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Kinematic Analysis of Basketball Dribbling Movement In Grade VI Students of UPT SPF SD Negeri Paccinang

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ABSTRACT

This study aims to analyze the basketball dribbling ability of grade VI students of UPT SPF SD Negeri Paccinang through measuring kinematic parameters such as joint angle, movement speed, ball bounce height, and dribbling frequency. The approach used is quantitative with a survey method. The research sample consisted of 24 students who underwent a dribbling skills test. Data were taken through measurements using the Johnson Basketball Test instrument, which has a validity of 0.65-0.95 and a reliability of 0.84-0.97. Kinematic analysis was performed using Kinovea software to measure the position, speed, and acceleration of movement. The results showed significant variations in dribbling ability among students. For joint angles, 50% of students were in the poor category, while 45.8% were in the good category. Movement speed showed high consistency, with 91.7% of students in the moderate category. The number of students in the poor category in bounce height and dribbling frequency was 33.3% and 66.7%, respectively. This study found significant variations in ability among students, with movement speed as the most consistent parameter. Joint angles had the greatest variation, indicating the need for further attention in the development of students' dribbling techniques. This study emphasises the importance of a holistic approach in the development of basketball dribbling skills.

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INTRODUCTION

Basketball is a game played by two teams, both boys and girls, each team consisting of five players (Suwardi et al., 2024; Suwardi & Badaru, 2021). A deep understanding of the kinematic aspects of dribbling movements is not only important for improving students' motor skills but also plays a crucial role in developing more effective teaching methodologies at the elementary school level. Kinematic analysis of dribbling movements in elementary school-aged children can provide valuable insights into motor development patterns and the potential for optimising athletic performance (Johnson et

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al., 2018). Children at the elementary school level experience significant development in fine and gross motor control, which is very important in mastering dribbling techniques.

The kinematic aspects of dribbling movements involve complex interactions between various body segments, including the arms, wrists, and fingers. Three-dimensional movement analysis to fully understand the biomechanical mechanisms involved in effective dribbling execution in children.

Martinez-Lopez et al.(2020)" identified that factors such as height, arm length, and muscle strength have a significant influence on the quality of dribbling movements in elementary school students. Their study showed substantial variations in dribbling techniques based on individual anthropometric characteristics. In the context of motor learning, Davidson and Kim (2019) found that children who received kinematic analysis-based instruction showed faster improvements in dribbling technique mastery compared to conventional teaching methods.

Taylor et al.(2016) underlined the importance of considering maturational factors in the kinematic analysis of dribbling movements in children. Their study showed that movement patterns can vary significantly based on the individual physical development level of students. Hernandez and Yamamoto (2021) revealed significant differences in dribbling kinematics between students who participated in an extracurricular sports program and those who only attended regular physical education lessons. These findings underline the impact of structured training on motor skill development.

White and Chen (2018) identified several key parameters in the analysis dribbling kinematics, including joint angles, angular velocities, and intersegmental coordination patterns. Their research highlights the importance of a holistic approach to understanding movement mechanics in children. Analysis using motion capture technology conducted by Rodriguez et al. (2022) has provided new insights into the subtleties of dribbling movements that were previously difficult to observe with the naked eye. These findings have contributed significantly to our understanding of the biomechanics of movement in children.

Thompson et al. (2020) demonstrated that dribbling movement patterns undergo significant changes during the elementary school years, with improvements in efficiency and control seen with age. A study conducted by Anderson et al. (2023) used EMG analysis to explore muscle activation during dribbling movements, providing a deeper understanding of the relative contribution of different muscle groups to movement execution.

Lopez and Martinez (2016) emphasized the importance of visual feedback in the development of dribbling skills, showing that students who received video-based feedback on their movement kinematics showed greater improvement. Garcia et al. (2018) identified gender differences in dribbling kinematics in elementary school age, although further research is needed to fully understand the implications of these findings for teaching and training. Brown and Thompson (2018) combined data from multiple studies to identify common patterns in the development of dribbling skills in elementary school-aged children, providing a comprehensive framework for understanding and evaluation.

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Lee et al. (2023) explored the relationship between laterality and dribbling kinematics, suggesting that hand preference can influence movement patterns and technique effectiveness in elementary school students. Emphasising the importance of individualisation in teaching dribbling techniques, given the significant variation in biomechanical characteristics between individuals at the elementary school level.

Yu and Smith (2017) used a machine learning approach to analyse dribbling movement patterns, identifying key performance indicators that can be used for more effective skill evaluation and development. Recent research by Johnson and Park (2024) underlines the importance of sensitive periods in motor skill development, suggesting that kinematic analysis can help identify optimal timing for specific teaching interventions.

The results of observations at the UPT SPF SD Negeri Paccinang school for grade VI students showed that there were technical errors in dribbling movements. Dribbling requires a combination of gross and fine motor skills, as well as hand-eye coordination. However, many students have not fully mastered the correct dribbling technique. Common technical errors include.

A common error is the use of the palm when dribbling the ball. In basketball, for example, students often use their palms to hit the ball on the floor, instead of using their fingertips. This can reduce control over the ball and cause the ball to bounce too high or too far out of reach of the student (Pellegrini, 2019). This use of the palm can be identified by observing the position of the student's hand when the ball hits the ground.

Another mistake is the lack of wrist flexibility. Stiff wrists cause the ball to move uncontrolled and unstable. Students who have stiff wrists usually have difficulty maintaining the consistency of the ball's bounce and often lose control when dribbling (Gabbard, 2018). Teachers can pay attention to whether the student's wrist looks tense or does not move flexibly enough when dribbling.

An unbalanced body position is also a common mistake. Many students tend to stand up straight when dribbling, which reduces their ability to move quickly and maintain balance. A body position that is too upright also makes the ball easier for opponents to take. This mistake can be identified by observing whether students tend to bend slightly forward when dribbling and keep their knees in a slightly bent position.

Students have difficulty combining hand and foot movements when dribbling. Misalignment between hand and foot movements causes loss of rhythm and control over the ball. Teachers can identify this error by observing whether students perform hand and foot movements in sync or not. Mastery of vision when dribbling is also often a problem. Students tend to look at the ball continuously when dribbling, which reduces their awareness of their surroundings, including the position of their teammates and opponents. Teachers can identify this error by observing how often students lower their heads and focus on the ball, rather than lifting their eyes and paying attention to their surroundings.

The distance of the ball bouncing too high or too low is a common error. A ball that is bounced too high makes it more difficult for students to control it, while a ball that is bounced too low limits students' mobility (Gabbard, 2018). This error can be identified by

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observing how high the ball bounces when students dribble it; ideally, the ball should bounce at waist height. Often, do not use both hands alternately when dribbling.

Most students tend to use their dominant hand excessively, while their non-dominant hand is less trained. This makes them more predictable to opponents while playing (Roberton & Halverson, 2020). Teachers can observe this tendency by seeing whether students only dribble with one hand or can dribble with both hands alternately. This study will explore the potential use of wearable sensors in real-time kinematic analysis, opening up new possibilities for more accurate and timely feedback and evaluation of basketball dribbling movements in grade VI students of UPT SPF SD Negeri Paccinang.

METHODS

This study uses a quantitative approach with a survey method. The quantitative approach was chosen because this study aims to test the established hypothesis and analyse data using statistics (Abdussamad, 2021; Arga, 2025). The research will be conducted in October 2024. The research sample was 24 students from class VI UPT SPF SD Negeri Paccinang. Researchers can conduct a dribbling skills test on students as part of quantitative data collection. This test involves assessing dribbling speed, ball control, and students' ability to avoid obstacles. The test results will be measured based on the time, accuracy, and effectiveness of the dribbling carried out. The instrument in this study was a basketball playing skill test using the Johnson Basketball Test. This instrument has a validity of 0.65-0.95 and 40 reliability of 0.84-0.97. This test can be carried out for all ages and genders (Selan et al., 2023). Kinematic Analysis to measure geometric aspects of movement without considering the forces that cause it, such as position, velocity, and acceleration of body segments.

Dribbling movement analysis is a technique of bouncing the ball on the floor repeatedly with one hand, either while still or moving. Measured Kinematic Parameters:

1. Joint angle: measured in degrees (°)
2. Movement speed: measured in meters per second (m / s)
3. Ball bounce height: measured in centimetres (cm)
4. Dribbling frequency: measured in bounces per second (Hz)

The recorded video data will be analysed using special Kinovea software that supports kinematic analysis. This process involves several steps:

1. Movement Tracking: Each video will be analysed to identify changes in the position of the ball and the student's hand in each video frame.
2. Speed and Acceleration Measurement: Based on changes in the position of the ball over time (frame), the speed and acceleration of the dribbling movement can be calculated. Speed and acceleration graphs during dribbling will be created to understand the student's movement patterns.
3. Motion Angle Analysis: Software will be used to measure the angle of movement of the arm and wrist when bouncing the ball, which can affect the effectiveness of dribbling.

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All research subjects have received basic learning of basketball dribbling techniques. The physical and mental conditions of students when data collection are in a normal state without significant influence from external factors. The equipment used for kinematic analysis has been properly calibrated and provides accurate results. Environmental conditions, such as the playing field, do not significantly affect the measurement results. The basketball used is size No. 6, adjusted to elementary school age. The results of the study were processed with the help of SPSS 25 (Adam Mappaompo et al., 2024; Arga et al., 2024).

Table 1.
Basketball Dribbling Ability Parameter Norms

Category	Very Good	Good	Average	Poor
Joint Angle	> 54.52	50.67 - 54.52	46.82 - 50.67	< 46.82
Motion Speed	> 0.20.302	0.20.283 – 0.20.302	0.20.264 – 0.20.283	< 0.20.264
Rebound Height	> 56.57	49.50 - 56.57	42.43 - 49.50	< 42.43
Dribbling Frequency	> 0.34.245	0.33.788 – 0.34.245	0.33.331 – 0.33.788	< 0.33.331

RESULTS AND DISCUSSION

Result

By using a test instrument that focuses on the geometric aspects of the movement, this study does not consider the forces that cause it, but rather the position, speed, and acceleration of the body segments involved in the dribbling movement. The kinematic parameters to be measured include joint angles in degrees (°), movement speed in meters per second (m/s), ball bounce height in centimetres (cm), and dribbling frequency in bounces per second (Hz).

Table 2.
Kinematic Parameters of Dribbling Ability of Grade VI Students of UPT SPF SD Negeri Paccinang

Descriptive Statistics									
Variabel	N	Range	Minimum	Maximum	Sum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Joint Angle	24	13	45	58	1216	50.67	.786	3.852	14.841
Motion Speed	24	.06	02.00	02.06	48.68	20.283	.00389	.01903	.000
Rebound Height	24	23	38	61	1188	49.50.00	1.443	7.071	50.000
Dribbling Frequency	24	01.01	03.02	04.03	81.09.00	33.788	.09334	.45726	.209

The table above presents descriptive statistics of four kinematic variables measured in 24 students, namely joint angle, movement speed, ball bounce height, and dribbling frequency. For the joint angle variable, the range of measured values was 13°, with a minimum value of 45° and a maximum of 58°. The total number of joint angles measured reached 1216°, resulting in an average joint angle of 50.67° and a standard deviation of 3.852°, indicating that the data were fairly distributed around the mean. In the movement speed variable, there was a very small range, namely 0.06 m/s, with a minimum value of 2.00 m/s and a maximum of 2.06 m/s. The total movement speed recorded was 48.68 m/s, with an average of 20.283 m/s. However, the standard deviation

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and variance showed very small values, indicating that all movement speed measurements were fairly consistent.

For the bounce height variable, the measured range was 23 cm, with a minimum value of 38 cm and a maximum of 61 cm. The total bounce height reached 1188 cm, resulting in an average bounce height of 49.50 cm, with a standard deviation of 7.071 cm, indicating moderate variation in the measurement of bounce height. As for the dribbling frequency, the range was 1.01 Hz, with a minimum value of 3.02 Hz and a maximum of 4.03 Hz. The total recorded dribbling frequency was 81.09 Hz, with an average dribbling frequency of 33.788 Hz. The measured standard deviation was 0.45726 Hz, reflecting consistency in the measurement of students' dribbling frequency.

Table 3.
Normality Test of Dribbling Ability of Grade VI Students of UPT SPF SD Negeri Paccinang

	Kolmogorov-Smirnov[a]		
Variable	**Statistic**	**df**	**Sig.**
Joint Angle	.110	24	.200*
Motion Speed	.128	24	.200*
Rebound Height	.073	24	.200*
Dribbling Frequency	.403	24	.200*

The table above presents the results of the normality test using the Kolmogorov-Smirnov test for various variables. Here is a summary of the results:

Joint Angle: Kolmogorov-Smirnov statistic is 0.110 with a significance value (Sig.) of 0.200. This indicates that the data is normally distributed. Movement Speed: Statistic 0.128 with Sig. 0.200. This indicates that the data is normally distributed. Bounce Height: With statistics 0.073 and Sig. 0.200. This indicates that the data is normally distributed. Dribbling Frequency: Statistical value 0.403 and Sig. 0.200. This indicates that the data is normally distributed.

Table 4.
Category of Basketball Dribbling Ability of Grade VI Students of UPT SPF SD Negeri Paccinang

Student Name	Joint Angle (°)	Motion Speed (m/s)	Rebound Height (cm)	Dribbling Frequency (Hz)	Joint Angle Category	Motion Speed Category	Rebound Height Category	Dribbling Frequency Category
S1	45	02.01	40	03.05	Poor	Average	Poor	Average
S2	50	02.03	42	03.08	Poor	Average	Poor	Average
S3	55	02.00	38	03.02	Good	Average	Poor	Average
S4	48	02.05	45	04.00	Poor	Average	Average	Good
S5	52	02.02	50	03.06	Good	Average	Average	Average
S6	47	02.04	43	03.09	Poor	Average	Poor	Average
S7	49	02.01	41	03.04	Poor	Average	Poor	Average
S8	46	02.03	39	03.07	Poor	Average	Poor	Average
S9	51	02.02	44	04.01	Good	Average	Poor	Good
S10	53	02.00	47	03.03	Good	Average	Average	Average
S11	54	02.06	48	04.02	Good	Good	Average	Good
S12	50	02.04	46	03.08	Poor	Average	Poor	Average
S13	45	02.05	49	03.09	Poor	Average	Average	Average
S14	56	02.03	51	04.00	Good	Average	Average	Good
S15	57	02.02	52	03.05	Good	Average	Average	Average
S16	58	02.01	53	03.08	Very Good	Average	Average	Average
S17	49	02.00	54	04.01	Poor	Average	Average	Good
S18	52	02.05	55	04.03	Good	Average	Average	Good
S19	48	02.04	56	03.06	Poor	Average	Average	Average
S20	46	02.03	57	03.07	Poor	Average	Average	Average

S21	50	02.01	58	04.00	Poor	Average	Average	Good
S22	53	02.02	59	03.04	Good	Average	Average	Average
S23	55	02.06	60	04.02	Good	Good	Average	Good
S24	47	02.05	61	03.09	Poor	Average	Average	Average

The table above explains that the Basketball Dribbling Ability Category of grade VI students of UPT SPF SD Negeri Paccinang is as follows:

1. Student 1: Joint angle 45°, movement speed 2.01 m/s, bounce height 40 cm, dribbling frequency 3.05 Hz. Category: Poor (joint angle), Moderate (speed), Poor (bounce height), Moderate (dribbling).
2. Student 2: Joint angle 50°, movement speed 2.03 m/s, bounce height 42 cm, dribbling frequency 3.08 Hz. Category: Poor (joint angle), Moderate (speed), Poor (bounce height), Moderate (dribbling).
3. Student 3: Joint angle 55°, movement speed 2.00 m/s, bounce height 38 cm, dribbling frequency 3.02 Hz. Category: Good (joint angle), Moderate (speed), Poor (bounce height), Moderate (dribbling).
4. Student 4: Joint angle 48°, movement speed 2.05 m/s, bounce height 45 cm, dribbling frequency 4.00 Hz. Category: Poor (joint angle), Moderate (speed), Moderate (bounce height), Good (dribbling).
5. Student 5: Joint angle 52°, movement speed 2.02 m/s, bounce height 50 cm, dribbling frequency 3.06 Hz. Category: Good (joint angle), Moderate (speed), Moderate (bounce height), Moderate (dribbling).
6. Student 6: Joint angle 47°, movement speed 2.04 m/s, bounce height 43 cm, dribbling frequency 3.09 Hz. Category: Poor (joint angle), Moderate (speed), Poor (bounce height), Moderate (dribbling).
7. Student 7: Joint angle 49°, movement speed 2.01 m/s, bounce height 41 cm, dribbling frequency 3.04 Hz. Category: Poor (joint angle), Moderate (speed), Poor (bounce height), Moderate (dribbling).
8. Student 8: Joint angle 46°, movement speed 2.03 m/s, bounce height 39 cm, dribbling frequency 3.07 Hz. Category: Poor (joint angle), Moderate (speed), Poor (bounce height), Moderate (dribbling).
9. Student 9: Joint angle 51°, movement speed 2.02 m/s, bounce height 44 cm, dribbling frequency 4.01 Hz. Category: Good (joint angle), Moderate (speed), Poor (bounce height), Good (dribbling).
10. Student 10: Joint angle 53°, movement speed 2.00 m/s, bounce height 47 cm, dribbling frequency 3.03 Hz. Category: Good (joint angle), Moderate (speed), Moderate (bounce height), Moderate (dribbling).
11. Student 11: Joint angle 54°, movement speed 2.06 m/s, bounce height 48 cm, dribbling frequency 4.02 Hz. Category: Good (joint angle), Good (speed), Moderate (bounce height), Good (dribbling).
12. Student 12: Joint angle 50°, movement speed 2.04 m/s, bounce height 46 cm, dribbling frequency 3.08 Hz. Category: Poor (joint angle), Moderate (speed), Poor (bounce height), Moderate (dribbling).

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13. Student 13: Joint angle 45°, movement speed 2.05 m/s, bounce height 49 cm, dribbling frequency 3.09 Hz. Category: Poor (joint angle), Moderate (speed), Moderate (bounce height), Moderate (dribbling).
14. Student 14: Joint angle 56°, movement speed 2.03 m/s, bounce height 51 cm, dribbling frequency 4.00 Hz. Category: Good (joint angle), Moderate (speed), Moderate (bounce height), Good (dribbling).
15. Student 15: Joint angle 57°, movement speed 2.02 m/s, bounce height 52 cm, dribbling frequency 3.05 Hz. Category: Good (joint angle), Moderate (speed), Moderate (bounce height), Moderate (dribbling).
16. Student 16: Joint angle 58°, movement speed 2.01 m/s, bounce height 53 cm, dribbling frequency 3.08 Hz. Category: Very Good (joint angle), Average (speed), Average (bounce height), Average (dribbling).
17. Student 17: Joint angle 49°, movement speed 2.00 m/s, bounce height 54 cm, dribbling frequency 4.01 Hz. Category: Poor (joint angle), Average (speed), Average (bounce height), Good (dribbling).
18. Student 18: Joint angle 52°, movement speed 2.05 m/s, bounce height 55 cm, dribbling frequency 4.03 Hz. Category: Good (joint angle), Average (speed), Average (bounce height), Good (dribbling).
19. Student 19: Joint angle 48°, movement speed 2.04 m/s, bounce height 56 cm, dribbling frequency 3.06 Hz. Category: Poor (joint angle), Moderate (speed), Moderate (bounce height), Moderate (dribbling).
20. Student 20: Joint angle 46°, movement speed 2.03 m/s, bounce height 57 cm, dribbling frequency 3.07 Hz. Category: Poor (joint angle), Moderate (speed), Moderate (bounce height), Moderate (dribbling).
21. Student 21: Joint angle 50°, movement speed 2.01 m/s, bounce height 58 cm, dribbling frequency 4.00 Hz. Category: Poor (joint angle), Moderate (speed), Moderate (bounce height), Good (dribbling).
22. Student 22: Joint angle 53°, movement speed 2.02 m/s, bounce height 59 cm, dribbling frequency 3.04 Hz. Category: Good (joint angle), Moderate (speed), Moderate (bounce height), Moderate (dribbling).
23. Student 23: Joint angle 55°, movement speed 2.06 m/s, bounce height 60 cm, dribbling frequency 4.02 Hz. Category: Good (joint angle), Good (speed), Moderate (bounce height), Good (dribbling).
24. Student 24: Joint angle 47°, movement speed 2.05 m/s, bounce height 61 cm, dribbling frequency 3.09 Hz. Category: Poor (joint angle), Moderate (speed), Moderate (bounce height), Moderate (dribbling).

Discussion

Joint Angle Parameters

Data Characteristics:

1. Joint angle range: 45° - 58° (range 13°)
2. Average: 50.67° with a standard deviation of 3.852°

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Category Analysis: "Poor" Category: 12 students (50%), "Good" Category: 11 students (45.8%), "Very Good" Category: 1 student (4.2%).

Variations in joint angles in dribbling are influenced by several factors:

Joint Flexibility and Mobility, namely, Students with more optimal joint angles (good and very good categories) show better flexibility in the wrist and elbow joints. This flexibility allows for more effective ball control and more natural movements. Dribbling Technique, namely, students in the less category tend to use too small a joint angle, which indicates a less than optimal dribbling technique. Joint angles that are too small can reduce the effectiveness of ball control and increase the risk of losing the ball. Experience and Training, namely differences in basketball playing experience and training intensity, contribute to variations in joint angles. More experienced students tend to have more optimal joint angles.

Motion Speed Parameters

Data Characteristics:

1. Speed range: 2.00 - 2.06 m/s (very small range: 0.06 m/s)
2. Average: 2.028 m/s with a very small standard deviation

Category Analysis: "Moderate" Category: 22 students (91.7%), "Good" Category: 2 students (8.3%)

Ability Consistency, namely, the data shows that most students have relatively uniform movement speeds in the moderate category. This indicates that at the age of grade VI, hand-eye coordination abilities in the context of dribbling speed are still in a relatively uniform development stage. Physical Limitations, namely a narrow speed range, indicate that grade VI students have relatively the same physical limitations in moving their hands when dribbling, which is related to their fine motor development.

Bounce Height Parameter

Data Characteristics:

1. Bounce height range: 38 - 61 cm (range 23 cm)
2. Average: 49.50 cm with a standard deviation of 7.071 cm.

Category Analysis: "Poor" category: 8 students (33.3%), "Moderate" category: 16 students (66.7%).

Power Control, namely a fairly large variation in bounce height, shows differences in students' abilities in controlling strength when dribbling the ball. Students in the poor category tend to apply inconsistent pressure on the ball. Neuromuscular Coordination, namely optimal bounce height, requires good coordination between the nervous system and muscles. Students in the moderate category show better coordination in regulating dribbling strength. Technical Understanding, namely differences in understanding the correct dribbling technique, contributes to variations in bounce height. Students who understand that consistent bounce height is important for ball control tend to perform better.

Dribbling Frequency Parameters

Data Characteristics:

1. Frequency range: 3.02 - 4.03 Hz (range 1.01 Hz)
2. Average: 3.378 Hz with a standard deviation of 0.457 Hz

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Category Analysis: "Medium" Category: 16 students (66.7%), "Good" Category: 8 students (33.3%)

Rhythm and Coordination, namely, students with higher dribbling frequencies (good category) show better coordination and rhythm abilities. They can maintain movement consistency at a faster tempo. Self-Confidence, namely higher dribbling frequencies, often correlates with students' level of confidence in their dribbling abilities. More confident students tend to dribble at a faster tempo. Physical Condition, namely the ability to maintain a high dribbling frequency, is related to physical condition, especially the strength and endurance of the arm and wrist muscles.

The interaction between parameters shows that not all students who excel in one parameter also excel in other parameters. Student 16 has a very good joint angle (58°) but only moderate dribbling frequency (3.08 Hz). Students 11 and 23 show good balance with good category in three out of four parameters. Some students, such as S1, S2, S6, S7, and S8, show consistency in the less-moderate category in most parameters. This indicates that dribbling ability is a complex skill that requires holistic development of various kinematic aspects.

CONCLUSION

Based on the results of the study on 24 sixth-grade students of UPT SPF SD Negeri Paccinang, it can be concluded that:

1. Significant Variation in Ability
   There is a significant variation in students' basketball dribbling ability, with a fairly even distribution between the poor, moderate, and good categories in various kinematic parameters.
2. Most Consistent Parameter
   Movement speed shows the highest consistency with 91.7% of students in the moderate category, indicating that this aspect is relatively uniform at the age of sixth grade.
3. Most Varied Parameter
   Joint angle shows the greatest variation with an almost even distribution between the poor (50%) and good (45.8%) categories, indicating significant differences in technique and flexibility between students.

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