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The influence of 10 weeks high-intensity interval Multiball training on aerobic fitness in adolescent table tennis players

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ABSTRACT

The main purpose of this study was to establish whether 10 weeks of high-intensity interval Multiball (HIMT) vs. continuous Table Tennis training (CT) would have improvements in aerobic fitness of healthy adolescent players. Twenty adolescent (12 males, 8 females) table tennis players (12.2±1.6 years, BMI 19.68 kg/m^{-2}) were assigned to a HIMT or CT groups (n=10 each) and performed three training Multiball or Continuous training sessions per week over a 10-week period, respectively. Training time commitment over 10 weeks consisted of three groups of exercises, where each included five sets of high intensity 30sec (80 balls/min) Multiball exercises for HIMT and approximately 20 min. for CT. High-intensity training seems to improve the maximal O_2 uptake (mean change: 1.82 ml/min/kg, std 2.64), and the concentration of Blood lactate (1.98 mmol /l). These values, although not statistically significant, show improved cardiopulmonary capacity after implementation of the intervention protocols in relation to the intensity of exercises. It seems that 10 weeks of Multiball Table Tennis training may result in changes in the cardiorespiratory capacity of adolescent table tennis.

Key Words: *Maximal oxygen uptake, Lactic acid concertation, Youth*

INTRODUCTION

The demands of the sport of table tennis can be described as repetitive short efforts interrupted by respective short rest breaks (31, 49). Phosphocreatine (PCr) is considered the main energy system supported by the anaerobic glycolysis in efforts lasting longer than 10-15sec. (23, 38, 48). However, since the duration of the games is not constant (21, 22, 24, 29, 36), the aerobic metabolism is regarded as a key energy producing mechanism. High aerobic adjustments help towards a faster recovery of players during breaks (37, 49) and are considered necessary for all racket sports (11, 12, 19, 37, 40, 45, 50). Consequently, the training design should both simulate the match conditions and cover the energy requirements of players.

The “Multiball” table tennis training method has been applied for more than three decades, regardless of the level or the age of the players. With the terms “Multiball” exercises we mean the type of training where the coach or a robot continues to supply the number of balls per unit time (24, 43, 44). The type, duration, direction and frequency of balls injection rate depend on the design of the training process. Since 1988, there has been an attempt to evaluate the different training methods including Multiball training. So far, the findings regarding this particular training have detected an increase in the concentration of blood lactate (4.3±1.9 mmol /l) compared to the levels of lactate during resting state (1.1±0.2 mmol /l), match conditions (33). Fayt et al., (8) using Multiball and changing the balls frequently rate evaluated the effects on performance of the athletes as well as the heart rate of players. The results of the study showed that the more the increase in the intensity of the exercises, the lower the performance of athletes.

In addition, Kasai et al., 1994 (20) indicated that athletes should make use of Multiball type of training because it can help them compete with fewer cardiopulmonary requirements during the games. The above study reached to this conclusion by means of Multiball stimulus (60 balls/min), in combinations of technical strokes with and without movement. Moreover, Jospin & Fayt, 2004 (19), used this method to determine whether there are changes in performance, under the same charges in relation to the training age of the athletes. So they altered the difficulty by changing the technical requirements of the exercise employing a combination of strokes and free strokes. Considering that the heart rate, during a table tennis match, appears to be growing (7) there should be a concern that athletes train with coaching stimuli similar to those of the competition. For this purpose, attempts have been made to identify the adaptations after applying specific training stimuli (8), with increasing intensity. For the measurements to be precise, exercises of the Multiball Type have been employed. The use of these exercises allows for precise control over both the execution of the exercises and the training stimulus caused, since the performance parameters are controlled.

The purpose of the present study was to determine whether 10 weeks of training with table tennis Multiball exercises may cause adjustments to cardio respiratory capacity of table tennis players.

METHODS

Participants

Twenty (12 males, 8 females) adolescent table tennis players volunteered to take part in this study. Their mean age, stature and body mass were 12.2±1.6 years, BMI 19.68 kg/m^{-2}. Participants were officially recognized by the Hellenic Table Tennis Federation as active players. The study followed the principles of Research Ethics Code of the Democritus University of Thrace. Both parents and players were informed prior to project about the procedures and potential risks and provided written informed consent. The participants were healthy and active.

Pre-experimental procedures

Subjects performed a progressive exercise test to exhaustion on a motorized treadmill (S 2500, Tecmachine, Andrezieux-Boutheon, France) and consisted of an initial 3min continuous workload at 6km/h followed by increases 1km/h every minute (0% in cline) in order to determine their maximum oxygen uptake $VO_{2max.}$ To assess the level of table tennis technique «Table Tennis Specific Test Battery» (13) was applied to the sample. Harpenden Skinfold Caliber (UK) was used to measure participants' skinfold. Percent fat was calculated using the equations of Slaughter et al, 1988 (37).

Experimental protocol

Each subject performed two experimental trials, before and after a 10- week table tennis training program. Initially, the subjects participated in a 10-minute warm up activity, which included slow running 400 meters and stretching both arms and legs. Heart rate was recorded continuously throughout task using Team2 Pro (Polar Electro Oy, Kempele, Finland) and pulmonary gas exchange and ventilation by means of Filmate Pro spirometer (Cosmed, Rome, Italy). Blood lactate samples were taken 3min after the end of the effort. There was dropwise obtaining of capillary blood from the left index of the participants by means of a test BM-Lactate tape and immediate processing by the Accoutered Plus meter (Roche, Mannheim, Germany). Blood lactate was determined by reflectance photometry at 657nm wavelength in colorimetric reaction of lactic acid oxidase mediator.

Training protocols

The training protocols were initiated a week after the experimental trials. Sample was divided into Multiball and control groups. The separation of the groups was a combination of the results of the original field and laboratory measurements, in order to create equal groups. The intervention program lasted for 10 weeks, during which the two groups performed typical table tennis training process. The Multiball group implemented the interventionist program with high intensity exercises with frequency of 3 times /week. The control group followed the same set of exercises as the other group executing the continuous training process. The duration of the daily training in Table Tennis is 2 ½ to 3 hours depending on the coaching period. The first part refers to warm up (general and specific). The main part of the training refers to technical exercises and the third and final part includes technical and tactical exercises depending on the level of the trainee and the requirements of the training plan. During the intervention program the duration of the training was 1 ½ hours (mixed time for all groups) and included: Warm up 10±5 min, Special Table Tennis warm up exercises 10±5 min. and the implementation of the training protocol. After the end of the training time 10±5 min. were allotted for recovery and restoration. The intervention Multiball program duration was 19:30s., whilst the control group training duration was 30:00s.

The experimental protocol included three groups of table tennis exercises: Forehand Counterdrive (FHCD), Backhand Counterdrive (BHCD) and Forehand/Backhand Counterdrive Footwork (FBCF). According to the training protocol the balls served by an experienced instructor in the forehandand backhand side of the players. The athletes had to perform a FHCD aiming diagonally on the table, in the second exercise a BHCD and in the third a FHCD and BHCD with a sideways movement (Fig.1). The positions of BHCD and FHCD are located in the side of the table, whereas for the right-handed FHCD is located on the left side of the table and BHCD on the right side of the table.

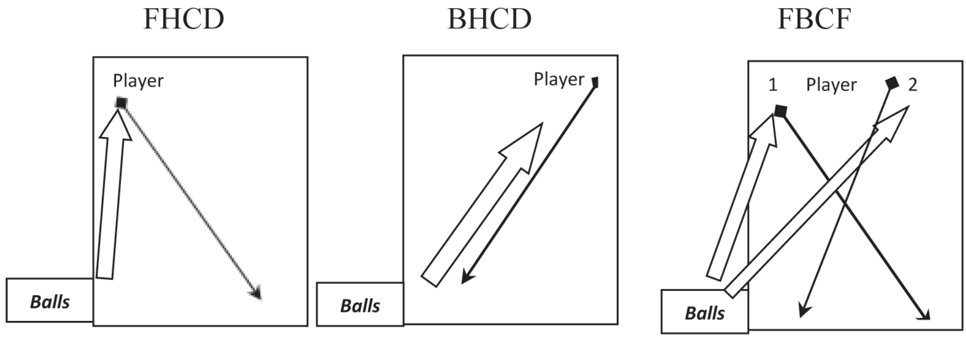

Figure1. *The experimental Multiball and Continuous table tennis protocol.*

Each group consisted of five (5) sets of interval exercises lasting 30sec. The break between exercises was 30sec. (1: 1) with active recovery (walking) and between sets the given time was 3 min. of passive recovery. Launch rate of 80balls min-1 was selected in order to meet the match rallies (5, 14, 22). The exercises of the control group were the same as those of the Multiball group in continuous training. By design, the protocols differed substantially in terms of total exercise training intensity and time commitment in order to evaluate adaptations in aerobic fitness of healthy adolescent players to two diverse training programs. During the projects there was no other sport activity in the sample so as to isolate any uncontrolled effects.

Statistical an alysis

Descriptive statistics with exploration was firstly generated for all categorical variables. The ANOVA analysis of variance with two repeated factors (group & measurements) and Bonferroni post-hoc test, were applied in order to compare the effect of different protocols on performance of the sample. The Receiver Operating Characteristic (ROC) curves were applied in order to illustrate in graphical plots the discrimination between performance before and after training programs. Spearman's rank correlation (ρ) analysis was employed to determine the testing variables that are significantly related. All statistical analyses were carried out by employing the SPSS-PASW 19.0 for Windows, (*SPSS Inc., Chicago, IL, USA*). The statistical significance was defined at 5% ($p<0.05$).

RESULTS

All the participants were trained continuously for ten weeks, without any absences whatsoever, thus achieving a 100% application of the interventionist project. The physical characteristics of the preadolescent athletes who participated in this study were derived from exploration statistics and they are illustrated in Table 1 & 2.

Table 1
The mean physical characteristics of HMIT group, (95% confidence interval)

Variables	Sample (n=10)
Age (yrs)	11.9±1.4
Body mass (kg)	44.5±13.8
Stature (cm)	152.8± 16.6
Body fat (%)	20.7

Table 2
The mean physical characteristics of Control group, (95% confidence interval)

Variables	Sample (n=10)
Age (yrs)	12.4±1.8
Body mass (kg)	44.8±10.9
Stature (cm)	154.6±11.3
Body fat (%)	17.8

The changes of the Maximum Oxygen uptake, the Heart Rate as well as the Lactic Acid uptake in blood, for both teams, are presented during the initial and final measurement are presented in Table 3 &4.

Table 3
The changes of the Maximum Oxygen uptake, the Heart Rate and Lactic Acid uptake in blood, for HIMT group

Variables	Initial	Final	Pre – post dif.
	Mean (SD)	Mean(SD)	%
VO_{2max}	45.62±3.2	47.47±2.6	4.10
HR_{max}	199.3±3.0	203±2.7	1.86
La	6.98±1.0	8.06±1.0	15.47

Table 4
The changes of the Maximum Oxygen uptake, the Heart Rate and Lactic Acid uptake in blood, for CT group

Variables	Initial	Final	Pre – post dif.
	Mean (SD)	Mean(SD)	%
VO_{2max}	46.75±5.2	38.20±6.5	-18.29
HR_{max}	195.5±5.8	202.2±4.8	3.43
La	11.07±2.5	13.72±1.3	23.94

The Anova analysis of variance showed no significant interaction in VO_{2max} between the two factors namely 'teams' and 'measurements' $F_{(2.27)}$=2,36, p>0.05. Likewise, analyzing the variable of the Maximum Heart rate no significant interaction between the two factors, namely "teams" and "measurements" was statistically noticed $F_{(2.26)}$=4,80, p>0.05. On the other hand, variances regarding the Blood lactate uptake were detected. Actually, by statistically analyzing the particular variable, a considerable amount of interaction between the factor of "teams" and that of "measurements" was found out. More specifically, the Bonferroni post-hoc test-presented a noteworthy difference between the average means of the 3rd and 1st teams.

DISCUSSION

The findings of the present study demonstrate that the ten-week table-tennis training period using Multiball 1. has beneficial influence on aerobic adjustments (VO_{2max}), 2. Cause changes on the physiological reactions (La) and 3. Do not affect any changes as far as the Body Mass Index is concerned. Therefore, it seems that the ten-week Multiball training of high intensity can ameliorate the aerobic adjustments in relation to the continuous training method.

VO_{2max}. Regarding the Multiball group, enhancement of VO_{2max} is noticed, whereas for the control group some sort of decrease is observed. More specifically, in the Multiball group there seems to be improvement of VO_{2max} (Initial= 45.62/ Final= 47.47 ml/min/kg) not statistically significant though, indicating that the change of practice time of interval training, following the same exercise type, brings about adjustments. Similar studies applied to adults, have demonstrated increase in VO_{2max} even during interval training that lasts shorter than 10 weeks (4, 9, 27, 41, 47). Likewise, in samples of young athletes, there seems to be direct connection between the high intensity interval training and the improvement of VO_{2max} (1, 30), even after a two-week training (2), an ascertainment that complies with the results of the present study. On the other hand, the Control group presented considerable decrease in the VO_{2max} values (Initial= 46.75/ Final= 38.20 ml/min/kg). The decrease of the VO_{2max} values in the whole sample range of the Control group is a factor which shows that the continuous training method cannot cause cardiorespiratory adjustments similar to those of the interval training (10). This probably explains the drop in the performance of the control group.

HR_{max}. In between the first and the second measurement an increase in the average mean of HR_{max}= 5 b/min-1 is noticed. This small HR_{max} increase does not seem to be the result of specific adjustments owing to the intervention protocol, since the HR_{max} increase is present in both groups and is not of significant importance from a statistic point of view. Furthermore, the values of $HR_{max\ are}$ mainly affected by the age rather than by purely coaching stimuli (6, 18, 42), a finding that the value range of HR_{max} appears to verify. However, the HR_{max} values in both groups tend to equate after the application of the intervention project. The HR_{max} mean value of each group is located over 202 b/min-1. These values correspond to almost the 80% of the maximum estimated value, an ascertainment that is in agreement with various similar research studies (19), confirming thus a high aerobic energy contribution, regardless of the training type. Nevertheless, more research is required in order to validate the relation between the HR_{max} and the table tennis training practice.

La. Variations appear at the Blood lactate concentration in both groups. Although in literature approaches concerning the training type, the lactic acid concentration as well as the respiratory threshold differ (15, 32, 34, 35), yet the biological adjustments that are triggered are taken for granted (26). The lactic acid levels increase in the blood is considered to be a significant index of predicting the performance enhancement regarding endurance (17). The differences of the samples' values of the present study between the initial and final measurement, although not statistically significant, they do bring about concentration increase during the second measurement in both groups. More specifically, the La values between the first and the final measurement present an amount of increase in the group of 30 sec (Initial= 6.98/ Final= 8.06 mmol/l). The same amount is also noticed in the control group (Initial= 11.07/ Final 13.72 mmol/l). Taking into consideration the data resulting from the Initial and Final measurement, where Blood lactate concentration increase is observed, it is deduced that the intervention project generated aerobic adjustments to the sample, especially in the Multiball group. According to literature increase in the lactic acid levels concentration is already noticed after six weeks of training (28), findings that are in accordance with the results of the present study. Yet, the Blood lactate levels concentration is rather low after the application of a short time interval training. Indicatively, the specification of the aerobic adjustment value is regarded the 4mmol/L (16, 46), although in many cases the values may vary between 2 and 7.5mmol/l (39). According to Borresen & Lambert (3), the lactic acid concentration in the blood can be used as a reliable index for the specification of the practice intensity. In both training types the circularity 'attempt-interval' is present. The increase of the Lactic acid concentration values in all groups may be probably explained by the fact that in both training types the same relation between attempt and interval can be noticed. Yet, it is generally accepted that the Blood lactate concentration is influenced by various factors which make its use quite significant in the observation of the practice intensity (46). Consequently, the results of the measurements indicate that remarkable adjustments are likely to have been brought about in our sample. However, in order to be able to have a trustworthy estimation of the particular training type, all the above mentioned physiological parameters must be taken into account. The maximum oxygen uptake of the control group decreased because although followed in time and technically the same program, continues training does not cause the same adjustments compared to interval method.

CONCLUSION

In conclusion, it appears that in the Interval training group improvement of VO_{2max} is observed, whereas decrease of VO_{2max} is noticed in the Control group. Moreover, the adjustments detected in HR_{max} and La. may indicate that the systematic application of the protocols causes changes, which, however, do not differ between the interval or continuous training method. Consequently, the use of specific set of exercises may cause similar stimuli and adjustments to a relevant sample. Interval training proved to be more efficient as the players presented better physiological adaptations by improving their VO_{2max} in shorter time.

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