Plyometric Training Improves Power and Agility in Jamaica's National Netball Team

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ABSTRACT

Objective: *Plyometric training is widely used in conditioning, power training and in prevention and rehabilitation of injuries in some sports. This study sought to investigate the effect of a three-week plyometric training programme on jump performance and agility in Jamaican national netball players.*
Method: *Eighteen national netballers participated in a Plyometric training programme. Subjects were evaluated using the Vertical Jump Test, the Broad Jump Test and the Illinois Agility Test prior to the start of the programme and at week 3.*
Data Analysis*: The data were analysed using SPSS version 12 for Windows. A One-Sample Kolmogorov-Smirnov Test showed normal distribution of data and a paired samples t-test was used to determine whether the mean change in jump performance and agility was significant.*
Results: *All eighteen subjects completed the three weeks of training. Three subjects were shown to be outliers at week 3 and this resulted in data from 15 subjects being analysed. At the end of the three weeks, there were significant improvements in Vertical Jump Scores (*$p = 0.023$*), Broad Jump Scores (*$p = 0.002$*) and Agility scores (*$p = 0.045$*).*
Conclusion: *Three weeks of Plyometric training can lead to significant improvements in jump performance and agility and should be integrated into the national training programme at intervals yet to be determined.*

Keywords: Illinois Agility Test, netballers, plyometric training

El Entrenamiento Pliométrico Mejora la Fuerza y Agilidad del Equipo Nacional de Netball de Jamaica

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RESUMEN

Objetivo: *El entrenamiento pliométrico se usa ampliamente para el acondicionamiento, y entrenamiento de fuerza, así como para la prevención y rehabilitación de lesiones en algunos deportes. Este estudio buscó investigar el efecto de un programa de entrenamiento pliométrico de tres semanas sobre el rendimiento en salto alto y la agilidad de las jugadoras del Equipo Nacional de Netball de Jamaica.*
Método: *Dieciocho jugadoras nacionales de netball participaron en un programa de entrenamiento pliométrico. Las sujetos fueron evaluadas usando la prueba de salto vertical, la prueba de salto largo y la prueba de agilidad de Illinois, antes del comienzo del programa y a la semana 3.*
Análisis de datos: *Los datos fueron analizados usando la versión 12 de SPSS para Windows. La Prueba de Kolmogorov-Smirnov para una muestra mostró una distribución normal de los datos y una prueba t de muestras pareadas fue usada para determinar si el cambio promedio en el rendimiento del salto y la agilidad fue significativo.*
Resultados: *Las dieciocho sujetos completaron las tres semanas de entrenamiento. Tres sujetos mostraron tener valores atípicos en la semana 3, y esto trajo por resultado que se analizaran datos de 15 sujetos. Al final de las tres semanas, se produjeron mejoras significativas en las puntuaciones del*

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*salto vertical (*p = *0.023), las puntuaciones del salto largo (*p = *0.002) y las puntuaciones de la agilidad (*p = *0.045).*
Conclusión: *Tres semanas de entrenamiento pliométrico pueden llevar a mejoras significativas en el rendimiento y agilidad, y deben integrarse en el programa de entrenamiento nacional a intervalos aún por determinar.*

Palabras claves: Prueba de agilidad de Illinois, jugadoras de netball, entrenamiento pliométrico

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INTRODUCTION

Netball is a popular female team sport played by over seven million persons worldwide. It is a non-contact sport and is described as "a game reliant on rapid acceleration to 'break free' from an opponent, sudden and rapid changes in direction in combination with leaps to receive a pass, intercept a ball or rebound after attempting a goal" (1). Since 1963, Jamaica has fielded a senior team at the World Championship held every four years. At the junior level, the team participated in the World Junior Championship in 1996, 2000 and 2005. The country has also hosted the Championship in 1971 and 2003. Locally, students participate in netball in schools from the preparatory/primary to the tertiary level and at the club and the business house levels. Training programmes that can improve the power and agility of the players of the national netball teams are therefore of great importance in order to maintain international status. Plyometric training may be a feasible option for accomplishing this.

Plyometrics is a quick powerful movement involving a pre-stretching of the muscle, thereby activating the stretch shortening cycle (2). Maximal-effort Plyometric training was first introduced in Russia by Yuri Verkhoshansky in 1969, to help in the development of "explosive speed strength" in sprinters. It was also referred to as "shock training" since it involved techniques of high intensity (3). Initial programmes involved drop jumps of over three metres which probably exceeded human safety limits. Plyometric exercises consist of three phases: the setting or eccentric phase which begins from the point of mental preparation and lasts until the stretch stimulus is initiated; the amortization phase which is the electromechanical delay between the eccentric and concentric contraction and the concentric response phase. The response phase is the summation of the amortization and eccentric phase and is represented as a facilitated contraction (2).

Several mechanisms have been proposed to explain the improvement in performance that occurs with plyometric training. These include increased speed of the myotactic stretch reflex and desensitization of the golgi tendon organ which raises the level of inhibition, thereby allowing for increased force production when greater forces are applied to the musculoskeletal system. A third mechanism is enhanced neuromuscular coordination leading to greater net force production (2).

Regardless of the mechanisms, plyometric training has been utilized by various athletes for the enhancement of their performance in sports (4, 5). This includes the increase or improvement in strength, power and speed which also encompasses agility. Plyometric exercises "usually involve stopping, starting and changing directions in an explosive manner" and these are the movements involved in playing netball (6). It is possible therefore that plyometric training could improve agility and power in netballers. The objectives of this study were to determine the effect of a three-week plyometric training programme on power and agility of Jamaica's National and Premier League players.

SUBJECTS AND METHODS

A single group experimental pretest/post-test study was conducted after the proposal was reviewed by the Faculty of Medical Sciences, The University of the West Indies/ University Hospital of the West Indies Ethics Committee and given approval.

Sample

This was a sample of convenience consisting of netballers from Jamaica's National Team. Sample size calculations were based on an effect size of 1.5 for the Illinois Agility Test (6). Using the sample size table for the paired *t*-test with an α level of 0.05 and power of 0.9; 12 subjects were deemed to be sufficient (7). Subjects were required to be competing at National and Premier League levels and must have given written consent to participate in the study. Anyone with a history of knee surgery, current musculoskeletal injuries leading to pain at the knees, back or ankles or medical conditions for which plyometric training would be contra-indicated were excluded from the study. In addition, anyone who was currently engaged in plyometric training was also excluded.

Procedure

A letter was sent to the president of the Jamaica Netball Association seeking permission to contact potential participants who may volunteer for this research study. The coaches of the respective teams were invited to a meeting and the study procedures and training programme explained to them. The players who volunteered for this research met with the researcher and the procedure was explained to them, following which they were required to sign informed consent

forms. All volunteers under the age of 18 years were given assent forms to be signed by their parents or guardians. Baseline evaluations were done by independent evaluators at the Leila Robinson Netball courts located at the National Stadium Complex in Kingston, Jamaica. The baseline measurements of reach height with the dominant hand overhead and weight of each volunteer were taken after which they did a ten minute warm–up jogging session followed by a trial run of the required tests. A 30-minute break was taken after the trial run, following which the pretest evaluation began. All subjects were required to do the Vertical Jump Test, Standing Broad Jump Test and the Illinois Agility Test. Following the baseline evaluation, subjects were required to participate in a plyometric training programme twice per week for three-weeks under the supervision of a trainer. Re-evaluations were done at the end of the three weeks.

The training programme was developed based on reviews of other studies involving plyometric training (5, 6, 8, 9) and knowledge of the game. The plyometric training was treated as a novel programme and commenced with low-level, progressing to medium and high-level exercises. Activities involving hops, jumps and sprints with directional changes were included (Table 1). All exercises were supervised by a therapist.

Table 1: Outline of the three-week training programme.

Time/Week	Training volume (foot contacts)	Plyometric drill	Set/Reps	Training intensity
1		Side to side ankle hops	2 x 15	Low
	90	Double leg jump backwards	5 x 6	Low
		Front cone hops	5 x 6	Low
2		Side to side ankle hops	2 x 15	Low
		Hexagon drill	5 x 6	Low
	120	Lateral jump over barrier right and left then sprint 9.14 m forward	6 x 5	Medium
		Dot drill – 4 corners (double leg)	5 x 6	Medium
3	120	Double leg jump backwards	3 x 8	Low
		Dot drill – triangle (double leg)	4 x 6	Low
		Lateral jump over barrier	2 x 12	Medium
		Double leg bunny hops	3 x 8	Medium
		Lateral cone hops then turn 90˚	2 x 12	Medium

Instruments

The Vertical Jump Test was used to determine anaerobic power. The test was done with the participant standing adjacent to the wall in a crouched position with knees flexed to 90˚. Arms were by the sides with tip of the middle finger dipped in washable paint. The subject was then instructed to jump as high as possible and touch a board which was mounted on a wall, with the inked finger. Three jumps were done with a one-minute interval between each jump and the value of the highest jump was recorded in centimetres. The Vertical Jump Test is on the list of fitness evaluations recommended by the American College of Sports Medicine (10) and has been used by other researchers investigating power (6, 8, 11, 12).

The Broad Jump Test was also used to evaluate anaerobic power. The subject was required to stand with both feet on level ground with the point of the shoe at a marked line; knees flexed at 90˚and arms by the sides. They were then instructed to jump as far forward as possible. The measurements were taken from the marked line to the heel that was closer to the marked line. The subjects did three jumps with a one-minute interval between each jump and the value of the best jump recorded. This test has also been used by other authors investigating anaerobic power (8, 11).

The Illinois Agility Test was used to determine the ability of the athlete to run and turn in different directions, accelerate and decelerate. It involved marking an area which was 10 metres long by 5 metres wide with four cones spaced 3.3 metres apart. The subject started in the prone position with hands at shoulder level. On the word go, they were required to get up and run as fast as possible to complete the course. The time to complete the course was recorded. Each subject was requested to complete the run only once at each evaluation. The reliability and validity of this test was reported by other authors (6, 13).

Data Analysis

All of the data collected was entered for analysis into SPSS (Statistical Package for Social Science) version 12 for Windows. The outcomes of interests were the change in vertical jump scores, broad jump scores and Illinois Agility Test scores all of which were measured as continuous variables. Scatter plots for all variables were used to screen for outliers. Following this a One-Sample Kolmogorov-Smirnov Test was done on the initial and change scores for the rest of the subjects to check for a normal distribution. All variables were found to be normally distributed and a paired *t*-test was

done to determine if the mean change in scores was significant.

RESULTS

Demographic Data

Twenty-seven volunteers returned their signed consent forms however, one person did not return to the squad at the time that initial evaluations were being conducted. A total of twenty-six subjects completed the initial evaluation and began the training programme. The mean age of the subjects was 18.6 ± 2.4 years. Prior to the week-3 test, one volunteer withdrew due to bilateral knee pain, one had an injury from participating in club competition, one defaulted without reason and five were absent for the week three test. This resulted in eighteen volunteers who completed three weeks of training and testing. Scatter plots of the data showed subjects 5, 10 and 25 to be outliers and they were excluded from all analyses. Data were analysed for a total of fifteen subjects at the end of week three.

Vertical Jump Scores

Figure 1 shows the individual scores for Vertical Jump Test at the initial evaluation and week three. Eleven subjects had an increase in jump height, three subjects had a small decrease and one subject showed no change at all. Table 2, shows a significant increase in the mean Vertical Jump Scores at the end of the three weeks (1.8 ± 2.7cm, $p = 0.023$).

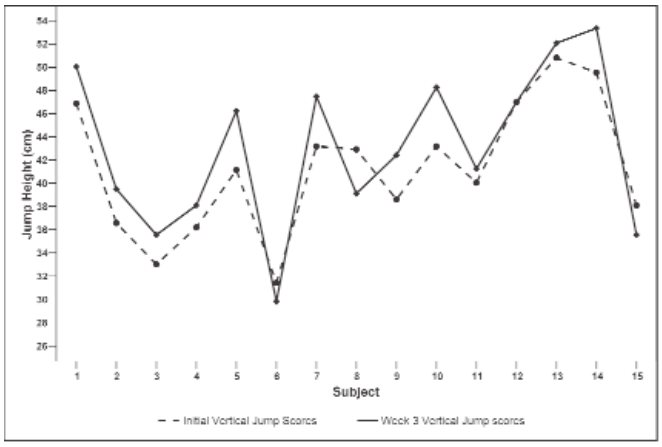

Fig. 1: Vertical Jump Scores at initial evaluation and week three for all subjects.

Broad Jump Scores

Figure 2 shows the individual scores for the Broad Jump Test at the initial evaluation and week – 3 evaluation. Twelve subjects had an increase in jump distance whilst three subjects had a small decrease. As shown in Table 2, the mean change in Broad Jump Scores over the three weeks was significant (12.04 ± 12.11cm, $p = 0.002$).

Illinois Agility Test Scores

Figure 3 shows the individual scores for the Illinois Agility Test at the initial evaluation and week-three evaluation.

Table 2: Descriptive statistics for all tests at initial evaluation and week three

Test Item	Minimum	Maximum	Mean	SD	*t*-test
Initial Vertical Jump Scores (cm)	31.44	50.80	41.24	5.76	
Week 3 Vertical Jump Scores (cm)	29.84	53.34	43.05	6.82	
Change in Vertical Jump Scores	-3.81	5.08	1.81	2.74	*t* (-2.5) *p* (0.023)
Initial Broad Jump Scores (cm)	191.16	229.73	211.53	12.16	
Week 3 Broad Jump Scores (cm)	199.0	249.80	223.57	14.60	
Change in Broad Jump Scores	-5.95	32.04	12.04	12.11	*t* (-3.8) *p* (0.002)
Initial Illinois Agility Test Scores (sec)	16.35	20.23	18.03	1.12	
Week-3 Illinois Agility Test Scores (sec)	16.82	18.78	17.58	0.58	
Change in Illinois Agility Test Scores	-0.49	1.96	0.45	0.79	*t* (2.2) *p* (0.045)

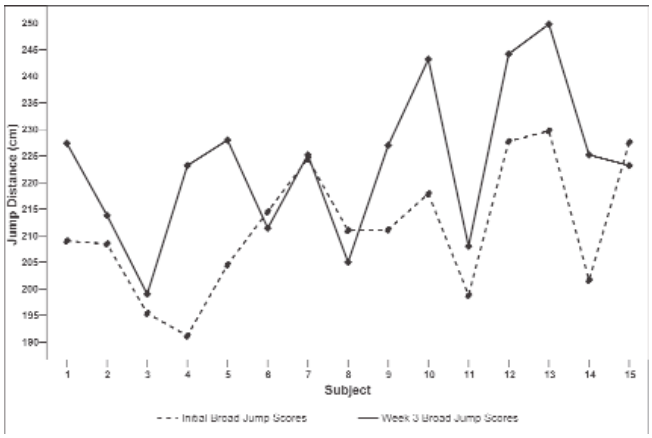

Fig. 2: Broad Jump Scores at initial evaluation and week-three for all subjects.

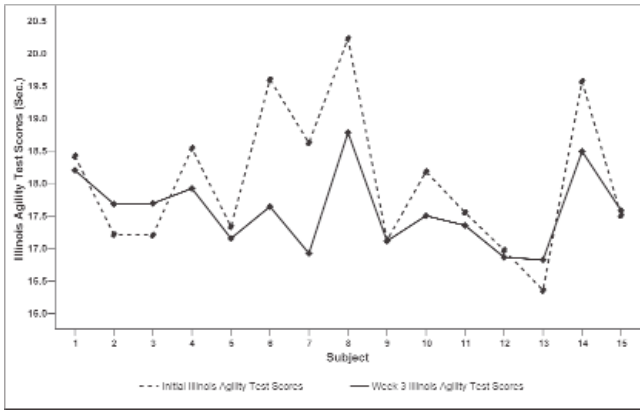

Fig. 3: Illinois Agility Test Scores at initial evaluation and week-three for all subjects.

Eleven subjects had a decrease in the time taken to complete the test. The mean change in Agility scores over the three-weeks was shown to be 0.45 ± 0.79 and this was statistically significant ($p = 0.045$).

DISCUSSION

The results of this research support the hypothesis that plyometric training does improve performance on the Vertical Jump Test, Broad Jump Test and Illinois Agility Test. The findings of this study were similar to previous studies which also showed significant improvements in these tests following plyometric training for basketball and volleyball (5, 6, 8, 9). The majority of studies conducted did their post-test evaluation at six-weeks with the exception of one which evaluated their subjects at two, four and six-weeks of participating in an aquatic based programme (5). The subjects in the present study trained on a netball court and at three weeks, they showed a significant increase in the mean vertical jump score. This change is important to netballers, since an increase in jump height enables them to intercept an opponent's pass, receive a pass above an opponent's reach or collect a ball rebounding from the opponent's attempt at goal. This also holds true for ball passes outside of the goal area where a player can advance her team's ball to goal or prevent the opponent's ball from advancing.

One study looked at vertical jump and broad jump performances following a six-week programme of plyometric and resistance training (8). The results of that study showed significant improvement in performance on both tests. The findings of the current study were very similar even though there was no resistance-training component. At three-weeks, the magnitude of change in the vertical jump score and broad jump score were almost the same as those accomplished by the previous study (8). This indicates that resistance training may not be as important for improving power as a plyometric training programme and lends support to the concept of specificity of training. Improvement in broad jump performance is very advantageous to netball, as any advancement towards the goal area should result in an increased number of goals scored with the least amount of ball passes.

A previous study examined the effects of plyometric training on agility (6). Subjects showed significant improvements in the Illinois Agility Test Scores after six-weeks of training. The present study also found significant improvements in Agility Scores; however, the change was not as large as that shown by the previous study. This may be due to the shorter duration of training for this study. The motor learning literature indicates that neural adaptation is responsible for improvements in performance during the first six-weeks of a training programme (14). At week three, some amount of neural adaptation probably occurred, however the subjects had not yet reached a plateau. If training had continued for six-weeks, the magnitude of change might have been similar to that of the previous author (6). Another reason for the difference in magnitude could be the number and choice of agility exercises. Shuttle runs with longer distances may have produced the same results as the previous study, with the three weeks of training. Agility is an important factor in optimizing performance during a match. During a game, the players have to receive or intercept a pass, stop suddenly, change direction and then sprint to another position on the court. This study indicates that even three-weeks of training can improve agility and possibly performance during competition.

One study compared a land-based plyometric training programme with an aquatic based programme (9). The authors found that both media produced equally significant changes in vertical jump performance. Many of the netballers in Jamaica complain of knee pain which may be caused by the type of surface on which they train. Plyometric training places compressive forces on many joints and it may be worthwhile in the future to consider water-based plyometric training programmes, especially for those who have knee pain.

This was a novel training programme and as such, consisted of more low and medium intensity and less high intensity exercises. It could be that a higher intensity programme may produce even better results. All changes were statistically significant and even though the degree of change may appear small, it is worth noting that, in most sporting events, even a fraction of a second could have an impact on the outcome of an event. In events requiring jumps, a fraction of a millimeter could also affect outcomes. The small changes in vertical jump height, broad jump distance and agility times could collectively make the difference between winning and losing a netball match.

This study showed that a three-week plyometric training programme could enhance the power and agility of professional netballers. These results are encouraging and can provide the coaches and trainers with a sound scientific basis for further improvement of the quality, effectiveness and appropriate training programmes for all levels of netballers. With respect to the sports medicine personnel, the knowledge and use of specific exercises involved in plyometric training will enhance the preventative and rehabilitative care of the netballers. All this will make vital contributions towards the national effort in helping to improve the National (under-21 and senior) Netball teams' chances of being finalists in their respective World Championships. The outcomes of this research may also be helpful to other sporting organizations in their quest for improved performance and international recognition of their respective national teams.

CONCLUSION

A three-week plyometric training programme can significantly improve jump performance and agility of netballers. Inclusion of this type of training may prove to be valuable in improving performance in competition thereby allowing the National team to maintain top international ranking.

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REFERENCES

1. McGrath AC, Ozanne-Smith J. Attacking the Goal of Netball Injury Prevention: A Review of the Literature. Monash University Accident Research Centre, USA Report #130. 1998.
2. Wilk KE, Voight ML, Keirns MA, Gambetta V, Andrews JR, Dillman CJ. Stretch Shortening Drills for the Upper Extremity: Theory and Clinical Applications. J Orthopaedics and Sports Physical Therapy 1993; **17:** 225–39.
3. Chmielewski TL, Myer GD, Kauffman D, Tillman SM. Plyometric exercise in the rehabilitation of athletes: physiological responses and clinical application. J Orthopaedic and Sports Physical Therapy 2006; **36:** 308–19.
4. Wilkerson GB, Colston MA, Shortt NI, Neal KL, Hoewischers PE, Pixley JJ. Neuromuscular changes in female collegiate athletes resulting from a jump-training programme. J Athletic Training 2004; **39:** 17–23.
5. Martel GF, Harmer M, Logan JM, Parker, CB. Aquatic plyometric training increases vertical jump in female volleyball players. Medicine and Science in Sports & Exercise 2005; **10:** 1814–19.
6. Miller MG, Herniman JJ, Ricard MD, Cheatham CC, Michael TJ. The effects of a 6-week plyometric training programme of agility. J Sports Science and Medicine 2006; **5:** 459–65.
7. Portney LG, Watkins MP. Foundations of Clinical Research: Applications and Practice. New Jersey, Prentice Hall Health; 2000.
8. Faigenbaum AD, McFarland JE, Keiper FB, Tevlin W, Ratamess NA, Kang J et al. Effects of short-term plyometric and resistance training programme on fitness performance in boys age 12 to 15 years. Journal of Sports Science and Medicine 2007; **6:** 519–25.
9. Stemm JD, Jacobson BH. Comparison of land- and aquatic-based plyometric training on vertical jump performance. J Strength and Conditioning Research 2007; **21:** 568–71.
10. American College of Sports Medicine [ACSM], ACSM guidelines for Exercise Testing and Prescription (6^{th} ed.), Philadelphia, Lippincott, Williams and Wilkins; 2000.
11. Blackburn JR, Morrissey MC. The relationship between open and closed kinetic chain strength of the lower limb and jumping performance. J Orthopaedic and Sports Physical Therapy 1998; **27:** 430–5.
12. Chimera NJ, Swanik KA, Swanik CB, Straub SJ. Effects of plyometric training on muscle-activation strategies and performance in female athletes. J Athletic Training 2004; **39:** 24–31.
13. Roozen M. Illinois Agility Test. National Strength and Conditioning Association's Performance Training Journal 2004; **3:** 5–6.
14. McArdle WD, Katch FI, Katch VL. Exercise Physiology: Energy, Nutrition, and Human Performance. Maryland, Lippincott Williams & Wilkins; 2007.