THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Effects of Lower and Upper Body Plyometric Training on Electrocardiogram (ECG) Parameters of University Athletes

Dr. Uzor Theresa Nkiru

Lecturer, Department of Human Kinetics and Health Education,
Nnamdi Azikiwe University, Awka, Anambra State, Nigeria

Dr. Ujuagu Ann Nonye

Lecturer, Department of Human Kinetics and Health Education,
Nnamdi Azikiwe University, Awka, Anambra State, Nigeria

Abstract:

Plyometric training is a form of specialised strength training that uses fast muscular contractions to improve power and speed in sports conditioning by coaches and athletes. Despite its useful role in sports conditioning programme, the information about plyometric training on the athlete's cardiovascular health especially Electrocardiogram (ECG) have not been established in the literature. The purpose of the study was to determine the effects of lower and upper body plyometric training on ECG of athletes. The study was guided by three null hypotheses. Seventy-two university male athletes constituted the population of 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 ($\leq 18.5 \pm 24.9$) (height, $x = 1.50 \pm 1.17$ cm; body weight, $x = 50.31 \pm 70.15$ kg), 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 Quasi none 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). The research questions were answered using mean and standard deviation, while paired samples t-test was used to test the hypotheses. The results revealed that athletes who were trained using LBPT had reduced ECG parameters better than those in the control group. The results also revealed that athletes who were trained using both LBPT and UBPT indicated lack of significant differences following ten weeks plyometric training than those in the control group in the ECG parameters except in QRS complex. 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 of university athletes to optimise performance as well as reduce the risk of cardiovascular diseases and promotes good healthy lifestyle.

Keywords: Concentric, eccentric, electrocardiogram, plyometric

1. Introduction

The term plyometric may sound unfamiliar, but most sports enthusiasts have at one time or the other taken part in plyometric training. It 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. It has been a useful training technique for optimising performance in most popular sports by coaches and athletes in the preparation for professional competitions. 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 (SSC). As a muscle stretches and contracts eccentrically, it lengthens while it contracts to produce storable energy (Abbas, 2005). The stored elastic energy within the muscle is used to produce more force than can be provided by using only concentric contraction alone (American College of Sports Medicine, 2015). Plyometric training bridges the gap between speed and strength. The two main categories of plyometrics are lower and upper body plyometric training (Quinn, 2013). 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 (Walker, 2014). Studies have shown that plyometric training greatly improved measures of muscular strength, power, speed, vertical jump, leg strength, agility and running economy after the training (Beardsley, 2014; Bhavna & Sarika, 2010; Coach Colleague, 2009; Matz, 2013; Quinn, 2013).

Plyometric training originated in the late 1960's from Soviet Union and was developed by Russian exercise scientist and coach, Yuri Verkhoshansky (Beardsley, 2014). Verkhoshansky wanted to discover ways to develop the jumping ability of his Olympic athletes. He used depth jumps focusing on reducing the ground contact times, switching from eccentric to concentric action more quickly to increase the speed and explosiveness of his athletes. The landing and takeoff were executed in an extremely short period of time. This training process at that time was called 'shock method' (Patalas, 2013). The term 'plyometric' was later coined by an American athlete Fred Wilt, who after watching the Soviets dominate the Olympics during the 60-70's, decided to investigate how they were training (MacDonald, 2013). As the Soviets began to produce superior athletes in various sports including track and field, gymnastics and power lifting, interest regarding this training increased. Since then other sports across the globe started incorporating plyometrics into their sports training programmes to help their athletes become faster, and exhibit more explosive power.

Electrocardiogram is a simple, painless and noninvasive medical test that measures the electrical activity of the heart as it contracts. It helps to understand how the heart works. The Electrocardiogram (ECG) can help diagnose a range of conditions including heart arrhythmias, heart enlargement, heart inflammation and coronary heart disease. As the heart contracts, it produces these three waves namely P wave, QRS complex and T wave. Any irregularity in the heart rhythm or damage to the heart muscle can change the electrical activity of the heart so that the shape of the ECG is changed and may lead to sudden death. Although plyometric training has been a useful training technique for developing optimal sports performance in most sports, yet it is relatively unknown whether plyometric affect the cardiovascular health and ECG of university athletes. To the limited knowledge of the researcher, there were no studies that have investigated the effect of ECG response of athletes following plyometric training in the literature.

Only a few studies known to the researcher have directly investigated the cardiovascular responses following plyometric training but without including the athletes and ECG. These few studies that investigated the cardiovascular responses to plyometric training have focused on the elderly, obese and patients with different ailments. 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 ailments without including ECG. There is need therefore for this study, so as probably to close this existing gap and provide a baseline data for future research.

1.1. Purpose of the Study

The purpose of this study is to determine the effect of 10 weeks lower and upper body plyometric training on ECG parameters of university athletes.

1.2. Hypotheses

The following null hypotheses were tested at 0.05 level of significance.

- There is no significant difference in the P wave on ECG readings 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 QRS complex on ECG readings 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 T wave on ECG readings 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. Seventy-two male university athletes constitute the population of the study. 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: {mass (kg)/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	UBPT
Exercise X sets X reps	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
Wk 7 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 t-test (-tailed). The level of significance was set at $P \leq 0.05$. However, t-test (2-tailed) 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

Data in figure 1 are used to answer research questions one, two and three.

Figure 1: Pretest and Posttest Mean Scores on ECG Variables of Athletes Who Were Trained Using LBPT

Figure 1 shows that the athletes who were trained using LBPT had the same posttest mean scores on P wave (.09) with their counterparts in the control group (.09). It also shows that the experimental group (LBPT) had reduced posttest mean scores of QRS complex (.04) better than the control group (.05). Fig. 1 also shows that athletes who were trained using LBPT had slightly posttest mean and standard deviation scores of T-wave (.14) with the subjects in the control group (.14).

Data in figure 2 are used to answer these research questions four, five and six

Figure 2: Chart Comparing Pretest Posttest Mean Scores on ECG Variables of Athletes Who Were Trained Using UBPT

Figure 2 shows that athletes who were trained using upper body plyometric training (UBPT) had better posttest mean scores of P wave (.09) better than their counterparts in the control group (.09). The figure also shows that athletes who were trained using UBPT had slightly posttest mean scores of QRS complex (.05) with those in the control group (.05). Figure 2 also revealed that athletes who were trained using UBPT had the highest posttest mean scores of T wave (.17) compared to the subjects in the control group that recorded (.14).

- Hypothesis 1: There is no significant difference in the P wave on ECG readings of university athletes who were trained using lower and upper body plyometric training and those in the control group.

LBPT Pair1 Pre-Post	.0000	.01512	.00535	-.01264	.01264	.000	7	1.000
UBPT Pair 2 Pre-Post	.00250	.01282	.00453	-.00822	.01322	.552	7	.598
Control Pair 3 Pre- Post	.00286	.01380	.00522	-.00991	.01562	.548	6	.604

Table 2: Summary of T-Test (2-Tailed) on P-Wave ECG Reading of Athletes Who Were Trained Using LBPT, UBPT and Control Group

Table 2 shows mean P-wave ECG readings of athletes who were trained using LBPT and UBPT and their untrained controls at posttest condition. The result revealed that the t-calculated value of (.000 and .552) were less than the P-value of (1.000 and .598) respectively at 0.05 level of significant. The t-test (2-tailed) indicates lack of significant differences in P-wave ECG reading of athletes who were trained using the LBPT and UBPT and those in the control group. Thus, the null hypothesis (Ho1) which predicted no significant was therefore accepted.

- Hypothesis2: There is no significant difference in the QRS complex on ECG readings of university athletes who were trained using lower and upper body plyometric training and those in the control group.

Paired Samples Test								
GROUPS P-Wave	Paired Differences					T	Df	Sig.(2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Differences				
				Lower	Upper			
LBPT Pair1 Pre-Post	.0000	.01512	.00535	-.01264	.01264	.000	7	1.000
UBPT Pair 2 Pre-Post	.00250	.01282	.00453	-.00822	.01322	.552	7	.598
Control Pair 3 Pre- Post	.00286	.01380	.00522	-.00991	.01562	.548	6	.604

Table 3: Summary of T-Test (2-Tailed) on QRS Complex on ECG Reading of Athletes Who Were Trained Using LBPT, UBPT and Control Group

Table 3 shows mean QRS complex ECG readings of athletes who were trained using LBPT and UBPT and their untrained controls at posttest condition. The result revealed that the F-calculated value of (2.25 and 0.004) were greater than the P-value of (0.161 and 0.949) at 0.05 level of significant respectively. The t-test (2-tailed) indicates lack of significant differences between the LBPT and UBPT and those in the control group. Thus, the null hypothesis (Ho2) was therefore accepted.

- Hypothesis 3: There is no significant difference in the T wave on ECG readings of university athletes who were trained using lower and upper body plyometric training and those in the control group.

Paired Samples Test								
GROUPS P-Wave	Paired Differences					T	df	Sig.(2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Differences				
				Lower	Upper			
LBPTPair1 Pre-Post								
UBPT Pair 2 Pre-Post	.0000	.01512	.00535	-.01264	.01264	.000	7	1.000
Control Pair 3 Pre- Post	.00250	.01282	.00453	-.00822	.01322	.552	7	.598
	.00286	.01380	.00522	-.00991	.01562	.548	6	.604

Table 4: Summary of T-Test (2-Tailed) on T-Wave on ECG Reading of Athletes Who Were Trained Using LBPT, UBPT and Control Group

Table 4 shows mean T-wave ECG readings of athletes who were trained using LBPT and UBPT and their untrained controls at posttest condition. The result revealed that the F-calculated value of (1.98 and 0.47) were greater than the P-value of (0.208 and 0.515) at 0.05 level of significant respectively. The t-test (2-tailed) indicates lack of significant differences between the LBPT and UBPT and those in the control group. Thus, the null hypothesis (Ho3) which predicted no significant was therefore accepted.

4. Discussion

4.1. Effect of Using Lower and Upper Body Plyometric Training on ECG

Result in Table 2, 3 and 4 showed that there were no significant differences in the posttest means scores of P-wave, QRS complex and T-wave on ECG readings of athletes who were trained using LBPT and UBPT and those in the control group. Table 2 revealed that the athletes who were trained using LBPT and UBPT had F-calculated value of P wave (0.61 and 0.01) significantly greater than the table value of (0.252 and 0.928) at $p > 0.05$ respectively. The result in Table 3 revealed that the F-calculated value of (2.25 and 0.004) were greater than the P-value of QRS complex (0.161 and 0.949) at 0.05 level of significant respectively. Table 4 revealed that the F-calculated value of T wave (1.98 and 0.47) were greater than the P-value of (0.208 and 0.515) at 0.05 level of significant respectively. The t-test (2-tailed) indicates lack of significant differences between the LBPT and UBPT and those in the control group in all ECG parameters. This is clarified in Fig. 2 where athletes who were trained using LBPT had the same P and T wave of (.09 and .14) with the control group (.09 and .14) respectively, while QRS complex had (.04) reduced posttest mean better than the control group (.05). Figure 2 also revealed that athletes who were trained using UBPT had the same P and QRS posttest mean scores, while T wave had highest mean scores with the control group.

This finding is in accordance with Bhavna and Sarika (2010) that found out that no significant change was found in ECG parameter after 10 days of eccentric or concentric training. This may be due to inefficient overloading of the cardiac muscles during training or the intensity or duration of training might not be enough to cause left ventricular or cardiac muscle hypertrophy, both of which are depicted in form of ECG interval changes. The improvement in cardiac muscles indicates that adaptation relating to increase in lower and upper body plyometric have occurred. Plyometric training is based upon the principle of overload and specificity. According to the specificity principle, the specific exercise elicits specific adaptations creating specific training effects. This could be attributed to a decrease in cardiac output or systemic vascular resistance. Moreover, the improvement in cardiac muscles indicates that it has been accompanied by a decrease in peripheral sympathetic activity and an increase in cardiac sympathetic activity.

5. Conclusions

Based on the findings of the study, the following conclusions were made:

At the end, we speculate that the use of LBPT and UBPT had reduced the ECG variables 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, the key mechanisms by which this is achieved include the refinement of an athlete's motor control strategies during the stretch-shortening cycle. However, proper plyometric training technique is important to fully understand the nature of this type of training.

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 non-athletes.

8. References

- i. American College of Sports Medicine [ACSM] (2015). *Guidelines for exercise testing and prescriptions* (7th ed.) Baltimore, MD: Lippincott Williams & Wilkins.
- ii. American College of Sports Medicine [ACSM] (2009). Current comments: Plyometric training for children and adolescents by American College of Sports Medicine –Retrieved February 2, 2014 from <http://www.acsm.org>, by D. Faigenbaum and Donald A. Chu, Ph.D., PT, ATC .
- iii. Ankur, K. &Maulik, S. (2013). A Comparative study on effect of exercise intensity on cardiovascular variables during concentric and eccentric resistance knee extension exercise on healthy male. Retrieved December 15, 2014 from <http://www.academia.edu/5655591/A>.
- iv. Arazi, H., Asadi, A., Rahimzadeh, M., &Moradkhani, A. (2013, December 4). Post- plyometric exercise hypotension and heart rate in normotensive individuals: Influence of exercise intensity. *Asian Journal Sports Medicine*. 4:235-240. PMID: PMC3977206.
- v. Arazi, H. Asadi, A., Seyed, A. M., &Seyed, O.M.N.(2014, March 23). Cardiovascular responses to plyometric exercise affected by workload in athletes. Retrieved from <http://www.ncbi.nlm.nih.gov/doi/10.5114/pwki.2014.4148>.
- vi. Bhavna, M. &Sarika, (2010). Effect of concentric vs. eccentric loading on cardiovascular variables and ECG. *African Journal Health Sciences* 17(3), 47-51July-December.
- vii. Garlock, S. (2013). Concepts of plyometric exercise. Retrieved from <http://www.prorehabpc.com/...concepts-of-plyometric>
- viii. Idea Fitness Journal (2011). Explosive power by Kenneth Fowler & Len Kravit. Retrieved March 19, 2014 from <http://www.ideafitness.com/fitness>
- ix. King, J. (2012). Plyometric safety considerations for young athletes, Part 1.Retrieved April 4, 2015 from <http://www.eliteftes.com/ed>.
- x. Lobo, A. (2012). Effects of detraining on physical fitness and cardiovascular variables in non-institutionalized elders. *Journal MedicalScience* (1) 4-8.
- xi. MacDonald, C. J. (2013). Plyometrics improve performance? The truth (guide to plyometrics) feeds. Retrieved June 11, 2015 from <http://www.thicksolidtight.me/wp>.
- xii. Moro, T., Ewan, T. & Gerardo, B. (2013). Blood pressure and heart rate response to two resistance training technique of different intensity. Retrieved from <http://www.ejss.journal.comdoi:10.12863/ejssbxix2-2013x2pdf>.
- xiii. The Victoria State Government (2015). ECG test. Retrieved June 20, 2015 from <http://www.m.betterhealth.vic.gov/>
- xiv. Walker, B. (2014). Plyometric workouts and plyometrics exercises use plyometric exercises to develop maximum power and strength for your favorite sport. Retrieved from <http://www.injuryfix.com/archives/plyometrics>.
- xv. WebMD, (2014, March 12). Electrocardiogram. Retrieved from <http://www.m.webmd.com/health/Electrocardiogram>.
- xvi. World Health Organization [WHO] (1981). Uses of electrocardiogram. Retrieved June 7, 2015 from <http://www.who.int/.../EURO-R&S-37fulltext.pdf>.