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Optimising University Athletes Cardiovascular Health using Lower and Upper Body Plyometric Training

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Abstract:
Although plyometric training has been a useful training technique for developing optimal sports performance in most popular sports, yet the information about this type of training on cardiovascular variables, especially on BP, is not completely understood. The study examined the effectiveness of lower and upper body plyometric training in optimising university athletes' cardiovascular health.30 male athletes who voluntarily participated in the study were purposively selected and drawn from university male athletes body mass index (BMI) within the range of underweight to normal weight (≤18.5±24.9)(height, x=1.50±1.17cm; body weight, x=50.31±70.15kg), all athletes whose age-range fall between 18 and 25 years old.The volunteered athletes were apparently healthy, physically active and free of any lower and upper extremity bone injuries for past one year and they had no medical or orthopedic injuries that may affect their participation in the study. The Quasinone randomised pretest posttest control group experimental design was used for the study. The participants were randomly assigned to one of the three groups: lower body plyometric training (LBPT), upper body plyometric training (UBPT) and control (C).Training consisted of six plyometric exercises: lower (ankle hops, squat jumps, tuck jumps) and upper body plyometric training (push-ups, medicine ball-chest throws and side throws) with moderate intensity. The general data were collated and analysed using Statistical Package for Social Science (SPSS version 22.0). Mean and standard deviation were used to describe the data collected for the study, Analysis of co-variance (ANCOVA) were used to test the hypotheses. The results revealed that athletes who were trained using LBPT and UBPT had reduced HR, SBP, DBP, MAP and RPP better than those in the control group. Analysis of covariance (ANCOVA) also showed that athletes who were trained using LBPT and UBPT indicated lack of significant differences following ten weeks plyometric training and those in the control group in all the cardiovascular variables. Based on the findings of the study, it was recommended among others that coaches should include both LBPT and UBPT as part of athletes' overall training programme from primary to tertiary institution to optimise performance as well as reduce the risk of cardiovascular diseases and promotes good healthy lifestyle.

Keywords: *Plyometric, blood pressure, heart rate, mean arterial pressure, rate pressure product*

1. Introduction

Plyometric training is a form of specialised strength training that uses fast muscular contractions to improve power and speed in the sports conditioning programme by coaches and athletes. Plyometric training involves a rapid stretching of muscle (eccentric phase) immediately followed by a concentric or shortening action of the same muscle and connective tissue. This rapid combination of eccentric and concentric action by muscle is called stretch-shortening cycle. As a muscle stretches and contracts eccentrically, it lengthens while it contracts to produce storable energy (Michael-Woods, 2017). The stored elastic energy within the muscle is used to produce more force than can be provided by using only concentric contraction alone (Abbas, 2005).Its health benefits include burning many calories in a single session and aiding in weight loss and reduced incidence of serious knee injuries (William, 2018), and running economy (Bhavna & Sarika, 2010).

Although plyometrics are widely used in athletic conditioning by coaches, the university athlete's cardiovascular responses to plyometric training have not been well established. Arazi, Asadi, Rahimzadeh, & Mordikhani (2014) compared the effect of post-plyometric exercise hypotension and heart rate in normotensive individuals: Influence of exercise intensity and they found out that after an acute exercise bout, blood pressure (BP) levels are reduced for minutes or hours in relation to post-exercise levels. This phenomenon is called post-exercise hypotension (PEH) and has been widely investigated because of its importance for the treatment and prevention of arterial hypertension. With regard to different workloads of plyometric exercise, (Arazi, Rahmaninia, Hosseini & Asadi, 2014) investigated the resting hormonal and cardiovascular responses to short term creatine supplementation and resistance exercises. The report showed that

high workload indicated greater increases in HR and RPP. The results of this study suggest that with increased exercise workload, the myocardial oxygen increases. This mechanism of this increase may be coupled increases in HR and SBP.
Additionally, Moro, Ewan, and Gerardo (2013) investigated the blood pressure and heart rate responses to two resistance training techniques of different intensity in obese individuals, the subjects showed the same cardiovascular response to different intensity. Only Bhavna and Sarika (2010) have directly conducted a study on the effects of concentric vs eccentric loading on cardiovascular variables and ECG in Amritsar but without using athletes. More so, the health and fitness requirements of athletes are different from other general population. Furthermore, these studies were not carried out in Nigeria.

Recently, a few systematic studies have directly investigated the cardiovascular responses following plyometric training but without including the athletes. These few studies that investigated the cardiovascular responses to plyometric training have focused on the elderly, obese and patients with different aliments. More so, athletes have different health and fitness requirements from other general population in any sport conditioning programme. The study by Lobo (2012) on cardiovascular responses to plyometric focused on elderly; Moro, Ewan, and Gerardo (2013) used the obese individuals, while Ankur and Maulik (2013) used the patients with different aliments and they were not done in Nigeria.

Plyometric training may demonstrate strong influences on cardiovascular health in young student-athletes which are capable of antagonising the sympathetic effects on the heart and blood vessels. Independently, the decrease in blood pressure (BP), heart rate (HR), mean arterial pressure (MAP) and rate pressure product (RPP) reduces the risk of cardiovascular diseases such as arterial hypertension. Therefore, more information is necessary, since it has not been well established.

1.1. Research Hypotheses

The following null hypotheses were generated:

There is no significant difference in the heart rate (HR) of university athletes who were trained using lower and upper body plyometric training and those in the control group.

- There is no significant difference in the systolic blood pressure (SBP) of university athletes who were trained using lower and upper body plyometric training and those in the control group.
- There is no significant difference in the diastolic blood pressure (DBP) of university athletes who were trained using lower and upper body plyometric training and those in the control group.
- There is no significant difference in the mean arterial pressure (MAP) of university athletes who were trained using lower and upper body plyometric training and those in the control group.
- There is no significant difference in the rate pressure product (RPP) of university athletes who were trained using lower and upper body plyometric training and those in the control group.

2. Methodology

2.1. Research Design

The quasi none randomized pretest posttest experimental and control group design was used for the study. The participants were purposively assigned into one of the three groups: two experimental groups using LBPT, UBPT and Control based on the type of sports the athlete plays.

2.2. Population

The population of this study was made up of all the male athletes in Nnamdi Azikiwe University, Nnewi Campus.Thirty male athletes volunteered to participate in the study, but only twenty-three completed the study. No sample was used in the study since the population was small.

2.3. Instrumentation

The instrument used to collect data for this study included:

2.3.1. Standard Stadiometer

Standard Stadiometer was used to obtain the height of the participants in centimeters. The height scale is calibrated in centimeters from 60-200 centimeters. Body height was measured to an accuracy of 1cm, with the subject in an upright position with a Standard Stadiometre.

2.3.2. The Calibrated Bathroom Weighing Scale

The Calibrated Bathroom Weighing Scale Model: BR9011 was used to measure the total body weight of the participants. The Weighing scale is calibrated in kilograms from 0-180kg. Body weight was measured to the nearest 0.1kg, with subjects lightly dressed and in stocking feet.

2.3.3. Digital Blood Pressure Monitor

An Automated Digital Blood Pressure Monitor manufactured by Fudakang Industrial LLC Plainsboro USA with cuff size cuff selection, Model: BP-FC11B was used for the study.
Body mass index (BMI) measure was used as an estimate of body composition. BMI was calculated using the standard formula: $\{\text{mass (kg)}/\text{height (m)}\}^2$.

2.4. Exercise Protocol

Participants had previous strength training experience and were working out on a regular basis. However, these athletes neither had previous plyometric training experience nor were they undergoing assessment of any cardiovascular response to any exercise.

Participants were purposively assigned into one of the three groups: two experimental groups using LBPT, UBPT and Control based on the type of sports the athlete plays. The training session took place 3 times a week on alternate days (Tuesday, Thursday and Saturday) for 10 weeks. Thus, the programme entailed thirty training workouts for each subject in both experimental groups. Training session in both experimental groups lasted 50 minutes and began with a 10-minute warm-up: 5 minutes of jogging and 5 minutes stretching, 35 minutes LBPT and UBPT, and 5 minutes cooling down. The control group did not go through any form of exercise, other than their normal sports training activities and normal daily chores.

All training sessions were preceded by a warm-up session, and the regular exercise training was made up of two training programmes. Both experiments were performed on outdoor at different venues. The training programme employed by each experimental group is outlined in Table 1. Specifically, the control group was advised to avoid plyometric exercises and continue with their normal training routine. The subjects were also advised to avoid alcohol, caffeine and smoking throughout the period under study.

LBPT Exercise X sets X reps	UBPT Exercise X sets X reps
Wk 1 ankle hops 3 X 3 X 8	push-ups 3 X 3 X 8
Wk 2 ankle hops 3 X 5 X 10	push-ups 3 X 5 X 10
Wk 3 ankle hops 3 X 7 X 10	push-ups 3 X 7 X 10
Wk 4 ankle hops 3 X 8 X 10	push-ups 3 X 8 X 10
Wk 5 squat jumps 3 X 7 X 10	chest throws (medicine ball) 3 X 7 X 10
Wk 6 squat jumps 3 X 8 X 10	chest throws (medicine ball) 3 X 8 X 10
Wk7 squat jumps 3 X 10 X 10	chest throws (medicine ball) 3 X 10 X 10
Wk 8 tuck jumps 3 X 8 X 10	side throws (medicine ball) 3 X 8 X 10
Wk 9 tuck jumps 3 X 10 X 10	side throws (medicine ball) 3 X 10 X 10
Wk 10 tuck jumps 3 X 12 X 10	side throws (medicine ball) 3 X 12 X 10

Table 1: Training Programme for the Lower and Upper Body Plyometric Training (LBPT and UBPT)

2.5. Variables and Corresponding Test

- Age: Recorded in years to the nearest birthday
- Height: Health-0-meter scale
- Weight: Health-0-meter scale
- Blood Pressure: Automated Blood Pressure Monitor(mmHg)

2.6. Method of Data Analysis

The general data were collated and analysed using Statistical Package for Social Science (SPSS version 22.0). The research questions were answered with mean and standard deviation, while statistical analysis was performed by analysis of covariance (ANCOVA). The level of significance was set at $P \leq 0.05$. However, ANCOVA was used in the study since the volunteered athletes were used intact without proper randomisation which indicated that the subjects were not equal at the baseline and the population was small. ANCOVA removes the initial differences between groups so that the selected or pretested groups can be correctly considered as equivalent for generalisation.

3. Results

The results of the study showed great reduction in cardiac variables in both lower and upper body plyometric training groups, when the post training variables were compared with the pre training cardiac variables.

Table 2 also shows that athletes who were trained using LBPT had reduced posttest mean scores of HR, SBP, DBP, MAP and RPP better than their counterparts in the control group. In Table 3, athletes who were trained using UBPT had reduced posttest mean scores of HR, SBP, DBP, MAP and RPP better than those in the control group. Whereas in the control group, no significant differences were found between the pre training and post training values. Analysis of covariance (ANCOVA) indicated that using LBPT and UBPT have no significant effect on the heart rate, systolic blood pressure, diastolic blood pressure, mean arterial blood pressure and rate pressure product of university athletes and those in the control groups. Thus, all the null hypotheses (Ho1-5) were therefore accepted.

Variables	Pretest Posttest				
	N	Mean (X)	SD	Mean (X)	SD
Experimental Group					
HR	8	63.38	10.81	56.38	7.27
SBP	8	110.38	10.14	104.13	8.59
DBP	8	76.38	7.98	66.25	6.45
MAP	8	87.71	8.25	78.88	5.85
RPP	8	6987.25	1344.80	5842.00	651.99
Control Group					
HR	8	67.00	7.80	61.50	7.98
SBP	8	114.50	15.48	107.13	15.08
DBP	8	75.13	10.89	70.25	12.28
MAP	8	88.53	8.62	82.53	9.53
RPP	8	7602.13	755.25	6648.63	1605.97

Table 2: Mean and Standard Deviation Scores on HR, SBP, DBP, MAP and RPP of Athletes Who Were Trained Using LBPT

Variables	Pretest Posttest				
	N	Mean (X)	SD	Mean (X)	SD
Experimental Group					
HR	8	59.13	16.85	56.13	7.34
SBP	8	110.50	7.48	102.25	4.30
DBP	8	70.50	5.61	72.38	3.81
Control Group					
HR	**8**	**67.00**	**7.80**	**61.50**	**7.98**
SBP	8	**114.50**	**15.48**	**107.13**	**15.08**
DBP	8	75.13	10.89	70.25	12.28

Table 3: Mean and Standard Deviation Scores on HR, SBP and DBP of Athletes Trained Who Were Using UBPT

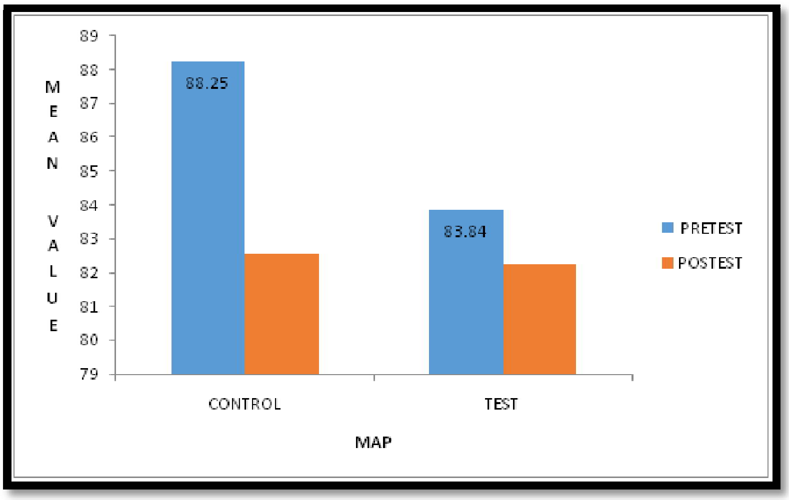

Figure 1

Figure 1 show that athletes who were trained using UBPT had slightly reduced posttest mean scores of MAP (82.24±3.34) better than their counterparts in the control group (82.52± 9.53)

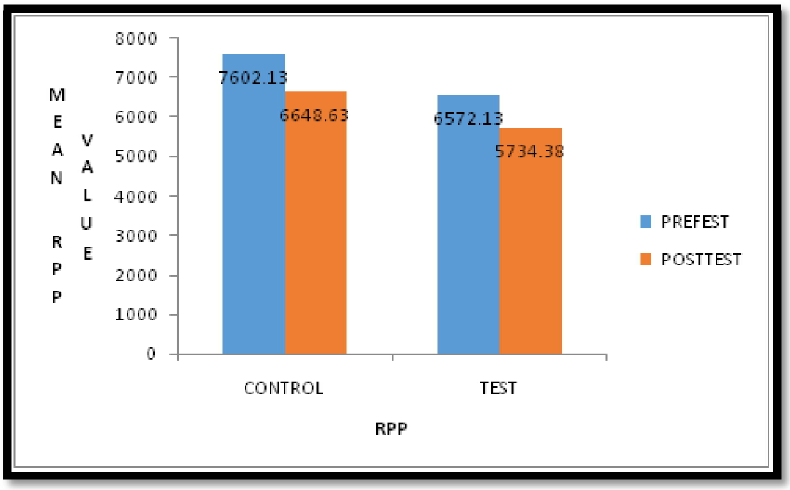

Figure 2

The Figure 2 also revealed that athletes who were trained using UBPT had reduced posttest mean scores of RPP (5734.38) better than the control group (6648.63).

VARIABLES	CONTROL	LBPT GROUP	F-STAT	P-VALUE
Heart Rate	61.50 ± 7.98	56.37 ± 7.26	2.13	0.169
SBP	107.12 ± 15.07	104.12 ± 8.59	0.20	0.659
DBP	70.25 ± 12.27	66.25 ± 6.45	0.59	0.455
MAP	82.52 ± 9.53	78.87 ± 5.84	0.74	0.406
RPP (x1 0^3)	6.65 ± 1.60	5.84 ± 0.65	1.64	0.225

Table 4: Age, BMI Adjusted Comparison in Cardiovascular Parameters Between the Athletes Who were Trained Using Lower Body Plyometric Training and Those in the Control Group at Post-Test Condition

Table 4 shows mean cardiovascular parameters of athletes who were trained using the lower body plyometric training and those in the control group at post-test condition. Analysis of covariance (ANCOVA) indicated lack of significant differences between the LBPT group and those in the control group in all the parameters.

VARIABLES	CONTROL	UBPT GROUP	F-STAT	P-VALUE
Heart Rate	61.50 ± 7.98	56.12 ± 7.33	1.96	0.186
SBP	107.12 ± 15.07	102.25 ± 4.30	0.66	0.432
DBP	70.25 ± 12.27	72.37 ± 3.81	0.24	0.628
MAP	82.52 ± 9.53	82.23 ± 3.34	0.002	0.969
RPP (x 10^3)	6.65 ± 1.60	5.73 ± 0.75	1.97	0.186

Table 5: Age, BMI Adjusted Comparison in Cardiovascular Parameters between Those Athletes Who were Trained Using the Upper Body Plyometric Training and Those in the Control Group at Post-Test Condition

Table 5 shows mean cardiovascular parameters of athletes who were trained using the upper body plyometric and those in the control group at post-test condition. Analysis of covariance (ANCOVA) indicated lack of significant differences between the UBPT group and the control in all the parameters.

4. Discussion

This study has demonstrated that the ten-week lower and upper body plyometric training can improve the cardiovascular health of young athletes. The results demonstrated that athletes who were trained using lower and upper body plyometric training had reduced heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure and rate pressure product better than those in the control group. These, supported what was initially stated by Arazi, et al. (2014) that the low intensity and high intensity protocols showed greater reduction in SBP and DBP at 40-70th minute in 10-50th minute post exercise. It therefore concludes that plyometric exercise can reduce SBP and DBP for post-exercise hypotension. This could be attributed to the relatively more use of low to moderate intensity plyometric training which leads to greater reduction in cardiovascular parameters.

This finding was not surprising because plyometric training involves lengthening (eccentric) muscular contraction quickly followed by shortening (concentric) muscular contraction. This finding is in line with views of Bhavna and Sarika (2010) to the effect that eccentric and concentric group improved but significantly more improvement was seen in concentric group when compared to eccentric group. The result of the study showed that eccentric exercise produced lower cardiovascular response than concentric exercise. A possible explanation of this could be that the lower and upper body plyometric training involves first the movement of eccentric immediately followed by a concentric muscle contraction. The findings could be attributed to the proper application of plyometric techniques which produced better result. The findings are also in agreement with that of Ankur and Maulik (2013) which revealed that eccentric exercise produced lower cardiovascular response than concentric exercise.These findings suggested that LBPT and UBPT could be used in an overall programme to properly prepare athletes for competition in events that require both aerobic and anaerobic metabolism components.

The findings of the present study arenot in accordance with Arazi, et al. (2014) that suggested that plyometric exercise increased heart rate, systolic and diastolic blood pressure, and RPP after each set of exercises. Also, heart rate and RPP were higher during the depth jump exercise ($p<0.05$). Plyometric did not induce any significant changes in muscle soreness ($p>0.05$). The blood lactate concentrations were significantly increased above resting levels($p<0.05$).Studies done in the past have focused on the information concerning the effect of moderate intensity resistance, aerobic or combined training on blood pressure in overweight and obese individuals (Suleen, Satvinder, Hills, & Sebely, 2012). Evidence suggests that there are no any significant changes in SBP, DBP or augmentation index (AI) between the interventions when assessed the entire cohort, although there was significant improvement in a subgroup of responders. The strongest points of this study included the multiple variables studied (HR, SBP, DBP, MAP and RPP) especially on BP, and most importantly the focus on the young university athletes. When compared, the two studies used the moderate intensity but the probable reason for this could be that the present study utilised proper plyometric training technique with low to moderate intensity while Arazi et al used depth jump exercise which is high intensity plyometric exercise. Additionally, Moro, Ewan, and Gerardo (2013) investigated the blood pressure and heart rate responses to two resistance training techniques of different intensity in obese individuals, the subjects showed the same cardiovascular response to different intensity.

Arazi et al, 2014 compared the effect of post-plyometric exercise hypotension and heart rate in normotensive individuals, and they found out that after an acute exercise bout, blood pressure (BP) levels are reduced for minutes or hours in relation to post-exercise levels. This phenomenon is called post-plyometric exercise hypertension.The results showed that all protocols increased SBP, HR and RPP responses at the 10th and 20th min of post-exercise. The study found increases in RPP for all of the workloads at the 10th and 20th min of post-exercise, and moderate workload (MW) and high workload (HW) remained elevated until the 40th min of post-exercise, whereas this elevation remained until 50th min of post-exercise for HW. Also, HW showed greater increases than LW at the 30th min of post-exercise in RPP. The results of this study suggest that with increased exercise workload, the myocardial oxygen increases. This mechanism of this increase may be coupled increases in HR and SBP (Arazi, et al, 2014).

In a nutshell, this study has established the fact that plyometric training produces lower cardiovascular responses than strength exercise alone. However, there is need for coaches to plan the preparation phase for competitions to involve low intensity plyometric training of longer duration. This will give athletes a base as they move into more intense plyometric training such as depth jump during the second half of the preparatory phase for competitions. This shows that LBPT and UBPT could be used in an overall training programme to properly prepare university athletes for competitions in events such as NUGA and NIMSA that require both aerobic and anaerobic metabolism components while it concomitantly promotes good healthy lifestyle.

5. Conclusions

At the end, we speculate that the use of LBPT and UBPT had reduced the cardiovascular variables especially the BP of young university athletes better than those in the control group. This implies that these two plyometric training can principally improve the explosive abilities of an athlete while it concomitantly promotes good healthy lifestyle. Moreover, in this study, athletes progress gradually from simple plyometric training to more intense drills.

6. Limitations of the Study

However, this study has some important limitations, such as the small population size, the discrepancies in the BP measurement procedures and the subjects were not camped to monitor and control their behaviours at home therefore they may tend to behave mechanically and fake most of their actions which may likely interfere with the dependent variables

7. Suggestions

Further research is needed to determine whether lower and upper body plyometric training could affect the cardiovascular variables and ECG of young athletes.

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