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# Effect of Graded Motor Control Core Exercise Program on Agility and Dynamic Balance Among Amateur Badminton Players a Randomized Controlled Trial

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**Abstract:**

- ***Background:***

**Badminton is a dynamic sport requiring high levels of agility, coordination, and neuromuscular control. Amateur players, who often lack structured training, face a higher risk of injury—particularly to the lower limbs—due to inadequate physical conditioning and poor motor control. This project explores the role of Graded Motor Control (GMC) as a progressive training approach to enhance core stability, dynamic balance, and agility among amateur badminton players. By incorporating targeted GMC exercises, the study aims to improve movement efficiency, reduce injury risk, and support long-term athletic performance and participation in the sport.**

- ***Methodology:***

**After designing the study Institutional Ethical Approval was taken. Consent was obtained from all the participants. 69 samples were screened based on eligibility criteria, 9 were excluded and 60 participants were further divided into Group A (experimental group) (n=30) and Group B (control group) (n=30). Pre-assessment was done at Week 0. The experimental group received the received Graded Motor Control Core Exercise Program for 4 session per week for 6 weeks. The control group did their regular exercise program. Post-assessment was done at week 6.**

- ***Result:***

**The Shapiro-Wilk test was used to assess the normality of data distribution. Analysis of variance (Sample T Test) was used for comparison of mean at different time intervals. which showed statistically significant difference for Dynamic Balance and Agility ($p < 0.005$), when measured after training.**

- ***Conclusion:***

**The findings revealed that graded motor control core exercise program showed significant improvements in both agility and dynamic balance compared to those in the conventional training group. Moreover, the between-group comparison indicated a statistically significant difference, confirming the superiority of the graded motor control approach over conventional training methods.**

***Keywords:*** *Graded Motor Control Core,3 Cone Drill Test, Star Excursion Test, Dynamic Balance*.

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## I. INTRODUCTION

Badminton is a fast-paced and dynamic sport that demands high levels of agility, coordination, speed, and neuromuscular control. Players are required to make rapid movements such as lunges, jumps, quick directional changes, and sudden stops. These actions place significant stress on the body, particularly the lower limbs, increasing the risk of injuries.

Studies indicate an injury rate of approximately 3.1 per 1,000 hours of play, with ankle sprains and knee injuries being the most common. Amateur players are especially vulnerable due to inadequate physical conditioning and the lack of structured, sport-specific training programs. Unlike professional athletes, who benefit from personalized coaching and supervised training, amateur players often rely on general fitness routines and casual play.

One major concern is the lack of neuromuscular control and dynamic balance in recreational athletes. Research shows that nearly 30% of amateur players experience injuries related to poor motor control, particularly in the early stages of their involvement in the sport. This highlights the need for specialized training to correct inefficient movement patterns and improve body control.

To address this, training should focus on core stability, proprioception, and movement coordination**.** A highly effective method is Graded Motor Control (GMC)**,** which involves a progressive series of exercises aimed at improving movement quality, muscular coordination, and balance. By targeting the neuromuscular system, GMC helps athletes develop the control needed to perform high-level movements safely and efficiently.

One such approach is graded motor control (GMC), a method designed to progressively improve motor skills and movement efficiency through a structured sequence of exercises. This method is aimed at improving proprioception, movement patterns, and muscular coordination, which are foundational for dynamic balance and agility. make it small only focused on major points

## II. MATERIALS AND METHODS

### *A. Design*

Randomized control trial was carried out, participants were divided into 2 groups. It was single blinded study (Participants involved in the group were blinded) The study has begun after the Ethical Clearance from the Institutional ethical committee. The IEC no is **(Dr. APJAKCOPT/MPT/PG/2024/25)** , And the study was guided by the principles outlined in the Declaration of Helsinki to ensure the protection and dignity of all human participants, Clinical Trials Registry-India (CTRI) registration is done. The CTRI registration no is **CTRI/2024/03/063835.**

### *B. Study Setting*

The study was conducted at Department of Orthopedic Physiotherapy, Dr. A.P.J Abdul Kalam college of Physiotherapy, Loni.

### *C. Study Duration*

2 Years.

### *D. Sample size calculation*

Sample size was calculated using open Epi software, with 95% confidence interval and power of 80%. Grounded on the above-mentioned assumptions, the sample size needed for this study was 60 participants. We added 9 subjects to compensate for any dropout.

### *E. Participant recruitment*

All participants were asked to deeply read the study procedures and sign a detailed consent from before starting study procedures. Participants who were, both male and female, ready to signed the consent were included in the study. Amateur badminton players, Age group 18 to 25 years, And any type of acute and severe systemic illness, Any recent surgical and medical history. Participants undergoing any other training program, Participants which Psychologically Unstable, Players in Medication that affects sports performance were Excluded.

### *F. Randomization Allocation*

The courts obtained from randomization were maintained in opaque sealed envelope until the intervention begin. The allocation was concealed by Sequentially numbered, opaque, sealed envelope (SNOSE).

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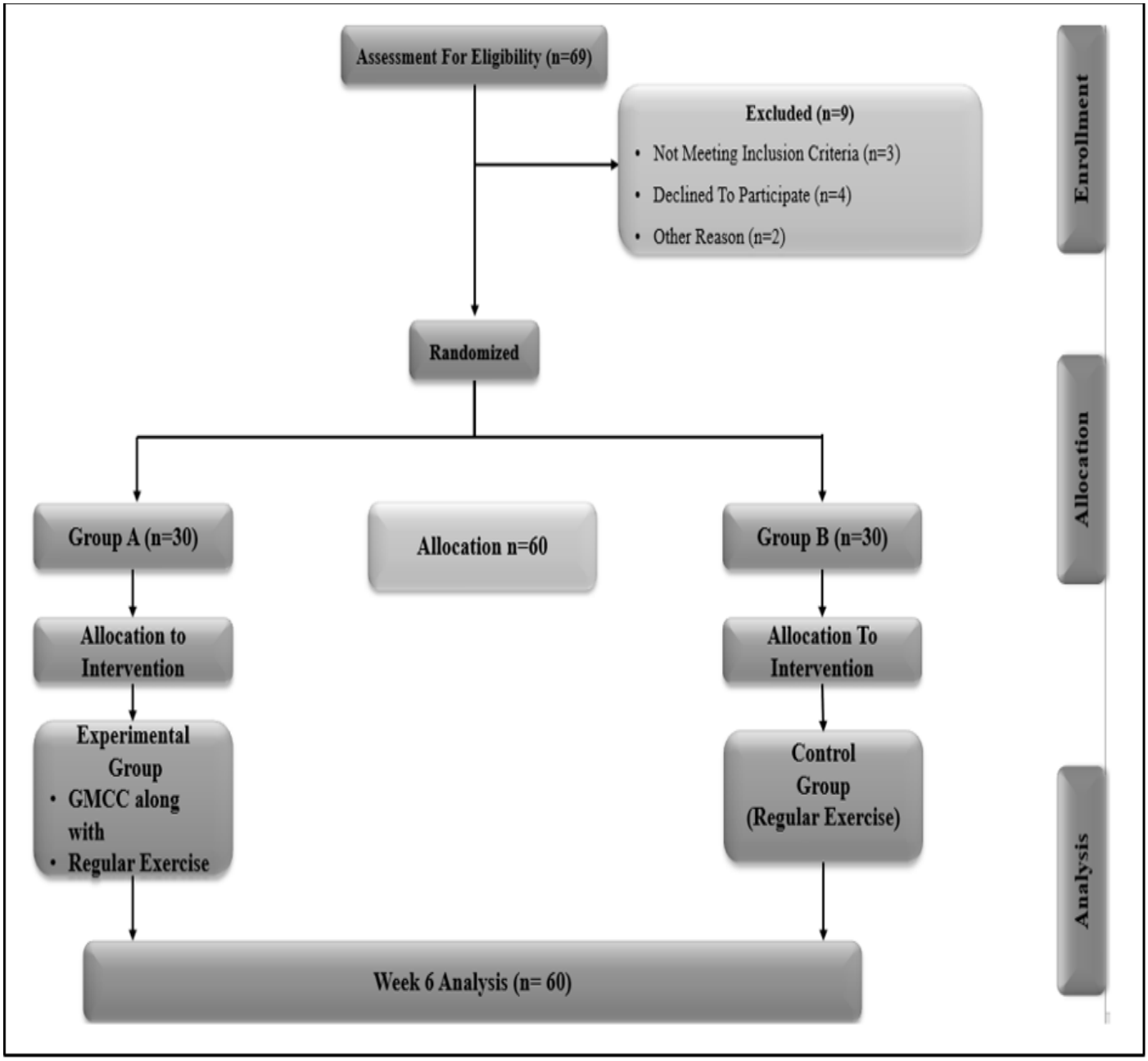


Fig 1 Design and flow of Participants through the trial

*G. Procedure*

Demographic data and baseline data were recorded. The players were then randomly allocated into two groups, Group A - Experimental and Group B - Control Group. Experimental group was administered with the graded motor control core strengthening exercises with normal daily training protocol and control group receive daily training program.

All the instructions were given verbally, provided demonstration and guided through a single practice trial. The participants were given exercise regimen and administered to perform for 35-40 mins per day for 4 days in a week for 6 weeks, The Agility is measured with T test and the Dynamic balance is measured with star Excursion balance test. Statistical analysis was done and results and conclusions were withdrawn.

*H. Statistical Analysis*

Analyses were conducted using IBM, SPSS V.20 software. The Shapiro-Wilk test was used to assess the normality of data distribution. Analysis of variance (Sample T Test) was used for comparison of mean at different time intervals. Post hoc test was used to identify between group difference. Quantitative variables were reported as mean and standard deviation. The mean between-group difference between the experimental and control groups was calculated with unpaired data and reported with a 95% confidence interval.

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Table 1 Exercise Protocol (EXP) Group

| **Exercise Category** | **Exercises** | **LEVEL – I Week 1-3** | | **LEVEL – II Week 4-6** | | **Frequency *(Sessions/ week)*** |
|---|---|---|---|---|---|---|
| Warm-up (7 min) | Walking knee to chest • Fast feet running • Joint Rotation • Bilateral countermovement jumps [3-5 Min] (1-6 weeks) | | | | | |
| Activation Of Core | 1. Shoulder Tapes, 2. Sit Up and Twist, 3.V-Sits (1-6 Weeks) *Exercises 05 repetition and 2 Set Every Day Before Start the exercise* | | | | | |
| | | Reps. | Sets. | Reps. | Sets | Freq |
| Core Strengthening Exercises | 1. Hundreds | 8 | 2 | 8 | 3 | 4 |
| | 2. Sited Twist with Medicine Ball | 8 | 2 | 8 | 3 | 4 |
| | 3. Heel Touches | 8 | 2 | 8 | 3 | 4 |
| | 4. Single leg bridge | 8 | 2 | 8 | 3 | 4 |
| | 5. Swimmer core exercise | 8 | 2 | 8 | 3 | 4 |
| Graded Motor Control Exercises | 6. Bird-Dog Plank | 8 | 2 | 8 | 3 | 4 |
| | 7. Superman extension | 8 | 2 | 8 | 3 | 4 |
| | 8. Dying bug | 8 | 2 | 8 | 3 | 4 |
| | 9. Single side plank (both side) | 8 | 2 | 8 | 3 | 4 |
| | 10. Dead Bug with Swiss Ball | 8 | 2 | 8 | 3 | 4 |
| Cool down (5 min) | Triceps dips, Side stretch, Hamstring stretch [3-5 min]. (1-6 weeks) | | | | | |

## III. RESULTS

At the baseline, there were non-significant differences between the groups in age, height, weight, BMI as $p>0.05$. The demographic and physical characteristics of participants at the baseline are shown in Table 2.

Table 2 There is no Significant Difference found in Baseline Characteristics between 2 groups for age height, weight and BMI.

| **Characteristics** | **Experimental (n=30)** | **Control (n=30)** |
|---|---|---|
| Age, mean (SD) | 19.9 (1.32) | 19.3 (0.69) |
| Height, mean (SD) | 156 (5.12) | 155 (4.89) |
| Weight, mean (SD) | 57.7 (4.13) | 57.1 (5.29) |
| BMI, mean (SD) | 23.4 (1.14) | 23.5 (1.21) |

Table 3 Conventional group exercises

| **Exercise Category** | **Exercise** | **Volume** | | **Frequency *(Sessions/week)*** |
|---|---|---|---|---|
| Warm Up | Walking knee to chest • Fast feet running • Joint Rotation • Bilateral countermovement jumps [3-5 Min] (1-6 weeks) | | | |
| | | Reps | Sets | |
| Strength Training | Push Ups | 10 | 3 | 4 |
| | Squats | 10 | 3 | |
| Aerobic group exercise Session | Running 100m | 2 | 1 | 4 |
| | Curl Ups | 10 | 3 | |
| Cool Down | Triceps dips, Side stretch, Hamstring stretch gentle walk for 3 minutes. (1-6 weeks) | | | |

Table 4 Mean (SD) between-group Difference.

| **Group** | **Time Frame** | **Group** | **Mean** | **SD** | **t-value** | **p-value** |
|---|---|---|---|---|---|---|
| Star Excursion Test Right | Pre | EXP Grp | 62.15 | 4.08 | 0.294 | 0.770 |
| | | CTR Grp | 62.52 | 5.59 | | |
| | Post | EXP Grp | 68.15 | 3.89 | 20.906 | 0.001 |
| | | CTR Grp | 63.36 | 3.81 | | |
| Star Excursion Test Left | Pre | EXP Grp | 61.12 | 3.12 | 1.840 | 0.071 |
| | | CTR Grp | 62.92 | 4.37 | | |
| | Post | EXP Grp | 67.37 | 1.83 | 30.061 | 0.001 |
| | | CTR Grp | 62.25 | 3.80 | | |
| Agility | Pre | EXP Grp | 12.20 | 1.49 | 3.450 | 0.001 |

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| | | | | | | |
|---|---|---|---|---|---|---|
| | | CTR Grp | 11.30 | 1.30 | | |
| | Post | EXP Grp | 9.20 | 1.10 | 3.700 | 0.001 |
| | | CTR Grp | 11.00 | 1.90 | | |

Table 5 Mean Diff and Effect Size of EXP and CON Group of Dynamic Balance

| Groups | Times | Mean | SD | Mean Diff. | SD Diff. | Effect size | t-value | p-value |
|---|---|---|---|---|---|---|---|---|
| EXP Group | Pre | 62.15 | 4.08 | 6.00 | 6.08 | 3.62 | 19.814 | 0.001* |
| | Post | 68.15 | 3.89 | | | | | |
| CTR Group | Pre | 62.52 | 5.59 | 0.84 | 6.76 | 0.12 | 0.685 | 0.499 |
| | Post | 63.36 | 3.81 | | | | | |

Table 6 Mean Diff and Effect Size of EXP and CON Group of Agility

| Groups | Times | Mean | SD | Mean Diff. | SD Diff. | Effect size | t-value | p-value |
|---|---|---|---|---|---|---|---|---|
| EXP Group | Pre | 12.20 | 1.49 | 2.22 | 1.30 | 1.71 | 9.343 | 0.001* |
| | Post | 9.98 | 1.48 | | | | | |
| CTR Group | Pre | 11.52 | 1.29 | 0.68 | 2.28 | 0.30 | 1.622 | 0.116 |
| | Post | 10.84 | 2.24 | | | | | |

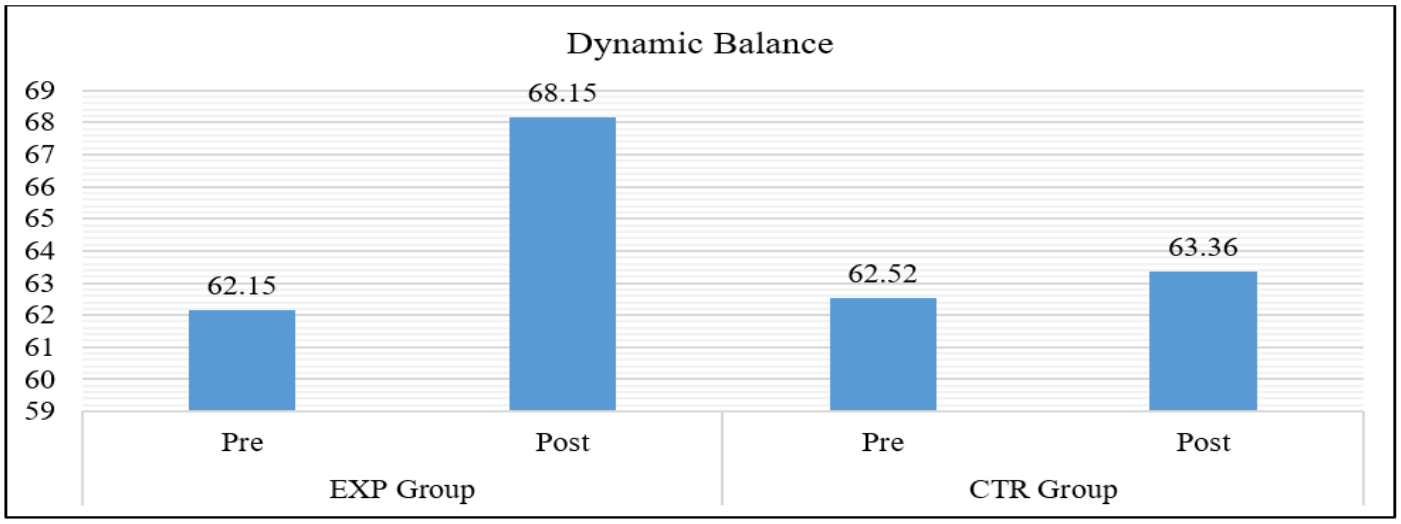


Fig 2 Dynamic Balance

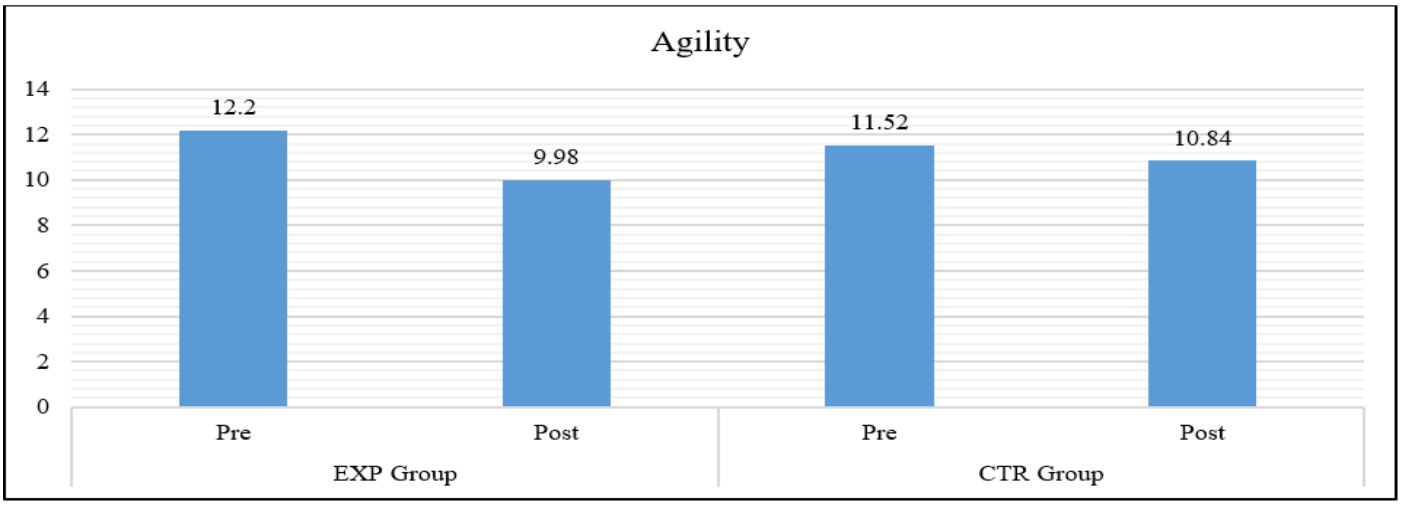


Fig 3 Agility

## IV. DISCUSSION

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The present study assessed the effects of a Graded Motor Control Core (GMCC) Exercise Program on **dynamic balance** and **agility** in athletes. Results showed that while both the GMCC and control groups improved, the GMCC group demonstrated significantly greater enhancements.

- *Dynamic Balance:*

The GMCC group exhibited a notable mean improvement of 6.30 cm in dynamic balance after 6 weeks. This improvement is attributed to enhanced neuromuscular control, proprioception**,** and postural stability**,** achieved through the activation of deep core muscles such as the transverse abdominis, multifidus, **a**nd pelvic floor. These adaptations allow for better movement control, reduced postural sway, and more efficient coordination between the limbs and trunk. Studies by Bashir et al. and Rodríguez-Perea et al. support these findings, emphasizing the role of core training in optimizing stability and performance, particularly in dynamic sports like badminton.

- *Agility:*

The GMCC group also showed significantly better agility, with a mean group difference of 3.20 seconds ($p<0.001$). Improved muscle activation, proprioception**,** and motor coordination contributed to faster and more controlled movement transitions. While some research, such as that by Tarik Ozmen, suggests that core training alone may not fully develop agility, our study demonstrates that incorporating motor control elements can bridge this gap effectively. Findings are further supported by Doğanay et al., who confirmed the link between core stability and multidirectional quickness in sport-specific scenarios.

- *Gender Comparison:*

The GMCC program proved equally effective for both male and female participants, with no significant difference in improvement rates for balance or agility.

## V. CONCLUSION

This study examined the impact of a 6-week Graded Motor Control (GMC) Core Exercise Program on agility and dynamic balance in amateur badminton players. Results showed significantly greater improvements in both parameters for the GMC group compared to conventional training. These findings support the inclusion of GMC exercises in training protocols to enhance performance in amateur badminton players.

- *Implication of Research*

Athletes, coaches, and sports professionals can benefit from this study by incorporating graded motor control core exercises to improve agility and dynamic balance in amateur badminton players. Enhancing core stability and neuromuscular control can lead to better movement efficiency, quicker direction changes, and potentially lower injury risk. Integrating this training into regular practice can boost performance and support the advancement of conditioning strategies in badminton.

## NOVELTY OF THE STUDY

This study uniquely explores the impact of a graded motor control core exercise program on agility and dynamic balance in amateur badminton players using a randomized controlled trial. Unlike traditional strength-focused core training, this program emphasizes motor control, proprioception, and stability—key elements for rapid movements and balance in badminton. The structured, progressive design ensures systematic neuromuscular improvements, offering high-quality evidence to support more specialized and effective training protocols for enhancing sport-specific performance.

## LIMITATION

Short Duration of Intervention – A 6-week training period may not be sufficient to observe long-term adaptations in agility and dynamic balance, and the effects over an extended period remain unknown. The study was restricted to amateur-level of sprinters between the ages of 18 and 24 years. All tests and methods used to evaluate the variables in this study was conducted on the field; additional laboratory tests and procedures can be considered in future.

## SUGGESTION FOR FUTURE RESEARCH

The same type Sports Specific Protocol can be designed and study can be conducted at various levels, such as semi-professional and professional badminton players.

A study could explore whether this training program reduces the incidence of injuries, particularly in the lower limbs and lower back, which are common in badminton players.

A similar study could be conducted on athletes from different sports that require agility and balance, such as tennis, squash, or basketball, to explore the broader applicability of graded motor control training.

## FUNDING

None

## CONFLICT OF INTEREST

There is no conflict-of-interest between the authors.

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