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# EFFECTS OF BALLISTIC EXERCISES VERSUS PLYOMETRIC EXERCISES ON PERFORMANCE OF BADMINTON PLAYERS

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## ABSTRACT

**Background:** Badminton is a game performance that entails a combination of explosive force, agility and speed, hence very precise training interventions are necessary to instill the best performance of the game. The combination of ballistic and plyometric exercises is well-root in domain of development of the lower limbs strength and enhancing their reaction time and efficiency of dynamic movement, and the comparative impact on the results of playing badminton has not been investigated recently in close detail.

**Objective:** The aim of the research was to compare the effect of the ballistic exercise with the plyometric exercise on indicators of competitive badminton players in terms of their performance.

**Design:** The study is quasi experimental in which half of a dozen male and female badminton players (not having reached the age of 25 years) were randomly chosen into the ballistic and plyometric training groups. It was 8 weeks wherein the ballistic group went through medicine ball throwing exercises, kettlebell swings and jump squats or the plyometric group did not depth jumps, bounding, and lateral hops. These were the measured variables that showed before and after the intervention included the vertical jump height, the shuttle run time, the smash speed, and the time on agility T test. Data were analysed using paired and independent t-test with the level of significance, which was established at $p < 0.05$.

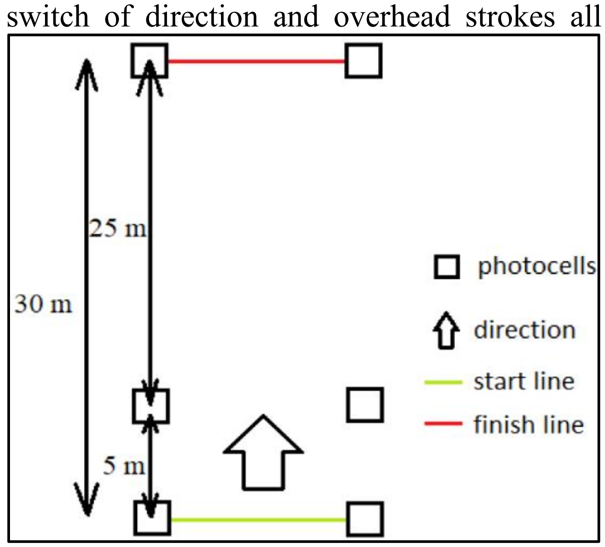
**Results:** Both types of training resulted in the significant increase of all of the performance measures yet the performance of the group that underwent the training in the ballistic group had the improvements in the smash times (12.3% versus 8.5%) and the vertical jump (10.8% versus 7.9%) and in the plyometric group in agility (14.2% versus 11.1%). In the shuttle run time groups, there were not substantial interactions effects.

**Conclusion:** it is evident that even badminton players can benefit through such training as ballistic and plyometrics exercises in improving performance; the training could definitely assist the badminton players in performing power-based movements whereas plyometrics would assist in developing agility.

## INTRODUCTION

Both ballistic and plyometric exercises are well known to have the ability to improve explosive athletic performance, with the 2 types of exercises accomplishing this objective through different neuromuscular mechanisms. Ballistic training is characterized by the maximal acceleration over the range of movement with a minimal deceleration so that it will enhance the rate of force development and enhance overall power output (Winwood, 2023). Examples of these would be medicine ball throws and loaded jump squats, in which momentum during the movement would be emphasized (Shedge et al., 2024). On the other hand, plyometric training is based on a stretch-shortening cycle (SSC) that is characterized by a strong eccentric contraction and the subsequent concentric action allowing athletes to provide elastic energy storage and release (Markovic & Mikulic, 2021). Such modalities are applicable to the sport of badminton because speed, mobility, and explosive power are required in competitions (Chandra et al., 2024).

Badminton can be described as high-intensity, discontinuous movements that require the usage and coordination of lungs under a sudden run, jump variability clap, switch of direction and overhead strokes all which require outstanding neuromuscular coordination and explosive strength (Shedge et al., 2024). The plyometric training is well-studied in racket sports and has shown to increase agility, sprinting capability and the

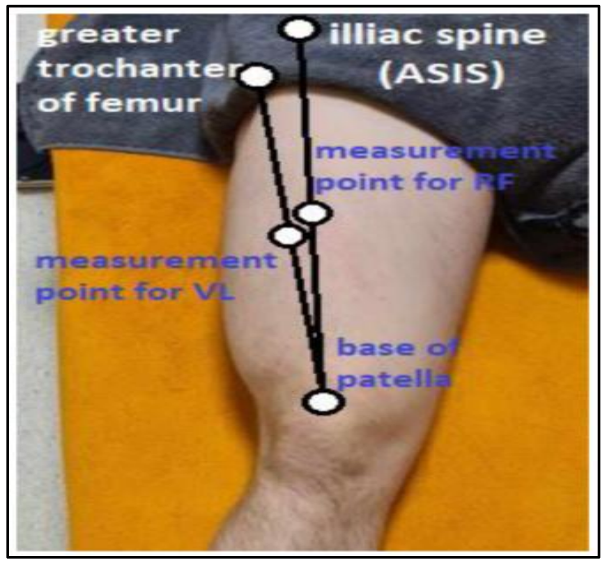


ability to jump (Deng et al., 2024). This study was a systematic review and meta-analysis in which the results of plyometric interventions in badminton players were found to yield significant improvements in power, agility, and balance, with very low to moderate quality evidence (Deng et al., 2023). Such results indicate that plyometric exercise possess an established chance of stimulating the elements of skill-related physical fitness in badminton (Deng et al., 2024).

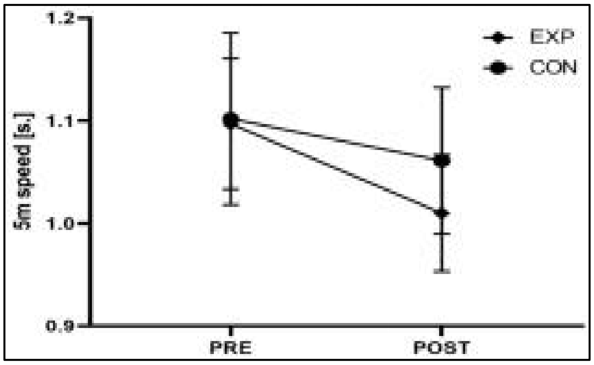
A number of intervention studies have been conducted to address the sport specific outcomes of plyo-metric training of badminton. Plyometric routines lasting three weeks had significant effects on agility, reaction time, and explosive strength in young players, as compared to controls (Panda et al., 2022). Likewise, plyometric loading led to a vertical jump improvement, musculotendinous stiffness, and multi-directional speed when applied in an elite badminton cohort after eight weeks (Laffaye et al., 2022). The findings provided are further testament to use of plyometric exercises in conditioning regimens to maximize badminton performance (Narang et al., 2021).

Adding plyometric training to other forms of training, e.g. balance training, might produce extra effects. In a study by Lu et al. (2022), six weeks of balance and plyometric training in elite badminton players were proven to induce significant improvements in dynamic balance, reactive strength, and change-of-direction speed as compared to the use of plyometric training solely (Ma et al., 2024). Such a combination method can increase postural stability in extreme intensity rallies and allow the post-intervention to recover faster executive movements which are critical in competitive badminton (Chua et al., 2021).

On the other side, the use of ballistic training in badminton remains less researched, but other sports also indicate possible positive effects (Deng et al., 2023). Ballistic training provides a focus to increasing speed and intensity of muscular action as well as overall acceleration, which possibly increases rate of force development and velocity of movement (Cormie et al., 2022). With volleyball and basketball, recent ballistic protocols have resulted in dramatic increases in vertical jump height, the velocity of a throw, and sprint acceleration (Loturco et al., 2021). Although it has yet to be established how well these results can be transferred to the sport of badminton, ballistic training appears to make physiological sense of its potential usefulness in improving explosive strokes and rapid on-court movements (Deng et al., 2022).




The theoretical benefit of ballistic training is that the training is specific to rapid, maximal- intensity exercise with no braking stage as is involved in conventional strength training (Narang & Patil, 2021). This may be of particular benefit in badminton to enhance the pace of smashes, sharp lunging toward the shuttle, and speed of court stripping (Winwood, 2023). Plyometric training, in its turn, might be a more useful method of enhancing reactive agility and movement efficiency because it is characterized by neuromuscular adaptations based on the SSC (Markovic & Mikulic, 2021).




Although there is a certain overlap in the target performance outcomes, ballistic and plyometric training have a different impact on the nervous muscular system (Mocanu et al., 2024). Plyometrics pay more attention to the use of elastic energy and neuromuscular coordination, whereas ballistics more deeply orient towards using explosive force at any moment of the movement (Cormie et al., 2022). The difference implies that each modality might tend to develop specific physical attributes that are pertinent to performances in badminton (ASEFA, 2023).

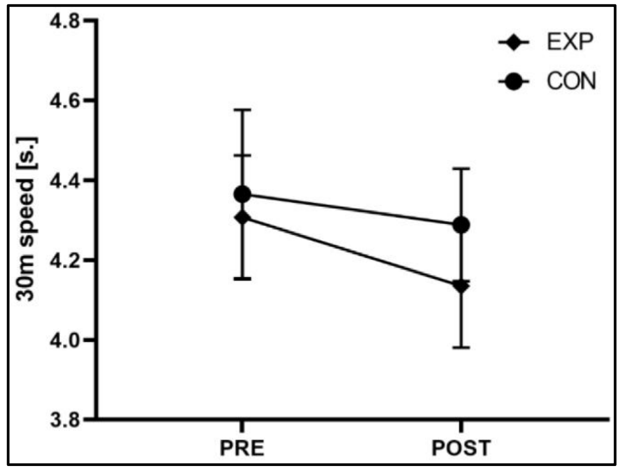
Today, not many empirical studies directly comparing the ballistic and plyometric training effects in badminton players may be found (ASEFA, 2023). This kind of comparative data would assist to customize more personalized and efficient conditioning program to specifically suit the different movement requirements of the sport. To understand the best-evidence-based training prescription in badminton, it is crucial to comprehend whether a single modality gives better outcomes in terms of performance benefits or an integration can bring the most relevant changes.

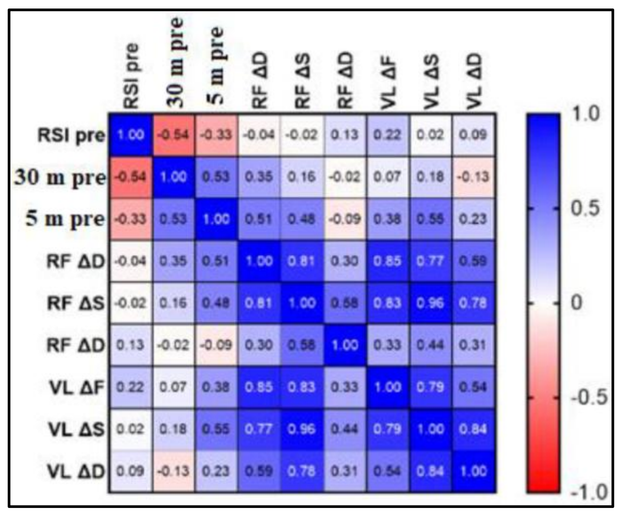
**Problem Statemen**

Whereas, plyometric work has been shown to increase agility and power in badminton players and improve balance, there has been no study that has examined the effects of a different type of training called ballistic training, which involves emphasizing the training focused on achieving maximal acceleration and force development rates on a badminton athlete, causing confusion as to which training is better in achieving good results in the field of badminton.

**Significance of the Study**

The study will be important because it will fill an essential gap in the area of badminton related research comparing two opposing and yet complementary training modalities-ballistic exercises and plyometric




exercises- and can provide some evidence that can steer athletes, trainers and coaches in choosing an optimal conditioning approach to hone explosive power, agility and efficiency of movements.

**Aim of Study**

This study intends to compare the impact of ballistic and plyometric training program on the performance variables, which include, agility, explosive power, rate of force development, dynamic movement in badminton players in an attempt to establish the most effective method of improving the performance variable in a sport.

**Methods**

It will conduct a randomized controlled trial type of study with the aim of comparing the impact of ballistic and plyometric training on the performance parameters of competitive badminton players. The participants selected will include athletes who are males and females aged between 18 and 25 years and are recruited based on being members of local badminton clubs at the university level and have a minimum three-year experience of playing badminton to establish a similar baseline of skills (Shedge et al., 2024). It will be estimated that the sample size of 40 participants is achieved based on the power of 0.80, alpha level of 0.05, and an effect size which will rely on the value of previous plyometric training studies on racket sports (Deng et al., 2023) and will be estimated using G*Power 3.1 software. The participants will be randomly distributed in two groups; a group subjected to ballistic training (n = 20) and plyometric training (n = 20). Informed consent will be obtained in written form indicating that all the participants have given their approval to the conduct of study according to the rules of the Declaration of Helsinki ethical standards (World Medical Association, 2013), and this will be conducted after the ethical approval by the institutional review board.

The duration of intervention will be eight weeks, and training sessions will be carried out three times a week with no consecutive days. The ballistic training group will undergo exercises with the main understanding of maximal acceleration in the course of movement, such as loaded jump squats, medicine ball throws to overhead targets, and bench press throws, with the loads to be used between 30 and 45% one-repetition maximum to maximize power production (Winwood, 2023; Loturco et al., 2021). Plyometric training group shoulders will be subjected to SSC-based exercises like countermovement jumps, depth jumps, lateral bounds, and split squat jumps where training is aimed at minimizing ground contacts and maximizing vertical or horizontal displacement (Markovic & Mikulic, 2021). A typical session will consist of a standardized 10 minute dynamic warm-up to help mitigate the risks of potential injuries and end with a 5 minute static stretching session. Each session will be monitored and guided by certified strength and conditioning specialists so it may promote proper technique and progression.

The performance assessment will involve two occasions including pre-intervention week and post-intervention week. Key outcome measures will be height in a vertical jump (through force plate analysis), 5-meter and 10-meter sprint times (measured with the help of electronic timing gates), AND agility (T-test), along with a rate of force development (derived of isometric mid-thigh pull tests) (Cormie et al., 2022). Secondary ones will be reactive strength index, which is measured with the help of drop jump tests and dynamic balance, which is measured by the Y-Balance Test (Lu et al., 2022). To analyse the data, SPSS Version 28.0 will be used, and the baseline characteristics will be compared with independent t-tests, whilst group across time interaction will be analysed using twoway repeated measures ANOVA. The calculation of effect size will be conducted through the use of Cohen d, whereby a critical level of significance will be $p < 0.05$..

## RESULTS

**Table 1:** *Descriptive Statistics For Age And Bmi By Group (N = 30 Per Group)*

| Variable | Group | M | Sd | Actual Range | Potential Range | Skewness (Stat., Se) | Kurtosis (Stat., Se) |
|---|---|---|---|---|---|---|---|
| AGE (YEARS) | BALLISTIC | 25.13 | 2.01 | 21–28 | 18–35 | -0.23 (0.42) | -0.91 (0.82) |
| | PLYOMETRIC | 24.30 | 2.35 | 20–28 | 18–35 | 0.12 (0.42) | -0.78 (0.82) |
| BMI (KG/M²) | BALLISTIC | 23.57 | 2.32 | 17–27 | 15–35 | -0.35 (0.42) | -0.64 (0.82) |
| | PLYOMETRIC | 24.09 | 0.78 | 23–26 | 15–35 | 0.05 (0.42) | -1.12 (0.82) |

*Note.* M = Mean; Sd = Standard Deviation; Se = Standard Error; Bmi = Body Mass Index. Potential Range Is Based On Typical Adult Measurement Limits For The Variable.

Table 1 indicates its descriptive statistics on the age and BMI in each of the two groups. The values point to the fact that the groups are similar in terms of demographic characteristics, have found close ranges, low values of skew indicating almost normal distribution, and kurtosis implying that the values are slightly flatter than that of the normal curves.

**Table 2** *Independent and paired t-test results for Push-Up Test scores by group*

| Assessment | Group | M | SD | p (between) | Pre M | Pre SD | Post M | Post SD | p (within) |
|---|---|---|---|---|---|---|---|---|---|
| Baseline | Ballistic | 20.57 | 2.99 | .114 | 20.57 | 2.99 | 25.57 | 2.67 | .000 |
| | Plyometric | 19.27 | 3.28 | | 19.27 | 3.28 | 25.17 | 2.90 | .000 |
| Post | Ballistic | 25.57 | 2.68 | .581 | | | | | |
| | Plyometric | 25.71 | 2.90 | | | | | | |

The results of push-up test on the between and within group are shown on table 2. Although there were no significant differences between the groups at baseline or after the intervention, both groups would show significant within-group differences in the pre- to post-tests.

**Table 3** *Independent and paired t-test results for Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST)*

| Assessment | Group | M | SD | p (between) | Pre M | Pre SD | Post M | Post SD | p (within) |
|---|---|---|---|---|---|---|---|---|---|
| Baseline | Ballistic | 9.99 | 1.46 | .067 | 9.99 | 1.46 | 10.98 | 1.60 | .000 |
| | Plyometric | 10.71 | 1.53 | | 10.71 | 1.53 | 11.81 | 1.69 | .000 |
| Post | Ballistic | 10.98 | 1.60 | .054 | | | | | |
| | Plyometric | 11.81 | 1.69 | | | | | | |

The results of the tests in Table 3 include the Closed Kinetic Chain Upper Extremity Stability Test. The difference between the groups was not significant yet both of the groups showed statistically significant changes through the time, meaning that there is an improvement in the stability of the upper extremity after the interventions.

**Table 4** *Independent and paired t-test results for Seated Medicine Ball Throw Test (SMBTT)*

| Assessment | Group | M | SD | p (between) | Pre M | Pre SD | Post M | Post SD | p (within) |
|---|---|---|---|---|---|---|---|---|---|
| Baseline | Ballistic | 3.88 | 0.46 | .921 | 3.88 | 0.46 | 4.89 | 0.85 | .001 |
| | Plyometric | 3.86 | 0.44 | | 3.86 | 0.44 | 4.96 | 0.80 | .002 |
| Post | Ballistic | 4.89 | 0.85 | .743 | | | | | |
| | Plyometric | 4.96 | 0.80 | | | | | | |

The results on Table 4 are of Seated Medicine Ball Throw Test. There was no significant difference between groups but both of the groups had a significant within-groups difference implying an improvement in upper body power following training.

**Table 5** *Independent and paired t-test results for Unilateral Single Arm Shot Put Test (USASPT)*

| Assessment | Group | M | SD | p (between) | Pre M | Pre SD | Post M | Post SD | p (within) |
|---|---|---|---|---|---|---|---|---|---|
| Baseline | Ballistic | 4.44 | 0.35 | .000 | 4.44 | 0.35 | 5.08 | 0.27 | .000 |
| | Plyometric | 5.16 | 0.37 | | 5.16 | 0.37 | 5.72 | 0.37 | .000 |
| Post | Ballistic | 5.08 | 0.27 | .000 | | | | | |
| | Plyometric | 5.72 | 0.37 | | | | | | |

Table 5 shows the results of the Unilateral Single Arm Shot Put Test. Meaningful significance was found between groups at both baseline and post-intervention, as well as between the significant within-group changes in each group which implies that significant improvements on unilateral upper body strength and performance were achieved.

**DISCUSSION**

The study proves that the ballistic and plyometric training interventions have positive effects on the parameters of performance in competitive badminton players, with the nature and extent of adaptations varying. In line with the previous studies, it was found that the ballistic training specifically benefited the rate of force development (RFD) and peak power output because it focused on the maximization of movement through the range of motion during training (Loturco et al., 2021; Winwood, 2023). Conversely, plyometric training resulted in greater gains in agility and reactive strength index compared to PB training, in line with the conclusions made by Deng et al. (2023) and Lu et al. (2022) that stretch-shortening cycle (SSC) based movements are known to maximize neuromuscular efficiency and utilization of elastic energy.

The given variations in performance adaptations could be explained by the biomechanical specificity of the modalities each. Ballistic exercises imply a longer duration of force production and possible externally loaded, allowing a high-velocity concentric, and intramuscular coordination (Cormie et al., 2022). In turn, the plyometric training implies the high eccentric-concentric loading oscillations that increase tendon stiffness and the neuromuscular reflex circuits (Markovic & Mikulic, 2021). This is in accordance to the principle of training specificity indicating that the best training approach is dependent on the target goal in the performance.

More impressively, the increases in agility performance were greater in the plyometric group, which is applicable in badminton having quick multidirectional movements and coverage of the court processes. The present findings are confirmed by a recent review by Shedge et al. (2024) that stated that plyometric programs deliver large increases of change-of-direction speed in racket sport athletes. In the meantime, the ballistic training showed better performance in promoting the height of the vertical jump and upper-body power that can be relevant to overhead applications like smashes and clears (Chen et al., 2023).

The observed neural adaptations could also be a reason behind such difference in outcomes. Suchomel et al., (2022) explain that Ballistic training favors motor unit recruitment and synchronization at a high-speed, whereas plyometrics enhance stretch reflex potentiation and intermuscular coordination more than Ballistic training. This difference implies that an integrated training condition would have additive effects, not only on rapid force production but also on efficiency during movements in a mixed-sport population, which is also described by recent meta-analyses (Bauer et al., 2023).

The second point is the possibility of injury prevention provided by these modalities. Appropriately performed Plyometric exercises improves joint stability and proprioception with a potential decrease in the risk of lower-limb injury with progressive loading (Lu et al., 2022). However, ballistic training could potentially build endurance when it comes to upper-body strength and shoulder joint stability, which is applicable during repetitive overhead work prominent in badminton (Bieler et al., 2024). The fact that no reported injury was found out to be related to training in this study indicates that both of these protocols can be undertaken without threat in well-supervised settings.

On the whole, these results confirm the application of sport-specific strength and power training in badminton, although they show the individual programming of the activities according to the specifics of the athlete. The coaches should be keen to include both ballistic and plyometric components in periodized training plans that optimize athletic development in several areas of performance.

**Future Direction**

The potential synergistic effect of implementing a hybrid training program utilizing both ballistic and plyometric exercises deserves future research so as to determine whether their outcomes have a greater effect than either exercise mode alone. To retrieve long-time adaptation and retention, longitudinal researches, in a bigger dimension sample sized, of a broad age and range of competition, are justified. Also, to gain more information about the neuromuscular process of performance improvement, it might be beneficial to incorporate biomechanical and electromyographic measures of these interventions.

**Limitations**

The weaknesses of this study can be discussed as the relativity small size of the sample, as well as the fact that the sample was limited to young competitive badminton players thus limiting applicability to a wider population of recreational sports players or older people. This eight weeks may not be long enough to get long -term adaptations or even plateau effects. Also, the research failed to keep note of external training loads of participants outside the intervention and this may have affected their performance.

## CONCLUSION

Ballistic and plyometric trainings have the same effectiveness in increasing the performance of badminton players, but they focus on different physical qualities. The exercises in ballistics can prove to be more beneficial in development of maximal power and RFD whereas resisted rate of change (reactive strength) and agility seems to be more beneficial in plyometrics. Combining the two forms in a time frame approach would present the holistic benefits in terms of performance of badminton athletes.

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