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RESEARCH ARTICLE

VJMP Effectiveness and Efficiency for Measuring Vertical Jump

Abi Fajar FATHONI[1*], MU'ARIFIN[2], Michael Chia Yong HWA[3] and Nur Azlina Mohamed MOKMIN[4]

[1,2]Universitas Negeri Malang, Faculty of Sport Science, Department of Physical Education, Health and Recreation, Malang / Indonesia
[3]Nanyang Technological University, National Institute of Education, Physical Education & Sports Science, Jurong / Singapore
[4]Universiti Sains Malaysia, Centre for Instructional Technology and Multimedia, Penang / Malaysia
*Corresponding author: fajarfathoniabi@um.ac.id

Abstract
The objective of this research is to devise a tool named Vertical Jump Measurement Portable (VJMP) with the purpose of facilitating practical and efficient measurements of vertical jumps, offering portability for use in diverse settings; concurrently, the research aims to evaluate the precision of VJMP in measuring vertical jumps. Employing research and development methodologies, this study involved the comparison of Vertical Jump Measurement Portable (VJMP) research products with traditional vertical jump measuring instruments. The research enlisted 42 participants who were athletes representing diverse sports disciplines. Data analysis included the application of the Mann-Whitney test to discern any statistically significant differences between the two vertical jump measuring instruments, with a threshold for significance set at $p>0.05$. The study outcomes revealed no statistically significant distinctions in the data obtained from two vertical jump measuring instruments, as indicated by a p-value of 0.754. This underscores the accuracy of VJMP in gauging vertical jumps. Furthermore, the tool exhibited notable efficiency, requiring a mere 41 seconds for the measurement of an individual. In conclusion, VJMP stands as an accurate and efficient instrument for assessing vertical jumps, thereby making it a viable choice for measurements across diverse sports and facilitating ease of use in practical field settings.

Keywords
Vertical Jump, Portable, Measurement

INTRODUCTION

Scientists in the field of sports say that measuring the level of jumping effectiveness is by measuring the vertical jump. Because the vertical jump already represents the muscles that work for jumping movements carried out in various directions (Bujang et al., 2021; Delang, Hannon, Goto, Bothwell, & Garrison, 2021; Hurr, 2021). So in many sports, vertical jump measurements are carried out if you want to measure the effectiveness of jumping (Carlos-Vivas, Martin-Martinez, Hernandez-Mocholi, & Perez-Gomez, 2018; Gray et al., 2017; Patel & Yadav, 2020; Pérez-Castilla, Rojas, Gómez-Martínez, & García-Ramos, 2021).

Each sport has a different training location. So when you want to take a vertical jump measurement, you must adjust the place or tool used. As an example of football in Indonesia, not all fields used for practice have walls. So to take measurements of vertical jumps, you cannot use a standing board jump tool because this tool requires a flat wall to attach the tool to and a flat floor for the jumping area. Then if using a tool that requires

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an electrical connection, it is necessary to ascertain whether there is a power channel in the field and whether there is a long cable to distribute the electricity. The above-mentioned example shows that different sports are played or practised at different venues with different conditions. This is the case for both indoor or outdoor sports, building facilities, and other alternative facilities (Kościański, 2021; Müller-Frączek, 2021).

Several tools are used to measure vertical jumps: Jump MD, standing board jumps, Vertical Jump Test (VJT), and Smart vertical jumps. All of these tools have their advantages and disadvantages (Kearns et al., 2019). As previously explained, the standing board jump is the simplest vertical jump measurement tool, namely by placing a board given a distance from the wall. Then, the athlete being measured jumps by touching his hand to the board and then to see the height of the vertical jump, that is, look at the touch mark on the number (Lim, Yu, Kim, & Park, 2021). The advantage of this tool is that it is easy to understand the principle of measurement and its use. Moreover, the tool is a real measuring scale range and visible to the human eye (Wilson et al., 2022). As well as this tool avoids system failure problems such as those that occur in devices that use electronic or computer technology that are difficult to identify. However, this tool has a drawback, namely the need to find a wall without any obstraction. Then when measuring, one person must remove the traces of chalk stuck to the board as a touch marker on the board. In addition, its use begins with measuring the height of the hand span when standing and then measuring the height range of the touch when jumping. Calculating the difference between the height of the hand span while standing and the touch height when leaping is still required to get the vertical jump height (Majid & Fauzi, 2021; Marković et al., 2021). Of course, this will require additional time to process the measurement results. Then in some cases, using this tool is difficult to determine the measurement results with decimal values. For example, if the measurement results are between two measuring scale ranges, then most of the measurement results are determined by rounding subjectively (Giustino et al., 2022; Pagaduan & Pojskic, 2020). So it must fulfill the measurement reliability principle (Haqiyah et al., 2023).

Figure 1. Vertical jump measurement using standing board jumps

Then another tool to measure vertical jumps is the Vertical Jump Test (VJT). The advantage of this tool is that it already uses an electronic system and utilizes a proximity sensor. But the drawback is that this tool requires an electric voltage of 5V, so it is less economical and practical because you have to find a power source. As well as in its use, it is necessary to assemble two boxes, and it will take more time. In addition, this tool does not directly show the measurement results. To see the measurement results, you must calculate the 2-meter formula minus the distance from the sensor to the measured person (Öncen, Aydın, & Pınar, 2018). So it is felt that this tool will require a lot of time to calculate the measurement results.

The tool to measure the next vertical jump is the Smart Vertical jump. The advantage of this tool is that it has taken advantage of electronics. The Smart Vertical jump uses 3 devices to be placed beside the person to be measured, one above, and another held by the person being measured (Słomka et al., 2017; Struzik, Winiarski, Popowczak, & Rokita, 2017). To install these three tools, a tall pole is required, and the pole must also have a stalk in a horizontal position. If you look at the tools needed, this tool is considered impractical because it requires a lot of tools and takes more time to assemble the tool.

Figure 2. Vertical jump measurement using Smart Vertical jump

Then the last one is Jump MD. Jump MD is considered practical compared to the tools previously mentioned. The way to measure this tool is that the person being measured stands on a disc-shaped plate and ties a belt around his waist (Ferdiana, Muhammad, & Wiriawan, 2020; Hendrey et al., 2018). However, this tool still needs to be considered more efficient. If you measure many athletes, it will take time to alternate using the belt from athlete to athlete.

Figure 3. Vertical jump measurement using Jump MD

Based on the weaknesses of several existing vertical jump measuring instruments, it is necessary to develop practical, economical, effective, and efficient tools to measure vertical jumps. This is also an urgency in this research and development. The advantages of some of these tools also need to be adopted to get a tool with complete features. For this reason, researchers developed a tool called VJMP (Vertical Jump Measurement Portable). This tool is considered as practical because of its small size with dimensions of 11.5 x 6 x 4 cm, and high mobility of use in all sports. Then this tool is also very economical because it only uses one device box, and the electrical energy can be supplied by a battery or power bank. This device is also considered effective since it uses a sensor to capture the height of the vertical jump. The tool is efficient because it is easy to use. The way to use this tool is to turn it on then have the person being measured perform a vertical jump next to the tool, after which the result to two decimal places is recorded and displayed on screen, without the need for any manual calculation.

MATERIALS AND METHODS

Research Procedure

Utilizing a quantitative approach, the research involved the development and investigation of VJMP tools as a fundamental methodological framework. Then proceed with making comparisons using the VJMP tool with conventional vertical jump measuring tools to see the performance of the tool that has been developed. The research procedures and steps are illustrated in Figure 4 presented below.

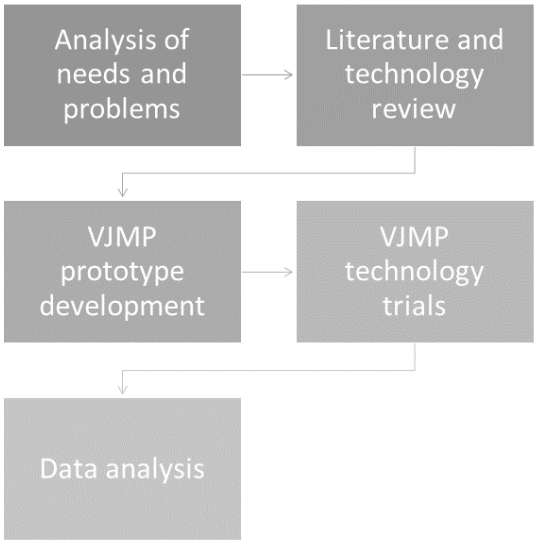

Figure 4. Research and development flow.

This study adhered to ethical guidelines and obtained approval from the Faculty of Medicine at Brawijaya University in Indonesia under reference number 165/EC/KEPK-UM/09/2022. Participants willingly gave informed consent through a volunteer form that outlined research specifics, potential risks, benefits, confidentiality assurances, and participant rights. The research strictly followed the ethical principles outlined in the Declaration of Helsinki, emphasizing the prioritization of participant rights, well-being, and confidentiality in the study's design, procedures, and protective measures.

The process of recruiting research subjects was by inviting 42 active athletes from various sports from all over Indonesia who were currently studying at the State University of Malang. Researchers invite research subjects randomly because this tool measures everyone's vertical jump without specifying certain types and characteristics. The trial use of this tool shows whether it can be used for all types of users or not.

Data Collection Tools

The research tools used were VJMP and standing board jumps. Recording was done using Microsoft Excel software. Standing board jumps have historically exhibited considerable validity and reliability in assessing vertical jumps on both national and international levels. Hence, our study entailed a comparative analysis to ascertain the equivalency of accuracy between the developed tool and the established method of standing board jumps. The data collection technique was carried out by looking at the results of measuring vertical jumps from the results of measurements using the VJMP and standing board jumps which were carried out together. In addition, vertical jump measurements were also carried out using the two tools separately, which aims to measure the time efficiency of using the two tools.

The use of the VJMP will be compared with a conventional vertical jump measuring tool, namely the standing board jump tool, to see the effectiveness of the vertical jump measurement results. The choice of this tool is a comparison because the standing board jump tool has the advantage of being easy to understand the measurement principles and their use. As well as this tool avoids system failure problems such as those that occur in devices that use electronic or computer technology that are difficult to identify. So, this tool has a strong basic value in measurement. Figure 5 below compares the standing board jump measurement tool with the VJMP tool during testing.

Figure 5. Measurements using the VJMP and standing board jump measuring tool simultaneously.

Statistical analysis

Data analysis used SPSS version 25 by carrying out the Mann-Whitney test to see the effectiveness of the tool's performance. The study investigated the outcomes of high jump measurements obtained through both VJMP and standing board jumps, assessing the comparative results to ascertain the presence of any disparities; a dissimilarity would indicate the inadequacy of VJMP for assessing vertical jump, whereas the absence of distinctions would affirm the accuracy of VJMP in gauging vertical jump. The accepted level of statistical significance is $p>0.05$. Then for the efficiency of the use of tools analyzed using qualitative description analysis.

RESULTS

Product Development Results

The product developed in this study is a tool called VJMP, which measures the distance of a vertical jump. With a size that can be held by hand, this tool is easy to carry anywhere and is suitable for people with high mobility, such as coaches, athletes, and others. The advantage of this tool is that it already uses a sensor system and displays measurement results digitally directly. So there is no need to reduce the measurement results after and before the jump as was done when using the Standing board jump measuring instrument. As well as, measurement results can be accurate to a decimal value. Using the tool is a straightforward process: activate it, position the individual intending to jump in front of the sensor, execute the jump, and upon returning to the sensor's range, the tool will promptly present the recorded jump height on the screen. Here's what the VJMP tool

looks like.

Figure 6. Appearance of the VJMP.

Results of Testing the Effectiveness of the VJMP Tool

The vertical leap height of the research subject was assessed concurrently using the standing board jump measuring tool and the vertical jump height measuring instrument to assess the instrument's efficacy.

Normality Test

The normality test results for data analysis of the standing board jump and VJMP distance measurements are shown in the table below. A normality test must be performed to determine whether the x and y variables are regularly distributed. If there are more than 30 pieces of data to be processed, the Kolmogorov-Smirnov table is utilized; otherwise, the Shapiro-Wilk table is used. The Kolmogorov-Smirnov test, with a significance level of 5%, was used in this work as the statistical normality test. Following are guidelines for decision-making using a significance level of 5%: (1) Significance value (sig) 0.05, non-normal data distribution (2) Significant value (sig) > 0.05, with normal data distribution.

The standing board jump measuring device and the data measured using the VJMP exhibit an irregular distribution of data, according to the data gathered and the normality test performed. Utilizing SPSS, the results are processed. The data are displayed in the Kolmogorov Smirnov column of the table below.

Table 1. Normality test

Tests of Normality			
	Kolmogorov-Smirnova		
	Statistic	df	Sig.
Data A (cm)	0.148	42	0.022
Data B (cm)	0.154	42	0.014
a. Lilliefors Significance Correction			

The data distribution is different based on the results shown in the above table. The significance value below 0.05 indicates an aberrant data distribution, which can be observed. Data were gathered using a 5% level of significance. The standing board jump measurement tool and the VJMP, which measure vertical jump, respectively, yielded results of 0.022 and 0.014 in the normalcy test. The two variables are, therefore, not normally distributed.

Homogeneity Test

The variance of each variable, including the VJMP and the standing board jump measuring device, was calculated using a homogeneity test. The results of the homogeneity test are listed below. If the significance value (sig) is less than 0.05, the data variance is homogenous; if it is greater than 0.05, it is heterogeneous.

Table 2. Homogeneity test

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Results Measure	Based on Mean	0.003	1	82	0.960
	Based on Median	0.010	1	82	0.921
	Based on Median and with adjusted df	0.010	1	81.994	0.921
	Based on trimmed mean	0.004	1	82	0.948

A significance value of 0.960 was determined using the findings of the homogeneity test using the Levene test. This value is greater than α (0.05). Therefore, the decision to accept H0 was obtained with the conclusion that the variance of each VJMP variable and the standing board jump measuring tool.

To see if there is a statistically significant difference between the variable results of measuring the distance using the VJMP and the standing board jump measuring device, a Mann-Whitney test will next be run. The data were not normally distributed, so the Mann-Whitney test was used.

Mann Whitney Test

The VJMP and the standing board jump measuring equipment were used to measure vertical jump height, and it was decided whether there were any significant differences in the data using the Mann-Whitney test. The Mann-Whitney test's findings are as follows.

Table 3. Mann Whitney Test Results

Test Statisticsa	
	Results Measure
Mann-Whitney U	847.000
Z	-0.313
Asymp. Sig. (2-tailed)	0.754
a. Grouping Variable: Group	

According to the Mann-Whitney analysis, the difference between the results of the vertical leap measurement made using the VJMP and the standing board jump measuring tool is statistically significant (0.754 > 0.05). The conclusion that there was no discernible difference between the results of the vertical jump measurement using the VJMP and the standing board jump measurement equipment led to the decision to approve H0. It can be said that the difference in the use of the measuring instrument between the VJMP and the standing board jump measurement tool does not cause a difference in the measurement results.

Measurement Efficiency of The Two Vertical Jump Distance Measuring Devices

The results of calculating the time of using the VJMP to measure the vertical jump distance of 42 people is 16 minutes 38 seconds. This time includes the acquisition of net measurement results. The results of calculating the time of using a standing board jump measuring instrument to measure the vertical jump height of 42 people is 29 minutes 11 seconds. This time includes the acquisition of the final data, which is processed by calculating the difference in the results of the measurements before the jump and after the jump by the data taker.

DISCUSSION

The VJMP efficacy test findings analysis revealed no appreciable differences between measurements made with VJMP and standing board jump meters. This means that it is certain that the VJMP is suitable and effective for measuring vertical jumps. Then for time efficiency, using the VJMP to measure 42 people takes 16 minutes 38 seconds. Meanwhile, using a standing board jump measuring tool to measure 42 people took 29 minutes and 11 seconds. That means using VJMP is 56% more efficient than using a standing board jump meter.

Community technology development aims to simplify work and obtain results faster (Mohsen, Saeed, Raza, Omar, & Muffatto, 2021; Sozinova, 2018). Likewise, the development of the latest technological tools in sports continues to be developed. Technology development aims to make it easier for sports players to help with training and obtain data useful for determining decisions and strategic steps (Chung, Lee, & Kim, 2022; Klaysung, Virasa, & Poprateep, 2022).

Employing VJMP to VJMP to measure vertical jump height is more valuable than other methods. With the work efficiency of the tool, it will provide speed in deciding steps based on measurement data (Martínez-Alonso, Martínez-Romero, & Rojo-Ramírez, 2022; Steblyanskaya et al., 2021). So that it can also be faster to immediately carry out the strategy that was decided to achieve the desired performance.

VJMP is very accurate and detailed in displaying measurement results. With digital technology on the VJMP, measurement results can arrive at decimal values. Accurate measurement results can minimize subjective levels in determining measurement results when measurement results are between two measuring scales so that the reliability principle in measurement can be fulfilled. This reliability principle is very important to fulfill, bearing in mind that measuring data is used not only by one party (Beato, Fleming, Coates, & Dello Iacono, 2021; Schumacher, Schmidt, Reer, & Braumann, 2019). The measurement results may be used to proceed to a higher level of verification and possibly repeat measurements (Haqiyah et al., 2023). If the two measurements have their respective subjective values, the data cannot be reliable, which is

doubtful (Hannon et al., 2019; Krstulović et al., 2023).

VJMP meets practical criteria due to its modest size. So, it is suitable for sports players who have high mobilization characteristics. When carrying VJMP, users can easily take it anywhere. This condition is also in line with the development of the times where many technological devices that were originally large are getting smaller daily. However, their features and uses are increasing (Li, Wang, & Yao, 2021; Lumintuarso, Suharjana, Widiyanto, & Ndayisenga, 2021). VJMP falls under the category of technological equipment that is simplified.

VJMP can also be said to meet environmentally friendly criteria. The VJMP can be used anywhere in indoor or outdoor sports venues. VJMP is also a standalone tool which means it can be used without other supporting tools. VJMP also only requires a small amount of energy which can be supplied by a battery alone without the need for large electrical power. In this way, VJMP also aligns with the principle of developing environmentally friendly technology. Environmentally friendly technology can work in all environmental conditions, can work without being affected by the condition of objects in the environment, and also does not use excess resources from the environment, which affects the safety of the surrounding environment (Suji & Kumar, 2020; Xu, Shu, & Su, 2023).

VJMP is included in economic technology. VJMP is an independent technology that does not require supporting facilities and infrastructure. So that by not requiring supporting facilities and infrastructure to run VJMP, costs can be reduced. This principle is also in line with economic technology, where all countries compete to develop economic tools with high use value (Hauser, Athrey, & Leberg, 2021; Langie et al., 2022).

Conclusion

The data shows that measuring vertical jump height using VJMP is effective and much more efficient. So VJMP is feasible to be used in measuring vertical jump distances. Furthermore, the VJMP can be published to the public so the community can feel the benefits. Especially people who are active in sports because the VJMP has proven effective and efficient in measuring the distance of vertical jumps.

Then with various customized features, VJMP can be used anywhere without having to look for a wall because it can be placed on the floor or the ground, and there is no need to look for a power source and cables because VJMP energy can be obtained from the battery. VJMP is also very practical with its small size, so it's easy to carry anywhere. Then VJMP has been equipped with a digital system so that measurement results are accurate up to a decimal value. So that subjective determination can be reduced, and the principle of measurement reliability can be fulfilled. The constraints within the realm of research and development primarily entail the exclusive focus on the hardware aspect in developing vertical jump measuring instruments. Future explorations in this domain could expand the scope by integrating software components, offering a potentially more practical avenue for utilization.

Conflict of interest

The authors unequivocally disclose the absence of any conflicts of interest, concurrently expressing appreciation to the State University of Malang for their indispensable financial support, which proved instrumental in the successful culmination of this research endeavor.

Ethics Statement

This study adhered to ethical guidelines and obtained approval from the Faculty of Medicine at Brawijaya University in Indonesia under reference number 165/EC/KEPK-UM/09/2022.

Author Contributions

Study Design, AFF, and M and; Data Collection, AFF and M; Statistical Analysis, AFF, MCYH and NAMM; Data Interpretation, AFF, MCYH and NAMM; Manuscript Preparation, AFF, MCYH and NAMM; Literature Search, AFF and M. Each of the authors has thoroughly reviewed and granted approval for the final published version of the manuscript.

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