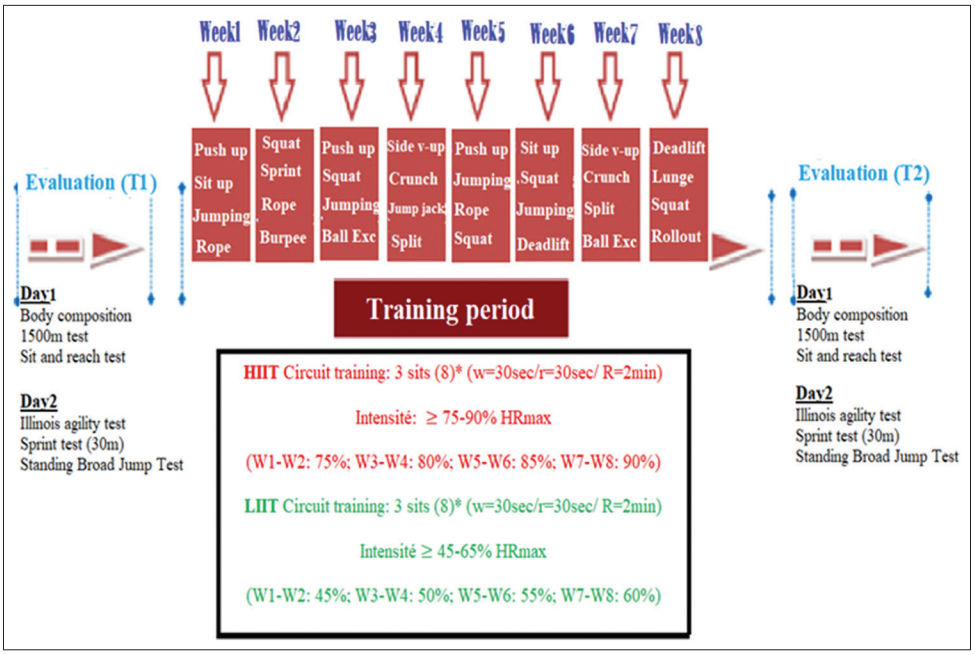


Figure 1: Experimental design
Evaluation T1: Before the training period.
Evaluation T2: After the training period.

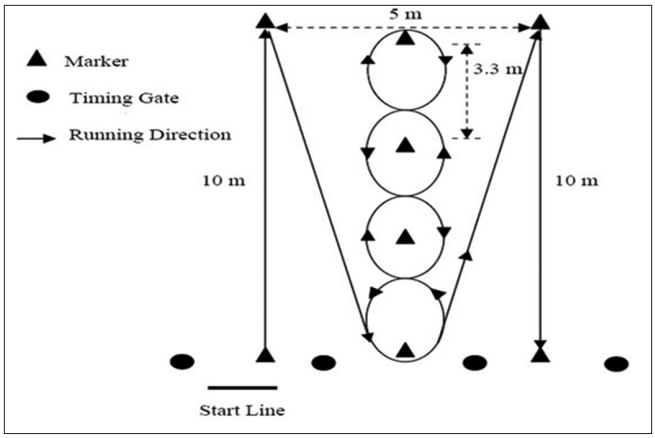


Figure 2: Illinois agility test

(Microgate, Bolzano, Italy). Three trials were separated by 6- 8 min of recovery for each sprint test. Players began from a standing position just before the starting photocell beam.

Standing broad jump test

As described by (Anup Krishnan et al.,2017), student stands behind a line marked on the ground with feet slightly apart. A two-foot take-off and landing is used, with swinging of the arms and bending of the knees to provide forward drive. The subject attempts to jump as far as possible, landing on both feet without falling backwards. Three attempts are allowed.

Measurements of Exercise Intensity

As an objective measure of exercise intensity, HR was measured every 5 s throughout the training sessions (Polar Team2 Pro System; Polar Electro OY). HR data are expressed both as percentage of HRmax (% HRmax) and HR reserve (%HR reserve). The average HR (HR mean) for each of the training sessions (ie, HIIT and LIIT) was calculated. The % HRmax for each form of training was calculated by the following formula:

$$\%\text{HR max} = \frac{\text{HRmean}}{\text{HR max}} \times 100$$

The % HR reserve was calculated by the following formula:(dellal.,2008)

$$\%\text{HRreserve} = \frac{\text{HRmean} - \text{HRrest}}{\text{HR max} - \text{HRrest}} \times 100$$

Statistical Analysis

Statistical Package for Social Science (SPSS) version 16.0 (SPSS Inc, USA) was used for the statistical analysis of the present study.

Data were presented as mean ± SD (standard deviation). The normality of data distribution was confirmed using the Kolmogorov-Smirnov test, the homogeneity of groups was determined using T-test for independent.

Differences within and between groups were analyzed using two-way analysis of variance (ANOVA) for repeated measures (time × groups).

ES were calculated using the following equation: ES = (post mean - pre mean) / SD (Cohen, 1988). According to Hopkins et al., ES were considered trivial (<0.2), small (0.2-0.6), moderate (0.6-1.2), large (1.2-2, 0) and very large (2.0-4.0) (Hopkins et al. 2009).

The percentage of variation (%) in physical fitness performance was measured by applying the following formula:

$$\left(\frac{\text{Postraining value} - \text{Pretraining value}}{\text{pretraining value}}\right) \times 100$$

Statistical significance for all analyses was set at $p < 0.05$.

RESULTS

All participants in this study reported a 100% adherence to study procedures. The anthropometric measurements and performance evaluation during the experiment and among the two groups of were statistically treated and analyzed.

Main Effects of Time

LIIT group

Results of Table 2 indicate the mean ± standard deviations (SD) and the level of significance for all physical fitness data on the pre and post measurements of the low intensity training group (LIIT).

Data shows that Low-intensity interval training have a significant benefic effect on all study variables; speed ($p<0.001$), agility ($p<0.01$), power ($p<0.01$), endurance ($p<0.001$), flexibility($p<0.001$). To find out the amount of improvement between the two tribal measurements, the researcher calculated the improvement percentages illustrated in Figure 3.

Looking at the previous figure, we found that speed variable achieved an improvement rate that reached

Table 2: Physical performance (means ± SD) among the HIIT and LIIT group evaluated before and after 8 week of training sessions. (n=20)

Variables	Test	Group	Pre-training	Post-training	Variation percentage%	P value Between groups (ES)
Speed	Sprint 30m	LIIT	4.22±0.30	3.82**±0.20	9.48	0.518 (0.65)
		HIIT	4.21±0.26	2.45**± 0.21	7.84	
Agility	Illinois agility	LIIT	46.53±1.72	43.81**±2.54	5.85	0.141 (0.53)
		HIIT	45.81±1.73	45.53±2.54	2.94	
Power	Standing Broad Jump	LIIT	2.03±0.22	2.23***±0.13	9.85	0.976 (0.42)
		HIIT	2.02±0.21	2.24**±0.15	10.89	
Endurance	Test 1500	LIIT	6.56±0.58	5.78**±0.45	11.89	0.592 (0.52)
		HIIT	6.52±0.47	5.91***±0.55	9.36	
Flexibility	Sit and reach	LIIT	2.80±6.01	9.10***±5.02	350	0.691 (0.32)
		HIIT	3.60±7.33	7.00 ***±5.02	150	

HIIT: high intensity interval training; LIIT: low intensity interval training; ***: P <0.001; **: P <0.01; *: P <0.05

(9.48%), while the agility achieved an improvement rate of (5.85%), power capacity achieved an improvement rate of (9.85%), endurance variable achieved an improvement rate that reached (11.89%), and finally, flexibility achieved an improvement rate of (350%).

HIIT group

The mean values ± standard deviations (SD) of the physical test results among physical education student during the 8-week of high-intensity interval training are shown in Table 2.

A significant time-related effects was found for all physical fitness tests; speed ($p<0.01$), power ($p<0.01$), endurance ($p<0.001$), flexibility($p<0.001$) except agility ($p=0.266$).

To found out the percentage of improvement between the two tribal measurements, the researcher calculated the variation percentage% in Figure 4.

Results show that speed variable achieved an improvement rate of (7.84%), while agility achieved an improvement rate of (2.92%), power capacity achieved an improvement rate of (10.89%), while the endurance was improved with a rate reached to (9.36%) and finally, flexibility achieved an improvement rate of (150%).

Interaction effect (group x time)

Table 2 present the mean values ± standard deviations (SD) and the level of significance differences in the fitness test measurement between the LIIT group and the HIIT group.

Results indicates that there are no statistically significant differences between the two experimental

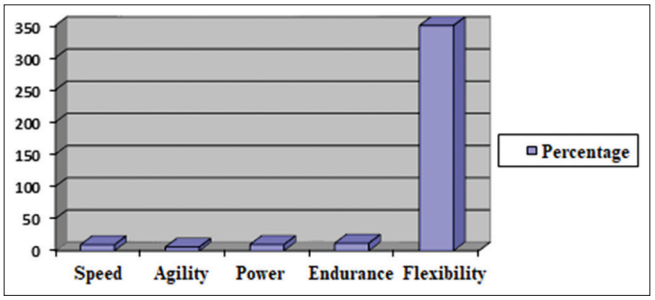


Figure 3: Percentage of improvement between the pre and post measurements of fitness variables among LIIT group

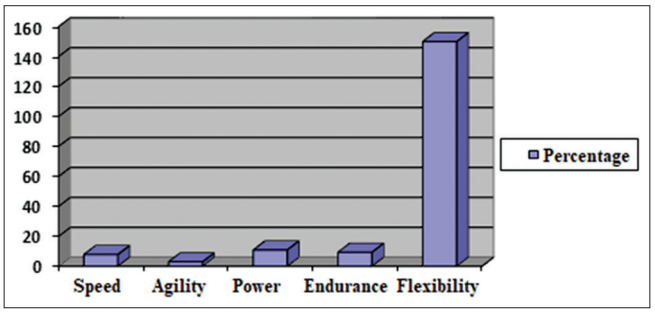


Figure 4: Percentage of improvement between the pre and post measurements of fitness variables among HIIT group

groups under the effect of different training protocols, on all study variables ($p>0,05$).

To identify the percentages of variation in all fitness capacities measured and between the two study groups, the researcher calculated the rate of change among the two groups (Figure 5).

The percentages of variations in speed, power and endurance capacities were approximately equal among the two groups and reached a difference of (1.57%,0.45%,2.25%) respectively, while the percentages

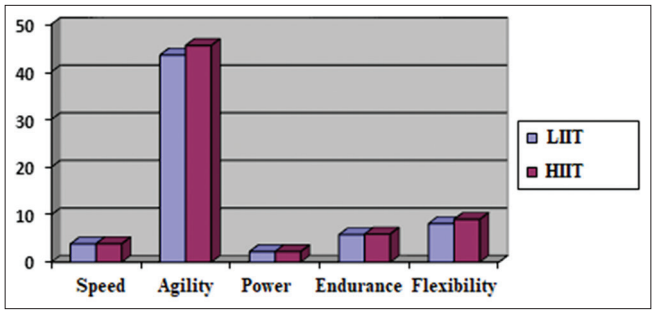


Figure 5: Difference of variation percentage of physical fitness variables between the LIIT group and the HIIT group.

of variations in agility and flexibility were better among the HIIT group than the LIIT group and reached a difference inter-group of 3.93% in agility and 11.11% in flexibility.

DISCUSSION

The aim of this study was to investigate the effect of two different training protocols (Low-intensity interval training and high-intensity interval training) on speed, agility, power, endurance and flexibility among the physical education students at An-Najah National University of Palestine.

The results showed that LIIT protocol improve all the fitness capacities measured in this study where the highest percentage of variation observed in flexibility (350%), following by the capacity of endurance (11.89%), power (9.85%), speed (9.48%), and finally the agility which achieved a rate of (5.85%) confirming with the finding of (De Oliveira and al., 2016) that demonstrates the advantage of short-term LIIT as the single mode of training able to simultaneously improve aerobic fitness and muscular strength. While results are in contradiction with other study (Stöggl and Björklund., 2017) they observe that a training regime based on low and moderate intensity interval training had no effect on any performance or physical capacities.

In fact, our results showed that HIIT protocol improved significantly all physical capacities measured in this study, where the highest percentage of change is observed in flexibility (150%), and power (10.89%), followed by the endurance (9.36%), speed (7.84%), and finally the agility has achieved the smallest improvement rate of (2.92%).

The results of this study are in confirmation with other study (Fernandez-Fernandez and al., 2012; Sperlich and al, 2011; Wong and al., 2010).

Previous study found that high-intensity interval training improves the ability of flexibility related to the type of exercise used during the protocol program (Baynaz and al., 2017).

Researchers attribute the development of both strength and speed capacities to the effect of HIIT in the improvement of anaerobic capacities (Ferley and al 2014) in fact, high-intensity work alternated with periods of low-intensity rest/work, is regarded as an overall effective training method for improving metabolic and energy efficiency, therefore, during bouts of high-intensity exercise, the large accumulation of H+ and lactate impairs muscular force production and ultimately leads to fatigue (Laursen et al., 2002).

The researchers also attribute the improvement of endurance to the development of cardio-respiratory system, where high-intensity exercises lead to an increase in the heart rate during performance (Tschakert et al., 2015) confirm that the heart rate rises with the increase in the intensity of physical pregnancy and the increase in the rate of oxygen consumption and, undoubtedly, this leads to increased respiratory cyclic tolerance.

However, this is not a universal finding, since controversial results also exist (Burgomaster et al. 2008; McKay et al. 2009). However, in some studies the improvement of endurance under the effect HIIT is due to their effect on VO2max. Similar results have been obtained with both trained and untrained subjects as well as among young and older adults and healthy and unhealthy persons. (Boutcher., 2010; Helgerud and al., 2007; Nybo and al., 2010; Tjonna and al., 2009).

Boutcher (2011) has summarized the results of 14 HIIT studies and noticed that different types of high-intensity interval exercise protocols lasting from two to 15 weeks improved VO2max from four to 46 %.

LIIT and HIIT are both two excellent protocols training for the development of physical capacities and fitness level, however, there is a slight difference between the two methods observed for the short term fitness capacities as power which improved in favor under the effect of high-intensity interval training, which is a logical result attributed to the nature of the high physical intensity during the HIIT method and duration of work and rest intervals which provides the anaerobic system contribution.

On the other side, endurance improved in favor during the LIIT due to the moderate intensity of training and long durations involves predominantly slow twitch motor unit recruitment and metabolic adaptation during the aerobic pathway (Laursen., 2010).

REFERENCES

Baynaz, K., Acar, K., Çinibulak, E., Atasoy, T., Mor, A., Pehlivan, B., & Arslanoğlu, E. (2017). The effect of high intensity interval training on flexibility and anaerobic power Yüksek yoğunluklu interval antrenmanın esneklik ve anaerobik kapasite üzerine etkisi. Journal of Human Sciences, 14(4), 4088-4096.

Billat, L. V. (2001). Interval training for performance: a scientific and empirical practice. Sports medicine, 31(1), 13-31.

Boutcher, S. H. (2010). High-intensity intermittent exercise and fat loss. Journal of obesity, 2011.

Buchheit, M., Laursen, P. B., Al Haddad, H., & Ahmaidi, S. (2009). Exercise-induced plasma volume expansion and post-exercise parasympathetic reactivation. European journal of applied physiology, 105(3), 471.

Cipryan, L., Tschakert, G., & Hofmann, P. (2017). Acute and post-exercise physiological responses to high-intensity interval training in endurance and sprint athletes. Journal of sports science & medicine, 16(2), 219.

Dellal, A., Chamari, K., Pintus, A., Girard, O., Cotte, T., & Keller, D. (2008). Heart rate responses during small-sided games and short intermittent running training in elite soccer players: a comparative study. The Journal of Strength & Conditioning Research, 22(5), 1449-1457.

de Oliveira, M. F. M. D., Caputo, F., Corvino, R. B., & Denadai, B. S. (2016). Short-term low-intensity blood flow restricted interval training improves both aerobic fitness and muscle strength. Scandinavian journal of medicine & science in sports, 26(9), 1017-1025.

Enoka, R. M., & Duchateau, J. (2008). Muscle fatigue: what, why and how it influences muscle function. The Journal of physiology, 586(1), 11-23.

Ferley, D. D., Osborn, R. W., & Vukovich, M. D. (2014). The effects of incline and level-grade high-intensity interval treadmill training on running economy and muscle power in well-trained distance runners. The Journal of Strength & Conditioning Research, 28(5), 1298-1309.

Fernandez-Fernandez, J., Zimek, R., Wiewelhove, T., & Ferrauti, A. (2012). High-intensity interval training vs. repeated-sprint training in tennis. The Journal of Strength & Conditioning Research, 26(1), 53-62.

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I. M.,… & Swain, D. P. (2011). American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. Medicine and science in sports and exercise, 43(7), 1334-1359.

Cazorla, G. (1990). Proceedings of the International Symposium of Guadeloupe

Helgerud, J., Høydal, K., Wang, E., Karlsen, T., Berg, P., Bjerkaas, M.,… & Hoff, J. (2007). Aerobic high-intensity intervals improve V· O2max more than moderate training. Medicine & Science in Sports & Exercise, 39(4), 665-671.

Holloszy, J. O., & Coyle, E. F. (1984). Adaptations of skeletal muscle to endurance exercise and their metabolic consequences. Journal of applied physiology, 56(4), 831-838.

Jarvis, S., Sullivan, L. O., Davies, B., Wiltshire, H., & Baker, J. S. (2009). Interrelationships between measured running intensities and agility performance in subelite rugby union players. Research in Sports Medicine, 17(4), 217-230.

Krishnan, A., Sharma, D., Bhatt, M., Dixit, A., & Pradeep, P. (2017). Comparison between standing broad jump test and wingate test for assessing lower limb anaerobic power in elite sportsmen. Medical Journal Armed Forces India, 73(2), 140-145.

Laursen, P. B. (2010). Training for intense exercise performance: high-intensity or high-volume training? Scandinavian journal of medicine & science in sports, 20, 1-10.

Machado, A. F., Baker, J. S., Figueira Junior, A. J., & Bocalini, D. S. (2019). High-intensity interval training using whole-body exercises: training recommendations and methodological overview. *Clinical physiology and functional imaging*, *39*(6), 378-383.

MacInnis, M. J., & Gibala, M. J. (2017). Physiological adaptations to interval training and the role of exercise intensity. The Journal of physiology, 595(9), 2915-2930.

Nybo, L., Sundstrup, E., Jakobsen, M. D., Mohr, M., Hornstrup, T., Simonsen, L.,… & Krustrup, P. (2010). High-intensity training versus traditional exercise interventions for promoting health. Medicine & Science in Sports & Exercise, 42(10), 1951-1958.

Roozen, M. (2004). Illinois agility test. NSCA's Performance Training Journal, 3(5), 5-6.

Seiler, S. (2010). What is best practice for training intensity and duration distribution in endurance athletes? International journal of sports physiology and performance, 5(3), 276-291.

Sperlich, B., De Marées, M., Koehler, K., Linville, J., Holmberg, H. C., & Mester, J. (2011). Effects of 5 weeks of high-intensity interval training vs. volume training in 14-year-old soccer players. The Journal of Strength & Conditioning Research, 25(5), 1271-1278.

Stöggl, T. L., & Björklund, G. (2017). High intensity interval training leads to greater improvements in acute heart rate recovery and anaerobic power as high volume low intensity training. Frontiers in physiology, 8, 562.

Tjønna, A. E., Stølen, T. O., Bye, A., Volden, M., Slørdahl, S. A., Ødegård, R.,… & Wisløff, U. (2009). Aerobic interval training reduces cardiovascular risk factors more than a multitreatment approach in overweight adolescents. Clinical science, 116(4), 317-326.

Tschakert, G., & Hofmann, P. (2013). High-intensity intermittent exercise: methodological and physiological aspects. International Journal of Sports Physiology and Performance, 8(6), 600-610.

Vollaard, N. B., Constantin-Teodosiu, D., Fredriksson, K., Rooyackers, O., Jansson, E., Greenhaff, P. L.,… & Sundberg, C. J. (2009). Systematic analysis of adaptations in aerobic capacity and submaximal energy metabolism provides a unique insight into determinants of human aerobic performance. Journal of Applied Physiology, 106(5), 1479-1486.

Wilkinson, M., Leedale-Brown, D., & Winter, E. M. (2009). Validity of a squash-specific test of change-of-direction speed. International journal of sports physiology and performance, 4(2), 176-185.

Wong, P. L., Chaouachi, A., Chamari, K., Dellal, A., & Wisloff, U. (2010). Effect of preseason concurrent muscular strength and high-intensity interval training in professional soccer players. The Journal of Strength & Conditioning Research, 24(3), 653-660.

Zierath, J. R., & Hawley, J. A. (2004). Skeletal muscle fiber type: influence on contractile and metabolic properties. PLoS biology, 2(10).

The Swedish Journal of Scientific Research

Original Article

Relationship of some Physiological and Biochemical Variables with Physical Composition as Health Indicators to Raise Awareness of the Seriousness of Obesity for Women

Suhair Salem Al-Shaqruni[1], Nidhal Jbabli[2], Khaled Jibril Abuzayan[1], Sabri Al-Qayed Chartan[2]

[1]Higher Institute of Medical professions in Tripoli, Lybie, [2]Higher Institute of Sport and Physical Education, Ksar-Said, University of Manouba, Tunis 2010, Tunisia

ABSTRACT

The purpose of the study was to determine the relationship of some physiological and biochemical variables with physical composition as health indicators to raise awareness of the seriousness of obesity for women. A total of 120 women (aged 20-50 years) were participated in this study. The present study showed a positive correlation was proved between between physiological variables and physical composition. Also, a significant relationship was detected between fitness score and physiological makers. Body compositions are among the main major indicators for the primary detection of the participants' state of health. The present study contribute to helping women reach an normal physical state by discovering the relationship between physical structure and certain physiological and morphological variables in the context of avoiding obesity.

Keywords: Body composition, physical activity level, conditioning, physiological markers

INTRODUCTION

The World Health Organization (WHO) inits2016 update cited facts about overweight and obesity: in 2014, more than 1.9 billion overweight adults aged 18 and over were obese. About 13% of the world's adults in general (11% of men and 15% of women) are obese. The form of overweight and obesity, once considered a problem of high-income countries, is now on the rise in low- and middle-income countries, particularly in urban settings. In Africa, the number of overweight or obese children almost doubled from 5.4 million in 1990 to 10.6 million in 2014. In 2014, nearly half of overweight or obese children under 5 years of age lived in Asia("Obesity and overweight", 2019)

Obesity has become a serious health concern in the Libyan context because obesity poses a significant risk to serious diet-related fatal diseases that lead to disability and premature death, which may be attributed to a significant increase in obesity rates in the Libyan adult population aged 20-74. (Altajori et al., 2019; Lemamsha et al., 2018).Moreover, obesity causes many psychological, social and economic effects, leading to increased morbidity, mortality and economic losses, and the highest annual mortality rate in the Middle East and North Africa region. (Altajori et al., 2019)، Obesity more than doubled, from a prevalence of almost 12.6% in 1984 to 30.5% in 2009. The direct costs directly associated with the costs spent on the treatment of obesity-related illnesses in Libya in 2012 were estimated at 1.3 billion Libyan dinars per year (approximately

Access this article online

Website: http://sjsr.se/

ISSN: 2001-9211

Address for correspondence:
Suhair Salem Al-Shaqroni. Higher Institute of Medical professions in Tripoli, Lybie.
E-mail: sohiralshgrone@gmail.com

£638 million), which accounted for 50-65% of Libya's total health care budget.

Similarly, determining a mass free of fat and muscle mass, fat mass, and bone intake and quality is an ongoing topic of interest and study in the multidisciplinary areas of sports and health sciences. It is necessary to infer the type of body and its general condition in order to obtain the appropriate strength of the type of work practiced by the individual, as many studies of the body, morphological and hormonal neurosis have confirmed the metabolism of the muscle and its direct effect in acute and chronic adjustment during the performance of the muscular function of different organs of the body.

BMI is widely used to evaluate the body and BMI is used ≥30kg/m^2 to determine the level of obesity (Quetelet, 2008) Despite its limited accuracy in estimating body fat and therefore, it is preferable to use modern techniques in measuring body composition (Oreopoulos, 2011). Preliminary results of body composition research confirmed the low percentages of fat levels in the body composition of athletes and reported overall body fat tend to be greater among female athletes compared to athletes (Lukaski, 1997). Wilmore (1983) has advised "The range of body ghee by sex for sport can be a single component of an athlete's physiological profile, and can be used by athletes with elite comparison supplications to customize training and dietary recommendations". Women have about twice as much body fat as men because ovarian hormone physiology favors fat deposition: higher levels of testosterone in men prefer to increase muscle and bone mass.(Bangsbo, 2003). It is recognized that the high percentage of body fat (fat tissue mass relative to total body weight) affects motor performance and sports and causes serious chronic diseases and may be associated with death (Ortega et al., 2016).

Obesity, Overweight and its Physiological Effects

A situation known since ancient times; obesity has grown from being the exception to a global public health challenge. A recent study revealed that between 1980 and 2013, rates of overweight and obesity worldwide increased by 28% in adults and 47% in children. As of 2013, 2.1 billion people were overweight and obese, compared to 857 million in 1980. The United States is home to about 13% of the world's 671 million obese people (Marie et al., 2014). Associated diseases associated with overweight lead to a health burden that has a significant economic impact (Wang et al., 2011). Obesity is associated with conditions such as type 2 diabetes (T2DM), chronic kidney disease.(Eckardt et al., 2013; Y. U. Kang et al., 2014)، depression.(Fabricatore et al., 2011), stroke (Kernan et al., 2013), Coronary artery disease(CAD) (Yusuf et al., 2005). These accompanying diseases, in addition to the type and invasion of the surgery, are associated with the occurrence and severity of postoperative complications(Buchwald et al., 2004; Guh et al., 2009).

Excess weight is also associated with conditions that in and of itself increase the likelihood of need for surgery and anesthesia: malignant tumors - especially cervix, endometriosis, colorectal and gallbladder cancer (Guh et al., 2009)؛ In the spine.(Aspden, 2011). Back pain(Mangwani et al., 2010)؛ Incontinence (Swenson et al., 2017) And gallstones.(Erlinger, 2000). These conditions are the result of both physiological changes as well as inflammatory changes associated with obesity.

In type 2 diabetes, the pancreas secretes insulin, but the body's cells are unable to respond to it. The causes are complex, including lifestyle factors. This type of diabetes is often associated with obesity and is a growing problem in rich societies. The disease can be controlled by a healthy diet, regular exercise and daily blood sugar monitoring.(Parker, 2019).

As for the concept of physiological fitness as the fitness and efficiency of the work of all its organs, therefore this term includes in addition to the six components recently agreed (flexibility, body composition, muscle strength, endurance, anaerobic abilities, aerobic abilities) some biological indicators associated with The health status of the individual, which is affected by the level of physical activity such as blood pressure, blood lipo-fats (and lipoproteins) as well as glucose tolerance.

Obesity is a condition of increased fatty tissue mass (Gray, 1989). Any increase in body weight exceeds as a result of excessive fat accumulation. Or triglyglate, since the storage of other energy (such as glycogen carbohydrates or protein in the liver and muscles) is unlikely to exceed the required limits. Although structural steroids can increase lean body mass and therefore body mass, this has only been described in those already malnourished (Ferreira et al., 1998).

Much has been learned in the past decade regarding the regulation of obesity in relation to the molecular

regulation of appetite that affects energy balance, especially as the positive energy balance disturbs the metabolism of fat and glucose. Fatty tissue is a tissue entity that, through enlargement and enlargement, can vary greatly between individuals, more than any other tissue. However, it is misleading to think of it as a single entity, where there are subtypes of fatty tissue (such as visceral and subcutaneous) that seem to have different effects on health (Björntorp, 1991). Fatty tissue is not just tissues for storing tri-glycerin, it also acts as endocrine organs, releasing many chemical messengers (fat) that communicate and affect other tissues. (Kershaw & Flier, 2004).

Obesity plays a key role in cellular metabolic imbalance that explains insulin resistance in type 2 diabetes. Excess lipo-cells secrete many cytokines that contribute to vascular dysfunction in high blood pressure and blood lipid dysfunction, as evidenced by hypercholesterolemia. These conditions ultimately contribute to atherosclerosis, and when associated with obesity and/or diabetes and insulin resistance, they form meta-syndrome.

New knowledge about fatty liver and its association with infections, as well as the effect of visceral lipids on gastroesophageal reflux, gallstone diseases and bowel cancer, make the liver and gut at risk of obesity and the physiology of obesity, or excess obesity, and diseases Accompaniment (Berg & Scherer, 2005; BUGIANESI, 2005; Lau et al., 2005; Michael W. Rajala, 2003).

Therefore, it is useful to know the relationship between physical structure and physiological changes and determine obesity levels to find smallpox solutions to women's health problems as obesity negatively affects these motor activities because it increases the cost of the total body mass movement.(Völgyi et al., 2008).

The importance of research is to identify the relationship between the physical structure and some physiological changes of women. The development of an initial database of careful research to spread awareness and knowledge of the members of the sample and their likes and to researchers and shed light on the ideal physical composition of women and the importance of measuring the league to detect obesity and identify its causes for finding solutions to it.

The research aims to identify the values of women's physical structure and its relationship to physiological variables.

Research Terms

Physiological variables

Are changes in human body functions such as (heart rate, breathing, blood pressure, temperature) (Draper & Hodgson, 2008).

Biochemical variables

Sometimes called biochemistry variables, are the study of changes in chemical processes within and in relation to living organisms (Etchells, 1975).

Body composition

This so-called body components of fat, muscles, bones, fluids, minerals, etc., usually divide the body's components into a mental and non-mental mass, including muscles, bones, minerals, connective tissues and cartilage.(Solanki et al., 2015).

Body mass index

This measurement is used to estimate obesity levels, body mass index is defined as body mass divided by the body height square, and is expressed globally in units of kg/m^2 (دبع احاتفـلا و سيس, 2003).

Bioelectrical impedance analysis

Is a commonly used method to estimate body structure, especially body fat and muscle mass(Mialich et al., 2014).

Obesity

is a medical condition in which excess body fat accumulates to the extent that it may have a negative impact on health(Vieiraa et al., 2018)

High-density cholesterol HDL

One of the lipoprotein compounds in the blood plasma, containing less fat and more protein than low-density cholesterol, and a concentration in blood plasma ranges from 35-40 milligrams per 100cm^3 plasma(نايمد, 2001).

Table 1: Shows the basic data of the study sample by BMI category

BMI categories	Age year	Height cm	Body mass kg	BMI kg/m^2	Fitness score point
Thin	35.6	161.2	57.4	22.22	65.7
Normal	32.14	160.14	68.64	26.87	63.95
Overweight	35.38	160.41	81.76	31.94	60.57
Obese	36.42	162.1	95.61	37.59	55.32
Obese 2	33.65	159.4	114.9	49.81	49.35

Three glycerides.T.G

One of the metabolites with a concentration of 30-170 mg per 100 cm^3 (دمايان, 2001)

High-density cholesterolLDL

One of the lipoprotein compounds found in the blood plasma contains less protein and a high fat content compared to high density cholesterol, and the concentration in blood plasma ranges from 160-190 milligrams per 100cm^3 plasma (LeMond et al., 2015).

C-Reactive protein (CRP)

It is the ring protein (ring-shaped), which is found in the blood plasma, whose circulating concentrations are high in response to inflammation. For most forms of tissue injury, infection and inflammation, CRP serum values are widely measured in clinical practice as an objective indicator of disease activity(Thompson et al., 1999)

Research method

The descriptive method was used in this study.

Research sample

The random class research sample was selected from 120 women who practiced physical activity and they were 20 -50 years old.

Table 2: Shows the basic data of the study sample

Statistics	Age year	Height cm	Body mass kg	BMI kg/m^2	Fitness score point
Mean	34.78	160.69	86.43	34.32	58.39
Median	35	160	86	33.05	59
Sd	9.38	4.89	18.95	7.95	8.03

Table 1 and Figure 1, the description of the sample members according to the BMI classification approved by the World Health Organization

It is clearly illustrated

1. **For the age variable:** the average age of the research sample was 34.78 years ±9.38 years and the highest value was 56 years while the value was less than 20 years (Table 2 and 3).
2. **For the length variable:** the average total length of the research sample was 160.69 cm ±4.89 cm and was higher than 173 cm while the value was 150 cm lower.
3. **For body mass variable:** The average body mass of the sample members was 86.43 kg ±18.95 kg and was higher at 160.00 kg while the lowest value was 49.00 kg.
4. **For BMI variable:** The average BMI of the sample personnel was 34.64 kg/m2 ±7.95 kg/m^2 and reached the highest value of 59.10 kg/m2 while the lowest value was 19.70 kg/m^2.
5. **For the fitness variable:** The average fitness score for the sample members was 58.39 degrees ±8.03 degrees and reached the highest value of 76.00 degrees while the lowest value was 42 degrees.

Anthropometric Measurements and Measurement of Body Composition Analysis

It consists of weight-height measurement and the use of the InBody 720 (Biospace Co., Ltd.; The united states of The United States of The United.

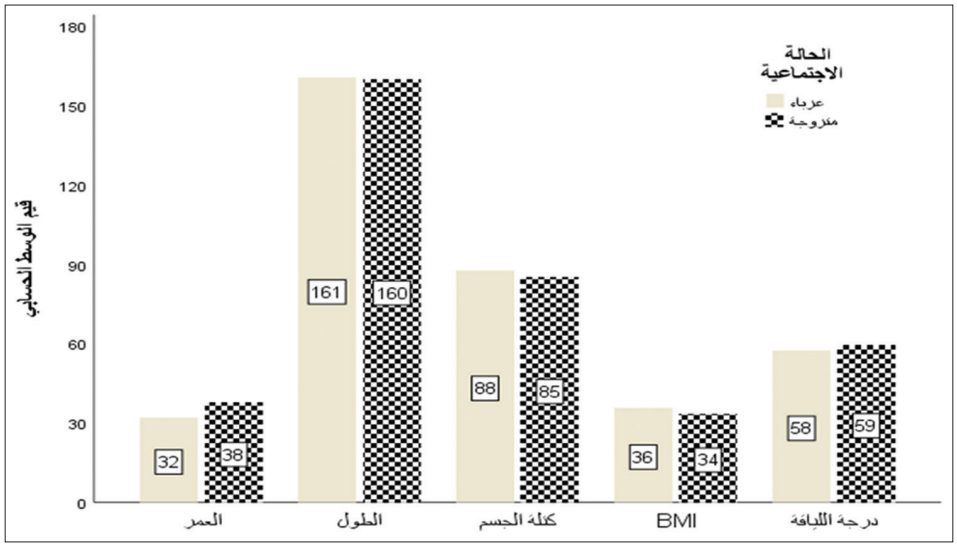


Figure 1: Illustrate the mean of variables

Physiological Measurements

It is the measurement of hemoglobin cholesterol (HDL) cholesterol (HDL) cholesterol (LDL density): triglycerides: systolic and diastolic blood pressure, blood components and vitamin D (Table 4).

Statistical Means

The Statistical Package for the Social Sciences (IBM©SPSS© version 25, 64 Bit edition (SPSS Inc., Chicago, IL (was used to analyze the data statistically and the alpha factor for moral indication will be prepared in advance at $p<0.05$.

RESULTS

The relationship of some physiological and biochemical variables to the physical structure as health indicators to raise awareness of the danger of obesity for women has been put in the form of tables and forms and were as follows:

Shown from Table 5:

1. For BMI variable: The average BMI for all sample members was 34.32 kg/m^2 ±7.95. the highest value was 59.10 kg/m^2 and the lowest value was 19.70 kg/m^2.
2. For body fat mass variable: The average body fat mass for all members of the sample was 40.05 kg ±13.74.
3. For the body fat ratio variable: the average body fat content for all members of the sample was 45.44% ±6.98.
4. For the visceral fat area variable: the average body fat content for all members of the sample was 125.87 cm^2 ±.30.24.
5. For the obesity variable: The average degree of obesity for all sample members was 125.87 degrees ±.30.24. It was the lowest value of 91.00 degrees and the highest value of 406.00 degrees.
6. For the skeletal muscle mass variable: the average skeletal muscle mass for all sample members was 25.93 kg ±.5.43. The lowest value was 18.40 kg and the highest value was 58.06 kg.
7. For the fitness variable: The average fitness score for allmembers of the sample was 58.39DG ±8.03.03.

Table 3: Shows distribution the components of the physical composition by BMI for the study sample members n=120

%	العدد	BMI
8.3	10	نحيف
18.3	22	عادي
30.8	37	وزن زائد
25.8	31	سمنة
16.7	20	سمنة مفرطة
100.0	120	المجموع

It is clear from Table 6 the correlation between physiological variables and the variables of physical composition were as follows:

For **pulse variable:** There are statistically positive correlations with both: weight T = 363. and body fat mass t = 346. The body fat ratio is t = 280. And the area of fat t = 286. The degree of obesity t = 365. The skeletal muscle mass t = 254. The Mass Index T = 363. All are moral functions at 0.01 <P.

A statistically negative correlation relationship with the degree of fitness t = -272. It is a statistical function at 0.01 <P.

Table 4: Shows basic variables and components of body composition by BMI

BMI year		Age year	Height	Weight kg	BMI kg/m^2	fat mass	Fat % %	Visceral fat score	Obesity degree score	Skeletal muscle mass kg	Fitness score
Thin 10	M	35.6	161.2	57.4	22.22	19.72	34.01	75.55	104.1	20.36	65.7
	s	11.02	6.18	4.6	2	3.57	4.28	18.24	9.77	1.68	6.33
Normal 22	M	32.14	160.14	68.64	26.87	27.5	39.76	101.45	128.73	22.56	63.95
	s	7.24	2.82	4.71	1.52	3.5	3.56	21.85	11.72	1.96	4.63
Overweight 37	M	35.38	160.41	81.76	31.94	36.58	44.45	124.08	147.62	24.89	60.57
	s	8.94	5.45	7.1	1.47	4.06	2.54	17.55	8.37	2.35	4.84
Obese 30	M	36.42	162.1	95.61	37.59	47.42	49.94	143.52	172.23	28.34	55.32
	s	10.74	3.92	7.4	1.19	6.08	3.71	16.5	10.91	5.56	7.98
Obese 2 20	M	33.65	159.4	114.9	47.86	59.02	52.25	153.87	207.15	30.65	49.35
	s	9.33	6.05	13.77	4.75	13.52	7.68	25.84	64.42	7.41	6.43

Table 5: Shows the components of the physical composition of N=120

	BMI kg/m²	Fat mass kg	Fat %	Visceral fat cm²	Obesity degree score	Skeletal muscle mass kg	Fitness score
Mean	34.32	40.05	45.44	125.87	156.81	25.93	58.39
Sd	7.95	13.74	6.98	30.24	40.48	5.43	8.03
Lowest	19.7	14.5	20.5	44.8	91	18.4	42
Hieghset	59.1	86.2	57.5	243.1	406	58.06	76

Table 6: Shows a matrix of correlation between the components of the physical terp and the physiological variables of the study sample

Physiological variables	Weight	Fat mass	Fat %	Visceral fat	Obesity degree	Skeletal muscle mass	Fitness score	BMI
Pulse	0.363**	0.346**	0.280**	0.286**	0.365**	0.254**	-0.272-**	0.422**
Hb	0.450**	0.461**	0.451**	0.440**	0.406**	0.320**	-0.277-**	0.525**
FBS	0.731**	0.718**	0.653**	0.612**	0.528**	0.480**	-0.488-**	0.803**
TC	0.746**	0.708**	0.649**	0.645**	0.610**	0.481**	-0.553-**	0.821**
HDL	-0.618-**	**-0.585-	-0.558-**	-0.494-**	-0.446-**	-0.423-**	0.323**	-0.694-**
LDL	0.785**	0.755**	0.607**	0.592**	0.633**	0.457**	-0.564-**	0.806**
TG	0.876**	0.825**	0.684**	0.663**	0.709**	0.595**	-0.626-**	0.919**
CRP	0.244**	0.217*	00.18	00.16	0.205*	00.12	-0.238-**	0.213*
SYS	0.406**	0.361**	0.301**	0.250**	0.307**	0.245**	-0.231-*	0.452**
DIA	0.382**	0.368**	0.322**	0.190*	0.282**	00.08	-0.346-**	0.385**
T3	0.263**	0.216*	00.13	0.238**	0.409**	0.249**	-0.196-*	0.268**
T4	0.239**	00.07	00.05	0.347**	0.411**	0.349**	-0.202-*	0.279**
Vit_D	-0.689-**	-0.691-**	-0.622-**	-0.496-**	-0.511-**	-0.445-**	0.464**	-0.751-**

*significant at 0.05 ** significant at 0.01

1. For the **hemoglobin variable:** There are statistically positive correlations with both weight = 450. and body fat mass t = 461. The body fat ratio is t = 451. And the area of fat t = 440. The degree of obesity t = 406. The skeletal muscle mass t = 320. The Mass Index T = 525. It is a statistical function at 0.01 <P.
   A statistically negative correlation relationship with the degree of fitness t = -277. It is a statistical function at 0.01 <P.
2. Ratio **of blood sugar** change to fasting **FBS:** There are statistically positive correlations with both weight = 731. and body fat mass t = 718. The body fat ratio is t = 653. And the area of fat t = 612. The degree of obesity t = 528. The skeletal muscle mass t = 480. The Mass Index t = 803. It is a statistical function at 0.01 <P.
   A statistically negative correlation relationship with the degree of fitness t = -488. It is a statistical function at 0.01 <P.
3. Cholesterol variable **ratio:** There are statistically positive correlations with both weight = 746. and body fat mass t = 708. The body fat ratio is t = 649. And the area of fat t = 645. The degree of obesity t = 610. The skeletal muscle mass t = 481. The Mass Index T = 821. It is a statistical function at 0.01 <P.
   A statistically negative correlation relationship with the degree of fitness t = -553. It is a statistical function at 0.01 <P.
4. HdL **ratio:** There are statistically negative correlations with both: weight t = -618. and body fat mass t = -585. The body fat ratio is t = -558. And the area of fat t = -494. The degree of obesity t = -446. The skeletal muscle mass t = -423. The Mass Index T = -694. All function is statistically at 0.01 <P.
   A statistically positive correlation with the degree of fitness t = 323. It is a statistical function at 0.01 <P.
5. LDL **ratio:** There are statistically positive correlations with both weight t = 785. and body fat mass t = 755. The body fat ratio is t = 607. And the area of fat t = 592. The degree of obesity t = 633. The skeletal muscle mass t = 457. The Mass Index T = 806. It is a statistical function at 0.01 <P.

A statistically negative correlation relationship with the degree of fitness t = -564. It is a statistical function at 0.01 <P.

6. Ratio of **Trig triglyceride variable:** There are statistically positive correlations with both: weight t = 876. and body fat mass t = 825. The body fat ratio is t = 684. And the area of fat t = 663. The degree of obesity t = 709. The skeletal muscle mass t = 595. The Mass Index T = 919. It is a statistical function at 0.01 <P.
   A statistically negative correlation relationship with the degree of fitness t = -626. It is a statistical function at 0.01 <P.

Ratio of **CRP:** There are statistically positive correlations with the weight variable T = 244. The degree of obesity t = 205. The skeletal muscle mass t = 595. The Mass Index T = 213. It is a statistical function at 0.01 <P.

A statistically negative correlation relationship with the degree of fitness t = -238. It is a statistical function at 0.01 <P.

There are also statistically non-Significant associations with variables in body fat and gut fat area 0.05> The government's support.

For systolic blood pressure variable **SYS:** There are statistically positive correlation synoun relationships with both weight t = 406. and body fat mass t = 361. The body fat ratio is t = 301. And the area of fat t = 250. The degree of obesity t = 307. The skeletal muscle mass t = 245. The Mass Index T = 452. It is a statistical function at 0.01 <P.

A statistically negative correlation relationship with the degree of fitness t = -231. It is a statistical function at 0.01 <P.

For dia dia **dia,** there are statistically positive correlations with both weight t = 382. and body fat mass t = 368. The body fat ratio is t = 322. The degree of obesity t = 282. The Mass Index T = 385. It is a statistical function at 0.01 <P.And there is also a statistically positive correlation relationship function and the areaof fat of the gut t = 190, which is a statistical function at 0.05 <P.

A statistically negative correlation relationship with the degree of fitness t = -346. It is a statistical function at 0.01 <P. There are also statistically non-Significant associations with variable and skeletal muscle mass 0.05 > The government's support

T3 trio-dothironin: There are statistically positive correlations with both weight t = 263. body fat mass t = 216 and area of gut fat t = 238. and degree of obesity t = 409. The Mass Index T = 268. It is a statistical function at 0.01 <P. and there is also a statistically positive correlation relationship function and the area of fat of the gut t = 190, which is a statistical function at 0.05 <P.

A statistically negative correlation relationship with a fitness score of T = - 196 is a statistical function at 0.05 <P. There are also statistically non-function association relationships with a body fat ratio variable of 0.05 > The government's support

Thyroxine T4**:** There are statistically positive correlation suppraved correlations with both weight t = 239. The Mass Index T = 279. It is a statistical function at 0.01 <P. and there is also a statistically positive correlation relationship function and the area of fat of the gut t = 190, which is a statistical function at 0.05 <P.

A statistically negative correlation relationship with a fitness score of T = -202. It is a statistical function at 0.05 <P.There are also statistically non-Significant associations with variable, body fat mass and body fat ratio of 0.05 > The government's support

Vitamin D: There are statistically negative correlation relationships with both weight t = - 689. and body fat mass t = -691. The body fat ratio is t = -622. And the area of fat t = -469. The degree of obesity t = -511. The skeletal muscle mass t = -445. The Mass Index T = -751. It is a statistical function at 0.01 <P.

A statistically positive correlation with a fitness score of 0.464

DISCUSSION

The first step was to conduct clinical physiological measurements to identify the functional characteristics of a mass index category and its impact on the results. They were informed of the conditions for implementing the selection of analysis of physical composition, through electro-bio resistance, and the detection of fat ratio according to the study sample (n=120), in order to determine the characteristics of

physical inactivity, the main factors of accumulated fatty tissue and decreased muscle mass. In addition, the sample of the study was compiled according to the Classification of the World Health Organization for Obesity (WHO,2018)after using advanced devices to determine the physical composition and classification of obesity through electro vitalised resistance, body mass index, total water accumulation, inside and outside the cell, as well as skeletal muscle mass, body fat mass, body fat ratio, area of infirmity, obesity and fitness. The results were noted that the percentages of the body mass index in the sample of the study by categories: skinny 10% and normal 22%, plus weight 37%, fat31% and hyper glyginable 20%.

Shows that there are statistically function correlation relationships at the level of 0.01 and 0.05, and this is the variables of the physical composition according to the classification of the mass index (BMI) (thin - normal - overweight - fat - excessive glycemic) with physiological variables and the results were in the following order: MERGEFORMAT.

Relationship of Blood Variables to Physical Structure

Pulse: There are positive correlations statistically Significant at 0.01 <P.with: weight, body fat mass, body fat percentage, gut fat area, degree of obesity, skeletal muscle mass and mass index.

Hemoglobin: There are statistically positive correlation relationships at 0.01 <P with both weight, body fat mass, body fat percentage, gut fat area, degree of obesity, skeletal muscle mass and mass index.

Fasting Blood Sugar FBS: There are positivecorrelation relationships statistically Significant at 0.01 <P with both weight, body fat mass, fat percentage, area of infirmity fat, obesity, skeletal muscle mass and mass index.

Cholesterol: There are positive correlations statistically Significant at 0.01 <P.with both weight, body fat mass, body fat percentage, area of infirmity fat, degree of obesity, skeletal muscle mass and mass index.

HDL: There are statistically negative correlation relationships at0.01 <P with both: weight, body fat mass, body fat percentage, gut fat area, obesity, skeletal muscle mass, mass index, all statistically significant.

LDL cholesterol: There are positive correlations statistically 0.01 <P with weight, body fat mass, body fat percentage, gut fat area, degree of obesity, skeletal muscle mass and mass index.

Triglycerides TG: There are positive correlations statistically function 0.01 <P with: weight, body fat mass, body fat percentage, area of infirmity, degree of obesity, skeletal muscle mass and mass index

CrP: There are positive correlation relationships statistically Significant at 0.01 <P.with variable weight, body fat mass, degree of obesity, skeletal muscle mass and mass index.

Systolic blood pressure SYS: There are positivecorrelations statistically with both weight, body fat mass, body fat percentage, area of infirmity, obesity, skeletal muscle mass and mass index, which is a statistical function at 0.01 <P.

Dia: There are positive correlation relationships statistically function at0.01 <P.with both weight, body fat mass, body fat ratio, obesity, mass index, and at 0.05 <P.,with astatistically negative function relationship at 0.01 <P.with fitness and at 0.05 <Pwith variable andmuscle mass.

Tri-iodothironin T3:There are statistically positive correlation relationships at 0.01 <P.with both weight, body fat mass, area of infirmity fat, obesity and mass index.

Thyroxine T4:There are positivecorrelation relationships statistically function at 0.01 <P with both weight, area of incarceration fat, obesity, mass index and at 0.05 <P.with the area of gut fat

A statistically negative correlation relationship with the degree of fitness t = -272. It is a statistical function at 0.01<P. which means that the higher the degree of fitness, the lower the heart rate is rest, which is consistent with (S. J. Kang et al., 2016) Which confirmed that exercise has beneficial effects on heart rate rest, fitness, and atherosclerosis of patients with metabolic syndrome which are risk factors for metabolic syndrome (weight,% body fat, waist circumference, systolic blood pressure, diastolic blood pressure, diastolic blood pressure, HDL) where it has improved significantly due to exercise: resting heart rate has decreased significantly; The maximum oxygen consumption, muscle strength and muscle endurance

has increased dramatically; The pulse wave velocity measurement also declined briefly.

This is consistent with most studies that have reported that anyone with weight gain/obesity and central (abdominal) obesity has been inversely associated with anemia. (Gozkaman et al., 2015),determine the relationship between different levels of hemoglobin (Hb)and body mass index and the relationship was positive lye and hemoglobin where the value of r = 0.199 and the level of indication P = 0.017, therefore it advises obese patients to consider the negative effects on the quality of life, exercise and follow-up of heart disease and blood vessels of anemia when planning changes in the lifestyle of obesity.

Vitamin D Vit D: There are statistically negative correlation relationships at 0.01 <P with both weight, body fat mass, body fat percentage, gut fat area, obesity, skeletal muscle mass, mass index, and a statistically positive correlation relationship with a function of 0.01 <P with fitness score.

CONCLUSIONS

In the light of the results of the research and analysis of statistical data obtained through measurements of physical composition and the results of the answers to the living method and analysis of biochemical and physiological variables, where the researcher reached the following conclusions:

1. The existence of a statistically function correlation between physiological variables and physical composition according to the classification of the mass index for the study sample.
2. This study helps to develop an initial database to thoroughly research the characteristics of sex and the nature of their exercise.
3. This study helps to identify the relationship between physical structure and certain morphological physiological changes and anthropometric measurements of women.
4. This study highlights the ideal physical makeup of women by comparing functional measurements to the type of relationship to predict the level of health fitness. T
5. This study helps spread awareness and knowledge to sample members and their likes and researchers.
6. This study contributes to helping women to reach physical health and fitness by finding out the relationship between physical structure and some physiological and morphological variables and anthropological measurements.
7. Educate women on the importance of measuring the league to detect obesity and identify its causes for solutions.
8. Know the values of women's physical components and determine the level of obesity for women.

Recommendations

In light of the findings, the researcher makes the following recommendations:

1. Encourage women to perform periodic physiological measurements and functional adequacy.
2. Rely ing on the use of physical composition analysis programs that rely on scientific foundations to develop physical and physiological abilities and improve the composition of their bodies.
3. Specific controls require women to maintain their weight and educate them on optimal, healthy nutrition and the amount of food available to maintain their weight and health.
4. Benefit from the results of the study, which has to do with physical composition and its relationship to physiological efficiency and the development of the physical aspects of women.
5. Conducting complementary studies of this study that take other physiological and psychological aspects of women in other cities, villages and regions.
6. Conduct similar studies on other categories of women and girls (at different age stages) as well as in other variables.
7. Interest in the refinement of trainers in gyms and sports courses through scientific courses and seminars in the field of physical composition analysis and nutrition physiology of sports.
8. Public awareness programmes, including exercise and diet education, are widely needed to address the growing burden of fats.

المراجع العربية والأجنبية 1

المراجع العربية **1.1**

أبو العلاء عبد الفتاح، أحمد نصر الدين سيد. (2003). فسيولوجيا اللياقة البدنية. (الطبعة الثالثة) دار الفكر العربي: القاهرة.

دميان, ك. ي. (2001). الرجيم السريع للألفية الثالثة. الدار العربية للعلوم: (الطبعة الثالثة). القاهرة.

المراجع الاجنبية **1.2**

Altajori, N. N., Elshrek, Y. M., Lemamsha, H., Randhawa, G., & Papadopoulos, C. (2019). Prevalence of overweight and obesity among Libyan men and women. *The Egyptian Journal of Hospital Medicine*, *2019*(3), 202–214. https://doi.org/10.12816/0034654

Aspden, R. M. (2011). Obesity punches above its weight in osteoarthritis. In *Nature Reviews Rheumatology* (Vol. 7, Issue 1, pp. 65–68). https://doi.org/10.1038/nrrheum.2010.123

Bangsbo, J. (2003). Physiology of training. In *Science and Soccer: Second Edition*. https://doi.org/10.4324/9780203417553

Berg, A. H., & Scherer, P. E. (2005). Adipose tissue, inflammation, and cardiovascular disease. *Circulation Research*, *96*(9), 939–949. https://doi.org/10.1161/01.RES.0000163635.62927.34

Björntorp, P. (1991). Metabolic implications of body fat distribution. *Diabetes Care*, *14*(12), 1132–1143. https://doi.org/10.2337/diacare.14.12.1132

Buchwald, H., Avidor, Y., Braunwald, E., Jensen, M. D., Pories, W., Fahrbach, K., & Schoelles, K. (2004). Bariatric surgery: a systematic review and meta-analysis. 2005 Apr 13;293(14):1728]. *Journal of the American Medical Association*, *292*(14), 1724–1737. http://jama.jamanetwork.com/data/Journals/JAMA/4947/JRV40082.pdf

BUGIANESI, E. (2005). Review article : steatosis, the metabolic syndrome and cancer. *Aliment Pharmacol Ther 2005;*, *22*(May), 40–43. https://doi.org/10.1111/j.1365-2036.2005.02594.x

Draper, N., & Hodgson, C. (2008). *The Adventure of Sport Physiologie*.

Eckardt, K. U., Coresh, J., Devuyst, O., Johnson, R. J., Köttgen, A., Levey, A. S., & Levin, A. (2013). Evolving importance of kidney disease: From subspecialty to global health burden. In *The Lancet* (Vol. 382, Issue 9887, pp. 158–169). Lancet Publishing Group. https://doi.org/10.1016/S0140-6736(13)60439-0

Erlinger, S. (2000). Gallstones in obesity and weight loss. In *European Journal of Gastroenterology and Hepatology* (Vol. 12, Issue 12, pp. 1347–1352). Lippincott Williams and Wilkins. https://doi.org/10.1097/00042737-200012120-00015

Etchells, A. H. (1975). Physiological Measurement. In *The Lancet* (Vol. 305, Issue 7920, pp. 1335–1336). SAGE Publications, Inc. https://doi.org/10.1016/S0140-6736(75)92338-7

Fabricatore, A. N., Wadden, T. A., Higginbotham, A. J., Faulconbridge, L. F., Nguyen, A. M., Heymsfield, S. B., & Faith, M. S. (2011). Intentional weight loss and changes in symptoms of depression: A systematic review and meta-analysis. In *International Journal of Obesity* (Vol. 35, Issue 11, pp. 1363–1376). https://doi.org/10.1038/ijo.2011.2

Ferreira, I. M., Verreschi, I. T., Nery, L. E., Goldstein, R. S., Zamel, N., Brooks, D., & Jardim, J. R. (1998). The influence of 6 months of oral anabolic steroids on body mass and respiratory muscles in undernourished COPD patients. *Chest*, *114*(1), 19–28. https://doi.org/10.1378/chest.114.1.19

Gozkaman, A., Okuturlar, Y., Mert, M., Harmankaya, O., & Kumbasar, A. (2015). *The relationship between haemoglobin and BMI in overweight and obese patients*. Endocrine Abstracts. https://doi.org/10.1530/endoabs.37.ep632

Gray, D. S. (1989). Diagnosis and prevalence of obesity. *Medical Clinics of North America*, *73*(1), 1–13. https://doi.org/10.1016/S0025-7125(16)30688-5

Guh, D. P., Zhang, W., Bansback, N., Amarsi, Z., Birmingham, C. L., & Anis, A. H. (2009). The incidence of co-morbidities related to obesity and overweight: A systematic review and meta-analysis. *BMC Public Health*, *9*(1), 88. https://doi.org/10.1186/1471-2458-9-88

Kang, S. J., Kim, E. H., & Ko, K. J. (2016). Effects of aerobic exercise on the resting heart rate, physical fitness, and arterial stiffness of female patients with metabolic syndrome. *Journal of Physical Therapy Science*, *28*(6), 1764–1768. https://doi.org/10.1589/jpts.28.1764

Kang, Y. U., Kim, H. Y., Choi, J. S., Kim, C. S., Bae, E. H., Ma, S. K., & Kim, S. W. (2014). Metabolic syndrome and chronic kidney disease in an adult Korean population: Results from the Korean National Health Screening. *PLoS ONE*, *9*(5), e93795. https://doi.org/10.1371/journal.pone.0093795

Kernan, W. N., Inzucchi, S. E., Sawan, C., MacKo, R. F., & Furie, K. L. (2013). Obesity: A stubbornly obvious target for stroke prevention. In *Stroke* (Vol. 44, Issue 1, pp. 278–286). https://doi.org/10.1161/STROKEAHA.111.639922

Kershaw, E. E., & Flier, J. S. (2004). Adipose tissue as an endocrine organ. *Journal of Clinical Endocrinology and Metabolism*, *89*(6), 2548–2556. https://doi.org/10.1210/jc.2004-0395

Lau, D. C. W., Dhillon, B., Yan, H., Szmitko, P. E., & Verma, S. (2005). Adipokines: Molecular links between obesity and atheroslcerosis. In *American Journal of Physiology - Heart and Circulatory Physiology* (Vol. 288, Issues 5 57-5, pp. H2031–H2041). https://doi.org/10.1152/ajpheart.01058.2004

Lemamsha, H., Papadopoulos, C., & Randhawa, G. (2018). Understanding the risk and protective factors associated with obesity amongst Libyan adults - A qualitative study. *BMC Public Health*, *18*(1), 493. https://doi.org/10.1186/s12889-018-5411-z

LeMond, G., Hom, M., & Mohan, C. A. (2015). The Science of Fitness. In *The Science of Fitness*. https://doi.org/10.1016/B978-0-12-801023-5.00023-5

Mangwani, J., Giles, C., Mullins, M., Salih, T., & Natali, C. (2010). Obesity and recovery from low back pain: A prospective study to investigate the effect of body mass index on recovery from low back pain. *Annals of the Royal College of Surgeons of England*, *92*(1), 23–26. https://doi.org/10.1308/003588410X12518836438967

Marie, N., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Margono, C., Mullany, E. C., Biryukov, S., Abbafati, C., Abera, S. F., Abraham, J. P., Abu-Rmeileh, N. M. E., Achoki, T., Albuhairan, F. S., Alemu, Z. A., Alfonso, R., Ali, M. K., Ali, R., Guzman, N. A.,… Gakidou, E. (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: A systematic analysis for the Global Burden of Disease Study 2013. *The Lancet*, *384*(9945), 766–781. https://doi.org/10.1016/S0140-6736(14)60460-8

Mialich, M. S., Maria, J., Sicchieri, F., Afonso, A., & Junior, J. (2014). Analysis of Body Composition : A Critical Review of the Use of Bioelectrical Impedance Analysis. *International Journal of Clinical Nutrition, 2014, Vol. 2, No. 1, 1-10*, *2*(1), 1–10. https://doi.org/10.12691/ijcn-2-1-1

Michael W. Rajala, P. E. S. (2003). Minireview: The Adipocyte—At the Crossroads of Energy Homeostasis, Inflammation, and Atherosclerosis. *Endocrinology*, *144*(9), 3765–3773.

Parker, S. (2019). *The Human Body Book* (D. P. Special (ed.); DK Publish). DK Publishing Special Markets. http://books.google.com/books?id=t7k2AwAACAAJ&pgis=1

Retrieved 18 November 2019, from https://www. who. (2019). *Obesity and Overweight*. World Health Fact Sheet. https://www.who.int/en/news-room/fact-sheets/detail/obesity-and-overweight

Solanki, J. D., Makwana, A. H., Mehta, H. B., Gokhale, P. A., & Shah, C. J. (2015). Body Composition in Type 2 Diabetes: Change in Quality and not Just Quantity that Matters. *International Journal of Preventive Medicine*, *6*, 122. https://doi.org/10.4103/2008-7802.172376

Swenson, C. W., Kolenic, G. E., Trowbridge, E. R., Berger, M. B., Lewicky-Gaupp, C., Margulies, R. U., Morgan, D. M., Fenner, D. E., & DeLancey, J. O. (2017). Obesity and stress urinary incontinence in women: compromised continence mechanism or excess bladder pressure during cough? *International Urogynecology Journal*, *28*(9), 1377–1385. https://doi.org/10.1007/s00192-017-3279-6

Thompson, D., Pepys, M. B., & Wood, S. P. (1999). The physiological structure of human C-reactive protein and its complex with phosphocholine. *Structure*, *7*(2), 169–177. https://doi.org/10.1016/S0969-2126(99)80023-9

Vieiraa, S. A., Ribeiroa, A. Q., Hermsdorff, H. H. M., Pereiraa, P. F., Priorea, S. E., & Franceschinia, S. do C. C. (2018). Waist-To-Height Ratio Index or the Prediction of Overweight in Children. *Revista Paulista de Pediatria*, *36*(1), 52–58. https://doi.org/10.1590/1984-0462/;2018;36;1;00002

Völgyi, E., Tylavsky, F. A., Lyytikäinen, A., Suominen, H., Alén, M.,

& Cheng, S. (2008). Assessing body composition with DXA and bioimpedance: Effects of obesity, physical activity, and age. *Obesity*, *16*(3), 700–705. https://doi.org/10.1038/oby.2007.94

Wang, Y. C., McPherson, K., Marsh, T., Gortmaker, S. L., & Brown, M. (2011). Health and economic burden of the projected obesity trends in the USA and the UK. In *The Lancet* (Vol. 378, Issue 9793, pp. 815–825). Lancet Publishing Group. https://doi.org/10.1016/S0140-6736(11)60814-3

Yusuf, S., Hawken, S., Ôunpuu, S., Bautista, L., Franzosi, M. G., Commerford, P., Lang, C. C., Rumboldt, Z., Onen, C. L., Lisheng, L., Tanomsup, S., Wangai, P., Razak, F., Sharma, A. M., & Anand, S. S. (2005). Obesity and the risk of myocardial infarction in 27 000 participants from 52 countries: A case-control study. *Lancet*, *366*(9497), 1640–1649. https://doi.org/10.1016/S0140-6736(05)67663-5

The Swedish Journal of Scientific Research

Original Article

Video Instruction Improve The Technical Skills Of 10-12 Year-old Volleyball Players

Youssef Zekailiche, Nidhal Jbebli, Jihen Khalfoun, Kamel Chethouna, Abderraouf Ben Abderrahman

Institut Supérieur du Spot et de l'Education Physique de Ksar Saïd, Université de Manouba, Manouba, Tunisie

ABSTRACT

The purpose of the study was to determine the effect of 6-weeks learning skills, using video instructions, on children volleyball players. Eighteen male Algerian volleyball players (age: 12.6±1.5 years; weight: 36.3±2.4 kg; height: 140.26±8.38 cm; BMI: 21.52±2.48 kg.cm^{-1}) were randomly assigned into two groups: experimental group (video instructions and usual training program) and a control group (usual training program). Pre- and post-testing included measures of technical-tactical skills performance (time-motion analysis of volleyball match). Result showed a significant increase of technical-tactical skills and score performance for experimental group compared to control group. Also, a significant decrease of technical and tactical error for experimental group compared to control group. Video training including observation, correction and instruction seems to be a viable option for improving the technical and tactical skills of child volleyball players.

Keywords: Video training, technical-tactical skills, children, volleyball

INTRODUCTION

Volleyball is a game requiring a specific physical and physiological attributes, as well as technical and tactical on-court demands like high aerobic capacity, power output, speed, vertical jump and agility, in different multiset games where a high level of performance over time is required (Lidor & Ziv, 2010). A volleyball team comprises 12 players with positions often defined as setters, hitters (outside and opposite), middle blockers, and liberos (Gabbett et al. 2006). Each positions player has a specific role in a volleyball match and requires different physical qualities to perform the demands of match-play (Marques et al. 2009).

The theory and methodology of sports training present two primary processes in physical, technical and tactical development in sports activity (McCullagh & Ross, 1989). In volleyball, the traditional training methodology is mainly based on learning physical, technical and tactical movements during the training session only, without having theoretical sessions as part of improving the child's learning skills. Observing or observational learning is considered to be one of the methods by which people acquire skills or behaviors (McCullagh & Ross, 1989; Bandura, 1986). This theory claims that the players, while watching the technical learning or video sequences of each training session in order to assess their faults and to also use it as a guide to develop technical competence. There is a debate about the effectiveness of audiovisual feedback by using audiovisual material, compared to traditional teaching.

Access this article online

Website: http://sjsr.se/

ISSN: 2001-9211

Address for correspondence:
Youssef Zekailiche, Institut Supérieur du Sport et de l'Education Physique de Ksar Saïd, Université de Manouba, Manouba, Tunisie. E-mail: zegyoucef7@gmail.com

For example, Emmen et al. (1985) and Van Wieringen, et al. (1989) who supported the notion that providing feedback by using visual material was very effective on athletes more than traditional teaching (Emmen et al., 1985; Van Wieringen et al., 1989).

Studies showed a positive effect in the observation using video instructions (Clark & Ste-Marie, 2007; Onate et al., 2005; Antoniou et al., 2003). Indeed, previous studies showed that self-monitoring observation of young female athletes of beach volleyball had better results than the expert-modeling and control groups on the improvement of the technique of beach volleyball skills (Zetou & Michalopoulou, 2008).

Also, observation, by using video, is more effective than other model types, in notable skills, such as landing from a jump in basketball (Onate et al., 2005), serving in volleyball (Zetou et al., 2012), and volleyball in school (Vernadakis, et al., 2006). However, Vernadakis et al. (2010) found a positive results of learning the Setting Skill in Volleyball, comparing to multimedia computer assisted instruction.

Modern scientists have paid attention to learning problems in sport and in physical and technical movement training in volleyball, where the lack of research using viewing and learning theory with video as a factor in the development of cognitive skills among child in volleyball. The aim of this study was to compare the improvement in technical performance of cadet volleyball athletes after 6 weeks of training, employing a video instruction program.

Consequently, the main aim of the current study was to examine the effects of 6 weeks of learning technical skill in volleyball, using video, along with the usual performance training on children volleyball players

METHODS

Subject

18 male Algerian volleyball players (age: 12.6±1.5 years; weight: 36.3±2.4 kg; height: 140.26±8.38 cm; BMI: 21.52± 2.48 kg.cm-1) from the same club were involved in this study. Only players who participated in at least 90% of all training sessions were included in the statistical analyses. They trained 3 days per week in the afternoon for ~1.5 h per session. The participants (see consort diagram, Figure 1) were randomly allocated by computer to two groups. There was no significant inter-group difference for age and anthropometric data (i.e., body height, Body mass, body mass index). None of the

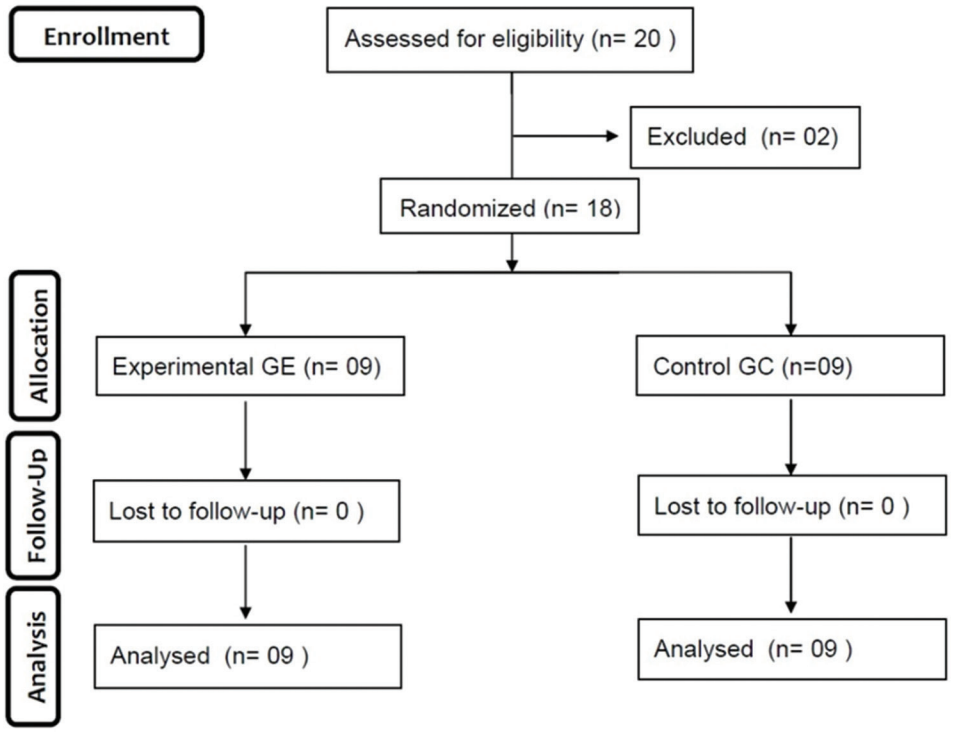


Figure 1: Consort diagram

participants reported any recent history of hip, knee or ankle injury. Coach was informed about the procedures of study. The study was conducted according to the Declaration of Helsinki and was approved by the research ethics committee of Mannouba University-Tunisia.

Video training sessions

During 6 weeks of training with video training, the players of the experimental group participated in this training twice a week: a viewing session of the usual training sessions, and a training session of technical and tactical framework . During these sessions, the players watched custom videos showing, the faults made during the training sessions and a standard sample videos to correct their faults.

Assessment procedure

To assess the effect of video training on player performance, two measurements were made. The first measurement (pre-testing) was carried out before the start of the intervention procedure; the second measurement (post-testing) was carried out after the end of the intervention. A quantitative evaluation of the groups' performance was analyzed during volleyball match between the experimental group and the control group. Match (pre-; post-testing) were recorded with a video camera (Go pro session 5). This camera was located opposite a volley ball court (transverse plane) to record the movements of the two groups during match.

Table 1: Match Score

	Set	Pre-testing		Post-testing	
		GC	GE	GC	GE
score	Set1	17	15	08	15
	Set2	15	13	13	15
	Set3	15	11	15	17

GC: control group; GE: experimental group

The movement patterns made by the players during the match and the duration of each point exchange were recorded by video cameras.

Statistical analyses

Data were expressed as mean values and standard deviations (SD). All statistical tests were processed using SPSS 20 software (Systat, Inc, USA). Normal data distribution was tested using the Kolmogorov-Smirnov test and confirmed. Paired t-tests for dependent samples were used to compare all parameters measured before and after the training program. Δ was also calculated to establish the change between success and error scores for each group.

RESULTS

Table 1 presents the scores matches (pre-; post-testing) by set for the two groups. The means and the standard deviations of game-related statistics are presented in table 2. The statistical analysis yielded statistically significant differences ratio between groups during post-testing periods. As seen in table 1 and affirmed in table 2, the difference ratio (Δ) that significantly contributed the most significant difference between defeat and victory (between CG vs EG) was composed of the serve point (GE: $\Delta = 3.9$; GC: $\Delta = 1.8$; $p < 0.01$), reception (GE: $\Delta = 2.2$; GC: $\Delta = -4.5$; $p < 0.01$) and attack (GE: $\Delta = 2.5$; GC: $\Delta = 0.3$; $p < 0.01$).

DISCUSSION

The main finding of this study was to investigate the effect of 6-weeks learning skills, using video instructions, on children volleyball players. A significant improvement of all technical-tactical skills was revealed between GE and GC during post-testing.

Table 2: Success (+) and error (-) mean± SD in different skills

	Pré-training						Post-training					
	GC			GE			GC			GE		
	(+)	(-)	Δ	(+)	(-)	Δ	(+)	(-)	Δ	(+)	(-)	Δ
Serve	2±0.3	2.2±0.5	-0.2	2±0.5	2.7±0.3	-0.7	3±0.5	1.2±0.3	1.8**	5±0.9	0.9±0.2	3.9**
Dig	0.5±0.1	2.2±1.4	-1.7	0.3±0.2	2.5±0.4	-2.2	1±0.6	2±1.1	-1	1.5±0.8	2±0.7	-0.5**
Reception	1±0.2	7±1.7	-6	1±0.1	0.8±0.6	0.2	1.5±0.4	6±1.1	-4.5*	2.7±0.8	0.5±0.2	2.2**
Attack	1±0.1	0.9±0.1	0.1	1±0.5	0.5±0.2	0.5	1.2±0.3	0.8±0.2	0.3	2.8±0.2	0.3±0.1	2.5**
Counter-attack	0.5±0.3	1.1±0.5	-0.6	0.5±0.3	1.5±0.2	-1	0.5±0.2	1.2±0.7	0.7*	1.8±0.2	0.3±0.1	1.5**

GC: control group; GE: experimental group; **: p<0.01; *: p<0.05

According to the results of the present study, during the final recording (post-testing), the players of GE which obtained a video training were significantly improved, concerning the technical execution and also the reception, attack and counter attack skills compared to pré training and to GC. That means that the athletes who received a video training, had the best degree of improvement and the least score of default.

Emmen et al. (1985) and Van Wieringen, et al. (1989) supported the notion that providing feedback by using visual material was very effective on athletes more than traditional teaching.

In a relevant study, Mohnsen and Tomson (1997), showed that, the use of audiovisual media and how they can help improve learning, it is advised to videotape the technique of each athlete and then to reflect and analyze, in order to correct any mistakes (Mc Cullagh, Stiehl & Weiss, 1990).

The results showed that there were differences between the two groups during post training and between each evaluation for the GE and GC, which mean that all groups improved their score with physical practice, and there were more significant improvement for GE with video training.

In this particular case, we can claim improvement in technique and as a result, improvement of the outcome scores for GE. The method of video training and the audiovisual feedback method are greatly accepted in the field of coaching and training. The means that technology can offer us today are numerous, easy to use and easily accessible.

To our knowledge, no study has studied the effect of training with video instructions for the youngest (10-12 years) because in this age group children begin to practice sports and acquire base sports skills. Therefore video training will be necessary to improve the cognitive and technical skills of the child in volleyball. It seems that this particular method of feedback (using video observations and instructions) helps participants perform and learn the technical and tactical skills in a volleyball game.

When examining our results of different skills performance during pré- and post-tessing volleyball matchs (serving, attacking, reception, and counter-attck), it seems reasonable that the team that makes the fewest errors should be the one that is most likely to succeed. Indeed, our results showed that the number of technical-tactique error reducing after vedio training (experimental group) compared to control group. These results were also observed by Castro et al. (2011) and Drikos et al. (2009) who revealed a significant influence of serve and attack efficacy (those that result in direct point) on the match outcome. Morover, attacks, blocks, and serves, due to the possibility of scoring a direct point, are considered efficacies scoring skills (Marcelino et al., 2010). So, instruction with video training during 6 weeks favors a significant reduction in the number of technical errors during the match for the GE with the improvement of the number of successes on serve, dig, reception, attack, counter attack, favorise a favorable condition for the victory of a volleyball match as already observed between GE vs GC (post-testing: 3 set- 0 set respectively) in the present study.

CONCLUSION

Video training including observation, correction and instruction with usual training program seems to be a viable option for improving the technical and tactical skills of child volleyball players.

Funding

This research received no external funding.

Conflicts of interest

The authors declare no conflict of interest.

REFERENCES

Antoniou, P., Gourgoulis, V., Trikas, G., Mavridis, T., & Bebetsos, E. (2003). Using Multimedia as an instructional tool in Physical Education. Journal of Human Movement Studies, 44(6), 433-446.

Bandura, A. (1986). Social foundations of thought and action. Englewood Cliffs, NJ, 1986.

Castro, J., Souza, A., & Mesquita, I. (2011). Attack efficacy in volleyball: elite male teams. Perceptual and motor skills, 113(2), 395-408.

Clark, S. E., & Ste-Marie, D. M. (2007). The impact of self-as-a-model interventions on children's self-regulation of learning and swimming performance. Journal of sports sciences, 25(5), 577-586.

Drikos, S., Kountouris, P., Laios, A., & Laios, Y. (2009). Correlates of team performance in volleyball. International Journal of Performance Analysis in Sport, 9(2), 149-156.

Emmen, H. H., Wesseling, L. G., Bootsma, R. J., Whiting, H. T. A., & Van Wieringen, P. C. W. (1985). The effect of video-modelling and video-feedback on the learning of the tennis service by novices. Journal of Sports Sciences, 3(2), 127-138.

Gabbett, T., Rubinoff, M., Thorburn, L., & Farrow, D. (2007). Testing and training anticipation skills in softball fielders. International Journal of Sports Science & Coaching, 2(1), 15-24.

Lidor, R., & Ziv, G. (2010). Physical characteristics and physiological attributes of adolescent volleyball players—A Review. Pediatric exercise science, 22(1), 114-134.

Marcelino, R., Mesquita, I., & Sampaio, J. (2010). Efficacy of the volleyball game actions related to the quality of opposition. The Open Sports Sciences Journal, 3(1).

Marques, M. C., Van den Tillaar, R., Gabbett, T. J., Reis, V. M., & González-Badillo, J. J. (2009). Physical fitness qualities of professional volleyball players: determination of positional differences. The Journal of Strength & Conditioning Research, 23(4), 1106-1111.

Mc Cueeagh, P. E. N. N. Y., Weiss, M. R., & Ross, D. (1989). Modeling considerations in motor skill acquisition and performance: An integrated, approach. Exercise and sport sciences reviews, 17(1), 475-514.

Mohnsen, B., & Thompson, C. (1997). Using video technology in physical education. Strategies, 10(6), 8-11.

Oñate, J. A., Guskiewicz, K. M., Marshall, S. W., Giuliani, C., Yu, B., & Garrett, W. E. (2005). Instruction of jump-landing technique using videotape feedback: altering lower extremity motion patterns. The American journal of sports medicine, 33(6), 831-842.

Van Wieringen, P. C. W., Emmen, H. H., Bootsma, R. J., Hoogesteger, M., & Whiting, H. T. A. (1989). The effect of video-feedback on the learning of the tennis service by intermediate players. Journal of Sports Sciences, 7(2), 153-162.

Vernadakis, N., Antoniou, P., Zetou, E., Giannousi, M., & Kioumourtzoglou, E. (2010). Comparison of Multimedia Computer-Assisted Instruction, Traditional Instruction and Combined Instruction on Knowledge Acquisition and Retention of Setting Skill in Volleyball. Computer-Assisted Teaching: New Developments, 133-149.

Zetou, E., Kourtesis, T., Getsiou, K., Michalopoulou, M., & Kioumourtzoglou, E. (2008). The effect of self-modeling on skill learning and self-efficacy of novice female beach-volleyball players. Athletic Insight: The Online Journal of Sport Psychology, 10(3).

Zetou, E., Vernadakis, N., Bebetsos, E., & Makraki, E. (2012). The effect of self-talk in learning the volleyball service skill and self-efficacy improvement. Journal of Human Sport and Exercise, 7(4), 794-805.

The Swedish Journal of Scientific Research

Original Article

The Effect of Pomegranate Juice on the Invasion and Migration of Glioma Cells

Manar Zraikat, Suheil M. Zmeili, Tasneem Al-shelleh

Department of Pharmacology, School of Medicine, University of Jordan, Amman, Jordan

ABSTRACT

Background: Cancer is considered as one of the fatal diseases in most countries. Despite the high medical care development, most cancers are resistant to treatment. Therefore, there is a continuous research for novel treatment methods. There have been increasing research interests in pomegranate as a result to its anticancerous effect, which is believed to be due to its high content of polyphenols. This work aims to study the effect of the pomegranate juice on the invasion of U87-MG spheres in 3D collagen model and on the migration of the same cells in 2D layer in scratch assay model. **Methods:** The 3 D collagen invasion assay and the 2 scrach assay was used to investigate the anti-invasive and anti-migration effects of pomegranate on the U87 cells. **Results:** Pomegranate juice has inhibited the invasion of U87- MG spheroids through the collagen in a dose and time-dependent manner. In addition, pomegranate juice showed more potent dose and time-dependent inhibition of migration of U87-MG cells in scratch assay. **Conclusion:** These results indicate that the 3D model was more challenging in evaluating the effect of pomegranate juice on the invasion of glioma cells

Keywords: Pomegranate, glioma cells, cancer, scratch assay

INTRODUCTION

The current problems associated with cancer chemotherapy resulted in a real shift toward natural alternatives for treatment of cancers (Bassiri-Jahromi, 2018a). Pomegranate is considered among those natural alternatives. Pomegranate (Punica granatum L.) is a round fruit with an outer hard shiny skin and an inner purple to reddish seeds that belongs to *Punicaceae* family. This fruit is widely consumed as raw seeds or as a juice by many people allover the world. Pomegranate has important medical history, and valuable medicinal properties (Bassiri-Jahromi, 2018a).

Access this article online

Website: http://sjsr.se/

ISSN: 2001-9211

Pomegranate is among the natural sources, which has shown to have an anti-proliferative and an anti-cancer effects against different cancer types such as breast, prostate, colon, and lung cancers (Longtin, 2003).

In addition to the anticancerous effect of pomegranate, it has been shown to have bioactive properties and an antioxidant activity (Sharma et al., 2017). Pomegranate is considered as a very important source of polyphenolics and tannin (Amakura et al., 2000a). Furthermore, the pomegranate peels contain active inhibitors, such as flavonoids and phenolics (Al-Zoreky, 2009). Practically, Pomegranate was found to be active against oxidative damage in diabetic rats (Longtin, 2003). Pomegranate has also shown to have an anti-invasive, anti-proliferative, anticancerous and anti metastatic effects in vitro and in vivo on different cancer cell line (Amakura et al., 2000b).

Although cancer as a whole is considered as a major human health problem, the tumor dissemination has

Address for correspondence:
Manar Zraikat , Department of Pharmacology, University of Jordan, School of Medicine, Queen Rania Street, Amman 11942, Jordan. Tel: +962 5355000/, Mobile: +962 776158989. E-mail: M.Zraikat@ju.edu.jo

a special interest, as it is the major cause of death for most kinds of cancers (Talmadge and Fidler, 2010).The difficulty in developing drugs that target controlling cancer is mainly due to tumor dissemination once it happens, in addition to the development of drug resistance by cancer cells (Glickman and Sawyers, 2012).

Tumor dissemination is a process that involves different definitions including invasion, migration, adhesion, metastasis and angiogenesis. Invasion is considered one of the most important steps in tumor dissemination process that includes alterations of many proteins (Barkan et al., 2010). Controlling the invasion and migration of the tumor is considered a key issue in the control of the whole dissemination process. This work aims to employ one of the important tumor invasion models, the 3D spheroid invasion model, to study the effect of the pomegranate fresh juice on the invasion of the U87 Glioma cells. This work also aims to investigate the effect of pomegranate fresh juice on the migration of the same cell line using the 2D scratch assay.

MATERIAL AND METHODS

Pomegranate Juice

Fresh Pomegranate juice was prepared from crushed pomegranate seeds without the peal. The freshly prepared juice was filtered using 0.45 filters and aliquotted then stored at -20C until used later.

The Cell Line

The source of the U87-MG Glioma cell line was the European Collection of Authenticated Cell Cultures ((ECACC), Salisbury, Wiltshire, England). The Cells were maintained under standard conditions. Briefly, the cells were maintained in full RPMI 1640 medium and cultured at 37°C in a 5% CO_2 humidified atmosphere.

Reagents and Solvents

Collagen I with catalogue number C4243 and all MTT assay reagents were purchased from Sigma-Aldrich (Poole, UK).

MTT Cytotoxicity Assay

The MTT cytotoxicity assay was done in triplicates. Briefly 5 mg/ml of MTT stock solution was prepared and diluted to a final concentration of 0.5mg/ml. The treated cells were incubated with MTT prepared solution at 37°C, 5% CO_2 for 4 hrs. After removing the MTT solution, the optical density of the plates was read at 550 nm.

Collagen Invasion Assay

Collagen I pH was corrected and prepared to a final pH 7.4. The U87 spheroids from hanging drops were seeded in 8-chamber cover glass (Nunc, Lab-TeK, Thermo scientific) between two layers of .the prepared collagen. After adding 200 µL of RPMI above the two layers of collagen they were incubated at 37°C, 5% CO_2 for 7 days. Daily images were captured for the spheroids for 7 days using inverted light microscopy at 10X objective lens. Image J program was used to analyze the spheroid invasion area.

Scratch Assay

After the cells were 70-80 % confluent the scratch assay was done. The cells were washed with media

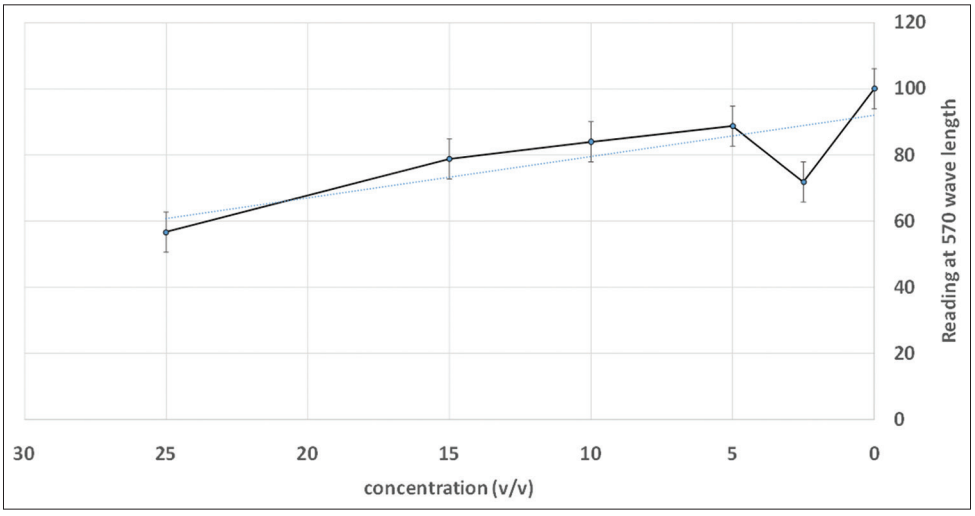


Figure 1: MTT assay done for pomegranate juice on U87 cell line

twice to remove unbound cells and the pomegranate juice with media were added. Representative pictures showing the area of the scratch were taken instantly, after 4 hours, 24 hours and after 48 hours. The pictures were analyzed by Image J program and analyzed as explained above.

Statistical Analysis

Statistical analysis of the data was performed using the t-test and the results were considered statistically significant if p values are less than 0.05.

RESULTS

MTT Assay

The MTT assay was repeated three times (Figure 1). The results showed that the IC50 of the used pomegranate juice was 18% (v/v). The concentrations used in the assays in this paper were selected to be less than this value.

3D Assay

The 3D invasion assay was repeated three times using three different concentrations, which are selected to be less than the IC50 as much as possible. The three different concentrations used were; 1.7% (v/v), 3.3%(v/v) and 5% (v/v).

The different concentrations of pomegranate juice showed a gradual inhibition of U87 spheres invasion in collagen as compared to the control (Figures 2 and 3). The results were statistically significant with p values between 0.05 and $p < 0.1$.

Scratch Assay

The scratch assay was repeated three time using different concentrations of the pomegranate juice. The results showed a gradual inhibition of the U87 cells migration. The effect was noticed on concentrations less than the concentrations used in the 3 D assay (Figures 4 and 5).

DISCUSSION

Pomegranate fruit, a popular constituent of healthy diet, is cultivated in many areas of the world particularly in the Mediterranean region (Lansky et al., 2000). The beneficial medical benefits of all parts of pomegranate fruit were known for thousands of years due to its high content of vitamin C and antioxidants. For example, it was used by many people in the management of diarrhea, sore throat, peptic ulcer, osteoarthritis, heart

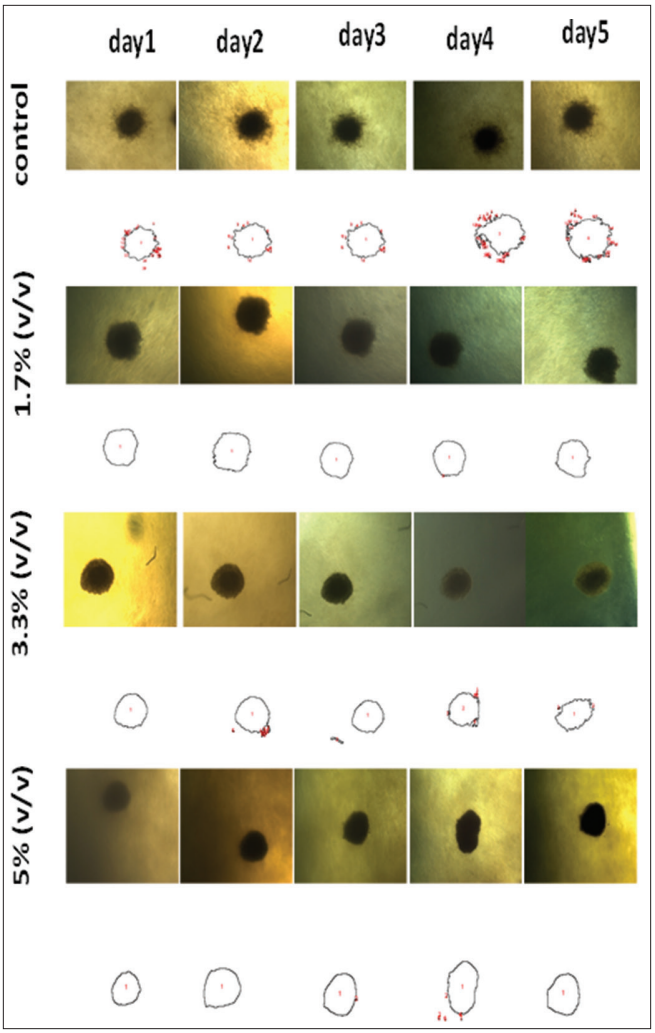


Figure 2: Gradual inhibition of U87 spheres invasion in collagen compared to the control

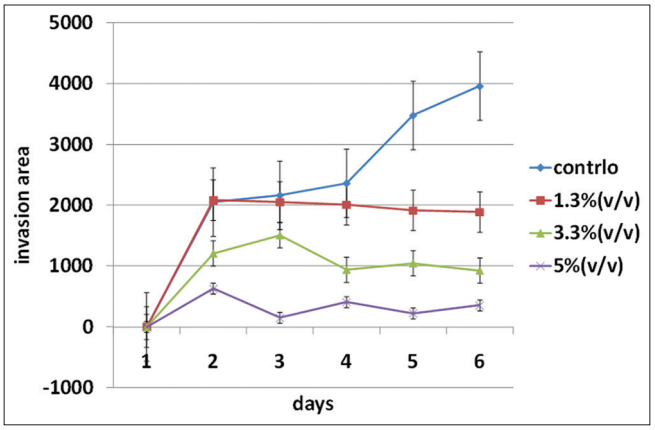


Figure 3: The effect of different concentrations of pomegranate juice on the invasion of U87 spheres

diseases and diabetes mellitus (Lansky et al., 2000) (Ismail et al., 2012) (Colombo et al., 2013).

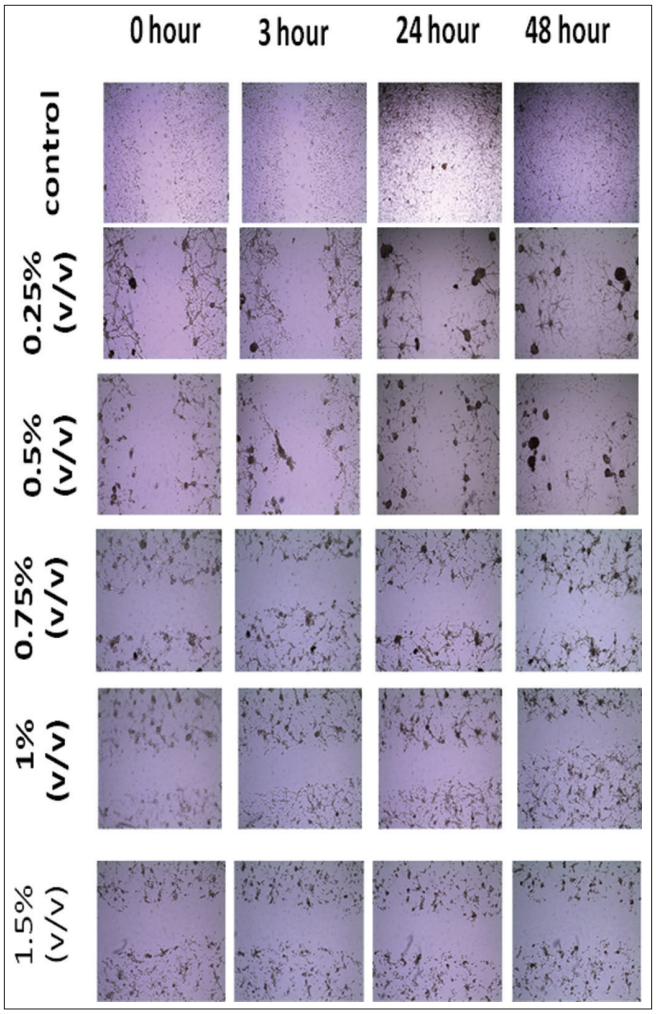


Figure 4: Gradual inhibition of U87 migration using different concentrations of pomegranate juice

Other traditional uses of pomegranate products have included hypertension, fertility aid, intestinal bacterial infection, intestinal inflammatory diseases as Crohn's disease, intestinal helminthes infestations and hemorrhage (Lansky et al., 2000).

In addition to the wide range of traditional clinical uses of pomegranate, it has been found that pomegranate juice, peel and oil have anticancerous activities, including interference with tumor cell proliferation, cell cycle, invasion and angiogenesis (Bassiri-Jahromi, 2018b). It is believed that the anticancerous effects to pomegranate are mainly attributed to its high anti-inflammatory and antioxidant properties (Lansky and Newman, 2007).

In the current study the effect of pomegranate juice on the invasion and migration of glioma cells was investigated. Gliomas are the most frequent invasive malignant tumors of the brain, and glioma cell lines are commonly used in research to assess anticancerous effect of drugs and their therapeutic application in terms of tumor growth, invasion, migration and angiogenesis (Remondelli and Renna, 2017) (Giakoumettis et al., 2018). Our results have shown gradual effect of pomegranate juice on the inhibition of U87 invasion and migration. The pomegranate juice has been more efficient in inhibiting the migration of the cells compared to its effect on the invasion. This effect is mostly because the 3D invasion assay is more challenging than the 2D migration assay.

The presence of collagen makes the invasion process more challenging and more able to mimic the in vivo situation. The 3D structure of the spheres makes the model able

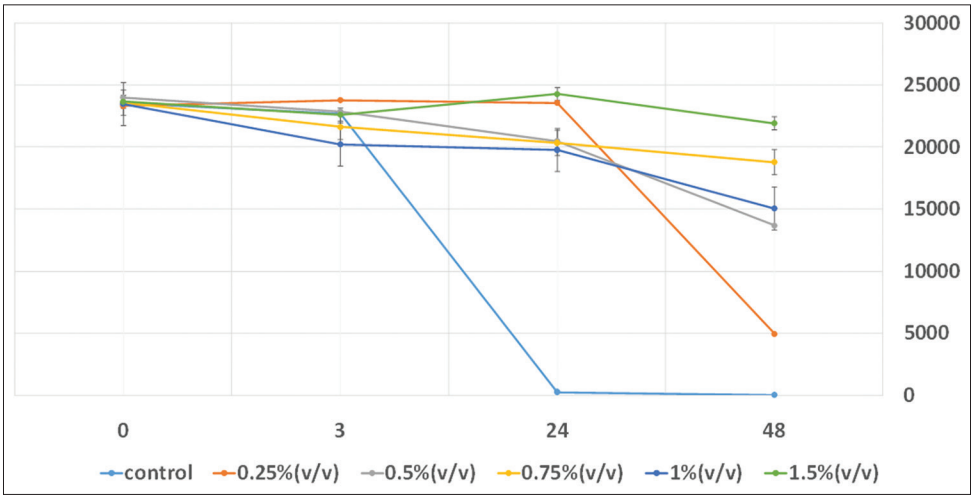


Figure 5: The effect of different concentrations of pomegranate juice on the inhibition of U87 cell migration

to mimic as much as possible the 3D structure of the in vivo tumors compared to the 2 D models in general.

CONCLUSION

The pomegranate juice is considered as promising agent in the field of Glioma treatment research that needs more investigation and analysis to characterize the active ingredients that are behind its anti-invasive and anti-migration effects.

ACKNOWLEDGEMENT

This work was financially supported by the dean of scientific research in the University of Jordan.

STATEMENT CONFLICT OF INTEREST

The authors declared no potential conflicts of interests with respect to authorship and/or publication of this manuscript.

REFERENCES

Al-Zoreky N (2009). Antimicrobial activity of pomegranate (Punica granatum L.) fruit peels. *International journal of food microbiology,* **134,** 244-8.

Amakura Y, Okada M, Tsuji S, et al (2000a). High-performance liquid chromatographic determination with photodiode array detection of ellagic acid in fresh and processed fruits. *Journal of Chromatography A,* **896,** 87-93.

Amakura Y, Okada M, Tsuji S, et al (2000b). High-performance liquid chromatographic determination with photodiode array detection of ellagic acid in fresh and processed fruits. **896,** 87-93.

Barkan D, Green JE, Chambers AF (2010). Extracellular matrix: a gatekeeper in the transition from dormancy to metastatic growth. *European journal of cancer,* **46,** 1181-8.

Bassiri-Jahromi S (2018a). Punica granatum (Pomegranate) activity in health promotion and cancer prevention. *Oncology reviews,* **12**.

Bassiri-Jahromi SJOr (2018b). Punica granatum (Pomegranate) activity in health promotion and cancer prevention. **12**.

Colombo E, Sangiovanni E, Dell'Agli MJE-BC, et al (2013). A review on the anti-inflammatory activity of pomegranate in the gastrointestinal tract. **2013**.

Giakoumettis D, Kritis A, Foroglou NJH (2018). C6 cell line: the gold standard in glioma research. **22,** 105.

Glickman MS, Sawyers CL (2012). Converting cancer therapies into cures: lessons from infectious diseases. *Cell,* **148,** 1089-98.

Ismail T, Sestili P, Akhtar SJJoe (2012). Pomegranate peel and fruit extracts: a review of potential anti-inflammatory and anti-infective effects. **143,** 397-405.

Lansky E, Shubert S, Neeman IJP, Processing, et al (2000). Pharmacological and therapeutic properties of pomegranate. **42,** 231-5.

Lansky EP, Newman RAJJoe (2007). Punica granatum (pomegranate) and its potential for prevention and treatment of inflammation and cancer. **109,** 177-206.

Longtin R (2003). The pomegranate: nature's power fruit? *Cancer Spectrum Knowledge Environment,* **95,** 346-8.

Remondelli P, Renna MJFimn (2017). The endoplasmic reticulum unfolded protein response in neurodegenerative disorders and its potential therapeutic significance. **10,** 187.

Sharma P, McClees S, Afaq F (2017). Pomegranate for prevention and treatment of cancer: an update. *Molecules,* **22,** 177.

Talmadge JE, Fidler IJ (2010). AACR centennial series: the biology of cancer metastasis: historical perspective. *Cancer research,* **70,** 5649-69.

The Swedish Journal of Scientific Research

Original Article

Biomechanical Analysis in Athletics: The Influence of Kinematic Parameters on The Results of Javelin Throw of Elite Athletes

Ratko Pavlović

Faculty of Physical Education and Sport, University of East Sarajevo, Bosnia and Herzegovina

ABSTRACT

Background: Biomechanical parameters are an indispensable segment in the analysis of all throwing disciplines, including javelin throw. Based on the results of the parameters, the most successful techniques of the motor structure of the competitors can be designed, programmed and analysed, which could serve to create a projection for the top model of the javelin thrower. In addition to morphological dimensions and motor skills, kinematic parameters are extremely important in the resultant performance, and depend on the degree of technical preparation, technical perfection of each competitor, regardless of gender. **Method:** The sample included a total of 32 male and female World Cup finalists (Berlin, 2009; Daegu 2011), with the aim of determining the correlation and influence of kinematic parameters on the resultant success in javelin throwing. 10 kinematic parameters have been defined (release velocity, angle of release, angle of attitude, angle of yew, length of impulse stride, length of delivery stride, distance to foul line, duration of impulse stride, duration of delivery stride, duration to release). **Results**: Multiple regression analysis was applied and the necessary statistical parameters were calculated. The results of multiple regression analysis confirmed the high impact of the defined predictor system on the criterion (R=0,8743), where about 76% (R^2=0,7635) explained the influence of the predictor on the criterion with a high degree of statistical significance (p<0,0001). **Conclusion:** release velocity has proven to be a dominant factor in best results..

Keywords: World championship, javelin throw, kinematic parameters, influence

INTRODUCTION

Athletics is one of the oldest sports with history that goes back to ancient times, and since the first competition in certain athletic disciplines, whose rules have been standardized, there is a progressive trend of growth of all results (Pavlović, & Idrizović, 2014). Javelin throw can be said to be the oldest sporting device. Throughout history, the original competitive javelin was later redesigned to avoid extremely long shots that could endanger the audience. This led to the opinion of the then coaches that the new javelin required more power than technique. By somatotype analysis, compared to other athletes in the throwing disciplines, javelin throwers show a predominance of meso-ectomorphic somatotype, lower quantitative morphological parameters, and do not belong to the group of overly obese individuals, but are dominated by a more developed active mass rather than by ballast, which corresponds to the technique of performing (Pavlović, 2012, 2013). However, in addition to the morphological and motor parameters, the biomechanical parameters of the javelin have great impact on the resultant success. First of all, the height, angle and speed of the ejection, the angle of deflection, the length of individual steps, the position of the knee at the ejection, etc. All of them, more or less,

Access this article online

Website: http://sjsr.se/

ISSN: 2001-9211

Address for correspondence:
Ratko Pavlović, Faculty of Physical Education and Sport, University of East Sarajevo, Bosnia and Herzegovina.
E-mail: pavlovicratko@yahoo.com

participate in the placement of competitors (Pavlović, 2016; Pavlović, Idrizović, Vrcić et al. 2020)

Often, in the research of athletic disciplines, the problem of research is the definition of biomechanical parameters and eventual predictions of performance, as well as adequate models of throwing disciplines. Some authors (Hubard, & Rust, 1984; Hubard, & Alaways, 1988) investigated and defined aerodynamic parameters of javelin throwing (ejection rate, ejection angle, ejection height, ground contact phases) by computer simulations. Also, Knuz and Kaufmann, (1983) analyzed, by correlation methods, the biomechanical factors most dominant in achieving a good result. The obtained results confirmed the high correlation between the release velocity and the spear throwing distance (r=0,76), the ejection angle (r=0,52). It follows that in order to achieve maximum results, a positive acceleration and an ejection angle of 32°-36° must be achieved. Based on the functioning of the neural network receptor, Maier, Wank, Bartonietz, & Blickhan (2000) developed a javelin flight prediction model and found that an release velocity with an attack angle (1°−3°) and a velocity of about 28m/s is the most important parameter in the success of the result. Similar research in elite male and female competition was conducted by Liu, Leigh, & Yu (2010). Saratlija, Zagorac, & Babić (2013) conducted a study aimed at influencing 17 kinematic parameters on the success in javelin throw with the best throwers of participants of the European Junior Championships in Novi Sad in 2009. The results of the correlation analysis showed a good correlation between the parameters where the speed of the device ejection, followed by the rapid placement of the front support leg, played a crucial role in the length of the shot. The results are expected and logical and can serve as a kinesiologic practice, especially in the process of adopting the technique of young javelin throwers and in developing motor skills relevant to success in this athletic discipline. Bartlett, Muller, Lindinger, Brunner, & Morriss (1996) found significant differences between javelin throwers (elite, subelite, beginner), in release velocity, ejection angle, and cranial extremity movement rate, while Sheker (2010) came to the conclusion that Qatari throwers have a slower ejection rate, weaker jerk and throw shorter than other javelin throwers in the Championship. Viitasalo, Mononen, & Norvaplo (2003) found in a sample of over 40 elite male throwers that the ejection rate had the highest correlation with the official throwing result, as much as 56% in the official score for male and 51% for female throwers. Johnson (2015) suggests that there are differences in javelin throwing technique, but that these differences are not necessarily related to the gender of the competitor, but are due to each other's individual differences, and are the result of muscle strength, flexibility and explosive power (Alexander, Lindner, & Whalen 1996).

Previous biomechanical tests of javelin throw have mainly focused on the parameters of the ejection, such as initial velocity, firing angle, attitude angle, attack angle, and ejection height (Bartlett, Muller, Lindinger, Brunner, & Morris, 1996). These studies have found that high release velocity is a key factor in achieving peak performance. Mero, Komi, Korjus, Navarro, & Gregor, (1994) analyzed the results from the 1992 Olympic Games and observed that the upper body contributes to the javelin throw, based on intermediate intragroup differences in several kinematic parameters between male and female finalists, and as many as 35% of kinematic parameter differences occur in the last stages of throwing (Campos, Brizuela, Ramon, & Gámez, 2002). Gregor, & Pink (1985) carried out a project to investigate elite javelin throwers in the US, including world record holder Tom Petranoff (99,72m). His release velocity of 32,3m/s has been recorded and is one of the largest ever recorded, with a javelin position of 36,66° and an attack angle of 4°. The obtained results served as a benchmark for the performance of all future javelin throwers with an emphasis on release velocity. Morriss, & Bartlett (1996), analyzing the biomechanical factors of critical performance of male lances, found that as much as 70% of the ejection rate developed in the last 0,1 seconds, which is a link between good results and the rate of force development in a short time interval. They suggest that the increase in speed can be optimized by transferring the force to a javelin with a short duration to maximize its momentum, which is correlated with the physical ability, i.e. the coefficient of force generated by its engaged muscles.

The results of the research by Murakami, Tanabe, Ishikawa, Isholeto, Komi, & Ito (2006) confirmed the importance of release velocity and greater speed of World Cup finalists than other throwers. They concluded that the finalists were approaching at a higher speed and had, during the final phase, an anterior leg angle in the extension position to convert the approach speed into forward torso rotation. They found that during forward rotation of the torso, the angle at the elbow joint and the shoulder separation

angle, at the moment of ejection, were also small, to more effectively transfer the internal velocity of rotation of the shoulder joint to the moment of ejection. They believe that it is first necessary to convert the horizontal velocity of the center of mass of the body into the rotational velocity of the fuselage, while maintaining an extended position in the locking leg, which can help to achieve a high initial velocity of the thrower. The movement pattern used in throwing a spear is similar to other movements used when throwing objects. All these activities are characterized by the fact that the body segments act sequentially to achieve maximum velocity in the outermost segment of the body at the moment when the object is guided or thrown. (Atwater, 1979; Menzel, 1987). All athletic throws, including javelin throws, are acyclic movements that are performed at maximum speed, so the speed of ejection is crucial to achieve maximum results and is a leading parameter. Hence, speed should be maximal while other factors should be optimal (Ogiolda, 1993). The results of Liu, Leigh, & Yu (2010) showed that the movements of the upper and lower extremities of elite throwers followed certain sequences but not a proximal sequence towards the distal one, which is consistent with the literature. It concludes that further studies are needed to determine the effect of upper and lower extremity movement sequences on knee ejection performance. It follows that the primary goal of javelin throw training is to develop high running speed during run-up and explosive power that would result in high release velocity.

To achieve maximum service distance, the ejection stop must have optimal ejection characteristics for maximum theoretical motion of the vacuum projectile as well as for useful aerodynamic impacts (Vitasalo, et al., 2007). The combination of basic physics and human abilities is vital to completing optimal spear throwing. According to some authors (Mero, Komi, Korjus, Navarro, & Gregor, 1994; Whiting, Gregor, & Halushka, 1991; Best, Bartlett, & Morris, 1993) kinematic and dynamic characteristics, technique, ejection rate, optimum angle and ejection height of the spear are the most important factors that define the total score of a javelin throw, unlike Clark (2014) who considers the attack angle and ejection height to be the primary factors in result performance. Abubshara, & Zureigat, (2008) identified the optimal ejection height in proportion to the length of the throw and the height of the competitor on a sample of elite throwers. The results of the study showed that the optimum javelin ejection height represents a proportion (105.75%) of the world champion throw length. They recommend that trainers reconsider determining the height of the javelin ejection with the optimum speed and ejection angle. This research was realized bearing in mind the aforementioned somatotype, biomechanical parameters that affect the resultant performance of throwers that occur in the structure of movement of elite javelin throwers.

The main objective of the research was to determine the correlation and influence of kinematic parameters on the resultant success of male and female finalists in World Championship in Berlin in 2009 and World Championship in Daegu in 2011.

METHOD

The sample included 32 top javelin throwers (16 male and 16 female) who competed in the 2009 World Championship finals in Berlin, average result (male 83,50m and female 64,24m) and in Daegu in 2011 with average result (male 83,67m and female 65,55m). Variables were identified for estimating of biomechanical parameters:

1. Release velocity (m/s)
2. Angle of release (°)
3. Angle of attitude (°)
4. Angle of yew (°)
5. Length of impulse stride (m)
6. Length of delivery stride (m)
7. Distance to foul line (m)
8. Duration of impulse stride (ms)
9. Duration of delivery stride (ms)
10. Duration to release (ms)

Kinematic parameters of male and female finalists are presented below (Table 1a, 1b).

RESULTS

Inspection of Table 2 shows a slight heterogeneity of results as a result of the different gender structure of the competitors, as shown by the values of the coefficients of variation (Coef. Var%). This is especially manifested in the parameters of space (pulse length and step length), which is expected given the different morphological characteristics of the male and female finalists. Greater homogeneity was evident in the release velocity, angle of release and angle of attitude. All other parameters are within the allowed values.

Table 1a: Parameters of kinematics male and female finalist WCh, Berlin, 2009. (Mendoza, et al. 2009)

Male athletics	Results (m)	Release velocity (m/s)	Angle of release (°)	Angle of attitude (°)	Angle of yew (°)	Length of impulse stride (m)	Length of delivery stride (m)	Distance to foul line (m)	Duration of impulse stride (ms)	Duration of delivery stride (ms)	Duration to release (ms)
A. Thorkildsen (NOR)	89,59	29,3	37,6	37,9	10,5	2,36	1,75	2,70	320	160	100
G. Martinez (CUB)	86,41	29,7	36,5	40,6	7,4	2,26	2,02	3,30	340	220	100
Y. Murakami (JPN)	82,97	28,9	31,9	34,1	11,6	2,45	1,75	2,90	300	200	80
V. Vasilevskis (LAT)	82,37	29,9	31,3	35,9	8,6	2,37	2,09	1,20	320	160	100
T. Pitkämäki (FIN)	81,90	28,9	34,3	42,7	13,3	2,24	1,93	3,50	260	200	100
A. Ruuskanen (FIN)	81,87	29,0	32,6	32,3	4,9	2,15	2,16	2,70	260	200	100
A. Kovals (LAT)	81,54	29,4	30,0	35,5	11,5	1,97	1,84	3,00	260	200	120
M. Frank (GER)	81,32	29,0	34,4	38,3	6,6	2,28	2,21	3,20	240	240	100
Female athletics											
S. Nerius (GER)	67,30	25,6	33,6	40,5	12,2	1,81	1,49	1,90	260	180	100
B. Spotakova (CZE)	66,42	25,0	38,8	44,7	13,4	1,73	1,89	3,00	220	220	100
M.Abakumova (RUS)	66,06	26,1	36,3	43,9	10,8	2,11	1,74	2,90	260	180	120
M. Stoian (ROM)	64,51	24,9	33,5	37,4	10,8	1,52	1,78	1,50	200	220	120
C. Obergföll (GER)	63,02	25,8	33,7	35,2	8,0	1,92	1,93	2,30	220	180	120
L. Stahl (GER)	63,23	24,6	33,9	40,2	10,0	2,09	1,65	1,68	260	200	120
O. Menendez (CUB)	63,11	25,7	33,9	41,1	8,4	1,86	1,98	1,40	260	240	120
S. Lika (GER)	60,29	24,3	33,2	35,4	10,9	1,99	1,48	1,40	280	200	100

Table 1b: Parameters of kinematics male and female finalist WCh, 2011. Daegu (Yoon, et al. 2011)

Male athletics	Results (m)	Release velocity (m/s)	Angle of release (°)	Angle of attitude (°)	Angle of yew (°)	Length of impulse stride (m)	Length of delivery stride (m)	Distance to foul line (m)	Duration of impulse stride (ms)	Duration of delivery stride (ms)	Duration to release (ms)
M.de Zordo (GER)	86,27	29,90	37,3	40,3	3,0	1,96	1,71	1,40	366	253	140
A. Thorkildsen (NOR)	84,78	28,62	35,9	39,2	3,3	2,39	1,89	1,84	400	170	107
G. Martinez (CUB)	84,30	28,33	36,7	35,7	1,8	2,51	1,99	1,45	443	243	124
V.Vesely (CZE)	84,11	26,79	34,6	39,9	5,3	1,92	1,83	0,85	320	180	120
F. Avan (TUR)	83,34	27,44	31,5	35,2	3,7	2,06	1,66	1,07	323	197	163
R. Avramenko (UKR)	82,51	27,93	34,2	41,5	7,3	2,53	1,58	0,65	374	183	137
J. Bannister (AUS)	82,25	27,11	31,5	31,2	0,3	2,39	1,61	0,37	427	193	143
M. Frank (GER)	81,81	27,04	35,2	35,8	0,6	2,13	1,87	1,88	374	213	143
Female athletics											
M. Abakumova (RUS)	71,99	25,11	39,4	43,8	4,4	1,87	1,74	2,36	313	194	140
B. Spotakova (CZE)	71,58	26,27	38,2	42,2	4,0	1,61	1,60	2,54	313	190	147
S.Viljoen (RSA)	68,38	24,42	39,3	43,0	3,7	1,59	1,41	1,66	310	167	113
C.Obergfoll (GER)	65,24	26,48	33,2	35,2	2,0	2,10	1,66	1,20	370	173	143
K. Molitor (GER)	64,32	26,09	38,8	41,3	2,5	1,91	1,51	0,57	433	203	154
K. Mickle (AUS)	61,96	25,10	38,9	43,9	5,0	1,81	1,74	1,91	350	203	130
M. Ratej (SLO)	61,65	27,49	37,3	32,3	5,0	2,51	1,51	1,64	450	164	133
J. Klimesova (CZE)	59,27	24,96	38,6	41,7	3,1	1,66	1,10	1,85	257	287	143

Table 2: Descriptive statistics male and female finalist WCh

The kinematic parameters	Mean	Min.	Max.	Std.Dev.	Coef.Var.	Skew.	Kurt.
Release velocity (m/s)	27,0	24,3	29,9	1,82	6,74	0,12	-1,40
Angle of release (°)	35,2	30,0	39,4	2,69	7,64	0,01	-1,08
Angle of attitude (°)	38,7	31,2	44,7	3,81	9,85	-0,23	-1,04
Angle of yew (°)	6,7	0,3	13,4	3,91	58,44	0,17	-1,23
Length of impulse stride (m)	2,1	1,5	2,5	0,29	14,00	-0,06	-0,93
Length of delivery stride (m)	1,8	1,1	2,2	0,23	13,38	-0,36	0,74
Distance to foul line (m)	1,9	0,4	3,5	0,85	44,00	0,12	-0,89
Duration of impulse stride (ms)	315,1	200,0	450,0	68,58	21,77	0,41	-0,67
Duration of delivery stride (ms)	200,4	160,0	287,0	29,02	14,48	1,05	1,27
Duration to release (ms)	121,3	80,0	163,0	20,15	16,62	0,10	-0,79

Pearson's correlation matrix recorded a total of 17 significant interrelationships, three of which were related to the resultant success in throwing a javelin (Table 3). A high correlation with the throwing result was recorded by the ejection rate (0.84), the impulse step length (0,57) and the ejection step (0,49). An inter-relationship analysis confirmed the relationship between the ejection rate and the impulse step length (r=0,68), the step provided (r=0,54), and the attitude angle (−0,33), which is consistent with the results of the authors of previous studies (Knuz & Kaufmann, 1983). Also, significant correlations were observed in the remaining correlations. Table 4 presents the basic parameters of the multiple regression function. The resultant success of the javelin throw in the World Cup finals indicates a statistically significant correlation of the whole system of kinematic parameters with the result of the javelin throw, where the coefficient of multiple correlation is significantly high (R=0,874), with a high coefficient of determination (R^2=0,763). Such high projections of regression coefficients indicate that the joint variability between the predictor system and the criterion variable is conditioned by the selected kinematic parameters of about 76%, while the remaining 24% is conditioned by other factors not covered by this study, primarily the motor, specifically motor and technical qualities of the thrower, by the influence of exogenous factors, etc. Analysis of the values of regression coefficients (Beta) in the system of predictor variables defines the individual contribution of the parameters of time (release velocity) and space (attitude angle and diversion angle). However, in the first place, as the leading predictor, in which all nine variables are saturated, is the variable ejection rate (0,84; p<0,001**), which achieved both the highest partial correlation value (0,69) and individual contribution in explaining the criteria (t=4,48). Based on the analysis of variance, it is evident that the regression variability is statistically significantly higher than the residual variability at both levels, which indicates to us and guarantees the statistical significance of the regression relationship (p=0,0001). This confirmed the information provided by the slightly smaller adjusted coefficient of determination (adjusted=0,650).

DISCUSSION

The aim of the current study was to determine the relationship and influence of kinematic parameters on the resultant success of the male and female finalists of the World Championships in Berlin and Daegu. Using multiple regression analysis, the obtained results confirmed the high coefficients of regression function of defined systems (R=0,874) and the good determination of the criterion variable by kinematic parameters, with more than 70%. The variable ejection rate was extracted as the best predictor in explaining the criteria (Table 4, Figure 1). The results obtained from this study are in line with those of previous studies that have treated the same or similar issues (Gregor, & Pink, 1985; Morriss, & Bartlett, 1996; Whiting, Gregor, & Halushka, 1991; Murakami, Tanabe, Ishikawa, Isholeto, Komi, & Ito, 2006). All these studies have contributed to a clearer and better quality analysis of the resultant success of the javelin throw and its dependence on kinematic parameters.

Specifically, javelin throw is a very demanding technical discipline that, due to its complex structure and attractiveness, attracts the full attention of athletes, audiences, coaches, and those involved in biomechanics, and belongs to monostructural cyclic-

Table 3: Pearson product moment corelation (significant at p< 0,05;p<0,01)

	Release velocity (m/s)	Angle of release (°)	Angle of attitude (°)	Angle of yew (°)	Length of impulse stride (m)	Length of delivery stride (m)	Distance to foul line (m)	Duration of impulse stride (ms)	Duration of delivery stride (ms)	Duration to release (ms)
Release velocity (m/s)	1,00									
Angle of release (°)	-0,33	1,00								
Angle of attitude (°)	-0,37 p=,039	0,66 p=,000	1,00							
Angle of yew (°)	-0,02	-0,26	0,21	1,00						
Length of impulse stride (m)	0,68 p=,000	-0,32	-0,49 p=,004	-0,07	1,00					
Length of delivery stride (m)	0,54 p=,001	-0,31	-0,17	0,17	0,34	1,00				
Distance to foul line (m)	0,26	0,11	0,22	0,52 p=,002	-0,01	0,40 p=,023	1,00			
Duration of impulse stride (ms)	0,28	0,21	-0,25	-0,69 p=,000	0,52 p=,002	-0,17	-0,52 p=,002	1,00		
Duration of delivery stride (ms)	-0,05	0,17	0,17	-0,13	-0,25	-0,00	0,09	-0,19	1,00	
Duration to release (ms)	-0,26	0,21	0,03	-0,68 p=,000	-0,21	-0,44 p=,011	-0,56 p=,001	0,44 p=,011	0,14	1,00
Result (m)	0,84 p=,000	-0,27 p=,131	-0,25 p=,164	-0,12 p=,499	0,57 p=,001	0,49 p=,004	0,14 p=,457	0,28 p=,126	-0,08 p=,675	-0,19 p=,310

Table 4: Regression summary for dependent variable: Result Javelin throw

	Beta	Partial-Cor.	b	Std.Err.- of b	t(21)	p-value
Intercept			-31,73	39,56	-0,80	0,431
Release velocity (m/s)	0,84	0,69	4,59	1,03	4,48	0,000
Angle of release (°)	-0,19	-0,17	-0,71	0,86	-0,82	0,420
Angle of attitude (°)	0,29	0,31	0,75	0,49	1,52	0,143
Angle of yew (°)	-0,35	-0,32	-0,90	0,57	-1,57	0,131
Length of impulse stride (m)	0,04	0,03	1,23	7,34	0,17	0,868
Length of delivery stride (m)	0,02	0,02	0,68	6,40	0,11	0,916
Distance to foul line (m)	-0,07	-0,07	-0,76	2,25	-0,34	0,738
Duration of impulse stride (ms)	-0,08	-0,06	-0,01	0,04	-0,28	0,780
Duration of delivery stride (ms)	-0,08	-0,14	-0,03	0,04	-0,66	0,517
Duration to release (ms)	-0,15	-0,18	-0,07	0,09	-0,83	0,414
Analysis of Variance	**Sums of – Squares**	**df**	**Mean - Squares**	**F**	**p-value**	
Regress.	2341,99	10,0	234,199	6,762	0,0001	
Residual	727,24	21,0	34,631			
Total	3069,23					

R= 0,874, R^2= 0,7635, Adjusted R^2=0,6502, F(10,21)=6,7628, p<0,0001

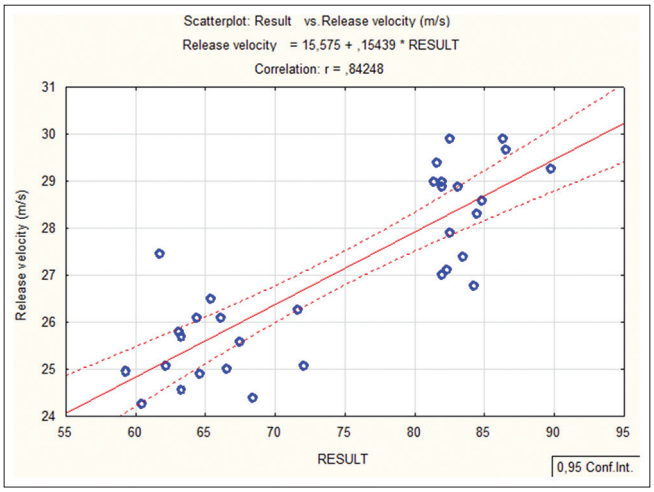


Figure 1: Correlation of release velocity and results

acyclic activities based on multi-phase motions based on specific biomechanical principles (Saratlija, Zagorac, & Babić, 2013). Many factors affect the end result, most often related to the athlete's potential, his/ er morphological, motor dimensions, training status, technique development programs, etc. The importance of biomechanical analyses is often overlooked i.e. kinematic javelin throwing movements that define spatial and temporal parameters as well as their interrelations (Katić, Retelj, Milat, Ivanišević, & Gudelj, 2008), which has been substantially confirmed by this research. In the technical structure, the thrower seeks to produce the greatest possible acceleration at the moment of ejection through the combined rectilinear-cyclic and rotational-acyclic body movements, in order to reach the maximum flight distance, as confirmed by the results of this study, where the average ejection rate of male finalists is close to 29m/s, and female 25m/s (Table 1a, 1b). Earlier studies (Knuz, & Kaufmann, 1983; Maier et al. 2000; Saratlija et al. 2013) have defined ejection rates as the primary kinematic factor of outcome. It is the result of the efficient transfer of kinetic energy, gained in the run-up through the effective positioning of the caudal extremities, by applying the laws of inertia, muscular kinetic chains and the transfer of energy to the system of cranial extremities (shoulder, elbow, and wrist). All this causes synchronous neuromuscular action that affects the so-called stretching of the muscular system. Such action represents harmonious intra-muscular coordination and so-called reflex action on stretching of individual muscle groups, where ultimately the angle of eruption should be between 33° and 36°, with a height of ejection that should be greater by 105% in proportion to the height of the body of the pitcher and its length of the throw, and any deviation from these parameters would result in a shorter flight of the device (Bottchner, & Kuhl, 1998).

It is an indisputable fact that throwing a javelin implies a sharp kinaesthetic feeling in handling the device and explosiveness at the moment of ejection. Contrary to the view that it is a simple throwing, this discipline utilizes whole-body activity, which involves the participation of strength and speed-power, coordination

and especially flexibility. It is important to emphasize that the take-off velocity is of great importance for achieving the maximum possible initial release velocity of the device, where the velocity of elite throwers at the end of the first part of the run-in goes over 8m/s, taking into account the optimal running speed with the technique of performing movements in the overtaking phase of the device (Pavlović, 2016). In order to realize such high initial velocities, it is evident that throwing disciplines require a large amount of force produced over a short period of time. Because of the lighter device, release velocity plays a greater role in javelin throwing than other throws, and is therefore significantly higher than in other throws. For elite javelin throwers, it goes well over 30m/s, with ejection duration of 0.16-0.18 sec (Zatsiorsky, 1995; Bartonietz, 2000). Maximizing the release velocity gives athletes the highest chance of achieving a good result, which is in line with the results of this study, where the first-ranked competitors in both finals had an ejection rate of about 30m s at 80ms-120ms (Table 1a, 1b).

It is known that the length of the javelin throw is defined by the velocity, angle and height of the ejection as well as the resistance to air flow. Although the angle and height of the ejection play an important role in achieving good results, nevertheless the ejection rate is the most important factor in javelin throwing distance (Liu, Leigh, & Yu, 2010; Saratlija et al. 2013), which was also confirmed in this study. The average release velocity of all participants of the finals is 27m/s, and the maximum ejection rate is 29.9m/s, at an ejection angle (35°), or a maximum angle of 39°, which is in line with the results of some previous studies (Gregor, & Pink, 1985; Bottchner, & Kuhl, 1998; Ogiolda, 1993; Viitasalo, Mononen, & Norvaplo, 2003). Elite throwers have been developing as much as 70% of the ejection rate in the last 0.1sec, which speaks to the importance of the speed of force exertion. It follows that athletes should train and develop during the training process how to produce the greatest amount of force in the shortest amount of time. These facts can well serve as a training practice in the process of adopting the technique of young throwers and as a parameter for the development of motor skills for success in javelin throwing (Morriss, & Bartlett, 1996). According to Pavlović (2016) it is found that the javelin has the lowest value of the force action on the device in the ejection phase due to the least weight (about 350N) at the ejection duration of 0.1 sec, which is absolutely confirmed in this research, which is closely related to the relative values the energy displayed and the personal results of the javelin thrower (Blazkewicz, Lyson, & Wit, 2019).

First-ranked Jan Zelezny confirmed in Gothenburg in 1995 that javelin ejection has a more important role to play than other throwing disciplines, when he achieved a high release velocity (30.2m/s), at an angle of 40°. Although the runner-up had a higher ejection height (by 21cm), what was predominant was a good ejection angle with the highest release velocity, confirming the dominance of release velocity and ejection angle. Today's elite spear throwers are aiming for a maximum ejection rate of up to 40°. Mostly the angle between the direction of the javelin and the horizontal is 29º to 36º, which also represents the individuality of each thrower. The average angle of ejection of male finalists in Berlin is close to 34° (Thorkildsen-37,6°) with the average release velocity approximately 30m/s (Vasilevskis-29,9m/s) (Table 1a). In Daegu, the average ejection angle was 34.6º (de Zordo-37,3º) and the average release velocity was 28m/s (de Zordo-29,90m/s) (Table 1b). For top throwers, the length of the kickback path ranges from 210-250cm and the maximum stress time interval is 0,12-0,18sec at an angle of ejection of 27º-40º, which is also consistent with the results of this study (Table 2).

It is important to emphasize that the speed of ejection of a javelin is not achieved by the maximum force exerted, such as in a shot put, a disk and a hammer, but by bringing the body to the best anatomic-biomechanical position to make the most efficient use of neuromuscular and biomechanical potentials (Young, 2000). This is primarily related to the significant utilization of the body's natural mechanisms to improve stretching reflexes and the cycle of shortening of stretching of the muscles (Komi, 1992). In this connection, these neuromuscular activities are of great importance for javelin thrower preparations, as electromyography studies have shown that in a strained javelin arch, muscular extensors of the torso, extensors and flexors of the hip joint, anterior muscles of the torso, chest and shoulder girdle bear the greatest load, with the highest activity being the clavicular and lumbar-rib parts of the muscle, while no electrical activity was detected in the abdominal part (Pavlović, 2016).

In order to maximize the maximal rate of ejection, neuromuscular strategies are of the greatest importance, generally proximal to the distal parts of the body, due to pre-activation in relation to the torso of the competitor (Coleman, 1998), which coincide with

the good execution of the impulse and extended step (Pavlović, 2016). These movement strategies help transfer momentum from the lower extremity to the upper and from the upper extremity to the javelin (Kearney et al., 1993; Bath & Kearney, 1996; LeBlanc, & Dapena, 1996).

This movement produces a whip motion that implies rapid movement of the proximal joints in the sagittal plane in the throwing direction, and then stops them abruptly by placing the extended left foot with the heel in front of the body with an inhibitory effect of 150-220cm (Murakami, Tanabe, Ishikawa, & Ito 2017), which is in line with current research. It is important that the foot of the left leg descends as quickly as possible after the right foot and is firmly placed on the ground to the left of the throwing line. By resisting the left leg, it eliminates any possibility of directing one part of the force during the ejection beyond the javelin, controlling the movement of the left hip and blocking the left side of the body. With the left leg positioned, the thrower is in a two-prong support, with a pronounced inclination of the longitudinal axis of the body backwards to the right. The lower part of the body represents the handle of the whip, and the upper part of the body, through the right hand carrying the javelin represents the whip itself. Certain dynamometric and kinematic analysis showed a high correlation between the inhibitory effect of the left leg and the sporting result, and the relevant parameters, path length and runtime, angle and height of the ejection, aerodynamic force are relevant for the entire spear ejection activity (Mero, Komi, Korjus, Navarro, & Gregor, 1994). It should be remembered that the level of quality of each thrower's technique depends on mechanical principles that are consistent with his motor-functional abilities and morphological dimensions (Pavlović, 2016).

Overall, this study showed that significant correlations were observed between the kinematic parameters analysed, but only a statistically significant effect of the release velocity on the resultant success of the male and female World Cup finalists in Berlin and Daegu was noted.

CONCLUSION

The study was conducted on a sample of 32 elite javelin throwers, both genders, finalists at the 2009 World Athletics Championships in Berlin and Daegu in 2011, with the aim of determining the correlation and influence of some kinematic parameters on the resultant success of the javelin throw. After analysing the obtained results, it was concluded that the ejection rate was the only kinematic parameter that had a statistically significant influence on the length of the javelin throw, which is in significant correlation with the results of some previous studies.

REFERENCES

Atwater, E.A. (1979). Biomechanics of over arm throwing movement and of throwing injuries. *Exercise and Sport Science Review*, 7, 43-85.

Alexander, M.J.L., Lindner, K.J., & Whalen, M.T. (1996). Structural and biomechanical factors differentiating between male and female shot put athletes, *J Hum Move Studies*, 30, 103-146.

Abubshara, A., & Zureigat, A,A. (2008) The optimum release height for javelin throwers proportion to their lengths Conference: 6 th International Conference on science culture and sport. At: Lviv –Ukraine

Bartlett, R.M., Mueller,E., Lindinger,S., Brunner,F., & Morris,C. (1996). Three dimensional evaluation of the kinematic release parameters for javelin throwers of different skill level. *Journal of Applied Biomechanics*, 12(1), 58-71

Bartonietz, K. (2000). Javelin Throwing: an Approach to Performance Development. In V. Zatsiorsky (Ed.), *Biomechanics in Sport* (pp. 401-434). London: Blackwell Science Ltd.

Bottcher, J., & Kuhl, L. (1998) The technique of the best female javelin throwers in 1997. *New Studies in Athletics,* 13 (1), 47-61.

Best, RJ., Bartlett, R., & Morriss, CJ (1993). A three –dimensional analysis of javelin throwing technique . *Journal of Sport sciences*, 11(4), 315-328.

Błażkiewicz, M, Łysoń, B, & Wit A.(2019). Mechanical energy flows between body segments in ballistic track-and-field movements (shot put, discus, javelin) as a performance evaluation method. *Acta Bioeng. Biomech.*, 21(1), 31-36.

Coleman, A.E. (1988). A Baseball Conditioning Program for all Seasons. In: *Injuries in Baseball.* (pp. 537-545). Philadelphia, PA: Lipincott-Raven Publishers.

Campos, J., Brizuela, G., Ramon, V., & Gámez, J. (2002). Analysis of kinematic parameters between Spanish and World class javelin throwers. 20 International Symposium on Biomechanics in Sports. ISBS 2002, Caceres - Exlremadura – Spain

Clark, J. (2014). Optimal Javelin Flight: Physics and Fixes. Retrieved June 11, 2015, from The Javelin Lab: http://www.just-fly-sports.com/optimal-javelin-flight-physics-and-fixes

Gregor, R., & Pink, M. (1985). Biomechanical Analysis of a World Record Javelin Throw: A Case Study. *Journal of Applied Biomechanics*, 1 (1), 73-77.

Hubbard M, & Rust HJ (1984). Simulation of javelin flight using experimental aerodynamic data. *J Biomech.*, 17 (10), 769-776

Hubbard, M., & Alaways, L.W. (1988). Implementation of a javelin trajectory instrumentation system. In G. de Groot, A.P. Hollander, P.A. Huijing, & G.J. van Ingen Schenau (Eds.), *Biomechanics XI-B* (pp. 972-977). Amsterdam: Free University Pres

Johnson, H. (2015). Kinematic Analysis of the Javelin Throw: A Gender Comparison. Cardiff Metropolitan University, Prifysgol Fetropolitan Caerdydd. CARDIFF SCHOOL OF SPORT

Komi, P.V. (1992). Stretch-shortening cycle. In P.V. Komi (Ed.). Strength and Power in Sport. (pp. 169-179). Blackwell Scientific Publications: Oxford

Kearney, J.K., Bath, D., Prasad, B., & Yuan, S. (1993). Efficient generation of whip-like throwing and striking motions. In N. Thalmann Magnenat & D. Thalmann (Eds.), *Models and Techniques in Computer Animation* (pp. 270 284). Tokyo: Springer Verlag,

Katić, R., Retelj, E., Milat, S., Ivanišević, S., & Gudelj, I. (2008), Development of Motor and Specific Motor Abilities for Athletics in Elementary School Male and Female First. *Coll. Antropol.,* 32 (4), 1141–1147.

Knuz, H., &, Kaufmann, D.A. (1983). Cinematographical analysis of javelin throwing techniques of decathletes. *Br J Sports Med*., 17(3), 200-204.

LeBlanc, M.K. & Dapena, J. (1996). Generation and transfer of angular momentum in the javelin throw. Presented at the 20th *Annual Meeting of the American Society of Biomechanics*. Atlanta, Georgia. October 17-19

Liu, H., Leigh, S., & Bing, Y.B. (2010). Sequences of upper and lower extremity motions in javelin throwing. *Journal of Sports Sciences*, 28(13), 1459-1467.

Maier, K.D., Wank, V., Bartonietz, K., & Blickhan, R. (2000). Neural network based models of javelin flight: prediction of flight distances and optimal release parameters. *Sports Engineering*, 3(1), 57–63.

Morriss, C., & Bartlett, R. (1996). Biomechanical Factors Critical for Performance in the Men's Javelin Throw. *Sports Medicine*, 21 (6), 438-446

Menzel, H.J. (1987). Transmission of partial momenta in javelin throw. In Johnson, B. (Ed) Biomechanies X8, Human Kinetics Publishers, Champaign (pp. 643-647).

Mero, A., Komi, P., Korjus, T., Navarro, E. & Gregor, R.J. (1994) Body segment contributions to javelin throwing during final thrust phases. *Journal of Applied Biomechanics*-III, 10(2),166-177.

Mendoza, L., Nixdorf, E., Isele, R., & Gűnther, C. (2009). Biomechanical Analysis of the Javelin throw Men and Women Final. *Scientific Research Project Biomechanical Analyses at the 12 IAAF World Championship*, Berlin, 2009 Final Report Javelin Throw

Murakami, M., Tanabe,S., Ishikawa,M., Isolehto, J., Komi, P., & Ito, A. (2006). Biomechanical analysis of the javelin at the 2005 IAAF World Championships in Athletics. *IAAF* 21(2), 67-80.

Murakami, M., Tanabe, S., Ishikawa, M., & Ito, A. (2017). The Relationship between Approach Run Kinematics and Javelin Throwing Performance. *Asian Journal of Coaching Science*, 1 (1), 1-14.

Ogiolda, P. (1993). The javelin throw and the role of speed in throwing events. *New studies in Athletics*, 8 (3), 7-13.

Pavlović, R., Radinović, Z., & Janković, M. (2012). Morphological status of finalists in throwing disciplines at Olimpic Games in Beijing. *SPORT MONT*,10 (34-36), 447-455.

Pavlović, R., Raković, A., Radić, Z., Simeonov, A., & Piršl, D. (2013). Morphological status of female athletes in throwing disciplines at the Olympic games in Beijing. *Research in physical education, sport and health*, 2 (2), 113-119.

Pavlović,R., & Idrizović, K. (2014). Differences Between Qualification And Final Results Of Javelin Throw Finalists Olympic Games In London 2012 . *Sport Science,* 7 (2), 34-41.

Pavlović, R. (2016). *Athletics*. Niš: Writers' Association Branko Miljković.

Sheker, I.M. (2010). *Movement analysis for javelin throwers in Qatar 2009 Championship*. Qatar Foundation, HSSE, Qatar, Doha.

Saratlija, P., Zagorac, N., & Babic, V. (2013). Influence of Kinematic Parameters on Result Efficiency in Javelin Throw. *Coll. Antropol*., 37 (Suppl. 2), 31–36

Zatsiorsky, V.M. (1995). Science and Practice of Strength Training. (1st ed.). Champaign, IL: Human Kinetics

Viitasalo, J., Mononen, H., & Norvapalo, K. (2003). Release parameters at the foul line and the official result in javelin throwing. *Sports Biomechanics*, 2 (1), 15-34.

Young, M. (2007). Preparing for the Specific Neuromuscular and Biomechanical Demands of the Javelin Throw. Available at http://citeseerx.ist.psu.edu/viewdoc/similar?doi=10.1.1.532.6962&type=ab

Yoon, C.J., Lee, H.S., Kim, J.W. et al. (2011). Biomechanical Analysis of the Javelin Throw Men and Women Final. *Scientific Research Project Biomechanical Analyses at the 13 IAAF World Championship, Daegu, 2011* Final Report Javelin Throw.

Whiting, W.C., Gregor, R.J & Halushka, M. (1991). Body Segment and Release Parameter Contributions to New-Rules Javelin Throwing. *Journal of Applied Biomechanics*, 7(2), 111-124.

www.sjsr.se