Effect of Plyometric Training on Blood Pressure of University Athletes

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Abstracts: The study examined the effectiveness of plyometric training on university athletes' blood pressure. Six plyometric training exercises were used for the study. Ankle hops, squat jumps and tuck jumps were chosen for lower body plyomeric training while push-ups, medicine ball-chest throws and side throws were used for upper body plyometric training with moderate intensity. The quasi-experimental research design was adopted for the study. 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 general data were collated and analysed. 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, and DBP better than those in the control group. These positive effects on blood pressure no doubt help in reducing the risk of cardiovascular diseases and promote good healthy lifestyle. Based on the findings, recommendations and conclusions were made.

Keywords: Diastolic blood pressure, Heart rate, Plyometric, Systolic blood pressure.

INTRODUCTION

Plyometric training is a kind of exercise where muscles contract to their maximum force in a little amount of time, increasing muscle power. Plyometrics is a rapid, forceful movement that consists of a series of reactive exercises and an eccentric contraction that is quickly followed by an explosive concentric contraction, according to Gothard (2022). Exercises like push-ups, throwing, running, jumping, and kicking can all be considered plyometric. Tennis, basketball, volleyball, and other sports requiring quick movements can all benefit from plyometric training.

Uzor and Emeahara (2019) describe plyometric training as a type of advanced fitness training that helps coaches and athletes perform better in sports by using quick muscular contractions to increase power and speed. During plyometric exercise, muscles are rapidly stretched (eccentric phase) and then the same muscles and connective tissue are quickly compressed (concentric phase). The term "Stretch-Shortening Cycle" (SSC) refers to the quick combination of eccentric and concentric muscular movement. More force is produced by the muscle's stored elastic energy than by concentric contraction alone (American College of Sports Medicine, 2015). According to Robinson (2020), muscles are stretched every time a person lands a leap, and the combination of the stretching and contacting of muscles whips it into shape.

Plyometric training bridges the gap between speed and strength. The two main categories of plyometrics are lower and upper body plyometric training (Nkiru & Nonye, 2020). Lower body plyometric training includes jumps, hops, bounds and lunges, while the upper body plyometric training requires the use of a medicine ball throws and plyometric push-ups (Uzor & Emeahara, 2020). Its health benefits include burning many calories in a single session and aiding in weight loss and reduced incidence of serious knee injuries (Nkiru & Nonye, 2020), and running economy (Bhavna & Sandhu, 2010).

Although plyometrics are widely used in athletic conditioning by coaches, the university athlete’s blood pressure responses to plyometric training have not been well established. Arazi et al. (2015) 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 Sandhu (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, Carvalho, and Santos (2010) on cardiovascular responses to plyometric focused on elderly; Moro et al. (2013) used the obese individuals, while Khant and Shah (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.

Research Hypotheses

The following null hypotheses were stated and tested at 0.05 level of significance: (1) 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; (2) 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; (3) 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.

RESEARCH METHODS

The quasi none randomised 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.

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.

The instrument used to collect data for this study included: standard stadiometer, the calibrated bathroom weighing scale, digital blood pressure monitor, BMI measure, and exercise protocol.

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.

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.

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.

BMI measure was used as an estimate of body composition. BMI was calculated using the standard formula: [mass (kg)/height (m)]^2.

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 subjects 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.

Table 1. Training programme for the Lower and Upper Body Plyometric Training (LBPT and UBPT)

Week	LBPT (Exercise X sets X reps)	UBPT (Exercise X sets X reps)
1st	Ankle hops 3×3×8	Push-ups 3×3×8
2nd	Ankle hops 3×5×10	Push-ups 3×5×10
3rd	Ankle hops 3×7×10	Push-ups 3×7×10
4th	Ankle hops 3×8×10	Push-ups 3×8×10
5th	Squat jumps 3×7×10	Chest throws (medicine ball) 3×7×10
6th	Squat jumps 3×8×10	Chest throws (medicine ball) 3×8×10
7th	Squat jumps 3×10×10	Chest throws (medicine ball) 3×10×10
8th	Tuck jumps 3×8×10	Side throws (medicine ball) 3×8×10
9th	Tuck jumps 3×10×10	Side throws (medicine ball) 3×10×10
10th	Tuck jumps 3×12×10	Side throws (medicine ball) 3×12×10

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.

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).

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 were performed by analysis of covariance (ANCOVA).The level of significance was set at *p*-value<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.

RESULTS AND DISCUSSION

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. Mean and Standard Deviation scores on HR, SBP and DBP of athletes who were trained using LBPT

Variable	N	Pretest		Posttest	
		Mean	SD	Mean	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
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 2 also shows that athletes who were trained using LBPT had reduced posttest mean scores of HR, SBP and DBP 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 and DBP 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.

Table 3. Mean and Standard Deviation scores on HR, SBP and DBP of athletes trained who were using UBPT

Variable	N	Pretest		Posttest	
		Mean	SD	Mean	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

Analysis of covariance (ANCOVA) indicated that using LBPT and UBPT have no significant effect on the heart rate, systolic blood pressure and diastolic blood pressure of university athletes and those in the control groups. Thus, all the null hypotheses ($H_0$1-3) were therefore accepted.

Table 4. Age, BMI adjusted comparison in blood pressure parameters between the athletes who were trained using LBPT and those in the control group at posttest condition

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

Table 4 shows mean blood pressure 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.

Table 5. Age, BMI adjusted comparison in blood pressure parameters between those athletes who were trained using the UBPT and those in the control group at posttest condition

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

Table 5 shows mean blood pressure 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.

Discussion of the Findings

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. Thesse, supported what was initially stated by Arazi et al. (2013) 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 Sandhu (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 Khant and Shah (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 is not 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 (Ho et al., 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 were 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 (2012) used depth jump exercise which is high intensity plyometric exercise. Additionally, Moro et al. (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. (2013) 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 10^{th} and 20^{th} min of post-exercise. The study found increases in RPP for all of the workloads at the 10^{th} and 20^{th} min of post-exercise, and moderate workload (MW) and high workload (HW) remained elevated until the 40^{th} min of post-exercise, whereas this elevation remained until 50^{th} min of post-exercise for HW. Also HW showed greater increases than LW at the 30^{th} 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 produce 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.

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.

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.

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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