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The Effects of Aerobic Endurance Training and Circuit Training Program on Cardiovascular Endurance among Junior Archers

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Abstract

The purpose of this study was to examine the effects of aerobic endurance training and circuit training program on cardiovascular endurance among junior archers. The study involved 21 junior archers (age= 15.0 ± 1.7 years) both from recurve and compound division of Terangganu and Penang State's team. The sample study was randomly divided into three groups: Aerobic Endurance Training group (AET; n=7), Circuit Training group (CT, n=7) and Control group (CON, n=7). Baselines data on height, body mass (kg), body mass index (BMI), percentage body fat (%), cardiovascular endurance (20m Endurance Shuttle Run Test) and VO_2 max (maximal oxygen uptake) were collected. The aerobic endurance training program is jogging for 2km in week 1-4, 3km in week 5-8, and 4km in week 9-12. Meanwhile, for the circuit training program included one circuit of ten stations of 30/60 seconds of work/rest interval with two cycles in week 1-4, 40/60 seconds of work/rest interval with three cycles in week 5-8, and 50/90 seconds of work/rest interval with four cycles in week 9-12. Both training program were performed two times per week during evening after archery training routine. Data were analyzed using mixed factorial analysis of variance (ANOVA). Statistical significance level was set at 0.05. The result show that after 12 weeks of a training program, cardiovascular endurance and VO_2 max increased significantly in the CT Group ($p < 0.05$), while for the AET Group revealed significant interactions after week 1-4 and week 9-12 of training and significant increase was not observed in the CON Group ($p < 0.05$). The results of this study suggest that the circuit training linearly improved cardiovascular endurance and VO_2 max of the study subjects throughout the

intervention. This training program may be used as a guideline for selecting a set of exercise in their training routine to improve cardiovascular fitness among archers.

Keywords**:** *Circuit training, cardiovascular endurance, cardiovascular fitness, junior archers*

Introduction

Archery is sports that launch an arrow from the bow straight to the target when shooting (Lee, 2009). Archery is also described as static sports requiring upper body strength and endurance, in particular, the shoulder girdle. (Mann, 1994; Mann and Littke, 1989; Ertan et al., 2005) and forearm muscles (Mann, 1989). Archery shooting technique can be described as drawing a bow, aiming and releasing (McKinney and McKinney, 1997). Furthermore, archery skills are defined as the ability to shoot an arrow with particular precision to the targets (Leroyer, 1993; Ertan et al., 1996). Archery is a very challenging event in certain muscles and the ability to perform well in all possible environmental conditions indoors or outdoors and if everything is the same (Açıkada et al., 2004).

An aerobic component to training is also essential. Aerobic fitness, such as cardiovascular and respiratory fitness, can have a barely noticeable outward effect but has a very significant effect on conditioning and an archer's ability to maintain concentration and structure for prolonged periods. Cardiovascular fitness can be any number of sustained exercise programs like jogging, swimming, or any other exercise that raises the heart rate for extended periods. Analysis of the event showed that there is a demand of cardiovascular fitness during long hours and high number of quality shooting for effective training capacity, and during competition which demands not less than 150 shots during the course of competition, for a day (Tinazci, 2001). Several investigations on archers have demonstrated that there is a notable specific stress on cardiovascular system of archers during repetitive shooting (Carrillo et al., 2011).

According to Musta (2004), the main objective of the archery fitness program is to build muscle and cardiorespiratory systems necessary to improve archery skills, competitiveness and score. Heart rate increases in a linear manner with increasing workload during aerobic activity (Franklin, 1998). Aerobic exercise training can increase the ability of the heart to pump blood at rest, thus contributing to some of the significant bradycardia (slower heart rate) observed in highly conditioned endurance athletes, with heart rates usually ranging from 40 to 60 beats/min. (Guyton, 1991; McArdle et al., 1994).

In the world of sports, the term VO2 max is very familiar; many experts say that achievement in sports can be determined by the level of VO2 max. Physical capacity of athletes is an important element of success in sports achievements. It involves a huge number of different capacities, with aerobic capacity being its major component. The higher the VO2 max, the longer the ability of the muscles to work, which means that the muscles do not get fatigue quickly, and vice versa. Thus, it can be said that the levels of a person's VO2 max can affect maximum achievement of athlete performance.

In additionally, there is a close relationship of cardiovascular training program and high level of cardiovascular endurance in archery. Even though, several researchers have endeavoured to offer

insight into need for the archers to possess certain physical fitness variables, to date, there has been little effort to investigate the most crucial cardiovascular fitness variables that could play a role in the successful performance of the game and to determine the less paramount fitness variable in the execution of the game which can serve as the basis for restructuring the training program to suit the need of the game. Thus, the aim of the present study was to examine the effects of aerobic endurance training and circuit training program on cardiovascular endurance among junior archers.

Research Methodology

A. Participants

Twenty-one archery junior players were recruited from Penang and Terengganu archery state's team with a mean age, height, body mass, body mass index (BMI) and percentage body fat of 15.0 ± 1.7 years, 162.08 ± 8.31 cm, 64.82 ± 12.96 kg, 24.70 ± 4.32 and 25.74 ± 8.01%, respectively. The participants consisted of 12 boys and 9 girls. The age of the participants was between 13 to 18 years old. In order for inclusion in this study, subjects must be physically healthy. Tests of cardiovascular endurance were done at one week before the intervention, after week four, after week eight and after week twelve of interventions. There were four times of experimental test throughout the study. The participants were randomly assigned into three groups - Aerobic Endurance Training group (AET; n = 7), Circuit Training group (CT, n = 7) and Control group (CON, n = 7). Informed written consent form was obtained from all participants after receiving verbal and briefing of potential risk and benefits derived from study participation.

B. Aerobic Endurance Training Program

The Aerobic Endurance Training group carried out jogging (self-pace) after archery training routine every Monday and Thursday at archery field. Briefly, training protocol included a five minute warm-up and jog for 2km in week 1-4, 3km in week 5-8, and 4km in week 9-12. This training session ended with a five minute cooling down. The aim of this training program is to improve cardiovascular endurance by improving lung and heart performance to more efficiently distribute oxygen to muscles during aerobic exercise.

TABLE I
Aerobic Endurance Training (Every Monday and Thursday) for 12 weeks

Jogging (Weeks)	Total duration (km)
1 – 4	2km
5 – 8	3km

9 – 12	4km

C. Circuit Training Program

The Circuit Training Program group was trained two times a week also on Monday and Thursday for 12 weeks. The circuit training program was developed based on the ACSM recommendation (American Collage of Sport Medicine, 2006). The training protocol included a five minute warm-up and two rounds in 20 min of ten stations circuit training with 30 sec exercise and 60 sec rest at each station for week 1 – 4, followed by three rounds in 30 min of ten stations circuit training with 40 sec exercise and 60 sec rest at each station for week 5 – 8, and in the last four weeks, the participants were trained four rounds of the same circuit in 50 min with increase period to 50 sec exercise and 90 sec rest at each station. The training sessions in this phase ended with ten minute cool down. The bodyweight circuit stations include squad, push-ups, burpee jump, crunches, lunges, plank, jumping jacks, back extensions, mountain climbs and Russian twist. The Control group maintained their normal training routine program. Training and data collection were done at the Indoor Gymnasium Majlis Sukan Negeri Terengganu and Majlis Sukan Negeri Pulau Pinang.

TABLE II
The Number of Cycle, Exercise Duration, Rest Period between Stations, Rest Periods Between Cycle and Total Duration Of The Circuit Training Program (Every Monday And Thursday) For 12 Weeks

Weeks	Cycles	Exercise duration (seconds)	Rest period between cycles (seconds)	Rest period between stations (seconds)	Total duration (minutes)
1 – 4	2	30	60	2	20
5 – 8	2	40	60	2	30
9 – 12	3	50	90	2	50

D. Measurements

1. Cardiovascular Endurance Assessment

Cardiovascular endurance was assessed with the 20 meter shuttle run test. The multi-stage 20-m shuttle run fitness test (was widely used to measure aerobic fitness from children to the athletes

at all levels (Leger and Lambert, 1982; Paradisis et al, 2014). It also has been reported suitable to predicting the aerobic fitness for field test to evaluate the effectiveness of training program (Castagna et al, 2006). In this particular test, the participant was divided into two groups and performs the test according to their respective group. Then, they performed a 5-minute general warm-up (self-paced) and followed by 5 dynamic stretching activities at lower body muscles (Ishak et al, 2019). Afterwards, they were instructed to run continuously back and forth on a 20 meter court for the measurement session. The running speed starts at 8.5 km/h, which increased at each level by 0.5 km/h; a single beep from the CD indicated the end of the shuttle and 3 beeps indicated the start of the next level. These runs must be synchronized with an audio CD that is pre-recorded and plays beeps at set intervals. The test will stop when the participants unable to maintain running speed according to the pace of the 'beep' sound (Leger and Lambert, 1982). Participants performed proper warmed up and stretching before the test begun. When the participant unable to make the next interval twice, the latest level they completed was rated as their final score or indicated as their fitness level during the test and to predict the maximal rate of oxygen uptake (Giannaki et. al., 2016). The final level and stage of 20 meter shuttle run test were recorded.

E. Statistical Analysis

Descriptive statistics (mean and standard deviations) for age, height, body weight, body mass (kg), body mass index (BMI), and percentage body fat (%) were calculated. The mixed factorial variance analysis (ANOVA) was used in this study to analyze differences between groups for all parameters and across experimental sessions. The analysis of data was performed using the software package by using $\alpha = 0.05$ confidence level (Özdamar, 1999) by Statistical Package for Social Sciences (SPSS) version 22.0. The data were screened for accuracy, missing values, outliers and basic assumptions before the main analysis.

RESULTS

The demographic characteristics data are reported as mean ± SD for the age, height, body mass (kg), body mass index (BMI), and percentage body fat (%) for all experimental groups and control group are shown in Table III.

TABLE III

Demographic Characteristics of the Participants

Variables	*Mean*	*SD*
Age (years)	15.00	1.70
Height (cm)	162.08	8.31
Body mass (kg)	64.82	12.96
Body mass index (BMI)	24.70	4.32
Percentage body fat (%)	25.74	8.01

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SD = Standard deviation

The result revealed a significant interaction between the experimental groups across the measurement sessions for 20 meter shuttle run test (TABLE IV) and VO_2 max (TABLE V). A post - hoc test was carried out. According to Table 1, in the second and fourth measurements (post - test) for the aerobic endurance training group, a significant multi - stage fitness test was found ($p = .01 < .05$) ($p = .04 < .05$). For the circuit training group, the second, third and fourth measurements ($p = .03 < .05$) ($p = .01 < .05$) ($p = .03 < .05$) were found significant for 20 meter shuttle run test and non-significant was found for the control group ($p > 0.05$).

TABLE IV
Pairwise Comparisons of 20 meter Shuttle Run Test across the Measurement Sessions

Group	***Measurement Sessions***	***Mean Difference***	***SE***	***P-value***	***95% Confidence Interval for Difference***	
					Lower Bound	***Upper Bound***
EAT	1	0.12	0.31	0.70	-0.53	0.76
	2	0.83*	0.30	0.01	0.20	1.45
	3	-0.42	0.21	0.06	-0.85	0.01
	4	0.72*	0.31	0.04	0.05	1.37
CT	1	-0.03	0.31	0.93	-0.67	0.62
	2	-0.70*	0.30	0.03	-1.33	-0.08
	3	-0.69*	0.25	0.01	-1.22	-0.16
	4	0.73*	0.31	0.03	0.07	1.38
CON	1	-0.30	0.25	0.25	-0.82	0.23
	2	-0.30	0.25	0.25	-0.83	0.23
	3	-0.43	0.31	0.18	-1.08	0.22
	4	-0.43	0.31	0.18	-1.09	0.22

EAT = Aerobic Endurance Training, CT = Circuit Training

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According to the TABLE V, in the second and fourth measurements, a significant amount of VO2 max was found for the aerobic endurance training group ($p = 0.03 < 0.05$) ($p = 0.02 < 0.05$). In the second, third and fourth measurements, a significant amount of VO2 max was found in the circuit training group ($p = .03 < .05$), ($p = .02 < .05$) ($p = .02 < .05$) and non-significant was found for the control group across the measurement sessions ($p > 0.05$).

TABLE V
Pairwise Comparisons of VO_2 max across the Measurement Sessions.

Group	***Measurement Sessions***	***Mean Difference***	***SE***	***P-value***	***95% Confidence Interval for Difference***	
					Lower Bound	***Upper Bound***
AET	1	-0.57	0.91	0.53	-2.50	1.33
	2	1.76*	0.74	0.03	0.20	3.32
	3	1.20	0.85	0.17	-0.58	2.98
	4	2.34*	0.92	0.02	0.41	4.27
CT	1	-0.26	0.91	0.78	-2.18	1.66
	2	1.96*	0.84	0.03	0.19	3.73
	3	2.21*	0.85	0.02	0.43	4.00
	4	2.37*	0.92	0.02	0.44	4.30
CON	1	-0.57	0.91	0.53	-2.54	1.32
	2	-1.51	0.84	0.10	-3.29	0.26
	3	0.20	0.73	0.79	-1.33	1.73
	4	-1.89	0.92	0.06	-3.82	0.04

EAT = Aerobic Endurance Training, CT = Circuit Training

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DISCUSSION

The present study finding showed statistically significantly for the aerobic endurance training group, a significantly for 20 meter shuttle run test was found in the second and fourth measurement (post-test). For the circuit training group, a significantly for 20 meter shuttle run test was found in the second, third and fourth measurement and non-significant was found for the control group across the measurement sessions. This finding was consistent with the previous study carried out by Musa et al. (2016) which also recognized the essential physical fitness components among archery. The study has emphasized the importance of endurance in competitions. Cardiovascular endurance is generally required for the individual to be able and sustain the physical activity for longer period. The essence of the archery requires more repetitions, a lot of energy and endurance, with long hours of training, competitiveness and systematic movement of back and forth.

Similarly, with the result of the 20 meter shuttle run test, the present study also revealed statistically significantly of VO_2 max (maximal oxygen uptake) were found in the second and fourth measurement for the aerobic endurance training group. While, for the circuit training group, a significantly of VO_2 max was found in the second, third and fourth measurement and for the control group, non-significant was found for the control group across the measurement sessions. As an indicator of cardiorespiratory fitness, VO2 max is widely used. VO2 max is the maximum rate of oxygen intake measured during incremental exercise (Clemente et al., 2009; Dlugosz, 2013). Maximum oxygen consumption reflects an individual's cardiorespiratory fitness and during prolonged exercise is also an important determinant of endurance.

This study is similar to previous researchers who have shown that cardiorespiratory endurance is important for archery competition because it takes about two days for the archers to last 144 arrows shot in the FITA round competition (Elferink - Gemser et al., 2006; Berthelot et al., 2010). The archers will work a lot in the game with or without the arrow. Athletes must execute a repetitive movement, shoot the arrows in the same rhythm, check their scores and deal with the weather condition and etc. the energy required to achieve this motive is aerobically provided which allows the heart, lung and blood system to provide oxygen to the working muscles throughout the shooting time (Humaid, 2014).Thus, in the archery game, endurance is a basic necessity (Graurav et al., 2011).

In additional, Musta (2004) mentioned that the main goal of the archery fitness program is to develop the muscle and cardiorespiratory requirement linearly with increased workload during aerobic activity (Franklin, 1998). The systems are to improve archery skills, competitive ability, and shooting score. The participants were performed aerobic exercises such as running a form of cardiovascular training. Aerobic exercise is physical exercises of low to high intensity that depends on the aerobic energy generating process (Sharon, Plowman, and Smith (2007). Aerobic refers to the use of oxygen to adequately meet energy requirement during aerobic metabolism (William et al., 2006) and it needs or involved free oxygen (Kenneth 1997). In general, light to moderate activities, supports sufficiently by aerobic metabolism are performed for long periods (Sharon et al, 2007).

In conclusion, the present study shown the improvement and higher value in 20 meter shuttle run test and VO_2 max were observed in circuit training groups after first months of intervention. The

circuit training program resulted in increases cardiovascular endurance among junior archers compare to aerobic endurance training and a normal training routine program. The training program could be used to improve cardiovascular fitness of the young archers.

RECOMMENDATIONS

The recommendations for future research suggested the training program for future compared separately according to the sport's discipline (recurve and compound) because it may also provide a more interesting outcome on research finding. Both categories have difference disciplines such as distances, scoring format during the elimination round, equipment used, and etc among each other.

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