Energy Expenditure and Cardiorespiratory Responses during Training and Simulated Table Tennis Match

SHU- CHUAN SHIEH[1], JU-PING CHOU[2], YING-HAO KAO[1*]
[1] National Cheangchi University, Taipei, Taiwan
[2]De Lin Institute of Technology, Taipei, Taiwan
[1*] Graduate Institute of sport coaching science , Chinese Culture University, Taipei, Taiwan
(Tel : +886-9-100-22711; E-mail: qeric20@hotmail.com)

Abstract:
Objectives: To investigate the energy expenditure and cardiorespiratory responses during training and simulated table tennis match. Sixty university male table tennis players from Division A (thirty, elite player) and Division B (thirty, amateur player) performed both laboratory test and simulated table tennis match. Bruce protocol were used to evaluate their maximum oxygen uptake ($\dot{V}o^2max$) and Cortex Metalyzer 3B were used to evaluate their peak oxygen uptake ($\dot{V}o^2_{peak}$) during simulated table tennis match . The results demonstrated that 1. The mean Vo^2max for all players were 42.1±6.4 ml/kg/min±6.4, the maximum value was 48.5 ml/kg/min, and the minimum value was 37.2 ml/kg/min ; 2. During practice session and simulation match, group A player's oxygen consumption rate during practice session and simulating competition were 29.8±7.2ml/kg/min and 36.8±13.2ml/kg/min, respectively. There were no differences between heart rate and oxygen uptake during practice session and forehand and backhand practice; 3. Group B player's Vo^2max during practice session and simulating competition were 33.5±7.5 ml/kg/min and 35.6±18.4ml/kg/min, respectively, no differences between heart rate and oxygen uptake during practice or forehand and backhand practice sessions.4. In this experiment the players of oxygen ability and good endurance that will be better exercise performance.5. During practice session an average METS to be 8.51 ± 1.0 METS ; the simulation match METS to be 8.51 ± 1.0 METS, It belongs to extremely heavy degree of sportses to carry on the intensity of movement that table tennis trains according to this research. The intensity of simulation match is fierce sports, the energy that the competition needs to consume is much higher than to training.

Key word : 40mm table tennis ball, eleven points, oxygen uptake

INTRODUCTION

Background

In 2000, the diameter of table tennis balls was regulated to change from 38 mm to 40 mm. By doing so, it maximizes the chances for players to play back and forth more in a game so as to draw larger audience (Xu, 2004). As the ball gets bigger, it is less subject to the drag force and Maguns force than the smaller ball (Chou,2001). Hence, owing to the fact that bigger balls have less velocity and don't spin as much as smaller balls, the number of games in a match will increase, and the players will hence be trained more to endure greater energy consumption in a match.

Table tennis is one of the sports whose matches last longer. During a practice or a match, if both players are more equivalent, the competition gets more intense. As a result, players consume more physical vigor. According to previous research, the energy that a world-class table tennis player requires in a world-class match amounts to the energy required for wave racket 5,400 times or running 8,100 meters in a day. For the purpose of winning, players need to be equipped with staunch will and perseverance to overcome extreme fatigue.

The action of hitting in table tennis demands enormous accuracy. Trainees must practice repetitively to acquire the hitting skills. Therefore, it is hard to get rid of those mechanical trainings. For players to finish the monotonous training requires strong wills.

In March, 2000, the International Table Tennis Federation (ITTF) made an announcement that starting October in the same year, the diameter of table tennis balls was to change from 38 mm to 40 mm. This small change not only led to a revolution in skills, tactics, and players' mindset and physical strength, but also to an adjustment in how the players should be trained. Research points out that the new-sized ball have less velocity and doesn't spin and bounce as much as the old-sized ball, reserve hits back more easily, and this maximizes the chances for players to play back and forth more in a game. Players have greater psychological （Chen, 2000；Krohne & Hindel, 1988）and physical burdens.

Based on PENG (1993), the training of table tennis focuses on the training on players' velocity, endurance, and explosive force, in other words, on players. The source of energy required for playing a 38mm-diameter ball comes from 60% of anaerobic, 20% of AT, and 20% of aerobic (LIN, 1986). Although a 40mm-diameter ball spins 23% less and has 13% less velocity, the increase in size requires a change in physical trainings. Nevertheless, previous studies focus more on the smaller ball and on the old match system; a scientific study on the energy consumption and on field assessment in a match with bigger balls has not been done and reported. It is probably due to the difficulty in measuring the complicate movements in a table tennis match with delicate apparatus.

Taiwan's performance in international matches has improved, but to maintain and expedite that

improvement needs the intervention of sports science. Systematically doing research on the evaluation of players' energy expenditure (EE) in a new match system with a new-sized ball is the most important of all. With the efficient research and development on cortex metamax 3B in recent years, the weight and quality of the apparatus are lighter and more reliable respectively, which results in more research on EE and field assessment conducted successively. Previous literature provides no report as to EE and field assessment in a table tennis match with a bigger ball, so this hopes to be a pioneer. Two Cortex Metalyzer 3B are used to conduct field assessment in a simulated table tennis match with a new match system and a larger ball. Players' Hr, Hr Max, gas exchange including $\dot{V}O2/kg$, $\dot{V}CO2/kg$, AT, $\dot{V}O2/HR$, $\dot{V}O2HRmax$, etc. will be analyzed breath by breath. By doing so, we expect to establish players' Energy Expenditure index that provides our national table tennis athletes with reliable training parameters. If the method and result of this experiment are proven valid, more studies on martial arts, Tai Chi, badminton, and so on can be conducted likewise so as to enrich the literature.

.

Purpose

This study used Cortex Metalyzer 3B to conduct field assessment in a simulated table tennis match with a new match system and a larger ball. Variables of players' Hr, Hr Max, gas exchange including $\dot{V}O2/kg$, $\dot{V}CO2/kg$, AT, $\dot{V}O2/HR$, $\dot{V}O2HRmax$, etc. were analyzed breath by breath. The main purposes of this study are: 1. to establish players' Energy Expenditure index; 2. to point out the difference in Energy Expenditure index between players from Division A and those from Division B.

Methods

The subjects of this experiment came from 30 male players from Division A and 30 males players from Division B. Pre- and post-match EE and field assessment in a match with a new match system and a bigger ball were evaluated with Cortex Metalyzer 3B. players' Hr, Hr Max and gas exchange were analyzed breath by breath.

Table 1 subjects' age, height and weight (N=60).

value	Mean	SD	MAX	min
age	22.6	2.58	27	19
Height(cm)	172.1	4.43	180	165
Weight (kg)	64.3	7.34	84	55

Experimental apparatus

CORTEX MetaMax 3B

CORTEX Biophysik MetaMax 3B portable CPX system (Cortex, Leipzig, Germany) analyzes subjects' HR, gas exchange, and ventilation breath by breath. Its accuracy was proved by Schulz, Helle and Heck (1997).

PROCEDURE

Cortex Metalyzer 3B was used for monitoring. Each player did warm-up and training to get adjusted to the equipment for 10 minutes with Cortex Metalyzer 3B on them. All the data were collected. When their heart rate returned to normal range, they started the competition. Each player underwent measurement twice on their Hr, Hr Max, gas exchange including $\dot{V}O2/kg$, $\dot{V}CO2/kg$, AT, $\dot{V}O2/HR$, $\dot{V}O2HRmax$, etc. to establish Energy Expenditure index.

All the data were analyzed via Microsoft Excel and SPSS softwares.

Results

Maximum oxygen uptake represents how well the body uses oxygen, which helps us understand how well a player restores from fatigue after physical training. If a player has higher values, he/she has better cardiorespiratory ability.

Totally there were 60 subjects: 30 male players from Division A and 30 male players from Division B. All confirmed before experiment that no previous history of heart-related diseases.

$\dot{V}o^2max$ represents the uptake of oxygen; it shows the ability of recovery from fatigue in physical training of players. The higher $\dot{V}o^2max$ represents the better cardiorespiratory ability. This research demonstrated the measurement of the oxygen uptake and the energy expenditure from 60 male table tennis players' during practice sessions and simulated competition by CORTEX MetaMax 3B.

This experiment included 60 male players divided into A (elite players for 30) and B(secondary players for 30) groups. For the security during the experiment, all players were ensured to be in a healthy status by filling in a form about self-health examination.

The mean of the oxygen uptake from players in Group A during practice sessions was about 29.8±7.2 $ml \cdot kg^{-1} \cdot min^{-1}$ and was about 36.8±13.2 $ml \cdot kg^{-1} \cdot min^{-1}$ during the simulated competitions. The heart rate and oxygen consumption did not rise apparently in practice sessions (including forehand /backhand practice) until the players started to take continuous attacks. Players group A who has better aerobic ability and endurance also gets better performance during the simulated competitions.

The mean of the oxygen uptake of players in Group B during practice sessions was about 33.5±7.5

$ml \cdot kg^{-1} \cdot min^{-1}$ and was about 35.6±18.4 $ml \cdot kg^{-1} \cdot min^{-1}$ during the simulated competitions. The heart rate and oxygen consumption did not rise apparently in practice sessions (including forehand /backhand practice) until the practice time was over 5 minutes. The longer of the practice sessions and competitions last, the more of the heart rate rose up. These measurements indicates that players in group B get worse aerobic ability and endurance.

This research divided all kinds of sport into five degree by intensity based on ACSM (1997) as follow:

The mean of METS from group A during practice sessions was 8.51 ± 1.0 METS and was 10.5± 1.0 METS during simulated competitions. The mean of METS from group B during practice sessions was 9.57± 1.0 METS and was 10.1± 1.0 METS during simulated competitions. According to the measurements above, the practice sessions and simulated competitions could be classified as below:

Division A training METS

$$METs = \dot{V}O2(ml/min/kg) \div 3.5\ ml/min/kg$$

$$= 29.8 \div 3.5\ ml/min/kg$$

$$= 8.51$$

Division A simulated match METS

$$METs = \dot{V}O2(ml/min/kg) \div 3.5\ ml/min/kg$$

$$= 36.8 \div 3.5\ ml/min/kg$$

$$= 10.5$$

Division B training METS

$$METs = \dot{V}O2(ml/min/kg) \div 3.5\ ml/min/kg$$

$$= 33.5(ml/min/kg) \div 3.5\ ml/min/kg$$

$$= 9.57$$

Division B simulated match METS

$$METs = \dot{V}O2(ml/min/kg) \div 3.5\ ml/min/kg$$

$$= 35.6(ml/min/kg) \div 3.5\ ml/min/kg$$

$$= 10.1$$

This research revealed that the oxygen uptake rose slowly in the first two rounds, and got rapid increase from the third round to the middle of the forth round. After this, most players star`ted to appear exhausted. The aerobic ability and endurance of table tennis players should be enhanced for better performances

It takes much more intensity to give continuous attack during new 11-scored competition. Some indexes also indicate` an apparent decline of physical capability in the final round. These indexes may be critical to the result of competition.

By wearing CORTEX MetaMax 3B, table tennis players usually feel difficult to reveal their skills. Documents for table tennis are also deficient in instantaneous energy measurements.

REFERENCES

[1] Chen, X. & Huan L. (1999). Stroke rhythm and skills of table tennis. *Journal of Wuhan Institute of Physical Education.* 33(4). 43-44.

[2] Li, Y. (1994). Review of the 1993 mational junior table tennis competition. *Chinese Sports Science and Technology.* 30, (7). 29-31.

[3] Su, Piren. (1996). *A discussion of penhold grip fast attact play. Journal of Beijijg University of Physical Education*. 19, (1), 76-81.

[4] Wang, J. Wang, X. (1994). A study on the method of evolution with 100 stroks in table tennis. *International Journal of Table Tennis Sciences.* 2. 84-85.

[5] Billat, V. L., Hamard, L. , & Koralsztein, J. P. (2002) The influence of exercise duration at VO2 max on the off-transient pulmonary oxygen uptake phase during high intensity running activity. *Arch Physiol Biochem.* 110(5):383-92.

[6] Chen, X., & Huang, L. (1993) Stroke and skills of table tennis. *Journal of Wuhan Instute of Physical Education*.3(4.)43-44.

[7] Dobrosielski, D. A., P. H. Brubaker, M.J. Berry, M. Ayabe, H.S. Miller.(2002) The metabolic demand of golf in patients with heart disease and in healthy adults. *J Cardiopulm Rehabil.* 22(2) 96-104.

[8] Doyon, K.H., S. Perrey, D. Abe, RL. Hughson. (2001) Field testing of VO2peak in Cross-country skiers with portable breath-by-breath system. *Can J Appl Physiol.* 2001 Feb;26(1):1-11.

[9] Doyon, P, Abe D. & Hughson RL Field. testing of VO2peak in cross-country skiers with portable breath by breath system. *Can J Appl Physiology*. 1-11.

[10] Krohne, H.W., & Hindel, C,. (1998) Trait anxiety,state and coping behavior as predictors of athletic performance. *Anxiety Research*, 1(3),225-234.

[11] Parkkari, J., Natri, A. Kannus, P. Manttari, M. Laukkanen, R. Haapasalo, A. A. Nenonen, M. Pasanen, P. Oja, I. Vuori. (2000) A controlled trial of the health benefits of regular walking on a golf course. *Am J Med.* 109(2):102-8.

[12] Schabort, E.J., J.A. Hawley, W.G. Hopkins, H. Blum. (1999). High reliability of performance of well-trained rowers on a rowing ergometer. *J Sports Sci*. (8):627-29.

[13] Su P. (1996). A discussion of penhold grip fast attact play. Journal of Beijijg University of Physical Education. 19, (1), 76-81.

[14] Wang J., Wang X. (1994). A study on the method

of evolution with 100 stroks in table tennis. *International Journal of Table Tennis Sciences*. 2. 84-85.

[15] Wu X., Y. Zhang.(1993). Adaptability of table tennis players. *Journal of Beijing University of Physical Education*. 16(2). 74-77.

[16] Chen X., Haung L. Stroke and skills of table tennis. *Journal of Wuhan Institute of Physical Education*. 1999;3(4). 43-44.