Badminton performance analysis of leg power, force and reaction time using a digital measurement system

Análisis del rendimiento en bádminton: potencia, fuerza y tiempo de reacción de las piernas mediante un sistema de medición digital

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Abstract

Introduction: Performance in badminton demands optimal physical abilities, particularly leg explosiveness, ground reaction force, and reaction time. These three components play a crucial role in supporting rapid movement, changes of direction, and response to the shuttlecock.
Objective: This study aims to analyze the comparison of leg power, ground reaction force, and reaction time using digital and manual measurement systems in badminton.
Methodology: The method used was quantitative with a descriptive correlational design. The subjects were 20 male badminton athletes selected using a purposive sampling technique. Result: The results of the study showed that the correlation coefficient value for measuring the reaction time variable (r = 0.4360) leg power (r = 0.7602) and ground reaction force (r = 0.7638), while the reliability value was (reaction time r = 0.765; leg power r = 0.752; ground reaction force r = 0.845 respectively using a significance level of 0.05.
Discussion: Several previous studies have reported that leg power measurements using sensor-based digital devices, such as vertical jump systems or force plates, have good to excellent Intra class Correlation Coefficient values . This is due to the digital device's ability to automatically record flight time, jump height, and ground reaction force, thereby reducing measurement errors due to human factors.
Conclusions: The conclusion of this study is that both digital measurement systems and manual tests have an acceptable level of reliability in measuring athletes' physical components. However, the digital measurement system is considered superior in terms of objectivity, precision and data consistency.

Keywords

Badminton; digital measurement; leg power; reaction time; sports technology.

Resumen

Introducción: El rendimiento en bádminton exige capacidades físicas óptimas, en particular la explosividad de las piernas, la fuerza de reacción al suelo y el tiempo de reacción. Estos tres componentes desempeñan un papel crucial en la rapidez de movimientos, los cambios de dirección y la respuesta al volante.
Objetivo: Este estudio busca analizar la comparación de la potencia de las piernas, la fuerza de reacción al suelo y el tiempo de reacción mediante sistemas de medición digitales y manuales en bádminton.
Metodología: El método utilizado fue cuantitativo con un diseño descriptivo correlacional. Los participantes fueron 20 atletas masculinos de bádminton seleccionados mediante un muestreo intencional. Resultado: Los resultados del estudio mostraron que el valor del coeficiente de correlación para la medición de las variables tiempo de reacción (r = 0,4360), potencia de pierna (r = 0,7602) y fuerza de reacción en el suelo (r = 0,7638), mientras que el valor de fiabilidad fue (tiempo de reacción r = 0,765; potencia de pierna r = 0,752; fuerza de reacción en el suelo r = 0,845 respectivamente, utilizando un nivel de significancia de 0,05).
Discusión: Varios estudios previos han reportado que las mediciones de potencia de pierna utilizando dispositivos digitales basados en sensores, como sistemas de salto vertical o plataformas de fuerza, presentan valores de coeficiente de correlación intraclase de buenos a excelentes. Esto se debe a la capacidad del dispositivo digital para registrar automáticamente el tiempo de vuelo, la altura del salto y la fuerza de reacción en el suelo, reduciendo así los errores de medición debidos a factores humanos.
Conclusiones: La conclusión de este estudio es que tanto los sistemas de medición digitales como las pruebas manuales tienen un nivel aceptable de fiabilidad en la medición de los componentes físicos de los atletas. Sin embargo, el sistema de medición digital se considera superior en términos de objetividad, precisión y consistencia de los datos.

Palabras clave

Bádminton; medición digital; potencia de piernas; tiempo de reacción; tecnología deportiva.

Introduction

Badminton is a popular and rapidly growing competitive sport, both nationally and internationally (Cui et al., 2022). This sport demands optimally integrated physical, technical, tactical, and mental abilities (Muslimin & Destriana, 2025). Badminton is characterized by fast, explosive movements, sudden changes of direction, and varying rally durations at high intensity (Pandiyan et al., 2025). Athletes are required to move efficiently, respond quickly to stimuli, and maintain optimal performance throughout the match (Wibowo et al., 2025). Therefore, an athlete's physical condition is a fundamental factor in supporting successful badminton performance (Widiyanto et al., 2025).

In the context of physical condition, several components play a very dominant role in badminton athlete performance, including leg explosiveness, force, and reaction time (Kusuma, 2025). Leg explosiveness is the ability of muscles to generate maximum force in a short period of time. This component is essential for various badminton movements, such as jumping during a smash, explosive steps to various corners of the court, and the ability to recover quickly after a shot (Choudhary et al., 2025). Athletes with good leg explosiveness tend to have greater mobility and are able to control the court more effectively.

Furthermore, the force generated by muscles, particularly in the lower extremities, also plays a crucial role in supporting an athlete's motor performance (Corrales et al., 2025). Force is the result of muscle contractions that enable acceleration of the body or specific body parts (Raibowo et al., 2024). In badminton, force plays a role in propelling the body during lunges, sudden changes in direction, and maintaining balance during explosive movements (Edmizal & Barlian, 2024). The amount of force an athlete can generate will affect the efficiency and effectiveness of movements during the match. Another physical component is reaction time (Arif et al., 2024). Reaction time is a person's ability to respond to a stimulus in the shortest possible time (Cui et al., 2022). In badminton, athletes are faced with highly dynamic game situations, where the shuttlecock can move at high speeds and in unpredictable directions (Green et al., 2023). An athlete's ability to respond quickly to visual and kinesthetic stimuli will determine their success in executing shots, defending against opponents' attacks, and making the right decisions within a limited time (Luteberget et al., 2023). These three physical components are interrelated and contribute directly to badminton athlete performance. However, in coaching practice, evaluation of these components is often carried out conventionally and subjectively. Assessment of an athlete's physical condition is generally based solely on the coach's observations or the results of simple tests that do not provide a comprehensive and precise picture of the athlete's true physical abilities (Fauzi et al., 2025).

Technological developments in sports have opened up new opportunities for evaluating and analyzing athlete performance (Alberca et al., 2022). One innovation that is increasingly being used is digital measurement systems. These systems enable objective, accurate, and consistent measurement of various physical components (Rusdiana et al., 2021). With the aid of digital devices, data can be recorded in real time and analyzed quantitatively, thereby reducing subjectivity in assessing an athlete's physical condition. The use of digital measurement systems in sports performance analysis offers many advantages, including increased measurement accuracy, easier monitoring of athlete development, and assisting coaches in designing more specific and targeted training programs (Wiriawan et al., 2024). In the context of badminton, digital measurement systems can be used to measure leg explosive power through vertical jump tests, force through pressure sensors or force plates, and reaction time through visual or auditory stimulus-based devices (Pratama et al., 2024). Despite the advancement of digital measurement technology, its use in badminton research and coaching practice remains relatively limited (Ihsan et al., 2024). Many training programs are not fully based on objective data from athletes' physical measurements. As a result, the training programs provided are often less specific and do not fully meet the individual athlete's needs. This can result in less than optimal performance improvements and an increased risk of injury due to poorly controlled training loads (Maulana et al., 2025). Therefore, scientific studies are needed that integrate aspects of badminton athletes' physical condition with the use of digital measurement systems (Corredor-serrano et al., 2023).

Based on the introduction description, this study aims to analyze the comparative results of leg explosive power, leg ground reaction force, and reaction time using digital and manual measurement systems in badminton. This research not only contributes to the development of sports science but also provides practical benefits for the world of badminton coaching.

Method

Research Design

This study used a quantitative approach with a descriptive correlational design. The aim was to analyze differences in results between leg explosive power, ground reaction force, and reaction time using digital and manual measurement systems.

Figure 1. Research data collection (source: Agus Rusdiana, 2020)

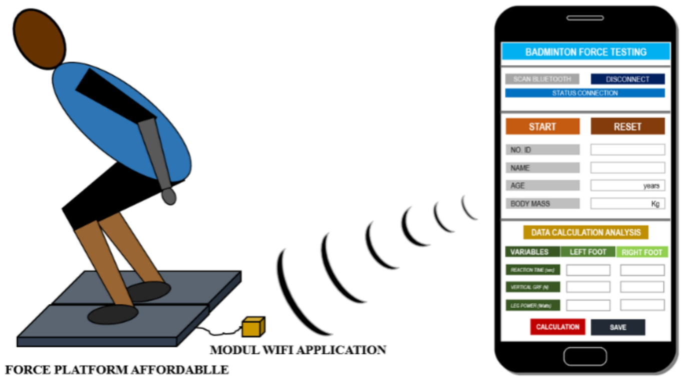
Participants

The subjects were 20 active male badminton athletes who participated in regular training (means and SD; age: 18 ± 0.31 years, height: 168.4 ± 7.3 cm, weight: 61.7 ± 8.1 kg). Participants were selected using a purposive sampling technique with inclusion criteria. Participants also had a minimum of two years of training experience and were in good health with no lower extremity injuries.

Procedure

Before administering the test, subjects were given an explanation of the study's purpose and procedures and signed a consent form. All subjects warmed up for 10–15 minutes. Each test was administered two times, and the best result was recorded as research data.

Figure 2. Digital measuring instrument application device (source: Agus Rusdiana, 2020)



Data analysis

The data were analyzed using descriptive statistics to obtain the mean, standard deviation, minimum, and maximum values. Data normality was then tested. Pearson correlation analysis was used to determine the relationship between leg power, ground reaction force, and reaction time, with a significance level set at α = 0.05.

Results

In table 1, it shows that the data obtained from digital and manual instruments on the physical component of reaction time is (0.58 ± 0.04; 0.72 ± 0.05), then, the average score of other variables, the leg power component is (606 ± 111.8; 430 ± 100.4), while the ground reaction force component is (1375 ± 123.1; 1212 ± 85.7).

Table 1. Mean and standard deviation of physical performance test results using digital and manual systems.

	Raction Time (sec)		Leg Power (Watts/kg)		Ground Reaction force (N)	
	Digital	Manual	Digital	Manual	Digital	Manual
1	0.51	0.65	456	411	1123	1112
2	0.58	0.69	521	415	1267	1145
3	0.52	0.68	449	318	1244	1105
4	0.55	0.71	487	325	1321	1146
5	0.52	0.68	621	425	1225	1134
6	0.57	0.72	542	312	1341	1157
7	0.61	0.76	559	314	1435	1233
8	0.57	0.66	661	519	1522	1232
9	0.57	0.72	511	320	1255	1167
10	0.61	0.78	732	525	1445	1222
11	0.51	0.71	496	326	1323	1189
12	0.62	0.78	774	567	1429	1265
13	0.64	0.81	762	559	1545	1359
14	0.57	0.62	486	312	1288	1121
15	0,61	0.78	697	525	1397	1137
16	0.62	0.76	732	577	1522	1345
17	0.64	0.72	772	483	1569	1334
18	0.57	0.69	567	488	1344	1231
19	0.58	0.68	559	358	1389	1245
20	0.64	0.72	737	524	1522	1368
Means	0.58	0.72	606	430	1375	1212
SD	0.04	0.05	111.8	100.4	123.1	85.7

Table 2 presents the results of data analysis which shows that the correlation coefficient scores of the measurements three test variables, namely reaction time, leg power and ground reaction force are r = 0.4360 (moderate), r = 0.7602 (high) and r = 0.7638 (high), respectively. The scores are on a scale of 0.41 - 0.70 which means that between the digital and manual tests have moderate validity, while the scale range of 0.71 - 0.90 has a high relationship with a significance level of 0.05.

Table 2. Results of the correlation test between digital and manual tests

Variable	Instrument	Pearson Correlation	Note.
Reaction Time	Digital Manual	0.4360	Moderate
Leg Power	Digital Manual	0.7602	High
Ground Reaction Force	Digital Manual	0.7638	High

From the data, for the reaction time test using digital and manual there is a moderate correlation value (r = 0.4360), while for the results of the leg power test the correlation value is r = 0.7602, which means there is a strong relationship between the tests using digital and manual. Furthermore, the results of the ground reaction force test show a strong correlation (r = 0.7638), this data shows that there is no significant difference between the tests using digital and manual.

Figure 3. Dispersion plot representing the reaction time of 20 badminton players in both digital (x-axis) and manual (y-axis). The best-fit line, the linear equation showing the relationship between x and y reaction time performances and the coefficient of determination are also presented.

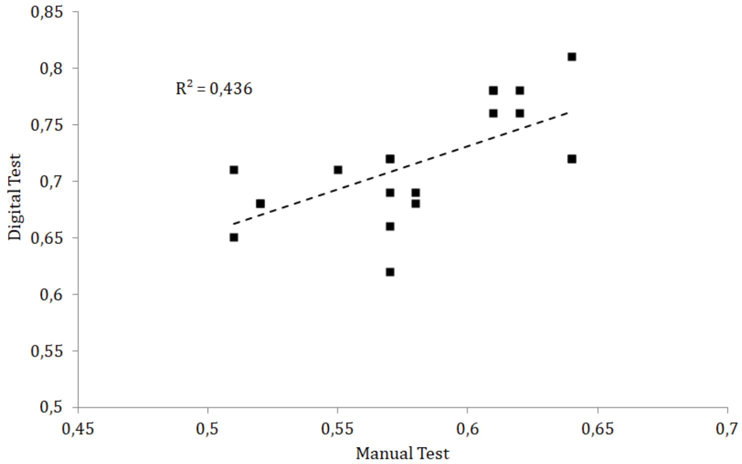


Figure 4. Dispersion plot representing the leg power of 20 badminton players in both digital (x-axis) and manual (y-axis). The best-fit line, the linear equation showing the relationship between x and y reaction time performances and the coefficient of determination are also presented.

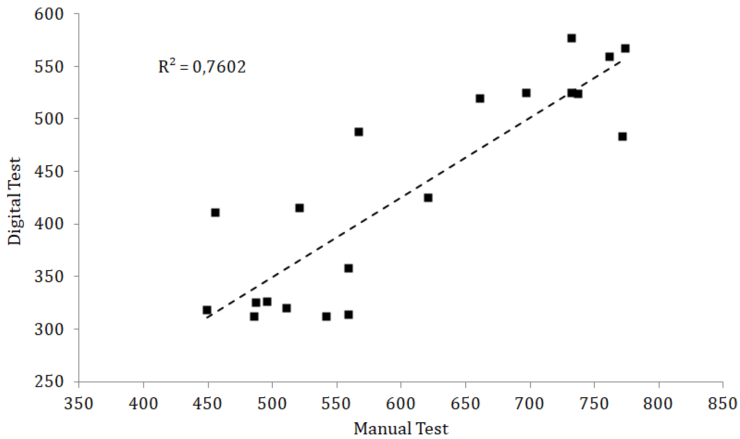
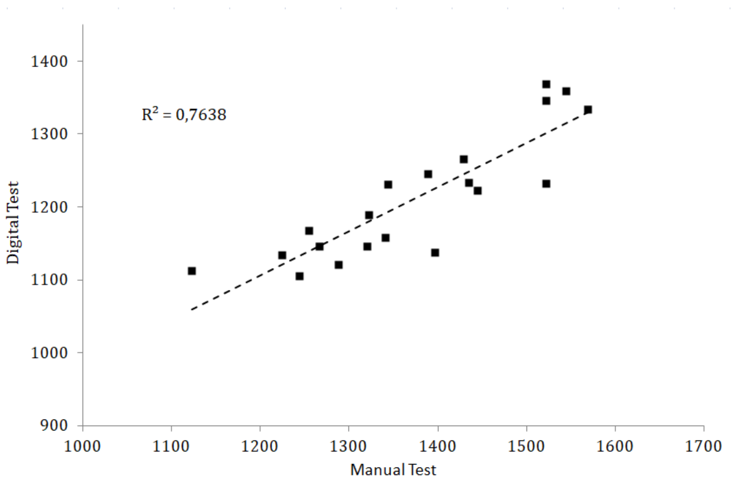


Figure 5. Dispersion plot representing the groung reaction force of 20 badminton players in both digital (x-axis) and manual (y-axis). The best-fit line, the linear equation showing the relationship between x and y reaction time performances and the coefficient of determination are also presented.



In addition, Table 3 shows that the score of reliability coefficient for each component variable is r = 0.765 for reaction time, r = 0.752 for leg power, r = 0.845 for ground reaction force. Those score are in between the scale of 0.80 < r > 1.00 which means that data of reaction time, leg power and ground reaction force have a good reliability.

Table 3. Results of Cronbach's Alpha Value Test

Variables	Test-retest Prototype	Cronbach's alpha	Information
Reaction Time	Test 1	0.765	Good
	Test 2		
Leg Power	Test 1	0.752	Good
	Test 2		
Ground Reaction Force	Test 1	0.845	Good
	Test 2		

Reliability of test measurements is the level of consistency of an instrument in producing stable and reliable data when measurements are carried out repeatedly under the same conditions. In this study, reliability tests were conducted to ensure that the measurements of reaction time (0.765), leg power (0.752), and ground reaction force (0.845) using both the digital measurement system and manual tests have an adequate level of consistency. The results of the analysis above indicate that the measurements of the three physical components using the digital system are in the good category, indicating high measurement consistency. Furthermore, measurements using the manual test also show good reliability, although the value is slightly higher than that of the digital system.

Discussion

Several previous studies have reported that leg power measurements using sensor-based digital devices, such as vertical jump systems or force plates, have good to excellent Intra class Correlation Coefficient values (Edmizal et al., 2024). This is due to the digital device's ability to automatically record flight time, jump height, and ground reaction force, thereby reducing measurement errors due to human factors (Ihsan et al., 2024). In contrast, manual tests such as conventional vertical jumps tend to have lower reliability due to the influence of measurement technique, scale reading accuracy, and test administrator consistency (Maulana et al., 2025).

In force measurements, previous research has shown that the use of digital force plates has very high reliability, as the device is capable of recording force continuously and precisely (Fauzi et al., 2025). Manual tests such as the standing long jump have also been reported to have good reliability, but variability in jumping technique and distance measurement accuracy can affect the consistency of the measurement results (Ilham & Yadav, 2025).

Meanwhile, measuring reaction time with digital devices based on visual or auditory stimuli has been reported to have excellent reliability (Susiono et al., 2024). Other research indicates that manual tests, such as the ruler drop test, have fairly good reliability and are often used as a practical alternative, although their precision is lower than that of digital devices. Subject attention and examiner response are sources of variation in results in manual tests (Karyono et al., 2024).

Conclusions

The study concluded that both digital measurement systems and manual tests had acceptable levels of reliability in measuring athletes' physical components. However, the digital measurement system was deemed superior in terms of objectivity, precision, and data consistency. Therefore, a combination of digital measurement tools and manual tests is recommended to obtain comprehensive measurement results and support more accurate evaluation of athlete performance. The results of this study can serve as a basis for coaches and sports practitioners in designing more targeted, data-driven training programs tailored to athletes' physical needs to optimally improve badminton performance.

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