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The Effect of Triceps Brachii Fatigue Due to Isometric Contraction on Elbow, Velocity and Accuracy of Overhead Smash in Badminton

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Abstract Introduction: In order to execute the overhead assault with the front racket in badminton, the triceps brachii muscle must stretch the elbow joint. Even though this muscle is crucial for accomplishing this talent, it's crucial to investigate how localised triceps brachii exhaustion affects the ability to execute the overhead shot with the front racket. Therefore, the central continuous contraction was chosen to cause local fatigue in the triceps brachii muscle. Accordingly, the purpose of this study is to ascertain how the central isometric contraction, which causes triceps brachii muscle exhaustion, affects the elbow movement, velocity, and accuracy of the shuttlecock when performing the forehand overhead jump smash skill. Method: The study sample consists of 12 international badminton players who have participated in the World Championships and Olympic Games and use the right hand as a favorite according to the following averages (age 25.3 ± 1.2 years, mass 70.20 ± 2.31 kg, height 1.81 ± 0.11 m, training age 7.9 ± 2.1 years, Medicine ball throw test (1) kg overhead 2.96 ± 2.31 kg, distance 1.81 ±0.11 m). They were asked to perform a crushing throw accuracy test, and then they were subjected to a maximal voluntary isometric contraction test. After that, they were asked to repeat the crushing throw accuracy test. The two tests of shooting the crushing throw, before and after, were filmed for the purposes of kinetic analysis through the Kinovea 0.9.5 program. The Automatic Shuttlecock Launcher and the Stalker Sport 2 Radar devices were used. Results: After using statistical means such as statistical averages, standard deviations, and the Wilkeson test, the results showed a negative effect with statistical significance at the level ($\alpha < 0.05$) of the triceps brachii muscle fatigue caused by the isometric contraction on the movement of the elbow, the velocity and accuracy of the crushing blow against the front racket overhead among the badminton players. Conclusion: According to the results of the study, it was recommended that the muscle strength of the triceps brachii should be raised to increase its tolerance to local fatigue resulting from its continuous use among badminton players.

Keywords Triceps Brachii Muscle, Muscle Fatigue, Isometric Contraction, Badminton, Elbow, Accuracy, Overhead Smash

1. Introduction

The triceps brachii is considered to be the only muscle that fully encloses the posterior humerus. There are three heads on this fusiform muscle: The Long Head, Medial Head, and Lateral Head. This muscle functions as a third-class lever in the anatomical lever system, increasing the line of resistance while decreasing the line of force in accordance with the fulcrum [1].

The long head arises through a specific range depending on the flat tendon of the inferior tubercle of the scapula,

where these are blended above with the humeral apical capsule [2]. As for the lateral head, it arises according to another path, which uses a flat tendon from an arrow, a linear, oblique edge on the posterior surface of the humeral body, and the lateral muscular septum. In terms of the medial head, it overlaps to a large extent posteriorly with the lateral and long heads, where it is connected to the entire posterior surface of the body of the humerus, below the radial groove at the medial border of the humerus, in addition to the lower part of the lateral muscular septum [1].

The elbow joint, which is more complex than the straightforward hinge joint that it seems to be, is extended as one of the triceps brachii's primary duties. Different structures hold the forearm's two bones to the humerus. While the humerordial joint is not a real hinge joint, the humeroulnar joint is. Although it has been categorized as an arthrodial or a gliding type of joint, a limited ball-socket joint is a more realistic description [3].

The elbow joint extension movement, for which the triceps brachii muscle is responsible [1], is the main movement for performing the overhead smash skill in badminton. Because the elbow angular velocity and how well the technique for performing the overhead smash skill is able to transfer this velocity to the racket and then to the shuttlecock with the racket pointing in the appropriate direction through the elbow angle, any functional or anatomical defect in this muscle will result in a defect in this skill [4]. One of the six fundamental talents in badminton, it is regarded as a classic skill and can be executed in one of two ways, either from stability or from jumping, as it was in the current study. In both forms, the shuttlecock must be shot with such force that it is moving diagonally and sinking downward past the upper edge of the badminton court. This kinetic form related to strength and velocity, expressed in accurate shooting, depends entirely on the movement of the elbow joint [5], especially on the triceps brachii muscle contraction, which is used to produce the extension movement in the elbow joint [3].

The importance of the player's mastery of the overhead smash skill, in both of its forms, is that it is the most effective skill in deciding the points and thus deciding the results. Indeed, 53.9% of the match-ending points are due to it, as it is one of the offensive strikes that is difficult to defend against, especially if it is characterized by accuracy [6]. In order to score points, the shuttlecock's orientation is also crucial. Force alone is insufficient; it must also be combined with the right direction so that the shuttlecock lands inside the opposing team's court and in a location where it will be challenging for him to return it. This requires a compatible neuromuscular action in the working muscles to ensure that the shot is executed with proper technique [7]. As a result, any muscle weakness, particularly in instances of muscle fatigue and when the player is unable to handle and tolerate it, results in a weak performance, which is expressed through the mechanical factors that make up the technique of this performance. This is what happens in the case of fatigue of the elbow extensor muscles in racket games, such as the fatigue of the triceps brachii muscle [8], where the fatigue of this muscle leads to a defect in the work variables of the elbow such as the angular velocity of the elbow and the velocity of the shuttlecock and thus a defect in the accuracy of its correction, which is the main mechanical goal of the skill [9]. Additionally, the execution of the extension action at the elbow joint plays a significant role in the accomplishment of this objective [6].

In fact, badminton requires quick and forceful arm movements in a variety of physical positions. Overhead smashes, which make up 20% of attacks in badminton matches, require the player to exert the greatest amount of force possible. By repeatedly performing the rally, which is done with high momentum and intensity and frequently lasts no longer than 10 seconds, the player develops positional fatigue in the arm muscles, particularly the triceps brachii [13].

Returning to previous studies in this field, we find that studies [7,9-12] dealt with the impact of fatigue on many sports, including racquet games, but they dealt with general fatigue without specifying the muscles involved in the specialized activity and specializing them in research. As for the studies [13-15], they investigated the mechanical variables related to overhead smash skill in badminton and agreed on the importance of elbow work when stretching on velocity and accuracy of skill, but they did not address the effect of muscle fatigue on skill performance.

We also find that studies [16,17] investigated the influence of triceps brachii muscle exhaustion on the accuracy of throwing skills, but not on the skill studied in this study, which is the overhead smash skill of the jump.

As a result, the current study's significance arose from how it sought to investigate the impact of muscle exhaustion unique to the working muscle and not others on skill performance. Indeed, the repetition of performance exposes the working muscles to the trouble of overuse, and the player may feel this fatigue in the matches and even before reaching the stage of general fatigue or local fatigue in the general muscles may also be associated with general fatigue. Due to the constant use of the working muscles, the feeling of fatigue in them is the most prominent. Therefore, it is crucial to research how local muscle tiredness affects performance accuracy, especially in sports like badminton where the playing tool is light and swift, making it possible for any skillfully off-balanced shot to send the badminton flying off the intended course.

From the foregoing, it can be said that the theory of the current study to be examined is: There is a negative, statistically significant effect at the level of $\alpha < 0.05$ for the fatigue of the triceps brachii muscle caused by the isometric contraction on the work of the elbow, the velocity and accuracy of the crushing blow against the front racket from above the head among the badminton players.

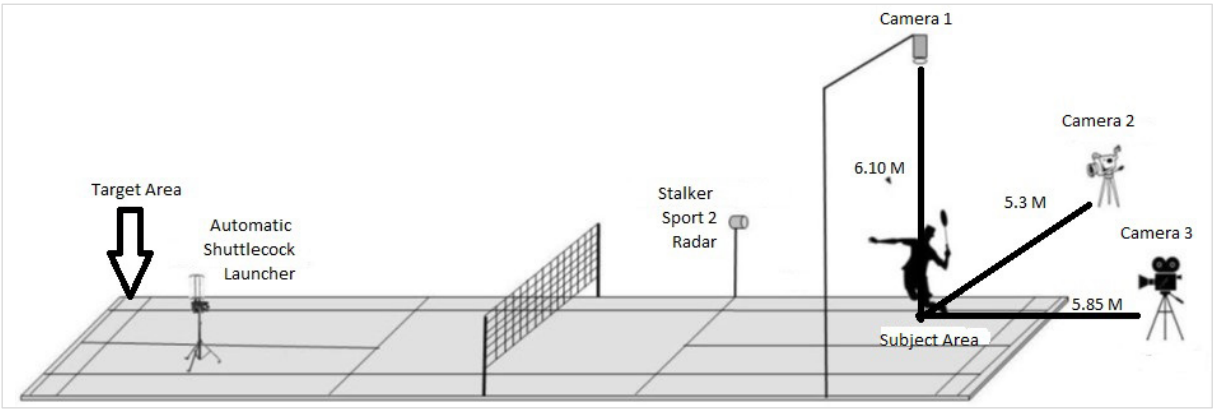

Figure 1. shows the shooting accuracy test and where to place the cameras, shuttlecock stalker radar and shuttlecock launcher [9]

2. Method and Procedure

Participants: (12) international badminton players who have participated in the World Championships and Olympic Games and used the right hand as a favorite according to the following averages (age 25.3 ± 1.2 years, mass 70.20 ± 2.31kg, height 1.81 ± 0.11m, training age 7.9 ± 2.1 years.

2.1. Field Tests

- **Testing the overhead jump smash accuracy.**

The players were required to complete the following test, which is specified in [9], following a good warm-up:

1. Using an overhead jump smash to hit the shuttlecock as it leaves the launcher, the player may guide it to a certain spot on the opposing court that corresponds to the left target area of your opponent's player (Figure 1).
2. The player receives one point for each successful shot and none for any errors.
3. Each player makes 10 shots.
4. Correct shot = 1 point.

- **Triceps Fatigue Test**:

The TBMF test mentioned in [16] was used as follows:
Maximal voluntary contraction force
Prior to the most intense voluntary isometric contraction, participants warmed up for 10 minutes (MVIC). The individuals were secured to a specific chair by straps and belts at the shoulder and waist level while the MVICs of the triceps brachii muscles were measured. A load cell (SIWAREX R, 500 kg, Siemens) is adjustable horizontal bar for the triceps brachii muscle. The participant performed a total of three 5-s MVIC of the triceps brachii by pulling on a strap attached to the load cell and wrist. With the elbow vertically aligned along the thorax, the shoulder internally rotated 45 degrees, and the wrist in a neutral posture between supination and pronation, the elbow was flexed at 90 degrees (0° being complete elbow extension) (Figure 2).

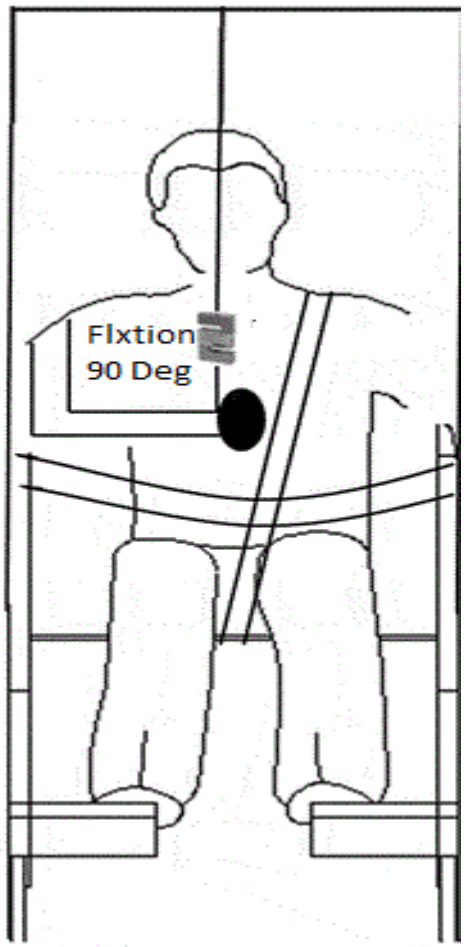

Figure 2. Schematic representation of MVIC measurement for the triceps brachii the participant sat comfortably on a chair with a belt fixing the position of the waist and shoulder. MVIC of the triceps (E-extension was measured by pulling on a strap attached to the load cell and wrist. The elbow flexed at 90° (0° being full elbow extension), with the arm in the vertical position along the thorax, the shoulder at 45° internal rotation, and the wrist in neutral position between supination and pronation.[16]

2.2. Study Procedures

The participants applied the following procedures:

1. Test the overhead jump smash accuracy.
2. Conduct triceps fatigue test on the next day.
3. Reconduct the test of overhead jump smash accuracy immediately after the triceps fatigue test.
4. The test of overhead jump smash accuracy was filmed with three 500 fps (Canon EOS 80 D) cameras, positioned on the lateral, deep and vertical performance axes.
5. The videos were analyzed after being downloaded by Kinovea 0.9.5 software for kinetic analysis.

2.3. Devices, Cameras, Tools and Software Used in the Research

1. 10 badminton rackets by YOUNEX.
2. 100 legal shuttlecocks by YOUNEX.
3. Kinovea 0.9.5 software for kinetic analysis.
4. 3 Canon EOS 80 D cameras.

Table 1 lists the research variables (before and after TBMF) together with their corresponding means and standard deviations. A general review of the means values revealed that triceps fatigue negatively impacted the stated variable. Triceps fatigue hurts the indicated variable, as was evident from a general examination of the means values. Before triceps fatigue, the elbow angle was (175.98), but it was reduced to (118.07) thereafter. The variable's mean value for the elbow angular speed decreased from (995.53) deg/s to (562.06) deg/s after triceps exhaustion. Before triceps stress, badminton velocity was (146.60) m/s on average, while after triceps fatigue, velocity is (105.10) m/s on average.

The accuracy was found to have drastically dropped from (8.33) before triceps fatigue to (4.92) during triceps strain. Elbow angular speed witnessed a 43.54 percent gt = retest reduction (decrease), whereas Badminton velocity saw a (28.31%) loss.

Figure 3 shows the responses of individuals in terms of their elbow joint angle value before and after TBMF, as well as the decrease, accompanied by fluctuation in the value of the elbow joint angle, appearing as a result of muscle fatigue that occurred in the triceps.

However, Figure 4 shows the responses of individuals in terms of the value of the angular speed of their elbow joint before and after TBMF, as well as the decrease, accompanied by fluctuation in the value of the angular speed of their elbow joint, appearing as a result of muscle fatigue that occurred in the triceps.

Table 1. The research variables (before and post) TBMF mean and standard deviations are shown in the table

variables	Pre fatigue		Post fatigue		Mean difference	Drop %
	mean	sd	mean	sd		
Elbow angle (deg)	175.98	1.93	118.07	13.15	-57.91	-32.91
Elbow angular speed (deg/s)	995.53	2.59	562.06	46.14	-433.47	-43.54
Badminton velocity (m/s)	146.60	4.01	105.10	15.24	-41.50	-28.31
Accuracy (score out of 10)	8.33	0.78	4.92	0.67	-3.41	-40.94

TBMF= Triceps Brachii Muscle Fatigue

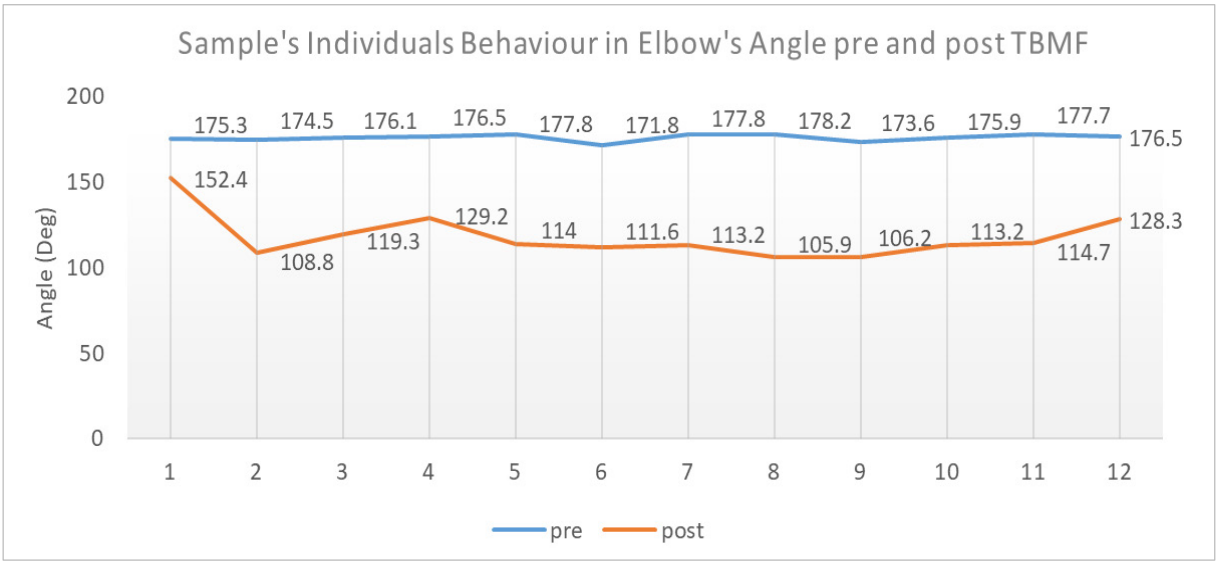

Figure 3. Sample Individuals Behavior in Elbow's Angle pre and post TBMF

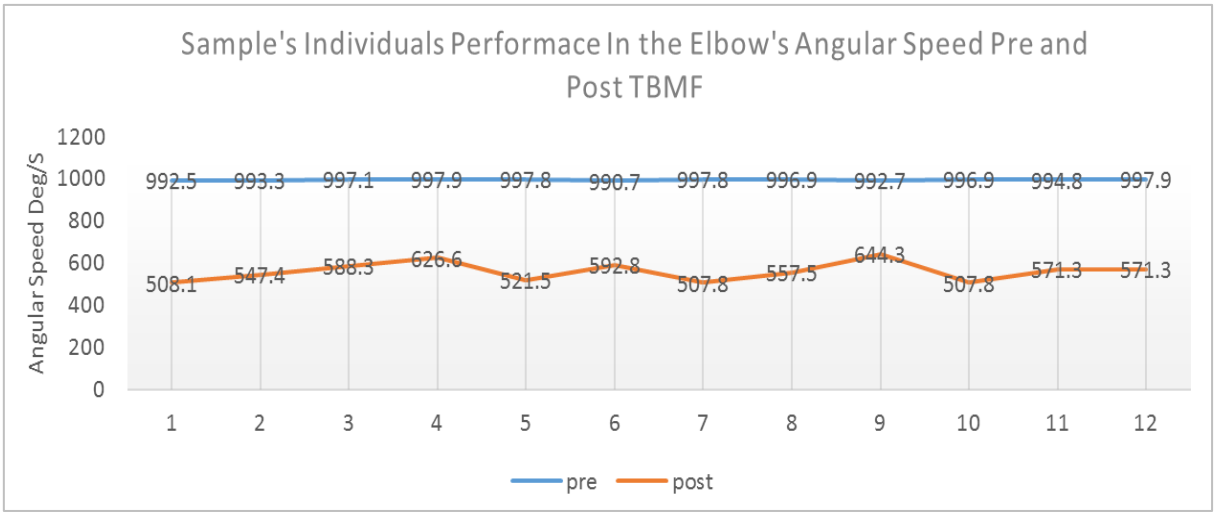

Figure 4. Sample Individuals Behavior in Elbow's Angular speed pre and post TBMF

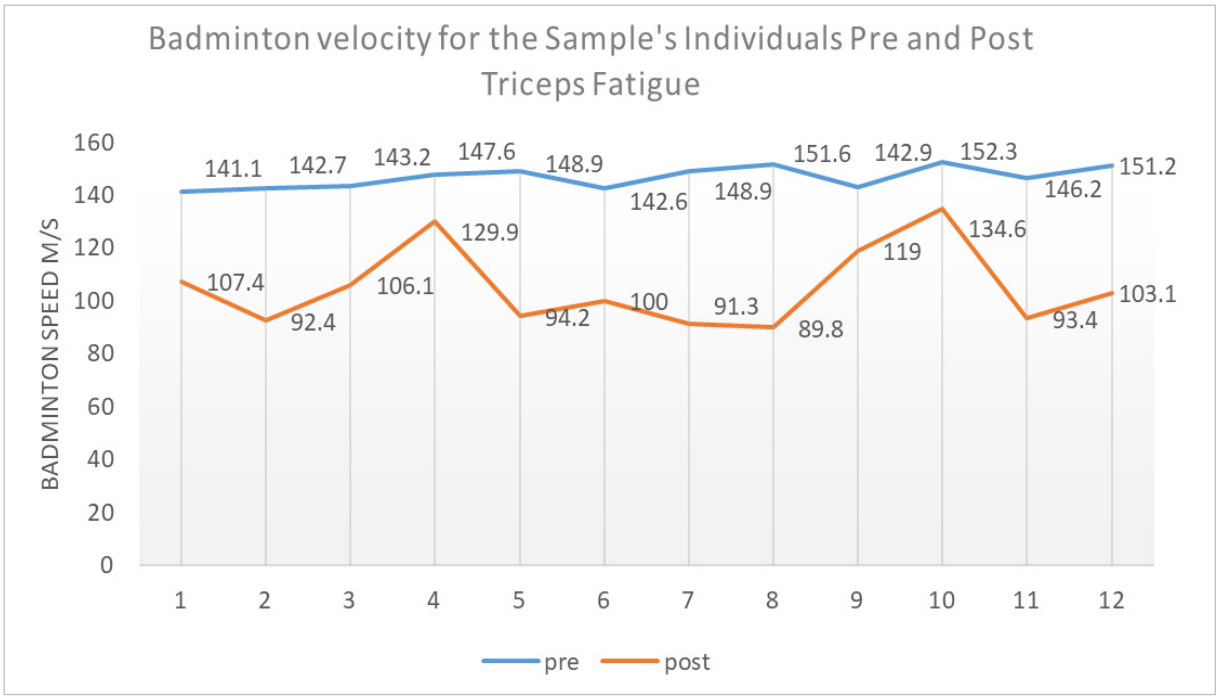

Figure 5. Sample Individuals Behavior in Badminton Velocity pre and post TBMF

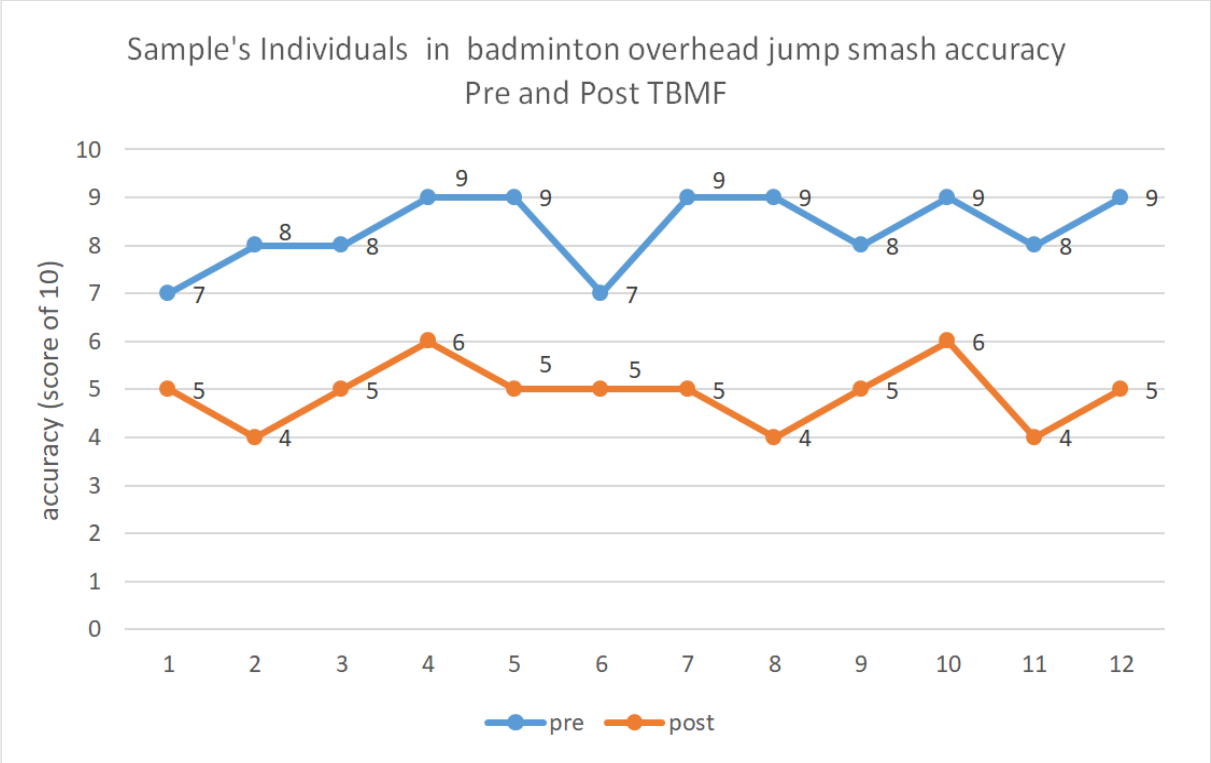

Figure 6. Sample Individuals Behavior in badminton overhead jump smash accuracy pre and post TBMF

Figure 5 also shows the responses of the individuals in terms of their shuttlecock velocity value before and after TBMF, as well as the decrease, accompanied by big fluctuation in the value of the shuttlecock velocity appearing as a result of muscle fatigue that occurred in the triceps.

Figure 6 shows the behavior of the sample individuals in badminton overhead jump smash accuracy before and after TBMF, as well as the apparent decline in shuttlecock shooting accuracy brought on by triceps muscle exhaustion.

3. Results

Hypothesis: For badminton players, triceps fatigue has a detrimental, statistically significant influence on the elbow strength, the speed, and the accuracy of the overhead jump smash (at the 0.05 level).

3.1. TBMF Effect on the Badminton Velocity, Angular Velocity, and Elbow Angle

TBMF has an impact on the elbow's angle, angular velocity, and badminton velocity, as indicated in Table 1. There were no parameters used during the execution of this Wilcoxon test. The final column, labelled prob, displays a statistically significant effect of triceps exhaustion on the fall of the mean previously provided in the means-only (Table 2). Because the appropriate variable's values before fatigue were used to interpret the accuracy, the prob values were 0.05, indicating substantial means drop differences before and after fatigue such that differences were in favor of the pre-fatigue.

Table 2. Results of the elbow variables and badminton velocity Wilcoxon signed ranks tests.

Variables	Rank sign	Sum of Ranks	N	Mean Rank	z	prob
Elbow angle (deg)	Negative Ranks	78.00	12[a]	6.50	**3.05**	***0.002**
	Positive Ranks	0.00	0[b]	0.00		
Elbow angular speed (m/s)	Negative Ranks	78.00	12[d]	6.50	**3.05**	***0.002**
	Positive Ranks	0.00	0[e]	0.00		
Badminton velocity (m/s)	Negative Ranks	78.00	12[g]	6.50	**3.05**	***0.002**
	Positive Ranks	0.00	0[h]	0.00		

3.2. TBMF Effect on the Accuracy of Service

Table 3. Wilcoxon signed ranks test results for accuracy

Variables	Rank sign	Sum of Ranks	N	Mean Rank	z	prob
Accuracy (score out of 10)	Negative Ranks	78.00	12[j]	6.50	3.05	∗0.002
	Positive Ranks	0.00	0[k]	0.00		

The impact of TBMF on accuracy is shown in Table 3. The Wilcoxon signed ranks test without parametric assumptions was used. The prob value (0.002) was less than 0.05, indicating that there were significant means drop differences before and after tiredness, with the accuracy being higher before fatigue.

From the aforementioned, it can be seen that the findings are in line with the study's hypothesis, which states that: There is a negative, statistically significant effect of triceps fatigue brought on by isometric contraction on the strength of the elbow, the velocity, and the accuracy of the overhead jump smash for badminton players against the front racket at the level of 0.05.

4. Discussion

The study's findings on the strength of the elbow joint in terms of joint speed and angle, which was reflected on the velocity of the shuttlecock shooting and its accuracy jointly, clearly show that TBMF, caused by the central contraction (isometric), led to a significant and statistically significant effect. The triceps is the muscle that extends the elbow joint until it forms a 180-degree angle [1], which is the main final movement affecting the forehand overhead jump smash [9]. Therefore, any defect in the work of this muscle will inevitably lead to a defect in the work of the elbow joint [1]. The motor cortex, the speed of neurotransmission, neuromuscular coordination, and the level of nerve excitability of the muscle fibers within the muscle are all impacted by the muscle fatigue brought on by the constant contraction of the triceps. This decreases the nervous stimulation of the muscles and disrupts the mechanism of muscle contraction [17]. As the central (isometric) contraction reduces the electrochemical excitability within the hyphae of the muscle, and consequently, weakens the discharge of calcium from the sarcoplasmic reticulum, which leads to a decrease in the sensitivity of the cross bridging located within the muscle fiber of calcium, which in turn weakens the coupling between actin and myosin filaments within the muscle fiber and prevents the filaments from sliding over one another. This denotes a weakness in the way the muscles perform since not enough of them are contracting to produce the necessary strength [18]. Additionally, it indicates that as a result of exhaustion, the net force chain-which runs from the feet to the shoulder through the elbow joint-that the body muscles make when they do the overhead leap smash breaks or become less effective. Thus, the momentum of the movement is transmitted to the racket [3], so any defect in the elbow joint will definitely affect the accuracy of the badminton smash, as this skill is mechanically linked to the elbow joint [4].

5. Conclusions

The elbow strength, the speed, and the accuracy of the overhead leap smash against the front racket among badminton players are all negatively impacted by the muscular exhaustion that developed in the triceps as a result of the central (isometric) muscle contraction. Comparing the levels of these variables before and after the triceps muscle, which is physically responsible for extending the elbow joint, it is apparent that triceps muscle became fatigued.

As a result, it is highly advised that badminton players strengthen their triceps in order to prevent the onset of local muscle fatigue, as it is one of the fundamental muscles that are heavily utilized during play.

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