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Original Article

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

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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.

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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

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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

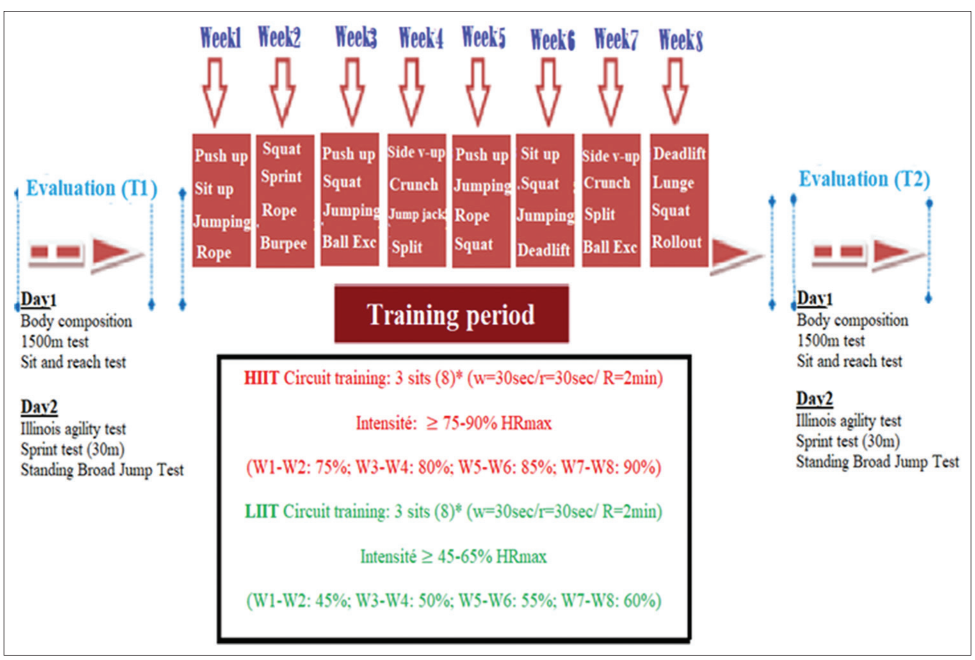

Figure 1: Experimental design
Evaluation T1: Before the training period.
Evaluation T2: After the training period.

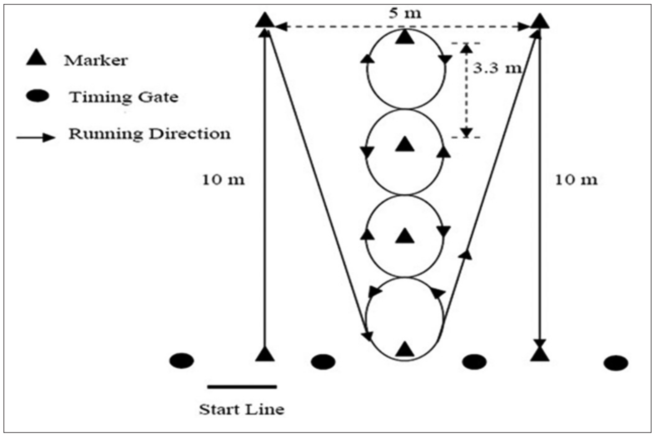

Figure 2: Illinois agility test

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

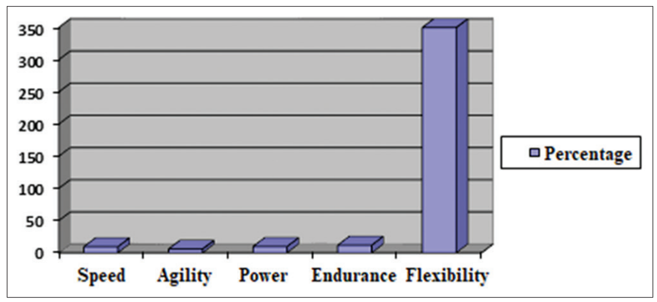

Figure 3: Percentage of improvement between the pre and post measurements of fitness variables among LIIT group

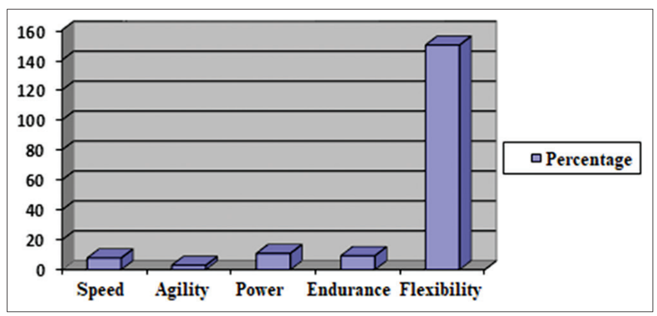

Figure 4: Percentage of improvement between the pre and post measurements of fitness variables among HIIT group

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

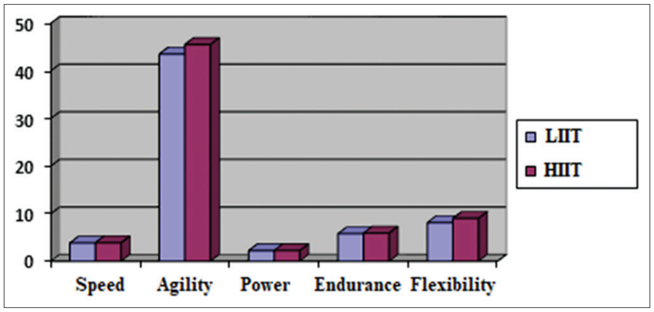

Figure 5: Difference of variation percentage of physical fitness variables between the LIIT group and the HIIT group.

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).

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