Comparison of effects of two interval Multiball training protocols on VO$_{2\text{max}}$ and lactate concentration

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ABSTRACT

Our aim was to examine the effect of 10 weeks of high-intensity interval Multiball training (HIMT) protocols on Maximal oxygen consumption (VO$_{2\text{max}}$), Lactate threshold (La) and Maximal Heart Rate (HR$_{\text{max}}$) responses to exercise. Twenty (12 male, 8 female) youth table tennis players were divided into two homogeneous according to their technical ability groups: (1) training at 30s; or (2) training at 15s with 1:1 work: relief ratio (1:1) for a 10-week Multiball table tennis training program. The subjects trained 3 times per week. Training time commitment consisted of three groups of Counter drive Forehand and Backhand exercises, where each included five sets of high intensity (80 balls/min) exercises for both groups. VO$_{2\text{max}}$, La and HR$_{\text{max}}$ were determined before and after the training program. There were no significant differences on any dependent measure although 30s. group presents improvement in term of maximal O$_{2}$ uptake (mean change: 1.85 ml/min/kg, s.e. 2.64) and both groups in lactate acid concentration. It seems that regardless of the duration of the stimulus, short duration high intensity Multiball exercises affects cardiorespiratory capacity of youth table tennis players.

Key Words: Table Tennis, Physiological responses, Youths
INTRODUCTION

Research regarding short time interval training can be traced back in 1960, when metabolism reactions with 5 to 30 sec stimuli were examined (3). This method has been proven more effective than the continuous one, which is implemented at the same speed to prevent glycogen reduction, extending the use of lipids. In Essen’s research (10) continuous exercise of high intensity (100-102% of VO$_{2\text{max}}$), which lasts until complete exhaustion ($t_{\text{lim}} = 4-6$ m.), and short-term interval training (total duration of 60 m., with 15 sec burden at 112% of pVO$_{2\text{max}}$ with a passive interval of equal time) did not decrease muscle glycogen in the same way. In the case of the interval training the concentration level of lactic acid in blood was 2 mmol/L, whereas in that of the continuous training it came up to 10 mmol/L. At the end of the interval training significant decrease in glycogen of types I and II muscle fibers was detected, whereas, regarding the continuous one, glycogen decrease was observed more in II type muscle fibers rather than in type I. Midgley and McNaughton, (31) claimed that during the short term interval training, with intensity ranging from 90% to 105% of vVO$_{2\text{max}}$, the exercise and break intervals should last from 15 to 30 sec., so that the ideal time length of remaining at high levels of VO$_{2\text{max}}$ can be ensured, which in turn leads to its improvement. Similar studies with the modification of such factors as intensity, duration and interval of the exercise point out that this type of training brings about significant adaptations to cardiorespiratory capacity of the samples.

Table tennis presupposes for granted both the general and the specific training. Specific training includes all those exercises that result in the improvement of technical training as well as in the application of approach tactics pertaining a match. Multiball exercises are a special Table Tennis training method (43,44,25). These types of training seem to have been widely used since the 60s (45). The procedure of applying Multiball training takes for granted the continuous ball throwing to the athlete. This is mainly done by the trainer, in other cases though, it may be done by throwing machines (43). The throwing frequency control and the ball contact points with the table can be directly achieved. Besides, the speed of the ball, the strength and the rotations as well as the kind or the combination of demanded strikes can be regulated. Consequently, technical and tactical exercises can be applied independently of the athletes’ level. Moreover, due to continuous strike exchange rate physical abilities can be also improved. Hence, it can be supported that Multiball is a training method that essentially simulates the match requirements of the sport. Despite all this, Multiball training is applied by the trainers although the volume, duration and frequency of the training stimulus application have not been defined by research. Furthermore, there is less natural adjustments take place upon the modification of the components of the method and its integration within the training micro circle.
The aim of the present study was to investigate the effect of two interval training protocols on youth table tennis athletes’ physiological adaptations.

**MATERIAL AND 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 13.3±0.9 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.

**Testing routine**

The participants of this study were firstly evaluated on the physical and anthropometrical characteristics. During this session, the athletes’ parameters of age, training experience, body mass, stature, body fat, table tennis technical ability were measured and the participants VO$_{2\text{max}}$ was estimated.

The determination of VO$_{2\text{max}}$ was performed on a motorized treadmill (S 2500, Tecmachine, Andrezieux-Boutheon, France). The subjects performed a progressive exercise test which was consisted of an initial 3min continuous workload at 6km/h followed by increases 1km/h every minute (0% in cline) to determine their maximum oxygen uptake VO$_{2\text{max}}$. Gas analysis was carried out using a Fitmate Pro (Cosmed, Rome, Italy) system. Heart rate was monitored by the Team2 Pro (Polar Electro Oy, Kempele, Finland). Blood sample was taken after the end of exercise and Lactate in plasma was evaluated by Accutrend Plus (Roche, Mannheim, Germany) analyzer. To assess the level of table tennis technique «Table Tennis Specific Test Battery» (13) was applied to the sample. These estimations were made in the 1st and the 10th week of the application of intervention protocols, in order to provide a more complete picture of the measured adjustments as possible and evaluate the entire sample. Then, as a result of the marks of the first measurement, the sample was divided into two homogeneous groups. The group A. of 15 seconds and that of group B. 30 seconds training, which was the implementation of the proposed training protocol. The separation of groups was a function of the results of the original field and laboratory measurements, in order to create equal groups. Descriptive data of the physical and physiological characteristics of the subjects before training in both training groups are presented in Table 1.
Table 1

Pre-training values* for subject characteristics – subjects were matched according to TTSTB and placed into one of two training groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Age (years)</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>VO$_{2\text{max}}$ (ml.kg.min)</th>
<th>HR$_{\text{max}}$ (bpm)</th>
<th>La (mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 15s.</td>
<td>11.92(1.4)</td>
<td>1.52(14.2)</td>
<td>44.59(13.1)</td>
<td>43.80(2.10)</td>
<td>201.2(2.17)</td>
<td>7.37(1.31)</td>
</tr>
<tr>
<td>(n=10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 30s.</td>
<td>11.86(1.2)</td>
<td>1.50(13.4)</td>
<td>47.58(12.9)</td>
<td>44.62(3.23)</td>
<td>199.3(3.04)</td>
<td>6.98(1.03)</td>
</tr>
<tr>
<td>(n=10)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

*Values are mean (s.e.)

Training interventions

The subjects participated in two different table tennis training programs, which included both an intervention training form with Multiball exercises. The intervention program lasted for 10 weeks during which the two groups followed the typical training procedure. During the implementation of the suggested training process the athletes did not take part in any table tennis events that might have affected our research results. The intervention program, containing exercises of high intensity, took place 3 times per week. During this program the training time was 1$^{1/2}$ hours (mixed time for all groups) and included: 10±5m general warm up, 10±5m. specific table tennis warm up, as well as the application of the intervention programs. The total duration of Multiball training protocol was 12:45min. and 19:30min for group A and B respectively. As soon as the training was over, there was a 10±5m. for recovery and restoration. The training program was designed in such a way as to exclude any kinds of inessential influence on the athletes’ adjustments.

The intervention program of both groups included three sets of exercises FHCD, BHCD, FTFB. On the left side of the table there was the coach who sent the balls to (pre) defined points. In the first set of exercises the athletes had to carry out the Forehand Counter Drive (FHCD) aiming diagonally on the table, in the second set the Backhand Counter Drive (BHCD) also aiming diagonally, whereas in the third set they were expected to carry out one FHCD and one BHCD with a sideways movement (Fig. 1). The points where the athletes were aiming at during the 3$^{rd}$ exercise were the same as in the 1$^{st}$ and the 2$^{nd}$ ones, respectively. The places of the FHCD and BHCD are located on the corresponding side of the table i.e., for the right-handed the FHCD is on the left side, while the BHCD on the right side of the table.
Each group consisted of five sets of interval exercises lasting for 15 sec. each. The interval between the exercises of group A was 15 sec (1:1) with active recovery, whereas between the sets there was given three minutes of passive recovery. The intervention program of group B included the same experimental designing, with similar exercises, by varying the time period of exercise and intervals. The duration of each exercise was 30 sec and the interval between the exercises 30 sec (1:1), with the same active recovery as that in group A. The frequency of the ball throwing in both groups was 80 balls per minute. The frequency of the ball throwing was chosen because it simulated the match conditions of moderate and high level of rallies (21,14,7). Moreover, the rates of such type are also used in other measurement protocols (22,6), as it seems they can describe the sport profile of Table Tennis (32,28,24,34). Finally, the specific protocols were selected because, during their application they allow athletes to reach high levels of maximum oxygen uptake (VO$_{2max}$), which is regarded as a crucial factor in racket sport performance (48,23,39). Respective measurement interval training protocols of short duration have been applied in Tennis (9) and in Squash (38). Specific details of the work: rest ratios of each training interventions are given in Table 2.

<table>
<thead>
<tr>
<th>Training Group</th>
<th>No. of Training/ week</th>
<th>No. of sets/ duration</th>
<th>Throwing Rate balls/ min</th>
<th>Rest Interval/ sec</th>
<th>Total training time/ min</th>
</tr>
</thead>
<tbody>
<tr>
<td>15sec</td>
<td>3</td>
<td>3x(5set x 15sec)</td>
<td>80</td>
<td>15</td>
<td>12:45</td>
</tr>
<tr>
<td>30sec</td>
<td>3</td>
<td>3x(5set x 30sec)</td>
<td>80</td>
<td>30</td>
<td>19:30</td>
</tr>
</tbody>
</table>
**Statistical analysis**

The dependent measures \( \text{VO}_2\text{max} \), \( \text{HR}_\text{max} \) and \( \text{La} \) were analyzed using a 2 (group) x 2 (test) analysis of variance with repeated measures on the last factor. Differences for all dependent measures were considered significant at the \( p<0.05 \). All statistical analyses were carried out by employing the SPSS-PASW 18.0 for Windows, (SPSS Inc., Chicago, IL, USA).

**RESULTS**

\( \text{VO}_2\text{max} \). After the 10\(^{th}\) week Multiball training program the 15sec. training group does not differentiate between the beginning and the end of the intervention program while the 30sec. group shows improvement in \( \text{VO}_2\text{max} \) after 10 weeks which is not significant (Figure 2).

![Figure 2. Mean (s.e.) changes in \( \text{VO}_2\text{max} \) for group 15sec. (training at 15s. work: 15sec. rest) from before to after test. No significant differences between groups were noted over time.](image)

\( \text{HR}_\text{max} \). The 15sec. group showed higher values after 10 weeks of intervention program. Similarly, the 30sec. group also showed similar results which are not significant (Figure 3).
COMPARISON OF EFFECTS ON VO\textsubscript{2MAX} AND LACTATE CONCENTRATION

Figure 3. Mean (s.e.) changes in HR\text{max} for group 15sec. (training at 15s. work: 15sec. rest) from before to after test. No significant differences between groups were noted over time.

La. Both groups of interval training improve their values after 10 weeks of intervention. There is no significant difference between measurements (Figure 4).

Figure 4. Mean (s.e.) changes in La for group 15sec. (training at 15s. work: 15sec. rest) from before to after test. No significant differences between groups were noted over time.
DISCUSSION

The racquet sports are characterized by continuous efforts of short duration and high intensity, while between the attempts there are short active breaks. In particular, the table tennis intensity of the effort is similar to the style of play (defense-offensive) and is influenced, among other factors, by sex and age (19,33), the type of rallies and the level of players (20,41,19,11).

The results recorded a slight increase in VO$_{2\text{max}}$ in the Multiball groups (15 & 30 sec). In the 15s. group the values of VO$_{2\text{max}}$ between initial and final measurement are similar (43.80 versus 43.90 ml.min.kg$^{-1}$), which indicates that adjustments to the coaching stimuli did not differentiate the VO$_{2\text{max}}$. However, the values of VO$_{2\text{max}}$ demonstrate stabilization of the aerobic capacity of the sample during the 10 weeks of intervention. The most important difference in the VO$_{2\text{max}}$ values was observed in the 30s group. It appears that the improvement in VO$_{2\text{max}}$ occurred after the values were increased (initial-final = 45.62 - 47.47 ml.min.kg$^{-1}$), indicating that the change of time of interval training exercises with the same exercises may entail significant adjustments. Similar studies in adults have shown increase in VO$_{2\text{max}}$ even when interval training is less than 10 weeks (27,12,5,47,42).

Likewise, in a sample of young athletes, there seems to be a direct relationship between the intermittent high intensity training and improvement of VO$_{2\text{max}}$ (1,30), even after short duration trainings (2), which is in agreement with the results of this study, mainly regarding the 30-sec group.

Similar changes occur in the lactate concentration (La). Although literature approaches about the type of training, the concentration of lactic and respiratory threshold differ (35,36,15,37), yet the biological changes cause dare taken for granted. (26). The increase in lactate levels in the blood are considered as a significant performance predictor regarding endurance (18,8). The variations of the study sample values between the first and second measurement, although not statistically significant, entail an increase in concentration during the second measurement in all groups.

More specifically, in the 15s. group (La) values between initial and final measurement showed an increase (7.37 versus 10.22 mmol/l$^{-1}$), which applies to the respective values of the 30s group, as well. (Initial= 6.98 / Final = 8.06 mmol/l$^{-1}$). Taking into consideration the data of the initial and final measurement it seems that the training protocol caused adaptations to the sample. According to the literature there is an increase in the concentration values of lactate within the first six weeks of training (29), which is in agreement with the study results. Nevertheless, the lactate concentration is low after a short time interval training application (3). Indicatively, value determination for aerobic adaptations is considered 4 mmol/l$^{-1}$ (16,46), although in many cases the values range from 2 to 7.5 mmol/l$^{-1}$ (40). According
COMPARISON OF EFFECTS ON VO$_{2\text{max}}$ AND LACTATE CONCENTRATION

...to Borresen & Lambert (4), the measurement of lactate concentration in the blood can be used as a reliable indicator for determining the intensity of exercise. However, La concentration is influenced by various factors, which are important to monitor the intensity of exercise (46). Consequently, the measurement results denote that the sample may have gone through significant coaching adjustments. In order to be able to proceed to safe assessment regarding this type of training, all the above-mentioned parameters should be taken into consideration.

CONCLUSION

It seems that regardless of the duration of the stimulus, short duration of high intensity Multiball exercises affects in cardiorespiratory capacity of youth table tennis players not statistically significant though. According to Jones & Carter (17), any improvement in physiological factors such as the oxygen intake, running economy and lactate concentration may be regarded as an indicator of improvement of performance, which is also observed in the sample groups of this study. Accordingly, the use of specialized exercises can bring about the appropriate stimuli and adjustments in youth table tennis players.

REFERENCES


42. Suchomei A. A Comparison of Exercise Intensity on Different Player Levels in Table Tennis. *International Journal of Table Tennis Sciences*, 6: 79-82, 2010.


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