

Development of the ultrasonic sensor based modification coordination test device Desarrollo del dispositivo de prueba de coordinación de modificaciones basado en sensores ultrasónicos

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Abstract. The nature of the endurance component, particularly coordination, is the aspect of physical condition most supportive in essential circumstances. Developing a technology-based test instrument is necessary to support the aspect of physical condition, including good endurance. This is carried out to support and improve the performance of coordination capability requirements. This research aims to develop a prototype product for a modified coordination test tool based on an ultrasonic sensor. The development of this device was implemented as a modification coordination test instrument. A set of devices consists of four circuit parts. This circuit involves a sensor, a Wi-Fi module, an RGB LED, and a doorbell. The placement of each LED depends on the user's needs. The function of the sensor is to detect objects around the sensor. The RGB LED functions as a sign when a sensor receives stimulation. The research method used is the Research and Development (R&D) method, which involves developing a prototype or modified coordination test. In this research, the tool development process was carried out in collaboration with a team of experts to develop measuring tool products. The sampling technique for this research is purposive sampling because the samples taken must meet certain requirements and considerations. In this study, researchers selected 33 futsal players from Universitas Suryakencana students. Based on the analysis results, it is concluded that the prototype for maximum device test modification coordination with motion sensors and hardware has very high validity and reliability values. Therefore, by using this system, an athlete can obtain more accurate test results, preventing an athlete's mistakes during the process test. In addition, the testing process can be carried out more efficiently.

Keywords: Device Development, Modification Coordination, Test Device

Resumen. La naturaleza del componente de resistencia, particularmente la coordinación, es el aspecto de la condición física que brinda mayor apoyo en circunstancias esenciales. Es necesario desarrollar un instrumento de prueba basado en tecnología para respaldar el aspecto de la condición física, incluida una buena resistencia. Esto se lleva a cabo para apoyar y mejorar el desempeño de los requisitos de capacidad de coordinación. Esta investigación tiene como objetivo desarrollar un producto prototipo para una herramienta de prueba de coordinación modificada basada en un sensor ultrasónico. El desarrollo de este dispositivo se implementó como un instrumento de prueba de coordinación de modificaciones. Un conjunto de dispositivos consta de cuatro partes de circuito. Este circuito involucra un sensor, un módulo Wi-Fi, un LED RGB y un timbre. La ubicación de cada LED depende de las necesidades del usuario. La función del sensor es detectar objetos alrededor del sensor. El LED RGB funciona como señal cuando un sensor recibe estimulación. El método utilizado en la investigación es el método de Investigación y Desarrollo (I+D) mediante el desarrollo de un prototipo o prueba de coordinación modificada. En esta investigación, el proceso de desarrollo de herramientas se llevó a cabo en colaboración con un equipo de expertos para desarrollar productos de herramientas de medición. La técnica de muestreo para esta investigación es el muestreo intencional, debido a que las muestras tomadas deben cumplir con ciertos requisitos y consideraciones. En este estudio, los investigadores seleccionaron a 33 jugadores de fútbol sala entre estudiantes de la Universidad de Suryakencana. Con base en los resultados del análisis, se concluye que el prototipo de máxima coordinación de modificación de pruebas de dispositivos con sensores de movimiento y hardware tiene valores de validez y confiabilidad muy altos. Por lo tanto, al utilizar este sistema, un atleta puede obtener resultados de pruebas más precisos. lo que puede prevenir los errores de un atleta durante el proceso de prueba. Además, el proceso de prueba se puede llevar a cabo de manera más eficiente.

Palabras clave: desarrollo de dispositivos, coordinación de modificaciones, dispositivo de prueba

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Introduction

Science and technology are developing rapidly, from changes in human mindset to the development of devices (Hidayah et al., 2024). It is used to provide convenience in carrying out daily activities. In this century, technological advances, especially in sports, are an integral part of improving the achievements of athletes. Sports require fast, good endurance, high intensity, and total concentration (Bellovary et al., 2019; Rose & Ray, 2011). Recently, a modified bleep test tool for athletes in sports has been

needed. Moreover, improving and measuring coordination using light and sensors is one of the new issues. According to Wangler & Jansky (Wangler & Jansky, 2023), good, healthy conditions can improve someone's physical abilities and give benefits of exercise for someone's health and fitness (Jatmiko et al., 2024; Wahyono et al., 2024). Dynamic health refers to a state of well-being achieved through consistent and regular physical exercise (Purwoto et al., 2024). A person who conducts exercises regularly will have a bigger and stronger heart, more substantial muscle mass, less fat tissue, stronger bones, and more flexible joints (Liu et

al., 2018). A person's fitness will help ward off the incidence of non-infectious diseases later in life, such as heart disease, back and back pain, and osteoporosis (Nalepka et al., 2017).

A healthy body will get far fewer sports injuries than someone who is not fit (Moseid et al., 2019). Similarly, there are signs that a person who exercises regularly improves his academic performance. According to the ancient Greek concept, a healthy body contains a healthy soul (Stone et al., 2013). In the development of coordination, there are two skills related to coordination, i.e., 1) fine skills, such as writing, drawing, and decorating, and 2) gross skills, which are related to large muscles, such as kicking, hitting, and slamming (Bondi et al., 2022; Priyono et al., 2021). Fine and gross skills can be integrated into conducting sports activities (Sunanto et al., 2022), such as archery and putting the ball into the hoop. However, in sports activities, fine skills have little influence. Thus, more gross skills or large muscles are used in sports activities (Raisbeck & Diekfuss, 2015). Sports activities mostly use elements of coordination in carrying out their activities (Sunanto et al., 2024), both general coordination and special coordination related to the branch of each sport. Coordinating motion activities is vital in sports' required power and strength (Mutaeva et al., 2020). Therefore, coordination occupies a unique role before other motion elements are built.

Coordination is the ability of an athlete to string various movements into one unit of time with movements that are in harmony and accordance with the goal (Lima et al., 2023). It can further be presented to use of skeletal muscles in a more effective manner, leading to efficient and practical overall movements (Hafidz et al., 2022). This encompasses the capacity to execute motor tasks, from fundamental movement patterns to fine motor skills that are essential for effectively managing daily activities (Ma et al., 2021; Nogueira et al., 2022). Sports skills involve eye and foot coordination, for example, kicking a ball into a target (Adil et al., 2018). Moreover, some sports skills cover coordination in small side games of the body and perfect coordination to modify small side games, some movements of several limbs into a series of beautiful movements. According to Nascimento et al., (2021) coordination is the ability of individuals to perform sequences of movements and their awareness of shared positions in space. Similarly, Liu et al., (2018) states that coordination is the basic movement ability of the complex. Coordination, as a psycho-motor ability, is presented in many areas of human activity. In line with the definition, coordination is a harmonious relationship of mutual influence among muscle groups during work, indicated by different levels of skill. Basically, coordination is divided into two types, namely general coordination, and special coordination (Bompa & Buzzichelli, 2019; Wong et al., 2019; Yue, 2023).

General coordination is the ability of the whole body to adjust and regulate movements simultaneously when performing a motion (Kamandulis et al., 2013). It means that every movement involves synchronizing small side games,

large muscles, systems, requirements, and joints. General coordination is essential in displaying motor and showing a person's ability level. Special coordination is between several limbs; it is the ability to coordinate the motion of several limbs simultaneously. Generally, every sports technique is the result of a combination of hand-eye coordination and footwork (Almeida et al., 2019; Bompa & Buzzichelli, 2019; Bompa & Haff, 2012). Therefore, athletes must have good coordination to support endurance ability (the endurance with VO₂max ability is supported well) (Hafidz et al., 2022; Jatmiko et al., 2024). Some research examples explain that motor coordination difficulties can affect physical activity and endurance, one of which interferes with Vo₂max (Rivilis et al., 2011).

Coordination is an essential factor for futsal players as it helps them to execute their skills, movements, and strategies effectively on the court. Good coordination helps futsal players to maintain balance, control their movements, and make quick decisions during gameplay (Miftachurochmah & Sukanti, 2022; Nascimento et al., 2021). Furthermore, coordination is of utmost importance in futsal due to the rapid pace of the game. Players must coordinate their movements with their teammates, anticipate their actions, and synchronize their efforts to create scoring opportunities and defend against the opposition. Furthermore, coordination helps futsal players maintain proper spacing on the court, coordinate their runs and movements with their teammates, and execute complex team strategies such as pressing, positional play, and quick transitions (Matzenbacher et al., 2014; Naser et al., 2017). Studies have emphasized the importance of reactive strength, rapid change of direction speed, and kicking ability as essential qualities for advanced performance in futsal (Sekulic et al., 2021). Furthermore, the physical demands of futsal have been explored, indicating the necessity of both aerobic and anaerobic systems for high-level performance in the sport (Charlot et al., 2016).

In terms of technology and data analysis, a systematic review has discussed the use of positional data to analyze collective tactical behavior in futsal, shedding light on the tactical variables crucial for assessing team behavior in the sport (Rico-González et al., 2020). Additionally, studies have utilized machine learning techniques to predict injury risk and soft tissue injuries in elite futsal players, showcasing the potential of novel approaches in injury prevention and performance optimization (Ruiz-Pérez et al., 2021). Having access to precise devices to measure performance indicators is critical in improving the overall performance of futsal players through coordination training. These tools can assess different aspects of coordination, such as agility, balance, reaction time, and spatial awareness. By using coordination tools, coaches and trainers can identify areas of improvement for individual players and the team, which allows for targeted training and development programs to enhance coordination skills. This will eventually lead to improved performance on the futsal court. The demand for additional tools or devices to measure coordination performance in futsal athletes still need more attention. Thus, this

research aimed to develop a prototype product of the Ultrasonic Sensor-Based Modification Coordination Test Device and investigate the effectiveness of the Ultrasonic Sensor-Based Modification Coordination Test Device.

Methods

Study Design

This study aimed to develop the ultrasonic sensor-based modification coordination test device. The development of the device is applied as the instrument of the modification coordination test. The method used in the study was Research and Development (R&D) method by developing a prototype or a modification coordination test. In this research, the process of the device development was in collaboration with a team of experts to develop a measuring device product, The sampling technique of the study was a purposive sampling since the samples should meet certain requirements and considerations.

Participant

In this research, researchers selected 33 futsal players from Universitas Suryakencana students. Purposive sampling is the technique of determining samples with specific consideration so that, elaborate with the criteria Futsal Team players men aged 18-22 and become part of the team of college student league participants in Indonesia especially in west Java.

Analysis design

Test the effectiveness of the tool using a validity test and paired test to see how significant the modification of test coordination is. With this system, an athlete can obtain more accurate coordination test results which can prevent human error during the test process since this test.

Research procedure

This study was conducted to produce products and investigate the effectiveness of those products. The stages adapted by the researchers in the study include seven stages namely: 1) potentials and problems 2) data collection 3) product design 4) validation and design correction 5) test of the product 6) data analysis 7) arranging report. In this study, the instrument used by the researchers to test its validity and reliability by testing the effectiveness of manual sample testing results with modification coordination test results.

The prototype product is the ultrasonic sensor-based modification coordination test device. the device is applied to measure athlete's coordination of sport movements. The following illustrations are the research and development steps based on the prototype product presented in Figure 1.

Figure 1 shows the design product of a specific ultrasonic sensor-based modification coordination test device. The specifications of the device cover microcontroller: (1) Voltage Microcontroller Sensor: 6 – 12 VDC (Adapter / Battery): Atmega 328P, (2) Sensor: Ultrasonic, (3) Display:

Dot Matrix 7x8, (4) Target: Steel 5 mm or 50 x 50 cm, (5) Cable: AWG24 4 pair, (6) Socket: Connector CB 8.

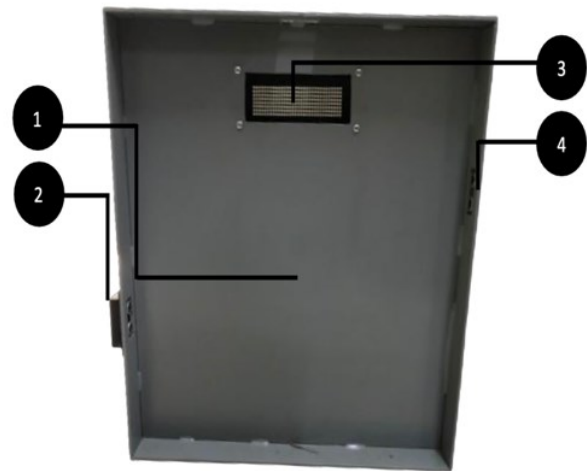


Figure 1. Research Stages and Process



Figure 2. The Working System of The Device (Front View of MST Device)

Figure 2 illustrates the working system of the device consisting of some steps. (1) The device is activated by pressing the button on the box behind the target. (2) The button only needs to be pressed once, it does not need to be pressed and then held. (3) The sensor is active immediately. (4) The display will turn on immediately. (5) The sensor counts the number of times, and the number of bounce ball is coming. (6) The number of incoming reflections is displayed directly on display. Moreover, Figure 3 describes the complete kit design of the device using a microcontroller covering (1) Iron Target 50 x 50 cm, (2) 1 Unit Modification Coordination Test Device, (3) 2 Ultrasonic Sensors, (4) 1 Display dot matrix.

The device of the ultrasonic sensor-based modification coordination test device presented in Figure 2 indicates that

(1) the target for the ball to be carried out, (2) sensor position 1, (3) the display presents the number of kick results read, (4) sensor position 2. Meanwhile, Figure 3 describes (1) the ultrasonic sensor-based modification coordination test device position and (2) the collapsible support pole.

The operation of the ultrasonic sensor-based modification coordination test device is conducted as follows. (1) Activate the device by pressing the power button at the bottom of the device stored behind the target. (2) After activating the device, the display will turn on. It immediately displays the number 0. (3) The automatic sensor is activated immediately and ready to detect the object-directed at the target. (4) Please immediately kick/pass with the ball directed at the target. (5) If the kick is correct, the number on the display increases according to the number of kicks/passes given. (6) If the use of the device has finished, then press the similar power button as when activating. (7) Wait for the display to turn off. (8) The device is no longer active and can be stored.

Result

Instrument validation was investigated by correlating test and re-test results and consulting with experts in their fields. The validity test results show a value (rxy) of 0.888. Compared with r-table = 0.433, the rxy value was higher than a sig value of $0.000 < 0.05$. Thus, it can be concluded that the use of the ultrasonic sensor-based modification coordination test device was valid. Besides, the validity of the experts was conducted by professors of sports and testing at the State University of Jakarta, i.e., Prof. Widiastuti M.Pd and Lecturer of Tests and Measurements of State University of Jakarta named Dr. Yasep Setiakarnawijaya. M. Pd and Futsal Coach named Bagja Sahlan, S. Pd. The reliability of the instrument was calculated using the Alpha Cronsbach formula of $0.876 > 0.6$. The result show that the implementation of the ultrasonic sensor-based modification coordination test device was reliable.

Table 1. Descriptive Result of The Prototype

Validity	Items	r-calculate	r-table	Information
N=33	Validity Prototype Modification coordination	0,888	0,433	Valid
N=33	Reliability Prototype Modification coordination	0,876	0,6	Reliable

The purpose of the mean difference test in the post-test, according to the table above, is to see more effectiveness between the control group and the relevant experiments. The ultrasonic sensor-based modification coordination test device is an instrument developed with wireless technology. The prototype product of the device innovation is wireless-based technology. In addition, the users of the coordination device are differentiated from previous test items. The prototype product of the ultrasonic sensor-

based modification coordination test device is essential and helpful for players or athletes to measure the ability of their coordination capacity. The application of specific futsal exercises:

Table 2. Statistical Analysis of Coordination Tests in Control Group

		Mean	N	Std Deviation	t-value	t-table
Pair 1	Pre-test	43,90	33	3,36	10,392	2,035
	Post-test	44,97	33	3,73		

From the pre-test and post-test analysis of the mean difference test in the control group, the t-value was 10.392, and the t-table was 2.035 with free degrees (db) 32 and $\alpha = 0.05$. Thus, $t\text{-value} = 10.392 > t\text{-table} = 2.035$. It means that H_0 is rejected.

Table 3. Statistical Analysis of Coordination Tests in Control Group (Paired Sample T-Test of Control Group)

		Mean	N	Std Deviation	t-value	t-table
Pair 1	Coordination Test Manual Prototype	44,967	33	3,73	2,755	1,997
	Modification coordination	47,294	33	3,10		



Figure 3. The Trial of Prototype Product of Modification Coordination Device

Trials of prototype products were conducted during the coordination process (see Figure 3). The working system of the device is manifested in some stages. (1) When the device is activated by pressing the button on the box behind the target. (2) The button only needs to be pressed once, it does not need to be pressed and then held. (3) The sensor is active immediately. (4) The display turns on immediately. (5) The sensor counts the number of times, and the number of ball bounces is coming. (6) The number of incoming reflections is displayed directly on the display criteria modification coordination test. The device is appropriate for athletes using foot and endurance sports players (e.g., football, futsal) but not for individuals who will coordinate the test. A degree of caution is required in admin-

istering the test, distinguishing it from the modified Coordination test. It observes the sensor and the lights and keeps the results given.

Discussion

The aim of this study is to develop an Ultrasonic Sensor-Based Coordination Test Device that can effectively measure coordination in sports performance. The discussion about the ultrasonic sensor-based modification coordination test device for futsal athletes illustrates how coordination devices can be changed or adjusted to meet futsal athletes' needs and unique characteristics. Coordination is a crucial motor skill in futsal because it combines up, down, and fast body movements. A further explanation is presented below.

The discussion revolved around identifying the specific coordination needs of futsal athletes, which is an essential aspect of their training. It was emphasized that futsal athletes require precise hand-foot coordination to control the ball, eye-hand coordination to kick, and coordination between their body and vision to adapt to the movements of their opponents and teammates. This information can be immensely constructive for coaches and trainers to design training sessions that enhance the coordination skills of futsal athletes. (Nascimento et al., 2021) highlight the essential to recognize the significance of coordination and reaction time in competitive sports performance, particularly in futsal where quick decision-making and adaptability are vital. Coaches and trainers can gain valuable insights by understanding the specific coordination requirements. This understanding can help tailor training sessions that aim to improve the coordination skills essential for success in futsal.

One potential modification is to adjust the configuration of jumping rope training to better simulate foot movement in futsal. Another option is to modify agility ladder training to improve athletes' foot agility and coordination in response to various on-field scenarios. Adjusting the configuration of jumping rope training to better simulate foot movement in futsal and modifying agility ladder training to enhance foot agility and coordination can significantly benefit futsal athletes. Research by (Naser et al., 2017) emphasizes the physical and physiological demands of futsal, highlighting the importance of specific training methods tailored to the sport. (Chaouachi et al., 2014) discuss the effectiveness of multidirectional sprints and small-sided games in improving agility and change of direction abilities in soccer players, indicating the potential benefits of agility-focused training for enhancing coordination in futsal athletes. By incorporating elements of multidirectional sprints and small-sided games into jumping rope and agility ladder drills, coaches can create training sessions that closely mimic the dynamic movements and agility requirements of futsal, thereby enhancing athletes' coordination skills. Moreover, studies by (Padrón-Cabo et al., 2021) and (Sekulic et al., 2021) highlight the positive effects of plyometric training

with agility ladder on physical fitness and agility performance in soccer players. These findings suggest that integrating plyometric drills with agility ladder exercises can improve jumping, sprinting, and agility performance, which are essential components of coordination in futsal. By incorporating similar training strategies into futsal athletes' routines, coaches can target not only coordination but also speed and agility, addressing the multifaceted demands of the sport. The combination of plyometric training and agility ladder drills can enhance athletes' overall physical capabilities, translating into improved coordination and performance on the futsal court.

To enhance the coordination skills of futsal athletes, it is recommended to incorporate innovative and creative training techniques. One such technique involves the use of various instruments such as baseballs, small balls, or mini hurdles for quick reaction exercises and body coordination drills. These exercises can be a fun and engaging way to help athletes improve their coordination abilities. (Nalepka, 2017; Stone et al., 2013) Moreover, the study by (Whelan et al., 2016) emphasizes the importance of running drills in developing optimal movement and coordination patterns in athletes. By incorporating drills that involve quick reactions and precise body movements using instruments like baseballs and mini hurdles, coaches can promote the development of coordination skills essential for futsal. These exercises not only enhance coordination but also contribute to athletes' overall agility and motor skills, aligning with the multifaceted demands of futsal. By integrating creative and varied training techniques that challenge athletes' coordination abilities, coaches can foster a stimulating training environment that promotes skill development and performance improvement in futsal players.

Futsal-specific exercises, designed to enhance the coordination of athletes, are crucial in a comprehensive training program. These exercises encompass dribbling drills incorporating a variety of variations, targeting precision in passing and shooting, and engaging in small-sided games that emphasize extensive movement and frequent ball contact. Furthermore, the evaluation of prototype products during coordination trials is integral to confirm their efficacy in improving athletic performance. (see Figure 8). Incorporating futsal-specific exercises into training programs is essential for enhancing the coordination skills of athletes. By focusing on dribbling drills with various variations, precision in passing and shooting, and engaging in small-sided games that emphasize extensive movement and frequent ball contact, coaches can create a comprehensive training regimen tailored to the specific demands of futsal. Research by (Duarte et al., 2009) highlights the importance of exercise duration and the number of players in small-sided games, indicating that specific drills can impact heart rate responses and technical skills in futsal players. By integrating a variety of exercises that target different aspects of coordination, coaches can provide athletes with a well-rounded training experience that enhances their overall performance on the futsal

court. The working system of the device is explained in detail as follows. (1) The device is activated by pressing the button on the box behind the target. (2) The button only needs to be pressed once; it does not need to be pressed and then held. (3) The sensor is active immediately. (4) The display turns on immediately. (5) The sensor counts the number of times, and the number of ball bounces is coming. (6) The number of incoming reflections is displayed directly on the Criteria Modification Coordination device's display. The device is appropriate for athletes using foot and endurance sports players (e.g. football, futsal, and rugby) but not for individuals for whom the test will be coordinated. A degree of caution is required in administering the test, distinguishing it from the modified bleep test. This study has examined the sensor, observed the lights, and gave the results. Moreover, the measurement and evaluation of results are explained as follows. After the exercise with modified instruments, the discussion measures and evaluates the exercise's results. This evaluation can be in direct observation or using coordination measurement devices, such as agility tests, reaction time tests, and the like. Furthermore, a study by (Oliveira et al., 2013) on seasonal changes in physical performance and heart rate variability in high-level futsal players underscores the need for comprehensive assessment tools capturing physiological and performance-related metrics. Coordination devices integrating measures of physical performance, such as repeated-sprint ability and aerobic capacity, provide a holistic view of futsal players' readiness and skill levels. These tools are essential for monitoring players' progress and adjusting training regimens to improve coordination and overall performance.

Referring to the research results, some recommendations for the device implementation are described below. Finally, the discussion includes recommendations on using devices that suit the needs of futsal athletes. These recommendations assist coaches and technical teams design effective and beneficial training programs to improve the coordination of futsal athletes. (Nascimento, 2021) By modifying coordination devices for futsal athletes, coaches can ensure that the training meets the futsal game's needs and demands. It improves the overall performance and coordination skills of futsal athletes (Barbieri et al., 2016).

Measurement and evaluation of exercise results using appropriate coordination measurement devices is a crucial aspect of the coordination modification toolkit. By conducting an objective evaluation, the coach can monitor the athlete's progress in the coordination aspects and make changes or adjustments in the training program when necessary. In sports training, coordination plays a crucial role because it involves regulating body movements with precision and efficiency. Modifying the coordination test device allows coaches to create more specific exercises, and it is appropriate for the demands of the sport undertaken by athletes.

Conclusion

This study is the pilot research developing the ultrasonic

sensor-based modification coordination test device. The ultrasonic sensor-based modification coordination device is an instrument developed with wireless technology. The prototype of the device innovation is wireless-based technology. The prototype of the coordination device product is essential for players or athletes to measure the ability of their coordination capacity. Developing a prototype of a maximum aerobic capacity tool using test coordination with sensors and motion analysis system software has been successfully designed with a simple prototype. Based on the results of the analysis, it is concluded that the prototype for maximum device test modification coordination with motion sensors and hardware has a very high value validity and reliability values. Therefore, by using this system, an athlete can obtain more accurate test results. which can prevent an athlete's mistakes during the process test. In addition, the testing process can be carried out more efficiently. This contributes to providing measurement tests to improve the quality and results of athletes' coordination abilities in developing coordination skills that are relevant to achievement in sports.

Conflict of Interest

None to declare.

Human Ethics and Consent to Participate declarations

All patients who started treatment signed a consent acknowledging that their data might be used for research purposes while maintaining their privacy. Universitas Negeri Jakarta Ethics Committee Approval Biomechanical Research Authority approval is also not required for this research database.

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