DOI 10.26773/smj.230214

ORIGINAL SCIENTIFIC PAPER

Development of a Digital-Based Tool to Measure Volleyball Players' Upper Limb Muscle Explosive Power

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Abstract

It is evident that manual tools used to assess volleyball players' upper limb muscles show some shortcomings in terms of time consumption, accuracy, and high concentration that forecast errors occur during measurement. To address such an issue, this Research and Development (R&D) aims to design and develop an effective digital-based instrument for measuring arm muscles' explosive strength. The participants of this study were 52 male students that were divided into a small group (n=12) and a large group (n=40). They are sports science students at Pahlawan Tuanku Tambusai University. There were also nine experts involved in this study. These experts are from some disciplines, namely volleyball, Information Technology (IT) media, as well as test and measurement. Data were collected by means of questionnaires adopting a 4-point Likert scale. After data analysis, results show that all nine-instrument development validators who are volleyball experts, IT media experts, as well as test and measurement experts confirmed that the product developed is Very Feasible (91.58%). Moreover, the reliability test conducted using the product-moment correlation obtained r of 0.652, while the results of the effectiveness test performed using the Independent Sample t-test was 1.000>0.05. The developed tool that functions as a digital-based tool for measuring volleyball players' upper limb muscle explosive power is considered Very Feasible by the experts. Thus, it can become a useful tool for mitigating errors and enhancing accuracy to measure arm muscle explosive power in various settings and purposes.

Keywords: *arm muscle development, digital instrument development, volleyball game*

Introduction

Being acknowledged as a world-famous sport, volleyball has become more popular in Indonesia. It is a sports game whose fans and spectators are larger in number than other games, for example, basketball. Competitions in volleyball have been intensified in different corners of the globe, therefore the World Cup, Asian Cup, Professional League, and inter village tournaments that are most popular in Indonesia are now getting more popular. For that reason, the achievement and interest in volleyball in Indonesia are exponentially increasing every year. This enables Indonesian volleyball athletes to compete at the international level (Rifki, Sazeli, & Syafrizar, 2017; Rifki, Sazeli, & Syafrizar, 2022).

However, this team sport is difficult to perform since it requires intermittent bouts of high-intensity exercise which is followed by periods of low-intensity activity like walking or standing (Vasić et al., 2021). Volleyball games have a variety of staple techniques that help players to perform well on the pitch such as service, passing, blocking with both hands, and smashing. Therefore, during a volleyball match, players are involved in various offensive jumps, blocks, knockouts, and sprints where power, strength, agility, and speed are demanded (Mielgo-Ayuso et al., 2015; Michalsik, 2018). Sports professionals in general and volleyball professionals in particular,

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along with some researchers view volleyball as a sport game that requires not only techniques and tactics but also arm and muscle strength. Pursuant to (Pratama, Bagas, & Sistiasih, 2021), despite the contribution of basic technical skills in the game previously highlighted, it is also very much needed to bear a high vertical jump ability to get more points and eventually win matches either through attacks, smashes, or blocks. In other words, a person's ability to perform a good vertical jump is mostly regulated by the strength of the upper limb muscles as well as the explosiveness of the upper limb muscles (Aouadi et al., 2012; Martinez, 2017). In addition, it is also important for volleyball players to strive to reach a maximum height above the net.

The combination of arm muscles to generate work in a very lapse of time is the definition of power upper limb muscle explosion (Fachrezzy et al., 2020; Fatoni, Muhad, Jariono, Subroto, & Triadi, 2021). However, it is reported that there is a lack of such skills in many Indonesian handball players (Fadilah & Wibowo, 2018; Sunawa et al., 2018). Other studies showcased that the obstacles that could hinder achievement in volleyball games are the coaching and conventional/classical training system administered. The cutting-edge technology existing so far is partially a good remedy for such shortcomings in volleyball players in Indonesia. In line with this statement, it can be understood that the presence and incorporation of technology in sports can help increase achievements since the use of technology has not been exploited to the maximum in different areas.

The use of technology is also closely related to tests and measurements, especially in data collection as a benchmark for determining exercise programs for both coaches and players (Komaim et al., 2022). To be able to achieve good performance, a coach or athlete must also be able to measure the extent of progress as training results by conducting a test and a regular measurement process (Sands & Stone, 2005; Ian Lambert & Borresen, 2010; Serrano et al., 2013). The existing test and measurement instruments to measure the explosive power of upper arm blow that have been employed are mostly developed by experts.

According to Wiriawan (2017), the test instrument used to see the explosive power of the arm muscles is the Two Hand Medicine Ball Put. The equipment used in this test is a Medicine ball of 3 kg for men, and 2 kg for women along with, a runway marked with a 30-meter line, a notebook, and trainees. As a matter of fact, these test instruments are still manually operated. Although they can still be used for tests and measurements of explosive power, they are not really effective, efficient, and reliable. Manual measurement may take a lot of time and require careful and highly concentrated human labor, especially if there are quite a lot of trainers observing. Subsequently, errors can occur during the measurement. For such inappropriateness, a digital-based test instrument should be developed to bridge that gap. It is a credible tool manufactured manually to measure the explosive power of volleyball players' arm muscles. However, this credible tool is rare to be found in the market. Even though making digital tools requires electronic devices and equipment, at the end of the day, it can operate properly and results in accurate data. The present research was carried out to develop a digital test instrument for measuring the arm muscle explosive power of volleyball players. The focus of this article is to present the development of the instrument and its appropriateness in terms of effectiveness and efficiency based on implementation results.

Methods

Research Design, Subject, and Setting

The design of this research is Research and Development known as (R&D) with which students from the department of physical education became the participants. Purposive sampling was employed to select 12 male students (for the small-scale population) and 40 male students (for the large-scale population) from Pahlawan Tuanku Tambusai University. Those students took a Volleyball course offered by the Sports Science study program.

In developing the test instrument named the digital-based test, the researchers adopted Borg and Gall's (2014) stages. The stages are 1) Problem and Potential, 2) Data or Information Collection, 3) Product Design, 4) Design Validation, 5) Design Improvement, 6) Product Testing, 7) Product Revision, 8) Product Testing, 9) Product Revision, and 10) Mass Production.

Apart from that, there had been also the development of research constructs/variables and indicators. Normally, the explosive power of arm muscles is measured manually using a medicine ball that requires a distance measurement process in meters. However, with this new digital tool, measurements are carried out automatically, and the results can be directly read on the monitor screen (LCD). The results show the explosive power that includes the aspects of strength and speed with units of kg. m/s. Then, when a volleyball hits the surface of the board it will be read by the sensor to be then forwarded to the Arduino Uno to be processed into information to be displayed on the LCD. Overall, the indicators and information obtained from the test are presented in Figure 1 below.

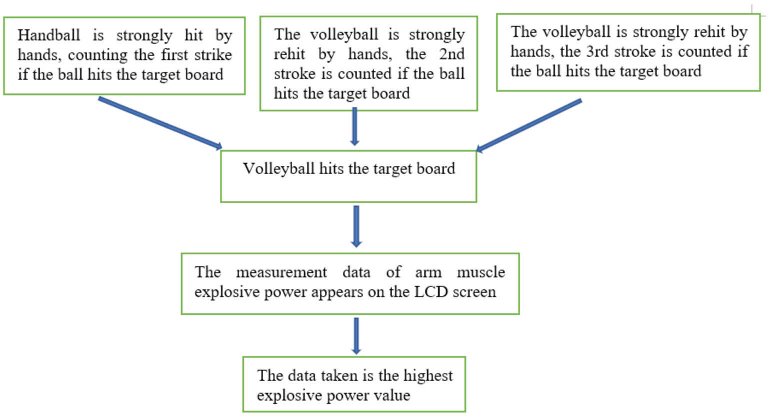

FIGURE 1. Flowchart Exhibiting the Tests Carried Out on the Developed Instrument.

Instrument and Scoring

To assess the content validity, questionnaires were developed to be then distributed to experts. The blueprint of the questionnaire contains variables of test on arm muscle explosive power indicators that include the developed tool's fitness, accuracy, convenience, practicality, reliability, and explosive power of the arm muscles. The instrument was developed based on a 4-point Likert scale where respondents are provided with answers that consist of categories of Very Good (4), Good (3), Fair (2), and Poor (1). To fill in the questionnaires, the respondents were asked to tick on the answer (Borg, 2014). The experts validating the developed test tool were from several disciplines, namely volleyball, test and measurement as well as IT. Data collected from the questionnaire were then analyzed and categorized into Very Feasible (76-100%), Feasible (56-75%), Not Feasible, 40%.

Small-scale testing was conducted with twelve students of Sports Science Education, Faculty of Education, Pahlawan Tuanku Tambusai University. This testing was done in two meetings (the first and second days), and repetition was done three times in each meeting. The categorization of the results of the reliability test is presented in Table 1 below.

Table 1. Category of r-product Moment Correlation Values

The values of 'r' Product Moment	Interpretation
0.000 – 0.199	There is a very low or very weak relationship.
0.200 – 0.399	There is a low or weak relationship.
0.400 – 0.599	There is a moderate or sufficient relationship.
0.600 – 0.799	There is a strong relationship.
0.800 – 1.000	There is a very strong relationship.

Data analysis

After addressing all data, an assessment was then carried out to obtain percentages to show the feasibility of the developed measurement device using the mathematical formula below.

$$Presentase\ (\%)\ \frac{Earned\ score}{expected\ score} X\ 100 \quad (1)$$

Then, quantitative data especially that from the Likert scale were qualitatively analyzed by SPSS software 26th edition based on an independent sample t-test (significance level=0.005) and Pearson correlation (Promthep et al., 2015; Isaac & Chikweru, 2018; Al-kassab, 2022).

Results

Product Description and Design

The expected final product is in the form of an electronic device to measure volleyball players' upper limb muscle explosive power (showing kg.m/s). The device has a sensor that reads the pressure generated by the field board. There is also a piece of microcontroller equipment to process the signal received from the sensor. Then, the processed information is displayed on the LCD screen, see Figure 4. The product developed as a digital-based tool is expected to be employed as a tool to measure volleyball players' arm muscle explosive power that

FIGURE 2. Censor Accelerometer.

FIGURE 3. Soccer Field Board.

FIGURE 4. LCD.

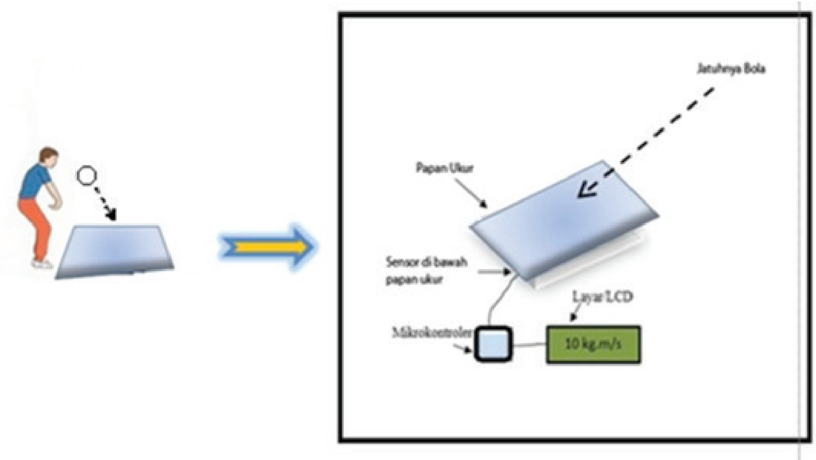

FIGURE 5. Product Proposed and Designed.

can be used in several settings such as in volleyball lessons at school, volleyball clubs, and sports science study program at university during the student admissions process.

This tool developed is equipped with other connectors and is operated together with software with an output server and LCD as depicted in Figure 5.

Volleyball Expert Validation

This developed tool was validated by experts, and the validity scores are presented below.

Table 2. Validation Results Obtained from Volleyball Sports Experts

No	Volleyball Expert Validation	Score Obtained	Max Score	(%)	Category
1	ALXL	14	20	70%	Good
2	SYXN	19	20	95%	Very Good
3	AAXN	16	20	80%	Very Good
Total		52	60	86.66%	Very Good

Based on the data shown in Table 2 above, the result of the expert judgment by volleyball experts toward the tool developed is Very Good (86.66%). It can be stated that according to volleyball experts, the aspect of the design feasibility belongs to the "Very Feasible" category.

IT-Media Expert Validation

Table 3 shows the extent of the IT-media expert validation. The total percentage obtained is 93.33%. Thus, it can be concluded that according to the IT Media Expert, the tool developed is Very Feasible.

Table 3. Validation Results from IT-Media Experts.

No	T-Media Expert Validation	Score Obtained	Score Max	(%)	Category
1	YXXH	39	40	97.5%	Very Good
2	MXXN	33	40	82.5%	Very Good
3	MXXR	40	40	100%	Very Good
Total		112	120	93.3%	Very Good

Test and Measurement Expert Validation

Table 4 shows that the cumulative result of the score obtained is 94.79%. Thus, it can be stated that according to the test and measurement experts, the tool developed is considered to be Very Feasible.

Profile of Field Trial Results (Small Group)

The rcount value (0.654) is the result of assessing the reliability which consists of test and retest. The result was obtained by correlating the best score during the first and the second days using product-moment correlation. Therefore, the reliability score of the tool to measure arm muscle explosive power in the small group is 0.654. This latter value was interpreted according to (Date et al., 1999). A simple interpretation of the "r" product-moment (rxy) correlation index number is generally used as follows: Based on Table 1, it can be seen that the product-moment correlation results obtained an r-value of 0.654. Thus, the reliability of the digital-based tool developed for measuring arm muscle explosive power is 0.654 and it is in the High category. Therefore, it can be concluded that the developed product can be used as a measurement tool.

Table 4. Validation Results Obtained from Test and Measurement Experts

No	Test & Measurement Expert Validation	Score got	Max Score	(%)	Category
1	IXXAZ	32	32	100%	Very Good
2	SXXDI	30	32	93.75%	Very Good
3	AXXIL	29	32	90.63%	Very Good
Total		92	96	94.79%	Very Good

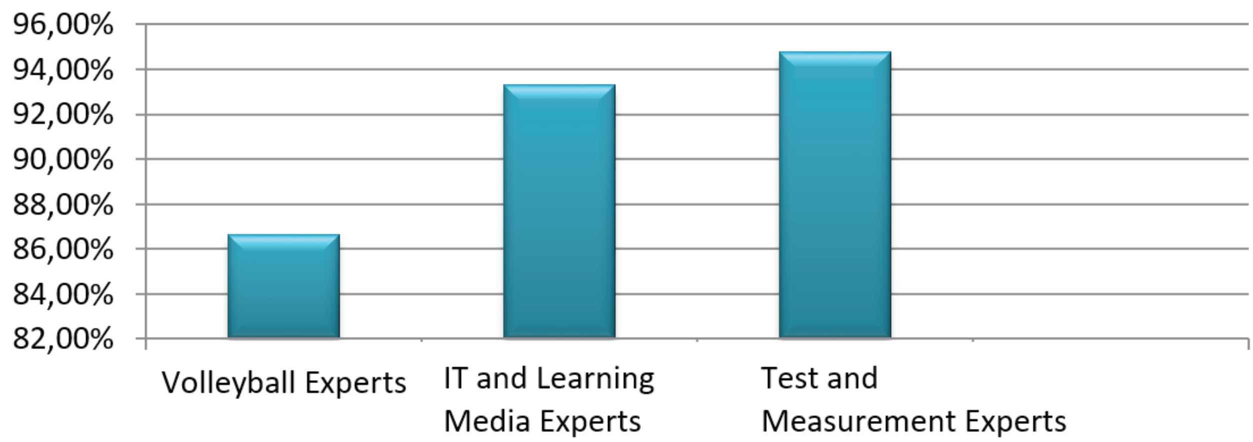

FIGURE 6. Chart Showing Data Obtained from All Experts.

Table 5. Results of the Large Group Trial with Students

No	Coded Names	Rated Explosive Power (Kg. m/s)	
		Best Results on Day I	Best Results on Day 2
1	AXXI	7.57	7.08
2	RXXI	7.78	8.78
3	AXXA	8.93	8.81
4	FXXR	7.48	7.53
5	HXXZ	7.43	7.53
6	IXXL	8.43	8.54
7	KXXL	7.67	8.78
8	KXXK	8.03	8.14
9	SXXU	7.31	8.42
10	AXXF	8.79	8.81
11	AXXF	8.64	8.70
12	SXXL	8.88	8.95
		r_{count}	0.654

Field Trial Results (Large Group)

Based on Table 6, the value rcount is 0.652. It indicates that the developed tool has high reliability. In other words, the digital tool developed is good enough to be used as a tool to measure arm muscle explosive power.

Table 6. Results of the Large Group Trial with Students

No	Coded Names	Explosive Power Score (Kg.m/s)	
		Best Results on Day I	Best Results on Day 2
1	AXXXX	8.79	7.97
2	XXXA	7.51	8.42
3	FXXXX	8.51	8.03
4	HXXXX	7.08	7.79
5	XXXXX	8.43	8.6
6	IXXXX	8.57	8.6
7	XXXXL	7.78	7.67
8	XXXXXK	7.93	7.86
9	MXXXXX	8.81	7.68
10	MXXXX	8.43	8.18
11	MXXXX	8.43	7.49
12	XXXXSXX	8.57	8.04
13	MXXXXX	7.93	8.6
14	FXXXXX	8.51	8.47
15	XXYXXX	9.79	8.79
16	XRXXXX	8.54	8.16
17	XXZXXX	7.93	7.41
18	XXAXXX	6.78	6.89
19	XXXCXX	9.40	8.6
20	XXXMXX	8.51	7.64
21	WXXXXX	7.54	7.15
22	RXXXXX	7.54	7.31
23	SXXX	8.78	8.61
24	XYXX	7.68	7.93
25	XXXX	7.93	7.86
26	WXXXX	7.79	7.51
27	WXXX	8.51	8.43
28	TXXX	8.79	8.43
29	AXXX	8.68	8.64
30	XXXIX	8.81	8.16
31	XXLXX	7.08	7.79
32	XXKXX	7.78	7.78
33	XXXY	8.57	7.73
34	AXXX	8.6	8.27
35	SXXXX	7.93	7.17
36	XDXXX	7.51	7.51
37	XXXHXX	8.08	7.94
38	XFXXX	8.43	8.66
39	XXXZX	7.51	7.21
40	XXVXX	7.79	7.85
		r_{count}	0.652

Testing the Effectiveness of the Product Developed

Based on the output in Table 7, power is shown as the value of Sig. Levene's Test for Equality of Variances of 0.792>0.05. This means that the data variance between digital tools and manual tools is homogeneous or the same. Therefore, the interpretation of the Independent Samples Test Output shown in Table 6 is in accordance with the values in the Equal Variances Assumed table.

Table 7. Output of Independent Sample T-Test

		Levene's Test		t-test for Equality of Means						
		F	Sig.	t	df	sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval	
									Lower	Upper
Explosive Power	Equal variance assumed	0.07	0.0792	0	78	1	-0.001	2.236	-4.452	4.450
	Equal variances not assumed			0	78	1	-0.001	2.236	-4.452	4.450

Discussion

The explosiveness of the upper limb muscle power can be broadly understood as the ability of a cluster of upper limb muscles to produce necessary work in a very fast time (Maffiuletti et al., 2016; Rejc et al., 2018). In other words, muscles can acquaint with at a very high concentration speed. Meanwhile, muscle strength is the adaptability and ability of the upper limbs to generate maximum power concentration to defeat or overcome burdens/loads (Eston & Reilly, 2013; Saputra & Ihsan, 2020). Based on the findings explained above, the digital-based tool for measuring upper limb muscle power is very feasible to be used and can serve as an alternative measurement tool. The feasibility value was obtained by assessing the validity and reliability of the tool developed.

Several previous studies investigated and developed an appropriate tool to measure the upper limb power of volleyball players (Stockbrugger & Haennel, 2003; Cretu & Vladu, 2010; Muslimin et al., 2020; Zecirovic et al., 2021). In this present study, modifications have been made by adding a medicine ball to the previously manual procedure. These modifications were done by considering volleyball game regulations. In addition, this study is in line with previous research, but it involves android to measure volleyball players' smash skills, instead of bio motor-physical skills (Muslimin et al., 2020). Therefore, this study has objective advantages and novelty.

The main contribution of this study is that it developed a tool to measure volleyball players' explosive power of the upper limb. The external validity and test-retest were performed to increase the validity and reliability of the product developed. The tool can be used by athletes, coaches, P.E. teachers, and lecturers in sports science study programs to measure upper limb explosive power. Moreover, this new digital measurement tool was validated by IT media experts and is categorized as Very Good (86.66%). The steps of product validation conducted in this study were corroborated by Riddell & Wallace (2011) who stated that in product development research, all new products should pass through the expert judgment stage.

However, in this study, several limitations need to be acknowledged. First, mass production was not carried out due to limited research funds. Second, the range of the subject ages was limited, so the results cannot be generalized, especially to other age groups and females. Thus, further research needs to consider norms of specific values, athletes in each development stage, and other variations of bio-motor aspects, such as speed, endurance, and agility.

Conclusions

From the obtained results it could be concluded that the development of the digital-based physical exercise tool to measure volleyball players' upper limb muscle explosive power is widely welcomed by both expert's judgment and trainees in volleyball players. It was found that anthropometric profile like arm muscles and explosive power determines playing position, especially in elite female volleyball players, and influence physical performance (Mielgo-Ayuso et al., 2015; Paz et al., 2017). Moreover, height offers a performance advantage for middle blockers, whereas lower body mass, like lower fat mass, seems to perform better than setters and liberos. As a matter of fact, the designed and developed digital-based tool was assessed by three teams of validation experts, namely volleyball experts, IT media experts, as well as test and measurement experts. Based on the judgment of these experts, the measurement tool is considered to be Very Feasible (91.58%). Thus, it can be stated that the tool developed can be used for physical education purposes.

Acknowledgments
There are no acknowledgments.

Conflict of Interest
The author declares that there is no conflict of interest.

Received: 24 June 2022 | **Accepted:** 30 January 2023 | **Published:** 01 February 2023

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