Evaluating basic chest pass skills in the 21st century using chest pass automatic board 2.0

Evaluación de las habilidades básicas de pase de pecho en el siglo XXI utilizando el tablero automático de pase de pecho 2.0

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How to cite in APA

Simbolon, M. E. M., Firdausi, D. K. A., Pasaribu, A. M. N., Dwisaputra, I., sari, D. R. A., & Pebriandini, C. (2025). Evaluating basic chest pass skills in the 21st century using chest pass automatic board 2.0. *Retos*, *64*, 431–444. https://doi.org/10.47197/retos.v64.110154

Abstract

Introduction: This research develops an automated tool to measure the chest pass ability in basketball. We developed this measurement to reduce human error in assessing the chest pass ability in basketball.
Objective: The product refines the previous version of the automatic chest pass board by adding a feature for automatic result calculation and utilizing wireless technology.
Methodology: This study utilized the research and development approach. A total of 42 participative students were involved in this research.
Results: The results of the first test showed a significance value of Sig. (2-tailed) = 0.047 ($p < 0.05$). In the second test, the significance value obtained was Sig. (2-tailed) = 0.008 ($p < 0.05$). Both tests showed significant differences. The results of three prototype reliability tests showed very good reliability (ICC = 0.990; 0.987 and 0.920) with a 95% confidence interval. The Bland-Altman plot analysis shows that there is a good level of agreement for this prototype. There is no measurement bias in chest passes using either the automatic board or the usual methods. This is because both instruments are very reliable.
Discussion: The inventions that make it easier and faster to evaluate chest pass test results include the use of vibration sensors, wireless data transmission, a computer program, and a database that directly obtains measurement results.
Conclusions: The prototype of the automatic chest pass board 2.0 is a reliable and stable potential substitute for measuring the chest pass ability of each individual in basketball games.

Keywords

Automation; basketball; chest pass; instrument; development.

Resumen

Introducción: Esta investigación desarrolla una herramienta automatizada para medir la habilidad del pase de pecho en baloncesto. Desarrollamos esta medición para reducir el error humano en la evaluación de la habilidad del pase de pecho en el baloncesto.
Objetivo: El producto mejora la versión anterior del tablero automático de pase de pecho al añadir una función para el cálculo automático de resultados y utilizar tecnología inalámbrica.
Metodología: Este estudio utilizó el enfoque de investigación y desarrollo. Un total de 42 estudiantes participativos estuvieron involucrados en esta investigación. Resultados: Los resultados de la primera prueba mostraron un valor de significancia de Sig. (2-tailed) = 0.047 ($p < 0.05$). En la segunda prueba, el valor de significancia obtenido fue Sig. (2-tailed) = 0.008 ($p < 0.05$). Ambas pruebas mostraron diferencias significativas. Los resultados de tres pruebas de fiabilidad del prototipo mostraron una fiabilidad muy buena (ICC = 0.990; 0.987 y 0.920) con un intervalo de confianza del 95%. El análisis del gráfico de Bland-Altman muestra que hay un buen nivel de acuerdo para este prototipo. No hay sesgo de medición en los pases de pecho utilizando ya sea la pizarra automática o los métodos habituales. Esto se debe a that ambos instrumentos son muy confiables.
Discusión: Las invenciones que facilitan y aceleran la evaluación de los resultados de la prueba de pase de pecho incluyen el uso de sensores de vibración, la transmisión de datos inalámbrica, un programa informático y una base de datos que obtiene directamente los resultados de las mediciones.
Conclusiones: El prototipo de la tabla de pase de pecho automático 2.0 es un sustituto potencial fiable y estable para medir la capacidad de pase de pecho de cada individuo en los juegos de baloncesto.

Palabras clave

Automatización; baloncesto; pase de pecho; instrumento; desarrollo.

Introduction

The chest pass is a basic and common technique in basketball (Putra, 2020a). In a prior study, this technique enables players to assemble scoring opportunities and maintain possession of the ball and is often used at the highest levels of competition, such as the Italian League, NCAA, and NBA, due to its effectiveness in game situations (Maimón et al., 2020). Chest pass is the most frequently used technique by regular-level participants in basketball games (Wang et al., 2006). The chest pass allows the ball to travel straight and parallel to the chest, making it very accurate and easy for players to direct the ball to the desired target. The ball can travel quickly towards a teammate, making it very useful in building a fast attack. Some coaches consider it the most important element of attacking technique because of its low, or even non-existent, margin for error (Gryko et al., 2020).This technique is effective for short- to medium-range passes and is relatively simple, so it is easy to master for both beginners and experienced players. With a chest pass, the game can switch quickly from defense to attack or vice versa and is difficult to anticipate and intercept by opponents if done correctly. This illustrates the great contribution of chest pass technique to the game of basketball. To assess chest passing skills, previous studies utilized the "Werfen und-Fangen ball test" in which participants threw and caught a ball against a wall (Putra, 2020b). In addition, another study measured passing ability where participants wore IMUs, adopted a triple-threat position, held the ball, stood behind a line 2.43 meters from the wall, and faced five 0.61 m × 0.61 m targets located on the wall at different heights and 0.61 m away from each other (Quílez-Maimón et al., 2021). Previous research also tested the first version of the chest pass automatic board prototype by throwing the ball against the wall and counting the number of balls bounced within 60 seconds, providing valid and reliable results for measuring chest pass skills in basketball (Firdausi et al., 2023). This measurement provides a basis for upgrading chest pass skills in basketball. With this tool, coaches and players may more objectively and efficiently track their progress in these skills so that targeted training can be practiced to reach optimal performance in the game of basketball.

The world is rapidly transitioning into the Internet of Things (IoT) generation, driven by the significant development of fifth-generation technologies (Anifah et al., 2024; Bincy et al., 2024; Kedarnath Navandar et al., 2025). Electronic tools and sensors in the field of sports have been applied and continuously undergone rapid development in recent years (Firdausi & Simbolon, 2020; Hribernik et al., 2021; Li et al., 2020; Rusdiana, 2021). This technology plays an important role in recording and monitoring human motion data. It is immensely necessary to drive the advancement of sports in sustainable coaching. Monitoring relevant data of athletes, such as physiological, biochemical, and anatomical data, has been incorporated to optimize athlete performance (Zhou et al., 2008). Several studies have launched developments in test technology and measurement of athlete performance. Earlier research conceived flexibility measurement using infra-red and potentiometer (Firdausi et al., 2024; Firdausi & Simbolon, 2020). Another study released a leg strength measurement device with infra-red sensor and load cell called Jump Power Meter (JPM) (Haryono & Pribadi, 2012). Wireless technology, fitness trackers, and body sensors in sports retain a significant impact on the life efficiency and trustworthiness of today's health systems (Li et al., 2020). The agility measurement of the hexagonal obstacle test was also applied with the help of infrared sensors (Firdausi & Simbolon, 2021). In addition, another study merged multiple sensors for precise timing, position detection, and motion measurement enabling the investment of previously inaccessible kinematic and spatiotemporal variables (Hribernik et al., 2021). Earlier research also concentrated on utilizing the technology in monitoring chest passes in basketball contests using nanogenerators (Jia et al., 2021). It functions to evaluate game movements and develop an earlier version of the chest pass automatic board prototype using vibration sensors. However it still needs improvements and corrections to create several features that can be fully functioned (Firdausi et al., 2023).

Advancements in nowadays science and technology authorize the creation of tools supporting the development of sports. The development of technology to measure chest pass ability in basketball has evolved into an urgent needs. Earlier research invented the first version of the chest pass automatic board with limited features. The product has not been integrated with further technologies such as mobile applications or wearable devices facilitating real-time data tracking and analysis (Firdausi et al., 2023). With these limitations, the intent of this research is to produce innovations that are more accurate and able to integrate other technologies in measuring basketball chest pass ability. Features of this chest pass automatic board prototype include counting the number of basketballs that hit the target with the desired vibration intensity, which is adjustable based on factors such as age, gender, or other considerations. This prototype serves not only for evaluation but also for chest pass training programs. It also enables users to customize the vibration sensor's duration and sensitivity to enhance the quality of the chest pass in actual matches.

Method

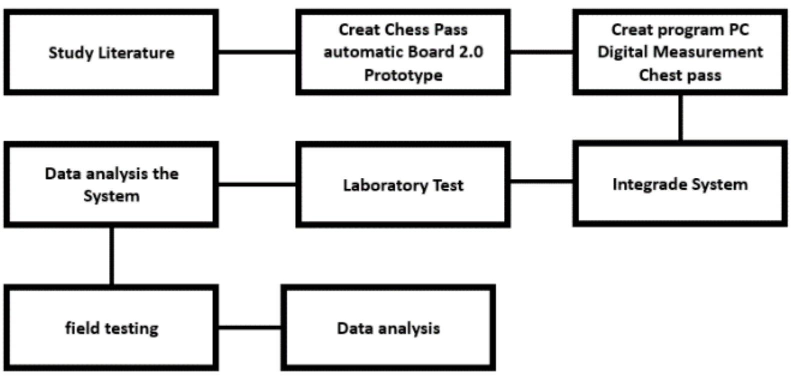
Research Design

This study adopted the research and development method to develop a measurement instrument for chest pass ability in basketball. This R&D approach allows for the creation of new tools, products or procedures (Paterson, 2016). Studies undertaken in the context of product development are known as research and design development (Marius, 2014). Problem identification, literature review, product design and development, product performance testing, analyzing product testing findings, and communicating product testing results are research processes in the R&D method (Gomes et al., 2019).

Considering the development model adopted in this study, some of the methods used in the development procedure of the chest pass automatic board 2.0 prototype are as follows. First, the researchers identified the possible causes of the performance gap between the conventional chest pass measuring instrument, and the chest pass using the previous version of the prototype automatic board during the analysis stage. The researchers further confirmed that the performance disparity was due to the testor in the conventional chest pass measurement. Furthermore, the researchers formulated the research objectives, namely to create and develop a chest pass technique measuring instrument that can function independently, namely the chest pass automatic board 2.0 prototype and requires the assistance of a tester in testing. Researchers also saw a difference in the development of existing sports and health technology. For this reason, a study of the demand for sports and health technology, especially in Indonesia, was also conducted. In addition, researchers validated these gaps with the target audience. Furthermore, the researchers evaluated the required resources, created a project management plan, and estimated the cost of manufacturing and delivering the product.

At the design stage, the researchers confirm the desirable outcomes and establish relevant product testing procedures. In addition, researchers conducted task inventories, set performance objectives, and generated test strategies. Furthermore, at the development stage, the researchers selected and developed the materials that to be attributed to create the product. The items were manufactured based on the predetermined design, and the product was then tested. The next step is to prepare items for field testing at the implementation stage. This method is adopted to test the product to create a legitimate and reliable system. The performance of the system is also evaluated to account for the results. The equivalency test method is used to conduct product trials. As the data was collected from one sample group using two instruments, the researchers evaluated the quality of the product and the test retest method at the evaluation stage. Furthermore, the stages of this study are as seen in Figure 1.

Figure 1. Research stages.

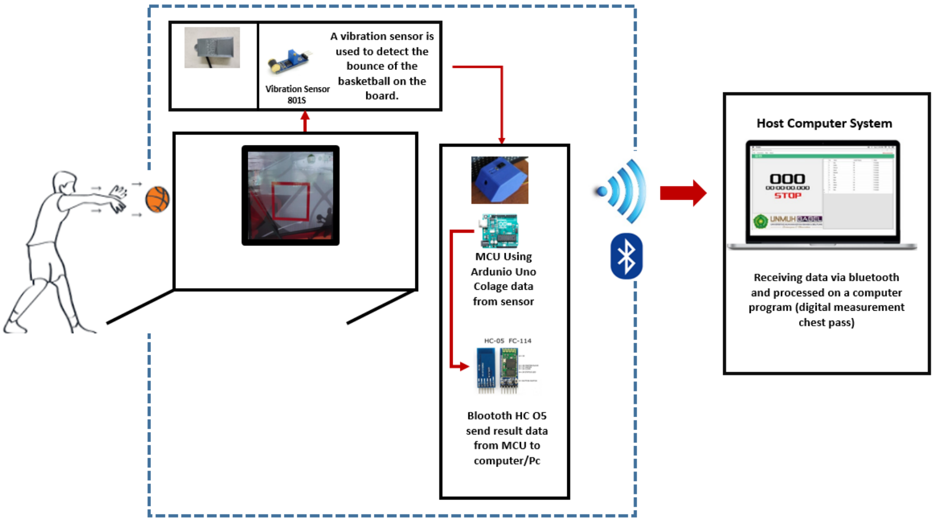


Source: Own elaboration

The Design of the system

The design of the chest pass automatic board 2.0 is based on the SW-42 vibration sensor model where this module can be altered for sensitivity thresholds. This research modernizes the previous version of the chest pass automatic board by counting wireless technology using Bluetooth and displaying the measurement results on a computer program developed using the c# programming language and net framework 4.7. In an earlier study, vibration sensors were utilized as learning media and for sprint competitions for blind children (Marpaung et al., 2021), besides, these sensors were also used to develop vests to detect laser beams and bullets in airsoft guns (Mutiara et al., 2020). Research utilizing wireless technology in sports has also previously been used to improve athletes' rapid response capabilities, combat response training testers based on force-measuring smart sensors and digital circuits designed to improve the response capabilities of martial arts athletes (Liu, 2023). This wireless technology is also used to understand the behavioral dynamics of ski equipment, ski routes in the mountains, and how individuals react while skiing (Crandall et al., 2022). In summary, the block diagram of the chest pass automatic board 2.0 system can be seen in Figure 2.

Figure 2. Block Diagram of Chest Pass Automatic Board 2.0 System.



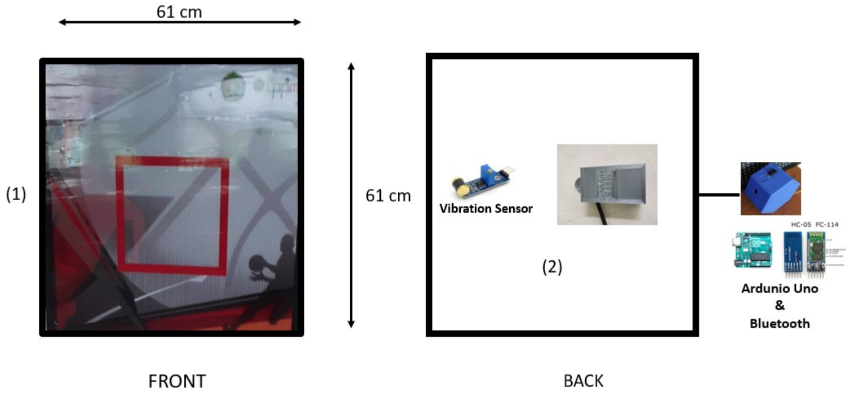
Source: Own elaboration

An automatic panel fitted with a vibration sensor which is the target area for throwing a basketball (1), and an application on a computer (2) as shown in Figure 2, exists installed on the target area to detect the bounce of the ball and send a signal to the microcontroller located in the toolbox. Furthermore, the data is sent to the computer and displayed on the application that has been available through Bluetooth. The count results commence at the first ball bounce and the automatic countdown time of the test is automatically displayed on the application display on the computer and an automatic sound signal if the countdown time has expired. The timer is adjustable to 30 seconds, 60 seconds, and so on as needed. The millisecond, second, and minute counts are displayed on the screen.

The flow of the electronic performance process on the prototype chest pass automatic board 2.0 is in the initial state of the controller box in standby and ready to connect to the computer. Subsequently, the software on the computer is connected to the controller box through the com port of Bluetooth. After the computer is connected, the score calculation process is ready to be executed. Whenever the computer software receives data in the form of the character 'S', as the ball hits the bouncing board, the data is recognized as a sign that the countdown calculation begins and the score value increases. During the calculation process, each bounce is recognized and calculated by the controller box. The calculated value is then sent to the computer software. In the computer software, in addition to receiving data from the controller box, it also functions as a countdown timer. Whenever the countdown time is complete, the computer program immediately stops to receive data from the controller box. The time interval required for the software to start calculating again is 5 seconds after the countdown timer is completed. It is to ensure all processes have been finished in order to start a new process.

Whenever the ball touches the scoreboard, the controller box receives vibration data bits of digital value converted from the analog voltage value. The value is adjusted as a reference to whether the scoreboard is hit by a ball throw or not. Assuming it, the controller box transmits the data to the computer using Bluetooth. On completion of the measurement process, the results of the overall measurement sample are available for download and displayed directly on the Microsoft Excel.

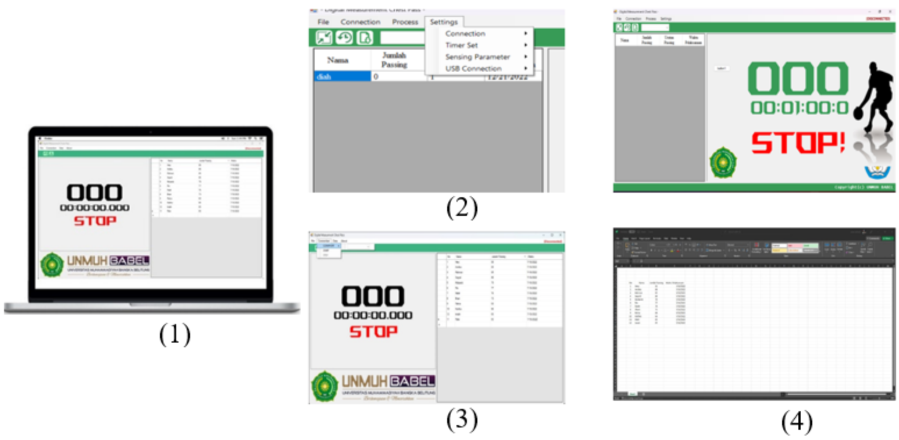
Figure 3. Automatic Board 2.0 as a target area for throwing balls.



Source: Own elaboration

The wooden square-shaped automatic board of 61 cm x 61 cm as the main material and a target mark is on the front, The height of the board can be adjusted according to the athlete's height or user needs (1). Electronic devices, including vibration sensors and catalysts, are set on the back of the board to be able to read the bounce data of the ball as it hits the surface (2). The device is hexagonal in shape, consists of an Arduino Uno microcontroller and a Bluetooth module, and is equipped with an on/off button to suit the user's needs (3).

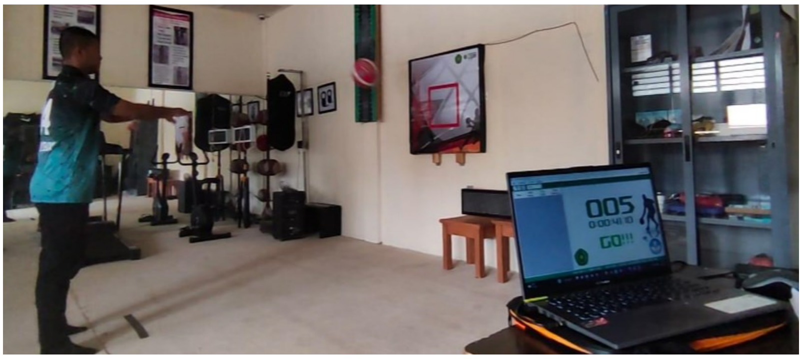
Figure 4. Computer Program View Digital Measurement Automatic Board 2.0 Computer Program View



Source: Own elaboration

All arrangements are directly executed through the application installed on the computer (1). Whenever the initial bounce of the ball lands in the target space, the timer is automatically counted down. After one minute has passed, the counter will automatically lock the result of the basketball chest passing ability. If the device resets, the timer is back to one minute and then restarted to neutral. The app allows the user to set the time as needed, not only for this instrument but also for practice (2). After all participants have performed the exercise, data is stored in the program in the form of names, number of bounces, scores, and score rankings of all test takers (3). The overall final results can be downloaded in Microsoft Excel file format (4). Testing the automatic board in the basketball chest pass test can be seen in Figure 5 below.

Figure 5. Chest pass automatic board 2.0 test



Source: Own elaboration

Participants

This research was conducted in the sports laboratory of Muhammadiyah University of Bangka Belitung. A total of 42 students from the 6th grade physical education, health, and recreation program were used as research subjects.

Data Analysis

To determine the compatibility between the results of conventional basketball chest pass test measurements using a stopwatch by manually calculating the bounce of the ball on the wall to automated measurements using the chest pass automatic board 2.0 prototype developed at this time might possibly be seen through the reliability test between the readings of the chest pass automatic board 2.0 product and conventional measurements based on the intraclass correlation coefficient (ICC) (Ismunarti et al., 2020; Manson et al., 2014; Peebles et al., 2018). If the inter-measurement ICC value is greater than 0.50, the tested measurement tool is considered to have appropriate stability. Meanwhile, if the value is greater than or equal to 0.80, the tool is deemed to have high stability (Rusdiana et al., 2021). In short, the ICC values of 0.9 to 0.75 are considered good, values of 0.75 to 0.5 are moderate, and values less than 0.5 are considered poor (Koo & Li, 2016; Peebles et al., 2018). A Paired Samples Test was performed to identify two differences in average performance measures (Parente et al., 2019; Perrotta et al., 2023; Rusdiana et al., 2021). The statistical tool called the Bland-Altman plot is for comparing two measurement methods (Alzahrani et al., 2015; Bravi et al., 2023; Hui et al., 2018; Rusdiana et al., 2021). The Bland-Altman plot can be used for this assessment (Bian et al., 2022). Bland-Altman analysis shows the systematic error (bias) of the measurement results (Bruzzo et al., 2020; Gupta et al., 2009; Maeda et al., 2023; Stitt et al., 2021) and is a graphical tool for comparing two measurement techniques and assessing the suitability between the conventional basketball throwing catch test and the automated board 2.0 Chest pass product. The plot provides a visual representation of the difference between two measurements (Giavarina, 2015). The statistical analysis was performed using SPSS (Version 26), with significance set at 0.05.

Results

The field testing process was carried out by involving 42 students performing chest passes in two turns. The test of passing and catching the ball was measured by conventional and automatic chest pass board 2.0 product that the researchers developed for multiple data collection (test-retest).

The first attempt of the basketball chest pass test had an average ± SD of conventional test data (41.7 ± 4.25), and an average ± SD of test data using the chest pass automatic board 2.0 prototype (41.5 ± 4.12). It is recognized that there is a difference in the minimum score of the conventional test (34) and the test using the chest pass automatic board 2.0 prototype (33), while there is no difference in the maximum score (54). Meanwhile, the second trial of the basketball chest pass test had an average ± SD of conventional test data (43.95 ± 4.35), and an average ± SD of automatic board chest pass test data (43.9 ± 4.3). It was determined that there was no difference in the minimum score between the conventional chest pass test and the test using the prototype chest pass automatic board 2.0 (30), as well as in the maximum score results there was no difference (55). The data description of the conventional basketball chest pass test results with tests using the prototype chest pass automatic board 2.0 first and second trial tests can be seen in table 1 below.

Table 1. Data Description of Basketball Chest Pass Test Results

	Chest Pass Basket Ball (First Trial)		Chest Pass Basket Ball (Second Trial)	
	Conventional (Test 1)	Prototype (Test 2)	Conventional (Test 1)	Prototype (Test 2)
n	42	42	42	42
Mean	41.7	41.5	43.95	43.40
Median	41.0	41.5	44	44
Mode	41.00	44.00	45	45
Standard Deviation	4.25303	4.12754	4.35023	4.35083
Range	20	21	25	25
Minimum	34	33	30	30
Maximum	54	54	55	55
Sum	1754	1743	1846	1823

The table 2 shows that the conventional chest pass test and using the prototype chest pass automatic board 2.0 have very good reliability in the first trial (ICC = 0.990) and the second trial (ICC = 0.978) on average measurements with a Confidence Interval of 95% in the first trial (CI = 0.982 - 0.995) and the second trial (CI = 0.959 - 0.988). Meanwhile, on a single measure with a Confidence Interval of 95% first trial (CI = 0.964 - 0.989) and second trial (CI = 0.922 - 0.977) the prototype chest pass automatic board 2.0 first trial produced a strong correlation (ICC = 0.980) and second trial (ICC = 0.957), values between 0.75 - 0.90 indicate a strong correlation or excellent reliability (Kadlubowski et al., 2021; Kerdaoui et al., 2021).

Table 2. Intraclass Correlation Coefficient Intraclass Correlation Coefficient of Conventional Chest Pass Trial and Using Prototype Chest pass automatic board 2.0.

Intraclass Correlation			95% Confidence Interval	
			Lower Bound	Upper Bound
First Trial (Prototypical and Conventional)	Single Measures	0.980	0.964	0.989
	Average Measures	0.990	0.982	0.995
Second trial (Prototype and Conventional)	Single Measures	0.957	0.922	0.977
	Average Measures	0.978	0.959	0.988

Based on the results of the analysis test using paired t-test (Table 3), there is a significant difference (p<0.05) between conventional measurement results and using the chest pass automatic board 2.0 prototype in both the first and second trials.

Table 3. The Paired Samples Test Chest Pass First and second trials

		Paired Differences	
		1st Testing	2nd Testing
95% Confidence Interval of the Difference	Mean	-0.26190	-.54762
	Std. Deviation	0.82815	1.27265
	Std. Error Mean	0.12779	0.19637
	Lower	0.00348	-.94420
	Upper	0.51997	-.015103
	T	2.050	-2.789
	Df	41	41
	Sig. (2-tailed)	0.047	0.008

Figure 6 shows the Bland-Altman plot with difference bias (mean difference = 0.261), upper limit (+1.96 SD = 1.83), and lower limit (-1.96 SD = -1.40). The results of the Bland-Altman analysis demonstrate good agreement between the two measurements. The inter-observer agreement test on the 42 sample measurements between the conventional test and the test using the chest pass automatic board 2.0 prototype indicated an average difference. However, a difference of >95% is well within that area (mean ± 1.96 SD). These results indicate that the use of the prototype chest pass automatic board has a high degree of stability.

Figure 6. The Bland-Altman Plot of the First Trial of the Conventional Basketball Chest Pass Test and Using the Prototype Chest Pass Automatic Board 2.0

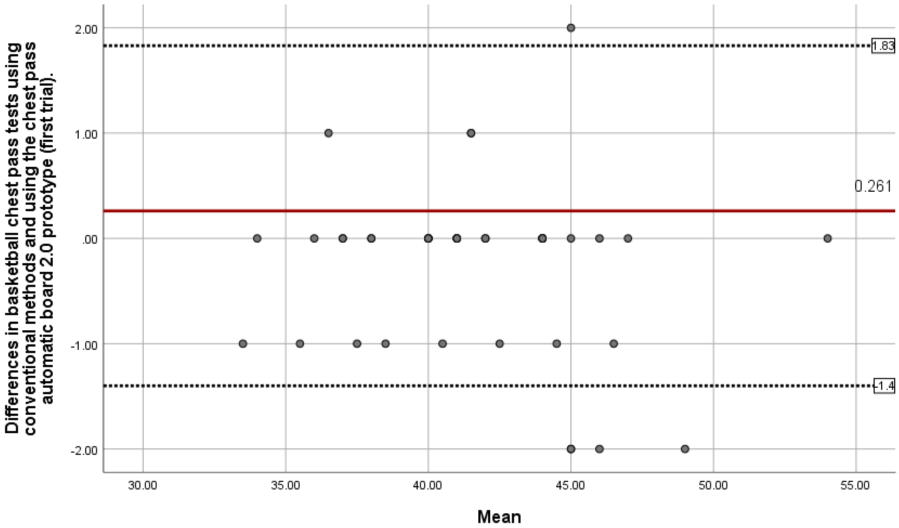
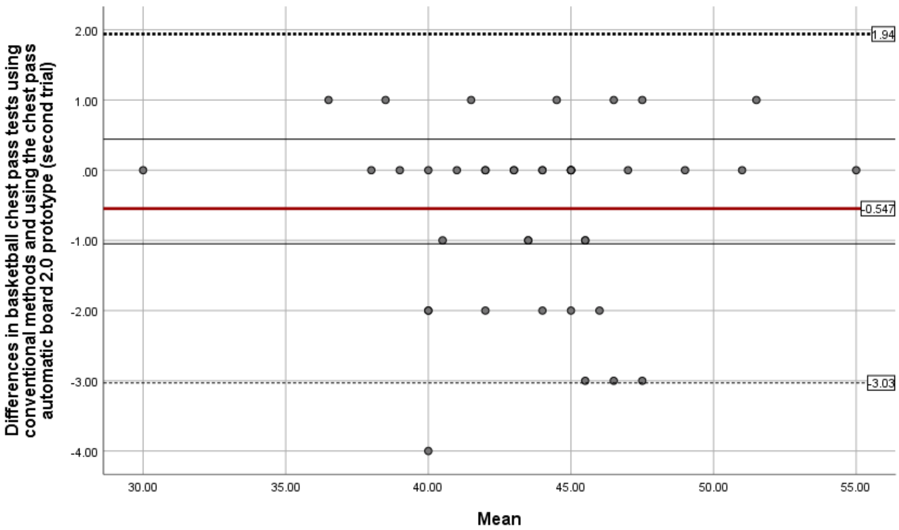


Figure 7 shows the Bland-Altman plot with difference bias (mean difference = -0.547), upper limit (+1.96 SD = 1.94), and lower limit (-1.96 SD = -3.03). The results of the Bland-Altman analysis showed good agreement between the two measurements. Inter-observer agreement test on 42 sample measurements between tests using the chest pass automatic board 2.0 prototype and conventional tests. The test demonstrated that there was an average difference. However, a difference of >95% means it is within that area (mean ± 1.96 SD). This result shows that the use of the prototype chest pass automatic board has a high degree of stability.

Figure 7. The Bland-Altman Plot of the second trial of the Basketball Chest Pass Test Conventionally and Using the Prototype Chest Pass Automatic Board 2.0



The results of testing the basketball chest pass testing utilizing the prototype chest pass automatic board 2.0 with an average ± SD of the first trial data (41.5 ± 4.12), followed by an average ± SD of the second trial data (43.4 ± 4.35). It is found that there is a difference in the minimum score of the basketball chest pass test using the prototype chest pass automatic board 2.0 with the results of the first trial (33) and the second trial (30), while the maximum score has a difference (54) in the first trial and (55) the second trial. The description of the data from the first and second trials of the basketball chest pass test using the chest pass automatic board 2.0 prototype can be seen in table 4 below.

Table 4. Data Description of Basketball Chest Pass Test Results Using Prototype Chest Pass Automatic Board 2.0 First and Second Trials.

	Throw And Catch Basket Ball Test	
	Chest pass automatic board 2.0 Prototype (First Testing)	Chest pass automatic board 2.0 Prototype (Second Testing)
n	42	42
Mean	41.5	43.4
Median	41.5	44.00
Mode	44.00	45.00
Standard Deviation	4.12754	4.35083
Range	21	25
Minimum	33	30
Maximum	54	55
Sum	1743	1823

Based on the test findings analyzed by means of paired t-test (Table 5), there is a significant difference ($p < 0.05$) between the measurement results using the Chest pass automatic board 2.0 product in the first trial and the second trial.

Table 5. The Paired Samples Test of Basketball Chest Passes Using the Prototype Chest Pass Automatic Board 2.0. First and Second Trial.

Paired Differences		
	Mean	-1.90476
	Std. Deviation	2.30386
	Std. Error Mean	0.35549
95% Confidence Interval of the Difference	Lower	-2.62270
	Upper	-1.18683
	t	5.358
	df	41
	Sig. (2-tailed)	0.000

The table 6 illustrates that the first and second trials of the chest pass automatic board 2.0 prototype had excellent reliability (ICC = 0.920) on the average measurement with a Confidence Interval of 95% (CI = 0.852- 0.957). Meanwhile, on a single measure with a Confidence Interval of 95% (CI = 0.742 - 0.918). The prototype chest pass automatic board 2.0 first and second trials produced a strong correlation (ICC = 0, 852) values between 0.75 - 0.90 indicate a strong correlation or excellent reliability (Kadlubowski et al., 2021; Kerdaoui et al., 2021)

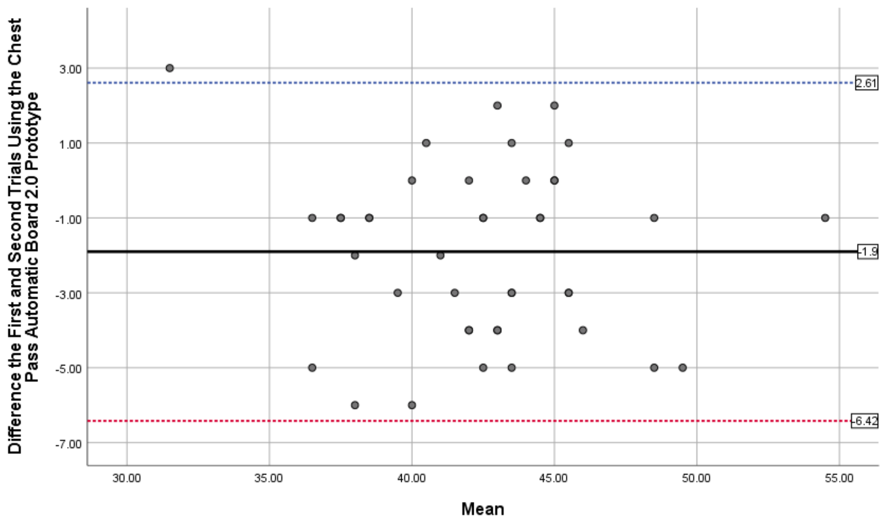
Table 6. Intraclass Correlation Coefficient of the Chest Pass Test Using the Prototype Chest Pass Automatic Board 2.0 First and Second Trials.

Intraclass Correlation			95% Confidence Interval	
			Lower Bound	Upper Bound
First and second test (Prototype Chest Pass Automatic Board 2.0)	Single Measures	0.852	0.742	0.918
	Average Measures	0.920	0.852	0.957

Figure 8 displays the Bland-Altman plot with difference bias (mean difference = -1.9), upper limit (+1.96 SD = 2.61), and lower limit (-1.96 SD = -6.42). The Bland-Altman test results showed good agreement between measurements. The inter-observer agreement test on the 42 sample measurements between the Chest pass automatic board 2.0 and the conventional calculation of the basketball chest pass test showed that there was a difference in the mean difference. However, a difference of >95% was within that area (mean ± 1.96 SD). These results imply that the use of the chest pass automatic board prototype has a high degree of stability.

In the first trial, there was a significant difference in chest pass test scores between the conventional method and the chest pass automatic board 2.0 prototype (Sig. (2-tailed) = 0.047, $p<0.05$), indicating a moderate contrast. In the second trial, the significance value acquired was Sig. (2-tailed) = 0.008 ($p<0.05$), which also signifies a significant difference. Meanwhile, the distinction test between the tests using the chest pass automatic board 2.0 prototype in the first and second trials showed a significance value of 0.000, which means there is a significant difference in the average score. Overall, the results of the analysis show that the use of the chest pass automatic board 2.0 prototype provides significantly different results compared to conventional tests. The reliability test results of the prototype showed outstanding reliability. In the first trial, Intraclass Correlation Coefficient = 0.990 with 95% Confidence Interval = 0.982 - 0.995. In the second trial, Intraclass Correlation Coefficient = 0.987 with 95% Confidence Interval = 0.959 - 0.988. Meanwhile, for the chest pass automatic board 2.0 prototype, the throw score in the first trial was 1.9 less than the second trial, with an Intraclass Correlation Coefficient = 0.920 and 95% Confidence Interval = 0.852 - 0.957. Bland-Altman Plot analysis revealed a reasonable level of agreement for this prototype.

Figure 8. The Bland-Altman Plot of the First and Second Trials Using the Chest Pass Automatic Board 2.0 Prototype.



Discussion

In general, this automatic chest pass test product has excellent reliability and stability. The incorporation of vibration sensors and wireless data transmission, as well as a computer program database that directly obtains measurement results, is an invention that facilitates and accelerates the evaluation of chest pass test results. The results of the chest pass measurement evaluation can help athletes strategy and improve their performance.

The basketball chest throw test is often utilized to evaluate the ability of basketball players (Xertion et al., 2020). The ability to pass the ball toward the chest of a player in basketball requires an assortment of strength and good technical skills (Juniardi & Wibowo, 2019). Proper motor coordination is indispensable for controlling motions accurately, especially in the dynamic sport of basketball (Mejia & Perez, 2021). The results of the evaluation of the chest pass can provide recommendations for designing the next training program by focusing on increasing power and strength to improve chest pass performance (Owen, 2004). Previous studies have also remarked that eye-hand coordination influences chest pass performance (Putra, 2020a). Coaches and athletes must pay attention to and improve technical skills, motor coordination, hand-eye coordination, upper body power, and strength in their training. By improving these aspects, it is expected that chest pass performance in basketball can be significantly improved. In addition, further research also needs to be conducted to investigate other elements affecting chest pass performance and to design more effective and efficient training programs.

Many studies have forged sports technology innovations aimed at monitoring development and improving athlete performance (Simbolon et al., 2023). The field of sports measurement is undergoing a significant transformation propelled by technological advances in incorporating sensor technology (Seshadri et al., 2019). Traditionally analyzing chest pass performance by performing chest passes against a wall with the "Werfen und-Fangen ball test" where participants throw and catch the ball against a wall (Putra, 2020b). The use of sensor technology renders assessing chest pass performance much more precise and efficient. Sensor technology enables researchers and coaches to track athletes in real-time and collect more accurate data. Thus, advancements in sports technology not only help athletes perform better but also broaden understanding of movements and strategies in various sports.

Chest pass automatic board products in terms of timers, counting the number of valid balls (hitting the target) are displayed using Light Emitting Diode (LED) and there is no special computer application in managing the database of measurement results (Firdausi et al., 2023). The dot matrix running text information board is equipped with a temperature sensor reader and digital clock, which will be processed by a microcontroller (A. Antu et al., 2020). The display or message in the running text display can be updated directly using computer and a certain cable in case the user is not in a predetermined place. If the data cable is not available, it will be a difficult to make the desired data changes/updates (Zainuri et al., 2015). Therefore, the current study improves the prescribed weaknesses of this product by adding computer program features to facilitate real-time data tracking and analysis. This computer program was developed using the c# programming language using the Net framework 4.7. In addition, this product operates wireless Bluetooth for data transmission between the microcontroller and the computer. The prototype development process experienced several obstacles, like misalignment of the countdown time in the computer program with a stopwatch of 100-300 milliseconds which was originally programmed based on the counter value, this was anticipated by data taken in real-time from the PC device time. Another problem was that sending data to the computer program experiences a delay when the ball hits the board. This problem is anticipated by increasing the data communication speed, the calculated data is stored in the controller so that the counter value is not lost. This device can be further enhanced in the future by adding communication features, making it a database accessible to coaches, parents, and athletes to monitor, create training programs, and motivate the improvement of chest pass skills.

Conclusions

This product shows its reliability and stability for measuring chest pass basketball skills. This automatic board 2.0 is consistently measuring the chest pass ability of each individual in basketball. The development of current technology can allow the development of similar products that may possibly be used to advance Indonesian sports, especially in the field of basketball. Further research is needed to evaluate the optimal angle for the chest pass and analyze differences in target sizes, in order to enhance the efficiency of basketball chest pass.

Acknowledgements

The authors would like to deliver incredible gratefulness to Universitas Muhammadiyah Bangka Belitung and Bangka Belitung Manufacturing Polytechnic for providing the resources necessary to conduct this research. We also thank the entire research team for their valuable contributions.

Financing

The publication of this article is funded by Balai Pembiayaan Pendidikan Tinggi (BPPT) and Lembaga Pengelola Dana Pendidikan (LPDP) through the Indonesian Education Scholarship (BPI).

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