Validity of the Integrated Digital-Based Jump Power Meter Instrument for Measuring Leg Muscle Power and Jump Height in Sports

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Abstract—

The content and empirical validity of an integrated digital-based jump power meter instrument for measuring legs muscle power and jump height are examined in this research. The research development technique was used. Five material experts from sports academics, physicists, and national sports coaches took part in the content validity examination. The empirical validity test included 38 male and female sports students ranging in weight from ± 50 to 79kg, height from ±156 to 179 cm, and age from 20 to 23 years. Delphi and test methodologies were used to obtain data. The instrument is a questionnaire and a jump power meter. The analysis technique uses the Aiken and Pearson product-moment formulas with the Excel application and SPSS version 23. The research is divided into three stages: (1) the researcher conducts a needs analysis by observing and reviewing the literature to rationalize the problem and gather needs for product development; (2) the researcher develops an instrument and then evaluates it to experts until a consensus is reached; and (3) the researcher carried out a direct test to determine the jump height and power. The assessment of five experts yielded a coefficient of 7.0 -1.00. The high jump's empirical validity is 0.968, its power is 0.772, and its sig value (2-tailed) is 0.000 < 0.05. In conclusion, the instrument has good content and empirical validity. The measuring instrument is expected to provide benefits and meaning in test and measurement activities, however, the authors recognize that further research is needed to seek dependability and determine norms, so more subjects are required to obtain better findings.

Keywords— **Jump power meters; Integrated digital based, leg muscle power, jump height**

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1. INTRODUCTION

Global industries are facing a new technological revolution known as the industrial revolution 4.0 (Kumar and Suhaib, 2021). The presence of the fourth industrial revolution fosters advanced technological innovation that transitions from a manual to a digital system (Kumar and Suhaib, 2021). This is noticeable in the world of sports. The use of digital technology will become increasingly important over time.

Sports science cannot exist in isolation, hence it must work with other supporting sciences to advance (Knobbe, Cunha and Torres, 2021). According to experts' view, the 4.0 age is an industrial era (Cimini *et al.*, 2019), which requires the development of technology-based instruments such as digital to provide efficiency and optimize work (Lorenz *et al.*, 2019; Knobbe, Cunha and Torres, 2021)

This becomes highly intriguing when sports science is transformed into a multidisciplinary science that discusses not only physical activity but also technology that aids in the growth of sports science (Ratten, 2020). As a result, innovative ideas and solutions are urgently required (Dinnigwa and Ojo, 2014).

Modern measuring instruments are required when discussing sports in terms of testing, measures, and evaluations. Technology is essential in sports to compete on a national and worldwide level (Luczak *et al.*, 2020; Ratten, 2020). According to experts, achieving success in athletics is heavily influenced by both internal and external variables (Bompa O. Tudor, no date). These external factors include an organized training program, parental support, facilities and infrastructure, and research findings that can be put into practice (Bompa O. Tudor, no date)

The absence of creativity in the production of a new tool is the underlying element of inequality in the development of technology-based tools (Dinnigwa and Ojo, 2014; Pagani *et al.*, 2016). However, technology-based measurement instruments in sports, such as equipment for measuring leg muscle strength from conventional to modern-based ones, have been widely created.

Existing techniques for measuring leg muscle power include the vertical leap, standing broad jump, and triple hop jump (Davey *et al.*, 2021; Janz *et al.*, 2021; Pérez-castilla *et al.*, 2021). Furthermore, more modern measuring instruments based on technology already exist, such as Takei's Jump DF (A and A, 2013), my jump apps (Balsalobre-fernández *et al.*, 2015), and, more recently, smart vertical jump (Astuti, 2020) and sensor-based leg power measurement device designs (Nurul Ihsan, Sujana and Permana, 2020).

According to a survey of the literature, traditional and modern measuring equipment have both strengths and weaknesses. Traditional tests are supposed to be simpler and less expensive, but in practice, data entry and accuracy must be taken into account (Ivan Matus, Pavel Ruzbarasky, Bibiana Vadasova, 2022).

Another factor is that when the athlete performs an automatic vertical jump, shoulder and arm flexibility is required; of course, flexibility has a significant impact on the results of the jump. Furthermore, calculating the vertical jump test results by subtracting the leap height from the height obtained is impractical (García-ramos *et al.*, 2015; F *et al.*, 2019).

The triple hop jump test, on the other hand, has been claimed to need obligatory posture stability and strength; of course, this test is appropriate for testing athletes who have already reached a trained level (Shultz, Schmitz and Perrin, 2008). As a result, it was determined that field-based examinations are no longer viable because data entry is still manual and several parameters, such as arm flexibility and posture stability, must be met to carry out the test (F *et al.*, 2019).

Power is defined as the product of strength and speed (Zabaloy *et al.*, 2020). The current tests only reveal the outcomes of high jumps or jumps, and these results are utilized as final guidelines in estimating power calculations. This is supported by multiple studies that say jump height is regarded as an indication of muscle strength; nevertheless, while this is widely accepted by the public, it appears to be contradictory to other methodologies (Markovic and Jaric, 2004, 2007; Markovic, G., Dizdar, D., Jukic, I., & Cardinale, 2004)

Based on the difficulties outlined, innovation in the development of integrated digital technology-based tools is required. According to expert opinion, standardized leg muscular power tests exist but must be digitally updated [46]. Thus, the objective of this study was to examine the content and empirical validity of a measuring device called an "integrated digital-based jump power meter to measure leg muscle power and jumping height in sports."

2. MATERIALS AND METHOD

The research method used in this study was the development of quantitative and qualitative approaches which aimed to obtain good research results (Yudhistira and Tomoliyus, 2020; Yudhistira, Siswantoyo, *et al.*, 2021; Yulianto and Yudhistira, 2021; Wardianti *et al.*, 2022)(Akhiruyanto, Pribadi and Yudhistira, 2022). The empirical validity of 38 male and female sports students ranging in height from 156 to 179 kilos was examined. The pupils were given instructions on how to take the test before they began. The validity of the jump power meter was evaluated utilizing empirical validity and content validity tests.

There are three stages in the content validity stage. The author did a qualitative study through examinations of existing leg muscle strength tests in the first step, then made field observations to understand existing problems, which provided the basis for building a product. The second stage involves creating a device called an integrated digital-based jump power meter. After the tools have been arranged, the researchers assessed the tools using the Delphi technique (Prinsen *et al.*, 2018; Yudhistira, Siswantoyo, *et al.*, 2021; Yudhistira, Suherman, *et al.*, 2021; Septian *et al.*, 2022) essentially the researchers met directly with 5 material specialists to assess the contents of the jump power meter tool. The fourth stage was quantitative analysis, which involved examining the data acquired from an expert assessment using a Likert scale of 5.

After receiving the results of the trial tests done by sports students, the empirical validity was assessed. The Aiken formula (lewis. R. Aiken, 1985; Thi and Nguyen, 2020; Nasrulloh *et al.*, 2022), was used to analyze the content validity coefficient as the basis for the findings of numerous experts' judgments of an item to determine how well the item represents the construct to be measured. Pearson product-moment computation is used in the data analysis technique for empirical validity, which is aided by SPSS version 23. Aiken's formula is provided below as follows:

V = ∑ s / [n (C-1)]
S = r – lo
Lo = lowest value
C = highest value
R = numbers given by the rater

3. RESULTS AND DISCUSSION

Based on the findings of data analysis through literature study and needs analysis, the following findings were reached:

a. *Arduino Mega 2560*

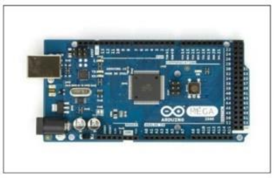


Figure 1. Arduino Mega 2560
Figure 2. MT3608

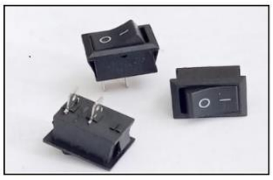


Figure 3. TP4056

The main processor is an Arduino Mega 2560. The microcontroller processes all incoming and outgoing data. A microcontroller is a miniature computer contained in an integrated circuit that is programmed to perform specific operations and tasks.

b. *MT3608*

MT3608 serves to increase the voltage of the 186650 li-ion battery from 3.7V – 4.1V to 7V.

c. *TP4056*

TP4056 functions as a micro USB charger to charge Li-Lon 18650 batteries

d. *TM1637*

Figure 4. TM1637

TM1637 is used to display weight, jump height, power in watts, and power in kilograms.

e. Mega 2560 Battery

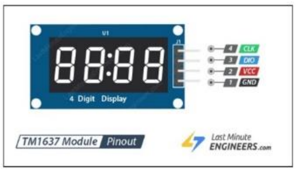


Figure 5. Mega 2560 Battery

The battery serves as a voltage source for the tool. Specific 18650, Voltage: 3.7V up (full charger 4-4.2

volts), Dimension: 65.0mm x 18mm.

f. *switch*

Figure 6. Switch

The switch functions as a breaker and the main voltage connector on the tool. Specifications: 250V 5A | 125v 10A, size 20x15mm.

g. *Switch Push On*

Figure 7. Switch Push On

The push-on switch serves to connect and disconnect the electric current with the unlock working system. When the button is pressed, the switch acts as a connecting device or checks circuit disconnection, and when the button is not pressed, the switch returns to its usual state. The tool's push-button serves as a reset and start button, with the following specifications: Momentary push button switch; voltage: AC 3A 250V, AC 6A 125V; the number of terminals 2 Pi erial

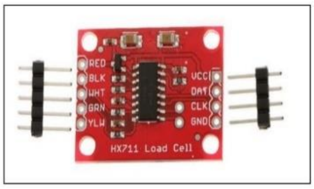
h. *Buzzer*

Figure 8. Buzzer

Buzzer serves vibrations into sound vibration other indicator in the form of e subject when taking data. Specifications: Voltage: 4 – 8 V; diameter 12 mm; distance between pins 6.6 mm; buzzer height 8.2 mm

i. *HX711*

Figure 9. HX711



HX711 works as a loadcell reader. HX711 is a module with a working principle for processing changes in resistance values with electrical output. The HX711 module is easy to use, stable and has high sensitivity and high processing speed.

j. Load Cell (300-400kgs)

Figure 10. Load Cell (300-400kgs)

A load cell is a transducer that converts units of pressure into electrical output. Load Cell is used as a weight reader.

k. *Liquid Crystal 2004 I2C*

Figure 11. Liquid Crystal 2004 I2C

Liquid Crystal 2004 I2C as a display behind the screen serves to see the running process.

l. *Wiring Diagram*

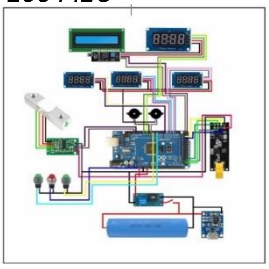


Figure 12. Wiring diagram

Picture of the contents of the existing design in the integrated digital-based jump power meter system.

m. *Spesifik box controller*

Figure 13. Box controller specifications

The controller box's front panel features an LCD screen, four Seven Segments, and three buttons. The 6x4 LCD panel displays all sensor parameters as well as the results of system calculations. The predicted height of the jump in cm is displayed using seven segments. The previous and next data buttons are used to support the data storage feature of the first and second jumps, allowing the Teste to compare the results of multiple jumps. The reset button is utilized if the Teste does not jump during testing and wishes to restart the weight measurement process from the beginning (reset system).

There are no components placed on the right side of the controller box. The left side of the controller box contains two parts, namely the on-off switch and the Arduino port. The on/off switch is utilized to power on and off the controller box, while the Arduino port serves as a connector for reprogramming the microcontroller as well as a location to deliver charging electrical resources. The box controller employs a charged battery, making disassembly easier and more energy efficient. When testing battery life,

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the charging box controller can run for roughly 90 minutes in one procedure.

The load cell cable connector and the tripod thread mount are located at the bottom of the controller box. A load cell cable connector is a cable that transmits data from a load cell sensor to a boxed controller, where it is processed and displayed. The tripod thread mount is the element that connects the tripod to the box controller.

n. *Plate frame and anvil*

Figure 14. Plate frame and anvil

Procedures:

• Press the switch or the switch button on the appliance to turn it on. Please wait for the buzzer to cease before turning on the appliance.

• Before turning on the tool, there should be no objects, subjects, or loads on the plate, as the tool will initially calibrate at the initial weight. When turning on the tool, if there is a load, the calibration process will fail. Calibration failure can be corrected by hitting the reset button and recalibrating.

• The first step is to take the subject's weight, the plate takes data with a minimum weight of 10 kg and takes 10 times the weight of the data sample to get the average value of the 10 times the sample.

•

p. *Formula*

The formula used to take the value of the jump height is based on the uniformly changing straight motion formula with the development of the formula:

•Formula = (((½ . g . t^2) . 0,3)+11) . 100//

The figure above is a plate that functions as a weighing platform as well as a leaping platform. Stainless steel plate 70 cm x 60 cm thickness 1mm 5x5 holo frame thickness Loadcell 2 mm plendes 10 mm, L 6 bolts, sensor mkcell (USA) single points 500kg.

o. *O. The result of developing a jump power meter*

Figure 15. Jump Power Meter

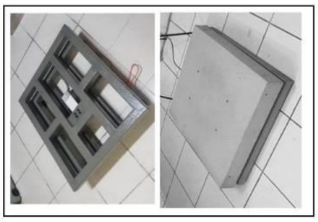
After receiving the weight, the buzzer will sound once. 200

• After then, the buzzer will sound once in a while, and the athlete will be requested to jump.

• The acquired data will be processed using a specified algorithm to get the jump power value.

• Scores are taken twice, with the same protocol.

• The TM1637 or seven-segment module will display



the final result achieved. Weight, jump height, power in watts, and power in kg are the four TM1637 modules with various value display functions. The gadget has three push buttons for displaying data "*next,*" displaying previous data "*back*," and a "*reset*" function on the red button.

Furthermore, to find out the amount of power using the following formula: :

• Power = $\sqrt{4.9 * Berat} * \sqrt{Tinggi\ Loncatan}$

q. *Q. Data Description and Validity Results*

TABLE I *DATA DESCRIPTION RESULTS*

Variable	N	Minimum	Maximum	Mean	Std. Deviation

Weight Measurement	38	38.09	77.38	58.2816	9.46681
Leap 1 Height Measurement	38	31	65	45.89	7.700
Leap 2 Height Measurement	38	25	69	46.39	8.830
Measurement Time 1	38	373	607	487.61	54.077
Measurement Time 2	38	318.00	629.00	488.9737	61.47972
Power measurement in watts 1	38	1.12	1.81	1.4889	.17738
Power measurement in watts 2	38	1.14	1.87	1.4955	.19076
Power Measurement in Kilograms 1	38	85.75	138.16	113.3353	13.43241
Power Measurement in Kilograms 2	38	87.04	188.41	115.6339	19.03638

TABLE 2 CONTENT VALIDITY ANALYSIS RESULTS

Pertanyaan	Assessor					S = r – lo					Σ	n*(c - 1)	V=S/(n* (c-1)
	1	2	3	4	5	1	2	3	4	5			
1	5	4	4	4	4	4	3	3	3	3	16	20	0.8
2	5	5	5	5	5	4	4	4	4	4	20	20	1
3	4	4	5	4	4	3	3	4	3	3	16	20	0.8
4	4	4	4	4	3	3	3	3	3	2	14	20	0.7
5	4	4	3	4	3	3	3	3	3	2	14	20	0.7
6	4	5	5	5	5	3	4	4	4	4	19	20	0.95
7	3	4	4	4	4	2	3	3	3	3	14	20	0.7
8	4	4	4	4	4	3	3	3	3	3	15	20	0.75
9	4	4	4	4	4	3	3	3	3	3	15	20	0.75

The results of content validity have been discovered based on the evaluation of 5 experts. The following are nine questions posed by the authors and judged by experts: (1) measuring instruments developed based on modern technology, (2) tools and equipment used in accordance to develop an integrated digital-based jump power meter, (3) the measuring instrument has good clarity and convenience in the operating system, and (4) the measuring instrument can present good sound, video, font, and color. (5) the developed measuring instrument serves the intended objective of measuring leg muscle power. (6) measuring instruments can present weight data well, (7) measuring instruments can present time data well, (8) measuring instruments can present power data in watts well, and (9) Power data in kilograms can be presented accurately using measurement devices. Based on the data acquired, it is deemed to have good content validity if the value of the validity coefficient is between 0.7 and 1.00, or near one.

TABLE 3
RESULTS OF ANALYSIS RELATED TO EMPIRICAL VALIDITY OF LEAP HEIGHT

		1st Leap Height	2nd Leap Height
1st Leap Height	Pearson Correlation	1	.968 .000

	Sig. (2-tailed) N	38	38
2nd Leap Height	Pearson Correlation Sig. (2-tailed) N	.968 .000 38	1 38

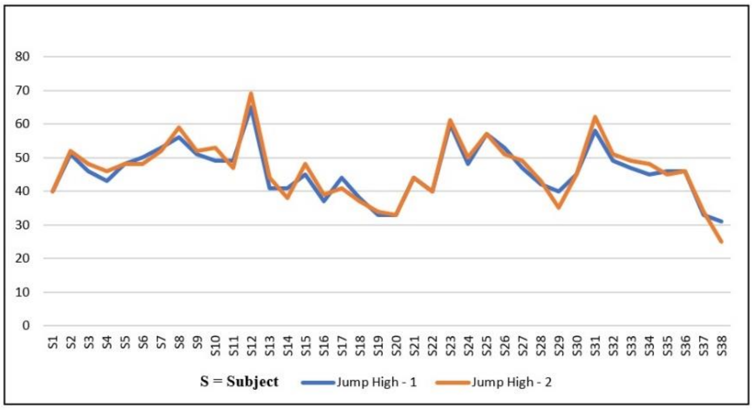


Figure 16. First and second Leap Height Diagram

TABLE 3
RESULTS OF THE EMPIRICAL VALIDITY ANALYSIS OF POWER IN KILOGRAMS

		1st Power Kilogram	2nd Power Kilogram
1st Power Kilogram	Pearson Correlation Sig. (2-tailed) N	1 38	.772 .000 38
2nd Power Kilogram	Pearson Correlation Sig. (2-tailed) N	.772 .000 38	1 38

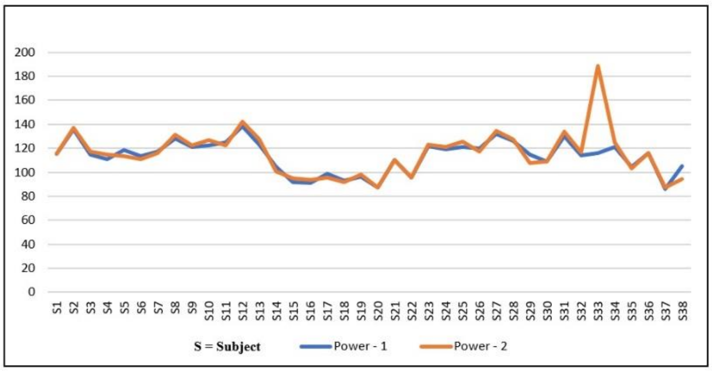


Figure 17. Diagram of the first and second power measurements

According to table 3, the validity test data utilizing the person product moment has found a Pearson correlation value of 0.968 and a sig. (2-tailed) value of 0.000 < 0.05, indicating that there is a significant correlation between the first jump height result and the jump height result. second. Furthermore, Figure 13 demonstrates that the outcomes of the first and second jumps have minor differences or are almost identical.

According to table 4, the validity test data using the person product moment has found a Pearson correlation value of 0.772 and a sig. (2-tailed) value of 0.000 < 0.05, indicating that there is a significant correlation between the results of the first kilogram of power and the results of the second kilogram. Furthermore, Figure 14 illustrates that the results of the first and second kilograms of power have minor differences or are almost identical.

Based on validity testing using person product moment analysis, the integrated digital-based jump power meter may be used to measure jump height and leg muscle power since it has strong validity, making this measuring instrument a technologically new tool.

Leg muscle power is an important test and measurement to determine the quality of power (Cadore *et al.*, 2014). Power is one factor that influences athletic performance (Malcata and Hopkins, 2014). So far, field-based tests that are performed manually are still used to quantify leg muscle power (Haryono, Kristiyanto and Suryana, 2022). Besides, a more recent technique to assess leg muscle power (Suharta, Dewi and Supriadi, 2019) exists, although it has not produced adequate findings, such as the perception of jump height being utilized as a predictor of leg muscle power. As a result, a novel measurement equipment known as an integrated digital-based jump power meter was created. An integrated digital-based jump power meter (JPM) is a current technical equipment developed by researchers for evaluating jump height and leg muscle power. In terms of data presentation, the jump power meter (JPM) is unique in that it displays data on weight, jump time, jump height, horsepower, and power in kilograms on a direct monitor. Modern technological advancements will have a favorable impact on sports achievement. According to past research, enhancement and development are always carried out for the advancement of sports (Lee and Lee, 2021). The advancement of science and technology is one of the efforts to assist individual and team successes, thus academics and practitioners must constantly innovate to build unique technology-based tools [(Onojohwevwo, Diejomaoh and Akarah, 2015).

For true sports practitioners, modern technology adds a new dimension (Soltani and Morice, 2020). Furthermore, technological advancements aid sports analysts, coaches, professors, and administrators greatly. For example, sports apps can be downloaded on the latest smartphones, as well development of smart garments, and smartwatches to aid in exercise activities (Tsai *et al.*, 2021). Then, in athletics, test, and measurement activities have shown improved progress (Gobinath Aroganam, 2019). Tests and measures in sports are very significant activities because they allow coaches, teachers, and sports activists to evaluate athletes' performance results (Sabin and Pomohaci, no date)

4. Conclusion

According to the presented results and discussions, the digital-based jump power meter measuring instrument for measuring leg muscle power and jump height has good content and empirical validity. The authors expect that the jump power meter will be useful and meaningful in sports technology, particularly in sports tests and assessments. However, the authors recognize that additional research is needed in this study to uncover dependability results, categorize norms in leg muscle strength, and compare with existing tests, thus more individuals are required to acquire better results. This will be accomplished through additional research.

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