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# Kinovea-Based Analysis of Jump Smash Biomechanics in PB Juwita Athletes

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**Abstract**
**Objectives:**
This study aims to describe the biomechanical characteristics of the jump smash movement of badminton athletes at PB. Juwita Tanjung Morawa using the Kinovea application as a two-dimensional motion analysis tool
**Materials and Methods:**
This study employed a descriptive quantitative method with a motion analysis approach. The sample consisted of 6 athletes selected using purposive sampling.
**Results:**
The results showed that the average shoulder joint angle was 82.33°, the average elbow joint angle was 100.67°, the average knee joint angle was 77.60°, and the average jump height was 80.58 cm. The highest jump height reached 96.30 cm, while the lowest was 63.65 cm
**Conclusions:**
The results show that Kinovea can be used to objectively analyze the biomechanics of badminton jump smashes through joint angle and jump height measurements. The six athletes showed different biomechanical characteristics, with average shoulder, elbow, and knee angles of 82.33°, 100.67°, and 77.60°, and an average jump height of 80.58 cm. Jump smash performance is influenced not only by jump height but also by coordination, balance, joint angles, and timing. Kinovea can therefore support technical evaluation and the development of more effective training programs.
**Keywords:** Biomechanics; Jump Smash; Badminton; Kinovea; Motion Analysis.

## Introduction

Knowledge of movement biomechanics is highly important because, through this scientific approach, technical variables that influence the efficiency and effectiveness of athletes' jump smash movements can be identified. Based on a systematic literature review, previous studies have confirmed that biomechanical analysis of the smash technique can provide an in-depth understanding of the mechanical factors that support offensive performance in modern badminton. A biomechanical approach to the smash technique can identify movement patterns that can be used to optimize performance and minimize the risk of injury among badminton athletes (Artazila, 2024: 241).

The success of a jump smash is determined not only by muscle strength but also by the quality of the athlete's biomechanics. Biomechanical principles explain that the effectiveness of a movement is influenced by joint angles, body balance, intersegmental coordination, and the proper sequence of movement phases. In the jump smash technique, minor errors such as improper knee position during take-off, incorrect shoulder angle during the swing, delayed hitting timing, or body imbalance in the air can cause the shot to be less powerful and inaccurate and may even increase the risk of injury to the athlete.

During training at badminton clubs, technical evaluation is often still conducted through direct observation by coaches. This method is subjective because it depends on the coach's experience and visual perception without being supported by quantitative data concerning movement angles, jump height, swing velocity, or the duration of movement phases. Consequently, the technical improvements provided to athletes are not yet fully based on scientific analysis, making the effectiveness of training less than optimal. This condition is also found among athletes at PB. Juwita Tanjung Morawa, where the athletes' jump smash abilities are generally adequate but have never been analyzed

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biomechanically using a technological approach. Without objective data on athletes' movement patterns, coaches experience difficulties in identifying in detail the aspects of movement that need improvement, including the preparation, take-off, airborne hitting, and landing phases.

Current developments in motion-analysis technology provide opportunities to evaluate technique in a more scientific and measurable manner. One software application that can be used is Kinovea, a video-analysis application capable of displaying movements frame by frame, measuring joint angles, calculating movement time, and tracking athletes' body trajectories. The application is relatively easy to use, does not require expensive equipment, and can be implemented directly in training environments, making it suitable for supporting athlete development at the club level. By utilizing Kinovea-based biomechanical analysis, coaches and athletes can obtain objective data regarding the quality of the jump smash technique, identify movement errors that were previously difficult to detect, and design more targeted training programs. This approach is expected to improve training effectiveness, enhance smash performance, and reduce the risk of injury resulting from improper technique. Based on the description above, research on the biomechanical analysis of jump smash movements among badminton athletes at PB. Juwita Tanjung Morawa using the Kinovea application is important to conduct. This research is expected to provide a scientific description of the athletes' movement characteristics, serve as a basis for technical evaluation by coaches, and contribute to the development of technology-based badminton training methods using motion analysis.

Badminton is one of the small-ball sports that requires a high level of technical mastery, upper- and lower-body muscular strength, agility, movement coordination, and rapid reaction ability in response to dynamic game stimuli. Stroke techniques such as the smash and jump smash are important for scoring points because both are offensive strokes capable of producing very high shuttlecock velocities compared with other stroke techniques in badminton. The jump smash, in particular, involves a complex combination of explosive jumping, coordinated movement of multiple body joints, and biomechanical mechanisms that optimize the speed and direction of the attack, making it an indicator of advanced athletic performance in competitive badminton.

Significant intra-individual variation in the jump smash movement among elite athletes still occurs, particularly in terms of racket velocity at the point of contact, the location of shuttlecock impact on the racket face, and swing time, all of which are associated with variability in stroke performance. The study indicates that consistency in technical movement is one of the factors determining the ability to produce fast and accurate smashes; however, its relationship with biomechanical structure still requires further investigation in more diverse athletic populations. Other studies have also shown that the biomechanics of the jump smash are closely related to agility, swing timing, and the transfer of kinetic energy through an effective kinetic chain, all of which can be measured through technology-based video analysis. Although technologies such as 3D motion-capture systems provide highly accurate data, they are often impractical and expensive for use at the club or routine training level. Therefore, 2D motion-analysis applications such as Kinovea have considerable potential because they are affordable, easy to use, and still provide relevant quantitative data for coaches and athletes in technical evaluation. The variation in jump smash techniques observed anecdotally at PB. Juwita Tanjung Morawa indicates differences in joint angles, jump height, and hitting timing among athletes that have not yet been scientifically investigated (Ramasamy, 2025: 11).

The problems associated with training and evaluating the jump smash technique have generally remained subjective and insufficiently measurable, particularly at local badminton clubs such as PB. Juwita Tanjung Morawa, where coaches often rely on visual observation without the assistance of advanced motion-analysis devices. Conventional

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observation may fail to capture key biomechanical differences that could determine the effectiveness of the jump smash, such as joint angles during take-off or peak racket velocity at the moment of contact with the shuttlecock. The availability of quantitative data would be highly beneficial for coaches in designing specific training programs, such as plyometric training or joint-strengthening exercises that are relevant to weak phases of movement. The development of motion-analysis technology has become increasingly digital, with affordable yet accurate video-based technologies, making technical analysis accessible not only to elite athletes or major universities. Such data are increasingly important considering the role of the jump smash in match strategies and the potential risk of injury when the technique is performed inefficiently. Based on international research findings, improper technical patterns may contribute to decreased performance and an increased risk of knee and shoulder injuries associated with high mechanical stress during the take-off and landing phases. The urgency of this research is further supported by the limited number of empirical studies utilizing Kinovea to analyze jump smash movements among club-level athletes, particularly within the existing scientific literature.

Based on the preliminary observation conducted by the researcher through an interview with the coach of PB. Juwita Tanjung Morawa in February 2026, it was found that the jump smash technique is one of the training materials routinely provided to athletes because it is a primary attacking technique in badminton matches. However, the technical evaluation process has so far relied primarily on the coach's visual observation without the use of motion-analysis tools. The coach stated that each athlete has different movement characteristics, particularly during the take-off, arm-swing, and landing phases, but these differences have not yet been objectively measured. In addition, the interview results indicated that the coach experiences difficulties in identifying technical errors performed by athletes in detail, such as the knee angle during take-off, the elbow and shoulder angles when hitting the shuttlecock, and the height of the jump achieved. Consequently, the feedback provided to athletes remains general and depends largely on the coach's experience. This condition means that the technical evaluation process is not yet fully based on quantitative data, so improvements in athletes' movement techniques cannot be maximized.

The coach also stated that, to date, PB. Juwita Tanjung Morawa has never utilized motion-analysis software such as Kinovea in the technical evaluation process. In fact, the use of such an application could assist the coach in obtaining more objective and accurate data concerning joint angles, jump height, and movement characteristics. Therefore, the coach welcomed the proposed research because the analysis results are expected to serve as a basis for technical evaluation and for developing more effective training programs to improve the quality of the athletes' jump smash technique.

## Materials and Methods

### Study Design

This study employs a quantitative method, as it aims to obtain objective data in the form of numerical values that can be systematically measured, analyzed, and interpreted regarding the biomechanical characteristics of the jump smash performed by badminton athletes.

### Study Participants

The population consists of all 15 active athletes at PB. Juwita Tanjung Morawa who participate in the badminton training program and regularly execute the jump smash technique during training sessions. From this population of 15 active athletes at PB. Juwita Tanjung Morawa, the researcher selected 6 athletes as the sample based on specific criteria.

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**Study Organization**

Data were obtained through video recordings of jump smash movements and analyzed using Kinovea based on the shoulder, elbow, and knee joint angles, as well as jump height.

**Statistical Analysis**

Descriptive analysis was used to describe the biomechanical characteristics of athletes' jump smash movements based on kinematic parameters measured using Kinovea. The parameters included shoulder, elbow, and knee joint angles, as well as jump height during the preparation, take off, and flight phases. The data were presented in tables and graphs to identify movement patterns and variations among athletes. The analysis results showed shoulder, elbow, and knee angles of 95°, 137°, and 66°, respectively, with a jump height of 43.78 cm.

**Results**

Data collection was conducted by recording each athlete's jump smash movement using a camera positioned perpendicular to the plane of motion. The video footage was then analyzed using the Kinovea application to obtain data on knee, elbow, and shoulder joint angles, as well as jump height. Measurements were taken while the athlete performed their best jump smash, in accordance with the research procedures.

The data obtained from the Kinovea analysis for the "on-target" category are presented below:

**Table 1.** Kinovea Analysis Results: On Target Category

| Nama | Shoulder Joint Angle (°) | Elbow Joint Angle (°) | Knee Joint Angle (°) | Jump Height (cm) |
|---|---|---|---|---|
| **Sanjeev** | 86 ° | 81 ° | 68 ° | 68.56 cm |
| **Faqih** | 73 ° | 126 ° | 76.2 ° | 63.65 cm |
| **Adam** | 75 ° | 109 ° | 76.4 ° | 90.6 cm |
| **Irgi** | 79 ° | 86 ° | 80.4 ° | 87.57 cm |
| **Rayyan** | 84 ° | 121 ° | 85.4 ° | 96.3 cm |
| **Fahri** | 97 ° | 81° | 79.2° | 76.77 cm |
| **Average** | 82.33 ° | 100.67 ° | 77.6 ° | 80.57 cm |

Analysis using the Kinovea program for the on target category indicates that the average joint angles and jump height resulting from the jump smash performed by the six athletes were as follows: shoulder joint angle of 82.33°, elbow joint angle of 100.67°, knee joint angle of 77.6°, and jump height of 80.57 cm.

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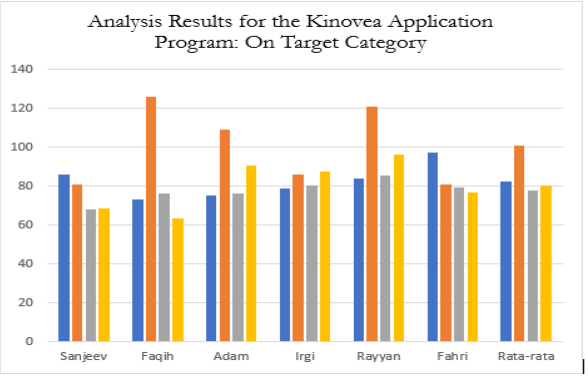


**Figure 1.** Bar chart showing the results of the biomechanical analysis of the jump smash movement accuracy category

Figure 1 presents the results of a biomechanical analysis of the accurate target jump smash performed by six athletes from PB. Juwita Tanjung Morawa, based on measurements taken using the Kinovea application. The variables analyzed include shoulder, elbow, and knee joint angles, as well as jump height. The graphs reveal that each athlete exhibits distinct biomechanical characteristics, indicating variations in technique during the execution of the jump smash.

**Table 2.** Results of Kinovea Program Analysis: Off Target Category

| Nama | Shoulder Joint Angle (°) | Elbow Joint Angle (°) | Knee Joint Angle (°) | Jump Height (cm) |
|---|---|---|---|---|
| **Sanjeev** | 95 ° | 98 ° | 78° | 54.5 cm |
| **Faqih** | 93 ° | 134 ° | 83.2 ° | 45.62 cm |
| **Adam** | 89° | 118 ° | 87.3 ° | 54.43 cm |
| **Irgi** | 97° | 110 ° | 93.2 ° | 75.65 cm |
| **Rayyan** | 96° | 134 ° | 96.2 ° | 60.78 cm |
| **Fahri** | 119° | 98 ° | 85.7 ° | 61.32 cm |
| **Average** | 98.17 ° | 98 ° | 87.3 ° | 58.72 ° |

Analysis using the Kinovea program for the on target category indicates that the average joint angles and jump height resulting from the jump smash performed by the six athletes were as follows: shoulder joint angle of 98.17°, elbow joint angle of 115.33°, knee joint angle of 87.3°, and jump height of 58.72 cm.

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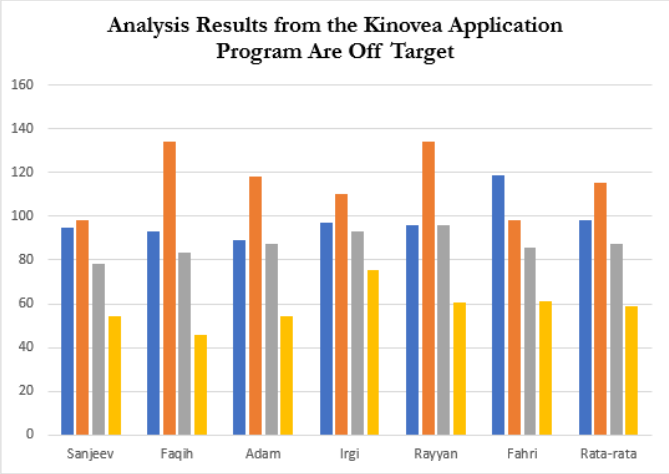



**Figure 2.** Bar chart showing the results of the biomechanical analysis of the jump smash movement off target category

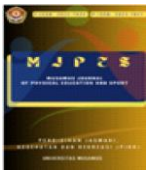
Figure 2 presents the results of a biomechanical analysis of off-target jump smashes performed by six athletes from PB Juwita Tanjung Morawa, based on measurements taken using the Kinovea application. The parameters analyzed include shoulder joint angles, elbow joint angles, knee joint angles, and jump height. The graphs reveal differences in the values for each variable, indicating variations in biomechanical characteristics among the athletes when executing off-target jump smashes.

**Discussion**

Biomechanical analysis of the badminton jump smash was conducted using the Kinovea application and classified into two categories: accurate and inaccurate shots. In the accurate category, the six athletes showed variations in shoulder, elbow, and knee joint angles, as well as jump height. The average shoulder angle was 82.33°, elbow angle 100.67°, knee angle 77.60°, and jump height 80.58 cm. Rayyan demonstrated the highest jump height at 96.30 cm, followed by Adam at 90.60 cm, while Faqih had the lowest at 63.65 cm. These differences indicate that jump smash performance is influenced by physical ability, movement coordination, joint flexibility, training experience, and technical mastery. Although Rayyan demonstrated the highest jump, each athlete displayed different movement characteristics while still achieving accurate shots.

In the inaccurate category, biomechanical variables also showed considerable variation. The average shoulder angle was approximately 98°, elbow angle 116°, knee angle 87°, and jump height 59 cm. Irgi recorded the highest jump at approximately 75 cm, whereas Faqih had the lowest at approximately 45 cm. The findings indicate that a high jump or large joint angle does not necessarily result in an accurate smash. Accuracy depends on the integration of several biomechanical components, including intersegmental coordination, synchronization between leg push-off and arm swing, body stability during flight, and the timing of racket contact with the shuttlecock.

Compared with the accurate category, the inaccurate category generally showed a lower average jump height and less consistent joint coordination. This suggests that jump smash accuracy is not determined by a single biomechanical variable but by the interaction of shoulder, elbow, and knee angles, lower-limb explosive power, balance, and contact timing. These findings are consistent with Phomsoupha and Laffaye (2015), who explained that badminton smash performance involves a kinetic chain extending from the lower limbs, hips, trunk, shoulder, elbow, to the wrist. Dwiwahyudi et al. (2023)



also reported that biomechanical analysis can help identify technical errors in different movement phases and serve as a basis for improving smash accuracy and effectiveness.
Overall, the results demonstrate that Kinovea can provide objective quantitative information about the biomechanical characteristics of the jump smash. The data can assist coaches in identifying athletes' technical strengths and weaknesses, correcting movement coordination, improving take-off and arm-swing mechanics, and designing more specific training programs to improve jump smash performance and accuracy.

## Conclusions

The results show that Kinovea can be used to objectively analyze the biomechanics of badminton jump smashes through joint angle and jump height measurements. The six athletes showed different biomechanical characteristics, with average shoulder, elbow, and knee angles of 82.33°, 100.67°, and 77.60°, and an average jump height of 80.58 cm. Jump smash performance is influenced not only by jump height but also by coordination, balance, joint angles, and timing. Kinovea can therefore support technical evaluation and the development of more effective training programs.

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## Conflict of Interest

The authors declare no conflict of interest.

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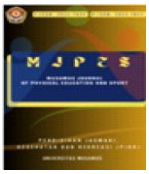

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