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Abstract:
Badminton is a highly dynamic sport that demands a diverse set of skills and physical attributes from its players. Athletes engage in a variety of movements including running, quick stops and starts, jumping, reaching, and rapid directional changes, all of which place significant demands on the cardiovascular, respiratory, musculoskeletal, and joint systems. The repetitive nature and intensity of these movements can lead to fatigue and potential impairments in physiological functions during extended play. Key movement techniques in badminton, such as crossover stepping and lateral sidestepping, are critical for maneuvering across the court and adjusting stride dynamics. Analysis of motion speed reveals substantial joint forces at the hip, knee, and ankle, with variations in joint angles and velocities impacting performance strategies. For instance, while rapid strokes like the forehand overhead exert high joint pressures, they also necessitate robust joint stability and muscle engagement. Lower body agility and strength are essential for executing varied shots like smashes, requiring frequent lunges and jump squats that impose significant impact loads on the lower extremities. Effective strength training programs are pivotal in enhancing players' speed and power capabilities, crucial for both offensive and defensive maneuvers on the court. High-intensity circuit training has emerged as a time-efficient strategy combining resistance and aerobic exercises with minimal rest intervals. This regimen enhances aerobic metabolism, facilitates muscle recovery processes like creatine phosphate resynthesis and lactate clearance, and promotes overall physical conditioning tailored for badminton athletes. Assessment tools such as the modified Sphygmomanometer for evaluating muscle strength and the Agility T-test for measuring agility provide valuable metrics in monitoring and improving athletic performance. These tests enable coaches and trainers to tailor training programs to individual player needs, optimizing their speed, power, and agility attributes crucial for competitive play. The integrating targeted strength and agility training regimens alongside strategic use of assessment tools is essential for enhancing the multifaceted physical demands of badminton. This holistic approach not only improves performance but also mitigates the risk of overuse injuries, ensuring sustained athletic success in the sport.
Keywords: Badminton biomechanics, High-intensity circuit training, Musculoskeletal demands, Agility assessment.

Introduction:
The game of badminton is intense and requires a wide range of skills and movement combinations. A variety of motions are required of the badminton player, such as running, abruptly stopping and immediately starting again, bouncing, reaching, turning swiftly, and taking large strides without ever losing balance or steadiness. Throughout the game, these moves are used more frequently and for longer periods of time. Players may become fatigued by doing these actions, which will impair the function of their heart, lungs, circulatory system, muscles, and joints. To manoeuvre across the court, badminton players utilize crossover stepping and lateral sidestepping techniques, adjusting their stride force accordingly. Analysing individual motion speed is crucial in assessing badminton performance. As motion speed escalates, notable joint contact forces are observed at the hip, knee, and ankle joints. However, distinct variations are evident in joint angles and velocities. Notably, the hip demonstrates smaller angles yet larger velocities, whereas the knee displays higher velocities. These findings indicate the necessity of employing distinct joint synergy strategies to enhance movement speeds effectively. Even while the forehand overhead stroke's swift movement speed is always motivating in offensive play, the larger joint contact pressures may result in increased demand on the joint stability and muscle forces. Playing badminton involves a lot of lower body movements, such as lunges and jump squats, to execute different shots, such as smashes. To provide severe impact loading on badminton players' lower extremities and prevent overuse lower limb injuries, quick and repetitive badminton lunges and hops have been advised. On the soft tissue structures of the lower limb, excessive upright and straight impact forces during the early contact phase will result in a significant joint torque. Given that the lunge step accounts for 15% of all badminton movements in a single game, it is one of the footwork drills used in badminton the most frequently. Strength training for the lower limbs enables players to move swiftly for various opposing and antagonistic shots during the game. In comparison to typical programmes, high intensity circuit training can yield multiple health benefits in a shorter amount of time by combining resistance and aerobic training with high intensity and minimal rest. In a high degree of aerobic metabolism is needed for the duration of a high-intensity badminton match to improve creatine phosphate resynthesize, lactate clearance from working muscle, and intracellular inorganic phosphate accumulation elimination. Strength is the goal of high intensity circuit training, which is made to be simple to follow. High-intensity circuit training involves minimal rest intervals between exercises and swift transitions to the next activity. Strength training constitutes a crucial element of a comprehensive physical fitness regimen, as it bolsters bone density, joint functionality, muscular strength, tendon and ligament resilience, and cardiovascular endurance. A dependable technique for gauging muscle strength is the modified Sphygmomanometer, which can be employed to assess the pre- and post-effects of body weight-based high-intensity circuit training in badminton players. This method focuses on evaluating hip flexion, extension, and abduction movements.
To evaluate various attributes such as leg speed, power, and agility, the Agility T-test proves to be an effective tool. This assessment can discern differences in athletic performance between individuals engaged in sports at different proficiency levels, indicating its reliability in measuring agility.

In seconds, agility time is measured. We may conclude that a player has outstanding agility if their time is measured in less than 9.50 seconds for males and less than 10.50 seconds for females. If their time is more than 11.50 seconds for males and more than 12.50 seconds for females, the player has bad agility. The 50-meter dash test, which measures acceleration and speed, is a valid and dependable method of measuring speed. Speed is defined as running a short distance in a short amount of time, and the purpose of this test is to gauge how well badminton players can sprint.

Need of Study:
According to prior studies, the most common injuries sustained during badminton games are to the ankle and hip joints, respectively. Less injuries from badminton games included lower limb sprains, strains, blisters, and an unexpectedly low frequency of tennis elbow. There is a significant lack of information concerning the effects of high-intensity circuit training on lower limb strength, agility, and speed, particularly tailored for badminton players. It is vital to create an effective lower limb muscle training routine for badminton players due to the increased incidence of lower limb injuries among this sport's participants. The degree to which high intensity circuit training can impact badminton players' lower limb strength, agility, and speed abilities must be understood in order to comprehend the required training programme for the sport.

Aim of Study:
The objective is to examine the effectiveness of body weight-based high-intensity circuit training in improving lower limb strength, agility, and speed in badminton players.

Objectives of the Study:
1. To determine how body weight training for high intensity circuits affects badminton players' lower limb strength.
2. To determine how body weight training for intense circuits affects badminton players' agility.
3. To determine how body weight training for intense circuits affects badminton players' speed.

Hypothesis:
Alternative Hypothesis:
- Body weight circuit training at high intensity has a notable impact on badminton players' lower limb strength.
- Body weight circuit training at high intensity has a noteworthy impact on badminton players' agility.
- Body weight circuit training at high intensity has a noteworthy impact on badminton players' quickness.

Null Hypothesis (H0):
Body weight circuit training at high intensity has no discernible impact on badminton players' lower limb strength, agility, or speed.
Methodology:

Study Design:
Type of Study: Comparative Study.
Study population and Sample: 20 Badminton players.
Place of Study: 1. Jaypee Sports Academy, Greater Noida.
Sampling Method: Randomized sampling.
Sample Size: 20 male and female Badminton players.
Duration of Study: 6 months.

Study tools:
1. Modified Sphygmomanometer
2. Cones.

Selection Criteria:
Inclusion Criteria:
- Participants aged between 18 and 30 years.
- Both male and female badminton players.
- Players with a minimum of 1 year of experience in playing badminton.
- BMI ranging from 18.5 to 24.9 kg/m².

Exclusion Criteria:
- Players having history of any soft tissue injuries (ACL tear, MCL tear, Meniscus tear, Ankle sprain, groin injury, hamstring strain etc.)
- Players undergone any lower limb surgery (Reconstruction or Arthroscopic surgery)
- Any recurrent injury.
- Any mechanical pain.
- Any congenital deformity (Genu Valgum, Genu varum, Coxa Valga, coxa Vara etc.)
- Any respiratory complication.

Variables:
Dependent Variable: Speed, Agility and Strength.
Independent Variable: High Intensity Circuit training and Routine exercises for sports.

Method:
Using randomised sampling, a total of twenty male and female badminton players were chosen for this investigation. Once the consent was properly signed, all the participants were included in accordance with the inclusion criteria. Individuals who did not meet the inclusion criteria or did not fit within them were not allowed to participate in the study.

Each participant underwent assessments of strength, speed, and agility through pre- and post-intervention data collection. Speed was evaluated using a 50-meter sprint, agility was measured with a T-test, and strength was
gauged using a sphygmomanometer. Twenty subjects were randomly allocated during the sampling phase, with ten assigned to the intervention group (Group A) and ten to the control group (Group B). The evaluation of strength, speed, and agility was conducted using pre-intervention data. Subsequently, participants underwent interventions tailored to address any observed performance discrepancies, with workouts designed accordingly. The aim of this study was to examine the effects of body weight training integrated into high-intensity circuit regimens on the lower limb strength, agility, and speed of badminton players. Twenty participants were divided into two groups for the study.

Group A (Intervention Group):
Participants in this group engaged in high-intensity circuit training exercises. The workouts began with a warm-up protocol (10 minutes of jogging and jumping), which was followed by main exercises (30 seconds/2 sets) of squats, jumps, burpees, mountain climbers, side steps, high knees, and step-ups. The circuit of all the exercises was completed in 7 minutes. Three circles were completed in a single session by them. They completed the Cool Down Protocol, which involved three rounds of all the activities (stretching of lower leg muscles). For eight weeks, this procedure was followed three times a week.

Group B (Control Group):
Control group have performed daily routine badminton sports specific exercises for lower limb which include warm-up for 10 min before starting exercises. After warm-up they gave performer badminton sports specific exercises which include, standing jump, side to side ankle hops, lateral cone hops, single leg bounding, heel raise, squats, lunges 10 reps/2 sets for each exercise and after performing all the above exercises they have performed cool-down exercise for 10 min. This protocol was performed thrice a week for 8 weeks.

**Program (Group – A)**

<table>
<thead>
<tr>
<th>Exercise Stage</th>
<th>Program</th>
<th>Intensity</th>
<th>Time</th>
<th>Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm-</td>
<td>Jogging</td>
<td>Sub-maximal</td>
<td>10 min</td>
<td>1-8</td>
</tr>
<tr>
<td></td>
<td>Jumping</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main exercises</td>
<td>Squat jump</td>
<td>Sub-Maximal</td>
<td>30 sec</td>
<td>1-8</td>
</tr>
<tr>
<td></td>
<td>Burpees</td>
<td></td>
<td>× 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High knees</td>
<td></td>
<td>30sec rest.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mountain climbers</td>
<td></td>
<td>For each exercise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Side steps</td>
<td></td>
<td>7 min</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lunge</td>
<td></td>
<td>circuit.3</td>
<td></td>
</tr>
</tbody>
</table>
7. Step-up circuits.

| Cool-down          | Lower limb muscles | 30 sec holds  
|                   | Stretching’s.      | ×3 reps for each  
|                   |                    | Stretching  

**Sports Specific Badminton Training Exercise Program:**

<table>
<thead>
<tr>
<th>Exercise Stage</th>
<th>Program</th>
<th>Intensity</th>
<th>Time</th>
<th>Week</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm-up</td>
<td>Jogging</td>
<td>Sub-maximal</td>
<td>10 min</td>
<td>1-8</td>
</tr>
<tr>
<td></td>
<td>Jumping</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main exercises</td>
<td>1. Standing jump</td>
<td>Sub-maximal</td>
<td>10 reps×2 sets. For each exercise</td>
<td>1-8</td>
</tr>
<tr>
<td></td>
<td>2. side to side ankle hops</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. lateral cone hops</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. single leg bounding</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. squats</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. lunges</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Heel Raise</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cool-down</td>
<td>Lower limb Stretching’s</td>
<td>30 sec hold×3 reps for each muscle</td>
<td>10 min</td>
<td>1-8</td>
</tr>
</tbody>
</table>

**Data Analysis:**

In order to accomplish this, the study evaluated the significance of the mean difference in strength, agility, and speed scores using a degree of freedom of 38, with a significance level set at 0.05. The analysis employed the parametric "t" test for the 50-meter sprint test, while the Mann Whitney U test and the Wilcoxon signed-rank test were utilized for assessing agility and strength, respectively.

**Results:**

The study utilized the parametric "t" test for the 50-meter sprint test, the Mann Whitney U test, and the Wilcoxon signed-rank test to evaluate the significance of the mean difference in strength, agility, and speed scores, with a degree of freedom of 38, at the 0.05 significance level.

Following the 8-week intervention, both groups of badminton players demonstrated a significant increase in strength, agility, and speed. However, group A (the intervention group) exhibited greater improvement attributed to the high-intensity circuit training. The tabulation, graphical presentation and statistically analysed interpretations with inferences are given underneath.
Comparison between effect of high intensity circuit training using body weight and badminton sports specific training on 50 M sprint test in badminton players

<table>
<thead>
<tr>
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<th>Intervention</th>
<th>Control</th>
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</thead>
<tbody>
<tr>
<td>Mean (pre)</td>
<td>7.84</td>
<td>6.753</td>
</tr>
<tr>
<td>Mean (post)</td>
<td>7.067</td>
<td>10.628</td>
</tr>
</tbody>
</table>

Fig:1

Comparison between effect of high intensity circuit training using body weight and badminton sports specific training on T-test agility in badminton players

<table>
<thead>
<tr>
<th></th>
<th>Intervention</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (pre)</td>
<td>10.781</td>
<td>9.8</td>
</tr>
<tr>
<td>Mean (post)</td>
<td>10.628</td>
<td></td>
</tr>
</tbody>
</table>

Fig:2
Comparison between pre and post effect of high intensity circuit training using body weight and badminton sports specific training on hip flexion strength in badminton players

<table>
<thead>
<tr>
<th></th>
<th>Intervention</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (L) pre</td>
<td>5.1967</td>
<td>5.88</td>
</tr>
<tr>
<td>Mean (Rt.) pre</td>
<td>6.08</td>
<td>6.9133</td>
</tr>
<tr>
<td>Mean (L) post</td>
<td>6.2167</td>
<td>6.1233</td>
</tr>
<tr>
<td>Mean (Rt.) post</td>
<td>6.8533</td>
<td>6.97</td>
</tr>
</tbody>
</table>

Fig:3

Conclusion:
Drawing from the research discussion, several conclusions emerge regarding the influence of body weight-based, high-intensity circuit training on the lower limb strength, agility, and speed capabilities of badminton players. It is known from the research that group A (the intervention group), which received body weight exercises for high intensity circuit training, had the best outcomes. Group B exhibited noteworthy outcomes in both the pre- and post-assessment phases. Therefore, we can conclude from this study that badminton players should include high intensity circuit training protocol in their daily routine along with badminton sports specific exercises which can improve their overall performance in the game. This study found that body weight circuit training at high intensity had a substantial impact on badminton players' lower limb strength, agility, and speed. Therefore, the alternative hypothesis positing a substantial influence of high-intensity circuit training on lower limb strength, agility, and speed among badminton players has been supported by the study's findings. Consequently, the null hypothesis is rejected, in line with the outcomes of this investigation.

References:

Bhat BA, Kumar A. A comparative study of the effect of circuit training on speed, agility and endurance among physical education students of Mewar University, Chittorgarh Rajasthan.


Phomsoupha M, Ibrahime S, Heugas AM, Laffaye G. Physiological, neuromuscular and perceived exertion responses in badminton games.

Ranjbar MA, Ab RS. The effectiveness of circuit training in enhancing muscle endurance among standard five boys in a primary school.


Vora M, Ranawat D, Arora M, Tiwari A. Biomechanics of Squat Jump in Junior Badminton Players.


Zhao X, Li S. A biomechanical analysis of lower limb movement on the backcourt forehand clear stroke among badminton players of different levels. Applied Bionics and Biomechanics. 2019 Jan 14;2019.