

EFFECTS OF PLYOMETRIC TRAINING ON AGILITY AND DYNAMIC POSTURAL CONTROL IN BADMINTON PLAYERS

***Kutty Nizar Abdul Majeed and **Majeeda Nishad Abdul Latheef**

1. Senior Lecturer, Faculty of Medicine and Health Sciences, University Tunku Abdul Rahman, **MALAYSIA**.
2. Senior Physiotherapist, A. M. Physiotherapy Centre, Kerala, **INDIA**.

Email: nizarkualalumpur@gmail.com

(Received September 24, 2015, accepted May 05, 2016)

ABSTRACT

In sports training, the concept of specificity has emerged as an important parameter in determining the proper choice and sequence of exercise in a training program. The aim of this study was to determine the effects of plyometric training on agility and dynamic postural control in badminton players. 32 male badminton players at the age of 20–30 years were randomly assigned to two groups, a plyometric training group (mean age=26.81 ± 1.12) and a control group (mean age=26.37 ± 1.17). Plyometric training group was submitted to 6 weeks of plyometric exercises, two sessions per week. The control group carried out the basic training program only. Agility was evaluated in all subjects using Illinois agility test and Dynamic Postural Control using Y Balance Test prior to and at the end of the trial. Paired and unpaired t-test was used to determine significant differences between pre-test and post-test periods among groups and between groups to analyze the data. The result of this study reveals a significant difference with plyometric training group showing faster times in Illinois agility test ($P \leq 0.0001$, $t = 11.7530$) and an increase in reaching distances in Y Balance Test after 6 weeks. The control group has not showed any significant difference in both outcome measurements. It can be concluded that plyometric training increased agility and dynamic postural control in badminton players.

Key words: Dynamic postural control, Agility, Illinois test, Y Balance Test, Badminton.

INTRODUCTION

The sport of badminton requires specific physical attributes such as advanced function of lower limbs and dynamic postural control. In sports training, the concept of specificity has emerged as an important parameter in determining the proper choice and sequence of exercise in a training program. Enhanced athletic performance emphasizes the muscle's ability to exert maximal force output in a minimal amount of time. Exaggerated maximal muscular force develops due to athletic movements producing a repeated series of stretch-shortening cycles. The stretch-shortening cycle occurs when elastic loading, through an eccentric muscular contraction, is followed by a burst of concentric muscular contraction. A form of exercise called plyometrics employs a quick, powerful movement involving a pre-stretch of the muscle, followed by a shortening, concentric muscular contraction, thus utilizing the stretch-shortening muscular cycle (Wilk KE, 1993). Plyometrics consists of a rapid stretching of a muscle eccentric action immediately followed by a concentric or shortening action of the same muscle and connective tissue (Baechle TR, 2000). The stored elastic energy within the muscle is used to produce more force than that can be provided by a concentric action alone. The landing component of the plyometric exercises induces a stretch to the tendon and muscle. This results in storage and recoil of elastic energy (Harrison AJ, 2001). Agility is the ability to decelerate one's momentum, stop, overcome inertia and accelerate one's body mass in another direction. Dynamic postural control can be defined as performing a functional task without compromising any part of the supporting leg which can be observed in many skills such as backhand in tennis and badminton. Badminton is a great all-round sport that not only demands muscle power, but also needs agility, dynamic postural control, good reflexes and hand-eye coordination. Dynamic postural-control involves some level of expected movement around a base of support. This might involve tasks, such as jumping or hopping to a new location and immediately attempting to remain as motionless as possible or attempting to create purposeful segment movements (reaching) without compromising the established base of support. Although these dynamic measures of postural stability do not exactly replicate sport participation, they more closely mimic demands of physical activity than assessments of static postural stability. Plyometric exercises "usually involve stopping, starting and changing directions in an explosive manner" and these are the movements involved in playing badminton (Miller MG, 2006).

Studies related to agility and dynamic postural control in badminton players are very limited. Although plyometric training has been shown to increase performance variables, little scientific information is available to determine if plyometric training actually enhances agility and dynamic postural control. Moreover, the statistically significant effects of plyometric training on effects of plyometric training on agility and dynamic postural control in teen age badminton players have not yet been established. We hypothesized that plyometric training would result in significantly greater improvements in agility and dynamic postural control in badminton players. The objectives of this study were to determine the effects of a 6-week plyometric training program on agility and dynamic postural control in badminton players.

METHODOLOGY

Thirty two subjects who had played badminton for at least 2 years were recruited for the study from Bharathiya Sports Club, Kerala, India. Subjects were randomly assigned to two groups, a plyometric training group and a control group. Subjects were all males between 20-30 years of age, free of lower extremity injuries, and were not involved in any type of plyometric training at the time of the study. Participants were advised to strictly abstain from smoking during the period of study.

Outcome Measurements

Illinois Agility Run Test:

Agility of the subjects was measured before and after the exercise drill using Illinois Agility Run Test. Getchell B. (1975) reported that the objective of the Illinois test is to monitor the development of the athlete's agility. This test requires the athlete to run the red line route as fast as possible. The athletes took a warm up before starting this test. It is a simple test which is easy to administer and requires little equipment. It has been shown that Illinois test assesses the ability to turn in different directions and at different angles (Bill F, 2001). The aim of the test is to complete a weaving running course in the shortest possible time (Davis B, 2000). Cones mark the course. The subject starts face down, with the head to the start line and hands by the shoulders. At the whistle, the subject runs the course, without knocking down any cones.

The length of the course is 10 meters and the width (distance between the start and finish points) is 5 meters. Four cones are used to mark the start, finish and the two turning points. Another four cones are placed down the center an equal distance apart. Each cone in the center is spaced 3.3 meters apart. Subjects should lie on their front (head to the start line) and hands by their shoulders. On the 'Go' command the stopwatch is started, and the athlete gets up as quickly as possible and runs around the course in the direction indicated, without knocking the cones over, to the finish line, at which the timing is stopped. The reliability and validity of this test was reported by other authors such as Miller MG and Roozen M.

Y Balance Test (YBT):

Dynamic postural control was evaluated by Y Balance Test (YBT) in anterior, posteromedial and posterolateral directions. The YBT Protocol was developed through years of research in lower extremity injury prevention using the Star Excursion Balance Test. This protocol is highly accurate and can be used for measuring pre and post rehabilitation performance, improvement after performance enhancement programs, dynamic balance for fitness programs, and return to sport readiness. Participants stood on the center of Y - junction shape surface. Then as long as they had no error, they did the reaching via indicators movement in a direction which was randomly selected by examiner, and finally, they returned to standing on double leg position (Gribble PA, 2012). The goal of the task is to have the individual establish a stable base of support on the stance limb in the middle of the testing grid and maintain it through a maximal reach excursion in one of the prescribed directions (Gray GW, 1995). The measurements were made before training and after six weeks of training.

Participants engaged in a warm up program prior to strength training. All subjects performed 3 sets of 10 repetitions on squat, bench press, overhead press, lateral pull down, standing calf raise, and biceps curl at the gymnasium. On second session of each week front squat, incline press, lateral pull down, upright row, standing calf raise, and triceps extension were included. Static stretching exercises were performed in a slow, deliberate manner during the six week training

period. The plyometric training group participated in a 6-week training program performing a variety of plyometric exercises designed for the lower extremity along with conventional strengthening and stretching exercises; while the control group did not participate in any plyometric training. All subjects were instructed not to start any additional lower extremity strengthening programs during the six week period and to only perform activities of normal daily living. Prior to the study, procedures and guidelines were presented orally and in written form. All subjects who participated in the study signed an approved consent form.

Plyometric training: Participants engaged in a warm up program prior to plyometric training. Plyometric training group was submitted to 6 weeks of plyometric exercises at the gymnasium, two sessions per week. As recommended by Miller et al. the training volume was 90 foot contacts to 140 foot contacts per session while the intensity of the exercises increased for five weeks before tapering off during week six (Miller MG, 2002). All subjects were under direct supervision and instructed on how to perform each exercise. Plyometric training is shown in Table: 1.

Table: 1

Plyometric drill for the experimental group

Week	Plyometric Drill	Frequency
Week - I	Side to side ankle hops	2X15
	Standing jump and reach	2X15
	Front cone hops	5X6
Week - II	Side to side ankle hops	2X15
	Standing long jump	5X6
	Lateral jump over barrier	2X15
	Double leg hops	5X6
Week - III	Side to side ankle hops	2X12
	Standing long jump	4X6
	Lateral jump over barrier	2X12
	Double leg hops	3X8
	Lateral cone hops	2X12
Week - IV	Diagonal cone hops	4X8
	Standing long jump with lateral sprint	4X8
	Lateral cone hops	2X12

	Single leg bounding	4X7
	Lateral jump single leg	4X6
Week - V	Standing long jump with lateral sprint	4X7
	Lateral cone hops	4X7
	Cone hops with 180 degree turn	4X7
	Single leg bounding	4X7
	Lateral jump single leg	2X7
Week- VI	Diagonal cone hops	2X12
	Hexagon drill	2X12
	Cone hops with change of direction sprint	4X6
	Double leg hops	3X8
	Lateral jump single leg	4X6

Statistical Analyses

Using Microsoft Excel, data was converted into SPSS (Statistical Package for Social Sciences) format for analysis. SPSS version 19 was used. The descriptive statistics were first calculated and the distribution of data was checked. Statistical analysis was done using independent t test to compare the descriptive characteristics (age, height, weight) and found no statistically significant difference. So the homogeneity can be ensured (Table: 2). The pretest scores for Illinois test of control group and plyometric training group has been compared using unpaired t test (Table: 3). By conventional criteria, this difference is considered to be not statistically significant ($P=0.6325$; $t=0.4831$). The pretest and post test scores of Illinois Agility Test of plyometric training group has been compared using paired t test (Table: 4). By conventional criteria, this difference is considered to be extremely statistically significant ($t=11.7530$). The pretest and post test values of Illinois test in plyometric training group has been compared using paired t test (time in sec) and found statistically significant ($t= 11.7530$) and for 3 directions of YBT, Anterior ($t=6.405$), Posteromedial ($t=8.273$) and Posterolateral ($t=11.361$) (Table: 5).

Table 2

Descriptive characteristics of the subjects

Variable	Plyometric group	Control group
Age	26.81 ± 1.12	26.37 ± 1.17
Height	169.11 ± 3.43	170.21 ± 3.21
Weight	67.21 ± 2.41	69.07 ± 2.49

Table 3

The pre-test scores for Illinois test of control group and plyometric training group has been compared using unpaired t test

Pretest Control (Mean)	Pretest Plyometric (Mean)	P value	t
16.131	16.206	0.6325	t = 0.4831

Table 4

The pre-test and post-test scores of Illinois Agility Test of plyometric training group has been compared using paired t test

Pretest Mean	Post Test Mean	p	t
16.206	15.813	P value is less than 0.0001	t = 11.7530

Table 5

Descriptive data for reaching distance in three directions in YBT comparing pre-test and post-test scores of Plyometric group using paired t test

Variable	Pre-test	SD	Post-test	SD	t
Anterior	76.81	1.0207	80.16	2.3830	6.405
Postero medial	80.06	1.1012	85.04	0.9518	8.273
Postero lateral	75.27	1.0324	78.86	0.93790	11.361

RESULTS AND DISCUSSION

The results of our study showed that agility and dynamic postural control were increased in the plyometric group while there was no significant difference in the control group. Illinois test time reduced from 16.20 sec to 15.31 sec. An increase in distance was found in all the three directions of YBT. The difference in YBT was as follows: Anterior (76.81 to 80.16 cm), posteromedial (80.06 to 85.04 cm) and posterolateral (75.27 to 78.86 cm).

The results of the current study showed that plyometric training has a positive effect on agility and dynamic postural control in badminton players. In our study, the badminton players who underwent plyometric training were able to improve their times significantly in Illinois agility test. The result shows improvement in all the three directions of YBT. The findings of this study were similar to previous studies which also showed significant improvements in physical attributes following plyometric training for basketball and volleyball (Faigenbaum, 2007; Martel GF, 2005). In his article, Craig stated that improved times in the agility test can be because of either better motor recruitment or neural adaptations (Craig BW, 2004). In addition, it has been shown that the increase in agility might be due to 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 (Roopchand-Martin S, 2010). Furthermore, the motor learning literature indicates that

neural adaptation is responsible for improvements in performance during the first six-weeks of a training program (McArdle WD, 2007). Notably, the results of our study are in accord with a previous study by Miller M. G. which examined the effects of plyometric training on agility (Miller MG, 2006). Enhanced neuromuscular coordination can lead to greater net force production. However, short-term plyometrics also improves the lower-extremity strength, power and stretch-shortening cycle (SSC) muscle function in healthy individuals. These adaptive changes in neuromuscular function are likely the result of (i) an increased neural drive to the agonist muscles; (ii) changes in the muscle activation strategies (i.e. improved inter muscular coordination); (iii) changes in the mechanical characteristics of the muscle-tendon complex of plantar flexors; (iv) changes in muscle size and/or architecture; and (v) changes in single-fiber mechanics. In their article Markovic & Mikulic suggest that plyometric training either alone or in combination with other typical training modalities, elicits numerous positive changes in the neural and musculoskeletal systems, muscle function and athletic performance of healthy individuals (Markovic G, 2010). Another study by Roper states that plyometrics can decrease ground reaction time because of increase in muscular power and movement efficiency (Roper RL (1998). Upon making contact with the floor, the athlete then goes into slight leg flexion to absorb some of the forces for safety. However, the main role played by the muscles and tendons is to withstand the forces that are experienced in the landing. These forces are withstood in eccentric contraction. When muscle contraction is sufficiently great, it is able to stop the downward movement very quickly. This phase is sometimes called the phase of amortization in which the athlete absorbs some of the forces and stops downward movement by the strong eccentric contraction of the muscles. The strong eccentric contraction prepares the muscles to switch to the concentric contraction in an explosive manner for takeoff (Verkhoshanski Y, 1967). The ability to shorten the amortization phase and also absorbing greater forces during the eccentric contraction will lead to greater force production in the concentric phase. In a previous study by Potteiger et al. the authors speculated that improvements in agility were due to a result of enhanced motor unit recruitment patterns (Potteiger JA, 1999). It has been proven that fast twitch muscle fibers are what allow you to have power and explosiveness. Being agile enables one to feel balanced between speedy movements as well as have control and co-ordination. As there are several changes in direction during a game of badminton, agility is very important.

The overall improvement in agility could have helped the players to augment their dynamic postural control measured using YBT. Hamstring muscle activity is needed for the activities of posteromedial and posterolateral directions. An increase in the strength of hamstrings is critical than the strength of other lower parts of the body for the improvement in these directions. Another reason for the difference in magnitude could be the number and choice of agility exercises.

The lower limb muscles play a major role in counter acting postural sway. The probable reasons of improvement in dynamic postural control after plyometric training are due to the improvement in muscle strength of participants in achievement action, force on neuromuscular system activating sensory receptors etc. The improvement in the strength of quadriceps might have helped in increased distance of anterior reach. Gastrocnemius contraction confronts anterior sway of body and tibialis anterior activates opposite posterior sway of body. Gastrocnemius counteracts anterior sway and hamstrings and para-spinals maintain thigh and knees in erect posture. Some benefits of plyometric training include increases in muscular power movements, brain signal efficiency, kinesthetic or body spatial awareness, motor skills, and reaction force time. In badminton, because of the very small court, an athlete will take a maximum of one or two steps in a particular direction to cover the court, involving a high frequency of diagonal, lateral and forward and backward movements. Plyometric training is a dynamic movement, so increase in balance would also be dynamic. In order for an athlete to perform at a high level in competition, and in training, the athlete must use their balance.

The ability to detect movement and sense position of limbs is mediated by mechanoreceptors found in both muscle and joints. Joint mechanoreceptors are found in ligaments, capsules, meniscus, labrum, and fat pads (Kaya D, 1998). They include Ruffini's endings, Pacinian corpuscles, and free nerve endings. They are most active in the end of ranges of motion. This end range motion is achieved in plyometrics.

Agility is an important factor in optimizing performance during a match. During a game, the players have to stop suddenly, change direction and then sprint to another position on the court. Notably, through proper plyometric training the foundation for this highly sought after skill is

built. Badminton is a great all-round sport that not only demands muscle power, but also need agility, dynamic postural control, good reflexes and hand-eye coordination. Plyometrics maximizes speed while minimizing drag required for specific body positions. The findings of our study are encouraging and can provide the coaches and trainers with a sound scientific basis for further improvement of the quality, effectiveness and appropriate training programs for all levels of badminton players.

CONCLUSION

The findings of the current study are very encouraging and demonstrated the benefits plyometric training on agility and dynamic postural control of badminton players. Badminton players require a high level of physical fitness to cope with the demands of the game and also to allow for their technical and tactical skills to be used to their full, throughout a match. Probably; the most important attribute for a successful badminton player is his skill. However, the right physical attributes can be trained better to refine the skills. The influence of the plyometric training on performance has not been thoroughly examined across developmental ages.

RECOMMENDATIONS

Plyometric training places compressive forces on many joints and it may be worthwhile in future to consider water-based plyometric training programs. The main limitation of the study was that female data could have also been incorporated to draw a generalized statement. This was a novel training program and as such, consisted of more low and medium intensity and less high intensity exercises. In future, studies should be directed to explore the influence of intensity levels on these outcome measurements.

REFERENCES

- Baechle, T. R., and Earle, R. W. **(2000)**. Essentials of strength training and conditioning (2nd edition). Champaign, IL: *National Strength and Conditioning Association*.
- Bill, F. **(2001)**. High-Performance Sports Conditioning. *Human Kinetics Publisher*. ISBN 0-7360-0163-8.

- Craig, B. W. **(2004)**. What is the scientific basis of speed and agility? *Strength Cond*; **226(3)**. P. 13-14.
- Davis, B. **(2000)**. Physical Education and the study of sport. 4th ed. *Spain: Harcourt*. P. 129
- Faigenbaum, A. D., McFarland, J. E., and Keiper, F. B. **(2007)**. Effects of short-term plyometric and resistance training programme on fitness performance in boys age 12 to 15 years. *J Sports Sci. Med*; **6**. P. 519–25.
- Getchell, B. **(1975)**. Physical Fitness: A Way of Life (2nd Edition). *New York: John Wiley and Sons, Inc.*
- Gray, G. W. **(1995)**. Lower Extremity Functional Profile. *Wynn Marketing, Inc.*
- Gribble, P. A., Hertel, J., and Plisky, P. **(2012)**. Using the Star Excursion Balance Test to Assess Dynamic Postural-Control Deficits and Outcomes in Lower Extremity Injury: A Literature and Systematic Review. *J Athl Training*; **47(3)**. P. 339–357. doi: 10.4085/1062-6050-47.3.08.
- Harrison, A. J. and Gaffney, S. **(2001)**. Motor development and gender effects on stretch-shortening cycle performance. *J Sci Med Sport*; **4**. P. 406-415.
- Kaya, D., Dilicikik, U., Guney, H., Demirel, H., and Doral, M. N. **(1998)**. Proprioception: Definition, clinical importance and evaluation methods. *J Sports Sci. Med*; **11**. P. 43.
- Markovic, G., and Mikulic, P. **(2010)**. Neuro-Musculoskeletal and Performance Adaptations to Lower-Extremity Plyometric Training. *Sports Med*; **(40)10**. P. 859-895.
- Martel, G. F., Harmer, M., and Logan, J. M. **(2005)**. Aquatic plyometric training increases vertical jump in female volleyball players. *Med Sci Sports Exerc*; **10**. P. 1814–19.
- McArdle, W. D., Katch, F. I. and Katch, V. L. **(2007)**. Exercise Physiology: Energy, Nutrition, and Human Performance. *Maryland, Lippincott Williams and Wilkins*.

- Miller, M. G., Herniman, J. J., and Ricard, M. D. **(2006)**. The effects of a 6-week plyometric training programme of agility. *J Sports Sci. Med*; **5**. P. 459–65.
- Miller, M. G., Berry, D. C., and Bullard, S. **(2002)**. Comparisons of land-based and aquatic-based plyometric programs during an 8-week training period. *J Sport Rehabil*; **111**. P. 269-283.
- Potteiger, J. A., Lockwood, R. H., and Haub, M. D. **(1999)**. Muscle power and fiber characteristic following 8 weeks of plyometric training. *J Strength Cond Res*; **113**. P. 275- 279.
- Roopchand-Martin, S., and Lue-Chin, P. **(2010)**. Plyometric Training Improves Power and Agility in Jamaica's National Netball Team. *W Indian Med J*; **59(2)**. P. 182-186.
- Roozen, M. **(2004)**. Illinois Agility Test. *Natl. Str. Cond. Assoc. J*; **3**. P. 5–6.
- Roper, R. L. **(1998)**. Incorporating agility training and backward movement into a plyometric program. *Strength Cond*; **20(4)**. P. 60-63.
- Verkhoshanski, Y. **(1967)**. “Are Depth Jumps Useful?” *Legkaya Atletika* (12th edition). Track and Field. P. 9.
- Wilk, K. E., Voight, M. L., and Keirns, M. A. **(1993)**. Stretch Shortening Drills for the Upper Extremity: Theory and Clinical Applications. *J Orthop Sports Phys Ther*; **17**. P. 225–39.

ACKNOWLEDGEMENT

The authors are thankful to the badminton players who took part in this study. They also wish to thank the office bearers of Bharathiya Sports Club and Power Gymnasium, Kerala, India. The valuable suggestions of Mr. Ajmal Sheriff, Sports Physiotherapist, Al Nasar Sports Club, Dubai, UAE is gratefully acknowledged. No financial support was received for this study.